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Document No. 020250
PBS&J Job No. 440951

CANYON RESERVOIR WATER QUALITY AND REGIONAL WASTEWATER PLANNING STUDY REPORT COMAL COUNTY, TEXAS

Prepared for:

GBRA
933 East Court Street
Seguin, Texas 78155

and

Comal County
150 N. Seguin, Suite 301
New Braunfels, Texas 78130

Prepared by:

PBS&J
206 Wild Basin Road
Suite 300
Austin, Texas 78746-3343

February 2003

Printed on recycled paper

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EXECUTIVE SUMMARY

During the 1990s rapid population growth occurred in the immediate watershed of Canyon Lake in Comal County. This Canyon Lake Regional Facility Planning Project was performed to assess the need for infrastructure to protect the quality of Canyon Lake waters. It addresses the need for central wastewater collection and treatment facilities, and also the need for controls of stormwater runoff in an urbanizing area. The study involved close coordination with a technical steering committee selected to represent a broad cross-section of study area residents and interests. The purpose of the steering committee was to guide the study on a range of future growth scenarios, planning objectives, and measures.

This planning study was performed in coordination with the Guadalupe-Blanco River Authority (GBRA) and Comal County, the Texas Water Development Board (TWDB), and PBS&J. The TWDB provided grant funding for this project through the Research and Planning Fund.

Development scenarios were quantified using various methods including estimates of loading from each type of wastewater system and the loads from runoff of rainwater in the watershed. The loadings from each scenario were related to reservoir water quality using simple models of reservoir system water quality. A specific aspect addressed in this task is the relative performance of regional wastewater collection and treatment versus on-site treatment in protecting groundwater resources.

The study team with steering committee input created a preferred regional water quality protection plan, including a facility plan to encourage centralization of wastewater treatment for new development, giving consideration to structural and non-structural alternatives. A set of water quality protection alternatives was developed considering the water quality effects addressed above and the fiscal implications of the alternatives. Specific watershed management practices were recommended that can be implemented by local government and the GBRA.

At the end of the study a disagreement arose within the steering committee over the desirability of including provision for central wastewater systems in the study recommendations. The basic issues were concerns that wastewater collection systems can leak and pollute the Trinity aquifer, and that they might encourage growth in the area. Attempts were made to find common ground and measures to reduce the potential for leakage to a level less than allowed for the Edwards Aquifer Recharge Zone are discussed in the final recommendations. However, it was not possible to reach a consensus within the steering committee on this point. The positions taken and attempts to reach accommodation with the minority view are reflected in Attachment D.

1.0 INTRODUCTION

During the 1990s rapid population growth occurred in the immediate watershed of Canyon Lake in Comal County. This Canyon Lake Regional Facility Planning Project was performed to assess the need for infrastructure to protect the quality of Canyon Lake waters. It addresses the need for central wastewater collection and treatment facilities, and also the need for controls of stormwater runoff in an urbanizing area. The study involved close coordination with a technical steering committee selected to represent a broad cross-section of study area residents and interests. The key objective of the steering committee was to guide the study on a range of future growth scenarios, planning objectives, and measures.

This report presents the process and results of the study. Section 2 is a description of the study area and the various regulatory programs that currently affect how development takes place. Section 3 describes the process of working with the steering committee to develop a common understanding of assumptions, goals and development scenarios to be evaluated. Section 4 describes the elements of a proposed water quality protection plan, while Section 5 quantifies the effects of the plan in terms of the loads of nutrients and sediment to Canyon Lake. Section 6 summarizes the study recommendations.

The purpose of this Canyon Lake Study is source water protection. Parallel to this study is an economic study of Canyon Lake, which is analyzing water quantity and the use of the reservoir for recreation and water supply. Another effort being conducted is an analysis of the environmental effects of changing the reservoir operating rules.

This planning study was performed in coordination with the GBRA and Comal County, the TWDB, and PBS&J. The TWDB provided grant funding for this project through the Research and Planning Fund.

2.0 STUDY AREA CHARACTERISTICS

Canyon Lake is an 8,230 surface acre reservoir located on the Guadalupe River, 18 miles east of the Comal County seat of New Braunfels, and 44 miles north of San Antonio, Texas (see Figure 2-1). The multipurpose reservoir is designed to serve flood control and water supply functions. It is also used for recreation and natural resources management functions. Built in the mid-1960s, Canyon Lake has over 80 miles of shoreline, seven public parks, two military recreation areas and two marinas. The watershed is part of the Edwards Plateau, with limestone soils and karst features. The bulk of development within the watershed is single family residential with individual water supplies and on-site sewage disposal. Details of the topographic, soil and vegetation for the area are provided on a project GIS library provided to the TWDB on two CDs.

Existing development includes residences and businesses serving the predominantly seasonal population in this resort area. Businesses surrounding the lake provide RV and campsites, hotels, boat and tube rentals, and a variety of food, gifts and clothing stores. Canyon Lake provides an assortment of game fish, including Black, White, and Guadalupe Bass, Stripers, Catfish and Crappie.

Canyon Lake is designated as Texas Commission on Environmental Quality (TCEQ), formerly the Texas Natural Resource Conservation Commission (TNRCC), stream segment 1805. This segment has designated uses of contact recreation, exceptional aquatic life, and domestic water supply with public supply and aquifer protection designations. The next downstream segment is 1812, Guadalupe River Below Canyon Dam, located near Sattler, Texas. The segment just upstream of the lake is 1806, Guadalupe River Above Canyon Lake. Segments 1806 and 1812 have the same designated uses as the Canyon Lake segment 1805, except that aquifer protection does not apply to segment 1806.

There are two existing wastewater discharges to Canyon Lake – The Canyon Park Estates Wastewater Treatment Plant (WWTP) and the U.S. Department of the Army Canyon Lake Recreational Area WWTP. The Canyon Park Estates Plant serves a small area that is limited to residences located along Parkview Drive, on the north side of the lake. The service area is shown in Figure 2-2. This tertiary treatment plant operates under high quality effluent standards and has total phosphorus limitations. The plant is permitted for 100,000 gallons per day. During summer months, the plant can be near capacity on the weekends because of the seasonal visitors, but otherwise it averages at 60% capacity. The Department of the Army WWTP serves a small recreational area at the lake (see Figure 2-2). The WWTP is permitted for 12,500 gallons per day, but averages 8,000, or about 65% of capacity.

2.1 WATER QUALITY CONDITIONS

Canyon reservoir is monomictic (stratifying in the summer and having one turnover per year), very stable and, because of its size and shape, has classic and predictable conditions (Groeger, 2001). The reservoir can be divided into three zones, moving down-reservoir toward the dam:

Riverine zone	-	no stratification, flow dominated and turbid
Transitional zone	-	where the river interacts with the lake, and
Lacustrine zone	-	clear and deep

The average residence time for water entering the reservoir is 1.5 years. This residence time depends on the flow and varies greatly from very dry years to very wet years.

Normally, Canyon Lake has low nutrient concentrations, low chlorophyll-*a* concentrations (typically only 2 to 3 ug/L) and high water clarity (Groeger, 2001). The excellent water quality conditions can be attributed to low population densities upstream of the reservoir. Additionally, calcium-rich soils in the watershed tend to bind with nutrients, making them unavailable for aquatic plant growth. Studies by Southwest Texas State University have shown that phosphorus tends to limit plant growth in wet years, and nitrogen and metals such as iron tend to be limiting in dry years (Groeger, 2001).

Table 2-1 shows a summary of two blocks of Canyon Lake water quality data. The more recent data were obtained from the TCEQ's Water Quality Database. The data from the period 1981–1992 were obtained from an earlier compilation by GBRA performed for the Texas Clean Rivers Program. Parameters shown include: Total Nitrogen, Total Kjeldahl Nitrogen, Total Phosphorus, Chlorophyll-*a*, Secchi Depth, and Total Suspended Solids.

Two points are apparent from this table. The first is that the measures of eutrophication such as chlorophyll *a* and water clarity as measured with Secchi depth tend to be quite good. From either data set there would be no indication of eutrophic conditions in the lake as a whole. The second is that based on these two decades of data, there does not appear to be a decline in water quality. If anything, the data from the 1990s are somewhat better than those from the 1980s, although the difference does not appear to be significant.

Based on there being no indication of a present water quality problem or a negative trend in the lake, and on the absence of strong indications of problems with the existing septic systems around the lake, the project did not invest major resources in looking at providing wastewater service for existing development. Instead, the project focused on preventing future water quality impacts to Canyon Lake.

2.2 POPULATION

Census data from 1990 and 2000 are designated as the Canyon Lake Census Designated Place (CDP) shown in Figure 2-3. The population for this designated area increased 69% from 1990 to 2000.

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TABLE 2-1

CANYON LAKE WATER QUALITY DATA

	January 1993 to January 2002						November 1981 to December 1992					
	TN (µg/L)	TKN (µg/L)	TP (µg/L)	Chl *a* (µg/L)	Secchi Depth (m)	TSS (mg/L)	TN (µg/L)	TKN (µg/L)	TP (µg/L)	Chl *a* (µg/L)	Secchi Depth (m)	TSS (mg/L)
Number of data	3	22	134	89	46	134	2	12	103	32	5	33
Mean	263	244	50	2.0	2.3	4.1	220	296	53	3.4	2.3	5.7
Standard deviation	119	96	47	1.9	1.3	2.5	7	171	135	3.1	1.1	7.0

[1] Storet code of parameters:

00625 TKN

00665 TP

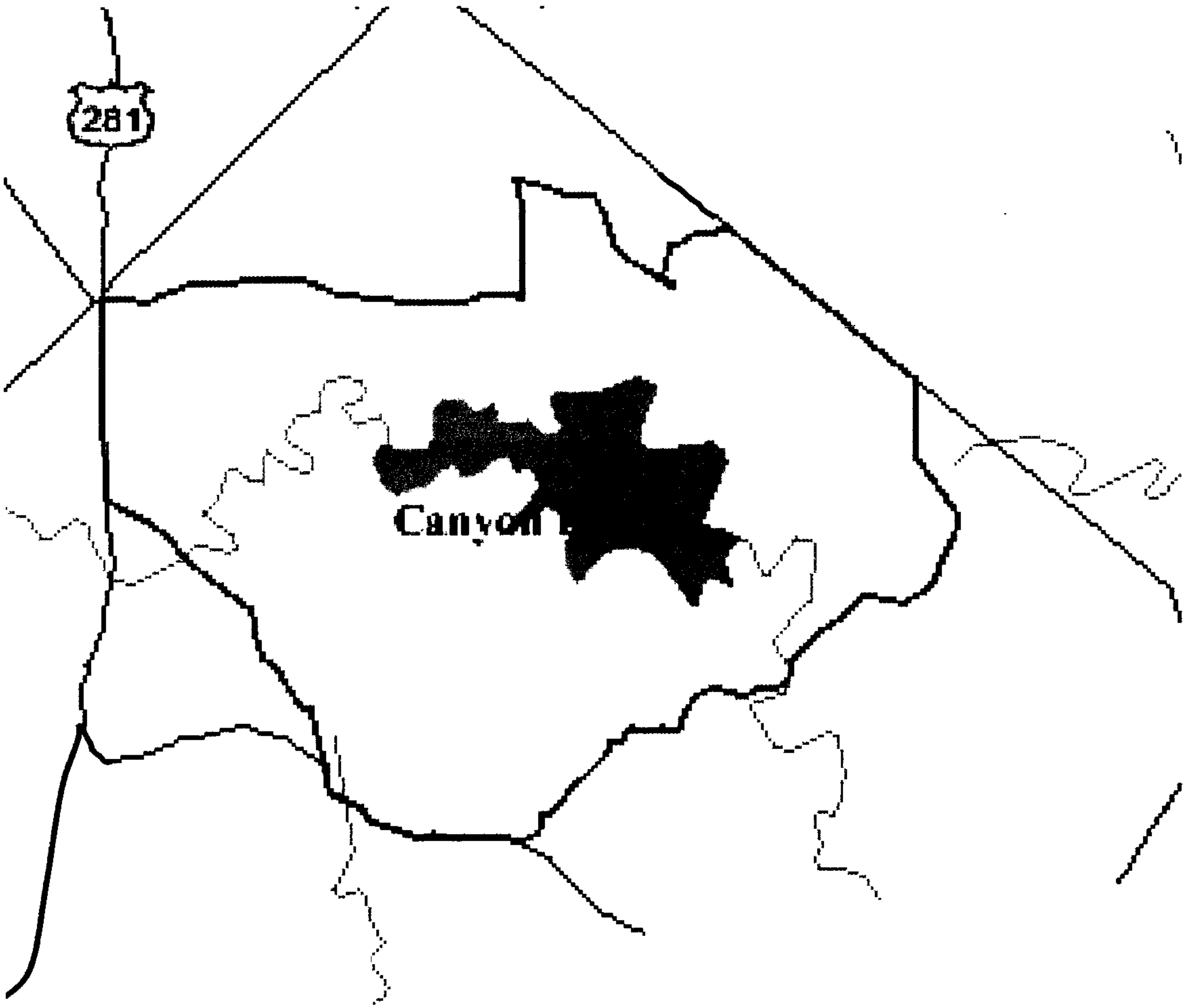
32211 Chl *a*

00078 Secchi depth

00530 TSS

[2] TN is calculated as the sum of TKN (00625), nitrite nitrogen (00615) and nitrate nitrogen (00620), or the sum of TKN (00625) and nitrite-nitrate nitrogen (00630).

Figure 2-3
Canyon Lake Census Designated Place
(boundary designated in purple)



Canyon Lake Census Designated Place

	1990	2000
Total Population	9,975	16,870
Households:		
Occupied	4,201	6,906
Vacant	2,028	1,787

In order to determine the impacts of development and growth in the drainage area surrounding Canyon Reservoir, the drainage area has been divided into 11 subwatersheds shown in Figure 2-4. Each subwatershed has an immediate influence on a portion or arm of the reservoir. The subwatershed analysis allows a comparison to be made of the relative impacts to the different arms of Canyon Reservoir.

2.3 EXISTING DEVELOPMENT REGULATIONS

The study area includes jurisdictions of TCEQ, Comal County, and the City of Bulverde. TCEQ has jurisdiction over water quality, water, and wastewater improvements. Comal County has jurisdiction over subdivision development and on-site sewage facilities (OSSFs). The extra-territorial jurisdiction of the City of Bulverde encroaches into a small portion of the study area. In this area only, the City of Bulverde has jurisdiction over subdivision development and water and wastewater improvements.

2.3.1 TCEQ

The Texas Commission on Environmental Quality (TCEQ), formerly TNRCC, is the State's primary agency overseeing the environment, with the goals of clean air and water, and the safe management of waste. TCEQ regulates discharges to surface waters through the discharge permitting process. The basic premise that drives the discharge permitting process is one of non-degradation. TCEQ must not issue any permit or allow any activity that degrades the water quality or designated use of the receiving stream. The majority of the waters of the state are divided into stream segments and TCEQ has developed stream standards, uses, and aquatic life use sub-categories for each segment. They evaluate the impact a discharge permit has or may have on these criteria before issuing the permit. The process includes an evaluation of the loading the discharge would have on the receiving stream.

Chapter 213 of the Texas Water Code regulates activities in the Edwards Aquifer region. Canyon Reservoir and the surrounding area lie over the Edwards Aquifer contributing zone. The activities that are regulated include construction, clearing and excavation, and building of roads, highways and railroads that disturb areas greater than five acres in size. Developments within the contributing zone that exceed 20% impervious cover are required to construct water quality controls to remove 80% of the increased total suspended solids (TSS) load caused by development. Developments that do not exceed 20% impervious cover are not required to install water quality controls. Wastewater collection lines and septic tanks in the contributing zone are not restricted by the regulations.

Chapter 285 of TCEQ regulations calls for review and permitting of OSSFs for construction and inspection during construction. These regulations are implemented and enforced by the Comal County Engineers Office.

EPA delegated the National Pollutant Discharge Elimination System (NPDES) program to TCEQ on September 14, 1998. The Texas (TPDES) program now has regulatory authority over the program, with the exception of discharges associated with oil, gas, and geothermal exploration and development activities, which are regulated by the Railroad Commission of Texas.

There are two types of TPDES permits involved. One is a TPDES permit required for industrial and municipal wastewater discharges. These permits contain limits for discharge flow, monitoring and reporting requirements, and other provisions to ensure that a wastewater discharge does not degrade water quality or impact human health. These permits are essentially a combination of the state wastewater permits and the federal NPDES permits.

The other type of permit involves stormwater runoff. In 1992 EPA started a permit program to regulate Municipal Separate Storm Sewers (MS4) from larger cities, and also industrial and construction activity. Phase II of the delegated program will extend to smaller communities, defined as urban areas serving a jurisdiction with 10,000 people or more, with an average density of 1,000 or more people per square mile. This definition includes New Braunfels. Developing Phase II requirements has not yet started for New Braunfels, and it is not clear that they would extend into the study area around Canyon. The rules will also apply to areas designated by TCEQ that substantially contribute pollutants to a physically interconnected regulated MS4. Specific regulations for the program are currently under development at the TCEQ. At this point it is clear that at least in the New Braunfels area the program will require six elements to be addressed that are part of the EPA and TCEQ Phase II program regulations:

- Public education and outreach on storm water quality issues
- Public involvement and participation
- Illicit discharge detection and elimination
- Construction site storm water runoff control
- Post-construction storm water management in areas of new development and redevelopment
- Pollution prevention and good housekeeping measure for municipal operations

The recommendations of this report address many of these six points.

2.3.2 Comal County

Comal County has regulatory authority over land development in the study area. The authority is limited to the subdivision of property. The procedure to receive an approved subdivision includes the submittal and approval of a preliminary plat, with accompanying construction drawings, and a final plat. Included in these requirements are criteria for providing schematic plans for roadway, drainage, water and wastewater improvements.

Comal County is authorized by TCEQ to enforce regulations governing OSSFs. For the most part the county has adopted the state OSSF rules. The county regulates OSSFs smaller than 5,000 gallons per day. Larger systems are regulated by the TCEQ. The following is a listing of the County's minimum lot sizes for the various water supply and wastewater treatment scenarios:

Water and Wastewater Source	Minimum Lot Size (Acres)
TCEQ Approved Public Water and Wastewater	No Minimum
TCEQ Approved Public Water and OSSF	1.0
Individual Water and OSSF	5.01

There are four types of OSSFs currently used in Comal County: the conventional system, the low pressure dosing system, the aerobic system and the evapotranspiration bed system. The requirements for the drain fields and their construction vary according to type.

For all types a License to Operate is issued once all inspections are finalized by the county. For conventional septic tank and drain field systems there is no monitoring program. For aerobic systems that discharge treated water to irrigation, regulations require quarterly inspection and reporting of status to the county. The county reserves the right to inspect at any time. Typically the only time they will inspect is if there is a complaint, or there is a known land use change. Counties can either adopt the TCEQ regulation verbatim, or designate more strict regulations for their area.

Some, not all, bank lenders require inspections of OSSFs during the home buying process. Since, not all lenders have this requirement, OSSF inspections are inconsistently applied.

Comal County has adopted new stormwater and water availability requirements for new developments. In order to develop property in the county, the developer must provide documentation that assures the lots have an available water supply, either from groundwater (testing to show a 30-year supply) or surface water (necessary permits have been obtained). The developer must also provide a property plan that:

1) shows the present 100-year flood inundation contour,

2) provides setbacks to prevent flooding of structures in the floodplain, and

3) provides for stormwater detention of the 100-year flood that protects downstream developments from adverse impacts. To do this a professional engineer must certify that the 100-year peak flow rate downstream of the development must not exceed pre-development runoff conditions.

Attachment C presents the applicable Comal County land development regulations.

2.3.3 City of Bulverde

The 2001 State Legislature mandated that municipalities and counties must have an agreement on development regulation for property located in both jurisdictions. One set of rules and one point of contact is required. Comal County and the City of Bulverde have an agreement in place. Comal County has waived their reviewing authority and development regulations, with exceptions, for development within the ETJ of the City of Bulverde. The City of Bulverde will review and approve development within their ETJ based upon the City's development regulations and the County's exceptions.

The City's procedure for subdivision includes the submittal and approval of a preliminary plat, with accompanying construction drawings, and a final plat. Included in these requirements are criteria for providing plans for roadway, drainage, water and wastewater improvements. Detention shall be provided for the 5-, 10-, 25-, and 100-year storm event. The City has water availability requirements similar to Comal County requirements.

Low density development may utilize OSSF and private wells. Medium density development may utilize OSSF, but water must be provided by a central water system. High density development must utilize a central sewerage collection system and treatment works.

Low density is considered to be less than 0.17 equivalent dwelling units (EDU) per acre. Medium density is considered to be 0.17 EDUs per acre to 0.4 EDUs per acre. High density is considered to be greater than 0.4 EDUs per acre.

All OSSFs must be designed in accordance with Comal County and TCEQ requirements. OSSFs shall be permitted and inspected by Comal County.

2.3.4 U.S. Army Corps of Engineers

The U.S. Corps of Engineers (USACE) has only one development regulation that affects Canyon Lake. The state requires a 75-foot buffer between an OSSF and a body of water, but this requirement is superceded in the area surrounding Canyon Reservoir by the USACE requirement for no OSSF within the 948 mean sea level (msl) elevation.

Most of these regulations are relatively new and their long-term effects are unknown. This study estimates the impacts of these new regulations.

3.0 CONCEPTUAL DEVELOPMENT SCENARIOS

This section of the report describes the process of working with the project steering committee to obtain a measure of consensus on development goals and a vision for the future of the immediate watershed. It also includes a review of population data and projections for the area.

3.1 SETTING PROJECT GOALS

The steering committee included interest groups, land developers, political subdivisions, and water supply customers. Communication was maintained through regular meetings during the course of the study so that the committee was prepared to provide key input on all tasks. It was discussed and generally recognized that future growth rates would depend on many unknowns such as growth and economic conditions in the region that would generate sufficient prosperity for new home construction. The focus of the study was not on predicting or managing growth with incentives or disincentives, either monetary or regulatory, but rather on accommodating the effects of anticipated growth while minimizing effects on water quality.

Early on consensus was reached on the following project assumptions:

- growth is likely to continue to occur rapidly in the area,
- while the reservoir will age, growth should not accelerate the aging process of the reservoir significantly, and
- different arms of the reservoir may have different needs.

Next, the following set of development goals for the Canyon Lake area was established by the steering committee as a guide:

- keep nutrient load increases to less than a target level, i.e., 10%, for a selected period of time
- require new development greater than a target size, i.e., 10 acres, to demonstrate "no net effect" in loading of nutrients and solids to the reservoir
- limit the use of on-site systems to "larger lots"
- maximize the beneficial reuse of wastewater
- minimize water demands of new development

Note that all of these statements are general. No attempt was made to define details such as a specific numerical goal of the level of nutrients in the lake or the minimum lot size for OSSFs. Rather, the goals were to build a recognition that some increase in nutrients was an inevitable consequence of the reservoir's aging process and that there would be no attempt to limit this by halting growth. Instead, the focus was on means that act to minimize the effects of growth. The goals also incorporated other important dimensions such as water conservation.

3.2 DEVELOPMENT PATHS

For planning purposes two broad visions or paths for the future were defined:

Path A - Continuation of the present path, with most developments using OSSFs, and establishing controls to minimize stormwater runoff volume such as overall impervious cover limits (i.e., 20%), and stormwater detention structures to control flooding impacts.

Path B - Regional Plan to encourage central wastewater systems for smaller lots with beneficial reuse of treated wastewater. New development would be encouraged to minimize the increase in runoff by building with minimal impervious cover and incorporating Low Impact Development features such as rainwater harvesting.

3.3 POPULATION PROJECTIONS

With either development path, it was accepted that population would grow. One of the first steps in determining the effects of future growth is to determine the expected growth and patterns for the study area. There are many available data sources for population projections, with rates varying depending on the data source and intended use of the projection.

For example, Comal County ISD hired a demographer to help determine projected student enrollment through school year 2004/2005. The demographic analysis predicted a steady growth rate of 4% for elementary grades. This growth rate is expected based on recent enrollment rates and the subdivision plats. Canyon Lake includes two elementary schools - Cranes Mill and Mountain Valley. Mountain Valley (south shore) is expected to grow slightly slower than Cranes Mill (north shore).

The Texas State Data Center (TxSDC) uses the 2000 census data as the basis of growth projections. This method uses mortality, fertility, and migration, in combination with other factors to create three growth scenarios. The growth scenarios factor different migration rates, based on previous census results for that area.

The TWDB developed its own projections for the State Water Plan and the Regional Water Plans, based on the 1997 consensus-based water plan. The methodology is similar to the Texas State Data Center projection methodology.

The steering committee agreed that the TxSDC seemed the most accurate data available. The school district projections do not account for the number of retirees or households without children, which is potentially a high number in this recreational area.

Three projection scenarios are calculated from the TxSDC. These projections include a scenario of no growth from migration to the area, 50% of the actual migration rate that occurred between 1990 and 2000, and 100% of the actual migration rate that occurred between 1990 and 2000. The population data for this study was projected in 10-year increments to 2040 using the high migration scenario. This migration scenario assumes the same migration rate measured from the 1990 to the 2000 census.

