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Kendall County and the City of Fair Oaks Ranch Water and Wastewater Planning Study

February 2011

Prepared for

Guadalupe Blanco River Authority, Texas

In association with

Texas Water Development Board

Study Participants

Kendall County Water Control and Improvement District No. 1

City of Boerne

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List of Acronyms

#/100 mL	Number per 100 Milliliter
Ac-ft/yr	Acre-feet per Year
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CCGCD	Cow Creek Groundwater Conservation District
CCN	Certificates of Convenience & Necessity
DFC	Desired Future Condition
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
ETJ	Extra Territorial Jurisdiction
GAM	Groundwater Availability Model
GBRA	Guadalupe Blanco River Authority
GCD	Groundwater Conservation District
GIS	Geographic Information System
GPCD	Gallons per Capita per Day
GPD	Gallons per Day
IH	Interstate Highway
KAD	Kendall Appraisal District
lb/yr	Pound per Year
LF	Linear Foot
MAG	Managed Available Groundwater
MGD	Million Gallons per Day
mg/L	Milligram per Liter
MUD	Municipal Utility District
NH_3	Ammonia
NH_3N	Ammonia Nitrogen

O&M	Operations & Maintenance
OSSF	On-Site Sewage Facilities
P	Phosphorus
QUAL2K	EPA's River and Stream Water Quality Model
QUAL-TX	TCEQ's River and Stream Water Quality Model
RWP	Regional Water Plan
SCTRWP	South Central Texas Regional Water Plan
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TNRCC	Texas Natural Resources Conservation Commission. (Currently TCEQ.)
TPDES	Texas Pollutant Discharge Elimination System
TSDC	Texas State Data Center and Office of the State Demographer
TSS	Total Suspended Solids
TWDB	Texas Water Development Board
UA	Urbanized Area
UCCWP	Upper Cibolo Creek Watershed Partnership
WCID	Water Control and Improvement District
WWTP	Wastewater Treatment Plant

Executive Summary

Background

As Kendall County, including all of the City of Fair Oaks Ranch continues to grow in population and associated commercial development, it is important to properly plan and manage the future water supply and wastewater facilities in the County and the City and to protect water quality in the region. The location of the study area is presented in *Figure ES.1*.

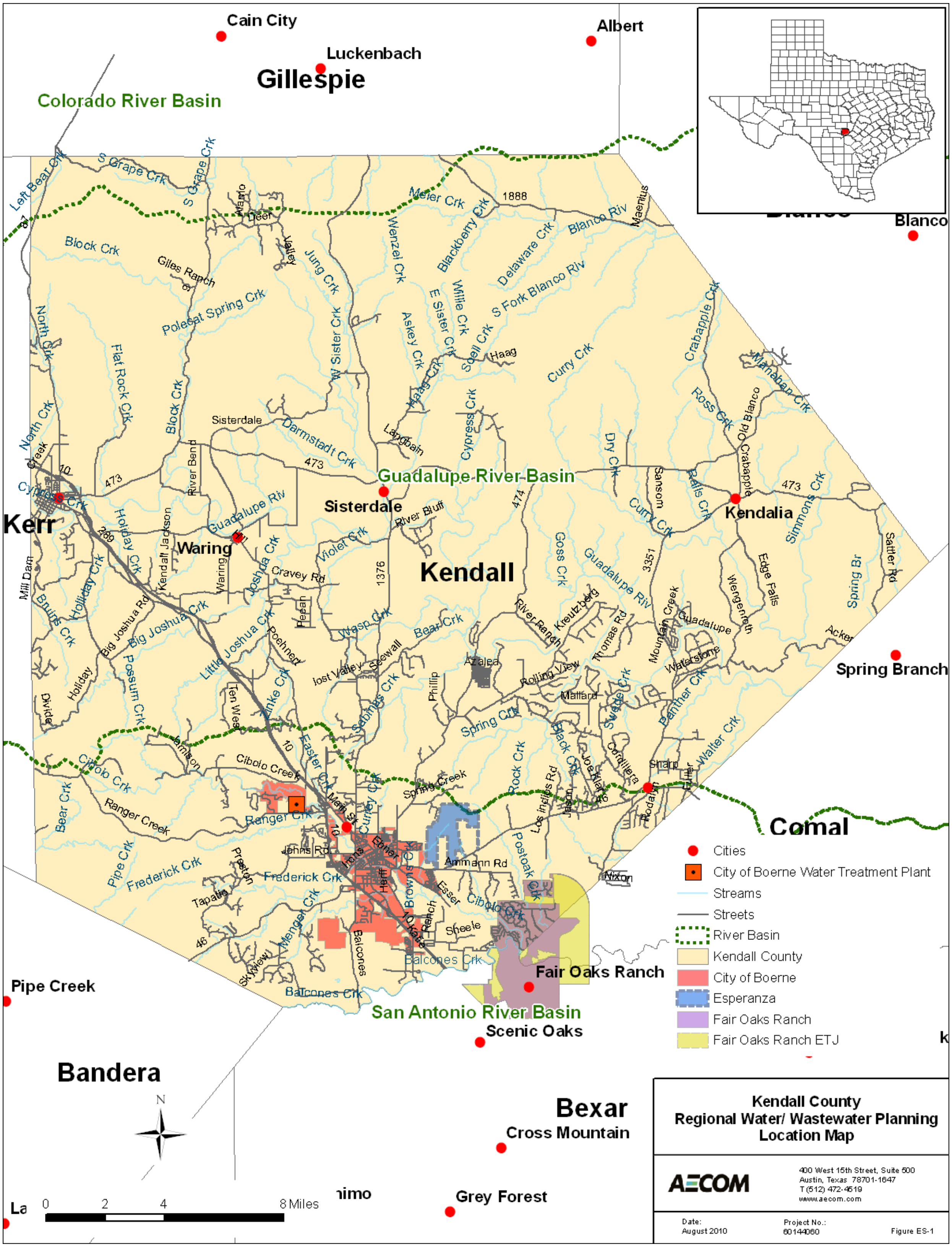
This Water and Wastewater Planning Study was funded by the Texas Water Development Board (TWDB) and the Guadalupe-Blanco River Authority (GBRA), with support by Kendall County Water Control and Improvement District (WCID) No. 1, the City of Boerne, the San Antonio River Authority and Grady Jolley of the law firm of Nunley, Jolley, Cluck, Aelvoet, LLP. It examines facilities needed to meet future demands in Kendall County and the City of Fair Oaks Ranch through a thirty year planning period from 2010 to 2040 while protecting the surface water quality and groundwater supplies of the region. The study also investigates potential regional management opportunities for water and wastewater facilities associated with development through this planning period.

Specific tasks included in this study are development of baseline information, public engagement, development of consensus on study objectives, formulation of development scenarios, analysis of surface water and groundwater supply options, analysis of water quality options, development of regional water supply and quality protection plan, attending project meetings, and preparation of study reports.

An extensive set of baseline data including Geographic Information System data for the study area was collected as part of this study and this data is documented and included with this report. A water utility survey was developed and sent to all water utilities in the study area. Responses from the survey are also compiled and included as part of this study report. Information, data and research reports formed the basis for the recommendations developed for the study region.

An advisory group was organized by the Guadalupe Blanco River Authority (GBRA) which included various stakeholders and interest groups in the region to ensure local participation and inclusion of local knowledge throughout the study. Three public meetings were also held as part of this study.

Figure ES.1 Kendall County Water and Wastewater Planning Study Location Map



Population and Water Demand

Kendall County is one of the fastest growing counties in the State of Texas. The County has seen rapid growth in the past two decades; it was the fifth fastest growing County in the State during the decade of 1990-2000. A preferred population projection for the Kendall County study area was adopted upon examination of projection information from various sources. Based on the preferred projections, Kendall County's population will grow from 35,720 in 2010 to 78,690 in 2040. The population of City of Boerne service area will grow from 11,500 in 2010 to 27,480 in 2040 and the population of the City of Fair Oaks Ranch, including Extra Territorial Jurisdiction (ETJ), is projected to grow from 6,491 in 2010 to 10,301 in 2040.

Based on input from the advisory group, Kendall County was divided into four different "zones" for estimating development, namely, 1) Northern Kendall County, 2) Western Kendall County, 3) Central Kendall County, and 4) the IH-10 Corridor. Northern and Western Kendall County are projected to grow at a slower pace compared to the other two zones. Subdivision and lot information obtained from Kendall Appraisal District, Texas State Data Center growth rates, and input from the advisory group were utilized to distribute the population to the four development zones in 2010 through 2040. Water and wastewater needs in Kendall County were analyzed based on the population in each zone. The four development zones and developable land areas in each zone are shown in Exhibits 2-1 and 2-2 (Appendix A). Projected population in each of the four development zones in Kendall County are presented in *Figure 2.6* within Section 2 of this report

Kendall County water use is primarily municipal (domestic and commercial), with some other smaller uses including irrigation, livestock, and a small amount of mining. The City of Fair Oaks Ranch water use is considered entirely municipal. Water demands for municipal use are calculated by multiplying the predicted population by the average number of gallons of water used per person (capita) per day (GPCD) for that population, also known as a water use factor.

Water use factors were determined using information from the 2011 Initially Prepared South Central Texas Regional Water Plan, as well as information from the Cow Creek Groundwater Conservation District Groundwater Management Plan. Water use factors for the four development zones in Kendall County outside of city areas ranged from 125 GPCD to 158 GPCD. Water use factors for the City of Boerne service area ranged from 156 GPCD to 163 GPCD, while the City of Fair Oaks Ranch ranged from 204 GPCD to 207 GPCD.

Total water demands for Kendall County and all of the City of Fair Oaks Ranch are expected to reach approximately16,200 ac-ft/yr by 2040. These future potential demands will need to be satisfied using a combination of existing supplies, reducing overall water use (conservation), and development of new supplies.

Water Supplies, Shortages, Supply Options and Strategies

Kendall County and Fair Oaks Ranch use a combination of surface water and groundwater to meet current water demands. The main source of groundwater in the area is pumped from the Trinity Aquifer, with a minor amount of groundwater originating from the Edwards-Trinity Aquifer in the northern portion of the county. Surface water sources include Boerne City Lake (City of Boerne) and Canyon Reservoir (GBRA), with a small additional amount of surface water coming from local surface water run-of-river rights and other small local supplies such as livestock ponds.

Water shortages are determined by comparing the water demand projections to the water supply projections. If demand exceeds supply, there is a shortage that should be met by either reducing demand through means such as conservation, or by providing additional supplies.

A Groundwater Availability Model (GAM) was used by the TWDB in December 2008 to determine an availability for the Middle Trinity Aquifer of 9,189 ac-ft/yr based on a 50 percent additional pumping condition. A more conservative and smaller availability of 6,336 ac-ft/yr was also determined, which is the current estimated baseline pumping condition used in the GAM (with no additional pumping added for future demand). Both annual volumes of supply have been considered when evaluating potential shortages for this study. Additional GAM run results were available in May 2010 (TWDB Draft GAM Task 10-005), which evaluated larger water supply availabilities, but for purposes of this study, the earlier more conservative groundwater availability numbers were used. The specific groundwater availability for the Trinity Aquifer is not known for each identified development zone; however, the amount of available Trinity Aquifer water for each of the four zones was estimated based on the proportional area of the zone with respect to the entire county.

Based on the growth predicted for the Northern Kendall County zone and the quantities of groundwater available, no shortage is predicted to occur within the study period. The Northern Kendall County zone is dependent almost exclusively on groundwater and there are limited options related to any type of regionalization of water supply facilities or alternative sources for water which can economically be made available during the study planning period.

Based on the growth predicted for the Western Kendall County zone and the calculated quantities of groundwater available, a shortage of approximately 20 ac-ft/yr already exists within Western Kendall County zone and is predicted to increase within the study period to 330 ac-ft/yr. Kendall County WCID No. 1 is the main public water system in this development zone, and it currently relies exclusively on groundwater.

For the Central Kendall County zone, a shortage of 120 ac-ft/yr is projected to begin in the 2020 decade and increase throughout the planning period to approximately 660 ac-ft/yr. Water suppliers within this zone have the use of both groundwater and surface water supplies.

Based on the growth predicted for the City of Boerne service area and the quantities of groundwater and surface water available to the City, a shortage of approximately 50 ac-ft/yr is predicted by the 2040 decade. The City of Boerne's water supplies include groundwater from the Trinity Aquifer, treated surface water from Canyon Lake Reservoir, and surface water from Boerne City Lake which is treated at their 1.5 Million Gallons per Day (MGD) water treatment plant.

The City of Fair Oaks Ranch's water supplies include groundwater from the Trinity Aquifer and treated surface water from Canyon Lake Reservoir. Based on the growth rate and build out expected for the City of Fair Oaks Ranch and the quantities of groundwater and surface water available to this City, no shortage is predicted within the study period, including assumed future development of their entire ETJ during this period.

The sources of supply for the non-city portion of the IH-10 Corridor zone include treated surface water from the Canyon Lake Reservoir, groundwater from the Trinity Aquifer, and some additional local surface water for livestock and irrigation uses. Based on the growth predicted for the non-city portion of the IH-10 Corridor and the quantities of groundwater and surface water available to the area, a shortage of 350 ac-ft/yr is predicted to occur by the 2040 decade.

If the available groundwater for the Trinity Aquifer in Kendall County is eventually determined to be greater than the assumed 6,336 ac-ft/yr from the December 2008 TWDB GAM run, shortages could be deferred beyond 2040 for all of the Kendall County zones.

Regardless of the predicted timing of future shortages for the Trinity aquifer within Kendall County, it is apparent that the growth of the County will eventually require additional water management strategies to be implemented. Initial small water shortages identified within this study can potentially be addressed in most areas through implementation of demand-management measures such as enhanced conservation, increased drought management restrictions, increased wastewater reuse for landscape irrigation, rainwater harvesting, and/or brush management practices. These types of demand management measures are almost always the most cost-effective method for meeting small shortages such as are predicted to occur during this planning period. Eventually during this thirty-year planning period or soon thereafter, increased importation of other supplies or increased use of interruptible supplies will likely be necessary.

For this 2010 – 2040 planning period, the additional water needs by Kendall County and Fair Oaks Ranch are relatively small and are scattered throughout the southern region of the study area. At this time, these additional needs do not warrant selection of a major water supply project or strategy that creates a single new source of supply. There are smaller projects/efforts that can help to better manage and supplement current supplies so that they can be stretched further to meet the expected demands. Consequently, there is no justification to construct additional large regional raw water supply or water treatment facilities for the study area.

Conservation and drought management are viable ways of reducing water demand long-term, and short-term, respectively. Wastewater reuse is another strategy which creates an additional source of supply and is already used in some parts of Kendall County and Fair Oaks Ranch to water golf courses, green spaces, and sporting facilities. Other water supply strategies such as rainwater harvesting and brush management can also have positive impacts on water availability during drought periods. Public education is an important part of any plan to implement all of the above-mentioned strategies. Additionally, incentives such as rebates and/or tax reductions for residents implementing rainwater harvesting and brush management strategies have been provided in other counties and may be viable strategies for Kendall County.

Two potential strategies identified for Kendall County, expansion of groundwater use and purchase of additional surface water from GBRA beyond the existing raw water reservations if it is determined to be available, are supply strategies that involve building additional infrastructure to obtain available water from its source, rather than reducing demand or reusing existing water.

The IH-10 Corridor may be the best candidate for regionalization of future water supply systems in Kendall County followed by Central Kendall County zone. Potential opportunities for purchasing additional water from GBRA or looking to SAWS to serve areas along the southern border of Kendall County should be explored.

Wastewater Demand and Facilities

Wastewater flows in Kendall County and Fair Oaks Ranch are currently treated using either local wastewater treatment plants or on-site sewage facilities (OSSF). Since there is only limited manufacturing water demand in Kendall County, water used for municipal purposes is the only water use type to generate wastewater flows. Wastewater flow factors in various development zones in Kendall County ranges from 80 to 150 gallons per capita per day of wastewater generated.

Wastewater demands were determined by multiplying the wastewater flow factor by the population in each decade of the planning period for the four development zones. Wastewater flow in Kendall County is expected to grow from 3.75 MGD in 2010 to 8.1 MGD in 2040. Projected population, estimated population density and wastewater flow in each of the four development zones in Kendall County and in the City of Fair Oaks Ranch are presented in Exhibit 4-1 (Appendix A).

A large portion of Kendall County's wastewater management needs is served by On-Site Sewage Facilities (OSSFs) and there are four existing and operational wastewater treatment plants (WWTPs) in Kendall County and one in the City of Fair Oaks Ranch. Northern Kendall County is served by OSSFs and does not have any community wastewater systems. In central Kendall County, Cordillera Ranch has a wastewater treatment plant which is owned and operated by the GBRA. In Western

Kendall County, Kendall County WCID No.1 owns and operates a wastewater treatment plant which serves the City of Comfort. The rest of the WWTPs and wastewater permits are located in the IH-10 Corridor, City of Boerne and Fair Oaks Ranch. The City of Boerne currently owns one operational WWTP and has permit for a second one. Kendall County Utility Districts operates a WWTP for Tapatio Springs.

City of Boerne and Kendall County WCID No. 1 do not have any regulations governing on-site sewage facility (OSSF) development. Any OSSFs within the city boundaries are regulated by Kendall County rules. Likewise, the City of Fair Oak Ranch does not regulate requirements for OSSF development. The OSSFs within the city boundary are regulated by Kendall County, Comal County, or Bexar County depending on the system's location.

Wastewater collection system alternatives that may be considered for development of regional facilities in Kendall County include:

- Conventional collection systems consisting of gravity sewers, lift stations and force mains;
- Alternative collection systems using pressure sewers, with on-site grinder pump stations and small diameter force mains; and,
- Alternative collection systems using Septic Tank Effluent Pump/Septic Tank Effluent Gravity (STEP/STEG) technology.

Table ES-1 indicates areas of potential applicability that may be considered for each of these types of Wastewater Collection System Alternatives:

Table ES-1 Potential Applicability of Wastewater Collection System Alternatives

Collection System Alternative	Areas of Potential Applicability
Conventional Collection System	Serve future growth and/or retrofit existing developed areas in City of Boerne; City of Fair Oaks; City of Comfort; Cordillera Ranch; Tapatio Springs; and other densely developed towns and subdivisions along the Guadalupe River and Cibolo Creek and other major drainages.
Pressure Sewer System	Serve future growth or retrofit areas served by failing OSSFs, in areas of complex topography with low to moderate development density in the North and Western parts of Kendall County.
STEP/STEG Collection System	Retrofit areas served by existing OSSFs in Fair Oaks Ranch to increase effluent available for golf course irrigation, and serve future growth or areas served by failing OSSFs in moderately steep areas with low to moderate development density throughout the County.

Feasibility of a single regional treatment facility, multiple treatment facilities and packaged treatment plant was investigated for the Kendall County study area. It was assumed that Northern Kendall County, which will have a projected population density of 0.025 persons per acre in 2040, will continue to be served by single-lot OSSF systems, except for possible limited subdivision-level centralization of wastewater service for localized areas.

A single regional WWTP was determined not to be a viable approach for wastewater master planning in Kendall County based on anticipated collection system costs versus relatively low long-term population density, and anticipated operations and maintenance (O&M) costs for pumping raw wastewater across multiple drainage basins.

Use of packaged treatment plants is not recommended for providing long-term wastewater service due to the high recurring cost of replacing the packaged treatment units, but may be an appropriate near-term approach for currently-unserved developing areas that will be connected to a centralized or regional WWTP collection system within 15-20 years.

The recommended development scenarios for wastewater master planning for Kendall County consist of multiple regional facilities as summarized in Table ES-2:

Table ES-2 Wastewater Treatment Development Scenarios

Development Zone	Anticipated WW Treatment Facilities	Anticipated 2040 Flow Rate
Northern Kendall County	OSSFs	< 5,000 GPD each*
Western Kendall County	Regional WWTP at Kendall County WCID No.1 Site	< 0.48 MGD + Kerr County Flows
Central Kendall County	Regional WWTP at GBRA Cordillera Ranch WWTP Site	< 1.73 MGD
IH-10 Corridor	Regional WWTP at City of Boerne Future WWTP Site	< 5.2 MGD

* State regulations require entities with greater than 5000 GPD of wastewater flow to be permitted for discharge and no-discharge systems. No community systems are anticipated for the Northern Kendall County zone.

Further investigation of the potential for regionalization of wastewater treatment within Western Kendall County and Central Kendall County will require evaluation of the feasibility and economics of the treatment requirements for effluent discharge, which is likely to require compliance with stringent effluent limits for nutrient removal versus the feasibility and economics of effluent disposal by land application at less stringent effluent quality limits, including land availability and costs, and construction and operation/maintenance costs of effluent storage ponds and irrigation systems.

Further investigation of the potential for regionalization of wastewater treatment within the IH-10 Corridor will necessitate discussion with the City of Boerne to confirm the City's amenability to siting a regional facility at either the City's future WWTP site, as well as the City's plans for the existing WWTP and evaluation of the cost of pumping from Fair Oaks Ranch to the regional WWTP.

In addition to these three identified potential locations for regional facilities, satellite facilities should be considered for the purpose of producing reclaimed water in fast-growing areas with high potential for reuse demands (such as golf course communities) where the cost of returning reclaimed effluent from a regional facility would justify the cost of a separate treatment facility. Where a regional collection system exists, a “scalping” satellite WWTP may be constructed for the sole purpose of reclaimed water production, with no effluent discharged, and residual solids returned to the collection system.

In consideration of anticipated development densities in much of rural Kendall County versus the density required to support the cost of centralized wastewater collection, and based upon the current development regulations for the County, many areas throughout the County will continue to develop at a low density and will use OSSF technology for treatment combined with effluent discharge via infiltration or irrigation disposal systems.

Conceptual-level construction costs for regional wastewater treatment facilities in Western Kendall County, Central Kendall County and IH-10 Corridor zones were estimated. These estimates did not include the cost of the collection system.

Water Quality

Water quality in the streams and rivers of Kendall County is generally good. The Texas Commission on Environmental Quality (TCEQ) assesses the health of water bodies within the state every two years in a report titled the Texas Water Quality Inventory and 303(d) List. When a water body does not meet quality standards for the stream, river or lake’s designated uses, the water body is added to the 303(d) list of impaired waters. The main stem of the Guadalupe River that flows through the study area and the tributaries into that section of river show no impairments or concerns in the *DRAFT 2010 Texas 303(d) List*, released in February 2010.

The majority of the existing population and the future populations are projected to reside in the IH-10 corridor area of the County which actually lies in the San Antonio River Basin. The Upper Cibolo Creek watershed which drains this part of the county has been listed a number of times for several parameters in the TCEQ’s biannual 303(d) lists. The *DRAFT 2010 Texas 303(d) List* shows the Upper Cibolo Creek from approximately 2 miles upstream of Hwy 87 in Boerne to the upper end of segment 1908_02 as being impaired for bacteria. While this impairment has been identified since 2006, TCEQ has determined that more data will need to be collected before proceeding with a Total Maximum Daily Load (TMDL) evaluation. The Upper Cibolo Creek Watershed Partnership (UCCWP) has been formed to take a proactive step in protecting and restoring water quality within Upper Cibolo Creek. The UCCWP is responsible for developing a non-regulatory Watershed Protection Plan to promote awareness and initiate action in reducing nonpoint source pollution within the watershed. A local stakeholder group has been formed to guide the planning phase of the protection plan.

High level water quality modeling was performed for both Cibolo Creek and Guadalupe River in Kendall County to determine the impact of point sources discharges and impact of non-point loading due to development through 2040. EPA’s water quality model, QUAL2K, was utilized for the Cibolo Creek Model and QUALTX was applied to develop the Guadalupe River Model.

The base model for Cibolo Creek water quality modeling effort for this study was provided by the City of Boerne. The model was prepared for ‘*Cibolo Creek Water Quality Monitoring and Modeling’* study for the City of Boerne in February 2009.

The water quality model used to evaluate point source and non-point source impacts to the Guadalupe River was developed from a QUAL-TX model used by the TCEQ to evaluate the point source impacts of the Kendall County WCID No. 1 wastewater treatment plant discharge. The original model was based on a short reach of river near the discharge site. The model developed for this study expanded the analysis to include the entire length of Guadalupe River within Kendall County.

Non-point loadings of Total Suspended Solids (TSS), Nitrogen, Phosphorus, and Fecal Coliform were computed based on information in “*Predicting Effects of Urban Development in the Cities of New*

Braunfels, San Marcos, Seguin and Victoria. Prepared in cooperation with GBRA and TNRCC by PBS&J, November 2000."

Comparisons of the concentrations of the various parameters for the 2010 and 2040 analyses were graphed versus stream location, while non-point source loadings were calculated in lb/yr or #/100 mL as model input data and compared to show how growth and development in the various watersheds from 2010 to 2040 can impact those loadings.

Results showed that maintaining high standards for wastewater effluent is important, but in the case of some parameters, non-point source loadings have a much larger impact. In those cases, additional wastewater discharge can reduce the concentration of the pollutant in the stream.

The stakeholders and officials in the study area desire to maintain a high quality of water in the streams and water bodies in Kendall County. Non-point source pollutant loadings are identified as one of the key contributors of possible water pollution in Kendall County. For the Cibolo Creek watersheds, high *fecal coliform* concentrations in runoff are expected to remain a concern if proper preventative measures are not implemented in the future.

The Guadalupe River provides a high quality recreational asset in Kendall County and for the entire region. The water quality modeling efforts conducted for this study demonstrate that maintaining a high standard of effluent discharge can maintain the quality of water in the river; however, the increased level of pollutants from increased growth and urbanization in this area must also be addressed.

Preventative measures and best management practices can be implemented to reduce non-point source pollution. Following is a list of measures and activities currently in place or that should be investigated:

- The Upper Cibolo Creek Watershed Partnership (UCCWP) was formed to take a proactive step in protecting and restoring water quality within Upper Cibolo Creek. The UCCWP is responsible for developing a non-regulatory Watershed Protection Plan to promote awareness and initiate action in reducing nonpoint source pollution within the watershed. (Source: http://www.ci.boerne.tx.us/index.aspx?nid=147)

- Best management practices (BMPs) to mitigate non-point source pollution. It should be noted that best management practices that are well documented as being efficient especially for sediment removal and to a great extent nutrient removal may not be as efficient at reducing the bacteria loading.

- Low impact and low density developments are helpful to reduce stormwater runoff pollution. Low density developments are prevalent in Guadalupe River watersheds. Low impact developments should be investigated and implemented in the Cibolo watershed for future developments.

- Training to individual homeowners in the County for maintenance of OSSF will enable proper maintenance of the systems and thus result in reduced accidental discharges. GBRA has specific programs to provide eight hours of training for individual wastewater treatment system owners.

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1.0 Introduction

1.1 Background

Kendall County is located approximately 30 miles northwest of San Antonio on IH-10 in the beautiful Texas Hill Country. The county is surrounded by Gillespie County to the north, Blanco County to the northeast, Comal County to the southeast, Bexar County to the south, Bandera County to southwest and Kerr County to the west as shown in *Exhibit 1-1*. (All exhibits are presented in Appendix A of the report.) The County includes the communities of Boerne, Fair Oaks Ranch, Comfort, Alamo Springs, Kendalia, Bergheim, Waring, Sisterdale and Welfare.

The Cibolo Creek, a tributary of the San Antonio River, flows through the city of Boerne and City of Fair Oaks Ranch. The Guadalupe River flows through the city of Comfort. A small portion of the northern part of the county falls in the Lower Colorado River Basin. *Exhibit 1-2* shows streams and aquifers in Kendall County and topography and floodplain in Kendall County are shown in *Exhibit 1-3*.

Kendall County is named for George Wilkins Kendall, a journalist and Mexican-American War correspondent. *Progressive Farmer* rated Kendall County fifth in its list of the "*Best Places to Live in Rural America*" in 2006. It is part of the San Antonio Metropolitan Statistical Area [22].

According to the U.S. Census Bureau, Kendall County has a total area of 663 square miles, of which 662 square miles is land and 1 square miles (0.09%) is water. The 2009 population estimate for Kendall County is 34,053 as of July 1, 2009 [20] and its county seat is the City of Boerne [18]. Major highways in the county are IH-10, US Highway 87 and State Highway 46, Farm to Market Road (FM) 473, FM 474, FM 1376, and Highway 3351. The county enjoys an approximate average rainfall of 40 inches per year [18].

The City of Boerne is located in the south central part of Kendall County along IH-10, approximately 22 miles northwest of San Antonio in the foothills of the Texas hill country. Estimated 2009 population for the City is 10,663 [19]. Approximate area of the City of Boerne is 10 square miles (6,402 acres). The City has an Extra Territorial Jurisdiction (ETJ) of 31.3 square miles.

The City of Fair Oaks Ranch is located in the southern part of Kendall County and it extends into the northern part of Bexar County. Based on Texas State Data Center information, estimated 2009 population for the City of Fair Oaks is 6,382 [17]. The City of Fair Oaks Ranch has an area of 9.0 square miles and 13.5 square miles including its ETJ.

Kendall County, including the cities of Fair Oaks Ranch and Boerne, is one of the fastest growing counties in Texas. The area is heavily influenced by the growth in Northern Bexar County and the City of San Antonio.

1.2 Objectives of the Study

As Kendall County and the City of Fair Oaks Ranch continue to grow in population and commercial development, it is important to properly plan and manage water resources and wastewater in the County and the City to protect water quality in the region for its residents to enjoy. The Guadalupe Blanco River Authority (GBRA) entered into a contract with AECOM in November 2009 to provide professional services for a regional water and wastewater planning study for Kendall County and the City of Fair Oaks Ranch. The study is partially funded by the Texas Water Development Board (TWDB).

The planning objective of this study is to identify the water and wastewater facilities needed for future demands in Kendall County and the City of Fair Oaks Ranch through a thirty year planning period from 2010 to 2040 while protecting the surface water quality and groundwater supplies. The study also investigates potential regional management for water and wastewater facilities associated with development through this planning period.

The major tasks included in the scope of the study are:

1. Develop baseline information.
2. Conduct public participation.
3. Develop consensus on study objectives.
4. Formulate development scenarios.
5. Analyze surface water and groundwater supply options.
6. Analyze water quality options.
7. Develop regional water supply and quality protection plan.
8. Prepare study reports and attend meetings.

Task 1 is covered in *Section 1.3* of this report. Task 2 is detailed in *Section 1.4* Task 3 was accomplished through the engagement of advisory group which is discussed in *Section 1.4* which also covers the additional meetings identified in Task 8.0 . A development scenario memo was prepared in May 2010 as outlined in Task 4 and the development scenarios are discussed in *Section 2.0* of this report. Task 5 is covered in *Section 3.0* and Task 6 is covered in *Sections 4.0* and *5.0* of this report. Task 7 is provided as a part of *Section 3.0* and *4.0* of this report. Finally, this report is the deliverable identified in Task 8.

1.3 Baseline Data

A comprehensive dataset including Geographic Information System (GIS) data for Kendall County have been collected for this study. A list of the different datasets collected is listed below. More detailed lists are included in Appendix B. Also enclosed with the study report is a data CD containing all data sets collected. A 'Data Log' file included in the CD lists the enclosed data.

Some of the GIS data collected as a part of the study are also exhibited on maps presented in the exhibits to this report. Aquifers, streams, impaired segments of streams and water wells located in Kendall County and the City of Fair Oaks Ranch are presented in *Exhibit 1-4*. Aerial images of Kendall County are presented in *Exhibit 1-5*.

