Cover Photo:
Waterfall between Sunken Garden (Old Mill) Springs and the east bank of Barton Creek, just downstream of the Barton Springs Pool, Austin, Texas.
Naismith Engineering, Inc. – 2004

March 21, 2005

Regional Water Quality Protection Plan for the Barton Springs Segment of the Edwards Aquifer and Its Contributing Zone

Project Sponsors

City of Dripping Springs

City of Austin

City of Buda

City of Kyle

City of Rollingwood

City of Sunset Valley

Village of Bee Cave

Blanco County

Hays County

Travis County

Barton Springs/Edwards Aquifer Conservation District

Hays Trinity Groundwater Conservation District

Blanco-Pedernales Groundwater Conservation District

Prepared by

NAISMITH ENGINEERING, INC.

In Association With

CAS Consulting and Services

Eco-Southwest Services

Good Company Associates

Hicks & Company

Kelly, Hart & Hallman, P.C.

NEI PROJECT NO. 7131

ACKNOWLEDGEMENTS

This planning effort and the preparation of this document were funded in part by grants from the Texas Water Development Board and the Lower Colorado River Authority.

In addition to these grants, the following entities assisted by providing local support through either monetary contributions, in-kind services or both:

Public Entities

The City of Austin
Austin Community College
The Barton Springs Edwards Aquifer Conservation District
The Village of Bee Cave
The Blanco-Pedernales Groundwater Conservation District
The City of Dripping Springs
Hays County
The Hays Trinity Groundwater Conservation District
The City of Kyle
The Lower Colorado River Authority
The City of Sunset Valley

Private Entities and Individuals

The Austin Waldorf School
Carpenter and Langford, P.C.
George Cofer
The Oak Hill United Methodist Church
John Orr
The Save Barton Creek Association
TechPeople, Inc.
Terri Buchanan, M.P.H.
The Urban Design Group

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PREFACE BY THE STAKEHOLDER COMMITTEE

The Stakeholders urge you to adopt the protections outlined in the plan. Failure to act is the greatest threat to both water quality and the economic viability of the region.

The Stakeholder Committee gratefully acknowledges the leadership of the Executive and Core Committees in initiating this pioneering regional water quality planning process. The long-standing public interest in preserving water quality in this area of Texas, coupled with unprecedented population growth, will require continued leadership as we move toward meaningful regional water quality protections.

The Executive and Core Committees challenged those most interested in the process and outcome of any such plan--ordinary citizens with a broad spectrum of interests and backgrounds--to form a stakeholder committee and take a leadership role in the plan's development. By guiding a professional consulting firm and acting on advice from nationally recognized experts, the stakeholders negotiated the key provisions of the plan. The Stakeholder Committee submits this Final Report in fulfillment of its charge.

The stated goal of the plan is to maintain or enhance the existing water quality of the groundwater and surface water within the study area. This goal is premised on the belief that water quality is vital to every person, and that protection of water quality is an individual as well as governmental responsibility. The Stakeholder Committee sought to balance responsible water quality regulation with economic interests.

Based on the best available science and engineering data specific to this area, this report is the culmination of months of education, analysis, collaboration, compromise and ultimately consensus on fundamental issues. Perhaps most fundamental is the decision to allow no increase in pollution under the plan. We believe that the protections offered by the plan will withstand exhaustive scrutiny. Indeed, we encourage all interested persons and organizations to review the entire report.

We believe that this Final Report, when implemented on a regional basis, will achieve the critical goal of preserving the most valuable assets of this region--the pristine waters and the natural physical features from which they flow. Preservation of these unique resources will enhance the future economic interests of the region. We believe that implementation of this plan will be met with broad public support.

The Stakeholders urge you to adopt the protections outlined in the plan. Failure to act is the greatest threat to both water quality and the economic viability of the region.

1. BACKGROUND

1.1. History

Rapid growth and development in northern Hays County and southwest Travis County have created community concerns with the increasing potential for pollution of groundwater and surface waters. Concerns have been raised with regard to the potential impacts to drinking water supplies and the recreational and aesthetic values of water, and to the threatened or endangered species that live in the area.

In December, 2002, Hays County Judge Jim Powers and City of Austin Council Member Daryl Slusher convened a Regional Summit to begin discussions on the impacts that development was having on the region and particularly to water quality in the Barton Springs Zone of the Edwards Aquifer. These discussions continued and from this initial effort a Regional Group was established to address the water quality issues facing the Barton Springs segment of the Edwards Aquifer and its contributing zone. The Regional Group was comprised of an Executive Committee and Core Committee whose members were initially made up of representatives from the Cities of Dripping Springs, Austin, Buda, Kyle, Rollingwood, Sunset Valley, the Village of Bee Cave, Hays and Travis Counties, the Barton Springs/Edwards Aquifer Conservation District and the Hays Trinity Groundwater Conservation District. During the process, the Core Committee was expanded to include representation from Blanco County and the Blanco-Pedernales Groundwater Conservation District. It was determined by this Regional Group that there was a need to develop a regional approach to water quality protection within the Barton Springs Zone in order to protect both the quality of drinking and recreational water and the endangered species in the area, particularly the Barton Springs salamander. It was the intent of the Regional Group that a regional water quality protection plan be developed to provide the basis for political subdivisions, to the extent allowed by law, to implement local water quality protection measures and ordinances and provide best management practices that could be adopted by local entities to protect water quality in the area. This effort has been termed the “Regional Water Quality Planning Project”, or simply the “Project”. This “Regional Water Quality Protection Plan”, or simply the “Plan” is the result of that effort.

1.2. Governmental Entities Involved

There are a number of governmental entities that initiated and have been involved in the planning process. Several of these governmental entities serve on the two (2) steering committees for the Project.

1.2.1. Executive Committee

The Executive Committee provides administrative and policy oversight to the Project. The following entities serve on the Executive Committee:

- The City of Austin
- The Barton Springs/Edwards Aquifer Conservation District
- The City of Dripping Springs
- Hays County
- The Hays Trinity Groundwater Conservation District
- Travis County

1.2.2. Core Committee

The Core Committee provides technical direction to the Project. The following entities serve on the Core Committee:

- The City of Austin
- The Barton Springs/Edwards Aquifer Conservation District
- The Village of Bee Cave
- Blanco County
- The Blanco-Pedernales Groundwater Conservation District
- The City of Buda
- The City of Dripping Springs
- The Hays Trinity Groundwater Conservation District
- Hays County
- The City of Kyle
- The City of Rollingwood
- The City of Sunset Valley
- Travis County

1.2.3. Other Entities

A number of other entities have been involved in the Project. These include:

- The Texas Commission on Environmental Quality (TCEQ)
- The Texas Water Development Board (TWDB)
- The Lower Colorado River Authority (LCRA)
- The Guadalupe Blanco River Authority (GBRA)
- The U.S. Fish and Wildlife Service (USFWS)

1.3. Project Team

The Project team consisted of the Executive Director and the consulting team. Mr. Terry Tull was appointed by the Executive Committee to serve as the project's Executive Director. His role was to serve as the primary liaison to the public and as the coordinator for the efforts of the consulting team.

Naismith Engineering, Inc., (NEI) was the lead firm for the consulting team. NEI was assisted by a number of sub-consultants:

- CAS Consulting and Services
- Eco-Southwest Services
- Good Company Associates
- Hicks & Company
- Kelly, Hart & Hallman, P.C.

1.4. Description of the Stakeholder and Public Involvement Process

From the outset of the Project, the Executive Committee determined that the development of the Plan should be guided by the participation of various stakeholders. The following sections describe the involvement of the stakeholders in the various phases of the planning process. Attachment 3 contains a general timeline of the stakeholder and public involvement process.

1.4.1. Past Stakeholder Involvement

While many previous efforts had attempted to identify issues and obtain input from various stakeholders, few gained much traction until the current effort began in late 2003. There was an initial stakeholder meeting held in September 2003, but it was not until May, 2004 that the Executive Committee was able to retain an Executive Director and a consulting team for the Project. On June 8, 2004, the Executive Director and consultant team conducted a meeting with the Stakeholders to identify issues and discuss their role in the process. This meeting included joint sessions with all stakeholders as well as break-out sessions by areas of interest.

1.4.2. Establishment of Stakeholder Committee

The consulting team, working with the Executive Director, reviewed information on the affiliations and interests of past stakeholders involved in the process. At the initial meeting in early June, 2004, the consulting team presented to the stakeholders a list of eight (8) categories of interest proposed for inclusion in a Stakeholder Committee (SHC). These categories were:

- Concerned Citizens
- Governmental Entities
- Neighborhood Interests
- Local Environmental Preservation/Good Governance Organizations
- Development Interests
- Economic Interests
- Property Owners
- Public Interest Organizations

After significant discussion to determine whether or not this was a proper division of interests for inclusion in the SHC, the stakeholders affirmed the categories initially identified by the consulting team. Following the initial selection of the SHC members, a public "validation" process was used to determine if the members of the wider public agreed that their interests were represented on the SHC. Based on the feedback received, several adjustments were made to the SHC to broaden the representation of landowner and local government categories, and to limit the representation of certain interest groups in more than one category. In August 2004, after organizing itself and establishing its Bylaws, the Stakeholder Committee began to work in earnest with the Executive Director and the consulting team to provide input on the Plan development.

1.4.3. Public Availability and Notice

The Executive and Core Committees charged the consulting team and the project Executive Director with making the development of the Plan an open public process. Several steps were taken to ensure that the public had opportunity to follow and offer input to the process. A project website was established on the internet that served as the primary repository for the project documentation. This provided a low-cost means to distribute information to the stakeholders and members of the SHC, but also made this information available to the general public. In addition to having the project documentation available on the website, hard copies of the project documents were maintained at the Executive Director's office in the City of Dripping Springs municipal offices and in the offices of the consulting team. Each meeting of the

Executive and Core Committees, as well as the SHC, were preceded with posted public notices as well as e-mails to anyone subscribing to the project notification list. Each public meeting included the opportunity for public comment. At each of the meetings and in each of the notices, stakeholders and members of the public were also invited to submit written comments to the consulting team. Through these steps, numerous opportunities were provided for public input to the process.

1.4.4. Stakeholder Committee Meetings

A series of Stakeholder Committee meetings were held to educate the stakeholder committee members, identify and rank relevant issues, and obtain stakeholder input on draft work products. At the request of the stakeholders, a technical review group of outside experts nominated by members of the SHC was set up to provide an independent review of the project work products. Various subcommittees and working groups were formed to address specific issues. All project documentation was furnished to the stakeholders and the public through the website prior to each meeting and throughout the process. While not all of the initial SHC members were able to serve for the entire term of the project, the vast majority attended every meeting and provided valuable participation. Attachment 1 contains the final listing of the representatives and alternates to the Stakeholder Committee.

1.4.5. Interface with the Consulting Team

While the consulting team was responsible for preparing the Plan, the input from the stakeholders was critical in its development. Working drafts of the Plan were presented at monthly stakeholder meetings between October 2004 and February 2005. The input obtained at the meetings as well as written comments submitted by members of the Stakeholder Committee and the technical review group were evaluated by the consulting team with many of the comments serving as the basis for subsequent revisions of the various project documents. This written Plan is the result of that effort.

1.5. Definition of the Planning Region

1.5.1. Geography

For the purposes of the Plan, the "Planning Region" is defined as the recharge zone for the Barton Springs segment of the Edwards Aquifer and its contributing zone. Located in the Texas Hill Country, one of the states' most unique natural areas, the Planning Region covers portions of northern Hays County, southwest Travis County and a small section of eastern Blanco County. It includes all or a portion of the Cities of Austin, Buda, Dripping Springs, Hays City, Kyle, Mountain City, Rollingwood, Sunset Valley, West Lake Hills and the Villages of Bee Cave, Bear Creek, Lakeway and portions of the Barton Springs/Edwards Aquifer and the Hays Trinity Groundwater Conservation Districts. Figure 1, on the following page, indicates the general location of the Planning Region, and shows the delineation between the recharge and contributing zones.

In common usage, the recharge and contributing zones are defined by geologic and hydrologic characteristics. However, it is important to note that these terms are routinely used as "terms of art" in several existing federal and state regulatory programs. In most instances, these regulatory programs allow the extent of the contributing zone to be modified by factors other than the geologic and hydrologic characteristics of the land, such as political, jurisdictional or administrative boundaries. For the purposes of The Plan, the extent of the contributing zone has been defined using the geologic and hydrologic characteristics. The consequence of this choice is that the Planning Region includes the portion of the hydrologic contributing zone within Blanco County, which is excluded from most regulatory programs.

The Plan also includes the description of the recharge zone as modified by changes recommended to the TCEQ by the Barton Springs/Edwards Aquifer Conservation District.[1] The petition for these changes involves changes to the current recharge, contributing and transition zone boundaries in southern Travis and northern Hays Counties. These changes involve a total of approximately 2,750 acres, with a net addition of approximately 490 acres to the recharge zone. For consistency, the boundaries of the recharge zone for the purposes of this Plan should conform to those ultimately adopted by the TCEQ.

Deleted: recognizes

1.5.2. Demographics

1.5.2.1. Historical Population Growth 1990-2000

Estimates of historical population growth trends for the Planning Region were developed based on 1990 and 2000 U.S. census data for tracts within the Planning Region using data obtained from the Texas Water Development Board (TWDB).[2] While the Planning Region does not correspond exactly to the census tracts or "designated places" and includes several cities as well as unincorporated areas of Travis, Hays, and Blanco Counties, this methodology is useful for analyzing general growth trends. Table 1 and Table 2, on the following pages, presents information taken from the 1990 and 2000 U.S. census data, and includes information on populations and household make-up for each census tract within the Planning Region.

[1] The map showing the proposed changes is available from the BSEACD internet website. (http://www.bseacd.org/graphics/Map_Rech_Zone_Chg.pdf)
[2] Detailed data was provided by staff from the TWDB. The underlying census data was obtained by the State of Texas directly from the U.S. Census Bureau for the years 1990 and 2000.

Table 1 – Information for Census Tracts within the Planning Region – 1990 Census

Census Tract Total	Population	Total Households	Family Households	Avg. HH Size
Travis County				
17.12	3,934	1,696	1,032	2.25
17.13	4,069	1,549	1,119	2.43
17.29	3,670	1,367	941	2.68
17.32	5,629	1,742	1,563	3.09
17.33	2,344	800	684	2.91
17.34	6,252	2,234	1,754	2.8
17.27	7,602	2,856	2,161	2.66
17.3	5,300	1,883	1,396	2.76
17.31	10,880	3,598	3,021	3.02
17.35	6,613	2,724	2,128	2.41
17.36	6,185	2,391	1,680	2.59
19.01	5,405	2,788	1,251	1.93
19.02	3,463	1,216	966	2.76
19.04	5,428	1,979	1,581	2.74
19.05	5,183	2,448	1,230	2.12
19.06	5,126	1,629	1,463	3.15
Sub-Total	87,083	32,900	23,970	2.64
Hays County				
108.01	7,031	2,461	1,967	2.82
109.01	4,749	1,485	1,348	3.2
109.02	3,341	1,094	922	3.03
Sub-Total	15,121	5,040	4,237	3.02
Total	102,204	37,940	28,207	2.69

Table 2 – Information for Census Tracts in the Planning Region– 2000 Census

Census Tract Total	Population	Total Households	Family Households	Avg. HH Size	Avg. Family Size
Travis County					
13.03	3,022	1,555	580	1.91	2.7
17.12	4,195	1,892	997	2.19	2.9
17.13	4,075	1,619	1,031	2.51	3.06
17.29	4,266	1,670	1,069	2.55	3.09
17.32	13,267	4,196	3,675	3.11	3.29
17.33	2,883	1,016	853	2.84	3.07
17.37	5,135	1,897	1,522	2.7	3
17.38	7,212	2,578	1,996	2.78	3.17
17.39	8,105	2,830	2,125	2.86	3.28
17.4	2,424	799	694	3.03	3.25
17.43	5,958	2,051	1,620	2.9	3.25
17.46	3,979	1,521	1,031	2.62	3.19
17.47	4,510	1,689	1,205	2.66	3.15
17.48	2,327	879	697	2.61	2.89
17.49	4,786	2,058	1,154	2.27	2.98
17.5	4,739	2,241	1,015	2.11	2.91
17.68	3,584	1,292	1,037	2.69	3
17.69	4,715	1,803	1,312	2.61	3.03
19.04	6,079	2,215	1,767	2.74	3.07
19.06	8,061	2,468	2,215	3.27	3.44
19.08	2,408	1,008	715	2.3	2.83
19.09	6,913	3,099	1,791	2.2	2.81
19.1	4,340	1,712	1,160	2.48	3.06
19.11	3,211	1,865	578	1.72	2.75
Sub-Total	120,194	45,953	31,839	2.57	3.05
Hays County					
108.01	12,908	4,455	3,709	2.86	3.01
109.01	6,609	2,173	1,933	3.04	3.22
109.02	5,512	1,871	1,558	2.95	3.26
Sub-Total	25,029	8,499	7,200	2.95	3.16
Total	145,223	54,452	39,039	2.63	3.07

Table 3, below, provides an analysis of the data in Table 1 and Table 2, and reveals that the census tracts within the Planning Region experienced a combined annual growth rate of 3.6% between 1990 and 2000. Census tracts within the Hays County portion of the Planning Region experienced a higher growth rate (5.2%) than tracts within the Travis County portion (3.3%). The census tracts located in the Hays County portion of the Planning Region also grew faster than Hays County as a whole, which experienced an annual growth rate of 4.1%. The census tracts within the Travis County portion of the Planning Region grew slightly slower than Travis County as a whole, which grew annually at a rate of 3.5%.

Table 3 – Historical Growth Trends in the Planning Region 1990 - 2000

	Total Population	Total Households	Family Households	Avg. HH Size
Travis County				
1990 Census	87,083	32,900	23,970	2.64
2000 Census	120,194	45,953	31,839	2.57
Amount of Change	33,111	13,053	7,869	(0.07)
Percent Change 1990-2000	38.0%	39.7%	32.8%	-2.8%
Annual Growth Rate	3.3%	3.4%	2.9%	
Hays County				
1990 Census	15,121	5,040	4,237	3.02
2000 Census	25,029	8,499	7,200	2.95
Amount of Change	9,908	3,459	2,963	(0.07)
Percent Change 1990-2000	65.5%	68.6%	69.9%	-2.2%
Annual Growth Rate	5.2%	5.4%	5.4%	
Travis and Hays Counties				
1990 Census	102,204	37,940	28,207	2.69
2000 Census	145,223	54,452	39,039	2.63
Amount of Change	43,019	16,512	10,832	(0.06)
Percent Change 1990-2000	42.1%	43.5%	38.4%	-2.4%
Combined Growth Rate	3.6%	3.7%	3.3%	

1.5.2.2.Population Projections

Population estimates and projections for the Planning Region were based on population projections developed as part of the Regional Water Plan for the TWDB and population projections from the City of Austin.[3] As mentioned above, one of the difficulties in developing projections for the Planning Region is that the boundaries do not coincide with those of the census tracts used by the U.S. Census Bureau, the Water User Groups (WUGs) used in the TWDB projections or the Zip Code Zones used by the City of Austin. However, the portion of the Planning Region which lies in Hays County is nearly identical to the portion of Hays County located in TWDB's Region K Planning Group. Thus, the TWDB

[3] Detailed population projections were provided by staff from the TWDB. The underlying projections were based on several sources of data, but constitute the officially adopted projections from the TWDB.

population projections were used for the portion of the Planning Region within Hays County. In developing the population projections for the portion of the Planning Region within Travis County, the short term growth rates developed by the City of Austin's Planning Department were applied to 2000 Census tract data to project population in the year 2010. The 2010 total population projection for the Travis County portion was then projected through the year 2060 using the average short term annual growth rate of 1.47% for all applicable zip codes. Populations for the portion of the Planning Region within Blanco County and Census tracts within Travis County, but outside the City of Austin's ETJ were excluded from projections. Table 4 shows the projected populations and annual growth rates for the Planning Region.