As described earlier, the census population data for the area was designated in the Canyon Lake CDP. This area is a different size and shape than the subwatersheds, as census data does not abide by hydrologic boundaries. Because census data were reported for the entire CDP, with no further distinction geographically, refinement and analysis was necessary. Population was determined for each subwatershed based on the Guadalupe Valley Telephone Cooperative (GVTC) customer database. Since the GVTC database consists only of households with phone service, some assumptions had to be made. First, the 2000 Census data show 68% of the homes in the area are seasonally used, not permanent residences. The assumption was made that one-half of those homes have phone service. Thus, the population was adjusted to remove the seasonal customers from the permanent resident population estimates.

The GVTC database was also used to estimate the number of OSSFs per subwatershed, as shown in Table 3-1.

TABLE 3-1

CANYON LAKE POPULATION AND OSSF ESTIMATES

Sub Watershed	Area (acres)	% Study Area	Residences	Present Population	Impervious Cover (acres)	Impervious Cover (%)	Estimated On-Site Systems
1	10,570	11	553	1,350	271.4	2.6%	741
2	8,365	9	277	675	135.7	1.6%	371
3	7,490	8	293	472	107.2	1.4%	393
4	10,540	11	1129	1,818	413.2	3.9%	1,513
5	2,955	3	230	370	84.2	2.8%	308
6	1,661	2	158	254	57.8	3.5%	212
7	6,098	7	1551	2,498	567.7	9.3%	2,078
8	8,553	9	1740	2,802	636.8	7.4%	2,332
9	5,203	6	538	866	196.9	3.8%	721
10	27,334	30	553	1,350	271.4	1.0%	741
11	3,581	4	1066	1,717	390.2	10.9%	1,428
Total	92,352	100	8088	14,173	3,132.4	3.4%	10,838

Present Population estimates based on 2000 census block group data for Canyon Lake CDP: 16,870. Assume 20% of census block group population is outside of study area, leaving population at 14,173. Population per subwatershed based on the GVTC customer database.

4.0 ELEMENTS OF PROPOSED WATER QUALITY PROTECTION PLAN

The Steering Committee established the goals for the study to help protect water quality from the effects of development in the watershed. The major threats to water quality considered were from wastewater and stormwater runoff that are consequences of development.

There are two basic approaches to controlling the effects of development. One is to restrict growth and development directly and the other is to accommodate the growth but manage the effects. Restricting growth could be accomplished by buying the property and putting it in public ownership or by establishing development regulations that would be extremely difficult to meet. While these approaches exist, they were never seriously considered. Instead, it was accepted that population would increase and efforts focused on means to manage the effects of development.

The specific parameters of greatest interest in protecting Canyon Lake water quality were identified to be the nutrients, nitrogen and phosphorus, because Canyon Lake now has very high quality waters and it is desired to maintain this quality to the extent possible. Another parameter considered is solids, simply because of their effect on reducing reservoir capacity.

While the primary focus of the study is on protecting the quality of Canyon Lake waters from wastewater and stormwater effects of development, the Steering Committee recognized the importance of both conserving the water itself and protecting groundwater. Accordingly, the overall objectives of the plan includes elements of water conservation and groundwater protection.

4.1 WASTEWATER

Almost all of the existing residences within the study area are served by OSSFs operated and maintained by individual homeowners. The County currently has policies related to the design, construction, and maintenance of OSSFs. While an OSSF can be operated and maintained by a responsible homeowner and perform well, some difficulties can be expected as systems age. Currently, many of the facilities in the immediate watershed are approaching 30 years of operation. While no quantitative information is available on the frequency of failures in the area, it is reasonable to expect an increase in problems with time.

In addition to the effects of age and maintenance for existing OSSFs that will only increase, continued reliance on OSSFs for wastewater imposes limitations on development patterns and land use. Use of OSSFs mandates larger lot developments and cuts off the option of more compact developments with smaller lot sizes. It also limits the extent to which treated wastewater can be used beneficially.

Regional WWTP can be planned to serve new development and selected subdivisions can also be retrofitted from OSSFs to organized wastewater collection. The advantages offered by central wastewater facilities include: avoiding OSSF concerns for both surface and groundwater, and providing an opportunity for beneficial use of the treated wastewater. A concern historically has been that WWTPs built to serve specific developments may over time not receive the quality of operation and maintenance that would be desired. To address this, the Steering Committee endorsed the view that a public entity may ensure the proper treatment of wastewater more effectively.

4.1.1 New WWTPs

In order to implement planning of new WWTPs, the needs and characteristics of local development must be considered. Several conditions will affect the feasibility of constructing WWTPs including development density, market conditions and permit timing.

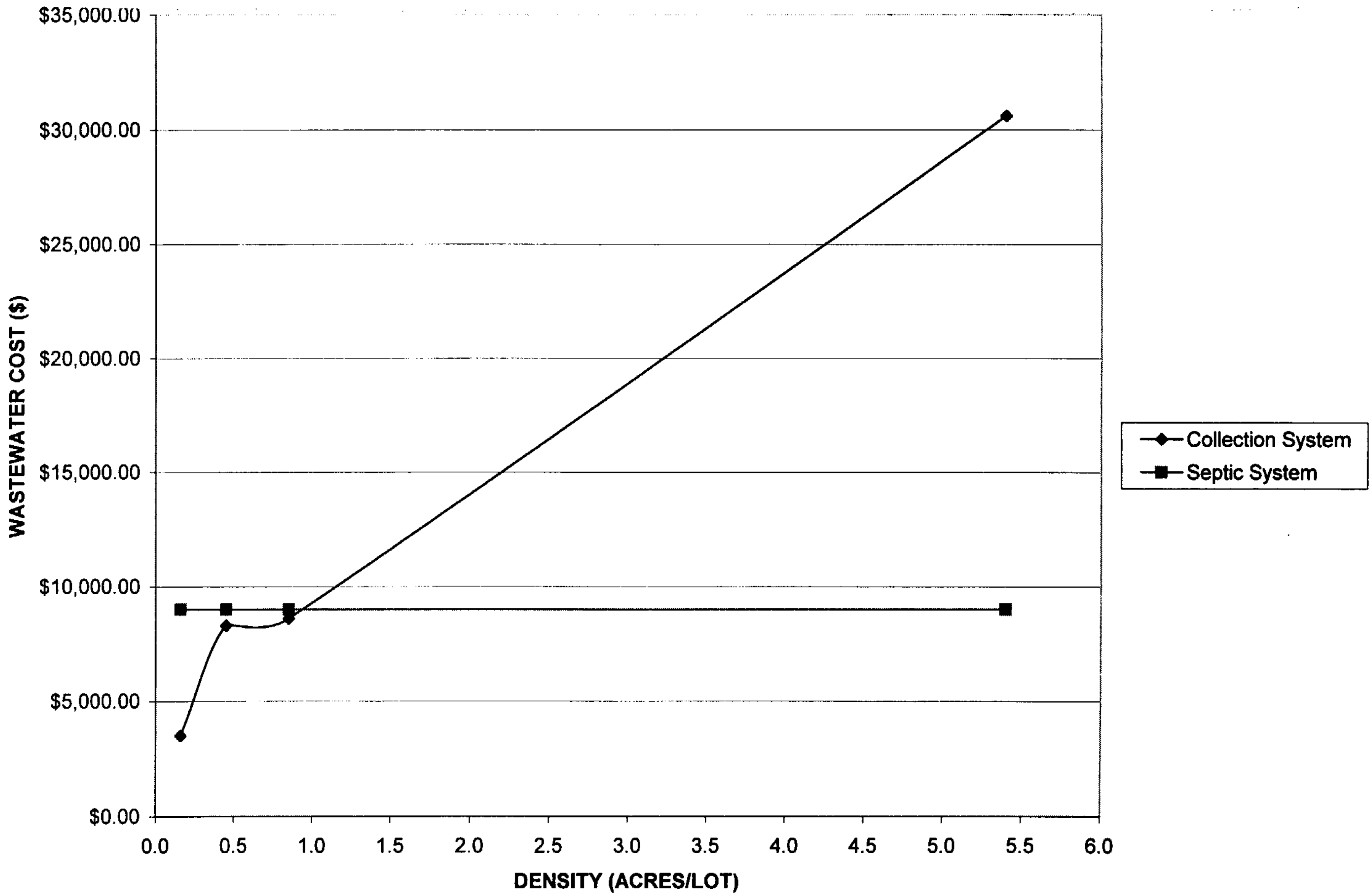
The developer decides on which type of wastewater system to install based on costs. The denser the development, the more likely organized collection systems and WWTP will cost less than installing OSSFs. Figure 4-1 illustrates the density cost relationship for both WWTPs and OSSFs. The data are based on four projects similar to the type of development occurring within the study area. The data suggests that one acre and smaller lot densities are more cost effective under the WWTP scenario than OSSFs. In order to make this scenario work, the developer may choose cluster development with open space or a golf course to irrigate the effluent from the WWTP. Note that while the traditional view is that treated domestic effluent is a waste to be disposed of by some type of discharge, that view has substantially changed. The more common view today is that treated effluent is a resource to be used for beneficial purposes such as irrigation, reducing demands on potable water.

It is difficult to know with certainty why there have been few proposed WWTPs to serve past developments. One reason could be market conditions. If the market demand is for larger lots, the WWTP scenario is probably not feasible. This can be illustrated by observing the Mystic Shores development. Mystic Shores is a large lot development on the northwest side of the Lake. The lot size was indicated to be determined based on market conditions. However, the more prevalent function on lot size determinations seems to be the difficulty involved in permitting wastewater treatment plants. The majority of existing development seems to hover near the minimum lot size required to make OSSFs work. This data suggests that the market might accept smaller lot sizes if the central wastewater option were available.

Recent history suggests that the majority of wastewater treatment plant permits have been protested and gone through contested case hearings. These hearings greatly extend the time and cost involved with obtaining a permit. A developer facing an unknown delay in the hearing process has a strong incentive to avoid central wastewater systems and the permit process unless absolutely necessary.

FIGURE 4-1

CAPITAL COSTS FOR WASTEWATER SERVICE PER CONNECTION



This problem could be solved by having an appropriate public entity do the planning and permitting in advance of specific development plans. The idea is for the entity to:

- identify specific areas that have the strongest development demand,
- obtain an option for the land needed for the wastewater system,
- prepare a permit application for a phased wastewater system that would include performance specifications but not detailed design, and
- carry the application through the process.

If a hearing were required, the delay would not be critical. The permit process should include obtaining a Certificate of Need and Necessity (CNN) that would define the service area in which the facility would operate and provide wastewater service.

The central wastewater system proposed here would be designed to not discharge to the lake but rather use the water for beneficial purposes including irrigation. This could include golf courses, and other public lands such as parks. In addition, it would be desirable to encourage new developments using the system to include provision for distributing the water for irrigation use. Integral to the beneficial use of wastewater are the TWC regulations governing its use (TWC Chapter 210). These regulations specify the quality of the effluent required and procedures that must be used to handle and apply the water. For wastewater that is disposed of by land application (as opposed to beneficial reuse of reclaimed water), groundwater protection is assured through the wastewater permit regulations.

Once the permit was obtained, the regional entity would be in a position to offer central wastewater service to developers. Land acquisition and detailed design would not occur until a developer committed to using the service.

The central wastewater proposal was considered as a means to address several water quality concerns, and not to either promote or discourage growth. This is because the method of providing wastewater service is rarely a significant factor in the marketability of new homes. The lowest cost, most efficient method should always be employed for a particular development. The purpose of the proposal is rather to make the central wastewater option available to address potential problems with OSSFs and to further the beneficial reuse of reclaimed water.

Figure 4-2 shows the study area subwatersheds along with the existing development. Subwatershed 9 appears to have the most potential to serve development with a regional plant. This area is also close to the lake where a greater water quality benefit might be obtained. Other areas with good potential would be subwatersheds 1 and 10.

Once a central wastewater facility was permitted, an option would be to convert existing neighborhoods from OSSFs to a collection system leading to the WWTP. However, this conversion can be costly, on the order of $5,000 per lot. In addition, a majority of residents in a target area would need to participate in the conversion to make it feasible. Without a strong need documented, it appears this would be a difficult task to accomplish. These factors make an enhanced monitoring program of OSSFs the appropriate path for the present. If this monitoring identifies areas with repeated failures, and a central wastewater facility has been constructed in reasonable proximity, this alternative may become feasible in the future.

There was a minority view in the steering committee as to whether a central wastewater treatment plant is a better method than individual OSSFs. The contrast was regarding the potential for acute vs. chronic problems with waste treatment. Whereas a septic system can malfunction and release partially treated water to either the ground or surface, such releases tend to be dispersed over a large area and may go undetected. This dispersed leakage can be considered a potential chronic problem. In contrast, opponents felt that a pipe conveying sewage to a treatment plant can fail and leak a greater amount, causing an acute pollution problem in a limited area.

This view was countered by those noting that with a properly monitored sewage collection system, major leaks can usually be identified and corrected while small leaks would be no worse than a single septic tank drain field. Opponents of central wastewater could not accept this view. Despite attempts to reach an accommodation by proposing measures more stringent than required over the Edwards Aquifer Recharge Zone, this portion of the steering committee could not support this study recommendation.

4.1.2 Existing OSSFs

The majority of existing and proposed developments within the study area utilize OSSFs. To a degree, the future water quality of Canyon Lake is related to the long-term performance of OSSFs. However, there is little in the way of monitoring or inspection that documents performance. In most cases problems are only identified by happenstance. To have a greater degree of confidence that water quality protection goals are being met, enhanced monitoring policies may need to be implemented.

Comal County's current policy is to rely on public reporting of failures to ensure continued performance of OSSFs. Enhanced efforts could further promote reporting of failed OSSFs and improve the global performance of the systems. A bi-annual newsletter could be distributed listing the reporting policy and the items to look for to determine failing OSSFs. The newsletter should stress the importance of the proper function of OSSFs for the water quality of the Lake.

An alternative given serious consideration in the study was encouraging the use of aerobic OSSFs. These facilities have been developed to function in areas where soil conditions are not suitable for conventional septic tank drainfields. Wastewater is treated by a small biological treatment plant and then used in spray irrigation on the lot. They are essentially micro-scale WWTPs. Because they involve mechanical components—aeration and pumping—they must be inspected quarterly and maintained. Having that inspection can be viewed as a positive element in that it produces a measure of confidence that the system is working properly. Another positive element is that the wastewater is used beneficially, contributing to water conservation.

On the negative side, the inspections required for aerobic systems now place a significant paperwork processing burden on the Comal County Engineers Office (Hornseth, 2001). Furthermore, the reports filed with the county indicate a significant percentage of homeowners in the county are not current in either their permit or their quarterly inspections. This produces an enforcement problem for the County, for which there is no mechanism to address.

In addition to the paperwork and enforcement problems, the systems cost more to operate than conventional septic systems and because of the mechanical components may not be as reliable. Even if the systems are very reliable, a small percentage can be expected to have a broken aerator at any time. In this case the system would be equivalent to a septic tank discharging to the surface rather than into the ground.

For these reasons, the study team elected to not recommend encouraging the use of aerobic systems. They will continue to be employed where OSSFs are needed and soil conditions do not allow the use of more conventional systems.

4.2 RUNOFF

A major impact associated with development in the watershed can be increased impervious cover and runoff loads. These runoff loads were analyzed for several communities in the Guadalupe River Basin, and the key points of this analysis are reproduced as Attachment A. The main way to address this load is by making runoff after development effectively the same as it was prior to development. Steps to achieve this are called Low Impact Development (LID).

LID is a development philosophy in which new developments incorporate measures to mimic the undeveloped drainage patterns of the land. The goal of LID is to promote groundwater infiltration and maintain or reduce runoff volumes from pre-developed conditions through all storm events. This philosophy mitigates water quality effects from stormwater runoff for new developments. Some LID measures include disconnection of drainage from impervious areas, rainwater harvesting, bioretention, and roadside ditch detention.

Disconnecting drainage is a measure designed to slow down runoff. Instead of routing roof drainage directly to a culvert and then a storm sewer, the flow is routed first to open ground where there is more opportunity for groundwater recharge. Rainwater harvesting is simply using roof gutter systems to capture runoff and store it in a rain barrel or cistern until it can be used for irrigation. Bioretention refers to locations that are designed with soils and vegetation that promote retention and infiltration of runoff. Roadside ditch retention is simply a way that the traditional drainage structure can be redesigned with shallow side slopes so that it can store and infiltrate more runoff water than would be the case with more conventional designs. Other LID measures are possible, depending on the particular features of a project. For more details of LID, refer to PGC (2000).

5.0 EFFECTS OF CONCEPTUAL DEVELOPMENT SCENARIOS

Nutrient and sediment loads to Canyon Lake were calculated to help quantify the effects of management alternatives in the Canyon Lake Study Area. Loads analyzed included the existing river, study area, runoff, septic, and point sources (permitted discharges). The method and results are described below.

The analysis is performed first for the Path A alternative, that is continued development with existing patterns, and no new efforts to manage effects of development. At the end of this section the effects of Path B, with the recommended management measures are quantified.

5.1 EXISTING LOADS TO CANYON LAKE

Existing loads from the Guadalupe River upstream of the study area were calculated using water quality data in the TCEQ Regulatory Activities and Compliance System (TRACS) database. Upstream and downstream Canyon Lake sites at Spring Branch (13700) and Sattler (13656) include observations from the TCEQ, USGS and the GBRA, with most of the data from GBRA. The period of record for the data is from 1993 through most of 2000.

The study area contains two classified stream segments, both which are effluent limited segments. Segment 1805, Canyon Lake, is from Canyon Dam in Comal County to a point 2.7 kilometers (1.7 miles) downstream of Rebecca Creek Road in Comal County, up to the normal pool elevation of 909 feet. Segment 1806, Guadalupe River above Canyon Lake, is from a point 2.7 kilometers (1.7 miles) downstream of Rebecca Creek Road in Comal County to the confluence of the North Fork Guadalupe River and the South Fork Guadalupe River in Kerr County. Both of the stream segments are designated for contact recreation, exceptional aquatic life use, public water supply and aquifer protection use (AP). The AP designation applies to the contributing, recharge, and transition zones of the Edwards Aquifer.

It should be emphasized that the purpose of this load analysis is to provide a means to put loads from the study area watershed into context, and not necessarily to produce a definitive loading analysis for the reservoir. A major limiting factor in the analysis is that most of the monitoring data for nitrogen and phosphorus were reported as non-detects. In an attempt to characterize the loads, a regression analysis was performed to relate observed concentrations to the daily average flow reported at each gage. In this regression, it was assumed that values reported as non-detects were actually at half of the reported detection limits. Parameters analyzed included TSS, Nitrate/Nitrite-Nitrogen (NO_3/NO_2-N), and Total Phosphorus (TP). Total Nitrogen (TN) is the sum of Total Kjeldahl Nitrogen (TKN) and NO_3/NO_2-N values.

A key point with this analysis is that the available TN and TP data are severely limited in that they were not analyzed with laboratory methods sufficiently sensitive to quantify actual levels. As a result, many of the observations are reported as "<" than some reporting level, which is potentially much higher than the actual level. The standard way to deal with this situation is to employ one half of the reporting level as an estimate of the actual concentration (TNRCC, 2001), but this must be recognized to be only a rough approximation. As a consequence, the nutrient loading analyses must be viewed as a means for putting study area loads into context, but may not be suitable for more detailed analyses.

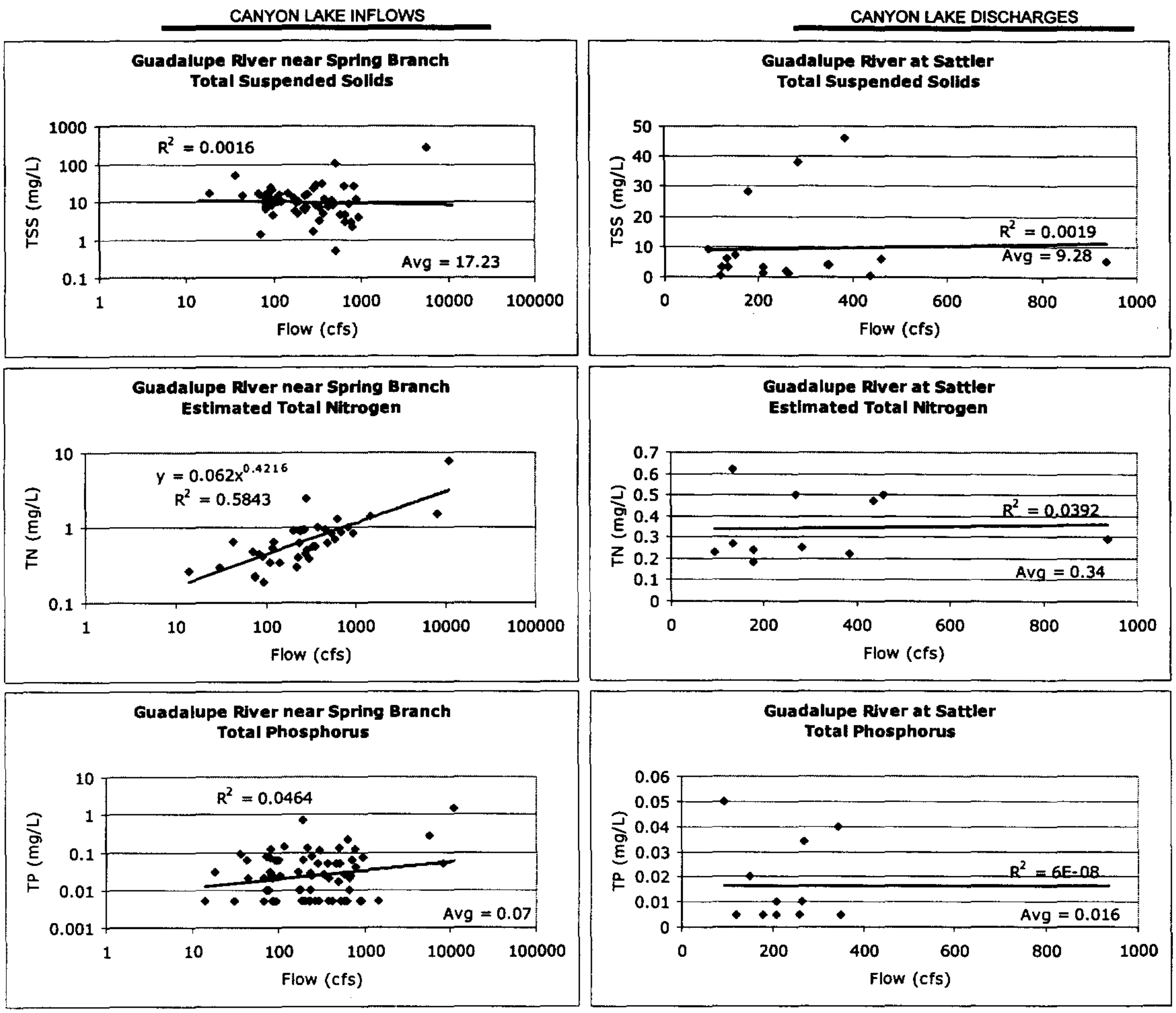
Figure 5-1 illustrates the data for the upstream and downstream stations and the regressions employed. For the inflows, the regression was performed using the log of the flow, following standard practice when a variable ranges over several orders of magnitude. Since the flow variation in the discharge is so much less, a linear regression was applied to these data. It can be seen that with TSS, there is essentially no relationship with flow. The upstream station has only one sample taken at higher flows so the regression is dominated by low to moderate flow samples. With a log-flow relation there is no significant relationship between TSS concentration and flow. However, a linear model shows a strong relation (R^2 of 0.83) that is dominated by the single high flow data point. For this analysis we elected to use the log-Q flow relation to avoid relying on a single data point even though experience indicates there would be a relation between flow and TSS if more higher flow samples had been collected. Since neither the upstream nor downstream stations show a relationship with flow, average concentrations for the data set were used in the analysis. The difference between the upstream and downstream concentrations reflects the ability of the reservoir to retain sediment and other forms of suspended solids carried in high flow periods. Also note that the range in the downstream flows is considerably less than for the upstream station, reflecting the regulating effect of the reservoir on river flows.

In contrast, the TN upstream data have a strong positive relation with flow. Like TSS, the downstream data appear to have no significant relation to flow. Accordingly, the downstream load was estimated using a constant average concentration of 0.34 mg/L. The upstream TN regression is dominated by the nitrate-N component of TN, with many of the TKN values being non-detects entered at half the reporting level. We believe that in this relatively undeveloped watershed, much of the nitrate-N at higher flows may be explained by concentrations in the rain itself, which can often reach higher concentrations. While the National Atmospheric Deposition Program data (NADP, 1999) summary suggests NO_3-N in rain averages approximately 0.2 mg/L, City of Austin data (PBS&J, 2000) have averaged 1.6 mg/L.

The TP data suggest no relationship between flow and concentration for upstream or downstream. Many values (33% upstream, 50% downstream) were below the detection limit. Overall, the data suggest that the average concentration of TP drops from 0.07 mg/L in the inflow to 0.016 mg/L downstream, both independent of flow.