A water utility survey was developed and mailed out to all active water utilities in Kendall County that are listed in the TCEQ database. The survey, list of all utilities the survey had been mailed to, a response log, and all the responses received are also included in Appendix B.

A list of baseline information collected for the study is provided below.

- GIS Data (Appendix B)
- Water supply and water quality data (Appendix B)
- Reports and studies, ordinances (Appendix B)

•Water utility survey (Appendix B)

•List of water systems in Kendall County (Appendix B)

•Publicly Available Data

- River basins. Watersheds, HUCs (8 digit).
- Major Roadways, Rivers, Reservoirs
- Administrative Boundaries: Counties, Cities, GCDs, River Authorities, Water/Wastewater CCN
- Major/ Minor Aquifers
- USGS Landcover Data
- Wastewater Outfalls
- 2000 Census Block and Census Tract Data
- 2009 Texas State Data Center TIGER/ Line Data

1.4 Public Participation

Three public meetings were held for the Kendall County Water and Wastewater Planning Study to receive public comments and to disseminate information and findings from the study. The schedule of the meetings, agendas, attendee lists and meeting minutes from these meetings are included in Appendix C. Slides from the presentations made at these meetings are included in Appendix D.

A technical advisory group was also formed by the GBRA in early March 2010 including entities representing various interest groups in Kendall County to provide input and feedback during the development of this project. A list of the advisory group members is included in Appendix C. These advisory group members were actively involved in the project and provided useful information and feedback to the GBRA and the study contractor. Three advisory group meetings were held during the course of the study as outlined below.

The first advisory group meeting was held on March 23, 2010 and focused on population projection, development zones, developable areas, and growth rates. Inputs from this meeting were used to select the most likely overall growth projections in Kendall County and to predict development trends for that growth. The objectives of the study were presented to the advisory group at this meeting and a consensus on objectives was acknowledged. The second advisory group meeting was held on May 27, 2010 and focused on water demand, supply options and strategies, and wastewater options. The third and final advisory group meeting was held on July 22, 2010 and water quality was the key topic of discussion at this meeting. Agendas, attendee lists, and meeting notes including key discussion outcomes of these three meetings are included in Appendix C. Slides from the presentations made at the advisory group meetings are included in Appendix D.

2.0 Population Projections and Development Scenarios

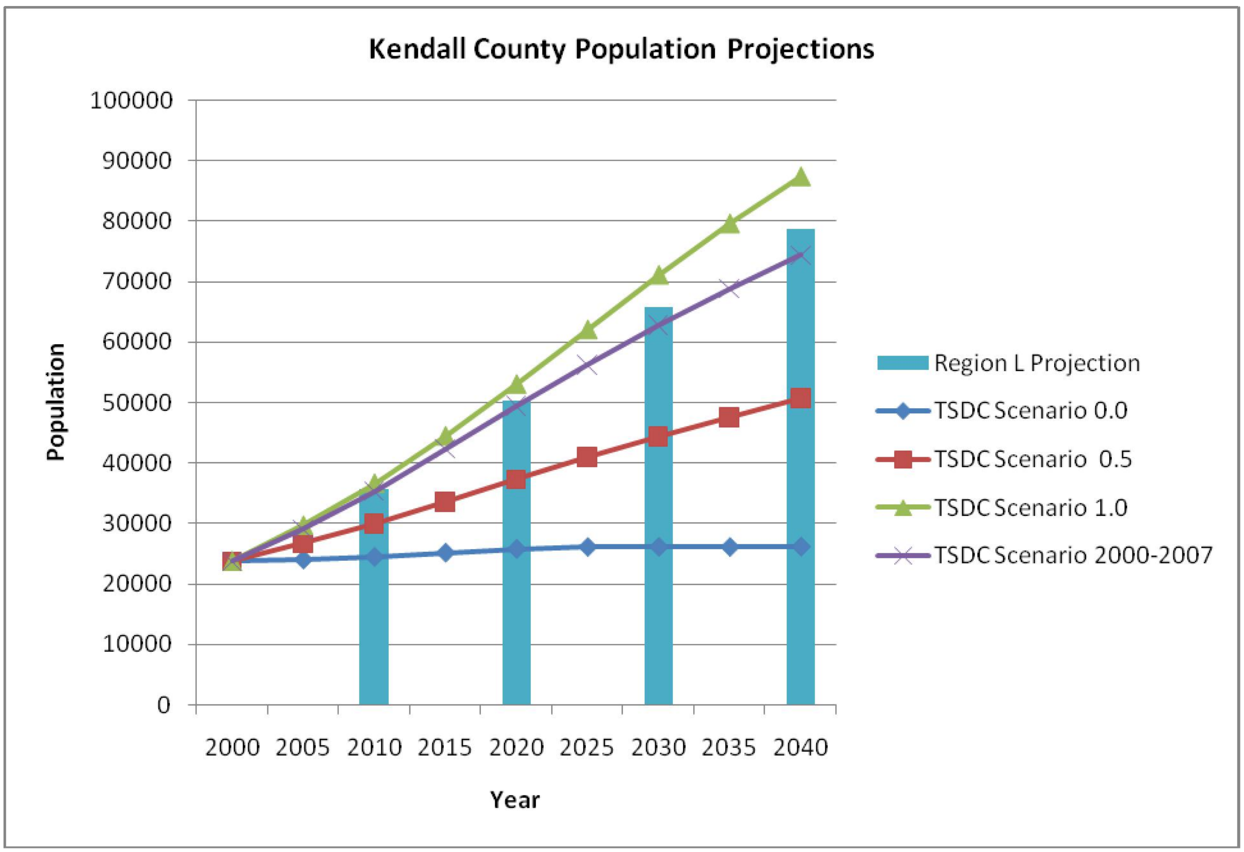
Kendall County is one of the fastest growing counties in the State of Texas. The County has seen rapid growth in the past two decades; it was the fifth fastest growing County in the State during the decade of 1990-2000. Kendall County is expected to see continued significant growth in the coming decades. This section of the report discusses that projected population growth in Kendall County and the likely distribution of the growth during the next thirty year planning period.

2.1 Population Projection Estimates

Population projections from Region L Water Plan (February 2010) by Texas Water Development Board (TWDB), Texas State Data Center (TSDC) (February 2009), Cow Creek GCD Groundwater Management Plan (December 2009), and Kendall County Thoroughfare Planning Citizens Committee (May 2007) were all considered in order to develop and select the preferred population projection for Kendall County for this study.

Comparison of the population projections from Region L and for various scenarios developed by TSDC are presented in *Figure 2.1*.

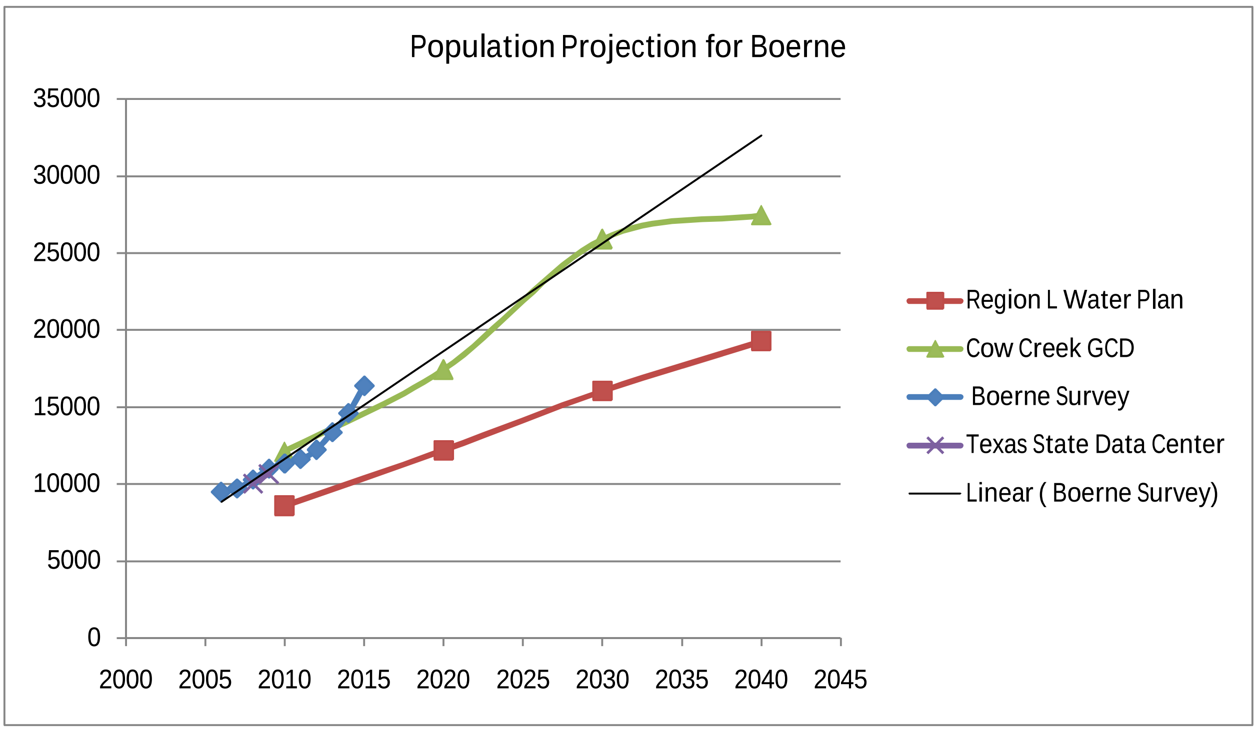
Figure 2.1 Comparison of Kendall County Population Projections



Population projection estimates developed by the TSDC have four scenarios of expected growth. The zero scenario is one which assumes that in-migration and out-migration are equal (i.e., net migration is zero) resulting in growth only through natural increases or decreases (the excess or deficit of births relative to deaths). The One-Half 1990-2000 Migration (0.5) scenario is an approximate average of the zero (0.0) and 1990-2000 (1.0) scenarios. The 1990-2000 Migration (1.0) scenario assumes that the trends in net migration rates of the 1990s will characterize those occurring in the future of Texas. The 1990s was a period characterized by rapid growth. The 2000-2007 projection scenario provides a scenario that takes into account post-2000 population trends. In the State overall and in some counties, the post-2000 period has resulted in reduced levels of net migration.

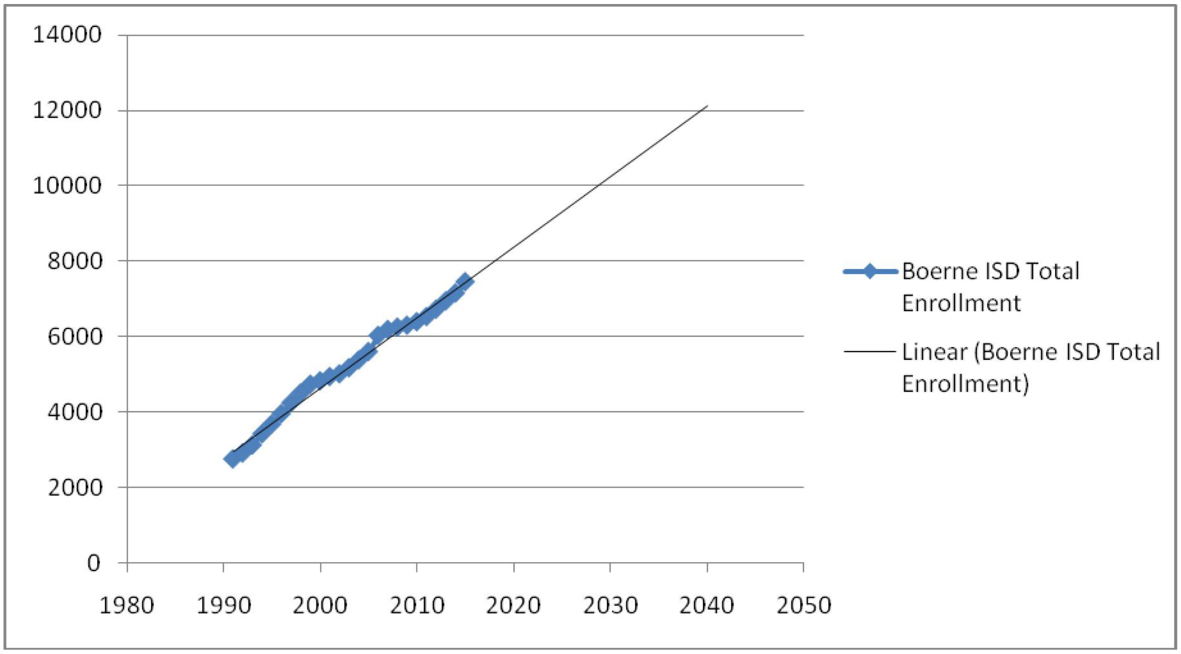
The largest population concentration within Kendall County is within the City of Boerne. Comparisons of the population projections for the Boerne service area are presented in *Figure 2.2* . The Boerne service area is comprised of the City of Boerne and the proposed Esperanza development (*Exhibit 4-1*). Population projections for the City of Boerne were considered from the Region L Water Plan (February 2010) by TWDB, TSDC (February 2009), responses provided by the City of Boerne to a survey conducted by AECOM for this study (February 2010), and from the Cow Creek GCD Groundwater Management Plan (December 2009) in order to develop and select the preferred population projection for the Boerne service area.

Figure 2.2 Comparison of Population Projections for Boerne Service Area



Historic and future projections of Boerne Independent School District (Boerne ISD) enrollment data were also examined to determine possible correlations with population projections in the area. *Figure 2.3* presents the enrollment data and trend for Boerne ISD. A general upward trend in the ISD enrollment data can be seen; however, there was no direct correlation between population data and the enrollment data that could be determined.

Figure 2.3 Historic and Future Projection of Enrollment Data for Boerne ISD



Recent population estimates from TSDC for Kendall County, City of Boerne and Fair Oaks Ranch are presented in *Table 2.1* for reference.

Table 2.1 Recent Population Estimates for Kendall County from TSDC

Entity	2000 Census Count	7/1/2008 Population Estimate	1/1/2009 Population Estimate
Kendall County	23,743	32,832	33,341
Boerne	6,178	10,039	10,663
Comfort	2,358	2,791	2,805
Fair Oaks Ranch	4,695	6,245	6,382

Source: Texas Stare Data Center (TSDC)

The selected population projections which were preferred for this study for City of Boerne, Kendall County portion of the City of Fair Oaks Ranch, entire City of Fair Oaks Ranch and Kendall County are presented in *Table 2.2*. These selected projections predict that the Kendall County's population will more than double by the year 2040. These study area projections were recommended by AECOM for use in this study and were the preferred projections by the advisory group.

Table 2.2 Preferred Population Projections

Entity	2010	2015	2020	2030	2040
Boerne [1]	11,500	16,375	17,457	25,924	27,480
Fair Oaks Ranch (Kendall County portion) [2]	1,234	-	1,282	1,308	1,335
Fair Oaks Ranch[3]	6,181	-	6,271	6,339	6,408
Fair Oaks Ranch (Including ETJ) [4]	6,491	-	7,841	9,191	10,301
Kendall County [5]	35,720	-	50,283	65,752	78,690

[1] 2010 and 2015 population estimate is provided by City of Boerne. 2020, 2030 and 2040 estimates are from Cow Creek GCD Water Management Plan.
[2] Region L Water Plan and Cow Creek GCD have same population projections for the Kendall County portion of Fair Oaks Ranch.
[3] Fair Oaks Ranch population projection excluding ETJ. Estimate from Region L Water Plan.
[4] Fair Oaks Ranch population projection including ETJ. 2010 estimate based on number of current water customer (2,404). 2020 and 2030 estimates based on number 50 lot/yr of development. 2040 estimate is based on number of future lots in the City including ETJ (3,815) provided by the City of Fair Oaks Ranch. Population estimated at 2.7 people/connection.
[5] Region L Water Plan.

These projections were selected based on the following factors:

Kendall County:

- Region L 2010 population estimate for Kendall County is closest to January 2009 Population Estimate by TSDC (Table 2.1).
- Region L projections are closest to TSDC 2000-2007 scenario.
- Advisory Committee did not see any valid reason to deviate from published TWDB projections.

City of Boerne

- 2010 and 2015 population estimate is provided by City of Boerne. 2020, 2030 and 2040 estimates are from Cow Creek GCD Water Management Plan.
- Projection preferred by City of Boerne official.

Fair Oaks Ranch

- Region L Water Plan and Cow Creek GCD have same population projections for the Kendall County portion of Fair Oaks Ranch.
- Region L 2010 population estimate for Fair Oaks Ranch is consistent with January 2009 Population Estimate by TSDC (*Table 2.1*).
- Region L planning data is best available information Fair Oaks Ranch population projection excluding ETJ.
- Fair Oaks Ranch population projection including ETJ. 2010 estimate based on number of current water customer (2,404). 2020 and 2030 estimates based on number 50 lot/yr of development. 2040 estimate is based on number of future lots in the City including ETJ (3,815) provided by Ron Emmons. Population estimated at 2.7 people/connection.

2.2 Development Zones and Distribution of 2010 Population

Based on inputs from the advisory group, Kendall County was divided into four development zones, namely, 1) Northern Kendall County, 2) Western Kendall County, 3) Central Kendall County, and 4) IH-10 Corridor as presented in *Exhibit 4-1*.

Northern and Western Kendall County are projected to grow at a slower pace compared to the other two zones. Some of the areas in the southern portion of the Western Kendall County zone are not expected to see much development due to steep slopes in that area. In the Northern Kendall County development zone, there is a proposed subdivision in the north-central part of the county named 'Diamond K', located off of Sisterdale Road. It is a large lot property where development is slow but in progress.

Central Kendall County encompasses some of the recent growth within the County such as Cordillera Ranch. This area is expected to continue to have significant growth along the Guadalupe River as population from San Antonio and retirement age populations continue to move to the area. The area has the scenic beauty of the Texas Hill County, a school district with a reputation for high quality, and relatively easy access to the major metropolitan area of San Antonio.

The IH-10 Corridor development zone for this study includes the Boerne service area, the City of Boerne and proposed Esperanza development, and the Kendall County portion of Fair Oaks Ranch. This area is also expected to see rapid growth, especially in the Boerne Service area and in areas with close proximity to the San Antonio metropolitan area.

Esperanza is a proposed 1,250 acre master-planned community located just east of Boerne on the north side of SH-46 (*Exhibit 2-1*). The proposed development is located in the IH-10 Corridor development zone. There are plans to develop 2480 lots over the next 15 years. Development of this community has currently slowed because of the economic downturn. The City of Boerne will provide water and sewer service to this area. The Esperanza development may be at the center of the next large area of population growth in the Boerne Service Area. Lerin Hills is the other planned development in the IH-10 corridor (*Exhibit 4-1*). It has an area of 893 acres of potential high density development. Development progress within this area has also slowed at this time.

Kendall County population in 2010 was distributed into the four zones (outside of Boerne service area and Fair Oaks Ranch) based on the number of currently occupied lots in each zone. The total occupied lots in each zone were estimated based on all subdivision lots with improvements and non-subdivision lots with homestead land or improvement value as identified by the Kendall Appraisal District (KAD). The population in each development zone, and for the City of Boerne service area and Kendall County portion of Fair Oaks Ranch are presented in *Figure 2.4* and *Table 2.3*.

Exhibit 4-1 shows the locations of improved and empty subdivision lots, and homestead lots. This information is based on parcel data and Kendall County appraisal data obtained from Kendall Appraisal District (KAD) in February 2010 and the datasets are dated 2010. Based on the input from Cow Creek GCD personnel, it is acknowledged that the KAD dataset is not complete. This dataset, therefore, is used for distributing population in different zones based on relative number of lots in each zone rather that making an estimate of total population or need.

Figure 2.4 2010 Population in Kendall County Development Zones

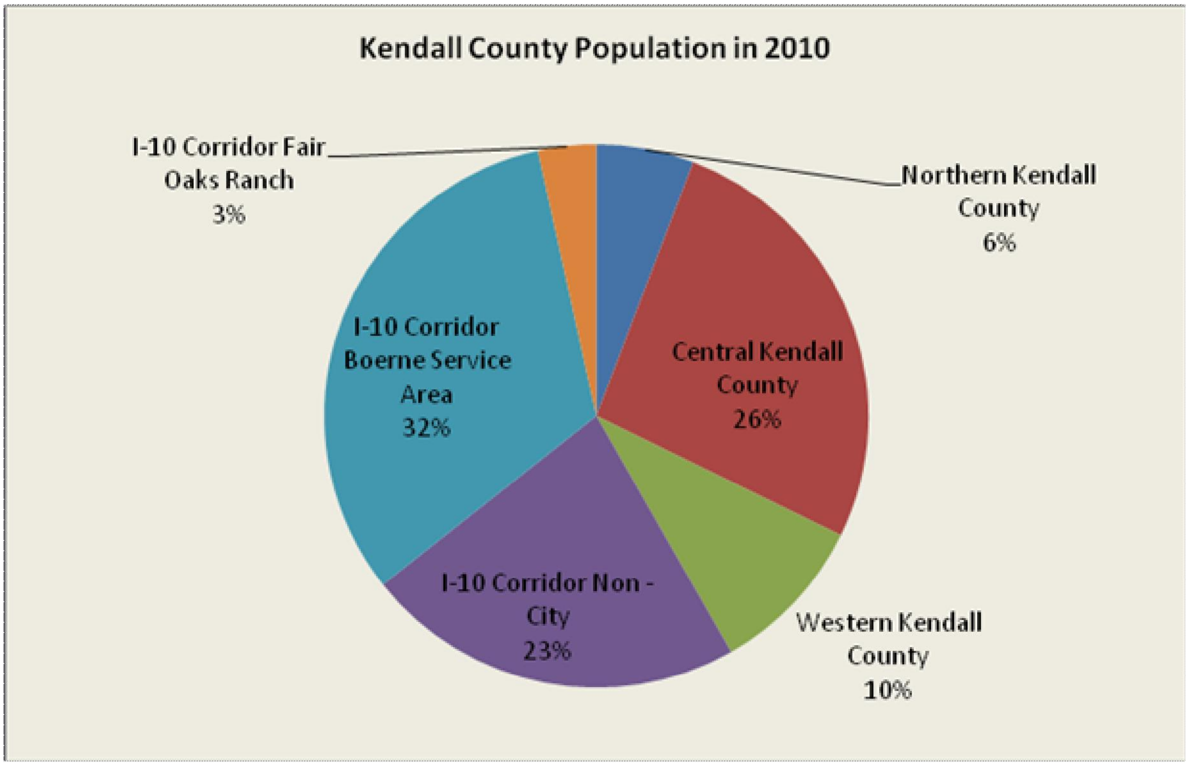


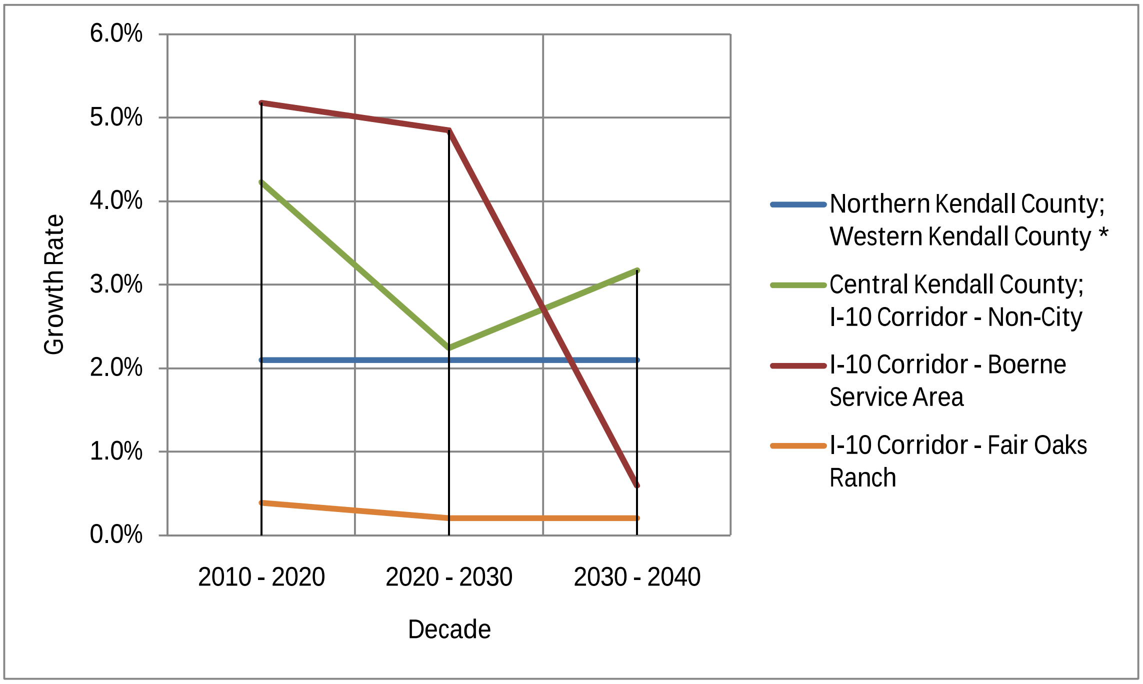
Table 2.3 2010 Population in Kendall County Development Zones

Zone	City	2010 Population
Northern Kendall County		2070
Central Kendall County		9445
Western Kendall County		3398
IH-10 Corridor	Non - City	8,073
IH-10 Corridor	Boerne service area	11,500
IH-10 Corridor	Fair Oaks Ranch	1,234
Total		**35,720**

2.3 Growth Rates

Northern Kendall County and Western Kendall County are expected to experience a relatively slower pace of growth and development compared to the rest of the County over the next three decades. The Texas State Data Center (TSDC) 2000 to 2009 growth rate for Comfort was chosen for these two zones. It is assumed that Central Kendall County and IH-10 Corridor (non-city) will grow at the same rate to accommodate the rest of the non-city growth in Kendall County. Within the IH-10 corridor much of the growth will occur in Boerne and Esperanza. Decadal growth rates used for this study within the different zones and areas in Kendall County are shown in *Figure 1.5*.

Figure 2.5 Growth Rates in Kendall County (%/year)



* Texas State Data Center (TSDC) 2000 to 2009 growth rate for Comfort CDP

2.4 Distribution of 2020, 2030 and 2040 Population

Kendall County population estimates in 2020, 2030 and 2040 were distributed into the four zones (outside of Boerne Service Area and Fair Oaks Ranch) based on growth rates discussed in the previous section. The resulting populations in each zone and in the City of Boerne and Kendall County portion of Fair Oaks Ranch are presented in *Figure 2.6* and *Table 2.4*.

Figure 2.6 Kendall County Population Projections in the Development Zones

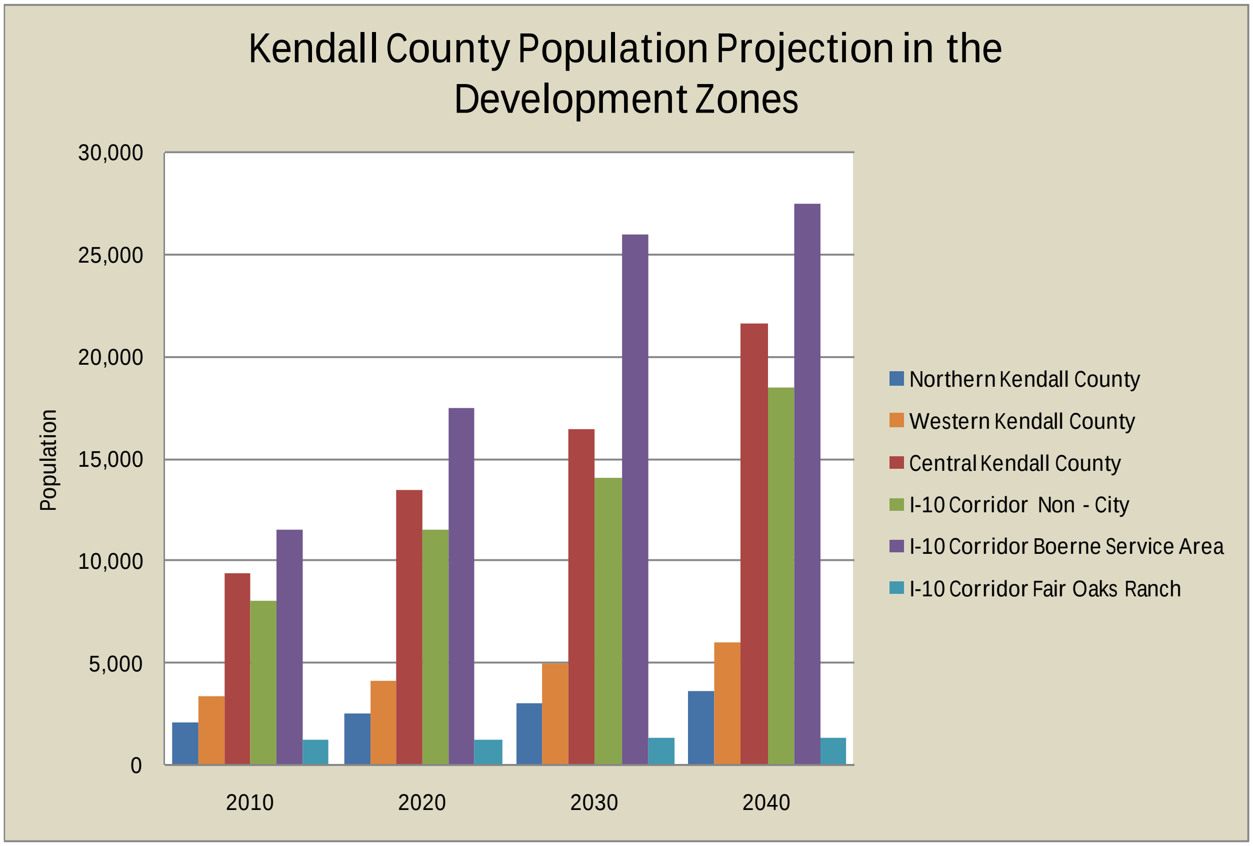


Table 2.4 Distribution of 2020, 2030 and 2040 Population in Kendall County Development Zones

Zone	City	2010	2020	2030	2040
Northern Kendall County		2,069	2,503	3,029	3,665
Western Kendall County		3,409	4,125	4,991	6,039
Central Kendall County		9,440	13,434	16,445	21,659
IH-10 Corridor	Non - City	8,068	11,482	14,055	18,512
IH-10 Corridor	Boerne Service Area	11,500	17,457	25,924	27,480
IH-10 Corridor	Fair Oaks Ranch	1,234	1,282	1,308	1,335
IH-10 Corridor	Total	20,802	30,221	41,287	47,327
County Total		35,720	50,283	65,752	78,690

2.5 Additional Population and Available Land Area

Additional population (i.e.growth) in the development zones in Kendall County by decade are presented in *Table 2.5*. Projected occupancy in unoccupied subdivision lots was estimated to determine how much of the projected population could be accommodated within existing undeveloped subdivision lots (*Table 2.6*). Based on the assumptions made for this study, existing lots should be able to absorb the projected growth through approximately 2020.