Table 4 – Population Projections for the Planning Region 2010 - 2060

County	2000 (Estimated)	2010	2020	2030	2040	2050	2060
Hays	25,090	46,143	69,377	88,887	108,495	132,051	150,574
Annual Rate		6.28%	4.16%	2.51%	2.01%	1.98%	1.32%
Travis	97,864	113,250	131,054	151,658	175,500	203,091	235,020
Annual Rate		1.47%	1.47%	1.47%	1.47%	1.47%	1.47%
Total	122,954	159,393	200,431	240,545	283,995	335,142	385,594
Annual Rate (Combined)		2.63%	2.32%	1.84%	1.67%	1.67%	1.41%

These projections indicate that the Planning Region could experience a combined annual growth rate of 1.9% between 2000 and 2060, with the total population within the Planning Region growing from an estimated 122,954 in 2000 to an estimated 385,594 in 2060. Utilizing an average household population of 2.6 (based on the historical trend), this corresponds to an increase of approximately 101,000 households by 2060, or approximately 1,680 households per year. The portion of the Planning Region located in Hays County is projected to experience a higher annual growth rate (3.03%) compared to the Travis County portion (1.47%). In addition, the portion of the Planning Region in Hays County is projected to grow faster than Hays County as a whole. according to TWDB projections. The portion of the Regional Planning Area located in Travis County is projected to experience a higher annual growth rate than Travis County as a whole, which TWDB projects to grow at an annual rate of 1.12% between 2000 and 2060.

It is important to note that these projections are based on historical growth trends. While these types of projections are typically utilized for infrastructure planning, the matters addressed through this planning process may influence ultimate population growth within the Planning Region. This is discussed in more detail in the Implications section.

1.5.3. Climate

The climate in the Planning Region is characterized as humid subtropical with hot summers and relatively mild winters. Daytime temperatures in summer are hot, with highs over 90 degrees Fahrenheit (°F) approximately eighty percent (80%) of the time. Overnight lows are generally in the 70s. On some occasions, lows can be in the 50s, while at other times highs for many days approach the 100s. During the summers, winds are generally from the south or southeast, with occasional periods experiencing hot west and southwest winds. Most of the time, the moderating effects of the Gulf of Mexico limit daytime highs; however, they also add to the discomfort with higher humidity. In summer, the average temperature is in the mid 80s, and the average daily maximum temperature is approximately 96°F. The highest temperature on record for Austin was 112°F on September 5, 2000.

During winter, the area is alternately influenced by cold air masses from the north and west, and by warm, humid air masses from the Gulf of Mexico. Mild weather prevails during most of the winter, but strong cold fronts occasionally usher in frigid conditions. Sub-freezing temperatures occur on average about 25 days each year. Alternatively, very warm days can occur during winter when dry west winds allow temperatures to climb into the 90s. In winter the average temperature is in the lower 50s, with the average daily minimum temperature approximately 40°F degrees. The lowest temperature on record for Austin was -2°F on January 31, 1949.

Average sunshine varies from about 50 percent in the winter to near 75 percent in the summer. Average yearly rainfall ranges from approximately 33 inches in southern Hays County, to approximately 31 inches in western Travis County. Precipitation is fairly evenly distributed throughout the year with heaviest amounts occurring in May and September, primarily because of tropical cyclones that migrate out of the Gulf of Mexico, or stalled out cool fronts. A majority of the precipitation (approximately 57%) occurs from April through September and usually results from thunderstorms, with large amounts of rain falling within short periods of time. Rainfall amounts have exceeded 5 inches in several hours, causing flash floods. While thunderstorms and heavy rains may occur in all months of the year, most of the winter precipitation consists of light rain. While the total annual precipitation usually is adequate for range vegetation, due to the high rate of evapotranspiration, it often is not adequate for optimum growth of most commodity crops. Although snow is not a significant source of moisture, it does visit the area during some winters. Total annual precipitation extremes measured in Austin vary from 11.52 inches in 1954 to 64.68 inches in 1919. [4-5-6]

[4] "Climatological Narrative for Austin, Texas", National Weather Service Forecast Office Austin/San Antonio, Texas, National Oceanographic and Atmospheric Administration, http://www.srh.noaa.gov/ewx/html/cli/auscli.htm, December, 2004.
[5] "Soil Survey of Comal and Hays Counties Texas", Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.
[6] "Soil Survey of Travis County Texas", Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C., June 1974.

2. GUIDING PRINCIPLES

The Stakeholder Committee developed a set of guiding principles to provide direction and a steady reference point as the plan progressed. These guiding principles are presented below.

1. *The economy and environment of this unique part of Texas depend upon the preservation, conservation and management of dependable supplies of clean water. We all recognize the unacceptable consequences that would result if we take no action to protect our water.*

2. *Both private individuals and the Public have a responsibility to respect the legitimate interests of others and to do no harm in their activities.*

3. *Those who benefit from an activity must bear the responsibility for the costs and impacts of that activity.*

4. *We will favor measures which, all else being equal, minimize the risk of failure or of damage to the watershed.*

5. *The water quality protection measures we recommend will strive to balance Government regulations with appropriate economic incentives.*

6. *The regulatory measures we recommend shall be accompanied by strategies for administration and enforcement that provide as much certainty as possible while discouraging exemptions and exceptions.*

7. *We will make all our decisions being mindful of the economic impact of the measures recommended and strive to achieve a fair and reasonable balance among the various interests.*

8. *We will not permit any party or group in this process to have undue or unfair control over the outcome.*

3. GOALS AND OBJECTIVES

Working within the guiding principles presented above, the Stakeholder Committee developed their goals and objectives for the Plan. These goals and objectives are presented below.

3.1. Stakeholder Committee Goals Statement

> ***"Develop an implement-able Regional Water Quality Management Plan that preserves and protects resources and manages activities within the planning region so that existing and future land use, land management, and development activities maintain or enhance the existing water quality of the groundwater and surface water within both the Barton Springs segment of the Edwards Aquifer and the contributing portion of the watersheds within the Planning Region, for the benefit of people and the environment."***

3.2. Objective 1

> ***How do we define "Water Quality" for this project?***

Develop a working definition of water quality for the planning region which can be utilized during the development of the regional plan.

> ***Water quality being defined for this project as: "The condition of water, as affected by chemical, physical, biological and habitat factors, and its hydrological regime, for use as public and private drinking water supplies, for protection and propagation of the Barton Springs Salamander, and for aesthetic and recreational use within the contributing area and aquifer boundary for the Barton Springs segment of the Edwards Aquifer".*** **– Executive Committee**

Based on stakeholder input the following items have been incorporated:

- The common definition of "environment" includes the earthen media, water, air, flora and fauna in the Planning Region.
- The definition of "hydrologic regime" includes flow rates, flow volumes, base flow and additional storm water flows.
- The Executive Committee's definition of "Water Quality" is expanded to include not only the protection and propagation of the Barton Springs Salamander, but also other beneficial plant and animal communities.

3.3. Objective 2

> ***What Causes Water Quality Problems?***

Identify activities within the planning region that have had or could have a short term or long term adverse impact on water quality in the Barton Springs Segment of the Edwards Aquifer or in the contributing watersheds within the Planning Region.

3.4. Objective 3

What Standards do we Apply?

Identify standards that can be used to establish goals and maintain or enhance baseline water quality, including: (1) existing regulatory standards for drinking water; (2) current analysis of groundwater quality in the Barton Springs Segment of the Edwards Aquifer; (3) current surface water quality in the contributing watersheds within the planning region; (4) scientifically-based thresholds for adverse impacts to human health and the environment; and, (5) existing hydrologic flow regimes.

3.5. Objective 4

Who Can Act?

Identify entities capable of implementing, monitoring, and enforcing water quality protection measures within the planning area, as well as any existing legal and institutional constraints on these entities, and develop procedures to educate and inform the public of voluntary measures they can implement.

3.6. Objective 5

What Measures are Already in Place?

Identify existing water quality plans and regulations currently in effect in the planning region including any parameters used to measure the success of those plans and regulations, identify any significant deficiencies in these plans and regulations, and identify proposed solutions for these deficiencies.

3.7. Objective 6

What New Measures are Needed?

Identify new structural and non-structural water quality protection measures to maintain or enhance the existing groundwater or surface water quality, as defined above, including any parameters used to measure the success of those protection measures.

3.8. Objective 7

What is our Strategy for Action?

Identify a strategy to: (1) enforce existing water quality protection measures; (2) implement the identified solutions for existing deficient water quality protection measures; (3) implement the identified new water quality protection measures; (4) monitor and assess the effectiveness of the water quality protection measures; and, (5) revise current and future water quality protection measures determined to be ineffective.

4. WHAT DOES THE REGIONAL PLAN PROTECT?

During the planning process, many asked: "What should the plan protect?" Responses vary significantly. Initially, many stakeholders answered "the Aquifer", while others answered "the Barton Springs Salamander". However, the real answer is much more complex. As charged by the Executive Committee, the Regional Plan was to protect "Water Quality". The definition of "Water Quality" for the Plan is presented above as a part of the Stakeholder Committees Goals and Objectives. Based on the Stakeholder Committee's definition of water quality, expanded definitions of certain physical elements were included in Plan development. These definitions are presented below.

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4.1. General Hydrology

Most people learn about the hydrologic cycle in elementary school. This same model is relevant in understanding water quality issues in the Planning Region. This Plan addresses three types of water resources: surface water, groundwater, and groundwater under the influence of surface water. Each is described in more detail in the following sections. Figure 2, on the following page, presents a simplified general model of the hydrologic cycle in the Edwards Aquifer region to illustrate the relationship between the different types of water discussed in the plan.

Based on this generalized hydrologic model, more detailed definitions have been incorporated for surface water, groundwater, and groundwater under the influence of surface water.

4.1.1. Surface water

"Surface water" includes all forms of water on the surfaces of the earth, including that flowing or stored in above or below ground watercourses or storage features.[7]

Watercourses can be natural, man-made or somewhere in between. Gullies, creeks, streams and rivers are examples of natural watercourses. Culverts, storm sewers, and gutters are examples of man-made watercourses. There are also many types of natural watercourses that have been modified by man, and are neither entirely natural nor entirely man-made. Storage features for surface water can also take many forms. These storage features can include lakes, depressions, ponds, impoundments and tanks. Water in these types of watercourses or storage features would be considered surface water.

4.1.2. Groundwater

"Groundwater" is water flowing or stored in the voids of natural earthen material below ground level.[8]

Groundwater is found in the voids of many natural earthen materials, often called media. While groundwater is found in all types of earthen media, it is most frequently encountered in useable quantities in sand, gravel and porous rock. Surface water becomes groundwater when it infiltrates into the earthen media through a process called "recharge". The location where this recharge occurs is referred to as the "recharge zone". The earthen media containing groundwater is often referred to as an "aquifer". When groundwater discharges to the land surface, for example at a "spring", the groundwater once again becomes surface water.

4.1.3. Groundwater Under the Influence of Surface Water

"Groundwater Under the Influence of Surface Water" is groundwater that is in continuous, open communication with surface water, such that the characteristics of the groundwater are determined almost entirely by the characteristics of the surface water.[9]

"Groundwater under the influence of surface water" is a special category of groundwater that is treated differently under certain state and federal regulatory programs. In most instances,

[7] This definition was derived from the definition of "surface water" cited in "Handbook of Applied Hydrology", V.T. Chow, et al, McGraw-Hill Publishing, and modified to include water in watercourses or storage features. [Pg. 27-27]
[8] This definition was derived from the definition of "groundwater" cited in "Handbook of Applied Hydrology", V.T. Chow, et al, McGraw-Hill Publishing. [Pg. 13-3]
[9] This definition was derived from the definition for "groundwater under the direct influence of surface water" as presented in the TCEQ's Public Drinking Water regulations, codified in Title 30, Texas Administrative Code (TAC), Chapter 290, "Public Drinking Water". [30 TAC §290.38(21)]

groundwater under the influence of surface water is located very near the recharge point, where it changes from surface water to groundwater. This proximity to the recharge zone does not allow an adequate time or distance buffer to offset changes in groundwater quality resulting from changes in surface water quality. There are two basic differences between normal groundwater and groundwater under the influence of surface water that form the basis for distinguishing between the two. The first difference is the presence of larger microorganisms (e.g. algae, bacteria, etc.). As groundwater flows through most earthen media, larger microorganisms are filtered out fairly rapidly. Normal groundwater will not have these larger microorganisms. The second difference is rapid, unpredictable changes in water chemistry due to fluctuations in the chemistry of the surface water influencing the groundwater. Normal groundwater has typically been buffered by the earthen media in the aquifer and will not typically experience rapid, unexpected changes in quality.

4.2. Surface Water (Hydrologic) Description of the Planning Region

Although the hydrologic cycle deals with both surface and groundwater, the term hydrology classically refers to surface water. There are several surface water features that influence the hydrology of the Planning Region.

4.2.1. Streams

There are several defined streams and watersheds within the planning region. The location of these streams and watersheds is portrayed in Figure 3, below.

Table 5, below identifies the streams/watersheds within the planning region[10] (generally proceeding from north to south) and presents their approximate relative size, in acres.[11]

Table 5 – Streams/Watersheds Intersecting the Planning Region and Their Relative Size

Stream/Watershed	Watershed Size*[12] (Acres)
Little Barton Creek	7,040
Barton Creek*	69,540
Bee Creek	1,920
Little Bee Creek	640
Eanes Creek	2,560
Williamson Creek*	19,200
Slaughter Creek*	19,840
Bear Creek*	17,280
Little Bear Creek*	14,720
Onion Creek*	135,040

Six (6) of these streams (Barton, Williamson, Slaughter, Bear, Little Bear, and Onion) cross the Recharge Zone on their lower reaches and are responsible for a significant portion of the recharge to the Barton Springs segment. Studies indicate that approximately eighty five percent (85%) of the surface recharge to the Barton Springs Zone occurs where these six (6) streams cross the recharge zone.[13]

4.2.2. Springs

There are numerous springs in and around the Planning Region. The most famous of these springs are the Barton Springs. A few hundred feet upstream of its confluence with the Colorado River, Barton Creek is dammed to capture spring flows at the Edwards Aquifer primary discharge point; the Barton Springs. The captured spring flows create a popular swimming facility known as the Barton Springs Pool.

[10] Stream/Watershed designations were based on the designations used by the City of Austin Watershed Protection and Development Review Department.
[11] Watershed size in acres was derived from the "Drainage Area" for each watershed from the individual fact sheets developed by the City of Austin Watershed Protection and Development Review Department.
[12] Portions of these watersheds extend south and east of the Recharge Zone boundary, which places these portions outside the Planning Region. The total watershed area reflected in Table 5 is approximately 40,000 acres larger than the area in the Planning Region as indicated in Table 13.
[13] "Hydrology and Water Quality of the Edwards Aquifer Associated with Barton Springs in the Austin Area, Texas", Report 86-4036,R.M. Slade, et al., U.S. Geologic Survey, 1986.

4.3. Geologic Description of the Planning Region

4.3.1. Edwards Aquifer Recharge Zone

The Edwards Aquifer Recharge Zone is the outcrop of the geologic unit known as the Edwards Group. The Lower Cretaceous age Edwards Group unconformably overlies the Lower Cretaceous Age Glen Rose Formation. The Edwards Group is characterized by light to dark beds of highly fractured limestone layers, and includes the Edwards and Georgetown limestones.

The Edwards Group consists of complex carbonate formations with characteristic karst features.[14] A significant number of faults are generally found in these formations in the Planning Region.

The Edwards Aquifer is comprised of groundwater bearing geologic formations within the Edwards Group. This aquifer extends generally southwest to northeast, from Kinney County southwest of San Antonio, to Bell County. There are three (3) recognized zones within the Edwards Aquifer: 1) the Southern (or San Antonio) Zone, the 2) Barton Springs Zone, and 3) the Northern Zone. The definition of the Planning Region coincides with the Barton Springs Zone, which is separated from the Southern Zone by a groundwater divide, occurring in the vicinity of the City of Kyle. The Barton Springs Zone is separated from the Northern Zone by the Colorado River in Austin. The flow of groundwater in the Barton Springs Zone is discussed in more detail below.

4.3.2. Edwards Aquifer Contributing Zone/Trinity Aquifer Recharge Zone

The Contributing Zone for the Edwards Aquifer in Hays and Travis Counties lies on the outcrop of the Lower Cretaceous Age Glen Rose Formation. These formations also serve as the recharge zone for the Trinity-Glen Rose aquifer. Within the Planning Region, the Glen Rose Formation is subdivided into the upper member and the lower member. The surface of the Contributing Zone is the exposed expression of the upper member of the Glen Rose Formation. As a result of the Balcones Fault System, rocks of the younger Edwards Group are in lateral contact with the Glen Rose Formation in southern Hays and Travis Counties.

The upper member of the Glen Rose (upper Glen Rose) is characterized by light to dark gray, resistant beds of limestone and dolomite alternating with softer clayey or marl layers. The alternating soft and hard layers create the stair-step topography common in the Central Texas region. The lower member of the Glen Rose Formation (lower Glen Rose) is generally more massive and fossiliferous than the upper Glen Rose. It is composed of pale brown to buff, massive, fossiliferous limestone with some interbedded marl layers. The lower Glen Rose tends to be more fractured and has dissolution features containing secondary calcite along fracture or dissolution planes. The lower Glen Rose unconformably overlies the Lower Cretaceous age Hensell Sand and Cow Creek Limestone members of the Travis Peak Formation in the

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[14] Geomorphic, topographic, and hydrologic features formed by solution of limestone by water. From Glossary, "Instructions to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zones", Application Form 0585, Texas Commission on Environmental Quality, October, 2004.

subsurface. At some locations, the base of the Cow Creek grades into the Hammett Shale member of the Travis Peak Formation. The Hammett Shale overlies the Sligo Limestone of the Travis Peak Formation (Sligo). The Sligo is usually light gray in color and is composed of argillaceous limestone interbedded with shale. The Sligo overlies the Hosston Sand member of the Travis Peak Formation (Hosston).

The Trinity aquifer is actually a series of three (3) differentiated aquifers: the Upper Trinity, the Middle Trinity, and the Lower Trinity. The Upper Glen Rose Formation comprises the Upper Trinity aquifer. The Lower Glen Rose formation and the upper Travis Peak formations (the Hensell Sand and the Cow Creek Limestone) comprise the Middle Trinity aquifer. The Hammett Shale serves a confining layer between the Middle Trinity aquifer and the Lower Trinity aquifer. The lower Travis Peak formations (the Sligo limestone and the Hosston Sand), comprise the lower Trinity Aquifer. Various studies have established some hydrologic communication between the Upper Trinity and the Middle Trinity, and between the Middle Trinity and the Lower Trinity. The Trinity Aquifer group is an important groundwater supply, which extends from Uvalde County in South Texas to Montague County along the Red River in North Texas.[15], [16], [17], [18]

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4.3.3. Groundwater Flow in the Barton Springs Zone

Abundant caves, sinkholes, and enlarged fractures provide further evidence of the karst nature of the aquifer and dictate the transport patterns of water (and pollutants) entering the aquifer.