FIGURE 5-1

CANYON LAKE SEDIMENT AND NUTRIENT LOADS



5.2 RUNOFF LOADS FROM STUDY AREA

Calculating the existing runoff loads to Canyon Lake involves several steps, shown in Table 5-1. The average loads for the three parameters at the upstream Spring Branch location are shown under line A. These loads are normalized in line B by dividing by the drainage area at the Spring Branch gage. These unit loads are used in line C to estimate the total load at the dam. The loads at the dam are roughly 10% greater reflecting the increased watershed area below the Spring Branch gage. That calculation assumes the study area watershed is similar to the upstream watershed.

Using the same load per acre values, line D shows the runoff loads for the study area, assuming the study area watershed had the same characteristics as the Spring Branch watershed. Since the study area has substantially higher population density and impervious cover than the watershed above Spring Branch, a load based on Spring Branch data can be expected to be an underestimate.

As development and impervious cover increase on a watershed, and when efficient drainage systems typical for modern development become more common, the volume of runoff and the peak rate of runoff increases. The increased volume of runoff causes scouring of downstream creeks or drainage channels that leads to higher TSS and nutrient loads to the reservoir.

In addition to the analyses using the Spring Branch gage data, runoff loads for the study were determined using runoff coefficients and event mean concentration (EMC) values that are a function of impervious cover in each individual subwatershed. Table 5-2 presents these calculations for each study area tributary, and a sum for the entire study area, using an annual average rain of 33.7 inches. These EMC values were developed from City of Austin data in a Clean Rivers Program study of urban development (PBS&J, 2000). The key data and methodology from this study are summarized in Attachment A. Impervious cover was based on a per capita rate of .16 acre developed in the same study. Population was estimated using the TxSDC population projections for each decade through 2040. Runoff loads were determined for each tributary in an average, dry, and wet year. Parameters included TSS, TN, and TP. The loads were calculated using the impervious cover in each tributary in the study area, and then summed for the entire study area. As projected, the runoff loads increase over time as the population and associated impervious cover increase.

Table 5-3 shows the calculations of the entire study area loads to Canyon Lake. The first group shows the total study area runoff loads calculated with the method shown in Attachment A. Block A of Table 5-3 is the sum of all 11 subwatersheds shown in Table 5-2.

The Year 2000 runoff loads determined from City of Austin runoff EMCs were adjusted to be consistent with the loads obtained from the local Spring Branch gage data (line D of Table 5-1). The method from Table 5-1 assumes that loading is a linear relationship to acreage. As such, approximately 10% of the existing loads for the total watershed down to the dam (estimated from Spring

TABLE 5-1

ESTIMATED CANYON LAKE SEDIMENT AND NUTRIENT LOADS

	TSS	TN	TP
A. Estimated Loads Upstream at Spring Branch Gage (kg/yr) [1]			
Average for all data	5,502,465	194,834	22,174
Dry Year (1996) average	2,598,184	92,383	10,470
Wet Year (1997) average	16,710,094	2,743,791	67,340
B. Normalized Loads (kg/ac-yr) [2]			
Average for all data	6.54	0.23	0.03
Dry Year (1996) average	3.09	0.11	0.012
Wet Year (1997) average	19.86	3.26	0.08
C. Total Loads at Canyon Dam (kg/yr) [3]			
Average for all data	6,003,787	212,585	24,195
Dry Year (1996) average	2,834,901	100,800	11,424
Wet Year (1997) average	18,232,527	2,993,774	73,475
D. Loads from Study Area Based on Spring Branch Load (kg/yr) [4]			
Average for all data	603,807	21,380	2,433
Dry Year (1996) average	285,109	10,138	1,149
Wet Year (1997) average	1,833,663	301,087	7,389
E. Estimated Loads Downstream at Sattler Gage (kg/yr) [5]			
Average for all data	3,261,484	120,409	5,680
Dry Year (1996) average	912,526	33,689	1,589
Wet Year (1997) average	9,572,311	353,396	16,670
F. Percent Reduction in Load Relative to Spring Branch [6]			
Average for all data	41%	38%	74%
Dry Year (1996) average	65%	64%	85%
Wet Year (1997) average	43%	87%	75%

(1) TSS and TN loads at gage estimated from regressions of concentration with daily flow. TP loads estimated based on average concentration.

(2) Loads from (1) divided by 841,600 acres in Spring Branch drainage area

(3) Unit loads from (2) multiplied by 918,277 acres at dam.

(4) Unit loads from (2) multiplied by 92,352 acres of study area.

(5) Estimated loads from relations in Figure 5-1.

(6) Percentage reduction in load = $\frac{A-E}{A}$

TABLE 5-2

CANYON LAKE SUBWATERSHEDS
CALCULATED RUNOFF LOADS FOR AVERAGE RAINFALL YEAR

	2000	2010	2020	2030	2040
TSS					
1	397,271	474,844	592,692	757,319	953,554
2	275,228	310,202	360,919	427,949	503,396
3	239,732	266,797	305,671	356,454	412,925
4	474,208	610,698	831,517	1,163,614	1,590,430
5	115,412	140,220	178,417	232,627	298,305
6	70,578	88,814	117,734	160,227	213,563
7	513,790	835,660	1,485,263	2,743,991	4,829,938
8	587,729	888,943	1,454,489	2,463,886	4,004,819
9	230,018	294,133	397,225	551,162	747,570
10	819,873	885,078	976,632	1,092,998	1,218,709
11	355,879	612,964	1,163,230	2,303,013	4,321,878
Study Area Total	4,079,716	5,408,353	7,863,788	12,253,239	19,095,088
TN					
1	1,737	2,106	2,663	3,431	4,327
2	1,188	1,355	1,596	1,914	2,269
3	1,032	1,161	1,346	1,587	1,854
4	2,103	2,748	3,773	5,259	7,075
5	506	624	804	1,055	1,351
6	312	398	533	726	959
7	2,332	3,740	6,303	10,536	16,302
8	2,660	4,024	6,411	10,218	15,256
9	1,019	1,322	1,802	2,494	3,337
10	3,506	3,815	4,250	4,804	5,402
11	1,613	2,700	4,736	8,184	12,974
Study Area Total	18,008	23,994	34,216	50,208	71,106
TP					
1	89	154	263	426	632
2	40	67	109	169	241
3	31	51	83	127	179
4	154	281	504	860	1,329
5	28	50	86	141	211
6	21	37	66	110	169
7	326	676	1,381	2,642	4,460
8	319	638	1,258	2,336	3,853
9	73	132	235	399	615
10	75	121	190	284	391
11	249	531	1,113	2,175	3,729
Study Area Total	1,407	2,739	5,288	9,671	15,809

TABLE 5-3

PROJECTED CHANGES IN LOADS TO CANYON LAKE (kg/yr)

	2000	2010	2020	2030	2040
A. Study Area Annual Runoff Load Based on City of Austin Formula (1)					
TSS	4,079,716	5,408,353	7,863,788	12,253,239	19,095,088
TN	18,008	23,994	34,216	50,208	71,106
TP	1,407	2,739	5,288	9,671	15,809
B. Study Area Runoff with Year 2000 Load Adjusted to Spring Branch Rate (2)					
TSS	626,044	829,927	1,206,720	1,880,293	2,930,194
TN	22,205	29,587	42,192	61,912	87,680
TP	2,686	5,228	10,094	18,461	30,179
C. Study Area Runoff with Reduction from Detention After 2010 (3)					
TSS	626,044	829,927	1,169,040	1,809,168	2,818,091
TN	22,205	29,587	40,931	59,814	84,894
TP	2,686	5,228	10,094	18,461	30,179
D. Study Area OSSF Loads at 90% Removal (4)					
TN	5,548	8,447	12,306	16,897	21,517
TP	1,048	1,596	2,325	3,192	4,065
E. Study Area WWTP Loads (5)					
TSS	207	207	207	207	207
TN	465	465	465	465	465
TP	79	79	79	79	79
F. Totals at Canyon Lake Dam (6)					
TSS					
Upstream	5,502,465	5,502,465	5,502,465	5,502,465	5,502,465
Study Area Runoff	626,044	829,927	1,169,040	1,809,168	2,818,091
OSSF					
WWTP	207	207	207	207	207
Total for TSS	6,128,715	6,332,598	6,671,712	7,311,840	8,320,763
TN					
Upstream	194,834	194,834	194,834	194,834	194,834
Study Area Runoff	22,205	29,587	40,931	59,814	84,894
OSSF	5,548	8,447	12,306	16,897	21,517
WWTP	465	465	465	465	465
Total for TN	223,052	233,333	248,536	272,010	301,710

TABLE 5-3 (Concluded)

PROJECTED CHANGES IN LOADS TO CANYON LAKE

	2000	2010	2020	2030	2040
TP					
Upstream	22,174	22,174	22,174	22,174	22,174
Study Area Runoff	2,686	5,228	10,094	18,461	30,179
OSSF	1,048	1,596	2,325	3,192	4,065
WWTP	79	79	79	79	79
Total for TP	25,987	29,077	34,672	43,907	56,498
Percentage Increase per Decade in Average Loads at Canyon Lake Dam					
TSS	0	3.33	5.36	9.59	13.80
TN	0	4.61	6.52	9.44	10.92
TP	0	11.89	19.24	26.63	28.68
Study Area Percent of Total Reservoir Loads (at 90% removal)					
Septic TN	2	4	5	7	8
Runoff TN	10	13	13	14	15
Septic and Runoff TN	12	16	18	21	24
Septic TP	4	5	7	9	11
Runoff TP	10	18	20	23	26
Septic and Runoff TP	14	23	28	33	37
Runoff TSS	10	13	14	15	17

(1) Refer to Attachment A for presentation of methods.
(2) Loads calculated for subwatersheds, scaled to the loading rate determined in Table 5-1, then summed here.
(3) Increase in loads after 2010 reduced by 10% to reflect effect of flood detention requirement.
(4) See Attachment A for methods.
(5) Loads from GBRA for Canyon Park Estates and Dept. of Army WWTPs.
(6) Upstream loads from Table 5-1 assumed constant over the study period.

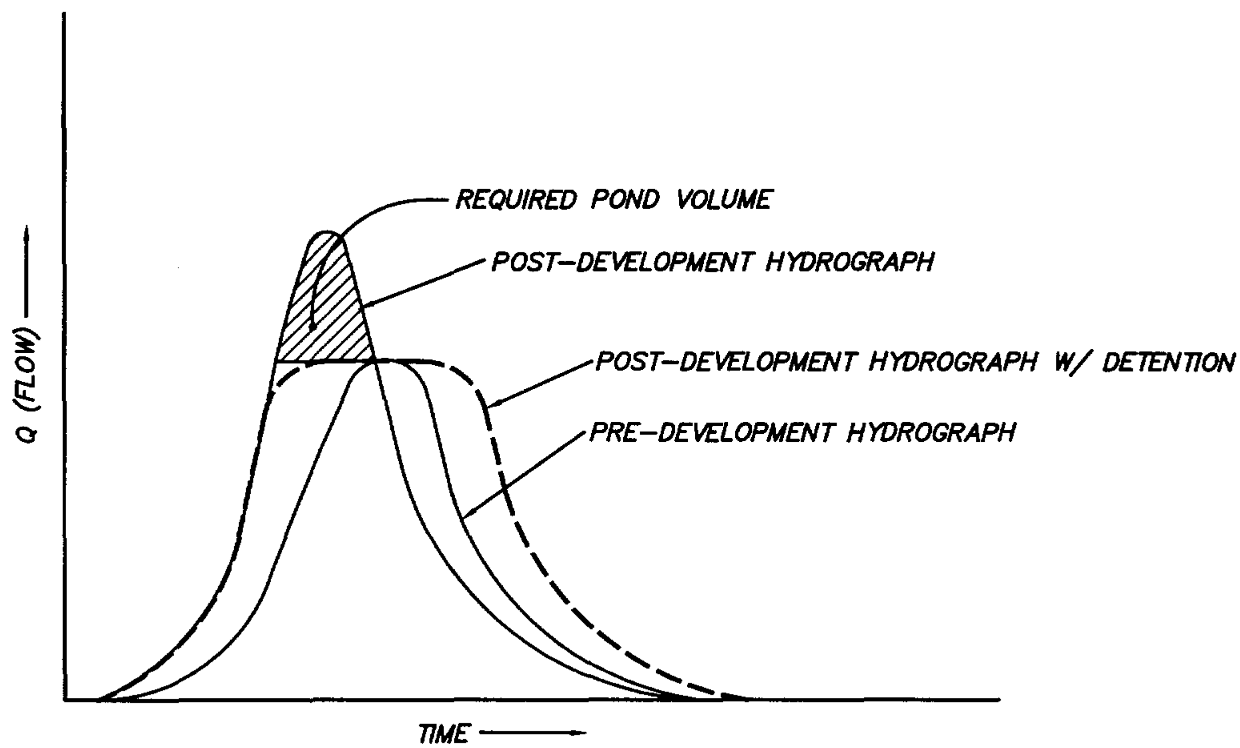
Branch data) were used as base or present runoff loads for the study area. As can be seen, the nutrient loads from the runoff formula are fairly close to those based on the Spring Branch gage, but the TSS loads are higher. The scaled loading was then used as the year 2000 starting point. Future loads on line B were determined with percentage increases from the calculations based on the runoff formula from the TxSDC growth projections and the impervious cover estimates based on that population growth.

Next, these projected loads are modified to reflect existing regulations. Comal County adopted new rules and regulations for subdivisions on April 16, 2001. These rules specify that for subdivisions of 10 acres or more, the peak runoff flow rate downstream of the subdivision will not be increased over the predevelopment condition. Also, areas within the platted subdivision that are within the 100-year floodplain shall be identified on the plat, and all buildings must be set back from these areas. The construction of buildings in the identified set-back areas would require Commissioners Court Approval.

Achieving no increase in the peak runoff rate downstream of a development typically requires a flood detention pond designed to capture the additional peak volume and release the water over a longer period of time after the peak has passed. The increase in the runoff peak with development is illustrated in Figure 5-2. To achieve no increase in the peak flow, a pond must be designed to function at the high runoff rates associated with the 100-year (typically 24-hour) event and to drain the pond within a 24-hour period so it can be ready to accommodate the next event. Because they are designed to deal with very large events, these flood detention ponds tend to have a fairly minor effect on smaller runoff events.

Because of these design requirements, such ponds typically have only a small effect on water quality. First, as noted in Attachment A describing the City of Austin data, the main issue with runoff water quality appears to be the increase in the volume of flow that scours streambeds. Typically the concentrations of runoff parameters are higher in the streams than in the runoff from developed sites that flows into the streams. The flood control pond does little to the increased volume of runoff other than distribute the peak out over a longer time. This might be somewhat beneficial in reducing downstream scour although the exact amount, if any, is difficult to estimate. While it is difficult to estimate the effect, we will assume that subdivisions constructed to comply with the new regulations will have their runoff loads reduced by 10% over what they would be in the absence of any flooding controls.

Currently there are a number of subdivisions that have completed the approval process but have not begun construction. Because these new platted subdivisions were approved before the new rules took effect, the flood requirements do not apply to them. To accommodate this delay in on-the-ground rule application, the analysis assumes that without any actions from this project, the 10% reduction will begin to take effect after the year 2010. This is shown on line C of Table 5-3.



PBSJ

FIGURE 5-2

CONCEPTUAL DETENTION HYDROGRAPH

PROJECT NO: CAD FILE:

To put the upstream loads into context, it is useful to compare them with the downstream loads at the Sattler gage, shown in line E of Table 5-1. The percentage reduction relative to the Spring Branch gage for each parameter for the average of all years, and for the years with the least and greatest flows are shown in line F. There are several points of potential interest with these percentage reduction results. On average, 41% of the solids that enter the lake at Spring Branch leave the lake via Sattler. On the wettest year (1997) the results are similar. In contrast, the driest year (1996) would have much lower sediment input and discharge, with an average reduction of 65%. The reason the percent reduction is higher in 1996 is that much more water entered (122,241 acre-feet) than left (79,663 acre-feet) the reservoir. On average and in the wet year, the downstream discharge is about 10% larger than the upstream discharge, reflecting the additional drainage area between the two gages. A similar pattern in percentage removal was shown for TP, although the absolute values are higher than for TSS.

In contrast, the TN results show a higher percentage removal in the wet year. This is a result of the regression yielding higher concentrations in the inflow during wet years. The dry year also showed a high percentage removal simply because the downstream flow was much less than the upstream flow.

5.3 ON-SITE SEWAGE SYSTEM NUTRIENT LOADS

On-site sewage systems release wastewater that is relatively high in nutrients. This water goes to the ground through a drainfield where it moves downgradient towards the lake. How much of this nutrient-rich water actually gets to the lake depends on many factors including uptake in the soil, distance from the lake, and age of the drainfield.

Nutrient loads to the lake were estimated using septic tank concentrations from various literature sources (see Summary in Attachment B), assuming 100 gallons per day discharged per system, and assuming a 90% nutrient removal rate in the drainfield. Parameters include TN and TP. TSS was not considered because migration through the soil would limit inputs from particulate materials. The number of systems in the study area was estimated using the Guadalupe Valley Telephone Cooperative's customer database. Future growth in the area was calculated based on the TxSDC population projections. The TN and TP loads for each decade are shown in line D of Table 5-3.

The OSSF loads are a relatively small percentage of the total. However, over time the growth projections show that this load increases at a significant rate, quadrupling the current load by the year 2040, if no changes are made. The sensitivity to different estimates of nutrient removal was considered in the review in Attachment B. If the 90% removal percentage for TN and TP were increased to 99%, the year 2000 total loads to the lake would be reduced by 2.2% for TN and 3.6% for TP. The corresponding percentage differences in the year 2040 would be less than shown in Table 5-3 by 6.4% for TN and 6.5% for TP. The effect of the reduced total load would be to reduce the percentage changes per decade in Table 5-3 by 1-2%. Because the OSSF loads are a modest percentage of the total, the sensitivity to the drainfield removal percentage is not high.

5.4 WASTEWATER TREATMENT PLANT LOADS

There are currently two WWTPs, Canyon Estates Wastewater Treatment Plant and the smaller Army facility plant. The loads shown in Line E are those for the present condition. The nutrient loads for the Army facility are not routinely monitored. For this analysis we assumed typical concentrations of 15 mg/L for TN and 4 mg/L for TP. Because there are no plans to expand either facility, the projected future loads are held constant. As can be seen, these WWTP nutrient loads represent a very small fraction of the existing OSSF and runoff loads.

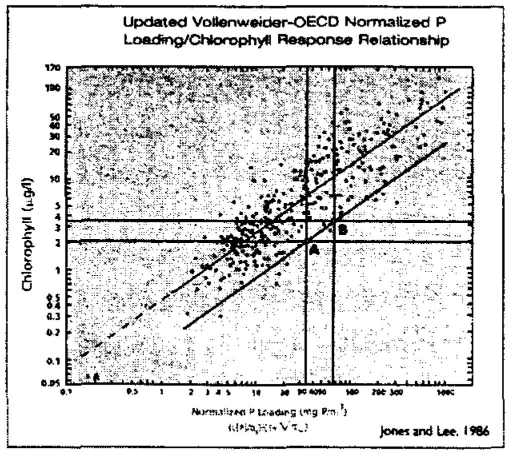
5.5 COMBINED EFFECTS

The combined effects of increases in runoff and OSSF loads as development occurs are shown in the lower part of Table 5-3 and illustrated in Figure 5-3. The calculations assume that the upstream loads stay constant, but that population growth in the study area will produce increases in impervious cover with associated increase in runoff, and additional OSSF loads. In reality, it is also likely that development will occur upstream of Comal County, so the assumption of upstream loads being constant is probably an underestimate of the actual future loads. The study area runoff load could increase at a relatively significant rate, essentially quadrupling in the 40-year planning period.

Figure 5-3 shows the effects of study-area development on the overall loads to the reservoir, expressed as a percentage of the present loads. In the present (year 2000) condition, the study area loads represent near 10% of the total reservoir load, consistent with the percentage represented by the study area. Note however that this result is based on assigning an initial runoff load that is based on the Spring Branch data, while the actual development density is already considerably higher than it is in the upper watershed. As such, the percentage estimate for the start and all those that follow are likely to be lower than the actual case.

If no action is taken, over time development of the study area will cause substantial increases in the nutrient and TSS loads. Figure 5-3 indicates the TP loads from the study area will increase from about 12% of the total to almost 58%. This translates to a 26% increase in the average TP load to the lake. This much of an increase is likely to produce a noticeable effect on plankton levels. It is not certain if such an increase would have a major adverse effect on the use of the water, but a restriction or limitation in use is certainly possible with this large an increase in average TP loads.

To estimate the effect on the lake of this increase in TP load, a Vollenweider model is employed. The adjacent figure, taken from Jones and Lee (1986), shows a plot of normalized TP loading versus average chlorophyll a levels for many lakes and reservoirs around the world. The loading is expressed in mass/area-time, and scaled by the mean depth and hydraulic residence time. The present average normalized load is plotted versus the current average chlorophyll a level of approximately 2 ug/L as point A. It can be seen that Canyon data plot somewhat below the world-wide regression, possibly reflecting the carbonate soils that act to bind phosphorus and reduce algal growth (Groeger, 2001). The regression slope and projected TP load for the year 2040 were used to predict a revised average chlorophyll *a* concentration at point B. The result is an average chlorophyll concentration of about 3.5 ug/L. This new value is still low relative to many Texas reservoirs, but it is an increase that would be detectable in routine data analysis.



5.6 LOAD WITH MANAGEMENT MEASURES

The preceding sections described the changes in loads if no action is taken and development continues at the rate exhibited in recent history. If actions are taken to control the growth in runoff and OSSF loads, these dramatic increases can be controlled but not eliminated.

Figure 5-4 and Table 5-4 show the increases in TSS, TP, and TN if the recommended management measures described in Section 4 are implemented. As can be seen, the amount of nutrient input to the lake is greatly diminished compared to the Path A/no action alternative (see Figure 5-5). Total loads to the lake from TP decrease from 61% to 37%. TN loads are reduced from 35% to 24%. Most notably, TSS loads are cut nearly in half, from 34% to 17%.

Table 5-5 compares the loads from the Study area for the no-action condition and with the recommended measures. Looking at runoff loads exclusively, by the end of the planning period, runoff loads for TSS, TN, and TP decrease by 60, 53, and 69%, respectively. Most of this reduction can be directly attributed to the LID management alternative. LID concepts applied to new development in the area contribute vastly to the reduction in runoff from sites, translating to far less loading to the lake.

Reduction in OSSF loads is not as dramatically diminished. Decreases amount to 4% by the end of the planning period. This difference is attributed solely to managing waste from future development in Subwatershed 9 via organized wastewater collection rather than OSSF.

TABLE 5-4

STUDY AREA LOAD CHANGES OVER PLANNING PERIOD (kg/yr)
WITH RECOMMENDED ACTION PLAN

	2000	2010	2020	2030	2040
Study Area Annual Runoff Load Based on City of Austin Formula (1)					
TSS	4,079,716	5,408,353	5,939,539	6,639,345	7,426,119
TN	18,008	23,994	26,296	29,251	32,470
TP	1,407	2,739	3,288	4,016	4,834
Study Area Runoff with Year 2000 Load Adjusted to Spring Branch Rate (2)					
TSS	626,044	829,927	911,439	1,018,826	1,139,558
TN	22,205	29,587	32,426	36,069	40,039
TP	2,686	5,228	6,277	7,667	9,229
Study Area Runoff with Reduction from Detention After 2010 (3)					
TSS	626,044	829,927	903,287	1,007,272	1,126,330
TN	22,205	29,587	32,142	35,677	39,603
TP	2,686	5,228	6,277	7,667	9,229
Study Area OSSF Loads at 90% Removal (4)					
TN	5,548	8,447	12,049	16,335	20,648
TP	1,048	1,596	2,276	3,086	3,901
Total at Canyon Lake Dam (Base Load, Runoff Load, OSSF Load, WWTP load)					
TSS	6,128,715	6,332,598	6,405,959	6,509,943	6,629,001
TN	223,052	233,333	239,491	247,311	255,550
TP	25,987	29,077	30,806	33,006	35,383
Percentage Increase in Average Loads at Canyon Lake Dam					
TSS	0	3.33	1.16	1.62	1.83
TN	0	4.61	2.64	3.27	3.33
TP	0	11.89	5.95	7.14	7.20
Study Area Percent of Total Reservoir Loads (at 90% removal)					
Septic TN	2	4	5	7	8
Runoff TN	10	13	13	14	15
Septic and Runo	12	16	18	21	24
Septic TP	4	5	7	9	11
Runoff TP	10	18	20	23	26
Septic and Runo	14	23	28	33	37
Runoff TSS	10	13	14	15	17

(1) Refer to Attachment A for presentation of methods.

(2) Loads calculated for subwatersheds, scaled to the loading rate determined in Table 5-1, then summed here.

(3) Increase in loads after 2010 reduced by 10% to reflect effect of flood detention requirement.