Table 2.5 Additional Population in Development Zones by Decade

Zone	City	2010 - 2020	2020 - 2030	2030 - 2040
Northern Kendall County		434	526	636
Western Kendall County		716	866	1,048
Central Kendall County		3,994	3,011	5,214
IH-10 Corridor	Non - City	3,414	2,573	4,457
IH-10 Corridor	Boerne Service Area	5,957	8,467	1,556
IH-10 Corridor	Fair Oaks Ranch	48	26	27
IH-10 Corridor	Total	9,419	11,066	6,040
County Total		14,563	15,469	12,938

[1] Occupancy estimate based on 80% lot occupancy and TSDC estimate of 2.7 person/ household for Kendall County.

Table 2.6 Estimate of Total Occupied Lots and Empty Subdivision Lots in Each Development Zone

Development Zone	City	Total Occupied Lots [2]	Unoccupied Subdivision Lots [3]	Projected Occupancy in Empty Lots [4]
Northern Kendall County		644	307	663
Western Kendall County		1057	447	966
Central Kendall County		2938	1864	4,026
IH-10 Corridor	Non - City	2511	831	1,795
IH-10 Corridor	Boerne	3381	1026	2,216
IH-10 Corridor	Esperanza	0	2480	5,357
IH-10 Corridor	Fair Oaks Ranch	529	242	523
IH-10 Corridor	Total	6421	4579	9,891
Total			**7197**	**15,546**

[1] Data presented in this table are based on 2010 Kendall Appraisal District's (KAD) data obtained in February 2010.
[2] Total occupied lots are estimated based on all subdivision lots with improvements and non-subdivision lots with homestead land or improvement value.
[3] Empty Subdivision lots are subdivision lots with no improvement value.
[4] Occupancy estimate based on 80% lot occupancy and TSDC estimate of 2.7 person/ household for Kendall County.

Available land areas for future subdivision development for each development zone (non-city) in Kendall County and maximum occupancy in these zones were also evaluated to ensure that the zones could accommodate the additional projected population (*Table 2.7*). A conservative estimate of eighty percent of available land area was used to estimate maximum possible occupancy. It is assumed that this should account for the Conservation Easements. Density assumptions in each zone were based on Kendall County development rules (*Table 4.4*). It was determined that available land area in each zone (non-city) could easily accommodate the projected population through 2040 in each zone.

Table 2.7 Developable Land Area and Resulting Maximum Possible Occupancy in Kendall County

Area Name	Developable Land Area[1] (ac)	80% of Developable Land Area (ac)	Density[2] (ac/ lot)	Maximum Possible No. of Lots	Maximum Possible Occupancy[3]	Additional Projected Population in 2040
Northern Kendall County	158,911	127,129	6	21,188	45,766	1,596
Western Kendall County	24,974	19,979	6	3,330	7,193	2,630
Central Kendall County	71,265	57,012	4	14,253	30,786	12,219
IH-10 Corridor (Non-City)	42,935	34,348	3	11,449	24,730	10,444

[1] Developable Land Area = Total Land - 100yr Floodplain - Roadway easement - Boerne - Esperanza - Fair Oaks Ranch - Subdivisions – Homesteads
[2] Kendall County development rules governing density assumptions can be found in *Table 4.4*.
[3]Occupancy estimate based on 80% lot occupancy and TSDC estimate of 2.7 person/ household for Kendall County.

Maximum possible occupancy in each zone was computed based on the minimum lot size allowed within Kendall County development rules and the TSDC estimate for persons per household. Actual population density in each zone will generally be much lower even at full build-out due to use of larger lots within typical subdivisions. For instance, in Northern Kendall County, based on projected population of 3,665 in 2040, the net density or average lot size would be 128 ac of land per lot. Even at full build-out, it is highly unlikely that the density of Northern Kendall County will reach a 6 ac/lot average size. A more reasonable expected density for the Northern Kendall County zone is closer to 20 ac/lot.

2.6 Future Population Density in 2040

The future population density in each development zone was computed based on estimated 2040 population divided by land area outside 100-yr floodplain, roadway easements and known conservation easements. Future population density in the Boerne service area and Fair Oaks Ranch were computed based on the estimated 2040 population divided by respective land area for these cities. The future population densities in each of the development zones and cities in Kendall County are presented in *Table 2.8* and *Table 2.9.*

Table 2.8 Future Population Density in Four Development Zones in Kendall County (outside city areas)

Zone	Estimated Population in 2040	Area* (ac)	Density (p/ac)
Northern Kendall County	3,665	177,164	0.021
Western Kendall County	6,039	31,544	0.191
Central Kendall County	21,659	95,556	0.227
IH-10 Corridor (non-city)	18,512	70,104	0.264

* Area = Total land area - 100yr floodplain - roadway easements – known conservation easement

Table 2.9 Future Population Density in Boerne service area and Fair Oaks Ranch

City	Estimated Population in 2040	Area (ac)	Density (p/ac)
Boerne service area*	27,480	7,650	3.59
Fair Oaks Ranch	6,408	6,126	1.05
Fair Oaks Ranch with ETJ	10,301	8,609	1.20

*City of Boerne and Esperanza

3.0 Water Supply Planning

3.1 Water Demands and Water Use Factors

Kendall County water use is primarily municipal domestic and commercial, with other uses including irrigation, livestock, and a small amount of mining. The City of Fair Oaks Ranch water use is considered entirely municipal. Water demands for municipal use are calculated by multiplying the population by the average number of gallons of water used per person (capita) per day (GPCD) for that population, also known as a water use factor.

Water use factors were determined using information from the 2011 Initially Prepared South Central Texas Regional Water Plan (SCTRWP), as well as information from the Cow Creek Groundwater Conservation District (CCGCD) Groundwater Management Plan. The CCGCD Groundwater Management Plan provided a more detailed breakdown of the populations, water demands, and water use factors of some of the smaller communities in Kendall County, rather than combining them all together under the County-Other water user group, as the SCTRWP does. *Table 3.1* and *Table 3.2* below show the water use factors for the study planning period from the SCTRWP and CCGCD Groundwater Management Plan, respectively.

Table 3.1 Water Use Factors from the 2011 Initially Prepared SCTRWP

Water User Group	Per Capita Water Use[1] (gallons per person per day)			
	2010	2020	2030	2040
Boerne	169	169	169	169
Fair Oaks Ranch	209	209	209	209
Water Services, Inc.[2]	129	129	129	129
County-Other	102	102	102	102

[1] SCTRWP recommends improvement of per capita water uses for municipalities as a water management strategy in the Region L Plan.
[2] It has been determined that this water user group from the 2011 Initially Prepared SCTRWP no longer exists, and therefore has not been included in this study.

Table 3.2 Water Use Factors from the CCGCD Groundwater Management Plan

Water User Group	Per Capita Water Use (gallons per person per day)			
	2010	2020	2030	2040
Boerne	163	160	158	156
Fair Oaks Ranch	207	206	205	204
PWS Other	123	121	119	119
Aqua Texas	149	160	160	169

Water User Group	Per Capita Water Use (gallons per person per day)			
	2010	2020	2030	2040
Kendall County WCID #1	140	135	130	125
Kendall County Utility Company	133	133	133	133
Cordillera Ranch (GBRA)	406	268	268	268
Lerin Hills*	N/A	140	135	130
County-Other	142	140	138	136

*Lerin Hills is not currently in operation

Once the population projections were distributed within the four development zones, the water use factors were used to determine municipal water demand projections through 2040 for the different zones. *Table 3.3* shows the water use factors that were used for the four development zones.

Table 3.3 Water Use Factors for the Four Development Zones

Zone	Entity	Per Capita Water Use (gallons per person per day)			
		2010	2020	2030	2040
Northern Kendall County		142	140	138	136
Western Kendall County		140	135	130	125
Central Kendall County		140	152	153	152
IH-10 Corridor	Non-City	142	140	138	136
	Boerne Service Area	163	160	158	156
	Fair Oaks Ranch (All)	207	206	205	204

The Northern Kendall County and IH-10 Corridor Non-City water use factors were assumed to equal the County-Other water use factors from the CCGCD Groundwater Management Plan. The Boerne Service Area and Fair Oaks Ranch water use factors were assumed to equal their respective factors from the CCGCD Groundwater Management Plan. The Western Kendall County water use factors were assumed to equal the Kendall County Water Control and Improvement District (WCID) #1 factors from the CCGCD Groundwater Management Plan. The Central Kendall County water use factors were an average of the PWS Other, Aqua Texas, Cordillera Ranch, and County-Other water use factors, based on relative percentages of total population and demand numbers presented in the CCGCD Groundwater Management Plan.

The water use factors mentioned in *Table 3.3* above were used with the population projections to determine the municipal water demands in each development zone. Mining, irrigation, and livestock demands were from the SCRTWP and were split proportionally into the different development zones based on their basin area. *Table 3.4* through *3.7* below show the calculated water demand projections by development zone.

Table 3.4 Population and Water Demand Projections for the Northern Kendall County Zone

Northern Kendall County Zone	2010	2020	2030	2040
Population	2,069	2,503	3,029	3,665
Municipal Water Demand (Ac-Ft/Yr)	329	363	468	558
Mining Water Demand (Ac-Ft/Yr)	6	6	6	6
Irrigation Water Demand (Ac-Ft/Yr)	261	255	250	245
Livestock Water Demand (Ac-Ft/Yr)	190	190	190	190
Total Zone Water Demand (Ac-Ft/Yr)	**786**	**814**	**914**	**999**

Table 3.5 Population and Water Demand Projections for the Western Kendall County Zone

Western Kendall County Zone	2010	2020	2030	2040
Population	3,409	4,125	4,991	6,039
Municipal Water Demand (Ac-Ft/Yr)	535	624	727	846
Irrigation Water Demand (Ac-Ft/Yr)	52	51	50	49
Livestock Water Demand (Ac-Ft/Yr)	35	35	35	35
Total Zone Water Demand (Ac-Ft/Yr)	**622**	**710**	**812**	**930**

Table 3.6 Population and Water Demand Projections for the Central Kendall County Zone

Central Kendall County Zone	2010	2020	2030	2040
Population	9,440	13,434	16,445	21,659
Municipal Water Demand (Ac-Ft/Yr)	1,480	2,287	2,818	3,688
Irrigation Water Demand (Ac-Ft/Yr)	208	204	200	196
Livestock Water Demand (Ac-Ft/Yr)	141	141	141	141
Total Zone Water Demand (Ac-Ft/Yr)	**1,829**	**2,632**	**3,159**	**4,025**

Table 3.7 Population and Water Demand Projections for the IH-10 Corridor Zone

IH-10 Corridor Zone	2010	2020	2030	2040
Boerne Service Area Population	11,500	17,457	25,924	27,480
Boerne Service Area Municipal Water Demand (Ac-Ft/Yr)	2,100	3,129	4,588	4,802
Fair Oaks Ranch (All) Population*	6,491	7,841	9,191	10,301
Fair Oaks Ranch (All) Municipal Water Demand (Ac-Ft/Yr)	1,505	1,809	2,111	2,354
Non-City Population	8,068	11,482	14,055	18,512
Non-City Municipal Water Demand (Ac-Ft/Yr)	1,283	1,801	2,173	2,820
Total Municipal Water Demand (Ac-Ft/Yr)	4,888	6,739	8,872	9,976
Irrigation Water Demand (Ac-Ft/Yr)	193	189	185	181
Livestock Water Demand (Ac-Ft/Yr)	80	80	80	80
Total Zone Water Demand (Ac-Ft/Yr)	**5,161**	**7,008**	**9,137**	**10,237**

* Assumed development of the Fair Oaks Ranch ETJ occurs by 2040

Total water demands for Kendall County and all of the City of Fair Oaks Ranch are expected to reach approximately16,200 ac-ft/yr by 2040. These demands will need to be satisfied using existing supplies, reducing overall water use (conservation), or finding new supplies.

3.2 Available Water Supply and Shortages

Kendall County and Fair Oaks Ranch use a combination of surface water and groundwater to meet current water demands. The main source of groundwater in the area is pumped from the Trinity Aquifer, with a minor amount of groundwater originating from the Edwards-Trinity Aquifer in the northern portion of the county. Surface water sources include Boerne City Lake (City of Boerne) and Canyon Reservoir (Guadalupe-Blanco River Authority [GBRA]), with a small additional amount of surface water coming from local surface water run-of-river rights and other small local supplies such as livestock ponds.

Data from the 2011 Initially Prepared South Central Texas Regional Water Plan (SCTRWP) shows that supplies needed to meet mining, livestock, and irrigation demands in Kendall County are available through either groundwater, local supplies, or surface water run-of-river rights, based on firm available quantities rather than authorized diversions. Based on that information, this planning study assumes that existing and future demands related to these water use types are met entirely throughout the planning period and will not require additional supplies. Municipal water supply for domestic and commercial uses have therefore been analyzed for shortages during the planning period as a part of this study and are discussed further below.

3.2.1 Available Water Supply

Table 3.8 below lists the five sources of supply for Kendall County and the City of Fair Oaks Ranch. Groundwater is generally used throughout the county, both in rural areas and by existing communities, including the City of Boerne service area, Cordillera Ranch, the City of Fair Oaks Ranch, and others. Canyon Reservoir is also a source of supply for the City of Boerne service area, Cordillera Ranch, the City of Fair Oaks Ranch, Kendall County Utility Company/Tapatio, and Lerin Hills, although the surface water delivery facilities for Lerin Hills and Tapatio have not yet been constructed by the developers. A potential supply of 150 ac-ft/yr from Canyon Reservoir to other water users is currently pending, and has been included in the figures.

Table 3.8 Water Supply Sources for Kendall County and Fair Oaks Ranch

Supply Source	Surface or Ground?	Annual Volume (Ac-Ft/Yr)	Notes
Middle Trinity Aquifer*	Ground	6,336 – 9,189	12/08 GAM run
Edwards-Trinity Aquifer	Ground	318	MAG
Boerne City Lake	Surface	833	Not 100% reliable
Miscellaneous Surface Water	Surface	242	Volume is 100% reliable
Canyon Reservoir (GBRA)	Surface	8,111 – 8,611	Volume is based on the raw water reservations of GBRA customers, and includes an anticipated reservation increase for Cordillera Ranch (500 ac-ft)
Total Water		**15,840 – 19,193**	

* A later GAM Run 10-005 was performed in May of 2010 which has a “Scenario 6” with Kendall County pumpage of 11,450 ac-ft/yr. This run was utilized for adoption of the DFC statement in the County on July 26, 2010.

Kendall County is located within Groundwater Management Area 9 (GMA-9), which is currently in the process of determining a Desired Future Condition (DFC) for the Trinity Aquifer. The DFC will then be used to develop a Managed Available Groundwater (MAG) quantity for each county within GMA-9. The MAG will be the amount of groundwater from the aquifer that is estimated to be reliably available under drought conditions. Since the process for determining the MAG is not yet complete, the estimated availability of the Trinity Aquifer in Kendall County remains somewhat uncertain. A Groundwater Availability Model (GAM) was used by the TWDB in December 2008 to determine an availability for the Middle Trinity Aquifer of 9,189 ac-ft/yr based on a 50 percent additional pumping condition. A more conservative and smaller availability of 6,336 ac-ft/yr was also determined, which is the current estimated baseline pumping condition used in the GAM (with no additional pumping added for future demand). Both volumes have been considered when evaluating potential shortages for this analysis.

A GMA 9 meeting was held on July 26, 2010 and a DFC statement was adopted for the Trinity Aquifer. The DFC statement for Trinity Aquifer allows for an increase in average drawdown of approximately 30 ft through 2060 consistent with “Scenario 6” in TWDB Draft GAM Task 10-005. This DFC statement was adopted by GMA 9 during the final weeks of this study and after the initial draft report was prepared. While a final determination of future availability for Trinity Aquifer in Kendall County will not be established until an official

MAG number is adopted, the adopted DFC is expected to allow approximately 11,450 ac-ft/yr of groundwater usage in Kendall County as per TWDB Draft GAM Task 10-005 Report. The Cow Creek GCD will then be able to determine how the District might modify or adopt new regulations to facilitate this higher level of aquifer usage and maintain the aquifer impacts to acceptable levels.

The MAG process for the Edwards-Trinity Aquifer has determined a sustainable availability for Kendall County of 318 ac-ft/yr.

Boerne City Lake has a storage volume of approximately 4,000 ac-ft and an authorized water right diversion of 833 ac-ft/yr. During some severe drought years, this source is not predicted to have adequate water to provide the entire authorized diversion amount; however, based on the State's surface water availability models, Boerne City Lake is adequate 99% of the months in the historical period of record to supply the City of Boerne and its service area the full authorized diversion of 833 ac-ft/yr.

Miscellaneous surface water includes local supplies such as livestock ponds, as well as small run-of-river water rights, which provide water for irrigation and livestock needs. The amount shown in *Table 3.8* is the amount available during the drought-of-record, so in most years, more water is actually available from these sources.

Canyon Reservoir is located in Comal County, east of Kendall County. Surface water from Canyon Reservoir is stored and delivered by or committed from water rights permitted to GBRA. GBRA has contracts with the various communities listed in *Table 3.9*, in which treated water is provided via the Western Canyon Regional Treated Water Supply Project. Water from this project supplies communities in Kendall County and other counties through a water treatment facility located south of Canyon Reservoir near Startz Hill and pumped through various transmission lines from 16 to 30 inches in diameter which move that water westward. The volumes shown below in *Table 3.9* are the current annual commitments for each community, as well as the maximum quantity of water each community presently has reserved. Cordillera Ranch currently has a request pending to increase their reserved annual volume by 500 ac-ft/yr.

The foresight and willingness of the City of Fair Oaks Ranch and the City of Boerne to commit to participating in the Western Canyon Regional Treated Water Supply Project has ultimately enabled over 8,000 ac-ft/yr to be supplied to the Kendall County area and significantly reduced the demands on the Middle Trinity Aquifer.

Table 3.9 GBRA Customers Receiving Canyon Reservoir Water Supply

Receiving Entity	Current Annual Commitment (Ac-Ft/Yr)	Raw Water Reservation (Ac-Ft/Yr)	Notes
City of Boerne Service Area	975	3,611	Includes Esperanza.
City of Fair Oaks Ranch	890	1,850	
Cordillera Ranch	200	1,000	Request for a raw water reservation increase of an additional 500 ac-ft/yr is pending, for a total of 1,500 ac-ft/yr
Kendall County Utility Company/Tapatio	200	750	Tapatio does not currently have a constructed delivery system for surface water

Receiving Entity	Current Annual Commitment (Ac-Ft/Yr)	Raw Water Reservation (Ac-Ft/Yr)	Notes
Lerin Hills	225	750	Lerin Hills does not currently have a constructed delivery system for surface water
Other water users (two years out)	30	150	Contract is pending
Total Water	**2,520**	**8,111**	A pending additional 500 ac-ft/yr reservation for Cordillera Ranch would give a total of 8,611 ac-ft/yr

3.2.2 Water Shortages

Water shortages are determined by comparing the water demand projections to the water supply projections. If demand exceeds supply, there is a shortage that should be met by either reducing demand through means such as conservation, or by providing additional supplies.

For the purposes of this study, the specific groundwater availability for the Trinity Aquifer is not known for each identified development zone; however, the amount of Trinity Aquifer water available for each zone was determined based on the proportional area of the zone with respect to the entire county.

3.2.2.1 Northern Kendall County Zone

The water demands, available water supplies, shortages, and surpluses for the Northern Kendall County Zone are shown below in *Table 3.10*. Based on the growth predicted for this zone and the quantities of groundwater available, no shortages are predicted to occur within the study period. Because the Northern Kendall County Zone is sparsely populated, it should be noted that the availability to meet the additional projected growth beyond 2010 is still likely to require additional infrastructure such as wells, pumps, and potentially distribution lines and treatment facilities, depending on whether the growth occurs as individual properties or as community systems connected to a community well field.

Table 3.10 Northern Kendall County Zone Comparison of Supplies and Demands

Northern Kendall County Zone	2010	2020	2030	2040
Water Demands (Ac-Ft/Yr)	786	814	914	999
Water Supplies (Ac-Ft/Yr)				
Edwards-Trinity Aquifer	77	77	77	77
Trinity Aquifer*	2,851	2,851	2,851	2,851
Miscellaneous Surface Water	95	95	95	95
Total Water Supplies (Ac-Ft/Yr)	3,023	3,023	3,023	3,023
Water Shortage (Ac-Ft/Yr)	0	0	0	0
Water Surplus (Ac-Ft/Yr)	2,237	2,209	2,109	2,024

* The amount shown as available from the Trinity Aquifer is the proportional amount by area of the suggested minimum total available aquifer volume for Kendall County (6,336 ac-ft/yr).

The Northern Kendall County Zone is dependent almost exclusively on groundwater and there are limited options related to any type of regionalization of water supply facilities or alternative sources for water which can economically be made available during the study planning period. The Edwards-Trinity Aquifer is a current source of supply and has additional availability to handle increased demands, but the minimal geographic distribution of the aquifer in the county and within this zone dictates caution in anticipating greater reliance on this source in the future.

3.2.2.2 Western Kendall County Zone

The water demands, available water supplies, shortages, and surpluses for the Western Kendall County Zone are shown below in *Table 3.11*. Based on the growth predicted for this zone and the calculated quantities of groundwater available, small shortages already exist within this zone and are predicted to increase within the study period. If the MAG for the Trinity Aquifer in Kendall County is determined to be greater than the assumed 6,336 ac-ft/yr, shortages could be deferred beyond 2040. Kendall County WCID No. 1 is the main public water system in this development zone, and it currently relies exclusively on groundwater. The proximity of the Western zone to the Northern zone, which has a calculated surplus of groundwater, provides opportunity for new remote well fields to supply the projected additional water supply required for this zone. Additional infrastructure to serve new customers, as well as infrastructure for individual groundwater wells that are not part of the public water system, will also be required to accommodate future growth in this development zone.

Wells drilled in the North and West development zones are potentially subject to contamination by naturally occurring radionuclides. Within Kendall County, only Kendall County WCID No.1 has any well sources that are in violation of radionuclide standards. Several water systems in neighboring Kerr and Gillespie Counties are reported to have radionuclide violations. These naturally-occurring radionuclides are most likely originating from the Hickory and Ellenberger formations. While not considered to be major sources of water for Kendall County, drilling into one of these formations presents the potential for the well to contain high levels of radionuclides. Care should be taken in the drilling process to minimize the influence of these formations on the water produced. Should future well supplies contain levels of radionuclides above the State's Maximum Contaminant Level, that well water would not be available for use as drinking water without further treatment.

Table 3.11 Western Kendall County Zone Comparison of Supplies and Demands

Western Kendall County Zone	2010	2020	2030	2040
Water Demands (Ac-Ft/Yr)	622	710	812	930
Water Supplies (Ac-Ft/Yr)				
Trinity Aquifer*	570	570	570	570
Other Surface Water	30	30	30	30
Total Water Supplies (Ac-Ft/Yr)	600	600	600	600
Water Shortage (Ac-Ft/Yr)	-22	-110	-212	-330
Water Surplus (Ac-Ft/Yr)	0	0	0	0

* The amount shown as available from the Trinity Aquifer is the proportional amount by area of the suggested minimum total available aquifer volume for Kendall County (6,336 ac-ft/yr).

3.2.2.3 Central Kendall County Zone

The water demands, available water supplies, shortages, and surpluses within the Central Kendall County Zone are shown in *Table 3.12*. Based on the growth predicted within this zone and the quantities of groundwater available, small shortages are projected to begin in the 2020 decade and increase throughout the planning period. Again, these shortages may be eliminated depending on the availability volume of the final MAG determination for the Trinity aquifer in Kendall County. Water suppliers within this zone have the use of both groundwater and surface water supplies. Cordillera Ranch is located within this zone and is the largest community. For this comparison of supplies and demands, it was assumed that Cordillera Ranch will have its pending contract increase of an additional 500 ac-ft/yr approved by GBRA for a total availability of 1,500 ac-ft/yr of treated surface water from Canyon Reservoir.

Table 3.12 Central Kendall County Zone Comparison of Supplies and Demands

Central Kendall County Zone	2010	2020	2030	2040
Water Demands (Ac-Ft/Yr)	1,829	2,632	3,159	4,025
Water Supplies (Ac-Ft/Yr)				
Trinity Aquifer*	1,635	1,635	1,635	1,635
Canyon Reservoir**	230	800	1,225	1,650
Other Surface Water	77	77	77	77
Total Water Supplies (Ac-Ft/Yr)	1,942	2,512	2,937	3,362
Water Shortage (Ac-Ft/Yr)	0	-120	-222	-663
Water Surplus (Ac-Ft/Yr)	113	0	0	0

* The amount shown as available from the Trinity Aquifer is the proportional amount by area of the suggested minimum total available aquifer volume for Kendall County (6,336 ac-ft/yr).
**Amount shown is the anticipated annual commitment total for Cordillera Ranch and other water users.

Cordillera Ranch expects to reach build-out by 2040 with a demand of 1,500 ac-ft based on a water use factor of 268 GPCD. Through conservation, the supply requirements could potentially be significantly reduced, which would either allow the community to have additional expansion beyond its current plans, or Cordillera Ranch could potentially release some surface water for an alternative user, either within the Central Zone or perhaps in the IH-10 Corridor Zone if needed. For this planning study, all growth outside of Cordillera Ranch was assumed to use groundwater as the source of supply. Additional supply to meet the projected shortages may be available for purchase from GBRA out of Canyon Reservoir, beginning as early as 2020, although transmission pipeline extensions and additional distribution line systems would likely need to be constructed to serve the demand areas. As of 2010, there are no supplies available for purchase from GBRA out of Canyon Lake Reservoir; however, GBRA is pursuing the development of additional supplies from other sources which might be used to supply existing contract holders from Canyon Reservoir and allow those supplies to be contracted to others as early as 2020.

3.2.2.4 IH-10 Corridor Zone

The water demands, available water supplies, shortages, and surpluses for the IH-10 Corridor Zone are shown in three separate tables. The IH-10 Corridor Zone includes both the City of Boerne and the City of Fair Oaks Ranch. These cities are shown separately from the rest of the zone to better compare their individual projected demands and supplies. *Table 3.13* shows the shortage analysis for the City of Boerne service area (City of Boerne including Esperanza Development). Based on the growth predicted for the City of Boerne service area and the quantities of groundwater and surface water available to the City, a small shortage is predicted by the 2040 decade.

Table 3.13 City of Boerne Service Area (IH-10 Corridor Zone) Comparison of Supplies and Demands

City of Boerne Service Area	2010	2020	2030	2040
Water Demands (Ac-Ft/Yr)	2,100	3,129	4,588	4,802
Water Supplies (Ac-Ft/Yr)				
Trinity Aquifer*	307	307	307	307
Canyon Reservoir**	975	1,989	3,448	3,611
Boerne City Lake	833	833	833	833
Total Water Supplies (Ac-Ft/Yr)	2,115	3,129	4,588	4,751
Water Shortage (Ac-Ft/Yr)	0	0	0	-51
Water Surplus (Ac-Ft/Yr)	15	0	0	0

* The amount shown as available from the Trinity Aquifer is the proportional amount by area of the suggested minimum total available aquifer volume for Kendall County (6,336 ac-ft/yr).
**Amount shown is the anticipated annual commitment for the City of Boerne service area.

The City of Boerne's water supplies include groundwater from the Trinity Aquifer, treated surface water from Canyon Reservoir, and surface water from Boerne City Lake which is treated at their 1.5 MGD water treatment plant. Under extreme drought conditions, the Boerne City Lake could become unreliable for short periods of time, which would reduce the City of Boerne's supplies. Water conservation and drought management measures can help to reduce the City of Boerne's water use long-term and short-term, respectively, in order to manage their existing supplies to meet demands. The City of Boerne is currently looking at wastewater reuse as another source of water supply that would also help to meet these future demands. Additionally, beginning as early as 2020, increasing their raw water reservation for Canyon Reservoir water from GBRA may be an option, as explained above for the Central zone.

Table 3.14 shows the shortage analysis for the City of Fair Oaks Ranch. The City of Fair Oaks Ranch's water supplies include groundwater from the Trinity Aquifer and treated surface water from Canyon Lake Reservoir. Based on the growth rate and build out expected for the City of Fair Oaks Ranch and the quantities of groundwater and surface water available to this City, no shortages are predicted within the study period, including assumed future development of their entire extra-territorial jurisdiction (ETJ) during this period.

Table 3.14 City of Fair Oaks Ranch (IH-10 Corridor Zone) Comparison of Supplies and Demands

City of Fair Oaks Ranch	2010	2020	2030	2040
Water Demands (Ac-Ft/Yr)	1,505	1,809	2,111	2,354
Water Supplies (Ac-Ft/Yr)				
Trinity Aquifer*	543	543	543	543
Canyon Lake Reservoir**	962	1,266	1,568	1,850
Total Water Supplies (Ac-Ft/Yr)	1,505	1,809	2,111	2,393
Water Shortage (Ac-Ft/Yr)	0	0	0	0
Water Surplus (Ac-Ft/Yr)	0	0	0	39

* The amount shown as available from the Trinity Aquifer is the proportional amount by area of the suggested minimum total available aquifer volume for Kendall County (6,336 ac-ft/yr) plus 500 ac-ft/yr from the wells in Bexar and Comal Counties.

**Amount shown is anticipated annual commitment for the City of Fair Oaks Ranch.

The comparison of supplies and demands for the remaining portion of the IH-10 Corridor Zone is shown in *Table 3.15*. The sources of supply for the non-city portion of the IH-10 Corridor Zone include treated surface water from the Canyon Lake Reservoir, groundwater from the Trinity Aquifer, and some additional local surface water for livestock and irrigation uses. Based on the growth predicted for the non-city portion of the IH-10 Corridor and the quantities of groundwater and surface water available to the area, a shortage of 350 ac-ft/yr is predicted to occur by the 2040 decade. Again, this shortage may be eliminated depending on the final MAG determination for the Trinity aquifer. Options for resolving this shortage could include various conservation program enhancements, including a combination of rainwater harvesting and drought management, or could involve purchasing/reserving additional Canyon Reservoir water from GBRA to supply new development areas should that option become available in the 2020 decade.

Table 3.15 Non-City Portion of IH-10 Corridor Zone Comparison of Supplies and Demands

Non-City Portion of IH-10 Corridor Zone	2010	2020	2030	2040
Water Demands (Ac-Ft/Yr)	1,283	1,801	2,173	2,820
Water Supplies (Ac-Ft/Yr)				
Trinity Aquifer*	930	930	930	930
Canyon Lake Reservoir**	425	835	1,300	1,500
Other Surface Water	40	40	40	40
Total Water Supplies (Ac-Ft/Yr)	1,395	1,805	2,270	2,470
Water Shortage (Ac-Ft/Yr)	0	0	0	-350
Water Surplus (Ac-Ft/Yr)	112	4	97	0

* The amount shown as available from the Trinity Aquifer is the proportional amount by area of the suggested minimum total available aquifer volume for Kendall County (6,336 ac-ft/yr).