Groundwater flow in the Barton Springs Zone of the Edwards Aquifer is dependent on a number of factors. These factors include recharge, groundwater withdrawal, and micro-geology. As indicated previously, the Edwards Aquifer is unusual in its karst geology manifested in faults, fractures, caves, sinkholes, and other micro-geologic features. In contrast to more homogeneous aquifers, these micro-geologic features serve as preferred pathways for groundwater flow. Darcy's Law[19] which normally is used to describe flow in porous media, typically does not properly represent flow in highly karstic formations such as the Edwards. Groundwater flow in the aquifer occurs primarily in these micro-geologic features with secondary transport through porous limestone. Unfortunately, these preferred pathways for water also serve as preferred pathways for pollutants. This feature makes the Edwards Aquifer in general and the Barton Springs Segment in particular extremely susceptible to contamination from pollutants.

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Recharge to the Barton Springs Zone occurs mostly in the channels of the six major creeks identified previously. Average recharge contribution calculations from the USGS gages in the watershed indicated that Onion and Barton creeks are the two largest contributors of recharge.

[15] "Groundwater Availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas", J.B. Ashworth, Texas Department of Water Resources, Report 273, 1983.
[16] "Geologic Atlas Map of Texas, Austin Sheet", Bureau of Economic Geology, University of Texas, 1974.
[17] "Geologic Atlas Map of Texas, Llano Sheet", Bureau of Economic Geology, University of Texas, 1981.
[18] "Evaluation of Groundwater Resources of the Paleozoic and Cretaceous Aquifers in the Hill country of Central Texas", R.L. Bluntzer, Texas Water Development Board, Report 339, 1992.
[19] "Handbook of Applied Hydrology", V.T. Chow, et al, McGraw-Hill Publishing

Their peak recharge rate also is larger compared to the smaller creeks. Data from these gages indicates that approximately 75% of the stream volume is generated from baseflow and 25% results from runoff. Runoff recharged into the Edwards Aquifer in this area comprises less than 13% of the total recharge volume. Once this water enters the aquifer, its movement is generally in an eastern direction until the edge of the confined portion is reached. At this point, flow moves generally northeast to discharge at the Barton Springs.[20]

4.4. Description of Critical Environmental Features in the Planning Region

Critical Environmental Features (CEFs) are defined as geological, topographical, physiographical, or hydrological components of the landscape within the Barton Springs Segment of the Edwards Aquifer that, if protected, would serve to remediate the quality of surface and ground water for consumptive and non-consumptive human use as well as protect biological components of the human environment such as terrestrial and aquatic biological resources including endangered species. Other entities and agencies have developed definitions and descriptions for some of these types of features as a part of various regulatory and natural resource protection programs.[21] For the purpose of this Plan, many of these definitions have been incorporated due to their current use in actual practice. Critical Environmental Features, as used in this Plan, are described as follows:

4.4.1. Category 1: Limestone recharge features

- Caves – natural underground open space formed by dissolution of limestone that are large enough for an average-sized person to enter.
- Solution Cavities – a natural cavity or depression formed as a result of dissolution of limestone.
- Solution-enlarged Fractures – fractures that show evidence of being locally enlarged by dissolution of limestone, may be part of interconnected voids connecting surface with subsurface strata.
- Faults- a fracture along which there has been displacement of one side of the fracture relative to the other.
- Manmade features affecting bedrock - unplugged abandoned water wells, quarries, or cultural features that would permit infiltration of surface water to subsurface strata.
- Swallet or swallow holes – a recharge feature in a streambed or drainage where surface flow is diverted to subsurface strata.
- Sinkholes – a broad topographic depression greater than 6 feet in diameter with more than 6 inches of topographic relief that provides a pathway to subsurface strata.

[20] "Barton Springs Management Plans for Groundwater Protection", C. Soeur, et al, presentation to the National Symposium on: Assessing the Cumulative Impacts of Watershed Development on Aquatic Ecosystems and Water Quality, Chicago, Illinois, March, 1996.

[21] Section III.A.2A, "Instructions to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zones", Application Form 0585, Texas Commission on Environmental Quality, October, 2004.

4.4.2. Category 2: Streams and associated streambeds

Streams and associated streambeds that transport water to recharge features or contain aquatic communities that would be adversely affected by degraded water quality. This category includes all creeks and associated tributaries lying over the recharge and artesian zones of the Barton Springs Segment of the Edwards Aquifer.

4.4.3. Category 3: Floodplains and Wetlands

Floodplains, wetlands, associated soils, and vegetation that would attenuate rainfall runoff, decrease the volume and velocity of flood flows, filter suspended solids and contaminants, and contribute to groundwater recharge. Construction and development activities in the vicinity of floodplains and wetlands are governed by several existing federal regulatory programs, as outlined below.

4.4.4. Category 4: Edwards Aquifer discharge areas

Involving seeps and springs including: Power House Spring near Tom Miller Dam, Seiders Springs on Shoal Creek, Cold Springs near Town Lake, Manchaca Springs on a tributary of Onion Creek, Barton Springs, and Barton Creek. These areas support biological communities including rare or endangered species that depend on spring discharge entirely or partially for survival. Because these features function as a result of the combined effects of pumping and recharge, they are directly affected by effects to the previous Categories 1-3.

As discussed in more detail below, all projects under the jurisdiction of the TCEQ's Edwards Aquifer rules requires a geologic assessment. These features should be identified and categorized as a part of this assessment. Categories 1-3 are geographically located with generally finite boundaries, and can function to substantially affect water quality. Therefore, protection of these features is the first line of defense in protecting Category 4 features. A number of structural and non-structural measures are identified in this Plan to protect Critical Environmental Features. Category 1, 2 and 4 features should be protected using dedicated offsets, as described below. Procedures for protecting Category 3 features (floodplains wetlands) have been incorporated into the protections for streams. Any development occurring in the vicinity of these features should incorporate the water quality protection measures prescribed in this Plan.

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4.5. Description of Threatened/Endangered Species in the Planning Region

While there are several threatened and/or endangered species that inhabit the Planning Region, the most prominent is the Barton Springs salamander. The Barton Springs salamander (*Eurycea sosorum*) was listed as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1997.[22] As a

[22] Federal Register, Volume 62, Number 39, Thursday, February 27, 2003, Pages 9094-9095. (62 FR 23377-23392, Service 1997). May 30, 1997.

part of its Draft Recovery Plan,[23] the USFWS indicates that it has listed the Barton Springs salamander as a Federally endangered species based on the following threats:

- Degradation of the quality and quantity of water that feeds Barton Springs resulting from urban expansion
- Modification of the salamander's surface habitat
- Lack of a comprehensive plan to protect Barton Springs watershed from increasing threats to water quality and water quantity, and
- The salamander's extreme vulnerability to environmental degradation because of its restricted range in an entirely aquatic environment.

The Barton Springs salamander is also listed as endangered by the State of Texas. The Barton Springs salamander has only been documented at four spring outlets (collectively known as Barton Springs) within the City of Austin's Zilker Park. Barton Springs salamanders live in flowing water within a narrow temperature range. Their habitat includes clean gravel aquatic plants and leaf litter. They are dependent on spring flow and the abundance of aquatic plants for survival. Sedimentation, poor water quality, and flooding can affect their habitat.

In response to the federal listing and the recognized threats to the Barton Springs Salamander, the USFWS has taken several measures to protect the species. In addition to the Draft Recovery Plan, the USFWS has also engaged in several cooperative efforts. Most recently, the USFWS has entered into a cooperative agreement with the TCEQ to allow for the implementation of optional water quality protection measures. The USFWS has determined that these optional measures will not result in a "take" of the Barton Springs Salamander. Individuals and entities that follow these optional measures will be in compliance with the requirements of the Endangered Species Act, as described below.

[23] "Draft Recovery Plan for the Barton Springs Salamander (Eurycea sosorum)". U.S. Fish and Wildlife Service, Albuquerque, NM., 2004.

5. EXISTING WATER QUALITY REGULATORY PROGRAMS

There are many existing water quality regulatory programs. Although there are numerous specific water quality regulatory programs at both the federal and state level, the major programs pertaining to the Planning Region are summarized below. More information on the specific requirements of each program can be obtained from the implementing agency. A detailed presentation of existing federal and state water quality regulatory programs is included in Attachment 4.

5.1. TCEQ Edwards Aquifer Regulations

The Edwards Aquifer regulations[24] are state instituted requirements intended to provide additional protection to the Edwards Aquifer, administered by the TCEQ. The regulations govern soil disturbance activities over the recharge zone, contributing zone and the transition zone of the Edwards Aquifer, through the approval of site specific Water Pollution Abatement Plans (WPAP). Approved WPAPs utilize a combination of "structural" and "non-structural" controls, and in addition to addressing construction and post-construction erosion and sedimentation control for any new development project, must also include special provisions for the following types of projects:

- Organized Sewage Collection Systems
- Underground Storage Tank (UST) facilities for hydrocarbons and hazardous substances
- Aboveground Storage Tank (AST) facilities for hydrocarbons and hazardous substances
- On-site Sanitary Sewage Facilities (OSSF)

5.2. TCEQ TPDES Regulations

The Texas Pollutant Discharge Elimination System (TPDES) regulations[25] are state requirements instituted based on the federal Clean Water Act (CWA) and the Texas Water Code (TWC). The TCEQ has been officially delegated federal permitting authority for the TPDES program under the National Pollutant Discharge Elimination System (NPDES). This means that the TCEQ administers the permitting and enforcement program for all NPDES discharges (all point source wastewater discharges and certain storm non-point source discharges) in the state.

The regulations require that a combination of "structural" and "non-structural" controls be utilized under the terms of an individual permit or other regulatory approvals, including permits by rule and general permits. These regulations include requirements for public notice and public involvement in the regulatory approval process. These regulations govern numerous types of discharges, including point source wastewater discharges and storm water non-point source discharges.

[24] The Edwards Aquifer regulations are codified in Title 30, Texas Administrative Code (TAC), Chapter 213, "Edwards Aquifer". [30 TAC §213.1-§213.28]

[25] The TPDES regulations are codified in 30 TAC §307, "Texas Surface Water Quality Standards", 30 TAC §308, "Criteria and Standards for the National Pollutant Discharge Elimination System, 30 TAC §309, "Domestic Wastewater Effluent Limitation and Plant Siting", 30 TAC §311, "Watershed Protection", 30 TAC §312, "Sludge Use, Disposal, and Transportation", 30 TAC §314, "Toxic Pollutant Effluent Standards", 30 TAC §315, "Pretreatment Regulations for Existing and New Sources of Pollution", and 30 TAC §317, "Design Criteria for Sewerage Systems"

5.2.1. Point Source Wastewater Discharges

TCEQ TPDES regulations govern all point source wastewater discharges in the state, including domestic and industrial wastewater. These discharges are required to meet the treatment standards and effluent quality identified in the regulations. In the Planning Region, the Edwards Aquifer rules restrict certain wastewater discharges.

The TCEQ has established Critical Water Quality Parameters listed in Chapter 7: Texas Surface Water Quality Standards, Chapter 307, §§307.1-307.10, required to allow human use and maintain aquatic life. These standards also include maximum threshold criteria for specific toxic materials for aquatic life protection. Parameters included in the TCEQ Water Quality Standards for specific stream segments in each river basin include: 1) low flow criteria; 2) chlorides; 3) sulfates; 4) total dissolved solids; 5) dissolved oxygen; 6) pH; 7) indicator bacteria; and 8) temperature. The standards also list acute and chronic criteria for 39 different toxic materials.

5.2.2. Municipal Storm Water Discharges

In the early 1990's, EPA adopted the Phase I Storm Water Regulations. Among other things, these regulations governed storm water non-point source (NPS) pollution from large (greater than 100,000 population) municipal separate storm sewer systems (MS4s). Under Phase I, MS4s were defined as publicly owned separate storm sewers that are located in an incorporated municipality or county with a population of 100,000 or more.[26] The owners and/or operators of these MS4s were required to obtain individual permits, characterize their storm water, institute certain monitoring and control measures, and conduct public education. The only permitted Phase I MS4 in the Planning Region is the City of Austin.

In 1999, the EPA adopted the Phase II Storm Water Regulations, which extended storm water NPS regulation to smaller MS4s in defined urbanized areas. Under Phase II, the definition of an MS4 was expanded to include any storm water conveyance or system of conveyances that is operated by a public entity within these defined areas.[27] While the Phase II storm water regulations do not require cities to obtain individual permits, they must characterize their storm water and develop, implement, and enforce a Storm Water Management Plan (SWMP), designed to reduce the discharge of pollutants from their MS4 to the "maximum extent practicable." The Phase II rules use narrative, rather than numeric, criteria for controlling water quality.[28] To comply with these regulations, SWMPs must include the following six (6) minimum control measures:

- Public Education and Outreach
- Public Involvement/Participation
- Illicit Discharge and Detection

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[26] See 40 CFR §122.26(b)(4) and §122.26(b)(7)
[27] See 40 CFR §122.26(b)(8)
[28] "Storm Water Phase II Final Rule, An Overview", Fact Sheet 1.0, Publication No. EPA883-F-00-001, U.S. EPA, January 2000.

- Construction Site Storm Water Runoff Controls
- Post Construction Storm Water Management in Areas of New and Redevelopment
- Pollution Prevention and Good Housekeeping Measures for Municipal Operations.

The Phase II regulations also allow SWMPs to be expanded to include a seventh minimum control measure, addressing construction activities conducted by the operator of the regulated MS4. This measure could be incorporated in lieu of obtaining coverage for individual construction projects under a general permit. The TCEQ has currently issued a draft general permit to be used by all small MS4s wishing to obtain coverage through a general permit.[29] However, this permit has not been issued in final form.

Based on information developed by the TCEQ and the EPA,[30] the following local government entities in the Planning Region are subject to these regulations:

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• Village of Bee Cave	• City of Rollingwood
• City of Buda	• City of Sunset Valley
• City of Hays	• Travis County
• Hays County	• City of West Lake Hills

5.2.3. Industrial Site Storm Water Discharges

In addition to regulating municipal NPS storm water discharges, Phase I of the EPA's storm water regulations also governed a wide range of industrial site discharges. The list of regulated industrial activities was expanded in the Phase II storm water regulations. These industrial discharges are subject to numerous technical standards. The TCEQ has currently issued a general permit that can be used to cover discharges from industrial facilities meeting certain conditions. Industrial storm water dischargers can also all obtain and individual TPDES permit. Both the individual and general permits require permittees to characterize their storm water and institute certain control measures. Industrial discharges obtaining coverage through a general permit are required to notify any applicable MS4s that may receive their storm water discharges.

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5.2.4. Construction Site Storm Water Discharges

The EPA's Phase I storm water regulations also governed storm water non-point source (NPS) pollution from construction sites greater than five (5) acres in size. With the implementation of the Phase II storm water regulations, this threshold has been reduced to one (1) acre in size. This threshold applies to all parts of sites with a "common plan of development", even if they are not constructed at the same time. The requirements of this provision apply regardless of the type or sequencing of construction. The application of this provision to commercial and multi-family residential construction is straightforward. However, this provision also governs all construction (including individual residences) within a typical residential subdivision, even if the residences

[29] The notice of Proposed General Permit No. TXR040000 was published in the Texas Register on September 27, 2002.
[30] Information on the requirements for these permits and a description of the areas covered is available on the TCEQ internet website (http://www.tnrcc.state.tx.us/permitting/waterperm/wwperm/ms4.html).

are constructed well after the construction of the common development components (e.g. streets, drainage facilities, etc) is completed.

Current federal and state regulations require controls to be implemented to prevent storm water discharges from construction sites from adversely impacting water quality. TCEQ rules and regulations prohibit discharges from construction sites that "would cause or contribute to a violation of water quality standards or that would fail to protect and maintain existing designated uses."[31] These regulations also require all control measures to be "adequately maintained to effectively reduce or prohibit erosion".[32] Owners and operators are required to "describe and ensure the implementation of practices that will be used to reduce the pollutants in storm water discharges associated with construction activity at the construction site and assure compliance with the terms and conditions" of the regulations.[33] Erosion and sediment controls must be designed to retain sediment on-site to the extent practicable with consideration for local topography, soil type and rainfall.[34]

5.3. TCEQ OSSF Program

The Texas On-Site Sanitary Sewage Facility (OSSF) Program[35] is based on the federal CWA and the TWC and is administered by the TCEQ. These regulations govern the installation, operation and maintenance of OSSF's including septic tanks, irrigation systems, proprietary treatment systems and others. The program utilizes primarily "structural" controls, is implemented through a permit program, and can be delegated to qualified local governments. In the Planning Region, the following local governments implement the TCEQ OSSF program:

- City of Austin
- Village of Bee Cave
- Blanco County
- Hays County
- LCRA
- City of Rollingwood
- Travis County

5.4. Federal Endangered Species Program

The federal endangered species programs are administered by the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) and are based primarily on the federal Endangered Species Act (ESA). The programs have several different elements. The first element is a "Listing Program" which includes procedures to evaluate and list "threatened" and "endangered" species, as mandated by the ESA. In instances where the implementing agency identifies a species as endangered, a Species Recovery Plan (SRP) is to be developed. Another element of the programs is a review of "Federal Actions" to avert or minimize their impact on endangered species. This requires all federal agencies

[31] Article II.B.3., TCEQ General Permit No. TXR150000, issued March 5, 2003, under the authority of the Federal Clean Water Act, Section 402 and the Texas Water Code, Section 26.040
[32] Article II.D.1.(c), TCEQ General Permit No. TXR150000
[33] Article III, TCEQ General Permit No. TXR150000
[34] Article III.F.2(a)(i), TCEQ General Permit No. TXR150000
[35] The OSSF regulations are codified in 30 TAC §285, "On-Site Sewage Facilities"

to aid conservation efforts for endangered species and to consult with USFWS on direct federal actions, actions using federal funds, and the issuance of permits under federal programs, including delegated states. A third element of the programs is to prohibit the taking of endangered species. The implementing agency is allowed to adopt provisions to prohibit the taking, possession, sale, or transfer of certain endangered species, to allow the issuance of incidental take permits, and to coordinate Habitat Conservation Plans (HCPs).

5.5. Other State Water Quality Programs

In addition to the programs presented above, there are several other state programs with a partial focus on water quality. These are listed below with a basic description of the regulated activities:

- Texas Oil and Gas Environmental Program[36] – administered by the Railroad Commission of Texas (RRC), regulates the exploration and production of oil, gas and geothermal resources and the disposal and clean-up of associated wastes.
- Texas Municipal Solid Waste Program[37] – administered by the TCEQ, regulates the transportation, storage, processing and disposal of municipal solid waste (garbage)
- Texas Petroleum Storage Tank Program[38] - administered by the TCEQ, regulates the installation, operation and pollution from petroleum storage tanks
- Texas Industrial and Hazardous Waste Program[39] – administered by the TCEQ, regulates the handling, transportation, storage, processing and disposal of hazardous and non-hazardous industrial solid waste
- Texas Agricultural and Silvicultural Water Quality Management Program[40] – administered by the Texas State Soil and Water Conservation Board (TSSWCB), is a voluntary program to control pollution from certain agricultural operations.

5.6. Other Federal Water Quality or Related Programs

In addition to the programs presented above, there are several other federal programs with a partial focus on water quality, that have not already been covered under another federal or state program. These include:

- Federal Spill Prevention, Control and Countermeasure (SPCC) Program - administered by the U.S. EPA, regulates the storage and handling of petroleum products and hazardous materials.[41]
- Federal Superfund Program – administered by the EPA, requires the compilation and management of the National Priorities List (NPL) for contaminated sites, governs the clean-

[36] The Texas Oil and Gas Environmental program regulations are codified in 16 TAC §3, "Oil and Gas Division" and 16 TAC §4, "Environmental Protection".
[37] The Texas Municipal Solid Waste regulations are codified in 30 TAC §330, "Municipal Solid Waste".
[38] The Texas Petroleum Storage Tank regulations are codified in 30 TAC §334, "Underground and Aboveground Storage Tanks".
[39] The Texas Industrial and Hazardous Waste regulations are codified in 30 TAC §335, "Industrial Solid Waste and Municipal Hazardous Waste".
[40] The Texas Agricultural and Silvicultural Water Quality Management Program regulations are codified in 31 TAC §523, "Agricultural and Silvicultural Water Quality Management".
[41] The Federal SPCC program regulations are codified in 40 CFR §112.

up of those sites and outlines the Emergency Planning and Community Right-to-Know program.