(4) See Attachment A for methods

FIGURE 5-5

TOTAL NITROGEN AND PHOSPHORUS LOAD CHANGES OVER TIME WITH AND WITHOUT RECOMMENDED ACTION PLAN

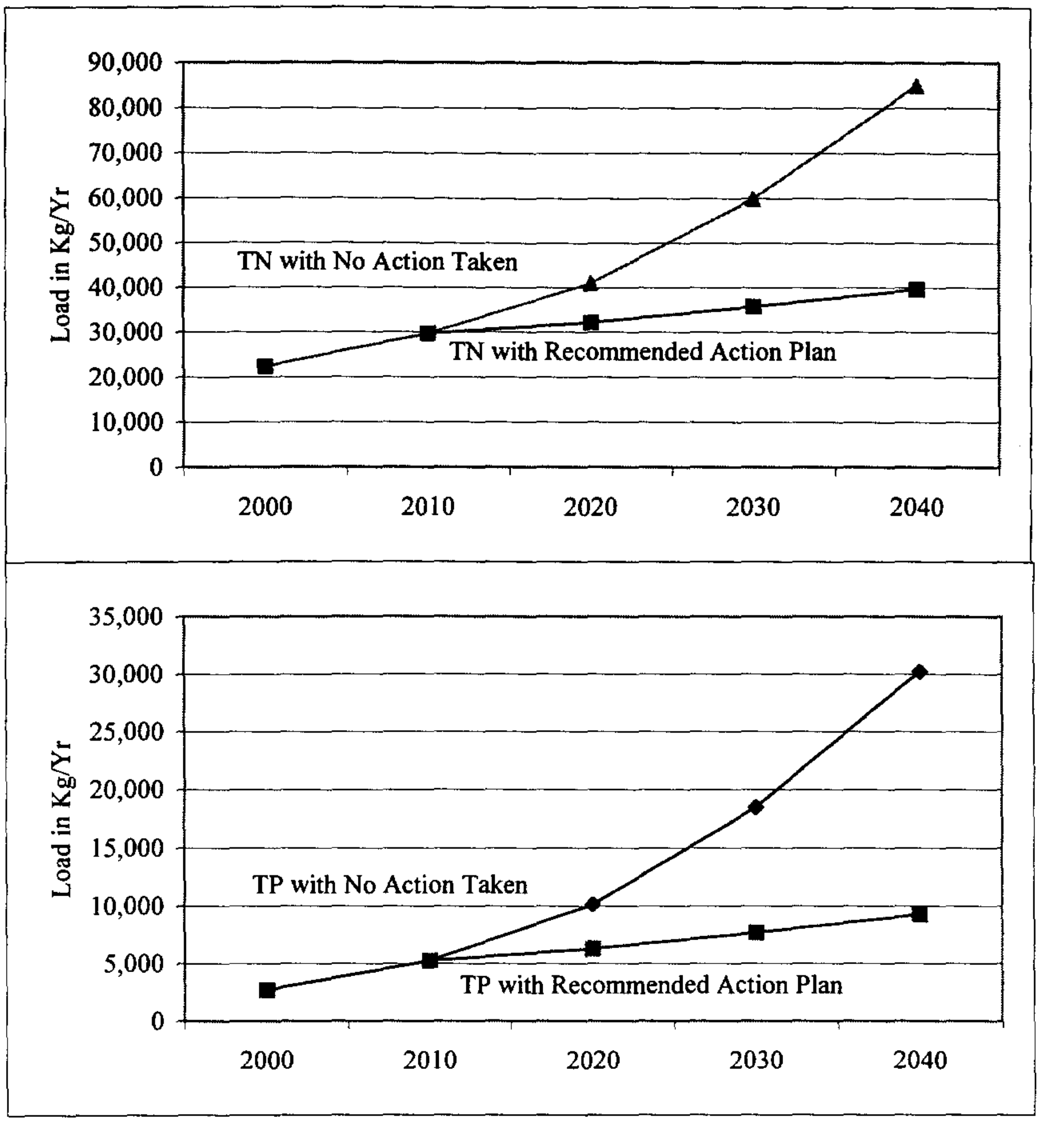


TABLE 5-5

STUDY AREA LOAD REDUCTIONS WITH RECOMMENDED ACTION PLAN

	2000	2010	2020	2030	2040
Path A - Continuation of Present Path					
Study Area Runoff with Reduction from Detention After 2010					
Path A TSS	605,271	788,427	1,086,908	1,637,151	2,482,179
Path A TN	21,432	28,117	38,278	55,024	77,071
Path A TP	2,439	4,699	8,977	16,265	26,398
Study Area OSSF Loads at 90% Removal (kg/yr)					
Path A OSSF TN	5,548	8,447	12,306	16,897	21,517
Path A OSSF TP	1,048	1,596	2,325	3,192	4,065
Path B - Implemented Recommended Action Plan					
Study Area Runoff with Reduction from Detention After 2010					
Path B TSS	78,842	128,234	149,030	177,140	209,560
Path B TN	2,875	4,612	5,307	6,214	7,220
Path B TP	623	1,290	1,575	1,957	2,393
Study Area OSSF Loads at 90% Removal (kg/yr)					
Path B OSSF TN	1,064	1,620	2,360	3,240	4,126
Path B OSSF TP	225	343	500	687	875
Percent Reduction in Runoff Load					
TSS	-	-	86	89	92
TN	-	-	86	89	91
TP	-	-	82	88	91
Percent Reduction in OSSF Load					
TN	-	-	80.8	80.8	80.8
TP	-	-	78.5	78.5	78.5

6.0 RECOMMENDATIONS

Growth and development is likely to occur in the immediate watershed of Canyon Lake. The analysis in this study indicated that in the absence of intervention, this development will produce substantial increases in the loads of sediment and nutrients to the lake. The increased population will also place additional demands on water supplies. To accommodate this growth while protecting the quality of Canyon Lake waters and minimizing withdrawals from the reservoir, the following are recommended.

- LID - Forecasted development in the immediate watershed will increase the stormwater runoff loads of nutrients and sediment to a degree that promises to have an impact on the lake quality, at least in the long term. Avoiding those impacts will require special efforts that are now only beginning to be seen. The basic premise of LID is to have site runoff characteristics (both flow and quality) be essentially the same as they were prior to any development. By satisfying the goal of LID, both the water quality and flood protection goals can be achieved. Turning the LID concept into practical measures that can be designed by the private sector, and reviewed and certified by the public sector, can be a challenge. Numerous manuals have been written on the subject (PGC, 2001; Milwaukee Metropolitan Sewerage District, 2002), but all offer a substantial degree of flexibility to the designer and none are as simple as "Include a pond that captures and treats the first half inch of runoff from the site". Generally, the LID design approach involves a mix of measures such as limiting impervious cover, disconnecting drainage systems, rain harvesting with reuse in irrigation, and incorporating features such as bioretention ponds. The County could implement LID as a part of the Comal County Subdivision Rules and Regulations.

  Comal County should be commended for implementing the ordinance to protect downstream homeowners from flooding caused by development, recommended by the county's Water Wise Committee. To strengthen the protection offered by the "no change in peak runoff" ordinance, the ordinance could be expanded to require developments of greater than a target size (10 acres is used in the existing flood protection ordinance and would be appropriate) to be designed with LID features and have a certification by a professional engineer (PE) that there would be no net change in runoff characteristics. This will put some burden on the development review staff of the County, but not one that should be particularly onerous. To further affect water quality, upstream counties could institute the same recommendations put forth for Comal County. The recommendation to manage the projected increases in runoff nutrient and sediment loads applies only to the project study area, but growth further upstream can have a similar effect. To control these effects, upstream counties should institute the same requirements put forth by Comal County.

- OSSFs - For larger lots (>1 acre), OSSFs will continue to be employed in new development. The procedures to design, construct and inspect new units are substantially better today than has been the case in the past. So long as soil conditions are suitable and routine maintenance is performed, these should continue to provide good service for an extended time. Ultimately, all facilities age to the point where substantial service is required. This is a concern for older facilities constructed prior to modern regulations. On the other hand, all OSSFs in the area are located a substantial distance from the lake by virtue of the USACE elevation and setback requirements, and there is no direct evidence of water quality problems from OSSFs. In light of this situation, we recommend that bi-annual newsletters be distributed to all residents within the study area to educate on the importance of OSSF operation and OSSF failure reporting procedures. In addition, documentation of OSSF failure data would determine if specific areas might warrant retrofit to organized collection systems and WWTPs.

During the study process serious consideration was given to encouraging the use of aerobic systems, because they had a requirement for inspection and because the wastewater treated aerobically is used for spray irrigation, contributing to water reuse. Ultimately the decision was made not to recommend this technology because it would impose a greater paperwork and enforcement burden on the county, and it would add to the cost of facilities.

- Regional WWTPs - For smaller lot development, regional wastewater collection, treatment, and beneficial reuse is recommended. However, as noted below, the steering committee was not unanimous in this recommendation. Key elements of this recommendation include having regional facilities operate with a zero-discharge permit (all the effluent being used for irrigation or some other beneficial use), and having it operated by a public entity that should provide a higher level of performance and reliability.

Lines of communication should be opened with developers and landowners to begin the planning and permitting process for regional wastewater treatment plants. A key problem with regional wastewater systems that might be provided by individual developments is that developers are often reluctant to propose such systems because of the potential for protracted delays and costs in the permitting process. To address that concern, we recommend that a set of three regional wastewater treatment plants be planned and possibly permitted in advance of a specific need. By doing this, developers will be able to plan their projects around the availability of this wastewater service. A key requirement is that the public entity, in this case, the GBRA, be willing to undertake this planning and permitting burden in advance considering historical growth and area for future growth. No area has been specifically selected in this project.

There was concern among some members of the project steering committee that central wastewater facilities would act to encourage growth and that leakage from sewers might pollute groundwater. As a result, a minority of the steering committee opposed this recommendation. Most of the committee agreed that growth was driven by market demand, with wastewater options being a very small part of the demand equation. While most felt that the effect on groundwater of thousands of OSSFs would be larger than sewer leakage, there was also broad agreement that sewer leakage was undesirable. In an attempt to reach compromise with opponents of central wastewater (see Attachment D), a set of additional design requirements was proposed. While opponents of the central wastewater recommendation rejected these additional requirements as being insufficient, and others did not feel there was a technical justification for such additional measures, several on the steering committee expressed support for what was perceived as middle ground. Because the proposal for additional measures was made in an attempt to reach consensus with the support of GBRA, one of the study sponsors, they are included as study recommendations.

In addition to the extended discussions with some committee members over attempts to resolve technical concerns, another steering committee member submitted additional written comments and questions. The comments expressed disagreement with the concept of central wastewater collection and treatment and suggested the use of non-structural controls to protect water quality.

On the question of whether the offers made in negotiation should be included as study recommendations, a polling of the steering committee members yielded three camps:

- Those who feel there has been no technical showing that current TCEQ design requirements for central wastewater are not appropriate,
- Those who feel the proposed efforts to reduce the risk to less than that required for the Edwards Aquifer Recharge Zone is not sufficient to accept a recommendation that central wastewater be considered where justified, and
- Those who support the compromise position offered during negotiations.

If it is assumed that those not accepting the proposal on the grounds that it was not sufficient would prefer the recommendations over none at all, then a substantial portion of the steering committee members support the following compromise measures.

Any central wastewater system constructed in the proposed WQPZ (Canyon watershed in Comal county) must follow the rules for construction in the Edwards Aquifer Recharge Zone including:

Inspections for karst features in the design report and making required modifications,

Providing stubs at residential locations for new construction,

Restrictions on building in the 5-year floodplain,

Inspections every 5 years.

Features beyond that required by the Edwards Rules that would also be recommended are:

Leakage for new construction to be one half of that allowed by TCEQ for the recharge zone,

Plastic tape buried over new lines to warn excavators, and

Signage marking the route of sewer lines outside of developed areas.

While these measures were supported by several members of the steering committee, their limitations must be recognized. First, these measures represent an attempt at compromise rather an established technical need. The basis for the compromise is that the cost increase for such measures would not be prohibitive, and there was a desire to see sewer leakage minimized. Second, no governmental agency in the County has the authority to enforce the measures. We expect that they could be required by the TCEQ in a wastewater permitting process, if requested by parties, but there is no guarantee of that outcome.

- Environmental Education - In addition to the material distributed for OSSF operation, other environmental concerns could be addressed. Environmental education could include the importance of LID concepts and other concerns such as proper disposal of grass clippings, appropriate lawn fertilization and pesticide applications, and rainwater harvesting options on the water quality protection of the lake.

- Water Conservation - A central theme of the above recommendations is managing water use and quality. While it is highly desirable to have wastewater treated and used beneficially for irrigation or other beneficial uses, it is not the intent to promote additional irrigation using potable water. Accordingly, we feel it would benefit overall lake water quality to minimize that consumptive use by encouraging use of native vegetation and plants that do not require irrigation.

- Water Quality Protection Zone (WQPZ) - A WQPZ should be adopted that would identify the area where specific measures described above would apply (see Figure 6-1). Regulations for the WQPZ could be enforced through Comal County's permitting process.

7.0 REFERENCES

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ATTACHMENT A

SUMMARY OF METHODS FROM PREDICTING EFFECTS OF URBAN DEVELOPMENT ON WATER QUALITY IN THE CITIES OF NEW BRAUNFELS, SAN MARCOS, SEGUIN AND VICTORIA

ATTACHMENT A

SUMMARY OF METHODS FROM
PREDICTING EFFECTS OF URBAN DEVELOPMENT ON
WATER QUALITY IN THE CITIES OF NEW BRAUNFELS,
SAN MARCOS, SEGUIN AND VICTORIA (PBS&J, 2000)

With the support of the Clean Rivers Program Basin Steering Committee, PBS&J completed a report (PBS&J, 2000) designed to enhance public understanding of urban nonpoint source runoff issues by developing a preliminary quantification of urbanization effects. Recognizing that there has been essentially no urban runoff monitoring in the basin, the quantification is based on available data from other areas, primarily the City of Austin. The goal is to improve the level of public understanding of the issues that will provide a stronger basis for public action and support for efforts to manage and mitigate the effects of urbanization on water quality. The report focuses on four cities in the basin: Victoria, Seguin, New Braunfels, and San Marcos. These will be covered in the new Phase II MS4 regulations.

This summary is an excerpt from the report. The methods described are the same methods used in the Canyon Lake Study. Section 2 was extracted from the study, which describes the data and how the data were used to develop the loading results. Part of Section 3 was also extracted, to show how these numbers effected the overall results. Tables and figures from the report have also been included to accompany the text.

The City of Austin has had a strong interest in analyzing urban water quality conditions for many decades and has had active monitoring programs dating back to the 1970s. This section summarizes work performed by the City and lays the groundwork for a methodology to assess development impacts.

The City has been responsible for two types of water quality monitoring activity. One is monitoring of the major creeks in the urban area under both runoff and base flow conditions. This is performed by the USGS under contract to the City. Figure 2-1 shows the locations of the USGS monitoring sites. The other major type of urban water quality monitoring is for smaller, typically single land use watersheds. City personnel perform this monitoring. Active monitoring stations run by the City are shown in Figure 2-2.

The creek monitoring performed by the USGS under contract to the City of Austin has included collecting flow-weighted averages of many parameters during rain events as well as non-rain periods. Table 2-1 describes the creek monitoring sites and the percentage that runoff flows represent of the overall creek flow. For example, with Barton Creek at Hwy 71, 36% of the total flow is rainfall runoff while the remaining 64% of the total flow is not associated with runoff. Almost all of these partly urbanized creeks in the Austin area are intermittent. However, they are large enough to have flows not

Figure 2-1
USGS Stream Monitoring Sites

USGS Stream Monitoring Sites

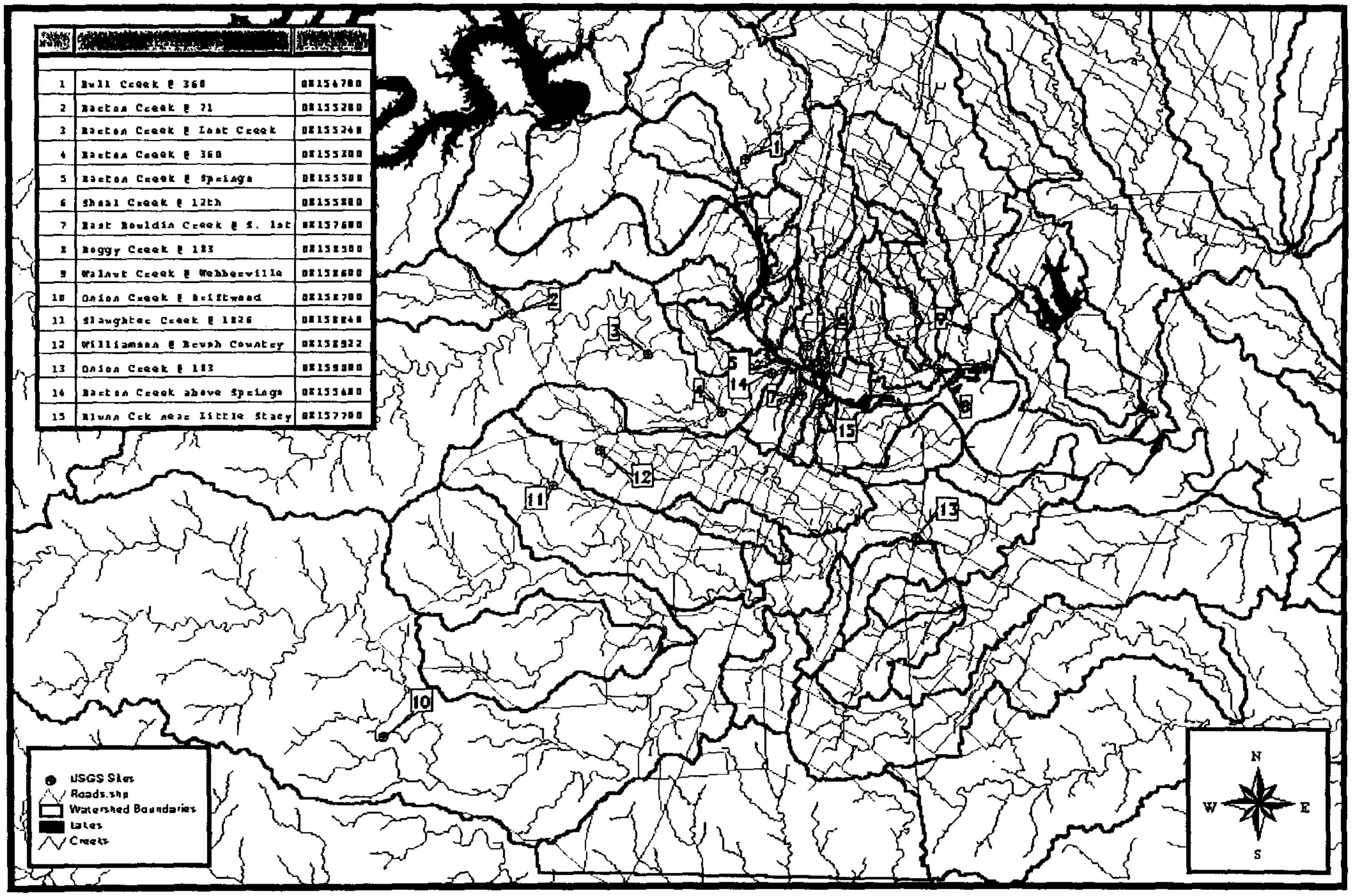


Figure 2-2
City of Austin Stormwater Sites

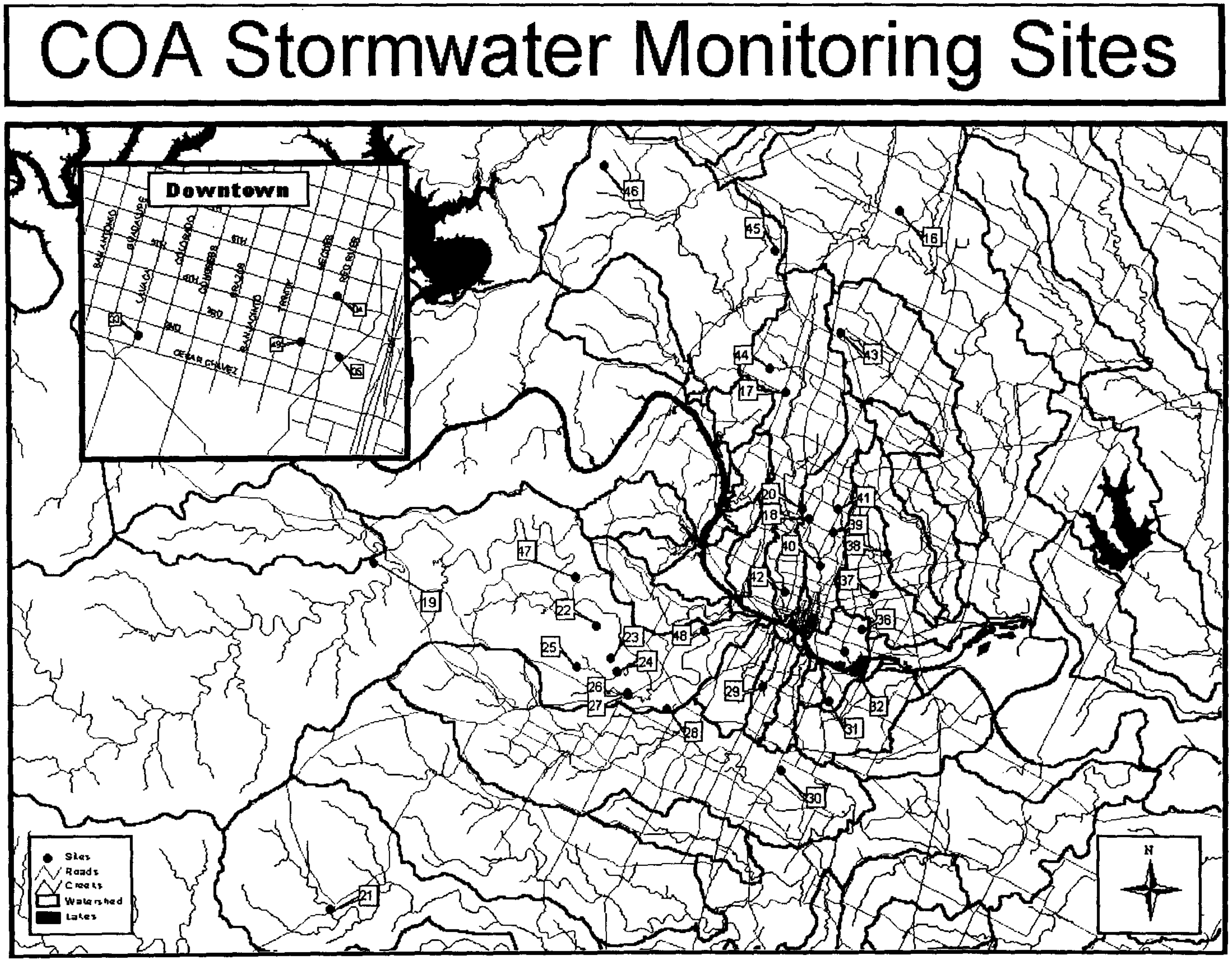


TABLE 2-1
USGS - CITY OF AUSTIN CREEK MONITORING DATA

ID Number[1]	Creek Monitoring Site	Drainage Area (Acres)	Drainage Area (Sq. Miles)	Impervious Cover (%)	Landuse	Period of Record	Runoff to Streamflow (%)
1	Bull Creek @ Loop 360	14,272	22.3	16	Mixed	78-96	39
2	Barton Creek @ Hwy 71	57,408	89.7	3	Mixed	78-96	36
3	Barton Creek @ Lost Ck. Blvd.	68,480	107.0	4	Mixed	89-96	36
4	Barton Creek @ Loop 360	74,240	116.0	5	Mixed	78-96	51
6	Shoal Creek @ 12th St.	7,872	12.3	46	Mixed	75-96	87
	Waller Creek @ 38th St.	1,443	2.3	47	Mixed	92-95	89
	Waller Creek @ 23rd St.	2,624	4.1	49	Mixed	92-95	87
8	Boggy Creek @ Hwy 183	8,384	13.1	43	Mixed	75-96	92
9	Walnut Creek @ Webberville Rd	32,832	51.3	26	Mixed	78-96	59
10	Onion Creek near Driftwood	79,360	124.0	3	Mixed		
	Bear Creek @ FM 1826	7,808	12.2	5	Mixed	78-96	28
11	Slaughter Creek @ FM 1826	5,274	8.2	8	Mixed	78-96	35
	Williamson Creek @ Oak Hill	4,032	6.3	22	Mixed	78-96	54

Source: City of Austin, 1997, Evaluation of Non-point Source Controls, Volumes 1-2, Report COA-ERM/WQM & WRE 1997-04

[1] Refer to Figure 2-1 USGS Stream Monitoring Sites

associated with runoff, at least during relatively wet periods. Only during prolonged dry periods do most of the creeks cease flowing entirely.

As noted above, the City has been monitoring smaller, single land use sites with varying degrees of urbanization. Table 2-2 lists the smaller City sites that were included in the City's 1997 data report, along with the land use and impervious cover percentages for these smaller watersheds. The ID numbers for the sites that are currently being used (Figure 2-2) is included in the left column of Table 2-2. Note that the largest drainage area shown in Table 2-2 is 371 acres (ac), while the smallest creek site listed in Table 2-1 is 1,443 ac. All of the smaller sites are normally dry and are only sampled during runoff conditions.