**Amount shown is the anticipated annual commitment is for Lerin Hills and Kendall County Utility Company/Tapatio.

3.2.2.5 Summary

Regardless of the predicted timing of future shortages for the Trinity aquifer within Kendall County, it is apparent that the growth of the County will eventually require additional water management strategies to be implemented. Initial small water shortages identified within this study can potentially be addressed in most areas through implementation of demand-management measures such as enhanced conservation, increased drought management restrictions, increased wastewater reuse for landscape irrigation, rainwater harvesting, and/or brush management practices. These types of demand management measures are almost always the most cost-effective method for meeting small shortages such as are predicted to occur during this planning period. Eventually, during this thirty-year planning period or soon thereafter, increased importation of other supplies or increased use of interruptible supplies will likely be necessary. The cost of such new strategies will undoubtedly be more costly and will likely require the implementation of fairly large projects to allow the unit price for water to remain reasonable for the future users of these supplies. As a consequence, these future water supply strategies could be somewhat complex and time-consuming to implement and could become an impediment to future growth in the County. For this reason, planning for additional water supplies will require careful consideration by water managers in this region and should not be delayed.

Water supply from Canyon Reservoir is currently fully committed to existing customers; however, other water supply strategies are currently being investigated for future development by GBRA, such as importation of groundwater into the Guadalupe Basin from the Simsboro Aquifer or other sources in more eastern regions of the State. If this strategy or other future supply strategies are successfully developed by GBRA and are used to serve existing communities that currently rely on Canyon Reservoir, additional Canyon Reservoir supplies may become available for the Kendall County area. Due to the relatively close proximity of Canyon Reservoir to Kendall County, this general strategy is considered to be the most desirable future supply source for the County's projected growth.

Groundwater is now and will continue to be a major source of water supply for Kendall County. A final determination of a MAG for the Trinity aquifer in Kendall County will provide additional insight into how soon new supplies may be needed. Regardless of the volume of water from the Trinity Aquifer that is determined to be available on a county-wide basis through the GMA process, there are many specific areas in Kendall County where groundwater pumping is already difficult with extremely low pumping rates. As growth continues, groundwater levels within existing wells in many parts of the County will likely decline and some of these wells will require modification in order to maintain their current pumping rates. Kendall County is fortunate and wise to have established a groundwater conservation district and empowered it to manage and plan for the proper use of this resource into the future. There are many activities the Cow Creek GCD can instigate to better prepare for and understand these future shortages so that water users who rely on this source can plan appropriately. The science of recharge and movement of water within the Trinity Aquifer within the Kendall County area can be substantially improved by better monitoring and analysis of existing geophysical well data, collection of more detailed well pumping data, and improvements to the groundwater availability modeling tools currently used by the TWDB. The GCD should encourage and support research investigations to improve the science in these areas in order to better equip the water planners and community leaders in dealing with this future water supply issue. Also, the GCD should actively encourage better and smarter use of all existing groundwater supplies in the County through adoption of demand management practices for both individuals and utility systems. This encouragement can be achieved by supporting and in some cases leading public education efforts and by adopting GCD policies that provide appropriate incentives for advancement of permanent water conservation measures and use of alternative supplies by utility systems in the County when possible.

3.2.3 Water Supply Strategy Options

This section of the report discusses water supply and strategy options appropriate for the study area. The first subsection lists all the water supply strategies identified in the initially prepared Region L water plan and investigates the feasibility of those strategies. The second subsection investigates other feasible water supply strategies and options identified during this water planning study.

3.2.3.1 Feasibility of Region L Recommended Water Management Strategies

The SCTRWP has identified limited water management strategy options for meeting water shortages in Kendall County during the 50-year regional planning period. The two main water strategies identified are municipal conservation and purchasing additional water from GBRA.

<u>Municipal conservation</u> - involves a community making efforts to reduce its overall water use permanently over time. Typical conservation activities include providing retail customers with encouragement and financial incentives for installing ultra-low-flow plumbing fixtures, reverse billing where billing rates go up at threshold volumes, reducing system leaks, planting native vegetation that requires less water, and education about how retail customers can reduce individual water use. Conservation is an effective and generally inexpensive method to extend available supplies and avoid, or at least delay, development of more expensive management strategies.

<u>Purchasing additional water from GBRA</u> - as described in the SCTRWP, this strategy involves two separate strategies based on timeframe. The short-term strategy identified within the SCTRWP is purchasing water from Canyon Reservoir that is currently committed to another user, but which the user does not yet need. This strategy has limited application at this time because there currently are no unused Western Canyon commitments that are immediately available for interim purchase. Reserved water that is currently not being used is now sold to the San Antonio Water System (SAWS) on a short-term annual basis. The long-term strategy described in the SCTRWP discusses creating an additional supply in or nearby to Canyon Reservoir within the Guadalupe Basin. The option recommended by the SCTRWP is to create an Aquifer Storage and Recovery system off of the Guadalupe River above Canyon Reservoir. High level flows would be diverted from the Guadalupe River during certain times that the flow is not needed downstream, treated at a surface water treatment plant, and stored underground in the Trinity aquifer until the water is needed. This strategy will need further analysis and refinement either because the amount of water available for diversion to aquifer storage and recovery may actually be very small once all of the downstream demands are considered or because the cost of this supply will likely be very expensive. It is clear that the cost of this waster will greatly exceed any other water supply cost within this region and this strategy would only practical if there are no other options available. Therefore, this option is only viewed as a very long-range possibility and unlikely to be seriously considered during the next thirty year planning horizon since there are other options that can be considered.

A related "purchase water from GBRA" strategy that is recommended in the SCTRWP after the 2040 decade involves the expansion of the Western Canyon water treatment plant. This strategy will be implemented, but the water supply that can be made available by the treatment plant expansion has already been committed through existing raw water reservations and will not be able to provide additional water above and beyond what is already reserved by Kendall County communities and the City of Fair Oaks Ranch. This strategy simply accounts for the cost of the additional infrastructure that will be required to deliver the already committed water to the Kendall County users after the 2040 decade.

3.2.3.2 Strategies Identified in Current Study to Create Sources of Supply or Reduce Demands

For this 2010 – 2040 planning period, the additional water needs by Kendall County and Fair Oaks Ranch are relatively small. At this time, these additional needs do not warrant selection of a major water supply project or strategy that creates a new source of supply. There are smaller projects/efforts that can help to better manage current supplies so that they can be stretched further to meet the expected demands.

Conservation and drought management are viable ways of reducing water demand long-term, and short-term, respectively. Conservation was discussed above as one of the recommended SCTRWP strategies which can help permanently reduce the per capita water use of a community. Implementation of drought management plans can also temporarily reduce water demand during periods of reduced water supply through outdoor watering restrictions, reverse billing, temporary use restrictions, and heightened public education during the drought period.

Wastewater reuse is another strategy which creates an additional source of supply and is already used in some parts of Kendall County and Fair Oaks Ranch to water golf courses, green spaces, and sporting facilities. By incorporating additional wastewater reuse in future plans, total water demands can be kept lower and less treated effluent will be discharged to the river in an area that already values the recreational aspects of its rivers and streams. The City of Boerne is currently planning a second wastewater treatment plant which will be considered a reclamation facility and should provide opportunities for additional reuse projects. A formal Development Agreement between the City and Marlin-Atlantis for the Esperanza development requires that all lawn irrigation on automatic sprinkler systems utilize the reuse water distribution system that will be constructed in the development. Reuse opportunities should be more fully evaluated as a part of future growth plans within the region.

Other water supply strategies such as rainwater harvesting and brush management can also have positive impacts on water availability during drought periods, but these strategies are difficult to quantify in regional water plans. Rainwater harvesting, coupled with appropriate treatment methods, works well under normal weather conditions and can provide water either specifically for outdoor use or as a source of supply for an entire household, thus reducing demands on the Trinity aquifer. During periods of drought when there is limited rainfall, supplies from rainwater harvesting are also restricted, so it is useful to have an additional source of supply available in order to avoid the necessity of extremely large storage facilities. Brush management involves clearing vegetation that either is known to require large quantities of water from the ground or that absorbs rain in its canopy, preventing it from reaching the ground and contributing to recharge of the groundwater aquifers. Brush management therefore has the ability to increase the amount of water in both the aquifers and in the surface rivers and streams. Because this strategy involves complex and site specific modifications, its quantifiable impacts to regional water availability during periods of drought have not been well established. A study done on the influence of juniper control in the upper Guadalupe watershed of Region L and included in the 2011 Region L Water Plan predicted increases in water availability for surface water with respect to Canyon Lake Reservoir, and the estimated increased costs associated with this strategy, but did not provide any information on the level of impact that groundwater availability might be increased. For that reason, the quantities of water supply and costs shown in this report related to brush management are only related to how clearing juniper brush in Kendall County would impact the overall firm yield of Canyon Lake Reservoir. Impacts to aquifer levels in Kendall County may be positive in some parts of the County as a result of brush management, but not enough evaluation has been performed at this time to quantify those impacts.

Public education is an important part of any plan to implement all of the above-mentioned strategies. Additionally, incentives such as rebates and/or tax reductions for residents implementing rainwater harvesting and brush management strategies have been provided in other counties and may be viable strategies for Kendall County.

Two potential strategies identified for Kendall County, expansion of groundwater use and purchase from GBRA of additional surface water beyond the existing raw water reservations, are supply strategies that involve building additional infrastructure to obtain available water from its source, rather than reducing demand or reusing existing water. The proximity of the Western zone to the Northern zone could allow for the development of new well fields in the Northern zone that would pump available groundwater from the Trinity aquifer and transport it via pipeline (5-8 miles) to the Western zone to meet their existing and future needs. A similar groundwater strategy could occur for portions of the Central zone which are proximal to the Northern zone. Areas in the Central zone and the non-city portion of the IH-10 Corridor zone could extend existing transmission pipelines and/or expand local distribution systems to provide additional surface water from Canyon Reservoir to future developments, if additional surface water is determined to be available.

Near-term implementation activities for the entire county should include encouraging water conservation and drought management, development of additional wastewater reuse for agricultural, institutional, and even some residential areas, and consideration of providing incentives to homeowners and businesses who install rainwater harvesting systems and landowners who implement responsible and long-term brush management. As identified in the Region L Water Plan, GBRA could also consider funding and coordinating the removal of juniper from Kerr County and/or Kendall County, which would potentially increase the firm yield of Canyon Lake Reservoir. In addition, enhanced understanding of aquifer data and modeling, including using updated local data to improve groundwater models, would provide the county with more confidence regarding the status of the Trinity Aquifer.

By 2020, the Western Zone and Central Zone will need to begin implementing additional strategies, such as importation of groundwater from the Northern Zone or building extensions to existing transmission or distribution pipelines in order to purchase additional surface water from GBRA out of Canyon Lake Reservoir. The IH-10 Corridor Zone does not show a shortage until 2040, but the proximity of the zone to the San Antonio Water System (SAWS) may provide opportunity for some areas to become SAWS customers and consequently bring new supply sources into the County. The County's water utilities should consider beginning talks with SAWS at some point in the near future to determine whether such opportunities may exist. In addition, the County may want to begin building a consensus on long-term water supply options.

By 2040 and continuing long-term, the IH-10 Corridor Zone is predicted to face shortages that will likely need to be met by additional surface water. If additional water is available out of Canyon Reservoir at that time, then that would likely be the best and most cost-effective option.

3.3 Water System Alternatives

3.3.1 Single Regional Water System Option

The option of developing a new regional water treatment and distribution system was considered during the study and found not to be justified for the following reasons:

1. For this 2010 – 2040 planning period, the additional water needs for Kendall County and Fair Oaks Ranch are relatively small and those shortages are distributed throughout the study area. A single regional water treatment system is therefore not appropriate to meet those needs.
2. The existing water supply sources in the County are primarily groundwater from the Trinity aquifer and surface water from Western Canyon Project. Future water supply options evaluated in this study included conservation, rainwater harvesting, purchasing additional water from GBRA, wastewater reuse, and other water sources which are generally also distributed throughout the County and often are utilized near their source. Consequently, there is no economic incentive to transport the source water to a central location for treatment facility and then re-distribute it to the demand areas.

3.3.2 Multiple Regional Water System Options

3.3.2.1 Northern Kendall County

The Northern Kendall County Zone depends nearly exclusively on groundwater and has limited options related to any type of regionalization of water supply facilities or alternative sources for water during the study planning period. Because the Northern Kendall County zone is sparsely populated with limited communities, the availability of supply to meet any projected growth beyond 2010 is likely to require additional infrastructure such as wells, pumps, and potentially distribution lines and treatment facilities, depending on whether the growth occurs as individual properties or as a community system connected to a remote well field.

3.3.2.2 Western Kendall County

Kendall County WCID No. 1 is the main public water system in this development zone, and relies exclusively on groundwater. Based on the growth predicted for this zone and the calculated quantities of groundwater available, small shortages already exist within this zone and are predicted to increase within the study period. The proximity of the Western zone to the Northern zone, which has a calculated surplus of groundwater, provides opportunity for new well fields to supply the needed water. Additional infrastructure to reach new customers, as well as infrastructure for individual groundwater wells that are not part of the public water system, will be required to accommodate future growth.

Wells drilled in the North and West development zones are potentially subject to contamination by naturally occurring radionuclides. Within Kendall County, only Kendall County WCID No.1 has any well sources that are in violation of radionuclide standards. Several water systems in neighboring Kerr and Gillespie Counties are reported to have radionuclide violations. The radionuclides in the Kendall County WCID No. 1 wells appear to be from isolated shale strata or faulting into the deeper Hickory and Ellenberger formations. While not considered to be major sources of water for Kendall County, drilling into one of these deeper formations presents the potential for the well to contain high levels of radionuclides. Care should be taken in the drilling process to minimize the influence of these formations or more localized formations on the water produced. Logging the wells gamma logs could be employed to determine if radionuclides are present in various strata. Should future well supplies contain levels of radionuclides above the State's Maximum Contaminant Level, that well water would not be available for use as drinking water without further treatment.

3.3.2.3 Central Kendall County

GBRA currently provides treated surface water to Cordillera Ranch from Canyon Reservoir through a transmission line as part of the GBRA Western Canyon Regional Water System. GBRA also has a pending contract with other water users to supply 150 acre-feet of treated water from the Western Canyon System. Cordillera Ranch expects to reach build-out by 2040 with a demand of 1,500 ac-ft based on a water use factor of 268 GPCD. To help meet this demand, Cordillera Ranch has requested a 500 ac-ft/yr increase in their raw water reservation (currently 1,000 ac-ft/yr) from GBRA. Through conservation, the supply requirements could potentially be reduced, which would either allow the community to have additional expansion beyond its current plans, or the Cordillera Ranch could potentially release some surface water for an alternative user, either within the Central Zone or perhaps in the IH-10 Corridor Zone if needed. For this planning study, all growth outside of Cordillera Ranch is assumed to use groundwater as the source of existing supply. Additional supply to meet shortages may be available for purchase from GBRA out of Canyon Lake Reservoir, beginning as early as 2020, although transmission pipeline extensions and additional distribution line systems would likely need to be constructed to reach the demand areas. Additional infrastructure will be needed for future growth outside of Cordillera Ranch.

3.3.2.4 Interstate-10 Corridor

GBRA currently provides treated surface water to City of Boerne and Fair Oaks Ranch, and has additional commitments to Kendall County Utility Company, Tapatio Springs, and Lerin Hills from Canyon Reservoir through a transmission line as part of the GBRA Western Canyon Regional Water System.

City of Boerne is currently planning for expansion of their treatment facilities at Boerne City Lake for peaking (expansion from 1.5 MGD to 4.5 MGD).

The City of Fair Oaks Ranch's water supplies include groundwater from the Trinity Aquifer and treated surface water from Canyon Lake Reservoir. Fair Oaks Ranch Utilities manages and operates groundwater pumps from the Trinity aquifer, four water treatment plants, and a distribution system to deliver water to residents. Treated surface water from GBRA is mixed with the treated groundwater. Based on their supplies, Fair Oaks Ranch has sufficient water to meet future projected demands, including assumed development of their entire ETJ during the study planning period.

The IH-10 Corridor may be the best candidate for regionalization of future water supply systems in Kendall County followed by Central Kendall County. Opportunities for purchasing additional water from GBRA or looking to SAWS to serve areas along the southern border of Kendall County should be explored.

3.4 Conceptual Level Costing for Water Supply Options and System Alternatives

For general comparison purposes, the potential costs associated with these various water management strategies and water system alternatives are provided below in *Table 3.16*. Costs shown for conservation can vary considerably based on the type of conservation activity implemented. These activities can range from simply replacing plumbing fixtures or creating public outreach literature and programs to more complex activities such as providing water audits to businesses and homeowners to and repairing leaking waterlines. Drought management costs can also vary based on the amount of public outreach implemented and whether significant effort is required for enforcement of restrictions.

Wastewater reuse costs are based on construction of storage tanks and new pipelines specifically for conveyance of treated effluent from the planned new City of Boerne wastewater treatment plant to the Esperanza development.

Rainwater harvesting costs assume a certain cost per home for installation of a 20,000 gallon treatment and storage system that can meet the water demands of a three-person household. An assumed $200 per year per home maintenance cost was included. These costs are similar to costs involved with installing a groundwater well to meet the same demands. Annual cost presented in the table assumes six households will use one ac-ft of water; therefore, annual cost per household will be approximately $2,400.

Table 3.16 Potential Costs Associated with Recommended Water Management Strategies

Water Management Strategy	Water Supply (Ac-Ft/Yr)	Decade Needed	Infrastructure Required	Capital Costs ($)	Total Costs ($)	Annual Cost per Ac-Ft[1] ($)
Conservation	Variable	2010	No additional	None	Variable	$200 - $800
Drought Management	Variable	2010	No additional	None	Variable	$50 - $100
Wastewater Reuse	1,120	2020	Storage tanks, pipelines, pump stations	$5,000,000	$7,200,000	$744
Rainwater Harvesting[2]	0.15 ac-ft per home per year	2010	Above-ground cisterns (20,000 gallons), filters, UV light, pump, pressure tanks, piping	$25,000 per home	$25,000 per home	$16,220
Brush Management[3]	1,400*	N/A	Brush removal equipment, including bulldozers, chemicals, and others	$3,897,650	$5,577,537	$417
Development of New Wellfield in Northern Zone to bring water to Western Zone	400	2020	Wells, distribution lines, transmission lines, pump station, treatment	$4,342,446	$6,256,441	$1,583
Development of New Wellfield in Northern Zone to bring water to Central Zone	700	2020	Wells, distribution lines, transmission lines, pump station, treatment	$5,879,441	$8,498,280	$1,289

Water Management Strategy	Water Supply (Ac-Ft/Yr)	Decade Needed	Infrastructure Required	Capital Costs ($)	Total Costs ($)	Annual Cost per Ac-Ft[1] ($)
Additional Surface Water from Canyon Reservoir to Central Zone (If Available)	700	2020	Transmission/ distribution pipelines	$1,774,080	$2,731,436	$512
Additional Surface Water from Canyon Reservoir to IH-10 Corridor Zone (If Available)	500	2040	Transmission/ distribution pipelines	$1,256,640	$2,048,969	$529

[1] Annual cost estimate includes maintenance, energy and debt services cost.
[2] Annual cost listed for rainwater harvesting serves six households. Annual cost for one household amounts to approximately $2,400.
[3] The volume of water made available by brush management in this table refers only to the increased firm yield of Canyon Reservoir and does not include additional groundwater due to lack of quantifiable data at this time.

Brush management costs are based on equipment and labor needed to clear 25 percent of the 122 square miles of juniper in Kendall County. Modeling efforts done as part of a study to support the Region L Water Plan show that the clearing of this amount of brush would increase the firm yield of Canyon Reservoir by approximately 1,400 ac-ft/yr. No information is available regarding whether the availability of the Trinity Aquifer would increase as a result of the brush clearing as well.

Development of new well fields in the Northern Zone to provide additional groundwater to the Western and Central Zones includes costs for the wells, pump stations, chlorination, and transmission and distribution lines (assuming the groundwater must be transported 5-8 miles to the respective Zone). Specific locations of well fields in the Northern Zone would depend somewhat on the location of the growth in the other zones, as well as on topography and existing/future roads, and have not been evaluated as part of this report.

Additional surface water from Canyon Reservoir to the Central and IH-10 Corridor Zones includes costs for extending the existing transmission pipeline and/or expanding the existing distribution system to area of new growth, as well as the cost to purchase the water from GBRA, which is assumed to be $96/ac-ft.

4.0 Wastewater Planning

4.1 Wastewater Demands and Flow Factors

Wastewater flows in Kendall County and Fair Oaks Ranch are currently treated using either local wastewater treatment plants or on-site sewage facilities (OSSFs). Since there is only limited manufacturing water demand in Kendall County, water used for municipal purposes is the only water use type to generate wastewater flows. Municipal wastewater flows are generated from households and commercial properties through sinks, toilets, showers, bathtubs, and laundry facilities. Most wastewater flows average 60% - 80% of average water use, with the remaining 20% - 40% of water demand being used mainly for irrigation purposes. Wastewater flows can increase beyond the returned flows due to inflow and infiltration from surface water and groundwater seepage, particularly during rainfall events.

Wastewater flow information was received from the City of Boerne, Cordillera Ranch, and Kendall County WCID No. 1. The information was used to help determine wastewater flow factors (gallons per capita per day [GPCD]) for the four development zones. *Table 4.1* below shows the determined wastewater flow factors for the different development zones.

Table 4.1 Wastewater Flow Factors for the Four Development Zones

Zone	Entity	Per Capita Wastewater (gallons per person per day)			
		2010	2020	2030	2040
Northern Kendall County		80	80	80	80
Western Kendall County		80	80	80	80
Central Kendall County		80	80	80	80
IH-10 Corridor	Non-City	80	80	80	80
	Boerne	120	120	120	120
	Fair Oaks Ranch (All)	80	80	80	80

The Northern Kendall County zone currently only uses OSSF to treat wastewater, rather than any centralized treatment plant. It is likely that the area will continue to use OSSF for future growth in the study planning period due to the limited development expected and low population density. A per capita factor and total wastewater demand were calculated for the Northern Kendall County Zone in case regionalization of wastewater treatment is an option for the area in the future.

The Western Kendall County zone wastewater flow factor was determined from the wastewater flow information received from Kendall County WCID No.1. The wastewater flow factors for the Central Kendall County zone and the Non-City and Fair Oaks Ranch portions of the IH-10 Corridor zone were determined using an average GPCD for new developments. Fair Oaks Ranch is a relatively young city, so while actual wastewater flow data was not obtained from its wastewater treatment plant, a GPCD similar to a new development was considered reasonable. The wastewater flow factor for the Boerne Service Area portion of the IH-10 Corridor zone was determined from the wastewater flow information received from the City of Boerne.

Wastewater demands were determined by multiplying the wastewater flow factor (GPCD) by the population in each decade of the planning period for the four development zones. *Table 4.2* below shows the calculated average daily demands in MGD (million gallons per day).

Table 4.2 Wastewater Demands for the Four Development Zones

Zone	Entity	Wastewater Demands (MGD)			
		2010	2020	2030	2040
Northern Kendall County		0.17	0.20	0.24	0.29
Western Kendall County		0.27	0.33	0.40	0.48
Central Kendall County		0.76	1.07	1.32	1.73
IH-10 Corridor	Non-City	0.65	0.92	1.12	1.48
	Boerne	1.38	2.09	3.11	3.30
	Fair Oaks Ranch (All)*	0.52	0.63	0.74	0.82

* Assumed development of the Fair Oaks Ranch ETJ occurs by 2040

The City of Fair Oaks Ranch uses OSSFs for 45% of their residential properties, so while total wastewater demands were calculated in the table above for potential regionalization purposes, it is not likely that the entire amount calculated would be treated at their 0.5 MGD wastewater treatment plant. Currently, the City of Fair Oaks Ranch does not plan to treat in excess of 0.4 MGD average daily flow at their treatment plant. This will be discussed further in the evaluation of wastewater system alternatives. The other development zones also have lots that use OSSFs, but no assumptions regarding usage ratios have been made at this time.

4.2 Wastewater System Alternatives

4.2.1 Summary of Existing Conditions

A large portion of Kendall County's wastewater management needs is served by On-Site Sewage Facilities (OSSFs) and there are three existing and operational wastewater treatment plants (WWTPs) in Kendall County and one in the City of Fair Oaks Ranch. Locations of the wastewater treatment plants and wastewater outfalls in Kendall County and Fair Oaks Ranch are shown in *Exhibit 4-1*. Locations of sewer CCNs in Kendall County are also shown in *Exhibit 4-1*.

Northern Kendall County is served by OSSFs and does not have any community wastewater systems. In central Kendall County, Cordillera Ranch has a wastewater treatment plant which is owned and operated by the Guadalupe Blanco River Authority (GBRA). In Western Kendall County, Kendall County WCID No.1 owns and operates a wastewater treatment plant which serves the City of Comfort. The rest of the WWTPs and wastewater permits are located in the IH-10 Corridor, City of Boerne and Fair Oaks Ranch. Entities owning wastewater treatment facilities and/ or permits are discussed below.

There are currently six wastewater permits in Kendall County and one for Fair Oaks Ranch. Summary of wastewater permits in Kendall County and City of Fair Oaks Ranch is presented in *Table 4.3*.

4.2.2 Wastewater Facilities by Entity

<u>City of Boerne</u>

The City is permitted by the Texas Commission on Environmental Quality (TCEQ) to discharge 1.2 million gallons per day from the WWTP located on the east side of the City. The plant discharges to Currey Creek, which flows into Cibolo Creek just south of State Highway 46. Their discharge permit limits are 10-15-3 milligrams per liter (mg/L) (CBOD – TSS – NH_4N respectively), *E. coli.* 126 colonies/100 mL, and a minimum Dissolved Oxygen (DO) of 5.0 mg/L.

The City's wastewater collection system provides service for customers within the city limits of Boerne. The City-owned and maintained portion of each customer's sewer service line extends from the sewerage collection system main to the customer's point of connection, typically located near the customer's property line.

The City of Boerne added a new wastewater discharge permit in 2010. The new permit allows Boerne to treat and discharge wastes from the Boerne Wastewater Treatment Plant located approximately 1.82 miles southeast of the intersection of Interstate Highway 10 (IH-10) and State highway 46 in Boerne to Menger Creek, thence to Upper Cibolo Creek in segment no. 1908 of the San Antonio River Basin. The end of pipe outfall locations associated with the Boerne permits are shown in *Exhibit 4-1*. The City is currently planning for construction of this wastewater treatment plant with a capacity of 1.4 MGD (expandable to 5.2 MGD). This plant is sited to accept flows which were originally routed to the existing plant as growth dictates in the future.

<u>Kendall County WCID No.1</u>

Kendall County WCID No.1 is permitted by the TCEQ to discharge 0.350 million gallons per day from its WWTP. However, discharges from the treatment plant are applied to a golf course and are rarely discharged to the Guadalupe River. Prior to the February 2010 discharges to the Guadalupe River during successive days of heavy rains, their most recent discharge was in 2007. The end of pipe outfall location associated with this permit is shown in *Exhibit 4-1*.

Cordillera Ranch

The Cordillera Ranch WWTP is owned and operated by GBRA. GBRA has a surface irrigation permit for Cordillera Ranch and applies their treated wastewater to the golf course. The permit authorizes the disposal of treated domestic wastewater at a daily average flow not to exceed 192,000 gallons per day via surface irrigation of 102 acres of golf course. No discharge to state waters is allowed under this WWTP permit. The treatment facility and disposal site are located in the drainage basin of Guadalupe River above Canyon Lake in Segment No. 1806 of the Guadalupe River Basin.

City of Fair Oaks Ranch

Fair Oaks Ranch Utilities manages and operates a collection system and a 500,000 gallon per day WWTP. The City of Fair Oaks Ranch holds a surface irrigation permit for its wastewater treatment plant. The permittee is authorized to dispose of treated domestic wastewater effluent at a daily average flow not to exceed 0.50 million gallons per day (MGD) via surface irrigation of 280 acres of Fair Oaks Ranch Golf and Country Club land. No discharge to state waters is allowed under this WWTP permit.

In addition, approximately 45% of the residential properties use OSSFs and are not a part of the city's wastewater collection system. OSSFs are permitted, inspected and monitored by the County where the property is located. OSFF aerobic treatment systems are designed to dispose of treated effluent via spray irrigation onto the designated property area as part of its operation.

Kendall County WCID No.2

Kendall County WCID No.2 maintains a TCEQ discharge permit but does not have any current treatment or discharge facilities. The end of pipe outfall location associated with this permit is shown in *Exhibit 4-1*. It is anticipated that the need for this plant will be supplanted by the development of the City of Boerne’s second treatment plant.

Tapatio Springs

Kendal County Utility INC manages and operates a collection system and a 150,000 gallon per day WWTP. Kendal County Utility holds a surface irrigation permit for its wastewater treatment plant. The permittee is authorized to dispose of treated domestic wastewater effluent at a daily average flow not to exceed 0.15 million gallons per day (MGD) via surface irrigation of 40 acres of Tapatio Springs Golf Resort land. No discharge to state waters is allowed under this WWTP permit.

Lerin Hills

Lerin Hills MUD maintains a wastewater discharge permit from TCEQ; however, they currently do not have any existing development, treatment plants or discharge. The end of pipe outfall location associated with this permit is shown in *Exhibit 4-1*.

Table 4.3 Summary of Wastewater Permits in Kendall County

	Entity	Permit Number	Type of Permit	Amount (MGD)	Exp. Date	BOD (mg/l)	CBOD (mg/l)	TSS	NH_3N	P	E. coli (colonies /100 ml)	Location	Comments
1	City of Boerne	WQ00100 66001	Discharge Permit	1.2	3/1/2015		10	15	3		126	350 S Esser Rd, Boerne TX 78006	
	City of Boerne Permit #2	WQ00100 66002	Discharge Permit	1.4	3/1/2014		5	12	2	0.5	126	Approx 1.82 mi SE of the intersection of IH10 and SH46 in Boerne, TX	
2	Kendall County WCID # 1 (Comfort)	WQ00104 14001	Discharge Permit	0.35	2/1/2015		5	5	2	1		Northeast and adjacent to the intersection of IH10 W and FM473, east of Comfort in Kendall County, TX	
3	GBRA (Cordillera Ranch)	WQ00143 85001	Surface Irrigation	0.192 (Final Phase)	2/1/2019	5		5	2			2293 Rio Cordillera, Boerne, TX 78006	0.064 MGD (Interim 1 Phase) , 0.128 (Interim II Phase)
4	City of Fair Oaks Ranch	WQ00118 67001	Surface Irrigation	0.5	3/1/2019	20		20				29745 No Le Hace, Fair Oaks Ranch, TX 78015	
5	Kendall County WCID # 2 (Esperanza)	WQ00149 06001	Discharge Permit	0.4	3/1/2012		5	5	1	0.5	126		
6	Lerin Hills MUD	WQ00147 12001	Discharge Permit	0.18	3/1/2014		5	5	1			Approximately 4.1 mile west of IH-10 then 200ft west of SH46 from the right of way and approx. 9000 ft south of	Pending

	Entity	Permit Number	Type of Permit	Amount (MGD)	Exp. Date	BOD (mg/l)	CBOD (mg/l)	TSS	NH_3N	P	E. coli (colonies /100 ml)	Location	Comments
												John's Rd in Kendall County.	
7	Kendall County Utility Company Inc.*	WQ0012404001	Surface Irrigation	0.15	04/01/2015	20		20					Formerly Tapatio Springs WWTP permit

* Further information currently unavailable.