- Federal Toxic Substances Control Program – administered by the EPA, regulates the creation, use, transportation, storage, processing and disposal of toxic substances.
- National Wetlands Program – administered by the U.S. Army Corps of Engineers, regulates construction activities, dredging and placement of fill in jurisdictional wetlands and navigable waterways.[42]
- National Floodplain Program – administered by the Federal Emergency Management Agency (FEMA), regulates construction activities and development in floodplains.[43]

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5.7. Local Water Quality Programs

There are a number of existing regulatory programs at the local level specifically intended to protect water quality, both inside and outside the Planning Region. The following sections describe in general the central elements of these local programs both inside and outside the Planning Region. A summary presentation of these programs is included in Attachment 5.

5.7.1. Local Programs Within the Planning Region

Several local jurisdictions within the Planning Region currently have local water quality protection programs. The City of Austin has a number of land development controls intended to protect water quality, including the Save Our Springs Initiative, adopted in 1992.[44] The resulting development ordinances require certain water quality protection measures within the Barton Creek watershed. In addition, the City of Buda and the Village of Bee Caves have water quality protection ordinances. The LCRA also has existing water quality protection ordinances applicable to portions of Travis County.

5.7.2. Local Programs In the General Area but Outside the Planning Region

There are several local jurisdictions in the general area, but outside the Planning Region that have existing water quality regulatory programs. However, due to the unique characteristics within the Planning Region, only areas with similar hydrogeology could be considered applicable for comparison purposes. The water quality ordinances from the Cities of New Braunfels, San Antonio and San Marcos[45] were selected for comparison due to their proximity to the Edwards Aquifer and similar hydrogeology.

[42] The National Wetlands Program is administered under the authority of Section 404 of the Federal Clean Water Act.
[43] The National Floodplain Program regulations are codified in 40 CFR §9, "Floodplain Management and Protection of Wetlands"
[44] Land development restrictions instituted by the City of Austin are codified in the Austin City Code, Title 25, “Land Development”.
[45] Land development restrictions instituted by the City of San Marcos are codified in the San Marcos City Code, Chapter 94, “Development Standards”.

6. WATER QUALITY PARAMETERS AND MONITORING

There were numerous water quality parameters evaluated as a part of the planning process. While many of these parameters were applicable to both surface water and groundwater, some were only applicable to one medium.

6.1. Definition of Water Quality Parameter

In general, "water quality parameters" are defined as physical, chemical or biological constituents in water or other indicators used to assess, monitor and control water quality. However, one of the objectives of the Plan is to institute water quality protection measures designed to minimize the introduction of pollutants into water. With this understanding, the working definition of a water quality parameter adopted for this Plan is:

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> ***Water Quality Parameter: A physical property or a chemical or biological constituent in water which is used to assess, monitor and control water quality***

Water quality parameters address specific chemical, physical, or biological aspects of surface or ground water that affect the ability of the water to support human uses or maintain aquatic life. The level of suitability for human use or maintenance of aquatic life would be determined by the quantity of water available, the type of water quality constituents present, and whether the minimum or maximum acceptable threshold concentration levels of the constituents have been exceeded. Many different public and private scientific studies of water quality have identified numerous water quality parameters used for different purposes. The further discussion of water quality parameters in this Plan will be subdivided by the water medium (surface water, groundwater or both) to which these parameters apply. In addition to their subdivision by medium, the Plan discusses the use of water quality parameters in four (4) general contexts:

- General Categories of Water Quality Parameters
- Historical monitoring
- Planning and design
- Monitoring and evaluation

6.2. General Categories of Water Quality Parameters

There are numerous ways to assign water quality parameters to general categories. Since regulatory programs are a significant factor in determining which water quality parameters are widely used, the general categories used by these regulatory programs serve as a good starting point for distinguishing between various parameters. Although numerous water quality parameters have been identified, a smaller (although still extensive) set of water quality parameters is used in these regulatory programs for the purposes of assessing water quality and evaluating compliance with regulatory standards. Also, since most regulatory programs require some type of monitoring, there is generally a much larger universe of available data for the monitored parameters through these regulatory programs. This is certainly true for the Planning Region. While the scope of this Plan prevents a complete listing of all the parameters utilized by all the current water quality regulatory programs, several general categories of water quality parameters have been identified that span most

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water quality regulatory programs.[46] These general categories will provide some background information on water quality parameters.

6.2.1. Solids

Solids in water originate from many sources and can vary widely in size and physical form. They are introduced into the water column in a variety of ways, including human activity and natural process. Solids can float on the surface, be suspended, or settle out of the water column. Floating solids are an anecdotal water quality parameter, since they are generally observed visually and do not require a specific measurement method. Suspended solids are most frequently measured in water as Total Suspended Solids (TSS). A secondary parameter for solids in water is turbidity. However, turbidity can also at times be affected by dissolved constituents.

Floating or suspended solids increase turbidity, reduce light penetration, and limit the growth of desirable aquatic plants. Solids that settle out as bottom deposits contribute to sedimentation and can alter and eventually destroy habitat for fish and bottom-dwelling organisms. Solids can also facilitate the transport, storage and accumulation of other pollutants. Pollutants bound up in settled solids remain in contact with the water column and are subject to re-suspension, and redeposition.

In most locations, solids are primarily a surface water issue, since they are often filtered out of groundwater by the earthen media. However, aquifers in karst environments, such as the Edwards Aquifer, can experience very pronounced solids impacts to groundwater due to the short-circuiting of groundwater flow through faults, fractures and secondary features. This short-circuiting prevents the natural filtering process which normally removes these solids. For this reason, TSS is a water quality parameter that applies to both surface water and groundwater in the Planning Region.

6.2.2. Dissolved Oxygen/Oxygen-demanding Substances

Adequate levels of dissolved oxygen in water are necessary for the survival of aquatic plants and animals. However, many pollutants sequester or extract oxygen when introduced into the water column. These pollutants are generally described as oxygen-demanding substances. While these substances vary in origin and composition, they all can adversely impact water quality by removing sufficient oxygen from the water column to reduce dissolved oxygen levels below those necessary to sustain aquatic life.

Several different water quality parameters are used to quantify this condition. The first is the direct measurement of dissolved oxygen (DO) in the water column, most frequently using a hand-held probe. Oxygen demand potential for substance in the water is typically measured by Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Organic Carbon (TOC), utilizing laboratory tests.

[46] "Preliminary Data Summary of Urban Storm Water Best Management Practices", Publication No. 821-R-99-012, U.S. Environmental Protection Agency, August, 1999.

Although oxygen demanding substances are most frequently encountered in surface water, insufficient DO levels can also occur in groundwater. If DO levels are reduced prior to surface water being recharged to groundwater, there is typically no mechanism available in the earthen media to reintroduce oxygen to the water. For this reason, DO, BOD, COD and TOC are parameters that apply to both surface water and groundwater in the Planning Region.

6.2.3. Nutrients (primarily nitrogen and phosphorus)

Nutrients are necessary to support aquatic life. The principal nutrients impacting water quality are nitrogen and phosphorus. Major sources of these nutrients include urban landscape runoff (fertilizers, detergents, plant debris), atmospheric deposition, and improperly functioning domestic waste management systems, and animal waste.

A number of water quality parameters are used to measure the various forms of nitrogen and phosphorus in water. Ammonia (NH_3) nitrogen is the nitrogen form that is usually the most readily toxic to aquatic life. Nitrate (NO_3) and nitrite (NO_2) are the inorganic fractions of nitrogen. Total Kjeldahl nitrogen (TKN) measures the organic and ammonia nitrogen forms. By subtraction, the organic fraction can be determined. Total phosphorus measures the total amount of phosphorus in both the organic and inorganic forms. Orthophosphate measures phosphorus that is most immediately biologically available.

Excessive quantities of nutrients in the water column can result in significant increases in primary biological productivity, with the major impact being excessive algal growth. In surface waters, this can lead to nuisance algal blooms and eutrophication. A secondary impact is increased oxygen demand resulting from the decomposition of dead algae.

As discussed above in the section on solids, the karst characteristics of the Edwards Aquifer often circumvent the natural filtering process which might normally remove these nutrients from groundwater. For this reason, the nutrient parameters identified above apply to both surface water and groundwater in the Planning Region.

6.2.4. Pathogens

Pathogens are disease-producing organisms that present a potential health threat when present in water. The principle pathogens from a water quality standpoint are bacteria, viruses, protozoans and toxigenic fungi. These pathogens are typically introduced to water through contact with human or animal waste products, or decomposing organic matter. Some types of pathogenic bacteria are also naturally present in soil and can be introduced where surface water or groundwater come in contact with that soil. Since they are living organisms, pathogens require favorable environmental conditions (e.g. suitable temperatures, etc.) for their continued existence. Pathogens pose potential health threats to humans, animals and aquatic life.

Due to the large number of species and significant variations within each species, the monitoring and identification of pathogens is difficult. However, a number of indicator organisms have been used historically to assess the presence of harmful pathogens in water. While not necessarily pathogenic themselves, these indicator organisms can provide a useful marker when

attempting to assess and quantify the presence of pathogenic organisms. Fecal coliform has been widely used as a parameter indicating the presence of harmful pathogens in wastewaters and storm water runoff. Other bacterial indicator parameters that have been used to evaluate the presence of harmful pathogens in water include escherichia coli, streptococci and enterococci. In more specialized situations, the presence of enteric viruses and/or protozoans such as Giardia lamblia and cryptosporidium are also monitored. Specific laboratory testing and evaluation is typically required to measure the presence of these pathogens and surrogate indicator parameters.

As discussed above in the section on solids, the karst characteristics of the Edwards Aquifer often circumvent the natural filtering process which might normally remove most pathogenic organisms from groundwater. For this reason, pathogens are water quality parameters that apply to both surface water and groundwater in the Planning Region.

6.2.5. Petroleum Hydrocarbons

Petroleum hydrocarbons include oil and grease; volatile and semi-volatile organic compounds (VOCs and SVOCs), and a variety of polynuclear aromatic hydrocarbons (PAHs). Sources of petroleum hydrocarbons include parking lots and roadways, leaking storage tanks, auto emissions, and improper disposal of waste oils and other petroleum products. Higher concentrations are typically found in soils and sediments along transportation corridors.

Numerous scientific studies have evaluated and identified various toxic effects of petroleum hydrocarbons, sometimes at very low concentrations. These toxic effects pose potential health threats to humans, animals and aquatic life. Numerous regulatory agencies have established water quality criteria for petroleum hydrocarbons, principally VOCs, SVOCs, and PAH compounds. Most petroleum hydrocarbons have low solubility in water and will generally remain phase-separated when in contact with water. In a phase separated state, petroleum hydrocarbons are still mobile in both surface water and groundwater. However, a few petroleum hydrocarbons have higher solubility and will partition readily into water when they are in contact. Once dissolved in water, petroleum hydrocarbons are very mobile in both surface water and groundwater. Specific laboratory testing and evaluation is typically required to measure the presence of petroleum hydrocarbon parameters.

Due to their mobility in both surface water and groundwater, petroleum hydrocarbon parameters apply to both surface water and groundwater in the Planning Region.

6.2.6. Metals

Metals are naturally occurring compounds that are frequently encountered in water. The principal sources of metals in water are industrial activity and mechanized equipment, including automobiles. Metals are introduced to water through a variety of processes, including storm water runoff, atmospheric deposition, leaching of earthen materials.

Various regulatory programs categorize “heavy metals” as priority pollutants. While the definition of this term varies some across regulatory programs, heavy metals generally include

arsenic, barium, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver and zinc[47]. In water, metals are most frequently encountered in dissolved form. Metals may also be adhered to suspended solids. In dissolved form, metals are very mobile in both surface water and groundwater. Metals in water have the potential to impact human uses and cause acute or chronic toxic impacts to aquatic life. Specific laboratory testing and evaluation is typically required to measure the presence of metals parameters.

Due to their mobility in both surface water and groundwater, metals parameters apply to both surface water and groundwater in the Planning Region.

6.2.7. Synthetic Organic Compounds

The term synthetic organic compounds (SOCs) is used to describe a variety of manufactured or refined organic compounds, including pesticides, solvents and household and industrial chemicals. The principle sources of SOCs are the residuals of these chemicals. SOCs are introduced to water through a variety of processes, including storm water runoff, discharge through point sources and atmospheric deposition.

Various regulatory programs categorize SOCs as priority pollutants. Most SOCs are soluble in water and are therefore very mobile in both surface water and groundwater. Numerous scientific studies have identified SOCs as posing serious health risks to humans and aquatic life, often at very low concentrations. One aspect generally unique to SOCs is their tendency for bioaccumulation in the food chain. Specific laboratory testing and evaluation is typically required to measure the presence of SOCs.

Due to their mobility in both surface water and groundwater, SOC parameters apply to both surface water and groundwater in the Planning Region.

6.2.8. Physical Parameters

Several physical parameters of water also play a key role in evaluating and assessing water quality.

6.2.8.1. Temperature

Water temperature is an important measure of water quality, since the temperature affects other physical properties of water, including conductance and the solubility of both chemical compounds and gases.[48] Other previously identified parameters, such as DO, are directly linked to temperature. The principal determinants of water temperature are natural. However, increased temperature can be imparted to water through the discharge or runoff of

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[47] Sources: Title 40, Code of Federal Regulations (CFR), Chapter 261, [40 CFR §261] "Identification and Listing of Hazardous Wastes", 40 CFR §403, "General Pretreatment Regulations for Existing and New Sources of Pollution", Appendix G, and 40 CFR §503, "Standards for the Use or Disposal of Sewage Sludge"

[48] Malina, J. F. 1996. "Chapter 8: Water Quality.", Water Resources Handbook. L. W. Mays, ed. McGraw-Hill. New York, NY.

water whose temperature has artificially been raised due to human activity. Temperature is measured directly using a variety of different instruments.

Elevated temperatures are typically a water quality issue for surface water since the significant geothermal capacity of earthen media tends to moderate groundwater temperatures rapidly. In surface water, elevated temperatures can significantly increase the metabolism, respiration, and oxygen demand of fish and other aquatic life. This poses a potential threat to aquatic life. While excessive temperature can sometimes cause direct mortality, it is more often the secondary conditions associated with elevated temperature (e.g low DO) which result in mortality. Even if significant aquatic life mortality does not result from elevated temperatures, it can result in a change of character in the aquatic life in surface water bodies[49] Sudden changes in temperature can also directly stress aquatic ecosystems. Due to its unique impacts to surface water, temperature is a water quality parameter which generally only applies to surface water in the Planning Region.

6.2.8.2.pH

pH is a measure of the effective concentration of hydrogen ions in water. While pH levels fluctuate naturally based on changes in temperature, circulation, and DO content, significant changes in pH can result from the introduction of additional water with differing pH levels, or through the introduction of other compounds in the water. Most aquatic ecosystems experience natural fluctuations of pH, but can be significantly harmed if human activity or natural events cause significant changes in pH levels. Rainwater typically has much lower pH levels than surface waters (e.g. acid precipitation), while storm runoff from alkaline environments can have much higher pH levels. Groundwater flowing through earthen media can also experience significant changes in pH based on the characteristics of the media. pH is measured directly using a variety of different instruments. pH is a water quality parameter that applies equally to surface water and groundwater.

6.3. Historical Monitoring in the Planning Region

A significant amount of historical monitoring has been conducted in the Planning Region by a variety of entities.

6.3.1. City of Austin

For many years, the City of Austin has conducted extensive monitoring for a wide variety of water quality parameters on both surface water and groundwater. Large volumes of data are available from this source for parameters such as total suspended solids, bacteria, oxygen consuming constituents, nutrients, petroleum hydrocarbons and metals. A lesser volume of data is available for infrequent constituents and priority pollutants.[50]

[49] "Water Quality Criteria, Second Edition", Publication No. 3-A, California State Water Resources Control Board, 1963.
[50] Various data compilations, publications and other documentation, obtained from the City of Austin Watershed Protection and Development Review Department, obtained October, 2004.

6.3.2. U.S. Geologic Survey

The U.S. Geologic Survey (USGS) has also conducted extensive monitoring for a wide variety of water quality parameters on both surface water and groundwater within the Planning Region. This data was compiled from a combination of fixed, continuous monitoring stations and one-time events. A large portion of this data is available to the public on the internet[51] in raw format. Additional data and data compilations are available in a wide range of reports, many of which are also available on the internet. [52]

6.3.3. Lower Colorado River Authority

The LCRA has also conducted monitoring in the Planning Region for a number of years. This monitoring includes chemical and biological monitoring on the Colorado River and its major tributaries on a periodic basis. The LCRA also has its own internal laboratory. A large portion of this data is available to the public on the internet.[53]

6.3.4. Other Public and Private Entities

Several other public and private entities have collected historical monitoring data in the Planning Region. This data is available in a variety of formats. Please refer to the Technical Reference List in Attachment 6 for other data sources used in conjunction with this planning effort.

6.4. Planning and Design

Water quality data used for planning and design should be evaluated and treated differently than data used for monitoring and evaluation. One primary difference is the number of parameters to be used. While in monitoring and evaluation, all parameters of concern should be addressed. However, for planning and design, a more limited approach can be taken. This limited approach typically focuses on using representative parameters. In this situation, one or two representative parameters are used to represent several monitoring parameters.

Water quality parameters used for planning and design have been selected to be representative of the major broad issues, while an expanded list of parameters is recommended for monitoring and evaluation purposes. In general the selected parameters represent the movement and transport of other similar parameters and can serve as surrogates for them during the design process. These other parameters will, however, be independently monitored as part of the comprehensive management process. The following water quality parameters have been identified for use in planning and design in conjunction with the study. In addition, these parameters have been further subdivided by the water medium which may be affected (surface water, groundwater or both).

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[51] http://tx.usgs.gov/aquifer/edwards.html and http://nwis.waterdata.usgs.gov/tx/nwis/qwdata
[52] http://tx.usgs.gov/aquifer/biblio_aquifer.html
[53] http://waterquality.lcra.org/sitelist.asp

6.4.1. Design Parameters Applicable to Both Surface water and Groundwater:

- Suspended Solids/Sediment
- Total Dissolved Solids
- Suspended biological constituents/oxygen depleting constituents

6.4.2. Design Parameters Applicable Only to Surface Water

- Floating constituents

6.5. Monitoring and Evaluation

An on-going water quality monitoring and evaluation process will be an integral part of implementing the water quality protection measures from this Plan. This monitoring program should encompass a variety of water quality parameters and should include all surface watersheds, and representative groundwater wells within the Planning Region. The recommended monitoring program is presented below. On-going evaluation of the monitoring data will take place as a part of implementing the Plan. Elements of the evaluation program have been described in the Implementation section.

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6.5.1. Benefits of Coordinated Monitoring

A coordinated monitoring program will provide many benefits to the Planning Region. As indicated previously, there are a number of different entities currently engaged in varying degrees of water quality monitoring and evaluation. Coordinating these efforts can result in more cost efficient monitoring which should result in corresponding savings in expenditures for the various public entities. The coordinated monitoring program can ensure that adequate data is collected in representative locations, and that the selected monitored parameters are adequately sensitive and predictive of changes in water quality. Specific recommendations for coordinating the monitoring program are outlined in the Implementation section.