One of the fundamental aspects of urban water quality conditions is the effect of impervious cover (streets, roofs, etc.) on increasing runoff volume. One measure is the Runoff Coefficient (Rv), defined as the ratio of total runoff depth to total rain depth for all runoff events in a normal rainfall year. Figure 2-3, reproduced from the City of Austin (1997) shows Rv plotted against the percentage of impervious cover in the non-recharge zone. The City (1997) notes that this relation is similar for the larger creek watersheds with the exception of two creeks where a recharge channel and stormwater detention basins act to reduce the average amount of runoff that would be predicted by the amount of impervious cover.

Another way to view the effect of impervious cover on runoff is use a runoff model. This is illustrated in Figure 2-4, taken from the Texas Nonpoint SourceBOOK; a web page developed for the Texas Public Works Association. For an example 1 square mile watershed and a given 3.8-inch rain, the figure shows how the runoff hydrograph changes in response to development. As the land is developed from woodland to paved surface, the amount of total runoff increases from about 1.37 inches to 3.5 inches, and the peak flow goes from about 600 cfs to nearly 2,000 cfs. An undeveloped parcel of land will have most of the rain either caught in vegetation and evaporated or soaked into the soil, while a fully developed site will have most of the rain leave the site as runoff.

When discussing the quality of runoff samples, it is customary to employ a flow-weighted average, frequently called an Event Mean Concentration (EMC). This is necessary because the concentration of any parameter varies greatly during runoff events. A good example is the well-known first flush effect, where the initial concentration of dissolved and particulate matter in the runoff is markedly higher than in samples collected later in the event. Chang et al (1990) and (1994) note how this phenomenon is strongest for smaller watersheds with higher impervious cover percentages. An EMC is calculated from individual flow and concentration measurements taken during the course of the runoff event, considering the initial runoff and the trailing limb of the hydrograph.

Concentrations in stormwater are highly variable during a rain event and also vary substantially from one rain event to the next. Some of the reasons for the variability include differences in the size and intensity of the rain and differences in antecedent soil moisture conditions from one event

TABLE 2-2
CITY OF AUSTIN URBAN RUNOFF MONITORING SITES

ID Number[1]	Code Name	Site Name	Drainage Area (Acres)	Impervious Cover (%)	Landuse	No. of Measure-ments	Mean Rv
	AV	Alta Vista PUD	0.7	62	Manufactured	19	0.422
	BC	Bear Ck. Near Lake Travis	301.0	3	Undeveloped	23	0.014
	BCSM	Barton Creek Square Mall	47.0	86	Commercial	23	0.784
27	BNI	Roadway #6 BMP inflow	4.9	59	Transportation	8	
28	BRI	Barton Ridge Plaza	3.0	80	Commercial	17	0.765
26	BSI	Roadway BMP # 5 inflow	4.6	64	Transportation	5	0.662
31	BUA	Burton Road	12.0	82	Manufactured	17	
36	E7A	Seventh Street East	29.3	70	Industrial	10	
38	ERA	Municipal Airport	99.1	46	Industrial	15	0.365
19	FWU	Windago Way	50.0	1	Undeveloped	13	0.036
	HI	Highwood Apt.	3.0	50	Manufactured	25	
44	HL	Hart Lane	371.0	39	SF Residen.	33	0.163
45	JVI	Jollyville Rd	7.0	94	Transportation	28	0.711
47	LCA	Lost Creek Subdivision	209.9	23	SF Residential	18	0.102
33	LUA	Lavaca Street	13.7	97	Commercial	24	
43	MBA	Metric Blvd.	202.9	60	Industrial	22	0.511
	MI	Maple Run	27.8	36	SF Residential	25	
48	OFA	Spy Glass	3.0	88	Office	13	0.797
	RO	Rollingwood	62.8	21	SF Residential	19	0.05
30	SWI	St. Elmo St. East	16.4	60	Industrial	6	0.592
23	TCA	Travis Co. Ditch	40.7	37	SF Residential	22	0.178
24	TPA	Travis Co. Pipe	41.6	41	SF Residential	18	0.167
34	W5A	Waller Creek @ 5th St	4.0	95	Commercial	18	

Source: City of Austin, 1997, Evaluation of Non-point Source Controls, Volumes 1-2, Report COA-ERM/WQM & WRE 1997-04

[1] Refer to Figure 2-2 COA Stormwater Sites

FIGURE 2-3
CITY OF AUSTIN Rv AND IMPERVIOUS COVER RELATIONS

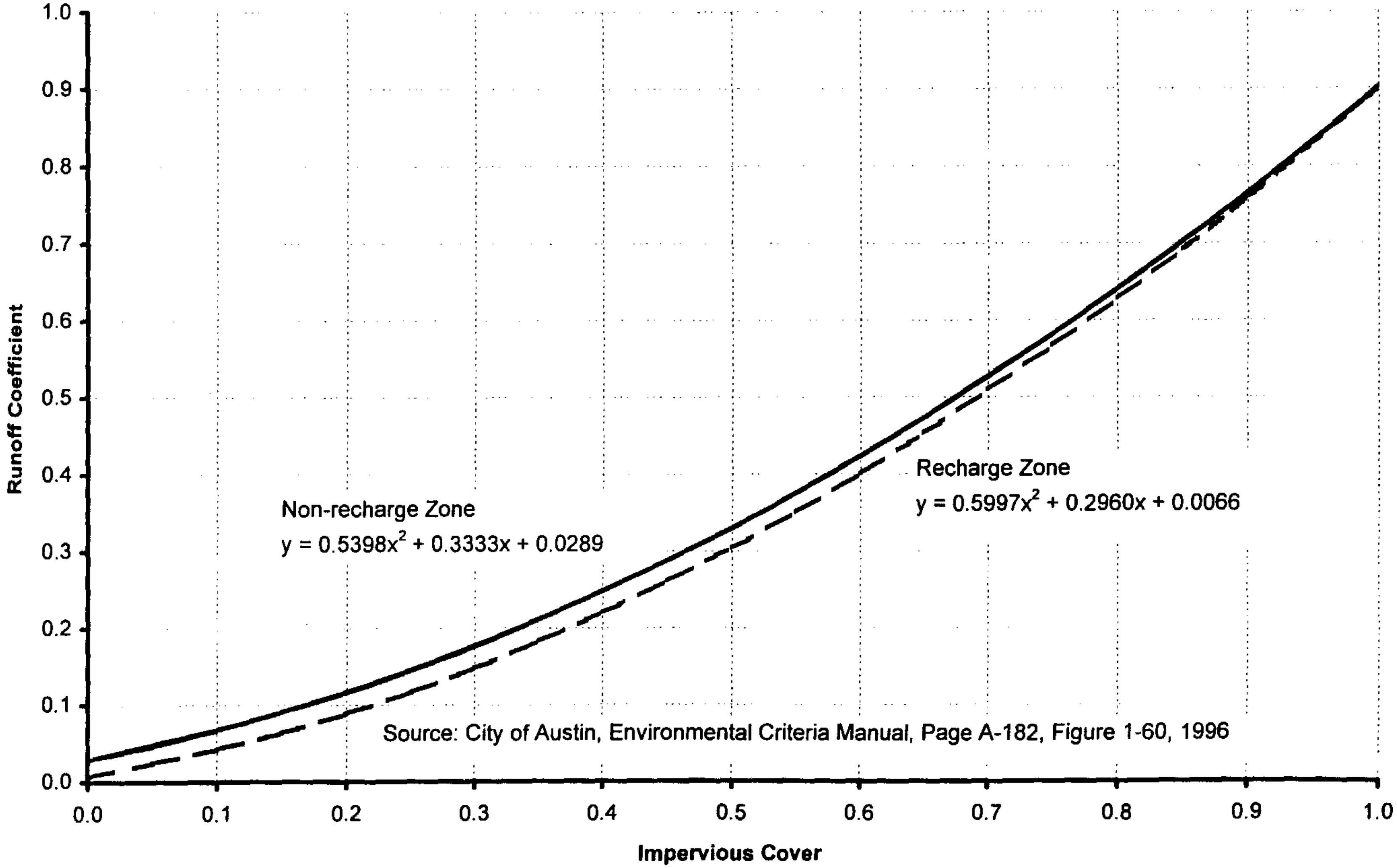
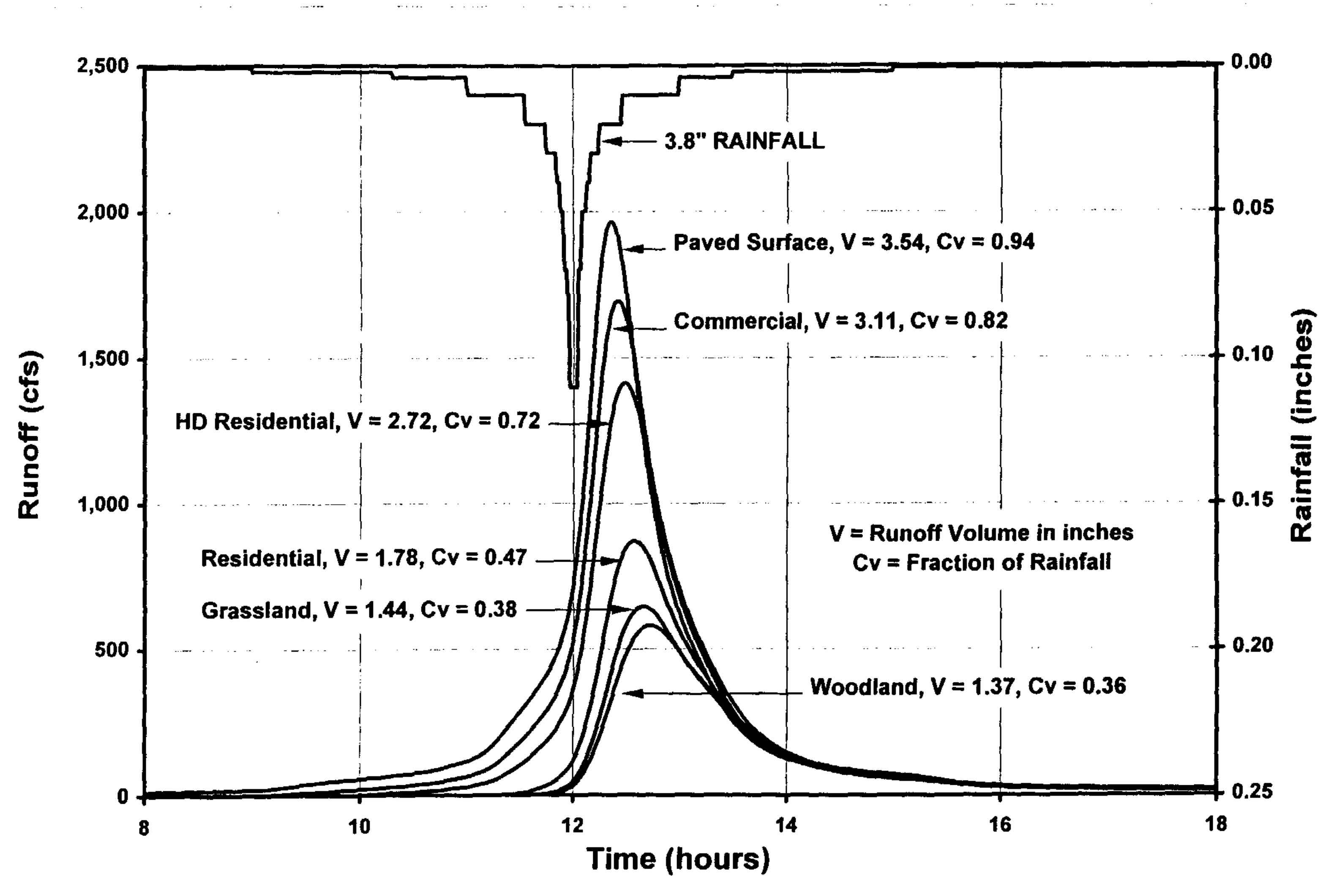


FIGURE 2-4
EFFECTS OF DEVELOPMENT ON RUNOFF VOLUMES



Source: Texas Nonpoint SourceBOOK, www.TXNPSbook.org to the next. Because of this variability the long-term concentration value for a site is an average or sometimes the median of a number of EMC values. With the data to be discussed, the City of Austin acceptance criteria was a minimum of 12 EMC values, with each consisting of at least three sets of flow and concentration for each parameter. Most sites have considerably more data.

Table 2-3 presents for the city stations the long-term flow-weighted average of Total Suspended Solids (TSS), Total Nitrogen (TN, the sum of Total Kjeldahl and Nitrate-Nitrite-N), Total Phosphorus (TP) and Fecal Coliform (FC). Also included are the medians of all the EMC observations for TSS and FC. Note that the flow-weighted average values are somewhat higher than the medians of the EMC observations.

Table 2-4 presents similar long-term average values for the same parameters for the USGS creek monitoring stations. With the USGS data the city computed the long-term average using empirical relations between flow and concentration for each site, using a method developed by the USGS. Also shown in Table 2-4 are the average concentrations collected under baseflow or non-runoff conditions. The non-runoff averages are substantially lower than the runoff data, as illustrated in Figure 2-5 for TSS and Figure 2-6 for FC. While the runoff concentrations are orders of magnitude larger than non-runoff data, the runoff conditions are relatively rare, lasting only a matter of hours each month. With FC, the runoff data are much higher than the geometric mean level of 200 cfu/dL the state water quality criterion for contact recreation use. The sites that have water and can be sampled during non-runoff periods (the creek stations) have much lower FC levels at these times. Accordingly, there appears to be little doubt that a major factor in stream FC bacteria levels is the presence of runoff. Landuse may not be as important a factor in the concentration of bacteria in runoff, but it is clearly a major factor in runoff flows, which appear to be a major factor in creek scour and the resultant concentrations of most parameters.

Figure 2-7 shows the long-term average EMCs for TSS for both the smaller sites and the larger creek sites listed in Tables 2-3 and 2-4, plotted versus impervious cover percentage in the contributing watershed. One observation from Figure 2-7 is that there is a major difference between the TSS levels in the smaller city sites and the larger creek sites. While the smaller sites are tributaries to the larger creek sites, the values appear to be substantially lower than the creek sites. The major reason for the difference noted by the City (1990) is erosion of the creek beds and banks due to greater flow energy. The smaller sites are almost always in a drainage structure such as a culvert or grassed channel where erosion is not a factor, while the creek sites are in streams that have a natural bottom. During runoff events, the creeks with a much larger volume of flow experience scour of the streambed, putting sediment into suspension at concentrations considerably higher than that of the small tributary inflows. This streambed scour is accelerated by larger amounts of runoff flows produced by higher impervious cover in some of the watersheds. In contrast, the smaller sites do not have established and erodible channels, and contribute relatively low TSS concentrations whether they have low or high impervious cover.

TABLE 2-3
CITY OF AUSTIN URBAN RUNOFF CONCENTRATION VALUES

Site Name	Impervious Cover (%)	Flow-weighted Mean				Median of All EMC Data			
		TSS (mg/L)	TN (mg/L)	TP (mg/L)	FC (cfu/dL)[1]	TSS (mg/L)	TN (mg/L)	TP (mg/L)	FC (cfu/dL)[1]
Alta Vista PUD	62	23	2.10	0.52		20	2.07	0.46	22,918
Bear Ck. Near Lake Travis	3	113	0.49	0.05	24,552	30	0.39	0.04	3,847
Barton Creek Square Mall	86	214	2.05	0.25		133	1.73	0.21	34,208
Roadway #6 BMP inflow	59	444	1.90	0.49		245	1.36	0.26	
Barton Ridge Plaza	80	224	2.23	0.33	12,482	183	1.94	0.27	1,737
Roadway BMP # 5 inflow	64	117	1.44	0.28		90			
Burton Road	82	267	2.36	0.52	84,797	127	2.10	0.42	42,117
Seventh Street East	70	123	2.07	0.67	83,866	98	1.86	0.54	29,082
Municipal Airport	46	51	2.02	0.70	11,378	42	1.74	0.55	6,939
Windago Way	1	254	1.61	0.15	15,729	105	1.30	0.14	3,776
Highwood Apt.	50	110	1.01	0.20	39,166	70	0.69	0.12	5,265
Hart Lane	39	187	2.06	0.29	48,097.	93	1.65	0.20	9,474
Jollyville Rd	94	328	1.56	0.24		248	1.39	0.20	
Lost Creek Subdivision	23	117	1.68	0.29	28,149	70	1.55	0.13	12,377
Lavaca Street	97	162	2.37	0.45	58,726	136	2.51	0.46	33,568
Metric Blvd.	60	277	2.00	0.43	18,311	165	1.98	0.42	8,483
Maple Run	36	305	1.23	0.25	35,600	111	0.88	0.19	15,189
Spy Glass	88	43	2.12	0.18	14,815	35	2.10	0.16	8,945
Rollingwood	21	228	1.92	0.27	15,180	133	1.63	0.18	5,663
St. Elmo St. East	60	172	1.87	0.31	30,426	109	1.73	0.29	7,391
Travis Co. Ditch	37	40	1.45	0.23	46,041	18	1.35	0.19	14,510
Travis Co. Pipe	41	139	2.17	0.45	36,458	84	2.17	0.38	34,615
Waller Creek @ 5th St	95	142	3.30	0.59	53,650	118	3.03	0.55	42,359

Source: City of Austin, 1997, Evaluation of Non-point Source Controls, Volumes 1-2, Report COA-ERM/WQM & WRE 1997-04
[1] (Colony forming unit/deciLiter)

TABLE 2-4

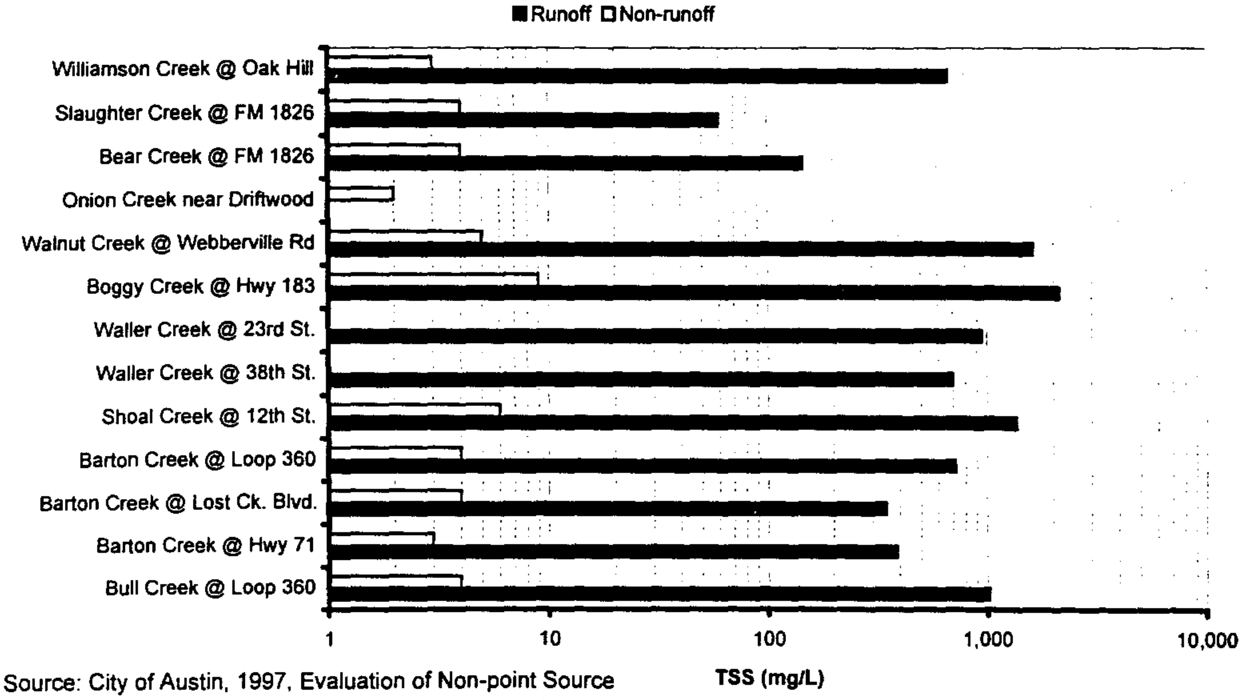
LARGE CREEK FLOW WEIGHTED AVERAGE RUNOFF AND NON-RUNOFF CONCENTRATION VALUES

Creek Monitoring Site	Impervious Cover (%)	Runoff				Non-runoff			
		TSS (mg/L)	TN (mg/L)	TP (mg/L)	FC (cfu/dL)[1]	TSS (mg/L)	TN (mg/L)	TP (mg/L)	FC (cfu/dL)[1]
Bull Creek @ Loop 360	16	1,023	2.90	0.28	29,426	4	0.55	0.02	564
Barton Creek @ Hwy 71	3	386	1.09	0.11	13,625	3	0.37	0.02	67
Barton Creek @ Lost Ck. Blvd.	4	345	1.05	0.13	12,381	4	0.39	0.03	80
Barton Creek @ Loop 360	5	719	2.08	0.18	22,940	4	0.62	0.01	38
Shoal Creek @ 12th St.	46	1,364	3.29	0.92	155,398	6	1.04	0.05	9,450
Waller Creek @ 38th St.	47	700	3.86	0.95	67,599				
Waller Creek @ 23rd St.	49	947	3.94	1.15	102,609				
Boggy Creek @ Hwy 183	43	2,131	3.74	1.35	190,441	9	0.82	0.05	3,023
Walnut Creek @ Webberville Rd	26	1,632	2.17	0.75	53,133	5	1.05	0.03	533
Onion Creek near Driftwood	3					2	0.42	0.02	85
Bear Creek @ FM 1826	5	146	1.09	0.05	5,217	4	0.52	0.02	112
Slaughter Creek @ FM 1826	8	60	1.00	0.06	20,131	4	0.51	0.02	94
Williamson Creek @ Oak Hill	22	674	2.91	0.51	71,197	3	0.56	0.17	251

Source: City of Austin, 1997, Evaluation of Non-point Source Controls, Volumes 1-2, Report COA-ERM/WQM & WRE 1997-04

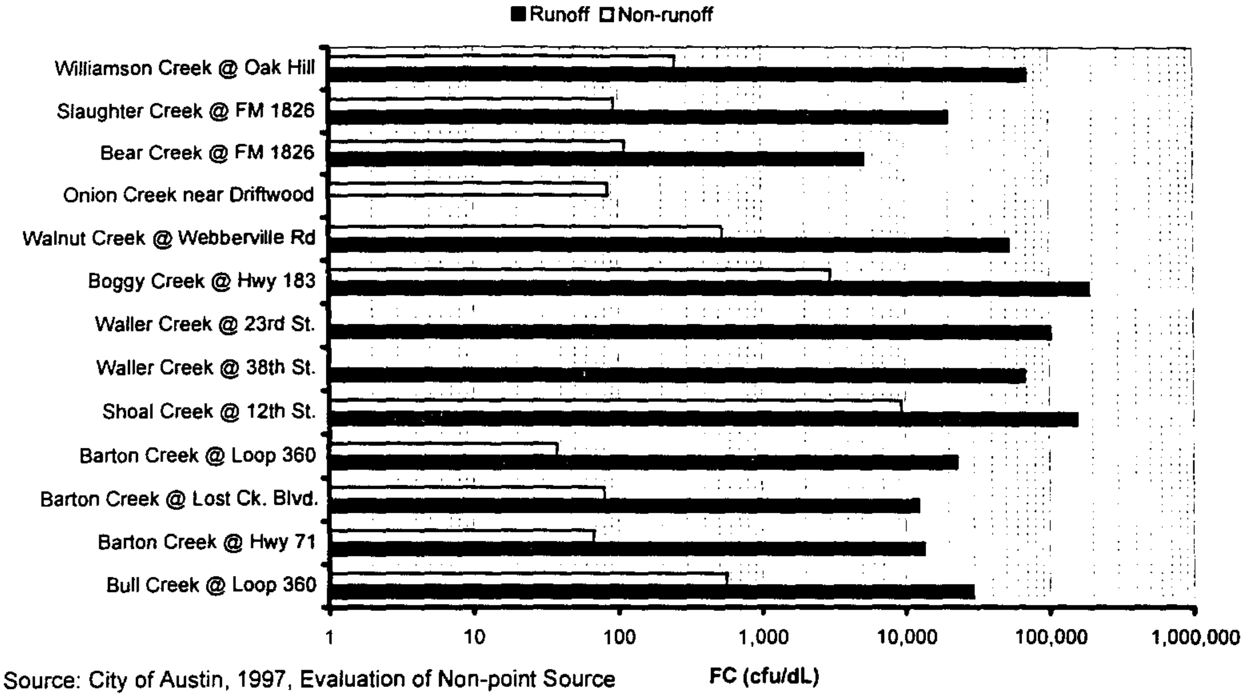
[1] (Colony forming unit/deciLiter)

FIGURE 2-5
CREEK RUNOFF AND NON-RUNOFF TSS DATA



Source: City of Austin, 1997, Evaluation of Non-point Source Controls, Volumes 1-2, Report COA-ERM/WQM & WRE 1997-04