4.2.3 On-Site Sewage Facilities (OSSFs)

City of Boerne and Kendall County WCID No. 1 do not have any regulations governing on-site sewage facility (OSSF) development. Any OSSFs within the city boundaries are regulated by Kendall County rules. Likewise, the City of Fair Oak Ranch does not regulate requirements for OSSF development. The OSSFs within the city boundary are regulated by Kendall County, Comal County, or Bexar County depending on the system's location. A summary of Kendall County rules and regulations governing OSSFs are listed in *Table 4.4*. Development rules for Kendall County are available at the following website: http://www.co.kendall.tx.us/development/development-rules

Table 4.4 Kendall County Development Rules for On-Site Sewage Facility (OSSF)

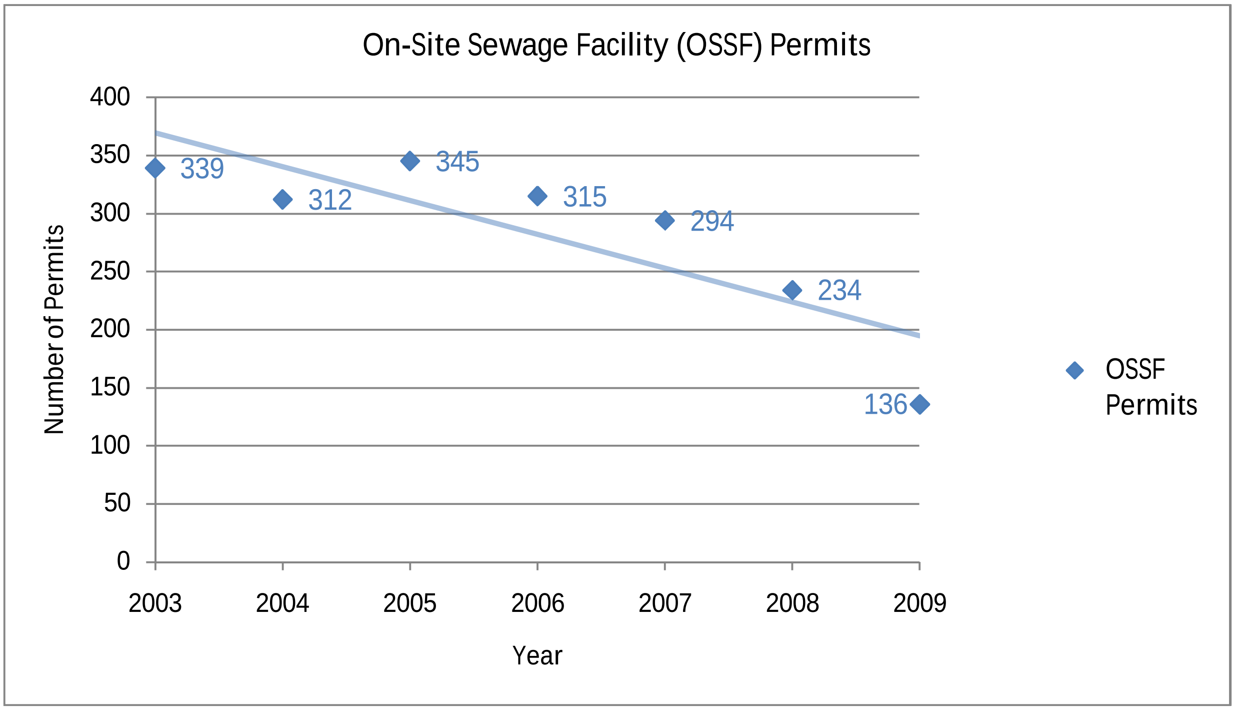
Source of Water and Type of Waste Disposal	Minimum Lot Size (Acres) (outside of Flood Plain)	Minimum Road Frontage (feet)	Maximum Density (Total Acres ÷ number of Lots)
Individual Water Well and On-Site Sewage Facility (OSSF)	3.0	250	6.0
Public Water (PW) System (ground water) and OSSF	1.0	150	4.0
PW (ground water) and Wastewater Treatment System	--	100	4.0
PW (out of county water) and OSSF	1.0	150	3.0
PW (out of county water) and Wastewater Treatment System	--	100	3.0

The State of Texas has rules governing lot sizes for OSSFs based on whether the lot is provided with public water or a domestic well. The County's lot size requirements are much more encompassing compared to the State's. Application for an OSSF in Kendall County requires a submittal of a formal application document, review of the OSSF design by County officials, and a final onsite inspection. The total number of OSSF permits in Kendall County is approximately 10,800 as of March, 2009. The number of permit applications annually for OSSFs in Kendall County has been in decline in recent years. *Figure 4.1* shows the trend in permits granted from 2003 to 2009.

Two years after the initial installation of an aerobic treatment unit, maintenance can be performed by homeowners for systems that use secondary treatment systems, non-standard treatment systems, drip irrigation, and surface application disposal. Maintenance contracts are required when the OSSFs are not maintained by the homeowners. For maintenance contracts, OSSFs must be maintained by a maintenance provider licensed by TCEQ. Homeowners who maintain their own systems are exempt from contract requirements; however, Kendall County is currently looking into adopting rules that will require training for individual homeowners who choose to self-maintain their OSSFs.

Kendall County and City of Boerne officials have expressed concerns that improperly maintained OSSF systems may contribute to water quality issues.

Figure 4.1 Trend in On-Site Sewage Facility (OSSF) Permits in Kendall County



4.3 Wastewater Collection System Alternatives

Wastewater collection system alternatives that may be considered for development of regional facilities in Kendall County include:

- Conventional collection systems consisting of gravity sewers, lift stations and force mains;
- Alternative collection systems using pressure sewers, with on-site grinder pump stations and small diameter force mains; and,
- Alternative collection systems using Septic Tank Effluent Pump/Septic Tank Effluent Gravity (STEP/STEG) technology.

4.3.1 Conventional Collection Systems

Conventional collection systems utilize gravity sewers designed to convey raw wastewater, including intact solids. Lift stations typically include non-clog solids handling pumps, although individual service connections in low-lying area may include onsite grinder pump stations. Conventional collection systems are typically the most costly (in terms of capital cost) of these three wastewater collection system alternatives, but are cost-effective for use in densely developed areas and in areas with consistently-sloping topography suitable for maximizing gravity flow. The feasibility and cost-effectiveness of conventional collection systems is diminished in areas with low development density or in areas with either very flat terrain requiring deep gravity sewers and numerous lift stations, or highly dissected topography requiring numerous lift stations. Conventional collection systems have relatively low operation and maintenance (O&M) requirements, and system components are located in the public right of way or in dedicated easements to facilitate maintenance.

4.3.2 Alternative Collection Systems

Alternative collection systems typically require less trench excavation and have a lower capital cost than conventional collection systems, and may be cost-effective for areas of lower development density or where topographic conditions are disadvantageous for conventional systems. The O&M requirements of alternative collection systems can be more intensive than for conventional systems since these systems typically include pump stations, septic tanks, or both for each individual service connection. TCEQ rules under 30 TAC § 217.95 stipulate that the collection system owner will be responsible for management of these onsite components, and require that an alternative collection system service agreement must be executed between a collection system owner and each property owner allowing the collection system owner access for installation and maintenance of onsite alternative collection system components.

<u>Pressure Sewers</u>

Pressure sewer systems utilize onsite grinder pump stations at service connections. Small diameter force mains typically convey flow from numerous service connections, and multiple small force mains may be connected into larger force mains. Pressure sewers are designed to convey raw wastewater including macerated solids through the system to the treatment facility. Larger re-pumping lift stations using non-clog pumps may be included in pressure sewer systems which convey wastewater over long distances or complex terrain.

Pressure sewers are well suited for use in areas of low population density or complex topography that would require numerous lift stations in order to implement a conventional collection system.

A primary O&M cost associated with pressure sewer systems is for maintenance of the grinder pump stations and replacement of pumps. Grinder pumps are subject to high O&M requirements due to their dual function of grinding solids and pumping. Centrifugal grinder pumps are commonly used in many existing pressure sewer systems. However, semi-positive displacement (semi-PD) grinder pumps are preferable to centrifugal grinder pumps for use in pressure sewer systems for the following reasons:

- Semi-PD grinder pumps provide a higher pumping head than centrifugal grinder pumps, thereby accommodating greater differences in elevation and longer pumping distances without a need for as many booster lift stations.
- Semi-PD grinder pumps curves exhibit a smaller range in flow rate over a larger range of pumping heads than centrifugal grinder pumps. This provides more consistent flow rates between service connections at different locations and elevations in the system, and more consistent service flow rates with varying numbers of pumps operating simultaneously.
- The reliability of centrifugal grinder pumps is adversely affected by imbalanced forces on the impeller caused by operating too near to shutoff head and/or run-out condition, caused by different locations and elevations in the system and by varying numbers of pumps operating simultaneously (in addition to the high wear inherently associated with grinding solids). Semi-PD grinder pumps use a rotor and stator rather than an impeller and volute. These components are not affected in the same way as a centrifugal impeller by extreme variations in pumping head.

<u>Septic Tank Effluent Pump/Septic Tank Effluent Gravity (STEP/STEG) Alternative Collection Systems</u>

STEP/STEG collection systems include onsite septic tanks equipped with internal baffles and effluent filters. Low-lying lots from which effluent cannot be connected by gravity include vertical-turbine type effluent pumps installed downstream of the septic tank effluent filters. Sewer pipes convey septic tank effluent only, (*i.e.*, filtered primary-treated effluent, rather than raw wastewater) with the wastewater solids captured in the onsite septic tanks. Sewers for these systems are typically small diameter variable grade sewers which may operate under pressure or gravity conditions depending on the topography and type of service connections to the particular sewer line. Larger pumping stations (using vertical turbine type effluent pumps) and force mains may be required in systems which convey the septic tank effluent over long distances.

STEP/STEG systems are well-suited for use in low-density areas with existing septic tanks that are in good condition, or where replacement of existing septic tanks is required and the utility desires an alternative collection system with lower energy costs and mechanical maintenance requirements than for pressure sewers. These advantages are greatest in locations where topography allows a significant share of the service connections to be accomplished by gravity flow. STEP/STEG systems are poorly suited to handling service connections that include large quantities of fat, oil, or grease (FOG), since these tend to clog septic tank effluent filters and may cause clogging of the small diameter sewers if FOG bypasses a filter.

The principal mechanical O&M cost associated with STEP/STEG systems is the cost of periodically removing the accumulated solids from septic tanks (at the same interval as for onsite septic systems) and trucking the solids to a WWTP that will accept septage for treatment and disposal. STEP service connection pumps and lift stations must be maintained, but because the vertical turbine effluent pumps are a clean water type pump, the pumping energy efficiency, mechanical reliability, and service life of these pumps is better than for either solids-handling non-clog sewage pumps or grinder pumps. Although STEP pumps are centrifugal pumps, the vertical turbine configuration allows the number of stages to be selected so that high pumping heads or a large number of service connections can be accommodated without sacrificing consistency of flow rate.

An additional O&M cost associated with STEP/STEG systems is periodically checking effluent filters and cleaning if needed (by pressure washing the exterior of the filter from outside the septic tank). Cleaning is required infrequently unless the system includes service connections that handle fat, oil, or grease.

4.3.3 Potential Applicability of Wastewater Collection System Alternatives to Kendall County

Exhibit 4-2 illustrates the topography of Kendall County using 100-foot contour lines. Since few extensive flat areas exist in Kendall County, the drivers for potential applicability of alternative collection systems are mainly low population density, highly dissected terrain, or existing septic tanks which are in acceptable condition that could be incorporated into an alternative collection system.

As shown in *Exhibit 4-2*, the topography of Kendall County slopes most gently in Central Kendall County, along with the eastern half of the IH-10 Corridor, the northeast part of Western Kendall County, and the southern edge of Northern Kendall County coinciding with the drainage basins and major tributaries of the Guadalupe River and Cibolo Creek. Isolated gently sloping valleys also occur in the extreme northeast and northwest of Northern Kendall County. In such topographic areas with sufficient population density to be cost-effective, conventional collection systems may be feasible.

The western half of the IH-10 Corridor, the southwest part of Western Kendall County, and most of the northern area of Northern Kendall County are much steeper and the topography is more complex than the areas closer to the Guadalupe River and Cibolo Creek. In these very hilly areas, in any locations where sufficient development density exists to support centralized wastewater treatment, alternative collection systems may be considered.

The areas that may be suitable for alternative versus conventional collection systems are not mutually exclusive, but may overlap in areas of marginal development density to support conventional systems.

Table 4.5 indicates areas of potential applicability that may be considered for each of these types of Wastewater Collection System Alternatives:

Table 4.5 Potential Applicability of Wastewater Collection System Alternatives

Collection System Alternative	Areas of Potential Applicability
Conventional Collection System	Serve future growth and/or retrofit existing developed areas in City of Boerne; City of Fair Oaks; City of Comfort; Cordillera Ranch; Tapatio Springs; and other densely developed towns and subdivisions along the Guadalupe River and Cibolo Creek and other major drainages.
Pressure Sewer System	Serve future growth or retrofit areas served by failing OSSFs, in areas of complex topography with low to moderate development density in the North and West parts of Kendall County.
STEP/STEG Collection System	Retrofit areas served by existing OSSFs in Fair Oaks Ranch to increase effluent available for golf course irrigation, and serve future growth or areas served by failing OSSFs in moderately steep areas with low to moderate development density throughout the County.

4.4 Wastewater Treatment System Alternatives

Wastewater treatment system alternatives that may be considered for development of regional wastewater systems in areas of Kendall County that will have sufficient build-out development density to be served by a system other than OSSF include:

- A single regional treatment facility;
- Multiple treatment facilities; and,
- Packaged treatment plants.

4.4.1 Single Regional Treatment Facility

In the absence of site-specific constraints and cost drivers, a single regional treatment facility would theoretically provide the lowest cost solution due to economies of scale, followed by multiple centralized treatment facilities, with individual packaged plants being the least cost effective solution.

In reality, the following considerations, constraints, and cost drivers influence the cost-effectiveness and feasibility of regionalization:

- Development density versus required length of collection system
- Topography and feasibility of gravity flow
- Locations of existing major wastewater treatment infrastructure
- Locations of potential effluent reuse applications
- Capital cost limitations versus life cycle cost considerations
- Differing goals and priorities between various political subdivision and developers

The anticipated 2040 population density for the development zones ranged from 0.214 persons per acre in Central Kendall County to 0.250 persons per acre in the IH-10 Corridor, with the exception of Northern Kendall County which had a predicted population density of only 0.025 persons per acre. A single regional treatment facility for all of Kendall County is obviously impractical due to both development density versus required length of collection system (requiring excessive cost per service connection for wastewater collection) and due to topography and feasibility of gravity flow (the county is divided into multiple sub-watersheds with significant differences in elevation across some of the watershed divides).

Therefore this evaluation of potential wastewater treatment location scenarios for Kendall County focused on a maximum-centralization case of three separate regional plants, for the Western Kendall County, Central Kendall County, and IH-10 Corridor development zones. It was assumed that Northern Kendall County, which will have a projected population density of 0.025 persons per acre in 2040, will continue to be served by single-lot OSSF systems, except for possible limited subdivision-level centralization of wastewater service for localized areas.

4.4.2 Multiple Regional Treatment Facilities - Western Kendall County Development Zone

The Western Kendall County development zone is projected to generate 0.48 MGD total wastewater flows in 2040 at a population density of 0.234 persons per acre. The majority of existing development is concentrated at the western edge of Kendall County in the vicinity of Comfort, at the upstream end of the portion of the Guadalupe River basin that lies in Kendall County. The existing development near and in Comfort is served by the Kendall County WCID No. 1 WWTP, which is the only existing WWTP and the only current Texas Pollutant Discharge Elimination System (TPDES) permit in Western Kendall County.

The site of the existing Kendall County WCID No. 1 WWTP located in Comfort was chosen for evaluation as the location for a potential Regional WWTP. As shown in *Exhibit 4-3*, the sub-watershed that includes Comfort extends approximately 3 miles downstream (to the east) from the existing WWTP. Upstream drainage areas within this sub-watershed extend approximately 4.5 miles to the west of the WWTP site (including 3 miles into Kerr County), approximately 6 miles to the south, and approximately 6 miles to the north (into the Northern Kendall County Development Zone) from the existing WWTP. The upstream tributaries to the north and south of the WWTP site reach points of confluence with the Guadalupe River within approximately 0.75 miles of the WWTP site, indicating that gravity wastewater collection may be feasible from the north and south upstream areas with a final pumping segment of a mile or less. The upstream area to the west of the WWTP site is likewise anticipated to be suited to use of gravity sewers.

It is anticipated that a Regional WWTP at this location would serve (within Kendall County) only the areas of the sub-watershed lying upstream to the north and south and west of the WWTP site, including flows generated upstream to the west in Kerr County, and that collection of flow from the portion of the sub-watershed downstream of the WWTP site would be limited by pumping costs. It is further anticipated that a collection system associated with a regional facility at the location would extend only as far in each direction as dictated by the economics of actual developed density.

The other sub-watersheds within the Western Kendall County development zone are anticipated to use OSSFs or to be served by subdivision-level wastewater treatment facilities. Based on these assumptions, the maximum projected 2040 flow to a Regional WWTP at the location of the existing Kendall County WCID No. 1 WWTP is anticipated to be the sum of an amount somewhat less than the total 0.48 MGD anticipated flow generated in Western Kendall County, plus an unknown but potentially significant quantity of additional wastewater flows generated upstream in Kerr County.

The existing Kendall County WCID No. 1 WWTP was previously permitted for land disposal of effluent via a TLAP permit, but currently is permitted to discharge treated effluent under a TPDES permit, and authorized for effluent reuse by irrigation at the Buckhorn golf course. Further investigation of regionalization at the site of the Kendall County WCID No. 1 WWTP will require evaluation of the feasibility and economics of increased discharge, which is likely to require compliance with stringent effluent limits for nutrient removal (5/5/2/1 or lower) versus the feasibility and economics of effluent disposal by land application at less stringent effluent quality limits, including land availability and costs, and construction and operation/maintenance costs of effluent storage ponds and irrigation systems.

4.4.3 Multiple Regional Treatment Facilities - Central Kendall County Development Zone

The Central Kendall County development zone is projected to generate 1.73 MGD total wastewater flows in 2040 at a population density of 0.214 persons per acre. The majority of existing development is concentrated in the eastern half of the development zone in the vicinity of Cordillera Ranch, at the downstream end of the portion of the Guadalupe River basin that lies in Kendall County, with additional concentrated development in subdivisions along Highway 46 north of Boerne and surrounding Bergheim. Existing development in Cordillera Ranch is served by the GBRA Cordillera Ranch WWTP, which is the only existing WWTP and operates under the only TLAP permit in Central Kendall County.

The site of the existing Cordillera Ranch WWTP was chosen for evaluation as the location for a potential Regional WWTP to serve the Central Kendall County development zone. The WWTP permit authorizes discharge of treated effluent to a 102-acre golf course internal to the subdivision at application rates not to exceed 2.1 acre-feet per acre per year in the final permit phase (corresponding to a maximum permitted effluent disposal for the golf course of approximately 192,000 GPD). Effluent storage ponds provide 4.0 acre-feet storage volume at the WWTP and 26.9 acre-feet at the golf course. Information was not available at the time of report preparation as to whether irrigation of the golf course using effluent is supplemented by irrigation with potable water or untreated surface water.

The potential for the golf course to serve as a site for additional effluent disposal appears likely to be far less than the potential wastewater flow that could be generated at buildout of a regional WWTP. Further investigation of regionalization at the site of the Cordillera Ranch WWTP will require investigation of the feasibility and economics of increased effluent disposal by land application (including land availability and costs, and construction and operation/maintenance costs of effluent storage ponds and irrigation systems) versus costs for discharge of treated effluent, which is likely to require compliance with stringent effluent limits for nutrient removal (5/5/2/1 or lower).

As shown in *Exhibit 4-3*, the sub-watershed that includes the existing WWTP site extends approximately 6 miles downstream (to the east) from the existing WWTP. Upstream drainage areas within this sub-watershed and other sub-watersheds in the development zone extend approximately 26 miles to the west of the WWTP site along the Guadalupe River, with tributary sub-watersheds extending to the north and south throughout the length of the Central Kendall County Development Zone. Subject to economic constraints, gravity wastewater collection to the existing Cordillera Ranch WWTP site may be largely feasible throughout much of the upstream portion of the Central Kendall County development zone. A major watershed divide exists along State Highway 46, between the Guadalupe River and Cibolo Creek drainage basins. The portion of the Central Kendall County development zone lying south of Highway 46 would not be suited to gravity wastewater collection to the Cordillera Ranch WWTP site, and the area lying downstream (to the east) of the existing WWTP site would similarly be unsuited for conveyance by gravity flow to the Cordillera Ranch WWTP.

It is anticipated that a Regional WWTP at this location could feasibly collect flows from the majority of the Central Kendall County development zone to the west of the WWTP site, potentially including flows generated further upstream to north (*e.g.*, in Sisterdale) and west (in the east portion of Western Kendall County development zone), and that the ability to provide service at the existing WWTP site over this area would be limited principally by collection system costs. Likewise, collection of flow from the portion of the sub-watershed downstream of the WWTP site would be limited by pumping costs. It is further anticipated that a collection system associated with a regional facility at the location of the existing Cordillera Ranch WWTP would extend only as far in each direction as dictated by the economics of actual developed density.

If substantial effluent reuse demands are developed at locations a significant distance upstream of the existing WWTP site, economics may favor construction of an additional sub-regional or local WWTP rather than development-zone wide regionalization of wastewater treatment.

Based on these assumptions, the maximum projected 2040 flow to a Regional WWTP at the location of the existing Cordillera Ranch WWTP is anticipated to be less than the 1.73 MGD total flow generation projected for Central Kendall County. An additional potential constraint is the fact the Cordillera Ranch WWTP currently disposes of effluent by land application to a golf course. The feasibility of the current disposal method to dispose the anticipated effluent quantity would need to be confirmed as part of the further evaluation of this site for a potential regional WWTP.

4.4.4 Multiple Regional Treatment Facilities - IH-10 Corridor Development Zone

The IH-10 Corridor development zone is projected to generate 5.60 MGD total wastewater flows in 2040 at a population density of 0.250 persons per acre. The majority of existing development is concentrated in the City of Boerne, the City of Fair Oaks Ranch, and several smaller subdivisions scattered throughout the development zone. Existing development in Boerne is served by the Boerne WWTP, and existing development in Fair Oaks Ranch is served by the Fair Oaks Ranch WWTP, with additional developed lots currently served by OSSFs. These two WWTPs are the only existing WWTPs in the IH-10 Corridor. Three additional TPDES permits have been obtained in the IH-10

Corridor: a second permitted outfall location by the City of Boerne, a permit held by Kendall County WCID No. 2, and a permit held by Lerin Hills Ltd. None of these three additional permitted outfall locations are associated with any existing treatment facilities or discharges of effluent.

The permitted locations held by Kendall County WCID No. 2, and Lerin Hills Ltd. were not considered due to the fact that these entities lack any existing wastewater infrastructure and these outfall locations are the furthest upstream and furthest from Cibolo Creek of the existing WWTPs and permitted outfalls in the IH-10 Corridor development zone. The permitted location held by Tapatio Springs was not chosen for the later reasons as well. The site of the existing Fair Oaks Ranch WWTP, the existing Boerne WWTP, and the permitted future WWTP site held by the City of Boerne were considered as possible locations for a regional WWTP to serve the IH-10 Corridor.

The Fair Oaks Ranch WWTP is permitted for an average daily flow (ADF) of 0.5 MGD, at effluent limits of 20/20 (mg/L BOD_5/TSS) with disposal by irrigation. The WWTP site is located in Bexar County, and currently 45% of the lots in Fair Oaks Ranch are served by OSSFs rather than being connected to the system.

The existing City of Boerne WWTP, located on the east side of the City, is permitted for 1.2 MGD AAF. The existing WWTP discharges to Currey Creek, thence to Cibolo Creek south of Highway 46, with effluent limits of 10/15/3 (mg/L $CBOD_5$/TSS/NH_3N).

The site of the future City of Boerne WWTP is located 1.8 miles southeast of the intersection of IH-10 and Highway 46. This location was selected to enable flows to be diverted from the existing Boerne WWTP to the proposed WWTP. The proposed WWTP is permitted for 1.4 MGD ADF at effluent quality limits of 5/12/2/0.5 (mg/l $CBOD_5$/TSS/NH_3N/TP).

The site of the future City of Boerne WWTP was chosen for evaluation as the location for a potential Regional WWTP to serve the IH-10 Corridor development zone, based on the fact that the City of Boerne service area, including Esperanza, has the highest existing and projected population density and wastewater flows in Kendall County. However, confirmation is needed from the City of Boerne as to whether the City's intent in acquiring and permitting this site includes potential siting of a regional facility to treat flows generated outside of the City's current wastewater service area. Additionally, the City's existing WWTP would need to be evaluated with respect to the remaining service life of the facility and the City of Boerne would need to be consulted with regard to the remaining value of the City's investment in the existing facilities.

As shown in *Exhibit 4-3*, the sub-watershed that includes the existing WWTP site extends approximately 6 miles downstream (to the southeast) from the proposed City of Boerne WWTP site to the furthest extents of Fair Oaks Ranch in Bexar County. The downstream portion of the IH-10 Corridor, including the portion of Central Kendall County lying inside the Cibolo Creek basin, extends about 8.25 miles to the northeast from the proposed City of Boerne WWTP site.

Upstream drainage areas within this sub-watershed and other sub-watersheds extend approximately 12 miles to the west of the WWTP site along tributaries of Cibolo Creek. Subject to economic constraints, gravity wastewater collection to the proposed City of Boerne WWTP site may be largely feasible throughout the upstream portion of the development zone that is within the Cibolo Creek basin.

In the western portion of the IH-10 Corridor development zone, sub-watersheds located to the north, west, and south of the Cibolo Creek basin flow away from Cibolo Creek. These sub-watersheds comprise approximately 20% of the IH-10 Corridor area. It is understood that gravity wastewater collection from these sub-watersheds to the proposed City of Boerne WWTP site is less likely to be feasible, as is the case for areas located downstream (to the east) of the proposed WWTP site.

It is anticipated that a Regional WWTP at the proposed City of Boerne WWTP location could feasibly serve the majority of the IH-10 Corridor development zone to the west of the WWTP site, potentially including flows generated in the Central Kendall County development zone south of SH 46, and that the ability to provide service at the existing WWTP site over this area would be limited principally by collection system costs. Likewise, collection of flow from the portion of the sub-watershed downstream of the WWTP site would be limited by pumping costs. It is further anticipated that a collection system associated with a regional facility at the location of the proposed City of Boerne WWTP would extend only as far in each direction as dictated by the economics of actual developed density.

Based on these assumptions, the maximum projected 2040 flow to a Regional WWTP at the location of the proposed City of Boerne WWTP is anticipated to be less than 5.60 MGD. If substantial effluent reuse demands are developed at locations a significant distance from the proposed WWTP site, economics may favor construction of an additional sub-regional or local WWTPs rather than development of a single zone-wide regionalization of wastewater treatment. Since the Fair Oaks Golf Course and Country Club will continue to require irrigation, evaluation of the cost-effectiveness of regional treatment of wastewater flows from the City of Fair Oaks versus continued operation of the City of Fair Oaks WWTP needs to consider the cost of returning treated effluent to the golf course.

The proximity of the City of Fair Oaks Ranch and the City of Boerne would indicate that a further evaluation of a larger regional treatment facility to serve both cities as well as the areas between them and areas upstream could be considered. Such a regional facility would eliminate or reduce the capacities needed at the Cities' facilities or allow those facilities to be converted to reclamation plants where the final solids treatment would be accomplished at the regional facility.

4.4.5 Packaged Treatment Plants

Packaged treatment plants have the advantages of low capital cost and rapid design and construction. These attributes make packaged plants attractive to land developers seeking to achieve wastewater service quickly while deferring capital costs. Properly designed, constructed, and operated packaged plants are capable of achieving outstanding effluent quality, although some units on the market do not meet these design and construction standards, and operation of package plants with minimal operator attention during under-loaded startup conditions may not achieve such desirable results.

The principal disadvantage of typical packaged treatment units is that the materials utilized, (such as painted or galvanize carbon steel tanks, pipes, and structural supports), provide a shorter service life than "permanent" treatment facilities using concrete tanks and stainless steel/aluminum metals components. Therefore, the life cycle cost of packaged treatment units is typically higher than for a "permanent" treatment plant due to the recurring replacement cost of the units. Consequently, use of packaged treatment units is not recommended as a generalized approach for long-term wastewater planning for Kendall County.

The most appropriate use of packaged treatment units is to provide a temporary treatment system in remote developing areas which will ultimately be served by a centralized or regional collection system, especially if the time period for connection to the centralized or regional collection is less than the 15-20 year probable service life of the packaged treatment units.

For developments in locations where centralized or regional wastewater service will not be provided within a 15-20 year period, there are more sustainable alternatives available. Recirculating filter systems are capable of reliably meeting very high effluent quality standards for small flows, and perform well with limited operator attention during under-loaded startup conditions. If well-designed and constructed, these systems can provide a service life comparable to a conventional "permanent" plant. Pond systems are economical, simple to operate, and very well suited to small and remote communities. "Advanced Integrated Pond Systems" can be designed to remove ammonia nitrogen and phosphorus; however, the effluent quality required for discharge or even for land application of effluent in Kendall County precludes use of even these advanced pond systems in most locations in the County without post-filtration to remove algae, and chemical addition for polishing phosphorus removal in locations where required.

4.4.6 Summary

A single regional WWTP was determined not to be a viable approach for wastewater master planning in Kendall County based on anticipated collection system costs versus relatively low long-term population density, and anticipated O&M costs for pumping raw wastewater across multiple drainage basins.

Use of packaged treatment plants is not recommended for providing long-term wastewater service due to the high recurring cost of replacing the packaged treatment units, but may be an appropriate near-term approach for currently-unserved developing areas that will be connected to a centralized or regional WWTP collection system within 15-20 years.

The recommended development scenarios for wastewater master planning for Kendall County consist of multiple regional facilities as summarized in *Table 4.6*:

Table 4.6 Wastewater Treatment Development Scenarios

Development Zone	Anticipated WW Treatment Facilities	Anticipated 2040 Flow Rate
Northern Kendall County	OSSFs	< 5,000 GPD each*
Western Kendall County	Regional WWTP at Kendall County WCID No.1 Site	< 0.48 MGD + Kerr County Flows
Central Kendall County	Regional WWTP at GBRA Cordillera Ranch WWTP Site	< 1.73 MGD
IH-10 Corridor	Regional WWTP at City of Boerne Future WWTP Site	< 5.2 MGD

* State rule allows entities with less than 5000 GPD of wastewater flow to be permitted as OSSF systems.

Further investigation of the potential for regionalization of wastewater treatment within Western Kendall County and Central Kendall County will require evaluation of the feasibility and economics of the treatment requirements for effluent discharge, which is likely to require compliance with stringent effluent limits for nutrient removal (5/5/2/1 or lower) versus the feasibility and economics of effluent disposal by land application at less stringent effluent quality limits, including land availability and costs, and construction and operation/maintenance costs of effluent storage ponds and irrigation systems.

Further investigation of the potential for regionalization of wastewater treatment within the IH-10 Corridor will necessitate discussion with the City of Boerne to confirm the City's amenability to siting a regional facility at either the City's future WWTP site, as well as the City's plans for the existing WWTP and evaluation of the cost of pumping from Fair Oaks Ranch to the regional WWTP.