In addition to coordinating the collection of the data, the reporting and public availability of the data should also be coordinated. There will be a number of entities, public and private, involved in the implementation of the Plan. The results of the monitoring data should be publicly available, ensuring that all of the entities involved have this data at their disposal during the decision-making processes required by this Plan. The data should be maintained in a central repository, with access to the raw data available over the internet or another suitable means.

6.5.2. Strategy for Defining the Monitoring Program

There was considerable discussion during the planning process over that strategy to be used to define the monitoring program. Some stakeholders suggested that a monitoring program be defined to include monitoring all outfalls for all new development, as well as representative monitoring points for both surface water and groundwater. The primary concerns expressed from this viewpoint involved the need to accurately assess the capabilities of the recommended water quality protection measures and to respond quickly to potential water quality problems. Other stakeholders as well as members of the technical review group indicated that a regional

monitoring network was sufficient. The primary concerns expressed from this viewpoint were the potential cost and the resources required to institute such an intensive monitoring program. The approach selected for defining the monitoring programs was to establish representative regional sites for periodic monitoring, combined with an evaluation and response procedure, and public education.

6.5.3. Recommended Monitoring Parameters and Frequency

6.5.3.1. Surface Water Monitoring Parameters and Frequency

Many different existing water quality regulatory programs require monitoring for a variety of surface water parameters. The consulting team prepared a comparison of these parameters across the various regulatory programs to identify representative parameters. This comparison also looked at the parameters included in the on-going monitoring in the Planning Region, as well as the studies conducted in the Planning Region. Based on this comparison, water quality parameters occurring at least twice were considered for inclusion in the recommended monitoring program. Table 6, on the following page, presents the results of that comparison.

These parameters are recommended for inclusion in a coordinated, monthly surface water monitoring program to be implemented throughout the Planning Region. In addition to the monthly monitoring, annual monitoring for an expanded list of parameters should occur at selected sites within the Planning Region. This expanded list of parameters should consist of those specified in the TCEQ's Surface Water Quality Standards (SWQS).[54]

[54] Appendix D, "Monitoring Variables and Analytical Methods", "Surface Water Quality Monitoring Procedures, Volume 1", RG-415, TCEQ, December 2003

Table 6 – Recommended Surface Water Quality Indicator Parameters for Use in Planning Region

Water Quality Parameter	USGS 1990[55]	COA [56]	LCRA [57]	TCEQ SWQS[58]	EPA NURP[59]	EPA Ph. I[60]
Field Parameters						
Conductivity		X	X			
Discharge	X	X				X
pH			X	X		X
Temperature			X	X		
Turbidity				X		X
Laboratory Parameters						
Copper (Cu)				X	X	X
E. Coli.			X	X		
Fecal Coliform				X		
Lead (Pb)				X	X	
Nitrogen, as Ammonia		X		X		
Nitrogen, as Nitrate		X	X	X		
Nitrogen, as Nitrate + Nitrite		X		X	X	X
Nitrogen, Total Kjeldahl		X		X	X	X
Oil and Grease				X		X
Organic Carbon, Total (TOC)	X			X		
Ortho-phosphorous as P		X		X		
Oxygen, Dissolved (DO)		X	X	X		
Oxygen Demand, Biochemical (BOD)	X			X	X	X
Oxygen Demand, Chemical (COD)				X	X	X
Phosphorous, Total		X		X	X	X
Solids, Total Dissolved (TDS)	X			X		
Solids, Total Suspended (TSS)	X	X		X	X	X
Sulfate		X		X		
Zinc (Zn)				X	X	

[55] Table 3, "Relation Between Urbanization and Water Quality of Streams in the Austin Area, Texas", Report 90-4107, J.E. Veenhuis, et al., U.S. Geologic Survey, 1990.
[56] See Note 50.
[57] "Water quality indicators" used as a part of the LCRA's "Colorado River Watch Network" (http://www.lcra.org/water/indicators.html)
[58] Selected parameters from the TCEQ's Surface Water Quality Standards. See Note 54.
[59] "Standard Pollutants Characterizing Urban Runoff", "Results of the Nationwide Urban Runoff Program, Volume I – Final Report", USEPA, 1983.
[60] From the EPA's Phase I Storm Water Regulations, 40 CFR §122.26(d)(1)(iii)(D)

6.5.3.2. Groundwater Monitoring Parameters and Frequency

Existing water quality regulatory and monitoring programs include a variety of groundwater parameters. The Texas Water Development Board (TWDB) has an extensive set of historic water quality monitoring data for groundwater wells throughout the state, including the Planning Region. The TWDB standard parameter list[61] has been adopted as the recommended indicator parameter list for general water quality monitoring in the Planning Region. Table 7, below, presents the list of recommended parameters for monitoring groundwater.

Table 7 – Recommended Groundwater Quality Indicator Parameters for Use in Planning Region

Field Parameters	
Conductivity	pH
Temperature	
Laboratory Parameters	
Bicarbonate (HCO3)	Nitrogen, as Nitrate
Calcium (Ca)	Potassium
Carbonate (CO3)	Silica
Chlorides	Sodium
Fluoride	Solids, Dissolved (TDS)
Hardness (CaCO3)	Sulfate
Magnesium	

These parameters are recommended for inclusion in a coordinated, quarterly groundwater monitoring program to be implemented throughout the Planning Region. In addition to the quarterly monitoring, annual monitoring for an expanded list of parameters should occur at selected wells within the Planning Region. This expanded list of parameters should consist of those specified in the TCEQ's Drinking Water Regulations[62] and should include all constituents with either a primary or secondary Maximum Contaminant Level, as defined under those regulations.

6.5.4. Recommended Monitoring Locations

If the recommended monitoring parameters are to be used to characterize water quality in the Planning Region, the resulting data must be collected from enough different locations to ensure that it represents the true diversity of the range of conditions present. While past monitoring data has been concentrated in the more developed portions of the Planning Region, the monitoring data from this point forward should be spatially diverse.

While monitoring locations should be selected based on their ability to provide representative data, they must also take into account practical considerations such as:

[61] Appendix G, "Database Field Descriptions", "Ground-water Data System Dictionary", Publication UM-50, Texas Water Development Board, May, 1999.
[62] 30 TAC §290

- Physical Accessibility (especially during sampling conditions)
- Legal Right of Access
- Accommodating (adequate to perform necessary sampling/measurement at the location)
- Continuity (sampling in the same location despite changes in conditions)
- Reliability (not unduly influenced by factors which might interfere with results)

These factors must all be evaluated on a site specific basis. Due to the need to do a site specific evaluation, specific locations have not been identified. Instead, general guidance has been provided to be used by the implementing entities in determining the exact location of the monitoring locations.

6.5.4.1. Surface Water Monitoring Locations

In general, at least one (1) surface water quality monitoring location should be identified in each of the previously designated watersheds[63] within the Planning Region. For larger watersheds, monitoring points should be located to be representative of each third of the watershed, based on reach length. Publicly available access points to surface water monitoring locations can typically be established in conjunction with public roadway crossings. However, additional locations may be required in some areas to accomplish the objectives of the monitoring plan.

6.5.4.2. Groundwater Monitoring Locations

Public water supply wells are obvious choices for groundwater monitoring locations. In fact, all such public water supply wells are required under current regulations to do extensive monitoring. While there are a few public water supply wells in the Planning Region, they are generally concentrated in the south and east portions. In addition to these public water supply wells, an additional set of between twenty (20) and twenty five (25) wells should be identified for incorporation into an on-going monitoring program. This number of wells should provide an approximate spacing of fifteen square miles.[64]

6.5.5. Monitoring for the Protection of Endangered Species

USFWS measures recommended to ensure the recovery of the various endangered species in the Planning Region rely heavily on water quality monitoring data. The Barton Springs Salamander Recovery Plan,[65] prepared by the USFWS specifies a number of water quality parameters to be measured to ensure the protection of the salamander. This monitoring should be coordinated with the surface water and groundwater monitoring recommended as a part of this Plan.

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[63] Refer to Figure 3 and Table 5.
[64] Refer to Table 13, indicating that the Planning Region includes approximately 240,000 acres, or approximately 375 square miles.
[65] See Note 23.

7. WATER QUALITY THREATS

Based on the goals and objectives established for the Plan, there are many potential water quality threats and many different types of pollutants that may affect water quality. Many of these threats or pollutants result in some way from human activity. The major threats identified by the consultant team and Stakeholder Committee are presented below.

7.1. Urbanization

Urbanization can threaten water quality in several ways. Construction activities remove natural vegetation and can potentially increase erosion and sedimentation. Urbanization often results in more impervious cover, which increases storm water runoff rates and volumes. Urbanization also increases the resident population, introducing more human activity into an area. This increase in human activity often results in additional pollutant loadings from storm water runoff, the generation of more wastes (solid and liquid), and an increased use of potentially harmful materials in the newly urbanized area.

The threat to water quality posed by urbanization has consensus agreement among the scientific community. This threat in general is acknowledged by the existence of a number of federal and state regulatory programs intended to control the effects of urbanization on water quality through restrictions on land development. On the local level, several scientific studies have established a direct relationship between increased urbanization and adverse impacts to water quality. A cooperative study prepared by the USGS and the City of Austin established this relationship for both storm flows and base flow in streams throughout the Austin area.[66] The results of this report demonstrated statistically significant increases in suspended solids, biochemical oxygen demand, total organic carbon, total nitrogen, total phosphorous, fecal group bacteria, inorganic trace elements, and synthetic organic compounds related to urbanization. At the Barton Springs, The City of Austin has also documented statistically significant reductions in water quality over time that have been attributed to urbanization[67].

7.2. Long-Term Groundwater Withdrawal Exceeding Recharge

In simplistic terms, aquifers are steady state systems with a finite storage volume, subject to the "hydrologic equation". The hydrologic equation states that "inflows" must equal "outflows" and changes in storage.[68] While there are many complicating factors associated with a real aquifer, a simplistic illustration is a glass into which water is poured. If the inflow exceeds the outflow, the level in the glass (e.g. storage) rises. Were the glass to have a hole in it, and the outflow exceeded the inflow, the level in the glass would fall. Using this simplistic illustration, the long-term effects of excess withdrawal would result in the glass going dry. The parallel would be true for an aquifer.

[66] "Relation Between Urbanization and Water Quality of Streams in the Austin Area, Texas", Report 90-4107, J.E. Veenhuis, et al., U.S. Geologic Survey, 1990.
[67] "Update of Barton Springs Water Quality Data Analysis - Austin, Texas" Martha Turner, P.E., Environmental Resources Management Division, City of Austin, May, 2000.
[68] "Handbook of Applied Hydrology", V.T. Chow, et al, McGraw-Hill Publishing

Many scientific studies over the years have referenced the potential adverse impacts to the Barton Springs Segment of the Edwards Aquifer due to long-term groundwater withdrawal exceeding available recharge. This condition is typically referred to as "over-pumping". However, until recently, few of these studies provided any definitive projections of the impacts of over-pumping. Since 2003, the Barton Springs Edwards Aquifer Conservation District (BSEACD) has performed groundwater availability modeling to assess the impact of pumping on the water levels within the Barton Springs segment[69] in pursuit of determining the sustainable yield.[70] Based on this modeling, the BSEACD concluded that with current pumping rates and a recurrence of the drought of record (1950-1956) the water levels in the Barton Springs segment could decrease up to one hundred (100) feet in certain areas. The model predicted that under these conditions, mean monthly flow from the Barton Springs would be approximately one (1) cubic foot per second (cfs). For comparison purposes, the historic low instantaneous flow from the Barton Springs is reported as 9.6 cfs. The BSEACD further concluded that this low flow would practically result in the Barton Springs going dry for short periods of time. While this condition might not change the quality of the water contained within the aquifer, it would severely impact plant and animal species, possibly resulting in the elimination of habitat for such endangered species as the Barton Springs Salamander. It would also adversely affect the aesthetic and recreational value of the Barton Springs and the Barton Springs Pool. Based on the Stakeholder Guiding Principles and Goals and Objectives, this would definitely be considered an adverse water quality impact.

Based on their groundwater availability modeling, the BSEACD also identified several other threats from over-pumping. One identified threat involves the intrusion of saline water into the fresh water zone of the aquifer due to the decrease in water levels. Were this to occur, several existing groundwater extraction wells, including some domestic supply wells on the east side of the Planning Region, could be rendered unusable due to excessive salinity. In addition, some of the existing domestic supply wells on the west side of the Planning Region would be dry because the water level in the aquifer dropped below the bottom of their intake screen.

The withdrawal of groundwater in Texas has historically been unregulated. Recent sessions of the Texas legislature passed legislation authorizing the formation of Groundwater Conservation Districts. The BSEACD was established "for the purpose of providing for the conservation, preservation, protection, recharging and prevention of waste of groundwater and of groundwater reservoirs in the Barton Springs segment of the Edwards Aquifer".

7.3. Point Source Discharges

Point source discharges result from a limited number of activities, but in most areas account for a majority of the non-storm water flows into hydrologic systems. Almost all point source discharges result from the treatment of either domestic wastewater or from industrial/commercial process wastewater. While many different types of pollutants exist in domestic wastewater, the major threat

[69] "Evaluation of Sustainable Yield of the Barton Springs Segment of the Edwards Aquifer, Hays and Travis Counties, Central Texas", Brian A. Smith, et al, Barton Springs Edwards Aquifer Conservation District, October, 2004.

[70] The BSEACD defined "sustainable yield" to mean "the amount of water that can be pumped for beneficial use from the aquifer under drought-of-record conditions after considering adequate water levels in water-supply wells and degradation of water quality that could result from low water levels and low spring discharge".

to water quality stems from the excessive discharge of biological constituents (e.g. bacteria, viruses, etc.) and nutrients (e.g. phosphorous, nitrates, etc.) The make-up and character of industrial/commercial process wastewater varies greatly and can include a wide range of chemical, biological, and nutrient constituents.

Point source discharges of wastewater were among the first environmental concerns to be regulated on a national level. Beginning in the early 1970's, the United State Congress established the Environmental Protection Agency (EPA) and initially charged the agency with evaluating and regulating point source discharges. In the intervening time, the EPA and various state-level agencies have identified and regulated most point source discharges. Due to the historic regulation at the federal and state levels, very little local-level regulation of point source discharges has occurred in the Planning Region. In addition, there is currently little or no legal authority for local entities to regulate point source discharges.

7.4. Storm Water/Non-Point Source Pollution

In contrast to point source discharges, storm water non-point source (NPS) pollution occurs as a result of rainfall events. When human activities or natural processes result in pollutants being present at or near the land surface, these pollutants can be taken up by storm water runoff and can result in NPS pollution. The impacts of NPS pollutants vary widely and depend on the following general factors:

- Topography
- Land surface characteristics
- Human activities or natural processes taking place
- Types of pollutants present

In the United States, NPS pollution has been documented to occur from urbanized areas, industrial/commercial areas, developing areas, agricultural areas, and areas affected by natural disasters (e.g. forest fires, volcanic eruptions, etc.)

Until relatively recently, storm water NPS discharges in the U.S. have been largely unregulated. In the early 1990's, EPA adopted the Phase I Storm Water Regulations, which attempted to address NPS pollution from industrial activity, construction sites greater than five (5) acres in size and from large (greater than 100,000 population) cities. In 1999, the EPA adopted the Phase II Storm Water Regulations, which extended storm water NPS regulation to additional industrial/commercial activities, smaller construction sites (greater than one [1] acre in size) and smaller cities in defined urbanized areas. Many states, including Texas, have been delegated the authority to implement these federal regulatory programs. Certain aspects of the TCEQ's Edwards Aquifer regulations also govern storm water NPS pollution. As discussed in the section on Urbanization, above, there are also a number of existing regulatory programs at the local level with water quality protection aspects. Further discussion of storm water NPS pollution is subdivided by the general types of activities that contribute to storm water NPS pollution.

7.4.1. Construction Storm Water Discharges

As discussed previously, existing regulations govern storm water discharges from construction sites as small as one (1) acre. These regulations require that operators control the discharge of pollutants from the site using a variety of measures. In actual practice, many of the control measures specified in the current regulations are improperly used or improperly operated. In many instances, even when otherwise properly used, certain technologies are inappropriate in certain circumstances. Numerous examples of failed construction site controls were provided by several different stakeholders. The Stakeholder Committee and the consulting team have determined that the failure to use the appropriate measures and the failure to properly install, inspect, maintain, and repair the measures used to control storm water discharges from construction sites poses a significant threat to water quality in the Planning Region. In addition, the current regulatory process contributes to this threat. Under the current regulatory program, significant failures can meet with regulatory enforcement, but only after they have adversely impacted water quality. Other than the existing design review under the TCEQ Edward's Aquifer rules, there are no other regulatory mechanisms for addressing potential problems before they occur. In addition, after problems occur, past enforcement actions have not publicized sufficiently to serve as a deterrent for future violations.

While many different types of pollutants may be discharged from construction sites, the primary pollutant discharged is sediment in the form of suspended solids. The Natural Resource Conservation Service (NRCS) has identified sediment from eroded soil as having the ability to adversely impact water quality.[71] Sediment with the potential to adversely affect water quality can be transported from construction sites in several different ways. The most prominent transport mechanism is direct discharge of sediment in storm water. Sediment can also be transported from construction sites on vehicle tires, through spillage onto roadways and areas outside of control measures, and through accumulated dust which blows off the site. Sediment which leaves the site through one of these mechanisms is then exposed to the elements and can be transported in storm water runoff during the next rain event. Sediment leaving construction sites can obstruct storm water and drainage facilities, can adversely impact the habitat of various plant and animal communities, and can result in significant changes in the appearance (aesthetics) and chemical characteristics of rainfall runoff.

7.4.2. Other Storm Water NPS Discharges

Other types of storm water NPS discharges can also pose a threat to water quality in the Planning Region. Discharges from industrial activities and from urbanized areas are currently governed by TCEQ's storm water programs. The potential pollutants typically found in NPS discharges from industrial activities are similar to those described above for point source discharges. Potential NPS pollutants resulting from urban areas have also been described previously under the discussion on Urbanization. In addition to these two regulated areas, other types of storm water NPS discharges can pose water quality threats. Discharges from agricultural activities can also generate significant amounts of pollutants. Failing to utilize proper tilling and erosion

[71] "Water Quality and Agriculture: Status, Conditions, and Trends", Working Paper #16, Natural Resource Conservation Service, U.S. Department of Agriculture, July, 1997.

control practices can result in significant sediment generation from areas under cultivation. The sale of agricultural chemicals (primarily pesticides and nutrients) is stringently regulated and their use is controlled through educational processes (e.g. labeling, training, advertising, etc.) However, in areas where these controls are not diligently enforced, significant pollutants can be generated from the improper use of these chemicals. These other storm water NPS discharges also pose a threat to water quality in the Planning Region.

7.5. Domestic Wastewater Collection, Treatment and Discharge

As discussed in the section above on Point Source Discharges, many different types of pollutants exist in domestic wastewater, with the major threats arising from biological constituents and nutrients. In the case of untreated domestic wastewater, the principal threats are the biological constituents. There are two basic types of domestic wastewater systems, with a multitude of variations: centralized and on-site. While both types of systems are designed to treat pollutants in domestic wastewater prior to release into the environment, the primary threat results from unintended discharges (e.g. exfiltration, overflow, line breaks, etc.) or inadequate treatment (e.g., from improper operation and maintenance) or improper design and application of treated wastewater effluent. Unlike storm water related discharges, significant threats to water quality can result from wastewater systems during periods of no or very little rainfall.