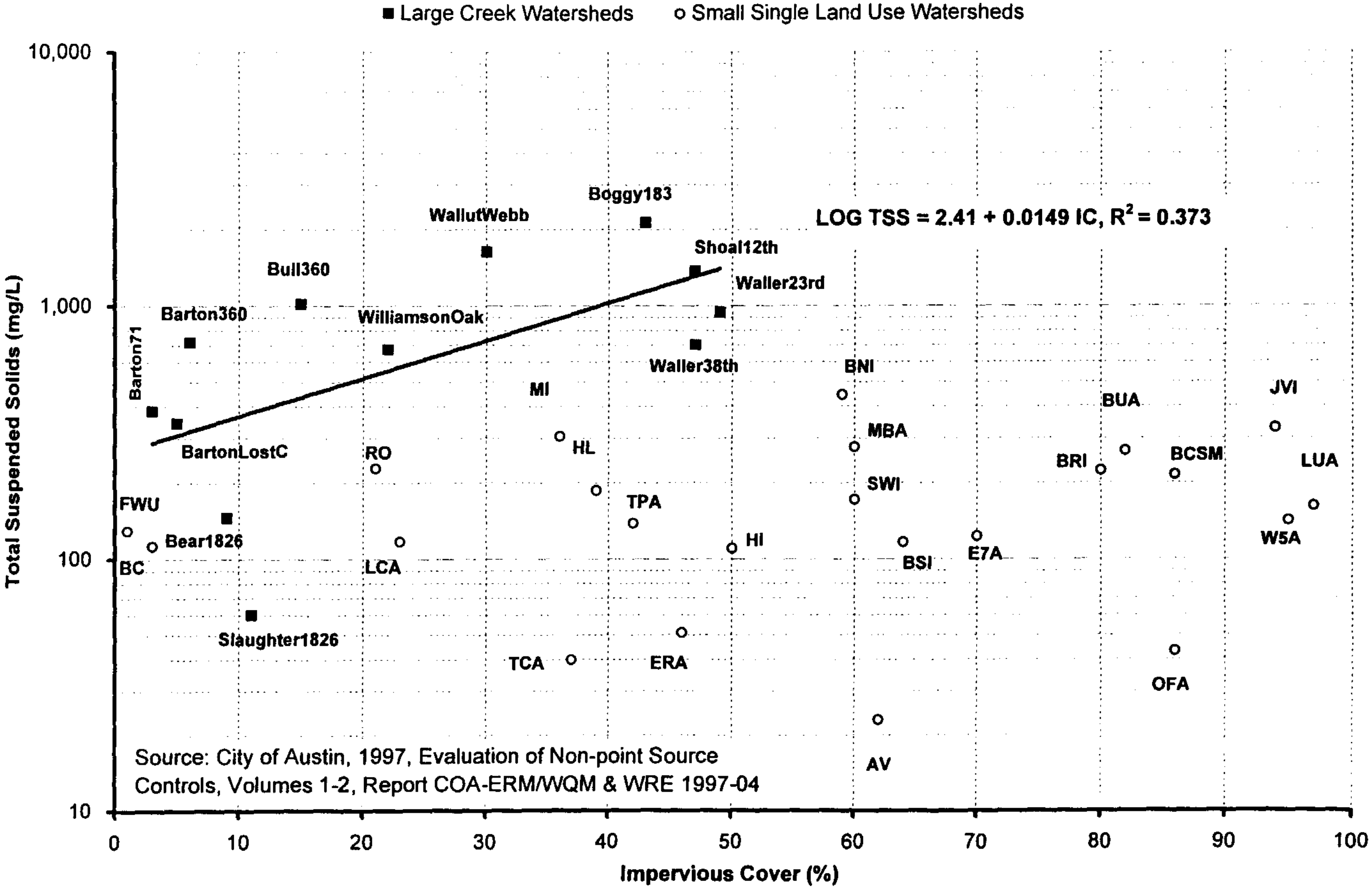
FIGURE 2-6
CREEK RUNOFF AND NON-RUNOFF FC DATA



Source: City of Austin, 1997, Evaluation of Non-point Source Controls, Volumes 1-2, Report COA-ERM/WQM & WRE 1997-04

FIGURE 2-7

TSS MEAN EMCs FOR CITY OF AUSTIN STORMWATER RUNOFF



The other major observation from Figure 2-7 is the different responses of the smaller and larger watersheds to impervious cover. For the smaller urban sites, there does not appear to be a relation between the intensity of landuse, as indicated by impervious cover percentage, and the long-term average runoff concentrations of TSS. With the larger creek sites in Figure 2-7, there does appear to be somewhat higher TSS concentrations with greater impervious cover. The regression line and equation fitted to the creek data has a correlation coefficient of 0.61.

A similar pattern can be seen for TN in Figure 2-8, TP in Figure 2-9, and FC in Figure 2-10. In some cases there may be a relation for the smaller sites, but if a relation exists, it is not strong. In general, increasing the amount of paved or roofed impervious surface in smaller watersheds does not generate additional erodible particulate matter or associated nutrients or bacteria so there is little change in the concentrations of these parameters with increasing impervious cover. In the smaller watersheds, say a parking lot, the amount of particulate matter that can be washed off in a rain is finite. In the creeks however, increasing impervious cover in the watershed increases the amount of runoff and stream flow, which increases the amount of streambed erosion, which increases the amount of sediment, nutrients and bacteria in suspension.

All of the runoff data start with rain. While rain does not contain much particulate matter or bacteria, with nitrogen and phosphorus there is a substantial contribution in the rain itself. Figures 2-8 and 2-9 show the average concentrations in Austin rainfall in relation to the runoff data. It can be seen that rainfall explains most of the TN in the runoff, while it only represents about a third of the TP in runoff.

Another factor that must be considered in assessing urban runoff data is the contribution from sanitary sewer leakage or overflows. While not an everyday event, unintended releases can occur particularly as wastewater collection systems age. This undoubtedly plays some role in the observed stormwater data. For example, the creeks in Austin that drain older and more developed areas, Shoal, Boggy, Waller, and Walnut, all have higher runoff FC values and also tend to show higher non-runoff values than do the creeks in newer and less developed areas. How much of this difference can be attributed to sanitary sewer leakage and how much is simply a result of greater urban density and higher impervious cover would be very difficult to quantify. While it may not be easily quantifiable, the sewer leakage potential in older urban areas must be recognized.

All of the urban drainage from New Braunfels goes to the Guadalupe River upstream of Lake Dunlap, a run-of-river impoundment that provides both hydroelectric power and recreational uses. A short distance downriver is Lake McQueeney that provides a similar function.

The calculations for those water bodies are shown in tables 3-10 to 3-13. Table 3-10 provides the watershed areas and estimated present impervious cover. Also shown are the assumed present distribution of population between watersheds and the assumed distribution of population changes. The basic assumption is that in the future slightly more of the development will occur in the Blieders Creek watershed than has been the case in the past.

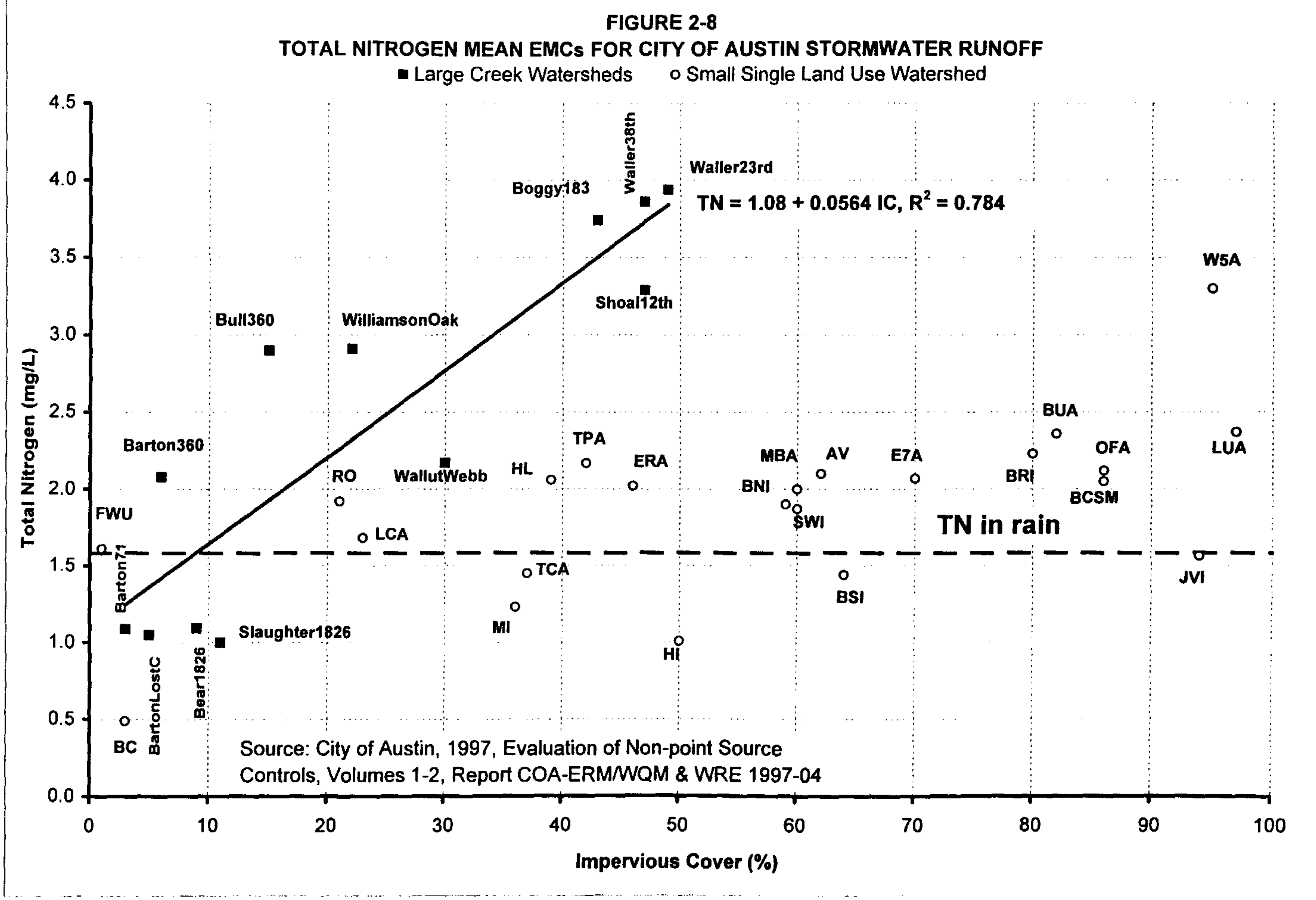


FIGURE 2-8
TOTAL NITROGEN MEAN EMCs FOR CITY OF AUSTIN STORMWATER RUNOFF
■ Large Creek Watersheds
o Small Single Land Use Watershed
Total Nitrogen (mg/L)
Impervious Cover (%)
TN = 1.08 + 0.0564 IC, R2 = 0.784
TN in rain
Waller23rd
Waller38th
Boggy183
Shoal12th
Bull360
WilliamsonOak
Barton360
WallutWebb
FWU
Barton71
BartonLostC
Bear1826
Slaughter1826
BC
RO
LCA
HL
TPA
ERA
TCA
MI
HI
MBA
AV
E7A
BNI
SWI
BSI
BUA
BRI
OFA
BCSM
W5A
LUA
JVI
Source: City of Austin, 1997, Evaluation of Non-point Source
Controls, Volumes 1-2, Report COA-ERM/WQM & WRE 1997-04

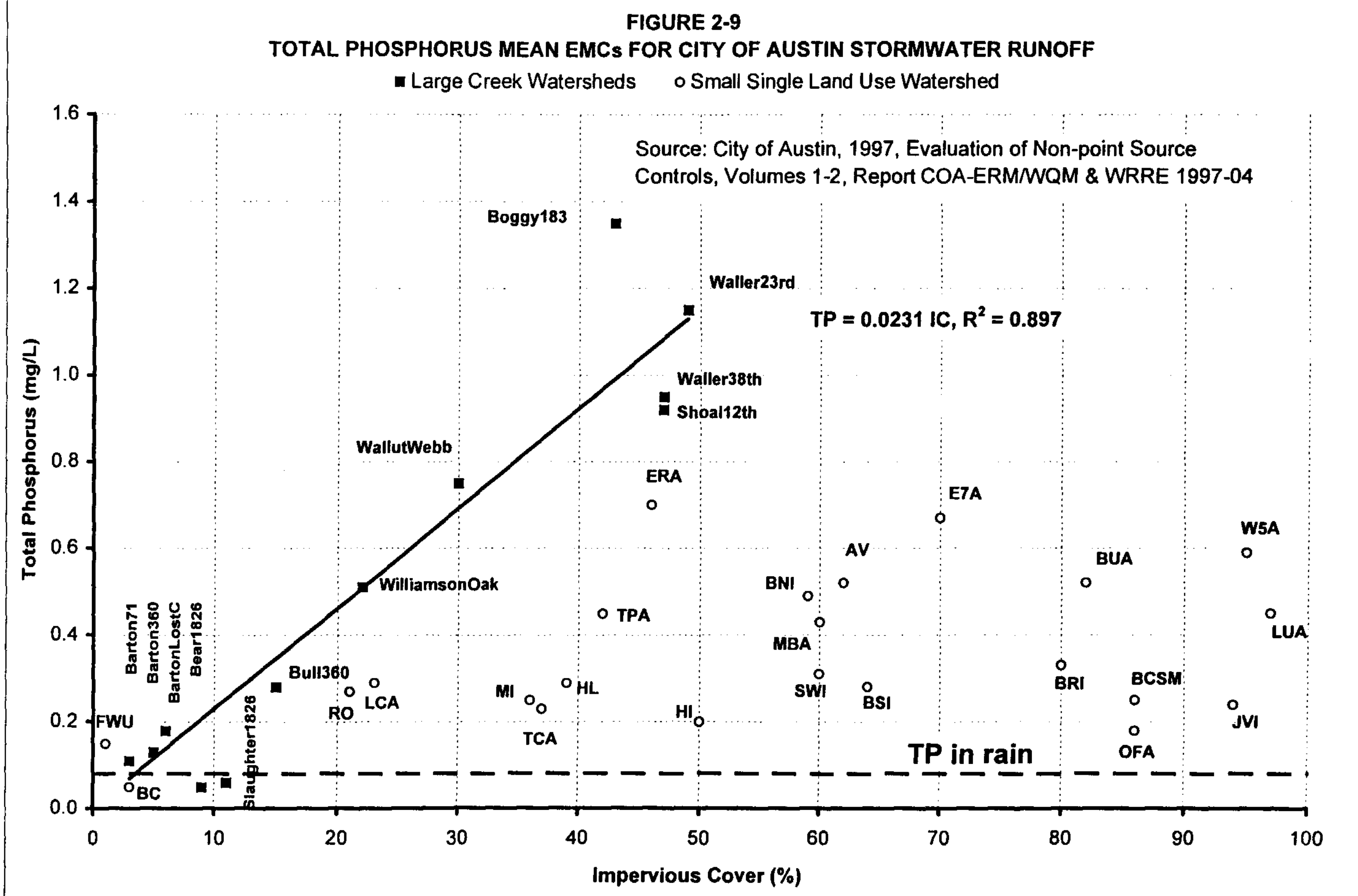


FIGURE 2-9
TOTAL PHOSPHORUS MEAN EMCs FOR CITY OF AUSTIN STORMWATER RUNOFF
Large Creek Watersheds
Small Single Land Use Watershed
Source: City of Austin, 1997, Evaluation of Non-point Source Controls, Volumes 1-2, Report COA-ERM/WQM & WRRE 1997-04
TP = 0.0231 IC, R² = 0.897
TP in rain
Total Phosphorus (mg/L)
Impervious Cover (%)
Boggy183
Waller23rd
Waller38th
Shoal12th
WallutWebb
WilliamsonOak
Bull360
Barton71
Barton360
BartonLostC
Bear1826
Slaughter1826
FWU
BC
RO
LCA
MI
TCA
HL
TPA
ERA
HI
BNI
AV
MBA
SWI
BSI
E7A
BUA
BRI
BCSM
OFA
W5A
LUA
JVI
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
10
20
30
40
50
60
70
80
90
100

FIGURE 2-10
FECAL COLIFORM MEAN EMCs FOR CITY OF AUSTIN STORMWATER RUNOFF

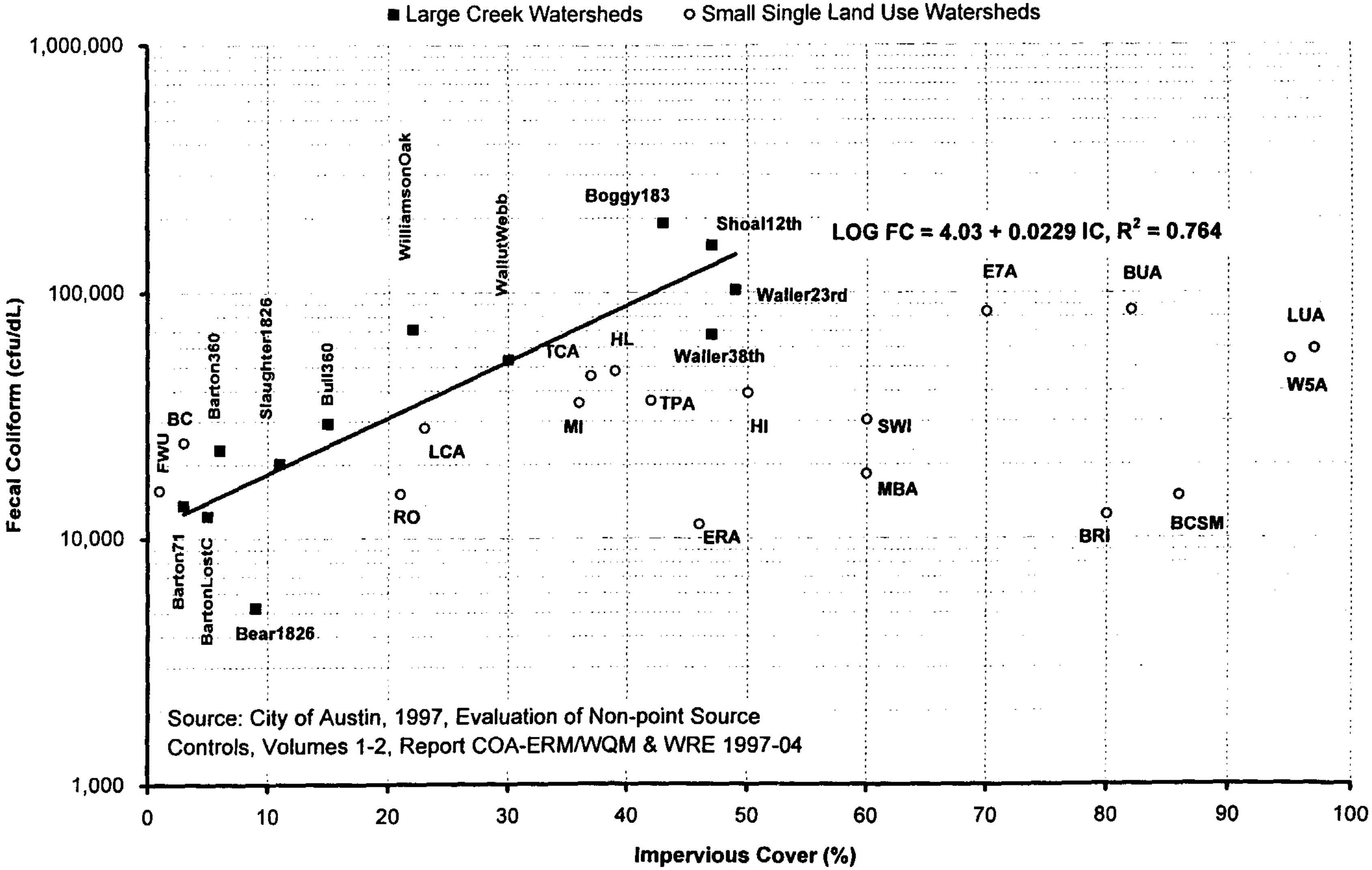


TABLE 3-10
DATA FOR SELECTED WATERSHEDS OF THE CITY OF NEW BRAUNFELS

Watershed	Watershed area (acres)	% Impervious cover	Impervious area (acres)	Assumed population distribution [2]	Assumed distribution of population change [3]
Dry Comal Creek	71,414	7.6%	5,427	30%	20%
Blieders Creek	10,525	16.2%	1,705	15%	20%
Comal River [1]	83,063	9.2%	7,610	55%	45%
Tributary of Guadalupe River	3,093	34.5%	1,067	15%	15%

[1] Includes Dry Comal Creek and Blieders Creek watersheds.
[2] Assumed distribution for 1960 to 2000 city population.
[3] Assumed distribution of city population change of 2010 and 2020 from 2000.

TABLE 3-11
ESTIMATION OF PERCENTAGE IMPERVIOUS COVER AND RUNOFF COEFFICIENT
FOR THE CITY OF NEW BRAUNFELS

Watershed	1960	1970	1980	1990	2000	2010	2020
Population							
Dry Comal Creek	4,689	5,358	6,721	8,200	11,521	13,882	16,924
Blieders Creek	2,345	2,679	3,361	4,100	5,761	8,121	11,163
Comal River [1]	8,597	9,822	12,322	15,034	21,122	26,434	33,278
Tributary of Guadalupe River	2,345	2,679	3,361	4,100	5,761	7,531	9,813
Total city population	15,631	17,859	22,404	27,334	38,404	50,207	65,417
Impervious area (acres) [2]							
Dry Comal Creek	4,334	4,441	4,659	4,896	5,427	5,805	6,292
Blieders Creek	1,158	1,212	1,321	1,439	1,705	2,083	2,569
Comal River [1]	5,606	5,802	6,202	6,636	7,610	8,460	9,555
Tributary of Guadalupe River	521	574	683	801	1,067	1,350	1,715
Percentage impervious cover							
Dry Comal Creek	6.1%	6.2%	6.5%	6.9%	7.6%	8.1%	8.8%
Blieders Creek	11.0%	11.5%	12.6%	13.7%	16.2%	19.8%	24.4%
Comal River [1]	6.7%	7.0%	7.5%	8.0%	9.2%	10.2%	11.5%
Tributary of Guadalupe River	16.8%	18.6%	22.1%	25.9%	34.5%	43.7%	55.5%
Runoff coefficient [3]							
Dry Comal Creek	5.1%	5.2%	5.3%	5.4%	5.7%	6.0%	6.2%
Blieders Creek	7.2%	7.4%	7.9%	8.5%	9.7%	11.6%	14.2%
Comal River [1]	5.4%	5.5%	5.7%	5.9%	6.4%	6.8%	7.4%
Tributary of Guadalupe River	10.0%	10.9%	12.9%	15.1%	20.8%	27.7%	38.0%

[1] Includes Dry Comal Creek and Blieders Creek watersheds.
[2] Change in impervious cover is estimated from the change in population and impervious area per capita.
[3] Values calculated from regression developed in Section 2.0.

TABLE 3-12
CALCULATED RUNOFF EMCs OF SELECTED PARAMETERS FOR THE CITY OF NEW BRAUNFELS [1]

Watershed	1960	1970	1980	1990	2000	2010	2020
TSS (mg/L)							
Dry Comal Creek	317	318	322	325	334	340	348
Blieders Creek	375	382	395	411	448	507	594
Comal River [2]	324	327	332	338	352	365	381
Tributary of Guadalupe River	458	486	548	625	840	1150	1723
TN (mg/L)							
Dry Comal Creek	1.42	1.43	1.45	1.47	1.51	1.54	1.58
Blieders Creek	1.70	1.73	1.79	1.85	1.99	2.20	2.46
Comal River [2]	1.46	1.47	1.50	1.53	1.60	1.65	1.73
Tributary of Guadalupe River	2.03	2.13	2.33	2.54	3.03	3.54	4.21
TP (mg/L)							
Dry Comal Creek	0.14	0.14	0.15	0.16	0.18	0.19	0.20
Blieders Creek	0.25	0.27	0.29	0.32	0.37	0.46	0.56
Comal River [2]	0.16	0.16	0.17	0.18	0.21	0.24	0.27
Tributary of Guadalupe River	0.39	0.43	0.51	0.60	0.80	1.01	1.28
FC (cfu/dL)							
Dry Comal Creek	14,757	14,874	15,115	15,382	15,997	16,449	17,051
Blieders Creek	19,145	19,665	20,770	22,038	25,176	30,420	38,820
Comal River [2]	15,295	15,487	15,885	16,329	17,370	18,333	19,653
Tributary of Guadalupe River	26,025	28,509	34,336	42,009	66,077	107,098	199,548

[1] Values calculated from impervious cover and regressions developed in Section 2.0.

[2] Includes Dry Comal Creek and Blieders Creek watersheds.