In addition to these three identified potential locations for regional facilities, satellite facilities should be considered for the purpose of producing reclaimed water in fast-growing areas with high potential for reuse demands (such as golf course communities) where the cost of returning reclaimed effluent from a regional facility would justify the cost of a separate treatment facility. Where a regional collection system exists, a "scalping" satellite WWTP may be constructed for the sole purpose of reclaimed water production, with no effluent discharged, and residual solids returned to the collection system.

In consideration of anticipated development densities in much of rural Kendall County versus the density required to support the cost of centralized wastewater collection, and based upon the current development regulations for the County, many areas throughout the County will continue to develop at a low density and will use OSSF technology for treatment combined with effluent discharge via infiltration or irrigation disposal systems.

4.4.7 Conceptual Cost Estimates

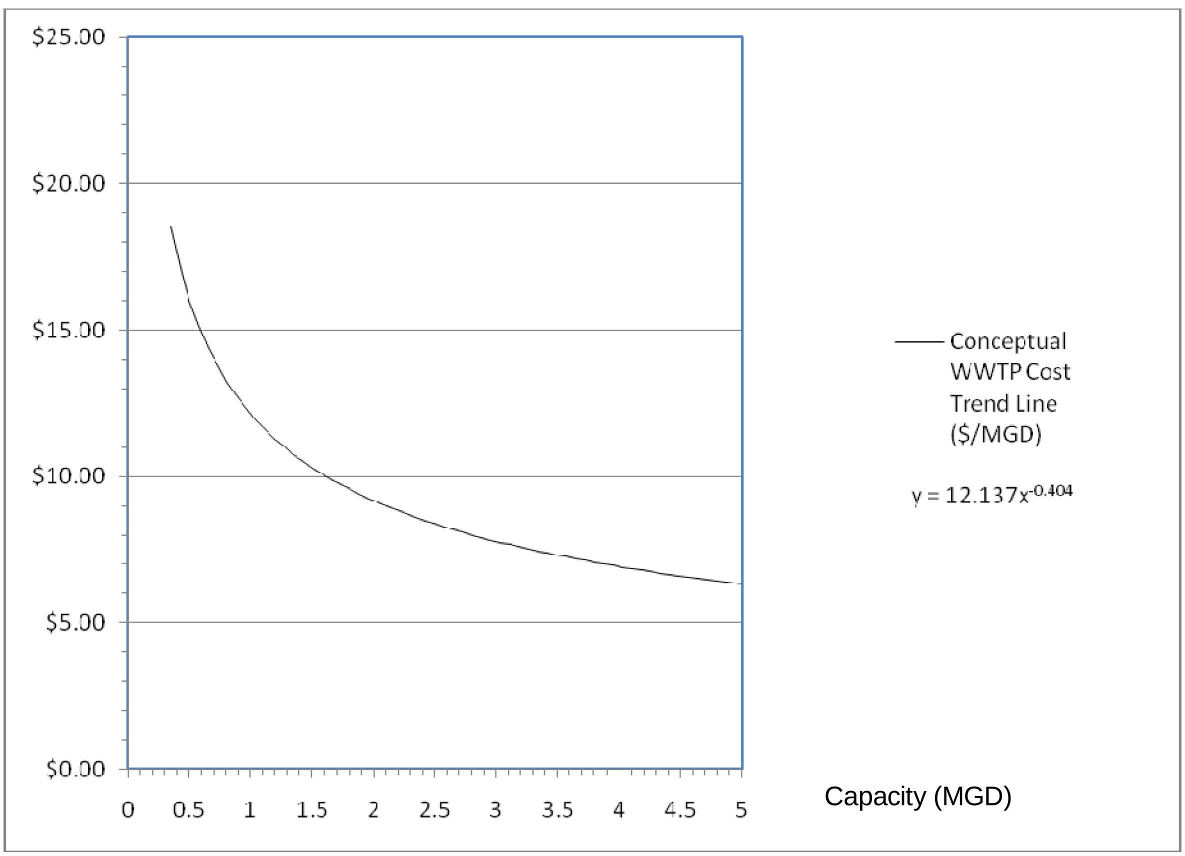
Conceptual-level construction costs for regional wastewater treatment facilities were estimated using the following methodology:

1. Construction cost data for wastewater treatment facilities in Central Texas were evaluated to develop a second order polynomial regression trend line for cost per unit treatment capacity.

2. The equation of the resulting trend line was used with the wastewater demand projections of *Table 4.2* to estimate costs for initial WWTP construction (to provide capacity through 2020) and for two subsequent expansion phases (to provide capacity through 2030 and 2040 respectively).

   Figure 4.2 shows the trend line used for estimation of conceptual level costs.

Figure 4.2 WWTP Construction Unit Cost vs. Capacity Trend Line



This second-order polynomial trend line was developed using construction cost data for wastewater treatment facilities capable of advanced treatment (5/5/2/1 effluent quality or better) constructed in Central Texas between 2004 and 2010, ranging from 0.35 MGD to 25 MGD constructed capacity increments. The data set for development of the conceptual cost curve, however, included only four facilities, indicating that these costs should not be relied upon for planning purposes beyond the conceptual level. The resulting cost estimates are for wastewater treatment facilities only and do not include wastewater collection system facilities or offsite effluent disposal systems. Cost of the collection system may be a determining factor which could outweigh the cost of treatment facilities, and should be evaluated prior to any decision making process.

Table 4.7 shows the resulting conceptual-level estimated construction costs for regional wastewater treatment facilities for Kendall County, based on the projected wastewater demands of *Table 4.2*:

Table 4.7 Conceptual Construction Costs of Regional WWTPs

Conceptual Construction Costs ($) for Regional WWTPs		Initial Capacity Through 2020	Expansion for Capacity Through 2030	Expansion for Capacity Through 2040
Northern Kendall County		OSSFs	OSSFs	OSSFs
Western Kendall County		$6,268,000	$2,488,000	$2,694,000
Central Kendall County		$12,636,000	$5,312,000	$7,134,000
IH-10 Corridor	Non-City	OSSFs or Small WWTPs	OSSFs or Small WWTPs	OSSFs or Small WWTPs
	Boerne	$18,833,000	$12,281,000	$4,511,000
	Fair Oaks Ranch[1]	$9,215,000	$3,257,000	$2,694,000
	Boerne + Fair Oaks[1]	$22,035,000	$13,054,000	$5,562,000

[1] Costs assume treatment of 100% of flows generated at Fair Oaks Ranch.

Although these costs are at a conceptual level, *Table 4.7* serves to illustrate the potential benefits of regionalization in terms of reduced unit costs for larger increments of capacity. This is notably the case in terms of potential cost savings for combined treatment of flows from Boerne and Fair Oaks Ranch, although the cost savings would likely be at least partially offset by increased collection system costs. The potential cost savings available indicate that regionalization of treatment should be further explored through subsequent facilities planning studies, including incorporation of collection system and disposal system costs and life cycle cost evaluations.

In general, the cost-effectiveness of each of these potential regional facilities needs to be further evaluated at the feasibility study with consideration of the planning-level costs associated with:

- Treatment, accounting for the savings due to economies of scale in larger facilities.
- Regional collection systems, accounting for costs associated with specific principal trunk sewers and/or lift stations and force mains needed to convey flow to regional facilities.

- Effluent Reuse, accounting for the cost of effluent pump stations and force mains or scalping WWTPs to supply effluent to anticipated locations of demands.

In many cases these cost factors are significant for the overall cost-effectiveness evaluation. As an example of these cost impacts, for a regional WWTP located at the City of Boerne's Future WWTP Site, Based on the anticipated flow generation shown in *Table 4.2* and assuming a 2-hour wet weather flow peaking factor of 4.0, and a maximum force main peak flow velocity of 6 feet per second, a lift station with about 2,300 gpm firm capacity and approximately 35,000 linear feet (LF) of 14-inch diameter force main would be anticipated to be required to convey 2040 flows from the existing Fair Oaks Ranch WWTP site to the regional WWTP. *Figure 4.3*, shows conceptual level unit costs for lift station firm pumping capacity, and *Figure 4.4* and *Figure 4.5* show conceptual unit costs per inch diameter per foot for force mains by open-trench construction and by bore-and-jack construction, based on construction projects completed in Central Texas, assuming 3%average annual inflation.

Figure 4.3 Lift Station Construction Unit Cost vs. Firm Pumping Capacity Trend Line

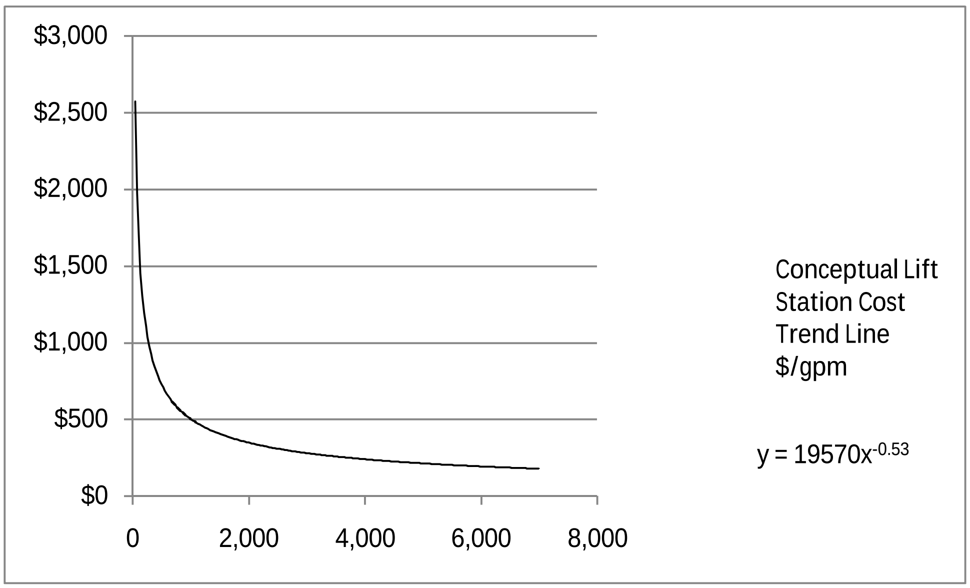


Figure 4.4 Force Main Construction Unit Cost vs. Diameter Trend Line (Open Trench Construction Method)

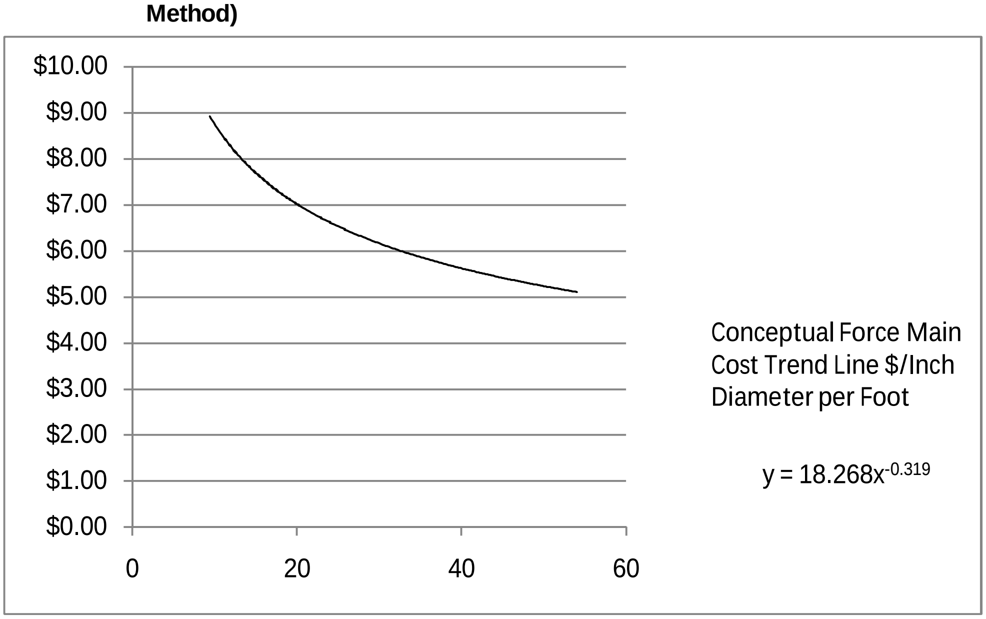
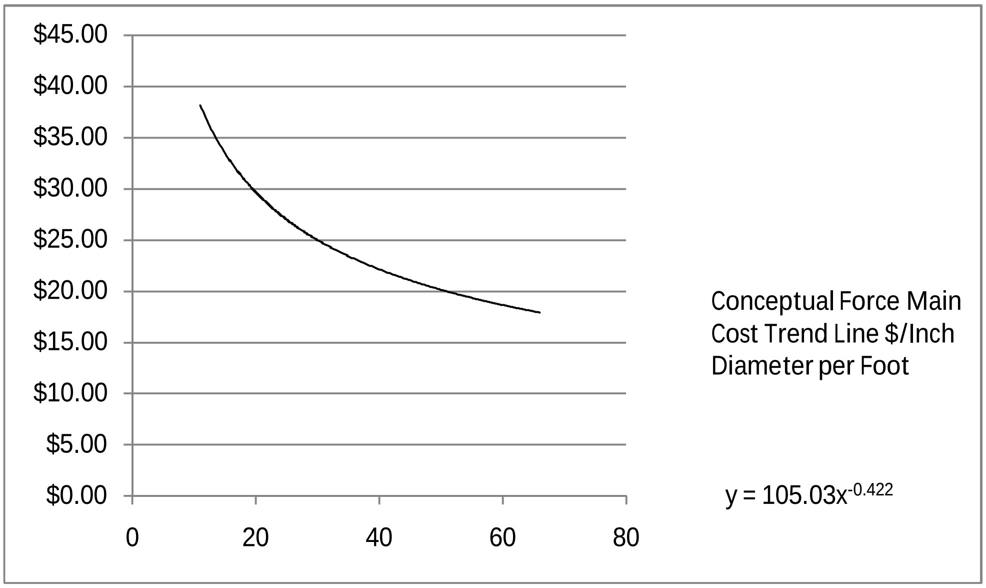


Figure 4.5 Force Main Construction Unit Cost vs. Diameter Trend Line (Bore and Jack Construction Method with Steel Encasement)



Based on the preceding assumptions, and assuming approximately 1,000 LF of the force main to be constructed by bore and jack installation with steel encasement, *Table 4.8* indicates that the estimated conceptual cost of pumping facilities and force mains sized to convey flows from the existing Fair Oaks Ranch WWTP site to the City of Boerne's future WWTP site sized for capacity required through 2040 could be nearly $5 million. Estimated costs of force mains do not include the cost of easements which can be variable based on the route of the pipelines and can potentially add substantial additional costs.

Table 4.8 Conceptual Construction Costs of Flow Diversion from Fair Oaks Ranch WWTP Site to City of Boerne's Future WWTP Site based on 2040 Capacity Requirements

Flow Diversion Components	Conceptual Construction Costs
Lift Station (2,280 gpm firm pumping capacity)	$741,000
Force Main (33,850 LF 14" Dia., Open Trench Construction)	$3,730,000
Force Main (1,000 LF Bore and Jack with Encasement)	$483,000
Total	$4,954,000

This represents an approximately 50% reduction versus the potential capital cost savings of regionalization that would be anticipated based on consideration of conceptual treatment facility costs alone, and clearly illustrates the need for case by case consideration of collection, treatment, disposal, and reuse costs within the capital cost evaluation at the feasibility study level for each of the potential regional facilities, along with life cycle costs including O&M as the cost-benefit basis for determining whether to move forward with regionalization. While savings in the capital and O&M costs of treatment facilities normally tend to favor regionalization, the capital and O&M costs of required collection systems can potentially negate or reduce these savings. The cost versus benefit of implementing effluent reuse is highly site specific depending on the reuse application, and could either tend to favor or to be a disincentive to regionalization for any specific service area.

5.0 Water Quality

5.1 Background

Water quality in the streams and rivers of Kendall County is generally good. The Texas Commission on Environmental Quality (TCEQ) assesses the health of waterbodies within the state every two years in a report titled the Texas Water Quality Inventory and 303(d) List. When a waterbody does not meet quality standards for the stream, river or lake's designated uses, the waterbody is added to the 303(d) list of impaired waters. The main stem of the Guadalupe River that flows through the study area and the tributaries located within that section of river show no impairments or concerns in the *DRAFT 2010 Texas 303(d) List*, released in February 2010.

The majority of the existing population and the future populations are projected to reside in the IH-10 corridor area of the County which actually lies in the San Antonio River Basin. The Upper Cibolo Creek watershed which drains this part of the county has been listed a number of times for several parameters in the TCEQ's biannual 303(d) lists. The *DRAFT 2010 Texas 303(d) List* shows the Upper Cibolo Creek from approximately 2 miles upstream of Hwy 87 in Boerne to the upper end of segment 1908_02 as being impaired for bacteria. While this impairment has been identified since 2006, TCEQ has determined that more data will need to be collected before proceeding with a Total Maximum Daily Load (TMDL) evaluation. The Upper Cibolo Creek Watershed Partnership (UCCWP) has been formed to take a proactive step in protecting and restoring water quality within Upper Cibolo Creek. The UCCWP is responsible for developing a non-regulatory Watershed Protection Plan to promote awareness and initiate action in reducing nonpoint source pollution within the watershed. A local stakeholder group has been formed to guide the planning phase of the protection plan.

In addition to the bacteria impairment of the Upper Cibolo Creek, the TCEQ has also determined that there are several parameters of concern. The segment that runs from the confluence with Balcones Creek to approximately 2 miles upstream of Hwy 87 in Boerne has shown from screening sample results to be of concern for levels of orthophosphorus, total phosphorus and dissolved oxygen. The segment that runs from approximately 2 miles upstream of Hwy 87 in Boerne to the upper end of the segment is of concern for impaired habitat.

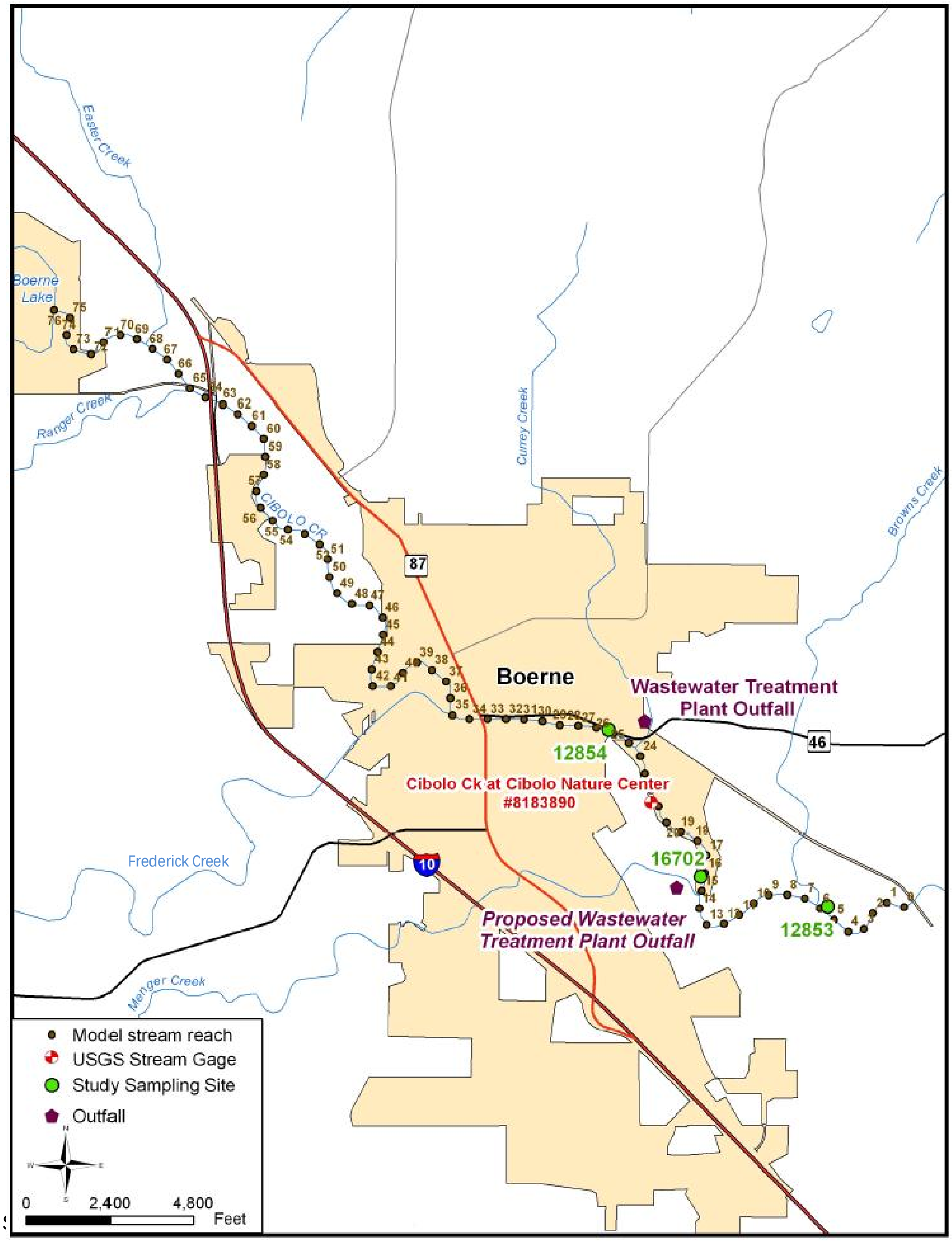
High level water quality modeling was performed for both Cibolo Creek and Guadalupe River in Kendall County to determine the impact of point sources discharges and impact of non-point loading due to development through 2040. Nutrients loadings from various wastewater treatment systems were calculated based on high level tertiary treatment standards of discharge permit limits (5-5-2-1 for BOD, TSS, NH_3N and P respectively). EPA's water quality model, QUAL2K, was utilized for the Cibolo Creek Model and QUALTX was applied to develop the Guadalupe River Model.

5.2 Cibolo Creek Model

The base model for Cibolo Creek water quality modeling effort for this study was provided by the City of Boerne. The model was prepared for '*Cibolo Creek Water Quality Monitoring and Modeling'* study for the City of Boerne in February 2009.

The EPA water quality model QUAL2K was applied to Cibolo Creek for the City of Boerne (Feb. 2009) study. The resulting calibrated models simulate concentrations of nutrients in Cibolo Creek with ambient conditions and wastewater treatment loads as input. The City of Boerne (Feb. 2009) study simulated several scenarios for Cibolo Creek. A single scenario of the model was provided to AECOM by the City of Boerne, which was the calibrated summer 2008 model (Scenario 13) which was modified for the purpose of this study. The summer 2008 model has low-flow and high-temperature conditions and represents a conservative case. The model was based on data collected as part of the City of Boerne study (Feb. 2009) in 2008 and that year was the third-driest year ever on record based on rainfall records in San Antonio. The 7.6 mile reach of the Cibolo Creek modeled in QUAL2K is shown in *Figure 5.1*.

Figure 5.1 The 7.6-mile Reach of Cibolo Creek and 0.1-mile Segments Modeled Using QUAL2K



5.2.1 Model Scenarios

Four model scenarios were simulated for this study as listed below:

1. Base model with point sources loadings. The City of Boerne (Feb. 2009) model scenario 13 which is a calibrated summer 2008 model with some point source loadings.

2. 2040 model with point source loadings.

3. Base model with point and non-point sources loadings.

4. 2040 model with point and non-point sources loadings.

A summary of point and non-point loadings for each of these simulations are listed in *Table 5.1*.

Table 5.1 Summary of Pollutant Loadings in the Cibolo Creek Model Scenarios

Scenario	Point Sources Loadings	Non-point Sources Loadings
1	• Existing Boerne WWTP at permit limit. 1.2 MGD. 10 BOD, 3 NH_3, 2 P.	• None.
2	• Existing Boerne WWTP at permit limit. 1.2 MGD. 10 BOD, 3 NH_3, 2 P. • Lerin Hills WWTP at permit limit. 0.18 MGD. 5 BOD, 1 NH_3. • Central Boerne WWTP at 5-5-2-1 discharge limit. 3.4 MGD. 5 BOD, 2 NH_3, 1 P.	• None.
3	• Existing Boerne WWTP at permit limit. 1.2 MGD. 10 BOD, 3 NH_3, 2 P.	• 2010 non-point loadings from three adjacent watersheds of the Cibolo Model Segments.
4	• Existing Boerne WWTP at permit limit. 1.2 MGD. 10 BOD, 3 NH_3, 2 P. • Lerin Hills WWTP at permit limit. 0.18 MGD. 5 BOD, 1 NH_3. • Central Boerne WWTP at 5-5-2-1 discharge limit. 3.4 MGD. 5 BOD, 2 NH_3, 1 P.	• 2040 non-point loadings from three adjacent watersheds of the Cibolo Model Segments.

* Summer 2008 model provided by City of Boerne is modified for all scenarios listed above.

5.2.2 Point Source Pollutant Loadings

The 2008 summer model includes the existing Boerne WWTP at its permit limit as a point source load. This load enters the Cibolo Creek at its confluence with Curry Creek. In the 2040 model, Lerin Hills WWTP is modeled at its permit limit and the central 2040 WWTP is modeled for additional flow for 2040 as an additional point source loading. Discharge from Lerin Hills is added at Frederick Creek confluence with the Cibolo Creek and the central WWTP discharge is added at the confluence with Menger Creek at the location of currently proposed second Boerne WTTP. DO concentrations in the discharges from the existing Boerne WWTP and proposed central WWTP at the location of Boerne WWTP 2 is 8.6 mg/L which is left unchanged from the City of Boerne (Feb. 2009) model. DO concentration in the discharge from proposed Lerin Hills WWTP is modeled at permit limit of 6.0 mg/L.

5.2.3 Non-point Source Loadings

The amount of run-off flows from watersheds adjacent to Cibolo Creek and the resulting non-point source loadings for the Cibolo Creek modeling was computed based on information found in '*Predicting Effects of Urban Development in the Cities of New Braunfels, San Marcos, Seguin and Victoria'* prepared in November 2000 in cooperation with GBRA and *TNRCC* (Texas Natural Resources Conservation Commission, Currently known as TCEQ). Run-off flows and non-point source loadings of nitrogen, phosphorus, total suspended solids and fecal coliform were computed for three watersheds adjacent to Cibolo Creek model segments. The location of these three watersheds, Cibolo 1, Cibolo 2, and Cibolo 3 are shown in *Exhibit 5.1*. Non-point loadings for phosphorus were added to the model as it was simulated in the base Summer 2008 model.

A list of the assumptions and basis for computing run-off flows is provided below:

- Average rainfall in Kendall County = 40 inches/yr (Source: Kendall County website. Additional supporting information provided in Appendix E).
- Runoff = Rainfall * Runoff coefficient.
- Runoff Coefficient, $y = 0.5398x^2 + 0.3333x + 0.0289$ where x is 'Impervious Cover'.
- Impervious cover is computed based on 0.16 acres of impervious cover per person (Source: GBRA 2000 study page 3-4). It was found that impervious cover increases from 24.0% to 57.4% in the Boerne service area and to 4.22% in the non-city area of IH-10 corridor.
- Runoffs from watershed 1 and 3 are added as diffused source to the model, runoff from watershed 2 is added as point source at the confluence of Frederick Creek and Cibolo Creek.
- For runoff computation of watershed 1 (Cibolo 1 on map), 40% of Boerne service area and 30% of non-city area of the watershed contributes to model reach.
- For runoff computation of watershed 3 (Cibolo 3 on map), 80% of Boerne service area and two-third of non-city area of the watershed contributes to model reach.

Non-point pollutant loadings for the three watersheds adjacent to Cibolo Creek model segments are presented in *Table 5.2*.

Table 5.2 Non-point Pollutant Loadings for the Cibolo Creek Watersheds

Watershed 1: Watershed North West of Boerne

	2010	2040	Percent Increase
Total area (acre)	6,197	6,197	
Total flow (ft^3/sec)	1.25	2.08	67%
Nitrogen (mg/L)	1.286	1.564	22%
Phosphorus (mg/L)	0.084	0.198	135%
TSS (mg/L)	299	424	42%
Fecal Coliform (#/100 mL)	13,952	30,403	118%

Watershed 2: Non-point flow added at Frederick Creek

	2010	2040	Percent Increase
Total area (acre)	10,257	10,257	
Total flow (ft^3/sec)	1.81	2.56	42%
Nitrogen (mg/L)	1.220	1.405	15%
Phosphorus (mg/L)	0.057	0.133	132%
TSS (mg/L)	283	342	21%
Fecal Coliform (#/100 mL)	12,569	19,431	55%

Watershed 3: Watershed South East of Boerne

	2010	2040	Percent Increase
Total area (acre)	11,303	11,303	
Total flow (ft^3/sec)	3.93	9.36	138%
Nitrogen (mg/L)	1.663	2.469	48%
Phosphorus (mg/L)	0.239	0.569	138%
TSS (mg/L)	393	890	126%
Fecal Coliform (#/100 mL)	21,852	93,065	326%

5.2.4 Results from Models with Point Source Loadings

Results from water quality model simulations with non-point loadings show addition of flows at each discharge point and the impact on dissolved oxygen concentrations and other stream constituents. Simulated streamflows for the point source loadings models in Cibolo Creek are shown in *Figure 5.2*, and demonstrate the additional flow for the 2040 model at the WTTP effluent discharge locations.

Dissolved oxygen (DO) values in the summer remain relatively low for both scenarios (*Figure 5.3)*. However, the extremely low flows can represent a challenge for the QUAL2K model as seen in the erratic fluctuations of the Summer 2008 model scenarios before flow from the WWTPs is introduced to Cibolo Creek (Source: City of Boerne Report, Feb 2009). Concentration of DO goes up in the 2040 scenario where effluent from the future Central WWTP is added to the model which has better DO concentration than the water in the stream.

Simulated NH_3 concentrations in the models, shown in *Figure 5.4*, show an increase from the measures non-detect value of <0.1 mg/L, to close to 2.5 mg/L at the WWTP discharge location for the 2008 model. In the 2040 model, the NH_3 concentration actually goes down at the discharge location due to additional WWTP discharge flow with lower NH_3 concentration. Simulated total P concentration in the models show an increase from the measured non-detect value of <0.1 mg/L to close to 2.5 mg/L at WWTP discharge location for the 2008 model. In the 2040 model, NH_3 concentration actually decreases at the discharge location due to additional WWTP discharge flow with lower NH_3 concentration.

Simulated total P concentrations in the models, shown in *Figure 5.5*, also shows an improvement in 2040 compare to 2010 concentration due to additional WWTP discharge flow with lower total P concentration.