Domestic wastewater collection, treatment and discharge have been regulated for some time at both the federal and state levels. The TCEQ's Wastewater regulations as well as certain aspects of the TCEQ's Edwards Aquifer regulations govern the design, construction and operation of domestic wastewater systems in the Planning Region. As outlined in subsequent sections of the Plan, several local jurisdictions have been delegated the regulatory authority for on-site domestic wastewater systems. However, due to this historic regulation at the federal and state levels, very little local-level regulation of centralized domestic wastewater systems has occurred in the Planning Region. In addition, there is currently little or no authority for local entities to regulate centralized domestic wastewater collection, treatment and disposal.

7.6. Lack of Water Quality Protection Measures on Existing Development

While current science indicates to us the threat posed by urbanization, this threat has not always been identified and understood. Based on this lack of understanding, development has been allowed to occur in many areas of the Planning Region without the benefit of water quality protection measures. As presented in the discussion on Urbanization, this development has resulted in additional impervious cover which increases storm water runoff rates and volumes, and has introduced more human activity, resulting in additional pollutant loadings. While more recent developments may incorporate some limited water quality protection measures, the vast majority of the existing development in the Planning Region incorporates little or no water quality protection measures. The existence of this previous development, with no water quality protection measures, poses a threat to water quality in the Planning Region. The same potential pollutants and general types of threats identified in the section on Urbanization apply to existing development with no water quality protection measures.

7.7. Failure to Implement/Enforce Existing Regulations

The failure to fully implement and enforce existing water quality regulations presents a significant threat to water quality in the Planning Region. With few exceptions, the water quality protection regulations currently in existence were implemented to address recognized threats. Failing to enforce existing regulations in effect neutralizes safeguards established to prevent adverse impacts from these recognized threats. Based on reviews of available scientific literature and observations and concerns offered by the Stakeholder Committee and individual stakeholders, the following specific areas of concern have been identified:

- Inadequate implementation/enforcement of construction site storm water controls
- Inadequate design, inspection, maintenance, and enforcement for sanitary sewer overflows
- Improper installation/permitting and lack of competent inspection of on-site, decentralized sewage facilities
- Improper operating/inspection of on-site, decentralized sewage facilities
- Inadequate maintenance, inspection and operation of structural best management practices (BMPs) and storm water control systems

These areas of existing regulation are currently authorized and delegated to a variety of state and local entities.

7.8. Use, Storage and Disposal of Harmful Materials

There are a number of harmful materials in use in our society that have the ability to impact water quality. Some of those identified by the consultant team and the Stakeholder Committee as being potential threats in the Planning Region are identified below.

7.8.1. Hazardous materials

In common usage, the term “hazardous material” is most often a substance, product or waste that poses some threat to the environment. There are numerous existing regulatory programs that have specific definitions for terms including “hazardous substances”, “hazardous materials”, “toxic substances” and “hazardous wastes”. For the purposes of this Plan, the term “hazardous material” will be applied based on its more common usage.

There are literally thousands of substances, with many thousands of different pollutants that would be considered hazardous materials. The most dramatic water quality threats from hazardous materials result from their accidental discharge or improper disposal. However, the unintended release of residuals from hazardous materials (e.g. the leaching of hazardous materials from building materials, etc.) can also pose water quality threats.

Many types of hazardous materials are regulated at both the federal and state levels. Due to this historic regulation, there is little or no authority for local entities to regulate hazardous materials directly.

7.8.2. Wastes

As with the term "hazardous material", there are a number of different definitions of the term "waste". Similarly, there are numerous existing regulatory programs that regulate all types of wastes (e.g., industrial solid waste; municipal solid waste; medical waste). For the purposes of this Plan, the term "waste" will be applied based on its more common usage of any material which can no longer serve its original intended purpose and therefore must be discarded or disposed of.

Many different types of waste materials containing various types of pollutants can pose water quality threats if not properly handled and disposed. The principal threats from waste materials stem from the release of pollutants into groundwater (e.g. leaching from a waste disposal unit) or into storm water (e.g. used motor oil dumped into a storm drain).

The management and disposal of most types of waste are regulated at both the federal and state levels. Due to this historic regulation, there is little or no authority for local entities to regulate wastes directly.

7.8.3. Pesticides

There are number of different chemicals used to control plants and animals perceived to be a nuisance by humans. Typically referred to as "pesticides", these chemicals also include herbicides (plants), insecticides (insects) and rodenticides (rodents). For the purposes of this Plan, the term "pesticides" will be used as the generic term covering all these chemicals. The principal threat is the unintended release of residuals from excessive or improper application, but water quality threats from pesticides can also result from their accidental discharge or improper disposal.

The use and disposal of most pesticides is regulated at both the federal and state levels. Due to this historic regulation, very few local entities currently regulate pesticides.

7.8.4. Nutrients

Many people do not consider nutrients to pose water quality threats. However, in excess quantities, nutrients (such as nitrogen and phosphorous) can lead to many water quality problems, including excessive algae build-up, oxygen depletion, aesthetic impacts (taste and odor), and eutrophication of water bodies.[72] Eutrophication is a process by which a body of water becomes enriched in dissolved nutrients (e.g. phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen. Major sources of excessive nutrients include residential lawns, golf courses, athletic fields, livestock pastures, commercial landscaped areas and some park lands. The principal threat from nutrients is the unintended release of residuals from excessive application of fertilizers.

[72] "Water Quality and Agriculture: Status, Conditions, and Trends", Working Paper #16, Natural Resource Conservation Service, U.S. Department of Agriculture, July, 1997.

7.9. Improper Vegetative Management

While undeveloped land left in its natural state can be an effective measure for maintaining water quality, other activities occurring on undeveloped land can have adverse impacts on water quality. The majority of undeveloped land that is subjected to human activity is utilized for either agriculture or recreation. The primary threats from undeveloped land subjected to human activity are excessive erosion/sedimentation from disruption of natural vegetation and excessive nutrients and biological constituents.

Other water quality threats from undeveloped land may result without human activity. The U.S. Department of Agriculture, in cooperation with the Texas State Soil and Water Conservation Board, reports that the invasion of noxious brush and weeds is a high priority in approximately thirty percent (30%) of the counties in Texas, including Hays and Travis.[73] In many areas of the Texas Hill Country, juniper (cedar) has propagated extensively. A series of studies conducted by the Texas Agricultural Experiment Station have indicated that juniper intercepts approximately forty percent (40%) of the total rainfall, and up to seventy five percent (75%) of light intensity rainfall.[74] The study authors concluded that with significant juniper propagation, areas which received thirty inches of rainfall would only have eighteen inches available for plant growth, recharge or runoff.[75]

7.10. Improper Management of Agricultural Operations

Improper agricultural practices also have the ability to adversely impact water quality. The primary threats agricultural operations include excessive erosion/sedimentation from improper tillage, excessive nutrients from improper fertilizer application and excess nutrients and biological constituents from improper animal waste management.

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[73] "Grazing Lands" A Valuable Resource for All Texans", U.S. Department of Agriculture, Natural Resource Conservation Service.
[74] "Evaporation and Interception Water Loss from Juniper Communities on the Edwards Aquifer Recharge Area - Final Report", M.K. Owens, et al, Texas Agricultural Experiment Station and Texas Agricultural Extension Service, Uvalde, Texas, June 25, 2001.
[75] "Uvalde Scientists Prove Cedar A Water Thief", S. Byrns, Ranch and Rural Living, November 2004.

8. STRATEGY FOR SELECTION OF WATERSHED MANAGEMENT AND WATER QUALITY PROTECTION MEASURES

8.1. Maintain or Enhance Existing Water Quality

As outlined in the Goals Statement developed by the Stakeholder Committee, the ultimate goal of the water quality protection measures presented in this Plan is to maintain or enhance the existing water quality. This objective includes the protection of the quality of both surface water and groundwater. To accomplish this objective, the strategy has been to select measures that facilitate no net increase in anticipated pollutant loadings in discharges (including pollutant loadings in recharge) for individual sites or developments. For areas to be developed, this strategy will require a thorough, site specific evaluation of pre- and post-development conditions, along with a technical demonstration that the objective can be met. This Plan does not require site specific pre and post-development water quality monitoring for this evaluation, but anticipates that this evaluation can be performed utilizing existing, publicly available data from a number of the sources identified in this document.

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8.2. Applicability Within the Planning Region

While the Planning Region has been designated based on the Edwards Aquifer recharge zone and contributing zone, the water quality protection measures presented in this Plan will also protect other water resources. These measures will protect surface water and groundwater in the Planning Region, including groundwater in the Trinity-Glen Rose aquifer system. These measures will maintain and enhance water quality where ever they applied.

8.3. Rationale for Selection of Measures

8.3.1. Structural and Non-Structural Measures

Numerous watershed management and water quality protection measures were presented and discussed during the stakeholder process. The measures presented and discussed included both "structural" and "non-structural" measures. In current water quality planning practice, these measures are typically referred to as "Best Management Practices" (BMPs). The EPA has adopted the following definitions for structural and non-structural BMPs:[76]

> ***Structural BMPs include engineered and constructed systems that are designed to provide for water quantity and/or water quality control of storm water runoff.***
>
> ***Non-structural BMPs include institutional and pollution-prevention type practices designed to prevent pollutants from entering storm water runoff or reduce the volume of storm water requiring management.***

[76] "Preliminary Data Summary of Urban Storm Water Best Management Practices", Publication No. 821-R-99-012, U.S. Environmental Protection Agency, August, 1999.

These general distinctions between structural and non-structural measures have been adopted for the purposes of the Plan. In addition, the term "BMP" has also been incorporated for use in the Plan. While this term sometimes has a poor connotation based on past failings, its use in the area of water quality planning and practice is too widespread to ignore. The approach outlined in this Plan is a combination of structural and non-structural BMPs. Although most people's perception of water quality protection measures is limited to classic structural BMPs, the EPA has acknowledged the effectiveness of non-structural BMPs. In the previously cited publication, EPA advocates their use in preference to structural BMPs:

> ***Non-structural BMPs can be very effective in controlling pollution generation at the source, which in turn can reduce or eliminate the need for costly end-of-pipe treatment by structural BMPs.***

Based on this approach, the measures recommended for inclusion in the Plan have been based on this same preference, as presented in Stakeholder Guiding Principal No. 4. While this preference is explicit in the plan, it is also acknowledged that non-structural BMPs alone will not always be satisfactory. If development activities are to occur and meet the Plan Objectives, they will typically require a combination of structural and non-structural controls working together.

8.3.2. Aspects Unique to the Planning Region

While there is extensive scientific literature available nationally on many different types of water quality protection measures, it is recognized that there are several aspects unique to the Planning Region that require any measures considered for implementation to be consistent with these unique aspects. This is particularly true of structural BMPs and their tendency to concentrate water quality pollutants in the vicinity of the structural control. Given the unique vulnerability of rapid recharge and movement through the Edwards Aquifer, structural BMPs which may be adequate in other settings may require augmentation for use in the Planning Region. For example, to prevent localized excessive pollutant loadings to groundwater recharge, it may be necessary to place a recharge barrier underneath some BMPs. Where these unique aspects are important to the description of a measure, they have been explicitly addressed.

8.3.3. Applicability of Water Quality Parameters

As outlined above, only a portion of the previously monitored water quality parameters have been selected for use in planning and design of new development. The parameters selected for use during planning and design were based on the availability of a relatively extensive database of monitoring data for these parameters and their relationship to a variety of activities. Certain selected parameters (e.g. total dissolved solids) are intended to be representative of other parameters (e.g. dissolved toxic compounds) that are transmitted in essentially the same way. Their use in planning and design is not intended to replace water quality monitoring.

There are other water quality threats posed by parameters which have not been selected for use in planning and design of new development. The general approach used to address these other parameters is through the use of non-structural measures, including use restrictions and public

education. These non-structural measures allow a wider range of parameters to be addressed than those traditionally addressed in current water quality protection programs.

9. DESCRIPTION OF WATERSHED MANAGEMENT AND WATER QUALITY PROTECTION MEASURES

A wide variety of different water quality protection measures were considered and evaluated during this process. Each of the measures considered was evaluated by the consulting team, the stakeholders, and the Technical Review Group. Based on the input received from the Stakeholder Committee and the technical evaluation performed by the consulting team and outside experts, a list of recommended watershed management and water quality protection measures (including BMPs) was developed. A general description of these measures is presented in this section. Implementation procedures for these measures are described in subsequent sections. The measures presented are in the general order of the level of water quality protection provided.

9.1. Natural Area and Open Space Conservation

Land that is allowed to stay in its natural state will not typically contribute significant pollutants that adversely impact water quality. Known as "natural area" or "open space conservation", the purpose of this measure is to restrict the land in that space from further development. During the initial identification of issues by the stakeholders early in the process, the concept of natural area/open space conservation consistently ranked among the most important objectives for the Plan. All entities and individuals inside and outside the Planning Region should be encouraged to voluntarily conserve natural areas/open space. In addition to voluntary conservation, several elements of the Plan require the conservation of natural areas in exchange for certain flexibility in implementation. While it often involves either the purchase of the land or purchase of development rights for the land, natural area/open space preservation is considered a non-structural protection measure. Natural area conservation accomplishes the objective of no net increase in pollutant loadings by restricting development activities that would generate these additional pollutant loadings.

There are a number of mechanisms that can accomplish natural area conservation. Each of these mechanisms involves establishing or identifying a Conservator, implementing restrictions to prevent the future development of the land, and providing long-term funding for its conservation. Specific procedures for securing the conservation area are provided in the section on Implementation. While each mechanism has one specific purpose for natural area conservation, it may also accomplish other purposes. Mixed use natural area conservation may be beneficial, but for the purposes of this plan, separate descriptions are provided for each mechanism, based on its intended purpose. The following natural area conservation mechanisms are identified for use within the Planning Region.

9.1.1. Conservation Easements

Conservation easements are tracts of land that are permanently set aside to remain in a natural state with minimal improvement. While some improvement may be made to facilitate access for maintenance or public recreation, other uses of the land (other than conservation) should be restricted. To qualify as a conservation easement for the purposes of the Plan, the land should remain in a reasonably undeveloped state in perpetuity, and comply with the restrictions outlined in the Implementation section. In instances where the ownership remains privately held, the maximum amount of build-out of the property should be established at the time the conservation

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easement is set aside. These areas should be subjected to proper vegetative management as described below. Public and private entities should be encouraged to voluntarily secure conservation easements as a means of natural area conservation. As discussed below, mandatory conservation easements may also be established under this Plan as a component of the transferable development rights program.

9.1.2. Land Acquisition for Habitat Protection

Natural areas/open space set aside for habitat protection has different objectives than natural areas set aside for other reasons. In most instances, areas of critical habitat for the species to be protected will be identified. Typically, no development is allowed on areas set aside for habitat protection except for that necessary for access. Land acquired for habitat protection may be on a voluntary basis or it may be required under some regulatory programs. Because the development rights must also be secured for habitat protection, land set aside for habitat protection may be considered a conservation easement under the Plan, if it complies with the requirements for conservation easements established under the Implementation section.

9.2. Transferable Development Rights

The concept of transferable development rights (TDR) was discussed extensively during the stakeholder process. This concept was considered important by the stakeholders in addressing the issue of providing economic incentive for controlling development (Guiding Principal No. 5) and the issue of equity (based on Guiding Principle No. 7). As a water quality protection measure, the concept of transferable development rights allows the flexibility to consider site specific constraints while ensuring that urbanization intensity is controlled at uniform levels protective of water quality.

To accomplish these objectives, the concept of transferable development rights has been coupled with development intensity. As discussed below, uniform levels of development intensity considered to be protective of water quality have been established for the Planning Region. By incorporating the concept of transferable development rights, development intensity could be exchanged between various tracts of land, allowing greater flexibility in development plans and creating a link between the economic incentives for development and the value of natural area conservation. This concept would allow development rights to be secured for land which is otherwise not suitable for development because it is largely taken up with water quality protection features such as stream buffers, critical environmental feature setbacks, or other water quality protection features.

As implemented under the Plan, the concept of transferable development rights would apply to all future proposed new development. This measure would allow a property owner or development planner to incorporate development exceeding the recommended uniform intensity levels on one tract, if additional development rights from other tracts were secured corresponding to the amount of development intensity on the first tract which exceeded the uniform levels. These additional development rights would be obtained either by setting aside a conservation easement or by obtaining intensity credit from a prior development. Conservation easements used to secure transferable development rights under this Plan must comply with the restrictions outlined in the

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Implementation section. Intensity credits may be obtained from prior development through physical impervious cover reductions (e.g. removing structures). When viewed together, this process would result in all the tracts conforming to the recommended uniform intensity levels. As outlined below, additional measures may be required to ensure that the higher intensity levels on the developed tract do not adversely impact water quality.

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There was extensive discussion among the stakeholders as to how the concept of TDRs could be utilized to allow flexibility, while minimizing the risk to the environment posed by the recognized threats from human activities. In accordance with Stakeholder Guiding Principle No. 4, the stakeholders recommended incorporating qualitative concepts of risk into the process. In general, the stakeholders felt that the most sensitive areas, expressed as the recharge zone and rural waterways in the contributing zone, should be subjected to lower risk than other areas. The application of lower risk strategies would involve greater reliance on non-structural controls of development location and intensity, with less reliance on structural control measures (e.g. structural BMPs). The intended outcome of this concept is to direct higher intensity development, which has a greater reliance on structural BMPs, either outside the Planning Region or into preferred growth areas within the contributing zone portion of the Planning Regions, as defined in more detail below. To accomplish this objective, several restrictions on the exchange of TDRs have been incorporated into the program:

- TDRs used to increase intensity for sites in the contributing zone (whether inside or outside preferred growth areas) should be obtained from land outside of preferred growth areas in the contributing zone or from the recharge zone.
- TDRs obtained from the recharge zone and used in the contributing zone allow the development to use the higher intensity levels from the contributing zone in determining the quantity of TDRs required.

9.3. Comprehensive Site Planning and Pre-Development Review

As outlined above, land development can often result in significant threats to water quality. There are many site specific issues associated with any proposed development that can impact water quality as well as future land management decisions. Once the decision is made to develop, these threats can be minimized by incorporating appropriate water quality protection measures. To ensure that these measures are incorporated into the site design, a comprehensive site plan should be prepared and a pre-development review should be performed. Given the diverse geological, topographical, and environmental factors, and the costs to the developer and the public, this planning and review should take place early in the process. They should address both the short term and long term consequences of the development on water quality.

The developer of the site should prepare a comprehensive site plan to demonstrate that the development complies with the water quality protection measures presented in this plan and those adopted by local jurisdictions. Currently, most development activities in the Planning Region are regulated by the TCEQ's Edwards Aquifer rules. A regulatory guidance document developed by the

TCEQ for use in the Edwards Aquifer program[77] has a section which describes a comprehensive site planning process. In addition, the municipalities within the Planning Region that currently have water quality protection ordinances also require a comprehensive site plan. By utilizing this planning process, the developer will ensure adequate planning and provide local jurisdictions with sufficient information to determine compliance with the applicable water quality protection measures. This comprehensive site plan may be done in phases to coincide with the review process of the applicable local jurisdiction.

This comprehensive site plan must include several different elements, including:

- A thorough site characterization
- A presentation of design details for the technical elements of the site plan
- A technical demonstration that the site design meets the water quality protection objectives of this Plan
- An operations, maintenance, monitoring and funding plan to ensure the long term function of the water quality protection measures for the site.

A more detailed discussion of these elements and how they should be integrated into the development review process is presented in the Implementation section.