TABLE 3-13
RUNOFF LOAD CHANGES FOR SELECTED PARAMETERS FROM THE CITY OF NEW BRAUNFELS

Parameter	1960	1970	1980	1990	2000	2010	2020
Dry Comal Creek							
TSS	85%	86%	89%	92%	100%	106%	114%
TN	84%	86%	89%	92%	100%	106%	114%
TP	71%	74%	79%	85%	100%	111%	126%
FC	82%	84%	87%	91%	100%	107%	116%
Blieders Creek							
TSS	62%	65%	72%	80%	100%	135%	195%
TN	63%	67%	73%	81%	100%	132%	181%
TP	50%	55%	63%	74%	100%	146%	221%
FC	57%	60%	67%	76%	100%	144%	226%
Comal River [1]							
TSS	78%	80%	84%	89%	100%	111%	126%
TN	77%	79%	83%	88%	100%	111%	126%
TP	62%	65%	72%	80%	100%	119%	146%
FC	74%	76%	81%	87%	100%	113%	132%
Tributary of Guadalupe River							
TSS	26%	30%	40%	54%	100%	182%	375%
TN	32%	37%	48%	61%	100%	156%	254%
TP	24%	28%	40%	55%	100%	169%	293%
FC	19%	23%	32%	46%	100%	216%	551%
Total [2]							
TSS	66%	69%	74%	81%	100%	127%	182%
TN	69%	71%	77%	83%	100%	119%	150%
TP	50%	54%	62%	72%	100%	135%	192%
FC	57%	59%	66%	74%	100%	145%	264%

[1] Includes Dry Comal Creek and Blieders Creek watersheds.

[2] Runoff loads are calculated as area-weighted averages of the watersheds (Comal River and Tributary of Guadalupe River).

Using those estimates of where population growth will occur, and the value of 0.16 ac of impervious cover per capita, the projected percentage increases in impervious area, runoff coefficients and concentrations are shown in tables 3-11 and 3-12. Table 3-13 shows the calculated runoff load changes for each of the watersheds for each parameter. The largest changes are calculated for the small tributary on the southwest side of the city. This is a consequence of assuming the same distribution of future population change in a watershed that is of modest size and already substantially developed. With additional development the watershed gets to 55% impervious cover, with corresponding higher runoff and concentration values. Whether this level of development will occur in this watershed remains to be seen, but it does serve to illustrate the sensitivity of the results to increases in development. The runoff loads from Blieders Creek, which drains to Landa Lake and the main areas of Comal Springs, are projected to increase by a factor of two.

ATTACHMENT B

SEPTIC TANK EFFLUENT DATA

ATTACHMENT B

SEPTIC TANK EFFLUENT DATA

Literature quantifying septic tank effluent varies substantially. Tables B-1 and B-2 (attached) summarize the data found from various sources. These studies measured the effective removal rate in various conditions over time. Data include different soil type and effluent application amounts, and different types of systems.

Most of the studies have focused on the movement of nitrogen through soils; thus, there is more data on nitrogen species. The Cogger et al. study (1984) measured the movement of effluent by monitoring groundwater surrounding septic systems. Shallow wells were monitored monthly. The Brown et al study (1984) was similar in that effluent was monitoring moving through different types of soil. Jensen et al. (1977) compiled data from several other sources and averaged these for use in this study. Canter et al. (1985) similarly compared data.

Best professional judgment was used to determine which numbers to represent the Canyon Lake study area. The data were compiled and used to determine loads based on 90% and 99% removal rates, and based on average usage of 100 gallons a day per household. These data are shown on Table B-3.

Table B-1
Septic Tank Effluent Data Compilation

Average of Septic Tank Effluent Data						
		*1	*2	*3	*4	*5
BOD	mg/L			129-147	140	110
TSS	mg/L			44-54	75	53
VSS	mg/L			32-39		44
Organic Nitrogen	mg/L		7			11.9
NH3-N	mg/L	38		28-34		24.9
NO2-N	mg/L		<.05			0.025
NO3-N	mg/L	<.5	0	<0.1-0.9		0.25
Organic Phosphorus	mg/L					3.1
PO4-P	mg/L			10-12		15.7
Total coliform	col/100 ml					44.6×10^6
Fecal coliform	col/100 ml					$.42 \times 10^6$
TKN	mg/L	44				
Total Phosphorus	mg/L	7		12	15	
COD	mg/L	384		310-344	300	
NH4-N	mg/L	38	25			
Total Nitrogen	mg/L		32	41-49	40	
pH	mg/L		7			
BOD Filtered	mg/L			100-118		

*1 = Cogger, CG and Carlile, BL. 1984. Field Perfomance of Conventional and Alternative Septic Systems in Wet Soils. J. Environ. Qual, Vol. 13, no. 1.

*2 = Brown, KW, Donnelly, KC, Thomas, JC, and Slowey, JF. 1984. The movement of nitrogen species through three soils below septic fields. J. Environ. Qual, Vol. 13, No. 3.

*3 = Canter, Larry W. and Knox, Robert C. 1985. Septic tank system effects on ground water quality. Lew Publishers, Inc. 53-54.

*4 = Canter, Larry W. and Knox, Robert C. 1985. Septic tank system effects on ground water quality. Lew Publishers, Inc. 53. Based on composite information from several different sources

*5 = Jensen, Paul A. and Weeks, Townsend. Analysis and Estimation of Discharges from Waterfront Septic Tanks, Tidal Marshes, and Recreational Boating. Task Report 2324. 1977.

Table B-2
Bacteriological Data

Bacteriological Data from a Typical Absorption Field in Sandy Soil			
	*1	*2	*3
Fecal streptococci	2-7.2 x 10^3	8 x 103 - 2 x 10^5	160,000
Fecal coliform	2.9-6.2 x 10^5	2.5 x 106 - 1 x 10^7	1,900,000
Total coliform	2.6-4.4 x 10^6		5,700,000
Total bacteria	2.5-4.8 x 10^8		3 x 10^{-7}

*1 = Canter, Larry W. and Knox, Robert C. 1985. Septic tank system effects on ground water quality. Lew Publishers, Inc. Pg 56.

*2 = Canter, Larry W. and Knox, Robert C. 1985. Septic tank system effects on ground water quality. Lew Publishers, Inc. Pg 56. Second reference in table

*3 = Jensen, Paul A. and Weeks, Townsend. Analysis and Estimation of Discharges from Waterfront Septic Tanks, Tidal Marshes, and Recreational Boating. Task Report 2324. 1977.

Table B-3
Canyon Lake OSSF Removal Rates

	FROM SEPTIC TANK (mg/L)	DRAINFIELD REMOVAL %		CONCENTRATION IN GROUNDWATER		LOAD TO LAKE PER HOUSE AT 100 GAL. DAY (grams/day)		Y2000 LOAD TO LAKE FOR TOTAL RESIDENCES (grams/day)		Y2000 LOAD TO LAKE FOR TOTAL RESIDENCES (Kg/Yr)	
				90%	99%	90%	99%	90%	99%	90%	99%
NH3-N	24.9	90	99	2.49	0.249	0.94	0.09	10,215	1,021	3,728	373
NO3-N	0.25	90	99	0.025	0.0025	0.01	0.00	103	10	37	4
Org- N	11.9	90	99	1.19	0.119	0.45	0.05	4,882	488	1,782	178
Total N	37.1			3.71	0.37	1.40	0.14	15,199	1,520	5,548	555
Total P	7	90	99	0.7	0.07	0.26	0.03	2872	287	1,048	105

ATTACHMENT C

APPLICABLE COMAL COUNTY LAND DEVELOPMENT REGULATIONS

Revisions to
Comal County Subdivision Rules and Regulations

Approved by Order of the Comal County Commissioners Court on April 16, 2001.
This Order takes effect April 16, 2001.

1. **<u>Section A, Regulations, Subsection IV. Plats, A. Accompanying Data for Submission for Preliminary Plat Approval, Paragraph 10:</u>**

Delete paragraph and replace with the following:

10. Engineering Design of Storm Water Drainage and Management Plan

a. 100-year Storm Event Inundation Analysis

Provide an engineering analysis showing those areas within the platted area that are subject to storm water inundation during the 100-year storm event. This analysis should be in the form of engineering calculations and an overall plan view of the subdivision showing the areas of 100-year inundation with the areas shaded or crosshatched. The analysis shall be based on the anticipated fully developed condition of the platted area, including any proposed building, paving, clearing, drainage, roadway, excavation, fill or other significant environmental modifications affecting peak flow rates of storm water runoff. The analysis shall only consider watersheds greater than 10 acres.

The analysis shall take into consideration all contributing watersheds to the extent that they affect or cause inundated areas within the platted area. A contributing watershed is a drainage area that drains storm water runoff to the platted area. Existing unplatted areas within contributing watersheds shall be analyzed considering their existing state of development. Existing platted areas within contributing watersheds shall be analyzed considering their fully built intended use and accounting for the effects of any existing drainage improvements.

The 100-year Storm Event Inundation Analysis shall be prepared, sealed, and signed by a professional engineer, currently registered in the State of Texas, and shall be reviewed and accepted by the County Engineer.

The subdivision plat shall have building set-backs containing all areas identified as being inundated by the 100-year storm event. A note shall be placed on the plat stating the following:

> A drainage study has been completed for this plat and is available for review at the Comal County Engineer's Office. Areas identified by the study as being inundated during certain storm events have been placed within building set-backs. The construction of buildings within building set-backs requires Commissioners Court approval.

b. Downstream Impact Analysis

Provide an engineering analysis stating that the effect of modifying the platted area to the anticipated fully developed condition, including any proposed building, paving, clearing, drainage, roadway, excavation, fill or other significant environmental modifications, will not increase the peak 100-year storm water discharge rate from the platted area to any contiguous property.

The analysis shall consider all contributing watersheds outside of the platted area to the extent that they affect the impact analysis. A contributing watershed is a drainage area that drains storm water runoff into the platted area. Existing unplatted areas within contributing watersheds shall be analyzed considering their existing state of development. Existing platted areas within contributing watersheds shall be analyzed considering their fully built intended use and accounting for the effects of any existing drainage improvements.

The Downstream Impact Analysis shall be prepared, sealed, and signed by a professional engineer, currently registered in the State of Texas, and shall be reviewed and accepted by the County Engineer.

c. Plans and Specifications for Storm Water Drainage Improvements

Provide plans and specifications for all storm water drainage improvements proposed within the platted area. Storm Water Drainage Improvements are manmade facilities such as detentions ponds, channels, storm sewer piping systems, culverts, catch basins, inlets, roadways, ditches, or other related facilities, which are constructed to control or modify natural storm water drainage.

Plans and Specifications for Storm Water Drainage Improvements shall be prepared, sealed, and signed by a professional engineer, currently registered in the State of Texas, and shall be reviewed and accepted by the County Engineer.

d. Drainage Easements and Rights-of-Way

Storm Water Drainage Improvements shall be placed within private drainage easements or public rights-of-way adequately configured to properly accommodate facility operation, maintenance, and access. Storm Water Drainage Improvements that are intended to be maintained by the County shall be placed within rights-of-way and shall be dedicated to the public for their intended use.

e. Surety for Drainage Improvements

Provide a surety, in the same form required for proposed roadway improvements, in an amount equal to the estimated construction cost estimate for all proposed Storm Water Drainage Improvements not located within proposed road rights-of-way. The estimate of the proposed Storm Water Drainage Improvements shall be prepared by an engineer and approved by the County Engineer. For Storm Water Drainage Improvements dedicated to the public, the Surety for Drainage Improvements shall not be released until the County has accepted the Storm Water Drainage Improvements. For Storm Water Drainage Improvements intended to remain private, the Surety for Drainage Improvements shall not be released until the County has approved the proper construction of said improvements and a maintenance entity has been established with the responsibility of future maintenance of all of the Storm Water Drainage Improvements not located within public road rights-of-way.

2. **Section A, Regulations, Subsection VI. Road Construction, Drainage:**

Delete entire section and replace with the following:

Storm Water Drainage Improvements within the Road Right-of-Way

a. Provide an engineering analysis determining the 10-year storm water flow rate at all locations, except as noted below in paragraph b., where storm water drainage is planned to cross a proposed roadway. Prepare plans and specifications for proposed drainage improvements showing that the proposed improvements will pass the 10-year storm water flow rate through the drainage improvements without over-topping the roadway surface. The engineering analysis, design, plans, and specifications shall be prepared, sealed, and signed by a professional engineer, currently registered in the State of Texas, and shall be reviewed and accepted by the County Engineer.

b. Provide an engineering analysis determining the 25-year storm water flow rate at all locations where storm water drainage is within a FEMA Special Flood Hazard Area and is planned to cross a proposed roadway. Prepare plans and specifications for proposed drainage improvements showing that the proposed improvements will pass the 25-year storm water flow rate through the drainage improvements without over-topping the roadway surface. In addition, provide an engineering analysis determining the 100-year storm water flow rate and show that the effect of the proposed drainage and roadway improvements will not inundate areas outside of the FEMA Special Flood Hazard Area. The engineering analysis, design, plans, and specifications shall be prepared, sealed, and signed by a professional engineer, currently registered in the State of Texas, and shall be reviewed and accepted by the County Engineer.

Revisions to
Comal County Subdivision Rules and Regulations

Approved by Order of the Comal County Commissioners Court on December 21, 2000.
This Order takes effect January 1, 2001.

1. **Section A, Regulations, Subsection IV, PLATS, Subsection A, Preliminary Plats, Paragraph 6,**

Revise item "x" to read as follows:

A person seeking approval of a plat which creates one or more lots or is seeking approval of a revision plat that results in an increase in the total amount of lots shall:

i) if no Public Water System is proposed or exists; and the proposed lots will be served by individual groundwater wells and not utilizing groundwater regulated by the Edwards Aquifer Authority,

Submit a Certification of Groundwater Availability For Platting Form pursuant to Title 30 Texas Administrative Code, Chapters 230, Sections 230.2 through and including 230.11, with the following additional requirements;

All supporting information, data, and calculations necessary to meet the requirements of Sections 230.2 through and including 230.11 shall be attached to the Certification of Groundwater Availability For Platting Form.

§230.3 (c), Form Required, the first sentence is revised as follows;

This chapter and the following form shall be used and completed if the county requires plat applicants to certify that adequate groundwater is available to provide water to the land to be subdivided.

Submit documentation from a Hydrogeologist indicating his/her concurrence with the findings presented within the above Certification of Groundwater Availability For Platting Form.

ii) if no Public Water System is proposed or exists; and the proposed lots will be served by individual groundwater wells utilizing groundwater regulated by the Edwards Aquifer Authority, .

Provide an analysis prepared by a registered engineer determining the projected water use of the final expected number of residences, businesses, or other dwellings in the platted area.

Submit documentation from the Edwards Aquifer Authority indicating a permit allocation of groundwater rights to the proposed platted area in an amount adequate to meet the water needs as identified in the above engineering analysis. The permit allocation cannot involve leased water rights.

iii) if the proposed lots are to be served by a new Public Water System utilizing groundwater wells and not using groundwater regulated by the Edwards Aquifer Authority,

Submit a Certification of Groundwater Availability For Platting Form pursuant to Title 30 Texas Administrative Code, Chapters 230, Sections 230.2 through and including 230.11, with the following additional requirements;

All supporting information, data, and calculations necessary to meet the requirements of Sections 230.2 through and including 230.11 shall be attached to the Certification of Groundwater Availability For Platting Form.

§230.3 (c), Form Required, the first sentence is revised as follows;

This chapter and the following form shall be used and completed if the county requires plat applicants to certify that adequate groundwater is available to provide water to the land to be subdivided.

Submit documentation from a Hydrogeologist indicating his/her concurrence with the findings presented within the above Certification of Groundwater Availability For Platting Form.

Submit a copy of the final approval letter and all supporting documentation from the executive director of the Texas Natural Resource Conservation Commission (TNRCC), pursuant to TNRCC Rule 30 TAC Chapter 290.41(c)(3)(A), for each new well and provide a copy of the TNRCC approval letter and supporting documentation for the engineering plans and specifications for the Water Production and Water Distribution Facilities.

Provide a surety, in a form acceptable to the County, in an amount determined by the County Engineer, to ensure the proper completion of any and all Water Distribution Facilities such as water mains, valves, and other necessary water distribution appurtenances.

iv) if the proposed lots are to be served by a new Public Water System utilizing groundwater wells using groundwater regulated by the Edwards Aquifer Authority,

Provide an analysis prepared by a registered engineer determining the projected water use of the final expected number of residences, businesses, or other dwellings in the platted area.

Submit documentation from the Edwards Aquifer Authority indicating a permit allocation of groundwater rights to the proposed platted area in an amount adequate to meet the water needs as identified in the above engineering analysis. The permit allocation cannot involve leased water rights.

Submit a copy of the final approval letter and all supporting documentation from the executive director of the Texas Natural Resource Conservation Commission (TNRCC), pursuant to TNRCC Rule 30 TAC Chapter 290.41(c)(3)(A), for each new well and provide a copy of the TNRCC approval letter and supporting documentation for the engineering plans and specifications for the Water Production and Water Distribution Facilities.

Provide a surety, in a form acceptable to the County, in an amount determined by the County Engineer, to ensure the proper completion of any and all Water Distribution Facilities such as water mains, valves, and other necessary water distribution appurtenances.

v) if the proposed lots are to be served by a new Public Water System utilizing surface water,

Provide a copy of the TNRCC approval letter and supporting documentation for the engineering plans and specifications for any required Water Production and Water Distribution Facilities, pursuant to TNRCC Rule 30 TAC Chapter 290.

Provide an analysis prepared by a registered engineer determining the projected water use of the final expected number of residences, businesses, or other dwellings in the platted area.

Submit a copy of an executed contract, agreement, or commitment letter from the TNRCC or the Guadalupe Blanco River Authority stating surface water, in an amount adequate to meet the water needs as identified in the above engineering analysis, has been committed to the platted area for a period of 20 years or greater. Said document shall identify the amount of surface water committed, the point of diversion, and the term of the commitment.

Provide a surety, in a form acceptable to the County, in an amount determined by the County Engineer, to ensure the proper completion of any and all Water Distribution Facilities such as water mains, valves, and other necessary water distribution appurtenances.

vi) if the proposed lots are to be served by an existing public water system utilizing groundwater and currently providing service to less than 1000 connections,

Provide documentation from the existing Public Water System indicating that the existing system has agreed to provide water service to the platted area.

Provide a copy of the latest TNRCC Public Water Sanitary Survey of the existing Public Water System indicating no alleged violations pertaining to water quality or water production capability.

Provide an engineering analysis of the existing Public Water System showing that the existing system has an adequate Water Supply and adequate Water Production Facilities to serve the final expected number of residences, businesses, or other dwellings in the existing service area in addition to the needs of the final expected number of residences, businesses, or other dwellings in the proposed platted area.

If the existing public water system uses groundwater regulated by the Edwards Aquifer Authority, submit documentation from the Edwards Aquifer Authority indicating the permit allocation of groundwater rights necessary to meet the needs identified to the preceding paragraph. The permit allocation cannot involve leased water rights.

If an expansion to an existing Public Water System is necessary due to the addition of the platted area or due to existing deficiencies in the system, as identified above, submit a copy of the final approval letter and all supporting documentation from the executive director of the Texas Natural Resource Conservation Commission (TNRCC), pursuant to TNRCC rule 30 TAC Chapter 290.41(c)(3)(A), for any new well, and provide a copy of the TNRCC approval letter and supporting documentation for the engineering plans and specifications for the required Water Production and Water Distribution Facilities.

Provide a surety, in a form acceptable to the County, in an amount determined by the County Engineer, to ensure the proper completion of any and all Water Distribution Facilities such as water mains, valves, and other necessary water distribution appurtenances.

vii) if the proposed lots are to be served by an existing Public Water System utilizing surface water or an existing Public Water System currently providing interconnected water service to 1000 connections or more,

Provide documentation from the existing Public Water System (Utility) indicating that the Utility has agreed to provide water service to the platted area.

Provide documentation from the Utility indicating that the Utility has had a Water Availability Report approved by the Comal County Commissioners Court within the last 36 months.

A Water Availability Report is defined as a document prepared by the Utility to reveal their ability to meet the needs of their existing users and show their preparedness to meet the needs of future water users as their system expands. The report shall include, but is not necessarily limited to, the following:

1. Copy of the latest TNRCC Public Water Sanitary Survey of the Utility's existing water system indicating no alleged violations pertaining to water quality or water production capability.
2. A map or maps of the Utility's service area showing:
    a) the Utility's current service area as define by their existing Certificate of Convenience and Necessity and the projected service area in 20 years.
    b) a schematic of the Utility's existing distribution system with line sizes identified.
    c) locations of water wells and/or surface water plants with capacities.
    d) locations of pump stations and elevated storage tanks with capacities.

3. An analysis of the population and land use development projections for the Utility's estimated service area in 20 years.
4. Copies of documents and/or an engineering analysis showing that the Utility has adequate groundwater rights, surface water rights, existing groundwater production capability, or other proofs of water rights or reservations in an amount sufficient to supply the anticipated water use of the expected population and land use within the projected service area in 20 years.
5. In areas where groundwater withdrawal is not regulated by the Edwards Aquifer Authority, if applicable, provide a report prepared by a registered engineer certifying that adequate groundwater is available from the source aquifer(s) to supply the Utility's anticipated groundwater needs for 20 years.

2. Section A, Regulations, Subsection 1, Authority and Purpose;

Add the following:

5. Plat Requirement

a) The owner of a tract of land located outside the limits of a municipality must have a plat of the subdivision prepared if the owner divides the tract into two or more parts to lay out:
   (1) a subdivision of the tract, including an addition;
   (2) lots; or
   (3) streets, alleys, squares, parks or other parts of the tract intended to be dedicated to public use or for the use of purchasers or owners of lots fronting on or adjacent to the streets, alleys, squares, parks, or other parts.

b) A division of a tract under Subsection (a) includes a division regardless of whether it is made by using a metes and bounds description in a deed of conveyance or in a contract for a deed, by using a contract of sale or other executory contract to convey, or by using any other method.

6. Exemptions to the Plat Requirement

The following exemptions may allow a division of property without the preparation of a subdivision plat. Under these exemptions, a property owner may not be required to prepare a subdivision plat for their division of their property, but the division of property must still meet the minimum lot size requirements set forth in the Comal County On-Site Sewage Facility Order.

a) The County shall not require the owner of an unplatted tract of land located outside the limits of a municipality who divides the tract into two or more parts to have a plat of the subdivision prepared if

   (1) the land is to used primarily for agricultural use, as defined by Section 1-d, Article VIII, Texas Constitution, or for farm, ranch, wildlife management, or timber production use within the meaning of section 1-d-1, Article VIII, Texas Constitution; and

   (2) the owner does not lay out a part of the tract described by above in 5. a(3); and

(3) if the tract described ceases to be used primarily for agricultural use or for farm, ranch, wildlife management, or timber production use, the platting requirements apply.

b) The County shall not require the owner of an unplatted tract of land located outside the limits of a municipality who divides the tract into four or fewer parts to have a plat of the subdivision prepared if:

(1) each of the lots is sold, given, or otherwise transferred to an individual who is related to the owner within the third degree of consanguinity of affinity, as determined by Chapter 573, Government Code;

(2) the owner does not lay out a part of the tract described by 5. a(3); and

(3) if any lot is sold, given, or otherwise transferred to an individual who is not related to the owner within the third degree consanguinity or affinity, the platting requirements apply.

c) The County shall not require the owner of an unplatted tract of land located outside the limits of a municipality who divides the tract into two or more parts to have a plat of the subdivision prepared if:

(1) all of the lots in the subdivision are more than 10 acres in area; and

(2) the owner does not lay out a part of the tract described in 5. a(3).

d) The County shall not require the owner of an unplatted tract of land located outside the limits of a municipality who divides the tract into two or more parts and does not lay out a part of the tract described in 5. a(3) to have a plat of the subdivision prepared if all of the lots are sold to veterans through the Veteran's Land Board Program.

e) The County shall not require the owner of an unplatted tract of land located outside the limits of a municipality who divides the tract into two or more parts to have a plat of the subdivision prepared if:

(1) the owner does not lay out a part of the tract described in 5. a(3); and

(2) one new part is to be retained by the owner, and the other new part is to be transferred to another person who will further subdivide the tract subject to the plat approval requirements of these regulations.

f) The County shall not require the owner of an unplatted tract of land located outside the limits of a municipality who divides the tract into two parts to have a plat of the subdivision prepared if:

(1) the owner does not lay out any part of the tract described in 5. a(3); and

(2) all parts are transferred to persons who owned undivided interest in the original tract and a plat is filed before any further development of any part of the tract.

g) The County shall not require the owner of an unplatted or platted tract of land located outside the limits of a municipality who divides the tract into two parts to have a plat of the subdivision prepared if:

(1) the owner does not lay out any part of the tract described in 5. a(3); and

(2) the subdivision is the result of the owner dividing a tract by granting a security interest in property to secure an indebtedness.

h) The County shall not require the owner of an unplatted tract of land located outside the limits of a municipality who divides the tract into two parts to have a plat of the subdivision prepared if:

(1) the owner does not lay out any part of the tract described in 5. a(3); and

(2) the subdivision is the result of the owner dividing a tract to convey property to an adjacent property owner.

i) The County shall not require the owner of a tract of land located outside the limits of a municipality to have a plat or revision plat of the subdivision prepared if:

(1) said tract was created prior to January 1, 2001, as evidenced by a document recorded in the Comal County Clerk's records before January 1, 2001; or

(2) said tract was the result of a division of land that resulted from the acquisition of public right-of-way by Comal County or the State of Texas.

3. Section A, Regulations, Subsection II, Definition of Terms

Delete definition for "Subdivision"

Add the following definitions:

Public Water System - A system, approved by the Texas Natural Resource Conservation Commission, for the provision to the public of water for human consumption through pipes or other constructed conveyances.