Figure 5.2 Comparison of Simulated Streamflow in the Cibolo Creek Base Model vs 2040 Model with Point Sources Loadings

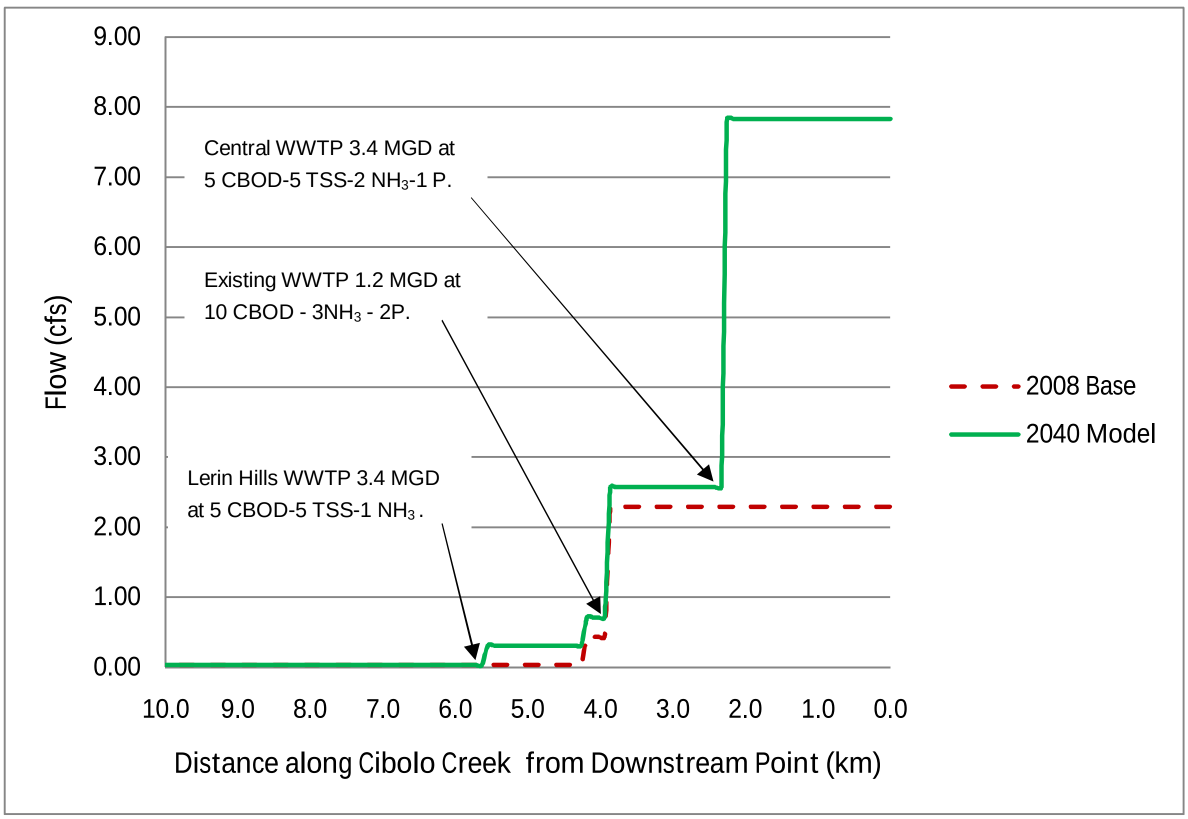


Figure 5.3 Comparison of Simulated DO Concentrations in the Cibolo Creek Base Model vs 2040 Model with Point Sources Loadings

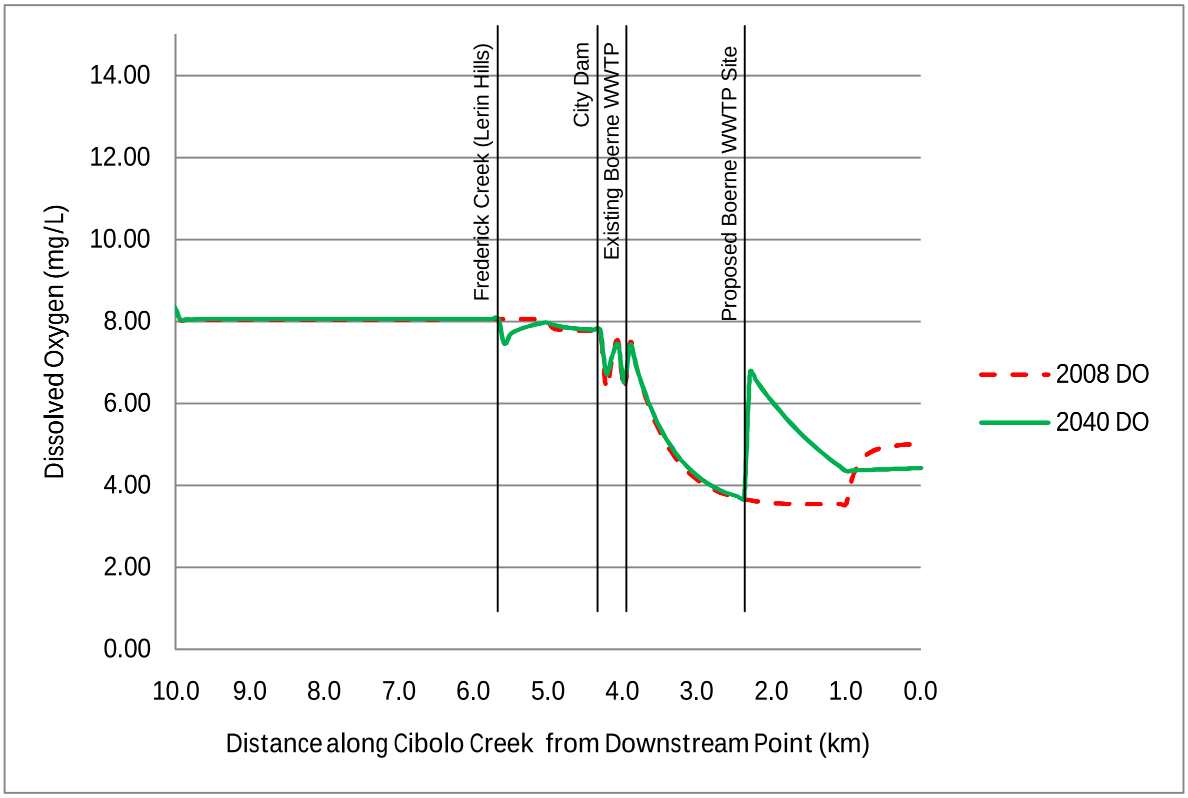


Figure 5.4 Comparison of Simulated Ammonia Concentrations in the Cibolo Creek Base Model vs 2040 Model with Point Sources Loadings

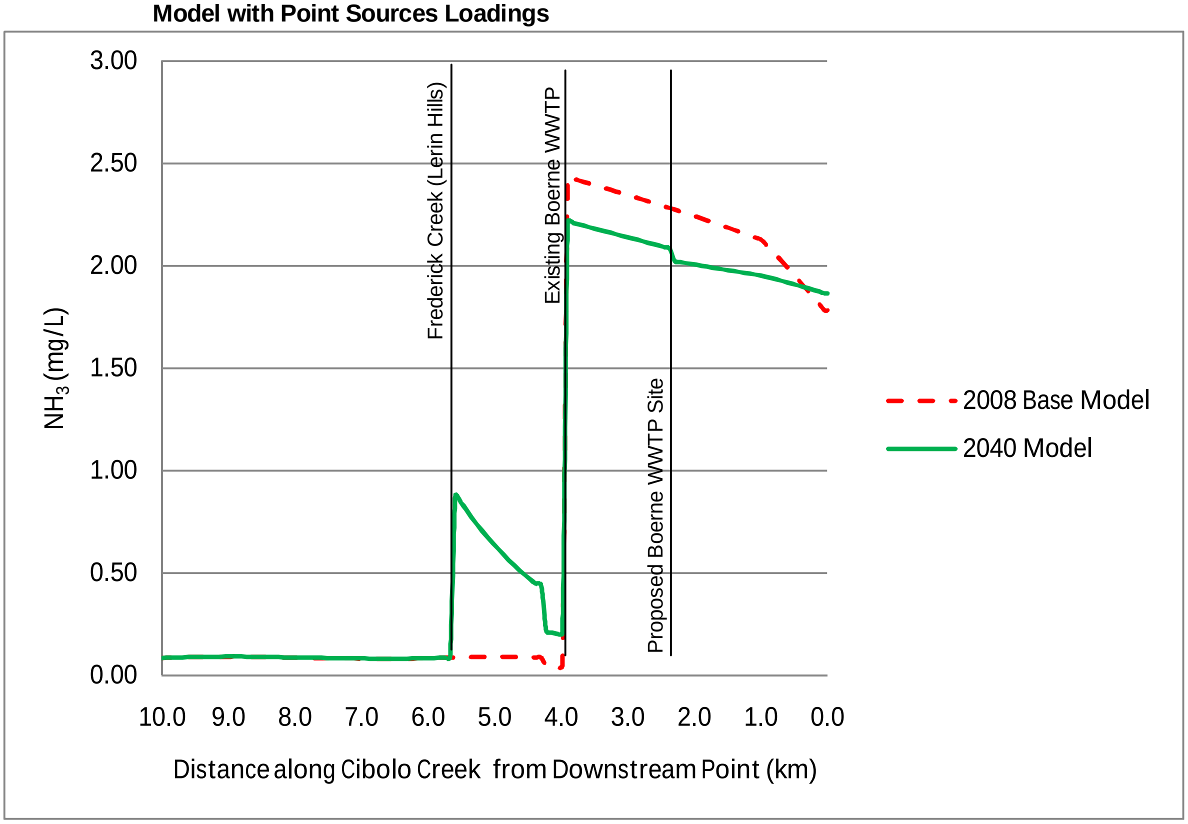
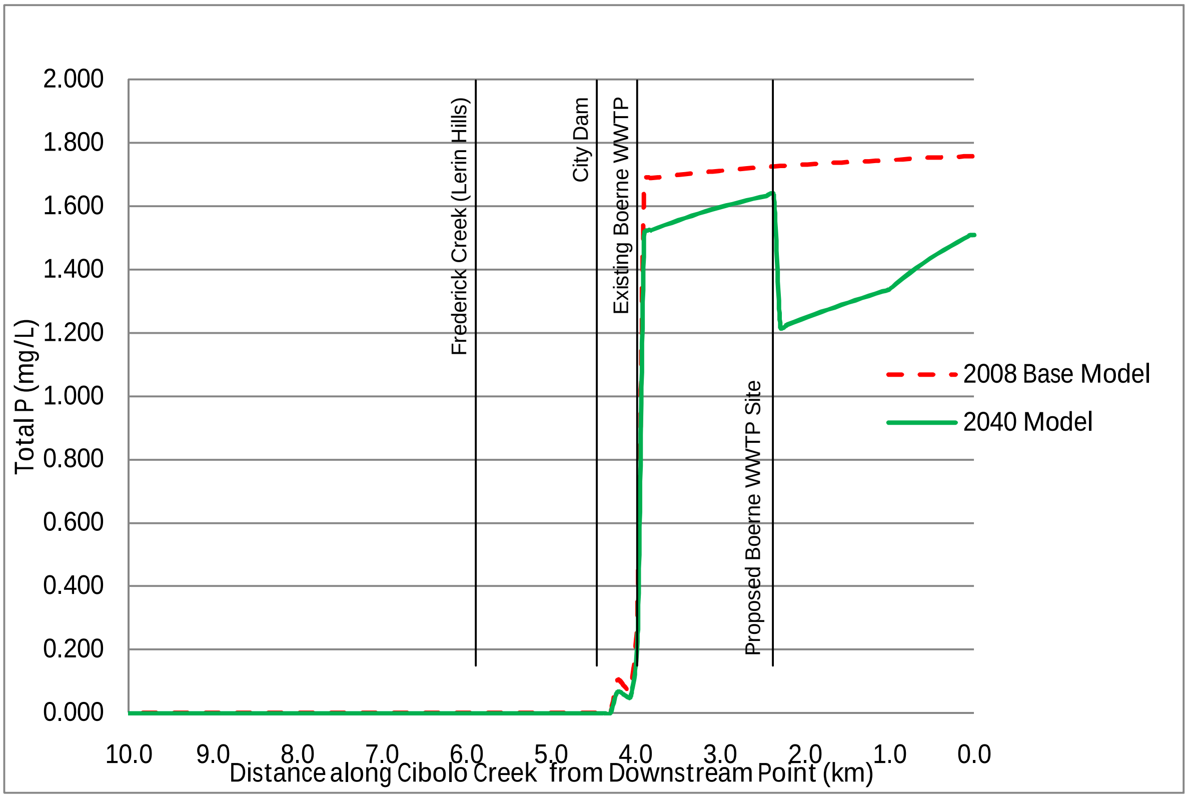


Figure 5.5 Comparison of Simulated Total P Concentrations in the Cibolo Creek Base Model vs 2040 Model with Point Sources Loadings



5.2.5 Results from Models with Point and Non-Point Source Pollutant Loadings

Figure 5.6 shows a comparison of base vs. 2040 simulated stream flow in Cibolo Creek with average annual non-point source loadings added to the models. Total stream flows have increased compared to the point source loading models. *Figure 5.7* and *Figure 5.8* show the comparison of DO and total P concentrations respectively between base and 2040 models with both point and non-point source loadings. Concentration of DO goes up in the 2040 scenario where effluent from the future Central WWTP is added to the model which has better DO concentration than the water in the stream. Comparisons of NH_3 concentrations are not shown since non-point loadings of NH_3 is not estimated. Since the concentration of phosphorus in the non-point loadings is lower than the WWTP discharges, the resulting total P concentrations are lower in this model.

Figure 5.6 Comparison of Simulated Streamflow in the Cibolo Creek Base Model vs 2040 Model with Point and Non-Point Sources Loadings

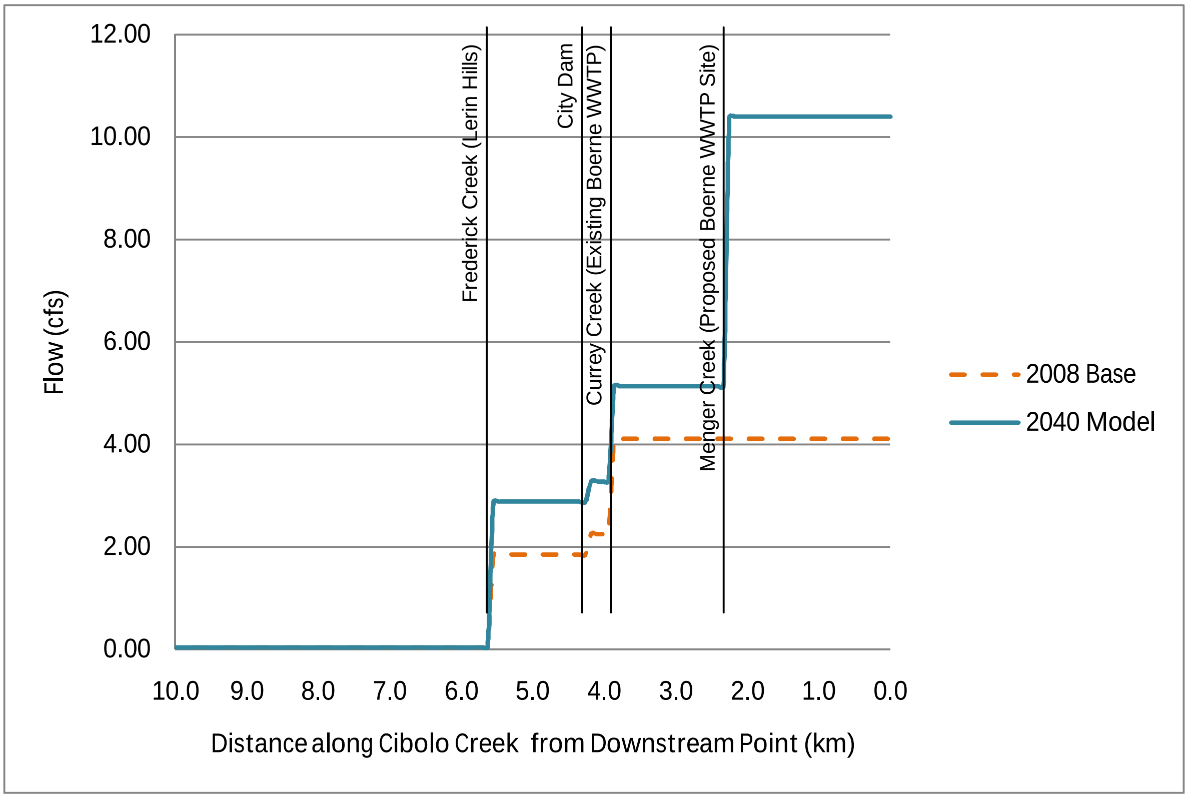


Figure 5.7 Comparison of Simulated DO in the Cibolo Creek Base Model vs 2040 Model with Point and Non-Point Sources Loadings

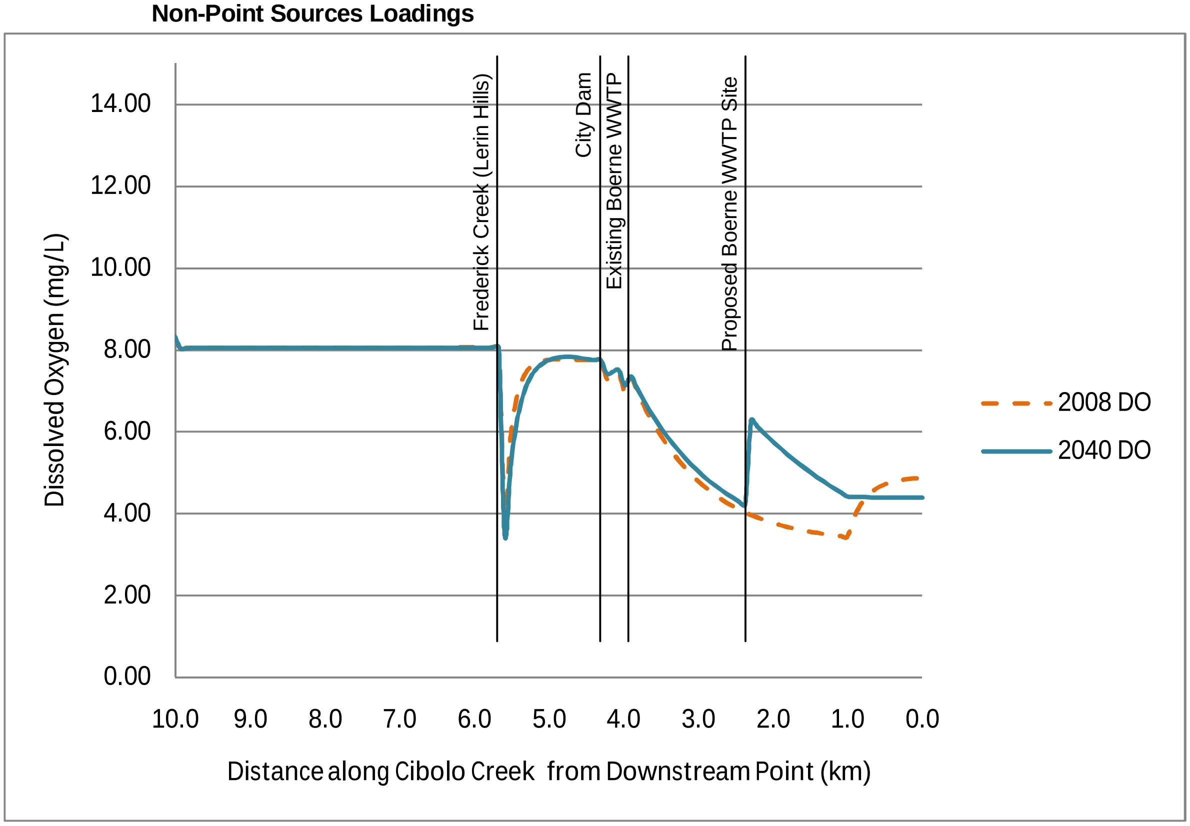
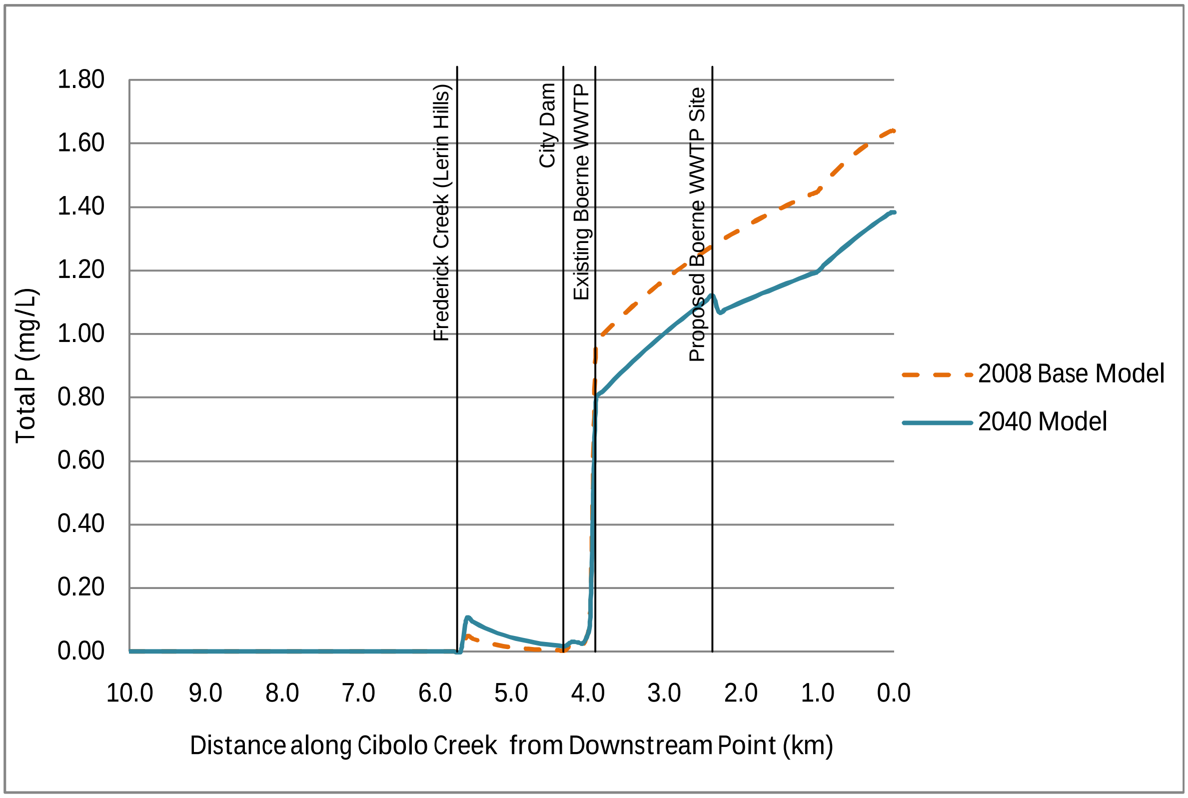


Figure 5.8 Comparison of Simulated Total P in the Cibolo Creek Base Model vs 2040 Model with Point and Non-Point Sources Loadings



5.3 Guadalupe River Model

The water quality model used to evaluate point source and non-point source impacts to the Guadalupe River was developed from a QUAL-TX model used by the TCEQ to evaluate the point source impacts of the Kendall County WCID #1 wastewater treatment plant discharge. The original model was based on a short reach of river near the discharge site. The model developed for this study expanded the analysis to include the entire length of Guadalupe River within Kendall County. A 2010 analysis and a 2040 analysis were performed and compared to determine how growth and development will impact water quality in the county.

The Guadalupe River was divided into seven reaches. Details regarding the reaches can be found below in *Table 5.3*. *Exhibit 5.2* displays the watersheds that drain to the various reaches and the locations of the wastewater treatment plants. Point and non-point source pollutant loadings were included in each model, where appropriate. Wastewater treatment plant discharges were determined based on existing conditions for 2010 (using 2009 discharge records for Kendall County WCID #1), and were based on the assumption that any discharge above and beyond existing land application permits would be discharged to the river in the 2040 analysis.

The percent impervious cover for each reach was calculated using the proportional population density based on development zone (see Section 2) and an assumed 0.12 acres of impervious cover per person.

Table 5.3 Summary of Reaches in Guadalupe River Model

Reach #	Reach Length (miles)	Drainage Area (acres)	2010 % Impervious Cover	2040 % Impervious Cover	WWTP within Reach?	2010 WWTP Flow (cfs)	2040 WWTP Flow (cfs)
1	8.0	26,277	1.01	1.78	KC WCID #1	0.03	0.228
2	8.4	44,898	0.42	0.81	N/A	N/A	N/A
3	4.6	34,511	1.27	2.64	N/A	N/A	N/A
4	9.6	56,527	0.35	0.75	N/A	N/A	N/A
5	1.5	11,080	1.19	2.72	N/A	N/A	N/A
6	11.0	25,757	1.14	2.60	N/A	N/A	N/A
7	11.4	38,180	1.19	2.72	Cordillera Ranch	0.00	2.38

5.3.1 Point Source and Non-Point Source Pollutant Loadings

Point source pollutant loadings were based on existing permit values for the 2010 analysis, and based on 5-5-2-1 loadings for 2040.

Non-point source runoff was calculated for each reach using the assumptions below:

- Average rainfall in Kendall County = 40 inches/yr (Source: Kendall County website. Additional supporting information provided in Appendix E).
- Runoff = Rainfall * Runoff coefficient.
- Runoff Coefficient, $y = 0.5398x^2 + 0.3333x + 0.0289$ where x is 'Impervious Cover'.

Non-point loadings of Total Suspended Solids (TSS), Nitrogen, Phosphorus, and Fecal Coliform were computed based on information in "*Predicting Effects of Urban Development in the Cities of New Braunfels, San Marcos, Seguin and Victoria. Prepared in cooperation with GBRA and TNRCC by PBS&J, November 2000*."

Table 5.4 below shows the point and non-point TSS loadings in lb./yr for the various reaches and how they increase with growth and development from 2010 to 2040. Only a small percentage of the TSS loadings come from point sources, the majority are from rainfall runoff.

Table 5.4 Point and Non-point Source TSS Loadings in Guadalupe River Model

	TSS (lb./yr)								
	2010			2040			% Change*		
Reach #	Non-Point	Point	Total	Non-Point	Point	Total	Non-Point	Point	Total
1	2,046,552	266	2,046,818	2,275,728	2,242	2,277,970	11.2%	0.1%	11.3%
2	3,213,438	0	3,213,438	3,399,176	0	3,399,176	5.8%	0.0%	5.8%
3	2,787,325	0	2,787,325	3,348,460	0	3,348,460	20.1%	0.0%	20.1%
4	4,004,588	0	4,004,588	4,243,114	0	4,243,114	6.0%	0.0%	6.0%
5	884,989	0	884,989	1,086,206	0	1,086,206	22.7%	0.0%	22.7%
6	2,042,973	0	2,042,973	2,486,188	0	2,486,188	21.7%	0.0%	21.7%
7	3,049,538	0	3,049,538	3,742,901	23,403	3,766,304	22.7%	0.8%	23.5%

* % change increase is based on total increase of both point and non-point sources.

Table 5.5 below shows the point and non-point Nitrogen loadings in lb./yr for the various reaches and how they increase with growth and development from 2010 to 2040. As point source discharges increase over the planning period, the nitrogen loadings from the point sources have a larger impact on the total quantity of nitrogen in the river.

Table 5.5 Point and Non-point Source Nitrogen Loadings in Guadalupe River Model

	Nitrogen (lb./yr)								
	2010			2040			% Change*		
Reach #	Non-Point	Point	Total	Non-Point	Point	Total	Non-Point	Point	Total
1	8,744	106	8,850	9,832	897	10,729	12.3%	8.9%	21.2%
2	13,601	0	13,601	14,478	0	14,478	6.4%	0.0%	6.4%
3	11,956	0	11,956	14,623	0	14,623	22.3%	0.0%	22.3%
4	16,929	0	16,929	18,056	0	18,056	6.7%	0.0%	6.7%
5	3,792	0	3,792	4,748	0	4,748	25.2%	0.0%	25.2%
6	8,746	0	8,746	10,852	0	10,852	24.1%	0.0%	24.1%
7	13,065	0	13,065	16,360	9,361	25,721	25.2%	71.6%	96.9%

* % change increase is based on total increase of both point and non-point sources.

Table 5.6 below shows the point and non-point Phosphorus loadings in lb./yr for the various reaches and how they increase with growth and development from 2010 to 2040. As point source discharges increase over the planning period, the phosphorus loadings from the point sources have a larger impact on the total quantity of Nitrogen in the river.

Table 5.6 Point and Non-point Source Phosphorus Loadings in Guadalupe River Model

	Phosphorus (lb./yr)								
	2010			2040			% Change*		
Reach #	Non-Point	Point	Total	Non-Point	Point	Total	Non-Point	Point	Total
1	179	53	232	342	448	790	70.3%	170.3%	240.5%
2	120	0	120	241	0	241	100.8%	0.0%	100.8%
3	305	0	305	726	0	726	138.0%	0.0%	138.0%
4	124	0	124	279	0	279	125.0%	0.0%	125.0%
5	91	0	91	242	0	242	165.9%	0.0%	165.9%
6	201	0	201	531	0	531	164.2%	0.0%	164.2%
7	313	0	313	833	4,681	5,514	166.1%	1495.5%	1661.7%

* % change increase is based on total increase of both point and non-point sources.

Table 5.7 below shows the non-point source Fecal coliform loadings in #/100 mL for the various reaches and how they are impacted by growth and development from 2010 to 2040. Fecal coliform data was not available for point sources, but is assumed to be negligible relative to the non-point sources. Percent change is greater in reaches where more development is expected.

Table 5.7 Non-point Source Fecal Coliform Loadings in Guadalupe River Model

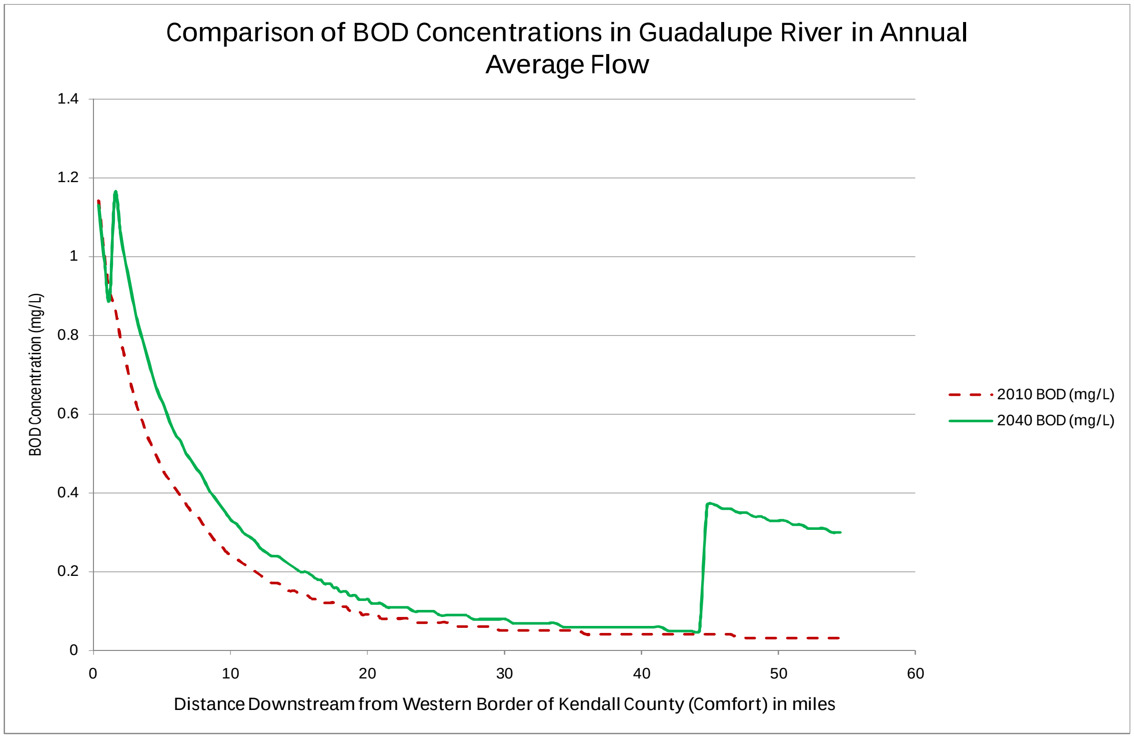
	Coliforms (#/100 mL)		
Reach #	2010	2040	% Change
1	11,301	11,770	4.2
2	10,955	11,183	2.1
3	11,457	12,316	7.5
4	10,915	11,147	2.1
5	11,409	12,368	8.4
6	11,379	12,290	8.0
7	11,409	12,368	8.4

5.3.2 Guadalupe River Water Quality Modeling Results

Figures 5.9 through 5.14 show comparisons of the results of the 2010 and 2040 analyses for various parameters under average annual flow conditions. Parameters include concentrations in mg/L of Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), TSS, Nitrogen, Phosphorus, and concentration of Coliforms (# / 100 mL).