While it is the developer's responsibility to prepare a comprehensive site plan and demonstrate compliance with applicable water quality protection measures, local jurisdictions also have a responsibility to review these plans. Entities or individuals who commit to develop property are responsible for ensuring that personnel with adequate qualifications are involved in the planning and design of the development. To meet the requirements of this plan, special expertise in engineering and geology will be required. Where necessary, these individuals must also posses the appropriate professional license to practice in their area of expertise. To ensure that the water quality protection measures contained in this Plan are incorporated into the comprehensive site design, the local jurisdiction should conduct a thorough pre-development review. In general, the personnel performing this review should possess qualifications equivalent to those required for those preparing the demonstration that development complies with the requirements of the Plan. Specific recommendations for conducting this review are contained in the Implementation section. Comprehensive site planning and pre-development review are non-structural measures that will ensure compliance with the goals and objectives of this Plan.

9.4. Location of Development

There is general consensus in the scientific community that the location of development activities can have significant impacts on water quality. To address adverse impacts due to the location of development, the following water quality protection measures are prescribed.

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[77] Section 2.2, "Comprehensive Site Planning", "Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices", Regulatory Guidance Document No. 348, Texas Natural Resource Conservation Commission, June, 1999.

9.4.1. Stream Offsets/Buffer zones

A number of scientific studies have documented the water quality benefits of maintaining naturally vegetated riparian[78] corridors along streams and watercourses. These riparian corridors serve a number of functions including filtering/sequestering pollutants, providing localized recharge to contribute to sustained base flow, providing flood flow attenuation, and providing habitat for various plant and animal communities. They also provide a pervious strip along the bank to accept sheet flow from developed areas and help minimize the adverse impacts of runoff.[79]

When development occurs adjacent to a stream or watercourse, the development should be offset from the streams to maintain these riparian corridors and minimize the impact of the development on the stream. The offset between the development and the stream is typically called a "buffer zone" and that term will be used in this Plan. These buffer zone areas are intended to protect the stream or watercourse and should not be utilized for other purposes. Activities or development taking place within the buffer zone (e.g. roadway crossings, utilities, etc.) can compromise the ability of this buffer zone area to perform its intended function. For this reason development within the buffer zone should be avoided when possible. The only development activities allowed in stream buffer zones are critical utility and transportation crossings, with the number and locations of these crossings minimized. Other than critical crossings, utilities and transportation infrastructure should not be located within stream buffers, and kept to a minimum (e.g. minimum number and surface area) when development is unavoidable. Where crossings are located, their design should incorporate protections from future damage to the stream from these crossings. Structural BMPs are specifically prohibited from buffer zones.

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Stream buffer zones should be designated using the centerline of the active channel. Based on the review of available literature, a number of sources recommend that the minimum width of buffer for a defined stream or watercourse[80] should be at least 100 feet on either side of the centerline. The available scientific literature does not provide definitive recommendations for any "practical minimum" contributing drainage area for streams requiring buffer protection. However, the Stakeholder committee determined that some practical minimum contributing drainage area was needed to minimize uncertainty in implementing these requirements. A review of the "practical minimum" contributing drainage areas for streams afforded buffer zone protection in existing local regulations[81] and environmental resource protection programs indicated ranges from twenty (20) to sixty four (64) acres.

[78] "relating to or living or located on the bank of a natural watercourse", Merriam-Webster Online Dictionary, 2004.
[79] Section 1.4.11 "Vegetative Buffers", "Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices", Regulatory Guidance Document No. 348, Texas Natural Resource Conservation Commission, June, 1999.
[80] "A definite channel of a stream in which water flows within a defined bed and banks, originating from a definite source or sources. The water may flow continuously or intermittently, and if the latter with some degree of regularity, depending on the characteristics of the sources.", 30 TAC §297.1, "Water Rights, Substantive – Definitions"
[81] Austin City Code, Title 25, "Land Development", Section 25-8-92, "Critical Water Quality Zones Established"

Based on this range, a minimum value of thirty two (32) acres has been established for use in the Plan. Table 8, below, provides the minimum required buffer zone widths (or offset distances) from the stream centerline:

Table 8 - Required Buffer Zone Widths (from Stream Centerline)

Contributing Area	Width/Offset (feet, each side of centerline)	Total width (feet)
32 to 120 Acres	100	200
120 to 300 Acres	150	300
300 to 640	200	400
Greater than 640 Acres	300	600

In circumstances where some natural stream features extend outside the minimum recommended buffer areas, the buffer width should be expanded based on the following conditions. These conditions should be evaluated on both sides of the stream independently, and adjustments applied to the affected areas only.

- Where a FEMA recognized 100-year floodplain has been established, or a 100-year floodplain has been calculated and the governmental authority has approved the calculations, the buffer zone shall be expanded to encompass the 100-year floodplain plus 25 feet beyond the edge of the floodplain.
- When federal jurisdictional wetlands extend beyond the edge of the required buffer, the buffer zone shall be expanded to encompass the extent of the wetland plus a 25-foot zone extending beyond the wetland edge.

Stream buffer zones are considered non-structural BMPs for the purposes of the Plan, and are intended to be requirements independent of other protection measures.

9.4.2. Offsets from Critical Environmental Features/Sensitive Areas

A "Critical Environmental Feature" (CEF) is a geologic or topographic feature of critical importance to the protection of the environmental resources in the planning region. CEF's include caves, sinkholes, springs, faults and fractures with solution enlarged openings, and other related features, as discussed previously. These micro-geologic features are important because they can become direct entry points where pollutants are introduced into the aquifer. When development occurs adjacent to a CEF, that development should be offset from the CEF to minimize the impact of the development. The TCEQ has determined that preservation of CEFs is an important nonstructural BMP and an important consideration for long term viability of the Edwards Aquifer.[82]

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[82] "Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices", Regulatory Guidance Document No. 348, Texas Natural Resource Conservation Commission, June, 1999.

Offsets from CEFs should begin at the edge of the feature with a minimum width of 150 feet. For the Planning Region, Table 9, below, provides required offset distances (or buffer zone widths) from CEF's.

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Table 9 - Required Offset Distances for Critical Environmental Features

Type of Feature	Upstream Offset (feet)	Downstream Offset (feet)
Point recharge feature (direct communication with aquifer)	Upper catchment divide or 300, not less than 150	150
Indirect feature (no direct communication with aquifer)	150	150

Setbacks from CEFs are considered non-structural BMPs for the purposes of the Plan, and are intended to be requirements independent of other protection measures.

9.5. Intensity of Development

As outlined in the section on Water Quality Monitoring, several scientific studies have identified a direct relationship between the intensity of development and water quality. In general terms, as development intensity increases, water quality impacts also increase. In the current practice of water quality planning, the intensity of development is most often described by using the percentage of impervious cover resulting from the development. Impervious cover consists of buildings, streets, driveways, parking lots, and other types of impervious surfaces that generally increase the amount of rainfall which turns to runoff and correspondingly decreases the amount of infiltration (recharge).

As areas change from undeveloped to developed, increases in pollutant loadings to surface water and groundwater correspond directly to increases in impervious cover. There is some disagreement among the scientific community on whether the impervious cover is actually the source of additional pollutant loading or whether it is an indicator parameter tied to additional human activity, which is the actual source of pollutants. In general, though, the scientific literature indicates that reductions in recharge and corresponding changes in groundwater quality, as well as increases in the volume and rate of surface water runoff and additional pollutant loading are directly correlated to increases in intensity of development. This would include additional sediment loading from erosion. However, the scientific literature also indicates that, for other types of pollutants and impacts, impervious cover is simply a correlation to increased human activity.

For the purposes of the Plan, the percentage of impervious cover has been adopted as the primary indicator of development intensity. While many scientific studies recommend controlling impervious cover or development intensity as a primary water quality protection measure, they differ on how to quantify impervious cover and how to control it. The strategies presented below provide a means of quantifying impervious cover and implementing measures to control it.

9.5.1. Impacts of Impervious Cover

Many of the scientific documents reviewed during the development of the Plan attempted to assess impact to water quality correlated to impervious cover. These publications provide varying degrees of underlying scientific justification for the correlation between impervious cover and adverse water quality impacts. In addition, many of these studies were performed in other areas of the country and the world where the hydrogeology is vastly different. While there is no single authoritative reference that precisely establishes the impacts of impervious cover upon water quality, a growing body of research clearly points to the conclusion that these measurable adverse impacts fall within a certain range.

While scientific studies performed in other areas of the country may not be directly applicable to the Planning Region, they can shed some light on the general relationship between urbanization and water quality. A study performed in Washington State indicated that impervious cover above approximately ten percent (10%) indicated irreversible loss of aquatic system function.[83] Another study performed in the Chesapeake Bay area of Maryland, based on the Impervious Cover Model, indicated that impervious cover above ten percent (10%) reduced overall stream quality to "fair".[84] However, this study also indicated that in watersheds where a high percentage (greater than 66%) of the impervious cover areas were subjected to storm water management, that the overall stream water quality could be maintained as "good" to just above twenty percent (20%) impervious cover. This study also cautioned about the applicability of the results being applied to areas with differing climates and hydrogeologic characteristics. While the hydrogelogic characteristics of these two areas are significantly different than the Planning Region, they do support the general correlations between urbanization and impervious cover, and between the implementation of protection measures and protected water quality.

The U.S. Fish and Wildlife Service (USFWS) has conducted numerous water quality evaluations in the Planning Region as they related to the protection of endangered species. Although rescinded as official agency guidance, measures previously proposed by the U.S. Fish and Wildlife service recommended impervious cover limits (on a net site areas basis) of fifteen percent (15%) for the recharge zone and twenty percent (20%) for the contributing zone.[85] [86] Although the correlation between net site area and gross site is site specific, industry practices generally recognize that impervious cover estimates using a gross site area basis is generally about five percent (5%) lower than impervious cover estimates using a net site area basis, for the same land areas. The USFWS measures also allowed an increase of impervious cover (30% in the RZ and 35% in the CZ) if offsite mitigation (establishing conservation easements sufficient

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[83] "Urbanization of Aquatic Systems: Degradation Thresholds, Stormwater Detection, and the Limits of Mitigation", D.B. Booth, et al, Journal of the American Water Resources Assocation, October, 1997.
[84] "Impervious Cover in the Chesapeake Bay Watershed", K. Cappiella, et al, Center for Watershed Protection and U.S. EPA Chesapeake Bay Program, August, 2001.
[85] *RESCINDED - see next footnote- "Background and Technical Guidance for U.S. Fish and Wildlife Service Recommendations for Protection of Water Quality of the Edwards Aquifer", U.S. Fish and Wildlife Service, November, 2002.
[86] The document "Background and Technical Guidance for U.S. Fish and Wildlife Service Recommendations for Protection of Water Quality of the Edwards Aquifer" was rescinded at official agency guidance. See Federal Register, Volume 68, Number 39, Thursday, February 27, 2003, Pages 9094-9095.

to achieve a net impervious cover equal to the established limits) were incorporated. Although they were intended for the limited purpose of protecting endangered species, these guidelines suggest that the USFWS acknowledged the correlation between increased urbanization and adverse water quality impacts.

A number of relevant water quality studies have been conducted in and around the Planning Region. One peer-reviewed study addressing surface water quality impacts to Lake Austin suggested that very little impact on surface water quality was observed below about 20% impervious cover.[87] However, it also acknowledged that a major component of the inflow to Lake Austin was from Lake Travis, with long residence times and generally good water quality. This study likely does not adequately represent streams in the Planning Region where substantially all of the flow (including storm flow and base flow) results from localized rainfall. This study did, however, provide specific correlations between some suspended and dissolved parameters with increasing development intensity. In general, each ten percent (10%) increase in impervious cover resulted in a corresponding increase of approximately 510% for suspended solids parameters and approximately 260% for certain dissolved parameters.

A previously cited cooperative study prepared by the USGS and the City of Austin[88] confirmed this general correlation for both storm flows and base flow. This study indicated that as drainage basins changed from rural (less than 10% impervious cover) to urban (greater than 40% impervious cover, there were marked increases in both suspended and dissolved parameters. For storm flows, suspended constituents generally increased between ten and fifty times (1,000% to 5,000%) while dissolved parameters generally maintained similar levels. For base flow, suspended solids parameters generally increased between three and four time times (300% to 400%) while dissolved parameters generally increased between one and two times (100% to 200%).

In various published and unpublished reports and in unpublished data compilations, the City of Austin has indicated that physical and biological degradation of streams begins to occur at between five and eighteen percent (5-18%) impervious cover.[89] The median data from one specific evaluation of Aquatic Life Use Criteria, as established by the TCEQ, indicates that the streams evaluated in the Planning Region could only maintain “limited” aquatic life (the lowest category) above approximately twenty percent (20%) impervious cover. This evaluation also indicated that above twenty percent impervious cover, even the upper bounds of the data fell only in the “intermediate” category.

Based on the evaluations of the scientific studies presented, the consulting team determined that the approximate quantity of impervious cover which can occur while remaining protective of water quality in the Planning Region is in the range of ten to fifteen percent (10% to 15%), on a

[87] “Impact of Land Use and NPS Loads on Lake Quality”, David A. Todd, et. al., Journal of Environmental Engineering, Volume 115, Number 3, American Society of Civil Engineers, June 1989.
[88] “Relation Between Urbanization and Water Quality of Streams in the Austin Area, Texas”, Report 90-4107, J.E. Veenhuis, et al., U.S. Geologic Survey, 1990.
[89] Various data compilations, publications and inter-office memoranda, obtained from the City of Austin Watershed Protection and Development Review Department, obtained October, 2003.

gross site area basis. In the application of this range, the lower end of the range will be applied to more sensitive areas, while the upper end of the range can be applied to less sensitive areas. However, as described below, adverse impacts can also occur from localized areas within a site whose total impervious cover falls within these ranges when viewed as an entire site.

9.5.2. Existing Development Intensity in the Planning Region

"As-built" development intensity is often difficult to assess. In most instances, development intensity is either estimated from land use or assessed from some type of physical observation, such as the evaluation of aerial photography. The City of Austin has previously performed land use assessments within each of the watersheds within the Planning Region.[90] The City's land use data was combined with some standardized estimates of development intensity (impervious cover) for each type of land use, to estimate the existing development intensity within each watershed within the Planning Region. Table 10, below, presents the City's land use data, the standardized intensity estimates by land use, and the resulting development intensity for each watershed. This information is presented graphically in Figure 4, on the following page.

Table 10 – Estimated Existing Development Intensity Based on Land Use by Watershed (Circa 2000)

		Est. IC Allocation for Land Use						
		20%	40%	30%	3%	70%	Est. As-	Area in
Watershed	Area (Ac)	Res.	Bus.	Civ.	Parks	Roads	Built IC	PR
Little Barton Creek	7,040	9%	2%	1%	1%	2%	4.33%	7,040
Barton Creek*	69,540	7%	1%	0%	10%	2%	3.50%	57,485
Bee Creek	1,920	35%	3%	1%	19%	9%	15.37%	1,920
Little Bee Creek	640	56%	0%	1%	5%	12%	20.05%	640
Eanes Creek	2,560	38%	13%	8%	5%	17%	27.25%	2,560
Williamson Creek*	19,200	33%	7%	3%	6%	14%	20.28%	15,872
Slaughter Creek*	19,840	26%	1%	1%	5%	8%	11.65%	16,401
Bear Creek*	17,280	10%	0%	0%	0%	1%	2.70%	14,284
Little Bear Creek*	14,720	8%	4%	0%	0%	1%	3.90%	12,168
Onion Creek*	135,040	4%	1%	0%	1%	3%	3.33%	111,630
Total	287,780	4%	1%	0%	1%	3%	3.33%	240,000

* For these watersheds, the total area is greater than the area within the Planning Region since a portion of their total area is outside the Planning Region.

[90] This information was furnished by the City of Austin and is also available on the internet (http://www.ci.austin.tx.us/watershed/learn_ws.htm).

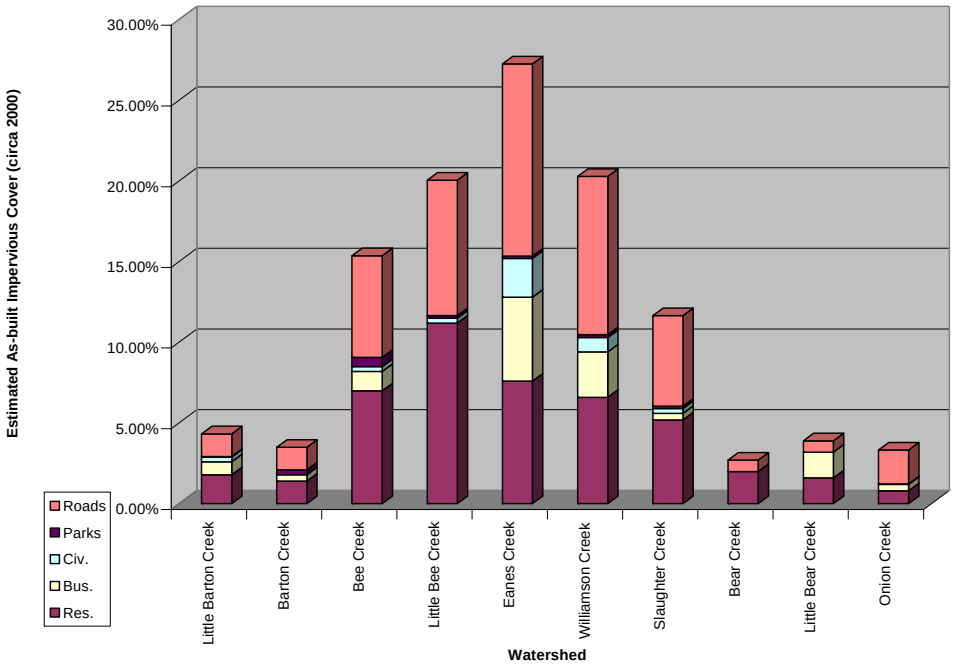

Figure 4 – Make-up of Impervious Cover for Watersheds Within the Planning Region

9.5.3. Strategy for Limiting Impervious Cover

Due to the established correlation between increasing impervious cover and decreases in water quality, the concept of limiting impervious cover would be one measure to help achieve the goals and objectives of the Plan. Many of the studies reviewed as a part of the development of the Plan attempted to assess the impact of impervious cover and then recommended impervious cover limits. For evaluation purposes, almost all of these studies estimated the impervious cover as a percentage of the entire watershed or study area, more commonly referred to as "gross site area". However, some of the studies included impervious cover limit recommendations based on gross site area while others based their recommendations on a concept called "effective impervious cover" or "net site area". Net site area is a concept of calculating impervious cover percentages based on excluding certain land areas from the total area based on the rationale that these excluded areas do not function as impervious. In addition, there are a number of existing municipalities and other governmental agencies that currently limit impervious cover for new development using the concept of net site area. It is impossible to develop a universal correlation between gross site area and net site area due to the site specific variations introduced by the net site area calculations. Correspondingly, it is difficulty to precisely correlate impervious cover recommendations based on gross site area to development regulations using net site area, and vice versa. Since the majority of the studies evaluated as a part of the Plan are based on gross site area, the gross site area calculation method has been adopted as the standard of evaluation,

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as outlined below. The use of gross site area for evaluating impervious cover provides a more equitable tie to development rights, as presented in the section on Transferable Development Rights.

However, one issue that was discussed extensively with the stakeholders and the technical review group was how irrigation areas (wastewater and stormwater) would be treated. Many existing jurisdictions make some adjustments to the impervious cover calculations either through excluding these areas (removing them from net site area) or considering them as some fraction of impervious cover. Based on the technical discussions, the consensus approach of the consulting team and the technical review group was to incorporate sufficient design standards and safety factors into the design of the irrigation application to allow them to be considered pervious rather than impervious. Specific design standards and safety factors have been incorporated to allow irrigation application areas to be considered pervious areas, and these standards and factors are described in detail in the detailed design sections below.