Water Production Facility – A collection of pumps, treatment equipment, tanks and other devices designed to extract water from a source, provide necessary treatment to purify and disinfect, pressurize, pump, and store potable water.

Water Distribution Facility – a system or network of pipes and valves designed to deliver potable water to users.

Water Supply – a source of water

Hydrogeologist – An individual with at least 5 years of progressively more responsible professional experience, following receipt of a baccalaureate degree, during which full competence has been demonstrated in the application of scientific or engineering principles and

methods to the execution of work involving:
(1) the understanding of the occurrence, movement, and composition of ground water in relation to the geologic environment,
(2) the development, management, or regulation of ground water, or
(3) the teaching and research of ground water subjects at the university level.

REVISIONS TO

COMAL COUNTY SUBDIVISION RULES AND REGULATIONS

Approved by Commissioners Court 6-4-98

1. **Revise Page 4, Section III, Item 1b(2)**

This paragraph currently reads as follows:

(2) Presentor to Commissioners' Court shall submit original and two (2) reproducible mylar prints (plus monies in the amount of $25.00 per sheet in subdivision plat) to the County Clerk immediately after approval by Commissioners' Court. Plat shall be in correct order to be recorded and shall not be removed from the County Clerk's possession prior to filing. The mylar copies will be filed on record with the County Clerk and original will be returned to the surveyor after filing.

This paragraph shall be deleted and replaced with the following:

(2) On the day the Commissioners Court considers a plat for final approval, the owner/agent shall submit three (3) blueline copies to Commissioners Court for their review. If the Commissioners Court grants final approval of the plat, the owner/agent shall, at that time, submit the following documents to the County Clerk:

a) the original plat, and

b) two (2) reproducible mylar copies (18 inches by 24 inches) of the original plat, and

c) one (1) reduced mylar copy (11 inches by 17 inches) of the original plat, and

d) other documents to be recorded as part of the final plat approval, as required, and

e) the appropriate County Clerk's recording fee.

Plat shall be in correct order to be recorded and shall not be removed from the County Clerk's possession prior to filing. The two (2) mylar prints and the reduced mylar print will be filed of record with the County Clerk, and the original plat will be returned to the surveyor after filing.

2. Delete Page 4, Section III, Item 1b(4)

This paragraph currently reads as follows:

(4) The surveyor (developer) shall submit a black print reduced version of the recorded plat with dimensions not to exceed 11 inches by 17 inches.

3. Revise Page 10, Section IV. PLATS, Subsection C. FINAL PLATS, Item 2c

This paragraph currently reads as follows:

c. One (1) signed original (to be returned to surveyor after filing) and two (2) signed reproducible mylars to be retained in the office of the County Clerk.

The paragraph shall be revised as follows:

c. One (1) signed original, to be returned to surveyor after filing, and two (2) signed reproducible mylars and one (1) reduced mylar print to be retained in the office of the County Clerk.

This revision shall be effective 7-1-98

REVISIONS TO

COMAL COUNTY SUBDIVISION RULES AND REGULATIONS

Approved by Commissioners Court 5-6-99

1. Revise Page 8, Section IV, Subsection A, Item 6j

This paragraph currently reads as follows:

j. Lot sizes: Minimum lot sizes for Comal County: over the recharge zone of the Edwards Aquifer one (1) acre; over other areas of the County, one (1) acre without public water and/or public sewage system; one-half (1/2) acre with public water and/or public sewage system, excluding drainage easements. Corner lots will have an 80' minimum frontage width. Regularly shaped lots will have 60' minimum frontage width. Cul-de-sac and irregularly shaped lots will have a 40' minimum frontage width. (See Chapter V for high-density.

This paragraph shall be revised as follows:

j.1 Lots sizes:

Subdivisions requiring platting, where each lot within the proposed subdivision will be served by a Texas Natural Resource Conservation Commission (TNRCC) approved public water supply and will utilize individual on-site sewage facility methods for sewage disposal, shall provide for individual lots having surface areas of at least 1.0 acre.

Subdivisions requiring platting, where each lot within the proposed subdivision will not be served by a TNRCC approved public water supply and will utilize individual on-site sewage facility methods for wastewater treatment, shall provide for individual lots having surface areas of at least 5.01 acres.

j. 2 Road Frontage:

Corner lots will have an 80' minimum frontage width. Regularly shaped lots will have 60' minimum frontage width. Cul-de-sac and irregularly shaped lots will have a 40' minimum frontage width. (See Chapter V for high-density development.)

The effective date of this revision is May 6, 1999.

REVISIONS TO

COMAL COUNTY SUBDIVISION RULES AND REGULATIONS

<u>Approved by Commissioners Court 3-26-98</u>

1. Section IV. PLATS, Subsection A. Preliminary Plats, Paragraph 6,

Add item "x." to read as follows:

A person seeking approval of a plat or revision plat which creates one or more lots shall,

REVISED 1-1-01

i) if no public water system is proposed or exists,
add a note on the plat or revision plat that states that an approved water supply for the proposed lots does not exist; or

ii) if a public water system exists,
provide a copy of the Texas Natural Resource Conservation Commission's most current Public Water Supply Sanitary Survey of the public water system showing no alleged violations pertaining to water quality or water production capability, and provide a letter from the servicing Water Supply Company stating that with the addition of proposed lots, the water system will meet the minimum requirements of the Texas Natural Resource Conservation Commission for a public water supply system; or

iii) if a public water system is proposed,
provide a copy of the approval letter and supporting documentation from the executive director of the Texas Natural Resource Conservation Commission pursuant to Texas Natural Resource Conservation Commission rule 290.41(c)(3)(A) for each well, and provide a copy of the Texas Natural Resource Conservation Commission approval letter and supporting documentation for the engineering plans and specifications for the water production and water distribution facilities.

This revision shall be effective 3-26-98

REVISIONS TO

COMAL COUNTY SUBDIVISION RULES AND REGULATIONS

<u>Approved by Commissioners Court 10/30/97</u>

1. Revise Page 7, Section IV, Subsection A, Item 6c

This paragraph currently reads as follows:

c. Name and address of the owner(s), subdivider, and lienholder (if applicable).

The paragraph shall be revised as follows:

c. Name and address of the owner(s), subdivider, and lienholder (if applicable). Required signature statements on Pages 27 and 27a.

ATTACHMENT D

EFFORTS TO REACH AGREEMENT ON WASTEWATER MANAGEMENT

ATTACHMENT D
EFFORTS TO REACH AGREEMENT ON WASTEWATER MANAGEMENT

Near the end of the project a portion of the steering committee objected to a draft recommendation to accommodate some of the projected growth in the study area with central wastewater collection and treatment systems with the effluent being beneficially reused. The stated reason for the objection was concern over leaks in the collection and treatment system that could contaminate the Trinity Aquifer. If was pointed out that any leaks from a wastewater system would be much smaller in volume than the wastewater flow produced by OSSFs where essentially all of the sewage goes to the ground. This was not accepted. Rather than debate that point, the discussion was moved to try to find a practical accommodation that would reduce the potential for collection system wastewater leaks.

The following exchanges document the efforts to achieve an accommodation. The exchanges were conducted by e-mail between September 24 and October 10, 2002, and are arranged in chronological order. All the exchanges were copied to a wide range of parties, but addresses are omitted from this summary. While the negotiations were ultimately unsuccessful, it was not because there was a lack of effort.

STEVE GRIGORY TO PAUL JENSEN

Rule 15 of the Southeast Trinity GCD is attached. Please do not be discouraged by the language and format. This is Chapter 213 for the EARS rewritten to make it less onrush for developers as far as paper work is concerned - unless they don't want to comply. The sewage plant rules are strict and do the best job of protecting the Trinity from leakage and spills as is possible. Effluent standards are the same as Kerrville and San Marcos. A standard package plant won't comply with these rules.

Our rule 15 covered hydrocarbon storage plant construction and some Regulatory stuff that would not be applicable to GBRA.

I am going to follow this email with a document that extracts the features I feel are essential to sewage plant construction and location. I will be happy to get together and go over these documents with you.

We are still opposed to any sewage plant over the Trinity aquifer as the best long-term protection of the groundwater resource.

Having pondered some of the statements made in the meeting concerning high density growth around the Canyon Lake area I offer the following thoughts.

1. Population growth estimates and predictions are just that. They are not truth cast in stone nor are they indicative of what SHOULD happen. They may be considered as warnings of bad things to come if policy and law is not changed. It is not proper for a state agency to try to make predictions come true.

2. Fighting high density development is not discrimination against the poor. It occurred to me last night when I visited a friend in Timberwood Park that this was a high density development. The house was at least $300,000 on less than 1/4 acre.

PAUL JENSEN TO STEVE GRIGORY

Hi Steve, this is quite a bit of material you've provided, but most of it appears to relate to the Edwards rules.

At the last meeting you expressed concern over sewer line leakage from central WW systems and wanted to see specific provisions required for such systems. You specifically mentioned using HDPE sewer lines with heat fused joints and berms surrounding treatment plants. I didn't have specific knowledge of the effect of such requirements, but it sounded like it might be reasonable. If the overall cost impact were reasonable, and it solved a strongly held concern, I would think we could get consensus on it.

My concern is that the document you've transmitted appears to go well beyond specific technical specifications to include a whole lot of other material (about 36 pages worth) that appears to have been developed for the specific requirements of the Edwards. I'm not a geologist, but I'm reasonably certain there are substantial differences between the Edwards and the Trinity. I would think we'd have a hard time getting consensus on these rules, that really are not targeted to Canyon water quality.

Question--would you be willing to go with a short list of specific practical design features that would apply to central WW systems in the proposed water quality protection zone (Canyon watershed in Comal County)? This would coincide more directly with the stated purpose of the study--Water Quality Assessment and Regional Facility Planning for the Canyon Reservoir Watershed.

Hope the answer is yes. Paul

STEVE GRIGORY TO PAUL JENSEN

This is the opening for my http://hillcountrywater.org website

"Comal County, along with other Hill Country counties, is a test bed for water legislation and all of Texas is watching. This county is a classic example of a projected population growth rate that exceeds the ability of the land to sustain, in the long term, the present level of water use." John Ashworth, noted hydro-geologist speaking to the Southeast Trinity Groundwater Conservation District.

John retired from the water board and went to work for LBG-GUYTON ASSOCIATES their in Austin office. He used to have a webpage bio at the company but they seemed to have taken the bios off. Look him up in the phone book.

PAUL JENSEN TO STEVE GRIGORY

Hi Steve, interesting material. But I can't see in it a direct answer to the question I posed. I'd rather not try to infer an answer, as someone might say later that I got it wrong. Could you help a simple Aggie out and let me know directly if the answer is a yes or a no? Thanks, Paul

STEVE GRIGORY TO PAUL JENSEN

I guess as a dumb ole Texas Tech Boy I am having trouble figuring out what you want a yes or now answer to.

1. Are the Trinity and Edwards geologically Identical - No. Are they geologically similar in physical makeup and recharge mechanism – emphatically YES.

2. If we are talking about Canyon Lake Water Quality then there is no way that a sewage plant is going to improve that over septic systems and a sewage plant can be very detrimental. So Yes, these rules do target Canyon Lake Water Quality.

3. If you are going to promote sewage plants, consider only the quality of Canyon Lake Water and ignore the perils to the Trinity Aquifer then we need have no further discussion. We will fight this report and GBRA every inch of the way. I thought we were going to compromise and come up with technical proposals for building sewage plants that will do the least damage. A water pollution abatement plan for construction, design and operation is a necessary first step. Protection of sensitive features that recharge the aquifer are absolutely necessary.

4. You are referring to my first email with the entire Rule 15. I stated I was going to cut out much of the text that did not apply and send it later in the day. I did that and sent a 13 page document which is a lot less but still a bunch. I highlighted essential technical items but that does not mean the rest of it is not important. I said again that it can still be honed down. Before I come up with a document that you can hand to a contractor (not my job but will do it) I would want to go over this with you. Please check over the ruleModifiedGBRA.doc file and see if you think we can work from there.

Thanks.

PAUL JENSEN TO STEVE GRIGORY

Hi Steve, sorry I missed your parallel email with the shorter version. While that is an improvement, the fundamental concerns remain.

Our study is focused on protecting Canyon Lake from water quality impacts of development. Neither GBRA or Comal County, or the TWDB signed on for imposing new aquifer protection rules. I'm not taking a position on that issue, but it is very much off track from what we signed to do. I just don't think we can launch off in that direction and expect to keep the committee and study sponsors together.

There is also the consistency issue. If your concern is aquifer protection from sewage released to the ground, it is hard to understand how having all the existing and future sewage going to the ground via septic tanks and drainfields is preferable to a miniscule fraction going to the ground in sewer leaks. Even the worst collection systems would leak much less than 100%. If they leaked 100% we wouldn't need treatment plants--just collection systems!

Kidding aside, no one favors leaking sewers and if a reasonable list of recommendations could be obtained, we might be able to get consensus and move forward with recommendations we can all support. Then again, we might not. I'm willing to give it a try. I take it by your shorter version that you are willing to go that way too. But I think we still have a bit of space between us. Here is my quick critique of the shorter version:

GBRA is not a regulating agency. My guess is that Comal County and TCEQ would permit WW facilities.

I'm having our design engineers look this over so may have other points. But my first concern is specifying a particular type of material (HDPE) for sewers. The approach TCEQ takes in the still draft 217 regs is pressure testing. Would meeting a smaller pressure drop accomplish the same thing and keep the regs on the performance spec level work for you?

I'm trying to get advice on stub outs and prohibiting placement of lines in the 5-yr flood plain.

I don't see the need for special requirements on the design report for WW systems that applies Edwards rules, for the reasons noted above.

If treated WW is to be used beneficially for irrigation, I don't see the need to require N & P removal. If it were to go to the lake directly, I'd be in agreement.

Not sure I concur on the need to mark all sewer lines every 100 ft with no dig signs. Most of the lines would run down the center of roads. Some marking would seem to make sense for force mains that cross open or undeveloped land.

If we could get agreement on using a tighter performance spec on initial leakage, and some form of inspection on a regular basis (not sure about 5 years but may be ok) then I have a measure of guarded optimism.

Thanks, Paul

STEVE GRIGORY TO PAUL JENSEN

Yours was a very favorable response with the exception that GRBA and PBSJ keep claiming that septic tanks are polluters. You have to go to old septic systems that have not been maintained or are overloaded beyond original design to find a problem. A WWTP in equivalent condition would be a much bigger problem. You belittle the problem of raw sewage leaking into the Trinity aquifer. If we talk new installations of both WWTP and Septic Systems then I think for the Trinity aquifer the septic system wins with no contest. I sent you pages of examples of line breaks and overflows from plants that meet today's TECQ standards - in only two cities.

The accumulation of raw sewage in lines and the plant proper is a very real problem for a karst aquifer and must be addressed. You cannot build a plant over recharge features and the lines must be leak free. With PE lines you can pressure test the line and FIX any leak that can be detected. PVC gasket joints are allowed to leak because they DO leak and it is impossible to put in a leak free system. In most areas this is acceptable but over a karst aquifer it is not.

From the beginning (Sept 17) we agreed that there is no regulatory process that exists in Comal County today that can impose these rules across the board. You and Debbie sat there and claimed that gentle persuasion was the way to go. If GBRA is going to operate these plants then you determine the way they have to be built. (I am still not clear on the funding and ownership arrangements planned for these sewage plants). As such, you can hand the contractor or owner a set of rules that requires the items I have listed including the water pollution abatement plan and say this is what you have to do if you are to build these plants. Otherwise there will be problems getting your permit. In theory, given the delays in the hearing process the builder/developer/GBRA or whoever, will chose the path of constructing a good plant and be a good steward of our resources (including groundwater) instead of going minimum TECQ Chapter 317 standards.

The rules I sent you ceased to be Edwards Rules when we rewrote them and were Trinity Aquifer Rules for Comal County when the Southeast Trinity Groundwater Conservation District was in place.

Third party damage is a real problem with buried utility lines. There are now society organizations that do nothing else besides try to implement ways to prevent third party damage to pipelines. It could be that the gas and electric companies in Austin have a One Call system to make it easy for contractors to locate utility lines before a dig. I doubt we can get something that sophisticated in Comal County so we need signs with a phone number for contactors to call to avoid digging across a sewer line. Other buried utilities in these neighborhoods might welcome such a warning system.

Believe it or not, once HDPE is 10 or 12 inches in diameter and rated 150 psi, it is hard to damage it. Regular ditching machines and backhoes operators know they have hit something before doing more than just nicking the pipe. I am afraid rock saws will go right through a PE pipe however because the operator is expecting to hit tough objects.

Canyon Lake Water Supply lays a main on one side of the road and then digs across the street to put in a lateral and meter when a house is build on the other side and not before. (They even have the gall to charge the customer extra for the longer lateral and the dig) The sewer line would have to be deep enough to avoid the rock saw for water and other utilities if it is in the middle of the street. In high density neighborhoods like the one I lived in San Antonio, the sewer line and gas line ran through the backyard easement and the waterline was on the street. Except in downtown areas and sometimes on large boulevards, I have never heard of running distribution utilities down the middle of a street but perhaps it is done. It is a more expensive dig if a repair is needed or new connections are attached.

In any case, if we are talking uncurbed streets with drainage ditches as is common in rural areas then that sewer line should be marked with no dig signs if it runs on the side of the street. Perhaps 100 feet is too small an interval for the signs considering 100 feet could be less than a lot width for a half acre. My 2.5 acre lot is 200 ft wide. Maybe every 500 to 700 feet is more reasonable. It was not intended to put a sign in every yard. Marking direction change is essential.

I would want a GBRA agreement that the reports and plans can be reviewed by engineers and attorneys for environmental groups without having to resort to Freedom of Information law as we have in the past.

As I have stated in the past, if GBRA is going to protect Canyon Lake water at the expense of our groundwater this is totally unacceptable. The report needs to reflect this problem concerning WWTP installations.

PAUL JENSEN

Ola Steve et. al.,

Since our exchanges last week we've been doing some back and forth and think we have an offer that addresses your sewer leak concerns in a meaningful and practical way. It isn't everything you mentioned but it is not too far off.

First, we'd agree that the special provisions in the Edwards Rules dealing with collection systems would be applied to the Canyon Lake watershed in Comal County. Specifically, these include:

1. Inspections for karst features as part of the system design report,
2. Stubbs in new construction,
3. 5-yr floodplain restrictions, and
4. Inspections every 5 years.

We understand your concerns over PVC joint leakage, but don't think we should be specifying a particular type of product. That is properly the purview of the design engineer, and might cause complaints by suppliers who feel they also have a good product. Instead, our proposal is to require new construction to achieve half of the leakage rate allowed under the Edwards Rules.

We also agree to marking and no dig signs outside of subdivisions. Also, sewer lines would be required to have a plastic tape buried over the line to further warn excavators. We don't feel any other marking is needed in subdivision streets as the alignment between manhole covers is not too challenging even for us Aggies.

If you agree that these measures do a reasonable job of addressing concerns over sewer leaks, we can go forward with a unified report that includes central wastewater systems with the effluent used beneficially (zero discharge) in the mix to accommodate future growth in the area. The specific recommendations can be included as an attachment to the document and discussed in the text.

If you don't agree that these go far enough, or simply don't want to agree to anything that might be perceived as encouraging the growth that is projected, we'll include that point of view in the report.

Either way it's been a pleasure working with you. We'll need to know the answer in a few days to get the report wrapped up and have one final meeting.

Paul

STEVE GRIGORY TO PAUL JENSEN

Paul, I would like for our viewpoints on sewage plants to be included in the report.

1. Sewage plants are a danger to the Trinity Aquifer, primarily because of the accumulation of raw sewage and the potential for a spill from leaking joints, broken lines and outages in the sewage plant.

2. Sewage plants encourage growth by allowing high density development (which can be half acre lots with $500,000 homes on them - not necessarily trailer homes) and Comal County does not have the water supply to sustain the projected population during a drought of record.

3. While we remain opposed to sewage plants over the Trinity Aquifer, certain reasonable construction standards and studies of the construction site, which we have conveyed to you in rough form, could be required of developers and contractors which would reduce the risk of raw sewage spills and thus the risk of polluting the Trinity Aquifer. You have refused to incorporate these basic standards or give them serious consideration. We must therefore remain categorically opposed to any sewage plant built over the Trinity aquifer constructed to Chapter 317 standards and meeting minimum effluent requirements of the TCEQ.

4. To convey these viewpoints to the Texas Water Development Board adequately, we ask that you attach all written materials sent to you as attachments via email, regular mail or handed to you at the

meetings. These should include materials submitted by all persons taking issue with the sewage plants. In addition, we would ask that you attach additional comments that will be submitted to you by Friday of this week that take issue with points you make in your report supporting regional sewage plants.

As we stated before, we cannot allow plans that purport to protect Canyon Lake Water Quality at the expense of groundwater. We do not think this is the intention of the Texas Water Development Board. We also see engineering difficulties in using sewage effluent as a water source on a small scale because of seasonal variations in use and need a few days to pull the numbers together.

STEVE GRIGORY TO PAUL JENSEN

Paul, I read Item 3 in my last email and feel it was unduly negative. You did make some important concessions on construction. They simply were not sufficient. Simply identifying sensitive features does no good unless they are protected. Sewer plant overflow was not addressed. HDPE pipe should be an easy switch from PVC because the use of HDPE is so mature in the sewer industry and is coming up strong in the water industry as recovering the loss of product from PVC, ductile iron and concrete is being found to be a major water source.

PAUL JENSEN TO STEVE GRIGORY

Hi Steve,

From your response it looks like there will be no basis for an accommodation. I'm sorry that is the case because we both put a fair amount of effort into reaching an agreement.

We plan for the report to recognize that there was a difference of views in the steering committee on the effects and desirability of central wastewater collection, treatment and beneficial reuse versus continued use of OSSFs to accommodate growth. Despite a substantial effort, a consensus on an accommodation was not reached. The report will include an attachment containing a summary of both points of view and the efforts made to reach an accommodation.

Despite the unsuccessful outcome, it has been an interesting interchange that contributes to a fuller understanding of the issues.

Paul

ATTACHMENT E

REVIEW COMMENTS ON CANYON RESERVOIR WATER QUALITY AND REGIONAL WASTEWATER PLANNING STUDY REPORT, COMAL COUNTY, TEXAS

ATTACHMENT E

Review Comments On
" Canyon Reservoir Water Quality and Regional Wastewater
Planning Study Report, Comal County, Texas "
Contract No. 2001-483-406

1. Components of the following tasks were not documented in the draft Final Report. Availability of information on the following items should be described in the draft Final Report.

   Task 1, Develop Baseline Information.
   - Topography, soils, karst features, and vegetation for each significant subwatershed.
   - An inventory of water systems
   - A history of public infrastructure development, such as roads, power lines, water and wastewater systems.
   - A project GIS library.

   Task 3, Formulation of Conceptual Development Scenarios.
   Staff was not able to locate a discussion of significant factors that could affect local growth.

   Task 4, Developing Consensus on Objectives.
   Staff was not able to locate a discussion of a purely regulatory option.

2. Task 5, Analyze Effects of Conceptual Development Scenarios.
   It was expected that the draft Final Report would include simple Vollenweider type models relating loading to Canyon Lake tropic status or similar analyses of impacts to the lake of increased nutrient loading, however, there was only a discussion of increased loads. More information should be included in the draft Final Report.

3. Task 6, Develop Regional Water Quality Protection Plan.
   Please provide additional detail regarding the facility plan recommendations (as noted below), including potential costs and fiscal implications of alternatives and note any potential measures for groundwater protection assuming a no-discharge wastewater treatment facility.

   On Page 4-4 of the draft Final Report, Subwatershed 9 is identified as the area most feasible for a regional wastewater treatment plant. This is consistent with a discussion on expected impacts on loads to the reservoir on Page 5-17. However, Figure 4-2 shows wastewater treatment plant proposed areas for Subwatershed 1 and for Subwatershed 10 as well. Please clarify.

4. Task 7, Recommendations for Watershed Management Practices.
   The draft Final Report recommends Low Impact Development (LID). A list of techniques that have been used to implement LID in other communities, including potential structural and non-structural alternatives, would be useful.

5. Board staff could not review the population projections used in this study since the values of the actual projections could not be found. The study references the method of projection

used, which was from the Texas State Data Center, which is a reliable and accepted methodology. However, the study references the three State Data Center projection scenarios as being based on past growth rates, when in fact the scenarios are based on migration rates. If the projections in this study were based on a continuation of past growth rates, it is likely to result in an over-projection of the population. **Please clarify how the projections were calculated and submit separately for review prior to the printing of the Final Report.**

6. Figure 4-1, clarify if wastewater costs shown are per connection.

7. Additional information could have been provided to increase confidence in the results during the treatment of septic system (OSSF) loading. A major assumption concerning impacts of OSSF is the degree to which seepage from drain fields finds its way to Canyon Lake. Additional calculations based on other rates could provide a sensitivity analysis that would be critical to interpretation of the findings.

8. For loadings from OSSF's, another important assumption is the amount of nutrients removed in the drain field. The draft Final Report is based on a 90% removal. Estimates of removal at lower levels have been noted. More information, such as sensitivity analysis would show whether this is an important assumption for the conclusions of the report.