In *Figure 5.9*, BOD concentrations increase at each of the wastewater treatment plant discharge points, but overall show a decrease through the length of the river in the model.

Figure 5.9 Comparison of BOD Concentrations in the Guadalupe River for 2010 and 2040



In *Figure 5.10,* dissolved oxygen concentrations decrease at the discharge point for each of the wastewater treatment plants, but overall the 2040 model results do not vary much from the 2010 model results.

Figure 5.10 Comparison of DO Concentrations in the Guadalupe River for 2010 and 2040

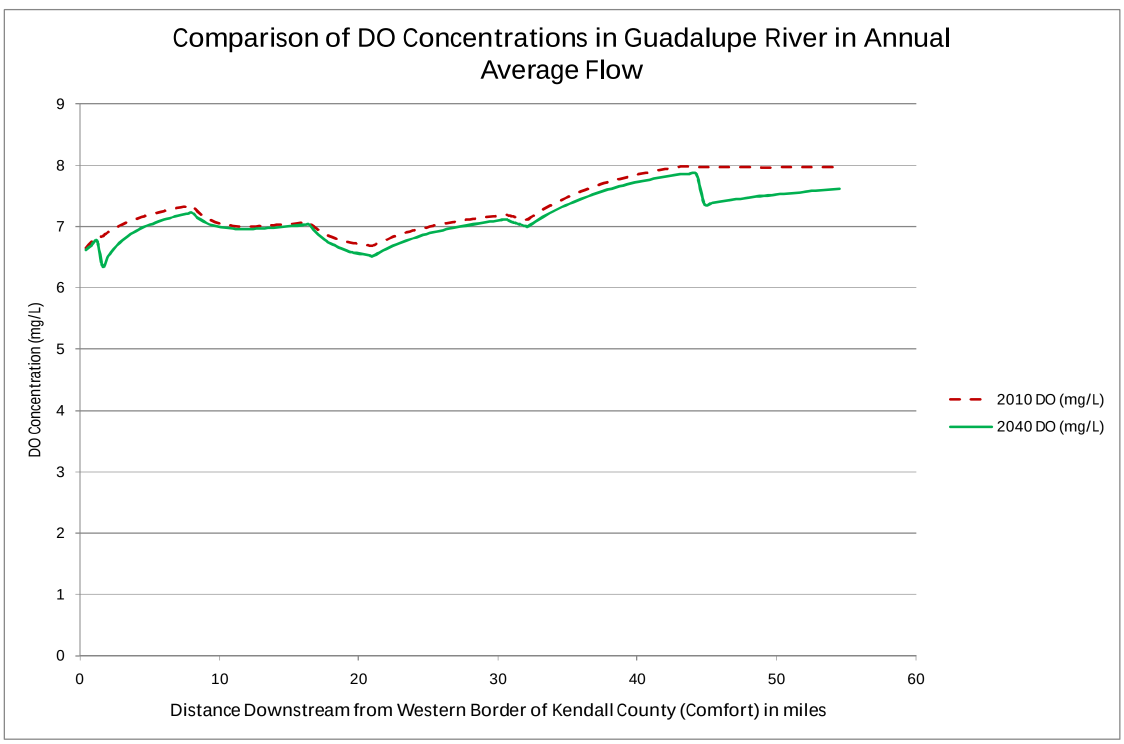
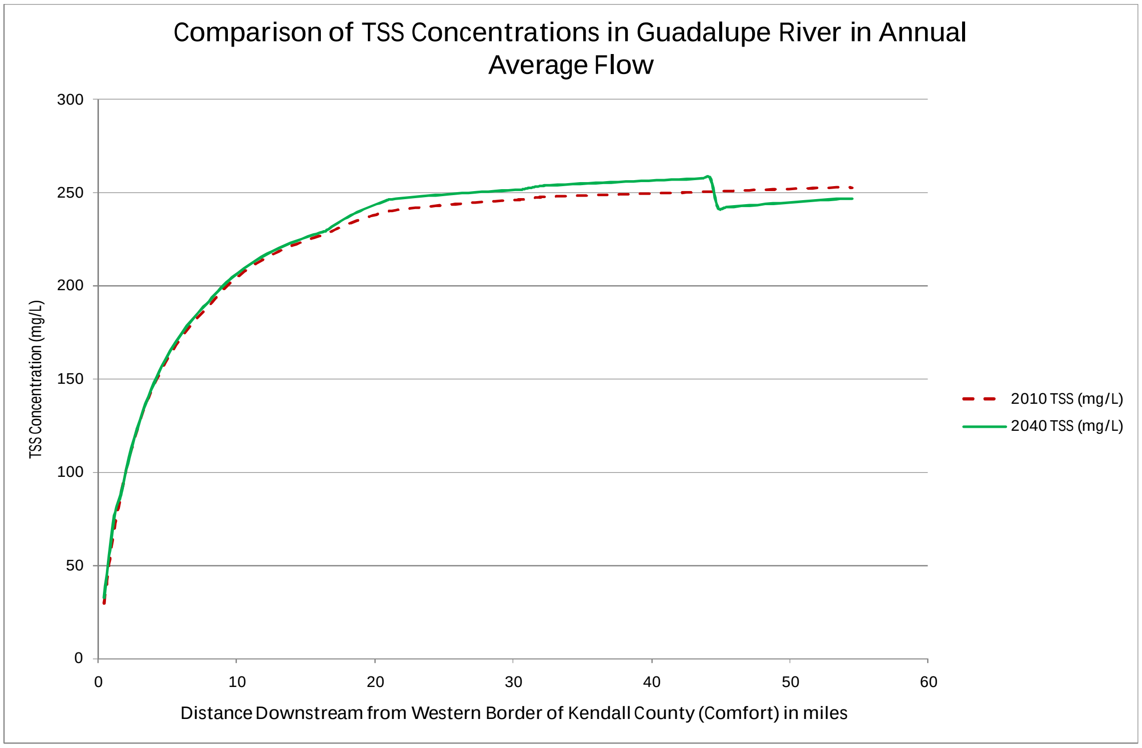


Figure 5.11 Comparison of TSS Concentrations in the Guadalupe River for 2010 and 2040



TSS concentrations show a slight increase in the 2040 model as compared to the 2010 model, until the assumed discharge from the Cordillera wastewater treatment plant provides sufficient flow to decrease the concentration in the river.

Figure 5.12 Comparison of Nitrogen Concentrations in the Guadalupe River for 2010 and 2040

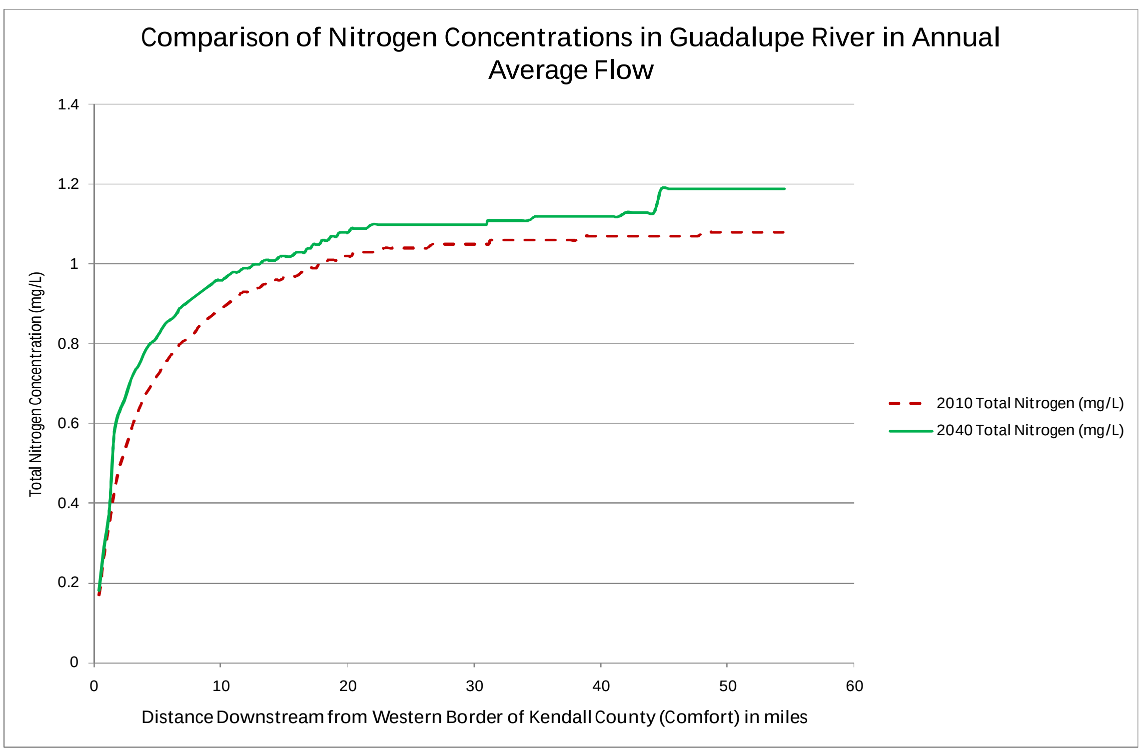
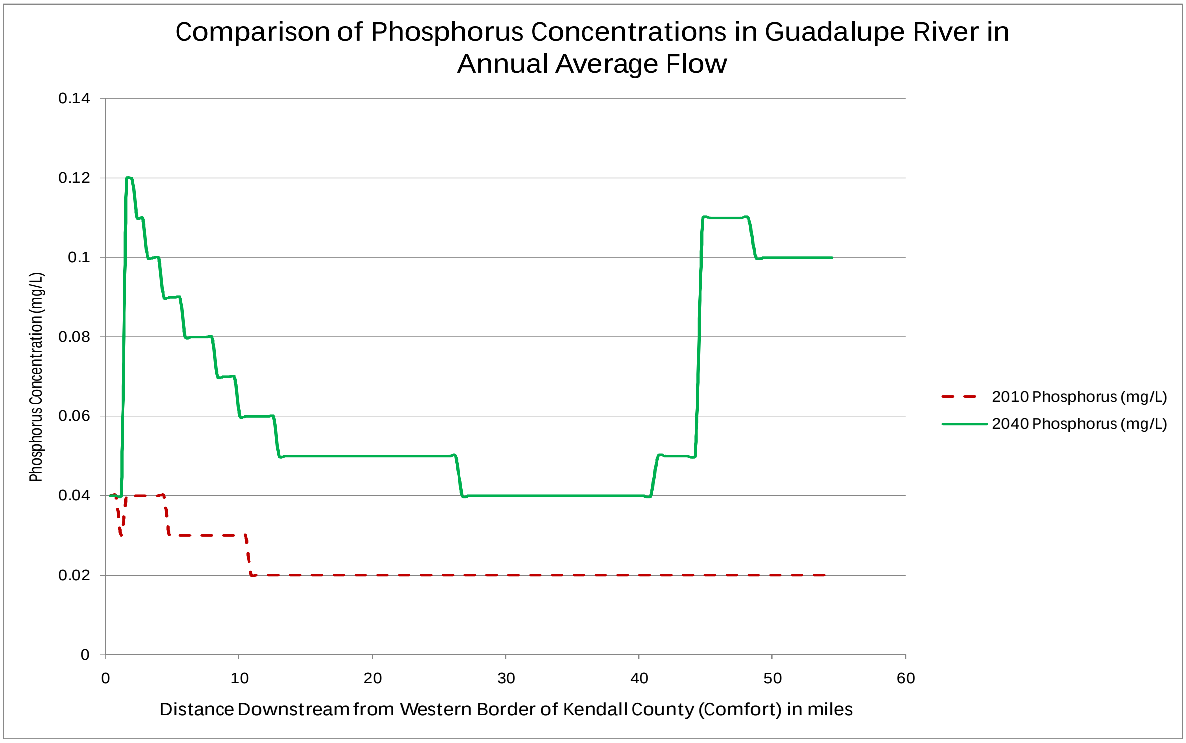


Figure 5.12 shows that the nitrogen concentrations in the 2040 model increase at the point of the Kendall County WCID #1 effluent discharge, and stay elevated throughout the length of the modeled river, increasing again at the discharge point of the Cordillera wastewater treatment plant.

Figure 5.13 Comparison of Phosphorus Concentrations in the Guadalupe River for 2010 and 2040



Phosphorus concentrations are mainly impacted by point source discharges, as is shown by the sharp increases at the wastewater treatment plant locations in *Figure 5.13*.

Figure 5.14 Comparison of Coliform Concentrations in the Guadalupe River for 2010 and 2040

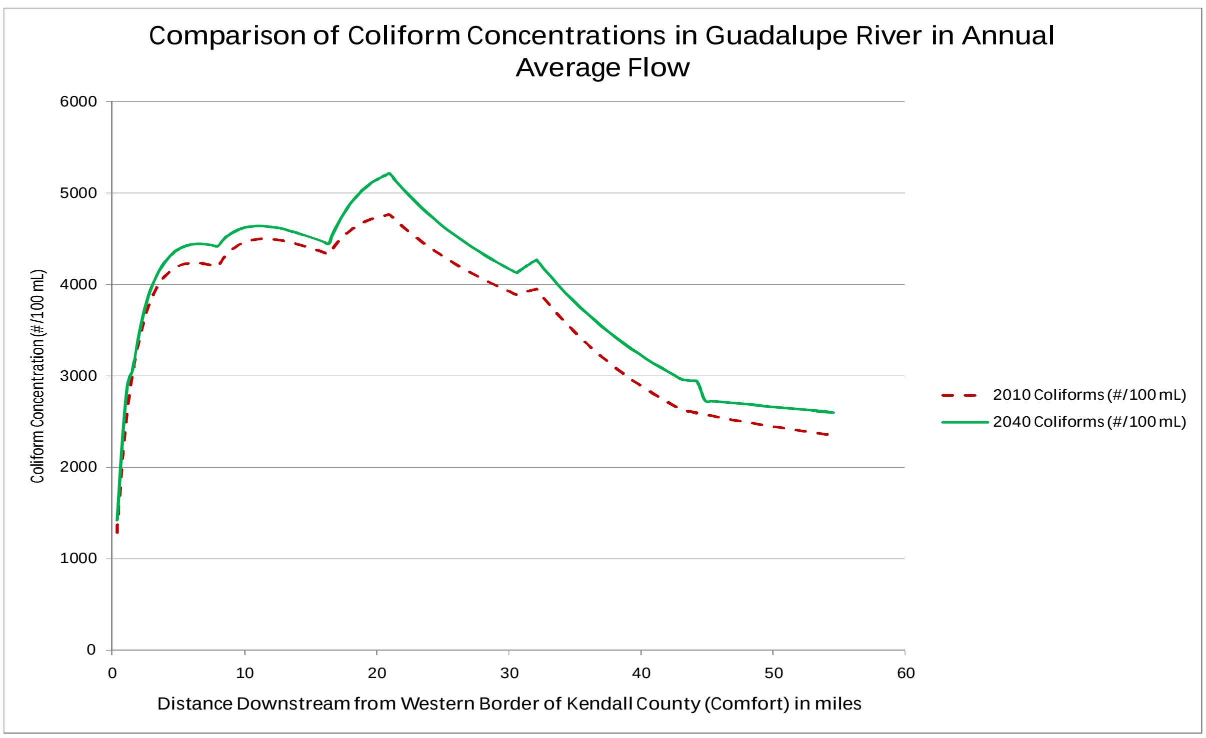


Figure 5.14 shows that concentrations of fecal coliforms increase as a result of growth and development.

5.4 Water Quality Options

The stakeholders and officials in the study area desire to maintain a high quality of water in the streams and water bodies in Kendall County. Non-point source pollutant loadings are identified as one of the key contributors of possible water pollution in Kendall County. For the Cibolo Creek watersheds, high fecal bacteria runoff will become an even greater concern if proper preventative measures are not implemented in the future.

The Guadalupe River provides a high quality recreational asset in Kendall County and for the entire region. The water quality modeling efforts conducted for this study demonstrate that maintaining a high standard of effluent discharge can maintain the quality of water in the river; however, the increased level of pollutants from increased growth and urbanization in this area must also be addressed.

Preventative measures and best management practices can be implemented to reduce non-point source pollution. Following is a list of measures and activities currently in place or that should be investigated:

- The Upper Cibolo Creek Watershed Partnership (UCCWP) was formed to take a proactive step in protecting and restoring water quality within Upper Cibolo Creek. The UCCWP is responsible for developing a non-regulatory Watershed Protection Plan to promote awareness and initiate action in reducing nonpoint source pollution within the watershed. (Source: http://www.ci.boerne.tx.us/index.aspx?nid=147)

- Best management practices (BMPs) to mitigate non-point source pollution.

    - Best management practices that are well documented as being efficient especially for sediment removal and to a great extent nutrient removal may not be as efficient at reducing the bacteria loading. Nutrient removal in both dry and wet ponds is accomplished by biological activity which "consumes" the nutrients. Bacterial activity can be a major component in this nutrient consumption. Unfortunately, recent studies have found that the *E. coli*, the indicator used to monitor for fecal contamination, may also be actively growing in these basins. This actually can mean that under the right conditions that the effluent from water quality basins may contain a higher concentration of *E. coli* than the influent. If stormwater quality basins are to be used efficiently, further studies may need to be performed to determine the structure of the basins necessary to achieve reduced bacteria loading as well as controlling the concentration of other contaminants. Monitoring of supplemental indicators of fecal contamination, such as Enterococcus, may also be considered to achieve a better understanding of the fecal load, the major contributors of fecal loads and to determine success of BMPs.

- Low impact and low density developments are helpful to reduce stormwater runoff pollution. Low density developments are prevalent in Guadalupe River watersheds. Low impact developments should be investigated and implemented in the Cibolo watershed for future developments.

- Training to individual homeowners in the County for maintenance of OSSF will enable proper maintenance of the systems and thus result in reduced accidental discharges. GBRA has the ability to provide eight hour training and has expressed interest to do so.

5.4.1 Phase II Municipal Separate Storm Sewer System (MS4)

No area of Kendall County or the City of Fair Oaks Ranch is currently covered as a regulated MS4. However, the population growth of San Antonio to the north up the I10 corridor presents the potential for areas along I10 to be designated based on the results of the 2010 census. Regulated MS4s are determined in several ways. The Phase II Rule requires nationwide coverage of all operators of small MS4s that are located within the boundaries of a Bureau of the Census-defined "urbanized area" (UA) based on the latest decennial Census. An UA is defined as

a land area comprising one or more places – central place(s) – and the adjacent densely settled surrounding area – urban fringe – that together have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile. It is a calculation used by the Bureau of the Census to determine the geographic boundaries of the most heavily developed and dense urban areas.

Additionally, the Phase II Rule requires the NPDES permitting authority (TCEQ) to develop a set of designation criteria and apply them, at a minimum, to all small MS4s located outside of a UA serving a jurisdiction with a population of at least 10,000 and a population density of at least 1,000 people/square mile. This case by case designation of a regulated MS4 has not been utilized in the past by TCEQ, but in the future, could be used to include areas which have stormwater discharges which may be contributing to a stream impairment.

The results of the 2010 Census are still unknown and information needed to determine UA status is not projected to be received by TCEQ until 2012. However, the impaired status of the Upper Cibolo Creek, the projected nonpoint source loading of bacteria, along with the ongoing City of Boerne sponsored Watershed Protection Plan development, could make the Upper Cibolo a prime candidate for CWA 319(h) nonpoint source pollution funding to proactively address the water quality.

6.0 Conclusions and Recommendations

GBRA and the Advisory Committee assembled for this study have provided invaluable knowledge and insight into Kendall County, the City of Fair Oaks Ranch, and all of the communities represented. Their participation and feedback, as well as their desire to address certain issues, have made this report a more complete picture of the water, wastewater, and water quality issues facing Kendall County than had they not been involved.

The planning objective of this study was to identify the water and wastewater facilities needed for future demands in Kendall County and the City of Fair Oaks Ranch through a thirty year planning period from 2010 to 2040 while protecting the surface water quality and groundwater supplies. The study also investigated potential regional management for water and wastewater facilities associated with development through this planning period. The major conclusions and recommendations listed in this section specifically address those objectives.

Population and Water Demand:

- Kendall County's population will grow from 35,720 in 2010 to 78,690 in 2040. Four geographic zones of similar characteristics were identified and used to distribute the anticipated County growth in accordance with the historical growth trends in each of the zones. There is sufficient available land area in each of the four zones to accommodate the projected population for each zone within Kendall County.

- Total water demands for Kendall County and all of the City of Fair Oaks Ranch are expected to reach approximately16,200 ac-ft/yr by 2040. These demands will need to be satisfied using existing supplies, reducing overall water use (conservation), or finding new supplies.

Water Supplies and Strategies:

- A final determination of the MAG volume for the Trinity Aquifer in Kendall County will provide a greater confidence in the available water supply quantity for that source, which will allow Kendall County and Cow Creek GCD to better plan ways to meet existing and future demands.

- A GMA 9 meeting was held on July 26, 2010 where a DFC statement was adopted for the Trinity Aquifer. The DFC statement for Trinity Aquifer allows for an increase in average drawdown of approximately 30 ft through 2060 consistent with "Scenario 6" in TWDB Draft GAM Task 10-005. This DFC statement was adopted after the shortage and water supply analysis option of this study was completed and the initial draft report was prepared. While a final availability for Trinity Aquifer in Kendall County is not certain until an official MAG number is adopted, the adopted DFC is associated with 11,450 ac-ft/yr of groundwater in Kendall County as per TWDB Draft GAM Task 10-005 Report.

- The foresight and willingness of the City of Fair Oaks Ranch and the City of Boerne to commit to participating in the Western Canyon Regional Treated Water Supply Project has ultimately enabled over 8,000 ac-ft/yr to be supplied to the Kendall County area and significantly reduced the demands on the Middle Trinity Aquifer. This source of surface water may have future quantities of water available for residents of Kendall County.

- Regardless of the predicted timing of future shortages for the Trinity aquifer within Kendall County, it is apparent that the growth of the County will eventually require additional water management strategies to be implemented.

- For this 2010 – 2040 planning period, the additional water needs for Kendall County and Fair Oaks Ranch are relatively small. At this time, these additional needs do not warrant selection of a major new water supply project or use of a single regional water treatment facility. Initial small water shortages identified within this study can potentially be addressed in most areas through implementation of demand-management measures such as enhanced conservation, increased drought management restrictions, and/or increased wastewater reuse for landscape irrigation, rainwater harvesting, and/or brush management practices. These types of demand management measures are almost always the most cost-effective method for meeting small shortages such as are predicted to occur during this planning period.

- Eventually during this thirty-year planning period or soon thereafter, increased importation of other supplies or increased use of interruptible supplies will likely be necessary. The cost of such new strategies will undoubtedly be more costly and will likely require the implementation fairly large projects to allow the unit price for water to remain reasonable for the future users of these supplies. As a consequence, these future water supply strategies could be somewhat complex and time-consuming to implement and could become an impediment to future growth in the County. For this reason, planning for additional water supplies will require careful consideration by water managers in this region and should not be delayed.

- There are many activities the Cow Creek GCD can instigate to better prepare for and understand these future shortages so that water users who rely on the Trinity Aquifer can plan appropriately. The science of recharge and movement of water within the Trinity aquifer within the Kendall County area can be substantially improved by better monitoring and analysis of existing geophysical well data, collection of more detailed well pumping data, and improvements to the groundwater availability modeling tools currently used by the TWDB. The GCD should encourage and support research investigations to improve the science in these areas in order to better equip the water planners and community leaders in dealing with this future water supply issue. Also, the GCD should actively encourage better and smarter use of all existing groundwater supplies in the County through adoption of demand management practices for both individuals and utility systems. This encouragement can be achieved by supporting, and in some cases leading, public education efforts and by adopting GCD policies that provide appropriate incentives for advancement of permanent water conservation measures and use of alternative supplies by utility systems in the County when possible.

- The IH-10 Corridor may be the best candidate for regionalization of future water supply systems in Kendall County followed by Central Kendall County. Opportunities for purchasing additional water from GBRA or looking to SAWS to serve areas along the southern border of Kendall County should be explored.

Wastewater Facilities:

- A single regional WWTP was determined not to be a viable approach for wastewater master planning in Kendall County based on anticipated collection system costs versus relatively low long-term population density, and anticipated O&M costs for pumping raw wastewater across multiple drainage basins.

- Use of packaged treatment plants is not recommended for providing long-term wastewater service due to the high recurring cost of replacing the packaged treatment units, but may be an appropriate near-term approach for currently-unserved developing areas that will be connected to a centralized or regional WWTP collection system within 15-20 years.

- The recommended development scenarios for wastewater master planning for Kendall County consist of multiple regional facilities.

- Further investigation of the potential for regionalization of wastewater treatment within Western Kendall County and Central Kendall County will require evaluation of the feasibility and economics of the treatment requirements for effluent discharge, which is likely to require compliance with stringent effluent limits for nutrient removal (5/5/2/1 or lower) versus the feasibility and economics of effluent disposal by land application at less stringent effluent quality limits, including land availability and costs, and construction and operation/maintenance costs of effluent storage ponds and irrigation systems.

- Further investigation of the potential for regionalization of wastewater treatment within the IH-10 Corridor will necessitate discussion with the City of Boerne to confirm the City's amenability to siting a regional facility at either the City's future WWTP site, as well as the City's plans for the existing WWTP.

- In addition to these three identified potential locations for regional facilities, satellite facilities should be considered for the purpose of producing reclaimed water in fast-growing areas with high potential for reuse demands (such as golf course communities) where the cost of returning reclaimed effluent from a regional facility would justify the cost of a separate treatment facility. Where a regional collection system exists, a "scalping" satellite WWTP may be constructed for the sole purpose of reclaimed water production, with no effluent discharged, and with the residual solids returned to the collection system.

- In consideration of anticipated development densities in much of rural Kendall County versus the density required to support the cost of centralized wastewater collection, and based upon the current development regulations for the County, many areas throughout the County will continue to develop at a low density and will use OSSF technology for treatment combined with effluent discharge via infiltration or irrigation disposal systems.

Water Quality:

- The stakeholders and officials in the study area desire to maintain a high quality of water in the streams and water bodies in Kendall County. Non-point source pollutant loadings are identified as one of the key contributors of possible water pollution in Kendall County. For the Cibolo Creek watersheds, high fecal coliform concentrations in runoff are expected to remain a concern if proper preventative measures are not implemented in the future.

- The Guadalupe River provides a high quality recreational asset in Kendall County and for the entire region. The water quality modeling efforts conducted for this study demonstrate that maintaining a high standard of effluent discharge can maintain the quality of water in the river; however, the increased level of pollutants from increased growth and urbanization in this area must also be addressed.

- Best management practices (BMPs) should be considered to mitigate non-point source pollution. It should be noted that best management practices that are well documented as being efficient especially for sediment removal and to a great extent nutrient removal may not be as efficient at reducing the bacteria loading.

- Low impact and low density developments are helpful to reduce stormwater runoff pollution. Low density developments are prevalent in Guadalupe River watersheds. Low impact developments should be investigated and implemented in the Cibolo watershed for future developments.
- Training to individual homeowners in the County for maintenance of OSSFs will enable proper maintenance of the systems and thus result in reduced accidental discharges. GBRA has the ability to provide eight hour training and has expressed interest to do so.

7.0 References

1. City of Boerne, Texas. February 2009. *Cibolo Creek Water Quality Monitoring and Modeling*. Prepared by HDR.

2. City of Boerne, Texas. September 2006. *Boerne Master Plan Update*.

3. City of Fair Oaks Ranch. Subdivision Ordinance. Provided by the City of Fair Oaks Ranch via mail dated January 11 2010.

4. Chapra, S., Pelletier, G., & Tao H. December 2008. *QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality* (Version 2.11).

5. Cow Creek Groundwater Conservation District. December 2009. *Groundwater Management Plan*.

6. Guadalupe Blanco River Authority (GBRA). August 2009. *Caldwell County Regional Water and Wastewater Planning Study.* Prepared by Klotz Associates.

7. Guadalupe Blanco River Authority (GBRA). November 2000. *Predicting Effects of Urban Development in the Cities of New Braunfels, San Marcos, Seguin and Victoria*. Prepared in cooperation with GBRA and TNRCC by PBS&J.

8. Guadalupe Blanco River Authority (GBRA). September 1976. *Comfort, Texas, Kendall County WCID No.1 Water and Wastewater Systems*.

9. Kendall County, Texas. May 2007. Thoroughfare Planning Citizens Committee Report.

10. Texas Water Development Board. September 1967. Groundwater Resources of Kendall County, Texas. Report 60.

11. Texas Water Development Board. Hutchison, W. May 2010. *Draft GAM Task 10-005.*

12. City of Boerne Demographics: http://www.ci.boerne.tx.us/planning/Demographics/tabid/509/Default.aspx

13. City of Boerne Ordinances: http://library7.municode.com/default-test/home.htm?infobase=12228&doc_action=whatsnew

14. City of Boerne Rules and Regulations: http://www.ci.boerne.tx.us/planning/PublicDocumentLibrary/tabid/507/Default.aspx

15. City of Boerne website: http://www.ci.boerne.tx.us/

16. City of Fair Oaks Ranch website http://www.fairoaksranchtx.org/

17. Kendall County Permit Applications: http://thecrossingatkenberg.org/sitebuildercontent/sitebuilderfiles/kendall_co._permit_applications.pdf

18. Kendall County Website: http://www.co.kendall.tx.us/

19. Texas State Data Center
http://txsdc.utsa.edu/

20. U.S. Census Bureau
http://www.census.gov/

21. Western Canyon Water Supply Project website:
http://www.gbra.org/Projects/WesternCanyon.aspx

22. Wikipedia:
http://en.wikipedia.org/wiki/Kendall_County,_Texas

Appendix A

Exhibits

List of Exhibits

Appendix B

Baseline Information, Water Utility Survey and Responses

Appendix C

Advisory Group and Meeting Information

Appendix D

Slides from Presentations

Appendix E

Rainfall Data

Appendix F

Comments and Responses