Impervious cover limits are a non-structural water quality protection measure. However, due to the sensitivity of the elements in the Planning Region, localized impacts may occur from localized areas of higher intensity development within a site meeting the established impervious cover limits for the entire site. For this reason, the impervious cover limits should be used in conjunction with other BMPs to control the effects from the developed areas, and are not intended to be utilized as the sole water quality protection measure for site development.

During the technical evaluation of the scientific studies addressing the impacts of impervious cover, the consulting team reviewed available information regarding the impact of structural BMPs working in conjunction with impervious cover limits. While a large database exists on the performance of specific structural BMPs, very little data is available assessing the ability of structural BMPs to control pollutant loading when viewed on a watershed basis. In a recent update of the Impervious Cover Model, it has been suggested that incorporating appropriate storm water BMPs might mitigate the impacts of impervious cover up to approximately five percent (5%).[91] Specific evaluation and design issues for structural BMPs are discussed elsewhere in this Plan. However, for the purposes of assessing how structural BMPs relate to the strategy of limiting impervious cover, this approach of allowing five percent of additional impervious cover where the structural BMPs are utilized to control surface water will be incorporated into the recommendations.

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9.5.4. Approach for Limiting Impervious Cover

As presented above, most of the studies evaluated indicated that measurable water quality impacts began to occur in the range of ten to fifteen percent (10% to 15%) gross impervious cover. In the contributing zone, the identified threat from urbanization results from surface water. Surface water from the contributing zone with elevated levels of pollutants can have localized water quality impacts in the Contributing Zone, can pose a threat to groundwater in the Barton Springs Zone due to surface water recharge once the water reaches the Recharge Zone,

[91] "Is Impervious cover Still Important? A Review of Recent Urban Stream Research", T. Schueller, Impacts of Impervious Cover on the Quality of Aquatic Systems, Center for Watershed Protection, March, 2003.

and can also pose a continuing threat to surface water in the Recharge Zone. One the other hand, the water quality threat from urbanization in the Recharge Zone can come from either surface water or from localized recharge to groundwater. For this reason, the lower end of the range of impervious cover limits will be applied to the Recharge Zone, while the upper end of the range will be applied to the Contributing Zone.

In the Recharge Zone, impervious cover on future new development shall be limited to ten percent (10%). In the Contributing Zone, impervious cover on future new development shall be limited to fifteen percent (15%). These limits shall be evaluated on a gross site area basis. These limits shall apply to all development types, including public and private development, roads and infrastructure. There shall be no variances from these limitations, except in conjunction with the implementation of transferable development rights, as outlined below. During the site evaluation process, the total planned percentage of impervious cover shall be determined by dividing the total impervious cover of the project by the gross area of the site. By applying these impervious cover limitations to all future projects individually, the uniform average impervious cover for all future development will be maintained within the limits presented above. These limitations shall apply irrespective of the requirements for other structural or non-structural BMPs, setbacks, buffers or other water quality protection measures set out elsewhere in the Plan.

9.5.4.1.Design Considerations Related to Impervious Cover

Should a development planner desire to institute a project that would result in a localized tract with a development intensity exceeding the impervious cover limits presented above, the concept of transferable development rights can be utilized. This concept allows development exceeding the recommended uniform intensity levels, if additional development rights are secured from other tracts or through reducing impervious cover in a prior development within the same aquifer zone (recharge or contributing). The amount of additional development rights shall be that necessary to achieve the recommended intensity levels (impervious cover) when evaluating both tracts together.

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While it is the responsibility of the party wishing to develop the land to design a site-specific water quality protection strategy, improperly controlled increases in development intensity have the potential to cause significant localized impacts, even if the uniform intensity levels are met. For this reason, safeguards are needed to ensure that the designs allowing the increased development intensity are protective of these localized effects.

9.5.4.2.Low Vulnerability Growth Areas

Some jurisdictions within the Planning Region may have designated preferred growth areas where it is their intent to encourage higher intensity development. The establishment of these preferred growth areas normally occurs through a comprehensive planning process carried out by the local jurisdiction, after considering a multitude of factors, including environmental considerations. Because these preferred growth areas are generally in less environmentally sensitive areas, where tighter controls can more easily be exercised, their objectives are in

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general agreement with those of this Plan. However, due to the potential threat of urbanization to groundwater through direct recharge, areas in the Recharge Zone should be considered environmentally sensitive. To provide incentive to steer higher intensity development into these less vulnerable and more controlled areas in the Contributing Zone, it is recommended that no upper intensity limit be imposed for preferred growth areas established through local comprehensive planning processes. These sites would still be required to include appropriately designed structural controls and offset this additional localized intensity by obtaining additional transferable development rights.

9.5.5. Summary of Recommended Impervious Cover Limitations

After considerable discussion by the Stakeholder Committee, consensus could not be reached on the content of a table to summarize recommended impervious cover limits. There was however, consensus reached on the general format of the table, including the distinctive areas to be considered (the rows in the table) and the approach to limiting impervious cover in each area (the columns in the table). The consensus direction of the Stakeholder Committee was that the consulting team should incorporate into the Plan its recommendations for impervious cover limits, and should also incorporate a representation of the range of stakeholder input received on the consulting teams proposals through the process. The following tables summarize the recommended impervious cover limitations presented above, based on location. All of the recommended impervious cover limits are given on the basis of gross site area. The concept of transferable development rights (TDRs) has also been incorporated into the recommended impervious cover limitations, as presented below.

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Table 11 - Required Impervious Cover Limits – Consulting Team Recommendation

Location	Simplified[92] [93]	Standard Methods[94]	Standard Methods + TDRs[95]
Recharge Zone	5	10	15
Contributing Zone, outside "preferred growth areas" (PGAs)[96]	7.5	15	25
Contributing Zone, Single Family Residential inside PGAs	7.5	15	30
Contributing Zone, Commercial and Multi-family Residential inside PGAs	7.5	25	45 or No Limit[97]

As presented below, Table 12 presents the range of comments received on the version of Table 11 included with the last draft of the plan submitted to the Stakeholder Committee. Please note that the footnotes from Table 11 would also apply to Table 12.

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[92] Only applicable to tracts with scattered and disconnected impervious cover (IC), also respecting stream buffers and CEF setbacks. No connected blocks of IC (buildings and parking lots) greater than 20,000 sf. All off-site discharges must be distributed to sheet flow. No hard-lined drainage conveyance structures. (e.g. no curb & gutters, storm sewers or hard lined drainage ditches/swales).

[93] Simplified review will constitute an on-site survey for CEFs and streams, a geometric review of the site plan layout demonstrating that the proposed activities (impervious cover) respects applicable stream buffers and CEF setbacks, but no technical demonstration of performance is required.

[94] Standard Methods include the use of primary and or secondary BMPs; a technical demonstration of "no net increase" and of "lowest risk" choice of BMPs; and comprehensive site design as defined in the Plan. Further, for categories where on-site IC is allowed to exceed the established CZ impervious cover limit of 15%, the following additional provisions apply: a) the implementation of an operations and maintenance program that includes site specific performance monitoring for water quality protection measures, b) the monitoring program must be administered by a public entity, and c) establishment of a secured funding source for the operations, maintenance and monitoring programs.

[95] TDRs used in the RZ must be obtained from the RZ and the combined IC of all tracts considered together must be 10% or lower. TDRs used in the CZ may be obtained from either the RZ or the CZ and should come from properties outside of PGAs. The combined IC of all tracts considered together must be 15% or lower.

[96] Preferred Growth Areas are areas defined by local governmental jurisdiction(s) through the comprehensive planning process (in accordance with the Texas Local Government Code, Chapter 213) as areas where future zoning is proposed to be industrial, commercial or high-density residential, provided these area are located within incorporated municipal boundaries.

[97] The "No Limit" option requires that building roof runoff be captured through rainwater harvesting with fourteen (14) days storage capacity, used for landscape irrigation.

Table 12 - Required Impervious Cover Limits – Range of Stakeholder Recommendations

Location	Simplified[98] [99]	Standard Methods[100]	Standard Methods + TDRs[101]
Recharge Zone	3 to 5	5 to 15	10 to 25
Contributing Zone, outside "preferred growth areas" (PGAs)[102]	5 to 10	10 to 25 + TDRs	15 to 3025
Contributing Zone, Single Family Residential inside PGAs	5 to 20	10 to 30 + TDRs	20 to 30
Contributing Zone, Commercial and Multi-family Residential inside PGAs	5 to 20	20 to 40 + TDRs	30 to No Limit

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The impervious cover limit approach presented above is intended to create a link between the economic incentives for development and the value of open space/natural area preservation. Specific discussion on the implementation of impervious cover limits is presented in subsequent sections.

9.5.6. Clustering/Low Impact Development

Clustering is the concept of concentrating the impervious cover within a tract of land to maximize separation from the impervious to potentially sensitive receptors, such as streams and critical environmental features. For the purposes of the Plan, the concept of clustering is recognized and recommended for incorporation into the impervious cover implementation strategy. However, as outlined above, the use of clustered development should take into consideration the potential localized effects of more intense impervious cover.

[98] Only applicable to tracts with scattered and disconnected impervious cover (IC), also respecting stream buffers and CEF setbacks. No connected blocks of IC (buildings and parking lots) greater than 20,000 sf. All off-site discharges must be distributed to sheet flow. No hard-lined drainage conveyance structures. (e.g. no curb & gutters, storm sewers or hard lined drainage ditches/swales).

[99] Simplified review will constitute an on-site survey for CEFs and streams, a geometric review of the site plan layout demonstrating that the proposed activities (impervious cover) respects applicable stream buffers and CEF setbacks, but no technical demonstration of performance is required.

[100] Standard Methods include the use of primary and or secondary BMPs; a technical demonstration of "no net increase" and of "lowest risk" choice of BMPs; and comprehensive site design as defined in the Plan. Further, for categories where on-site IC is allowed to exceed the established CZ impervious cover limit of 15%, the following additional provisions apply: a) the implementation of an operations and maintenance program that includes site specific performance monitoring for water quality protection measures, b) the monitoring program must be administered by a public entity, and c) establishment of a secured funding source for the operations, maintenance and monitoring programs.

[101] TDRs used in the RZ must be obtained from the RZ and the combined IC of all tracts considered together must be 10% or lower. TDRs used in the CZ may be obtained from either the RZ or the CZ and should come from properties outside of PGAs. The combined IC of all tracts considered together must be 15% or lower.

[102] Preferred Growth Areas are areas defined by local governmental jurisdiction(s) through the comprehensive planning process (in accordance with the Texas Local Government Code, Chapter 213) as areas where future zoning is proposed to be industrial, commercial or high-density residential, provided these area are located within incorporated municipal boundaries.

While the concept of Low Impact Development (LID) has many elements common to clustering, the underlying premise is to take a holistic approach to design that minimizes the overall impact of development on the site. Instead of removing pollutants, LID concepts reduce runoff volumes, thereby reducing the impacts from the associated runoff, and further reducing the need for conventional structural BMPs.[103] LID includes the following essential elements:[104]

- Minimizing Impervious Areas
- Directed Growth (through land use ordinances and zoning)
- Sensitive Area Protection
- Open Space Preservation

While these concepts can certainly be applied on a broad scale, the general concepts can also be applied to design on an individual site. For instance, minimizing contiguous impervious areas allows the surrounding pervious areas to more effectively offset the effects of increased runoff from the pervious areas. This process, in turn reduces the need for structural BMPs. Since they rely less on structural BMPs and more on the interaction of several different water quality protection measures working together, the use of LID procedures reduces the water quality risk from the catastrophic failure of a single BMP. For this reason, LIDs should be encouraged in preference to high impact designs which rely heavily on structural BMPs.

9.5.7. Use of Semi-pervious Cover

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In many areas, semi-pervious cover is recommended as a means to reduce overall impervious cover. While this practice may reduce impervious cover, and corresponding storm water runoff rates and volumes, the potential for increased recharge warrants careful consideration. For the purposes of the Plan, the use of semi-pervious cover should be encouraged in conjunction with other measures to control recharge and runoff. However, additional study is necessary to assess the actual reduction in impervious cover realized by utilizing semi-pervious cover. Until such time as those relationships can be established, no such preferential consideration for semi-pervious cover can be incorporated into the Plan.

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9.6. Control of Hydrologic Regime

Scientific studies have established that increases in the rate and volume of storm water runoff generally have an adverse impact on water quality in natural streams. In past practice, most discussions regarding hydrologic regime have addressed large, infrequent storm water runoff flows. While these flows can do significant damage to natural streams, smaller and more frequent storm flows can result in significant erosion and sedimentation. For the purposes of the Plan, the control of the hydrologic regime for flows from developed areas is recommended. The hydrologic regime represents the total volume and the rate/timing/duration of storm water runoff flows. To address adverse impacts, the following measures are recommended to control the rate and volume of storm water runoff from developed areas within the Planning Region.

[103] Section 5.2.3, "Preliminary Data Summary of Urban Storm Water Best Management Practices", Publication No. 821-R-99-012, U.S. Environmental Protection Agency, August, 1999.
[104] Ibid

9.6.1. Erosive Flows Control

A number of scientific evaluations in central Texas have indicated that a significant portion of the total estimated long-term erosion occurs during runoff events with a one (1) to two (2) year return frequency and durations of one (1) to six (6) hours.[105],[106] The control of erosive flows is an essential element in the overall engineering design of a developed site. For site designs that provide for discharge of surface water, adequate retention/detention should be incorporated into the site design to limit flows into the receiving stream consistent with the volume from the two (2) year, three (3) hour duration rainfall, evenly distributed over a twenty four (24) hour period. This will provide the added benefit of reducing siltation in drainage ditches, culverts and other public storm water systems. In addition to limiting the rate of discharge, prior to discharge into the buffer zone, all concentrated flows should be properly distributed to provide for sheet flow through the buffer zone into the stream channel.

9.6.2. Flood Flows Control

Although infrequent, flood flows can also result in significant erosion to natural streams. Drainage structures providing discharge routes for flood flows should be sized to maintain flood flow velocities below erosive levels, up to the twenty five (25) year, three (3) hour duration. All discharge points from ponds or other accumulation areas must provide for energy dissipation prior to exiting the site, in order to minimize erosion.

9.7. Structural BMPs for Discharges from Developed Land

As indicated previously, structural BMP's should be utilized in conjunction with the other water quality protection measures presented in this Plan, to minimize the localized impacts of development. The procedures for incorporating their use into an overall water quality protection strategy are presented below.

9.7.1. BMP Performance

There are numerous structural BMPs for which a significant amount of actual performance data exists. However, this data is not always in a readily useable form. In many existing regulatory programs, the concept of "removal effectiveness" is most often quantified using a "percentage removal efficiency". The U.S. EPA has commissioned several studies to determine how the performance of structural BMPs should be assessed so that realistic capabilities can be incorporated into the design process. The conclusions from several of these studies reveal that the removal effectiveness of most structural BMPs varies significantly (e.g. are not "linear") based on a number of site specific factors, including:[107]

- the size, type and design of the BMP

[105] "Water Quality and Quantity Inputs for the Urban Creeks Future Needs Assessment", M.E. Barrett, et al, The University of Texas at Austin, Austin, Texas, 1998.
[106] "Barton Creek Watershed Study", C. Soeur, City of Austin, Texas, 1995.
[107] "Preliminary Data Summary of Urban Storm Water Best Management Practices", Publication No. 821-R-99-012, U.S. Environmental Protection Agency, August, 1999.

- the soil types and characteristics
- the geology and topography of the site
- the intensity and duration of the rainfall
- the length of antecedent dry periods;
- climatological factors such as temperature, solar radiation, and wind
- the size and characteristics of the contributing watershed; and
- the properties and characteristics of the various pollutants.

Due to these significant variations, these studies generally recommend that performance requirements should not be specified in terms of percent removal.[108] These studies also generally indicate that several BMPs operating in sequence together, or "treatment trains" are required to achieve specific performance goals.[109]

In addition to the uncertainty of actual performance for constituents for which data exists, another practical obstacle to assessing BMP performance is the small amount, or complete lack, of data for certain constituents. This is particularly true for dissolved constituents. Only limited data is available for assessing the performance of BMPs in reducing dissolved constituents. The assessment of removal effectiveness for dissolved constituents differs significantly from suspended constituents due to the different mechanisms used to accomplish the removal (e.g. settling for suspended solids, versus uptake or sequestering for dissolved solids). [110] In general, most studies have concluded that BMPs are less effective at removing dissolved constituents than at removing suspended constituents.

9.7.2. BMP Design Considerations

The uncertainty and variability in the performance of structural BMPs suggests that several considerations be incorporated into the design process.

9.7.2.1.General Design Considerations

Regardless of the specific BMPs utilized, they should all be incorporated into a site specific design to meet the objectives of the Plan. It is imperative that the performance data used for the design of BMPs be reliable and realistic. The U.S. EPA's BMP database[111] contains a large database of performance data on various BMPs, but the data is technical in nature and not always readily adaptable for use in design. While there is a substantial amount of data, the specific correlation of influent (water received by the BMP) quality to effluent (water discharged from the BMP) quality for particular types of BMPs is not always adequately consistent to allow reliable predictions of effluent to influent quality. Unfortunately, this type of comparison is necessary to demonstrate that a particular design meets the objectives

[108] "Determining Urban Stormwater Best Management Practice Removal Efficiencies, Task 3.4 – Final Data Exploration and Evaluation", Geosyntec Consultants, et al and U.S. EPA, June 2000.
[109] "Urban Stormwater BMP Performance Monitoring - A Guidance Manual for Meeting the National Stormwater BMP Database Requirements", Geosyntec Consultants, et al and U.S. EPA, April 2002.
[110] "Preliminary Data Summary of Urban Storm Water Best Management Practices", Publication No. 821-R-99-012, U.S. Environmental Protection Agency, August, 1999.
[111] "International Stormwater Best Management Practices (BMP) Database", U.S. EPA, (http://www.bmpdatabase.org/)

of this Plan. In addition, the EPA's BMP database contains very little performance data on capture-based (e.g. retention/irrigation or rainwater harvesting) BMPs that are currently prevalent in the Planning Region and that have been considered for use in this Plan. Given the known limitations of the data, it is imperative that technical demonstrations made to document compliance with the design standards in this Plan, properly account for the uncertainties in this data. Site specific evaluations used to demonstrate the capabilities of BMPs should utilize the following factors of safety:[112]

- 1.25 for BMPs without a significant operational component (e.g. vegetative filter strips, grassy swales, etc.)
- 1.50 for BMPs with significant operational components (e.g. retention/irrigation, sand filters, etc.)

Previously cited EPA publications and regulatory guidance documents[113] address the processes used to evaluate the performance of BMPs and design recommendations for these BMPs. Proper design of BMPs and utilizing realistic performance data as the basis for that design was determined by the Stakeholder Committee to be very important to the overall process, since unrealistic designs will not provide the desired level of water quality protection intended as an outcome of the Plan. To accomplish this proper design, the procedures presented in these studies should be utilized to assess the capabilities and apply them in actual design situations.

In addition to the need to utilize realistic design parameters for the pollutant removal effectiveness of the BMPs, the hydraulic characteristics of the BMP must also be considered. BMP components must have adequate capacity to convey the range of hydraulic loadings they will likely experience. The hydraulic design of the BMPs must also consider discharges from the BMP. For BMPs designed to have routine discharges, the outlet should be designed to provide erosive flows control, as outlined above, and must provide for distribution of the discharge to allow sheet flow through the buffer zone to the receiving stream. Bypass and overflow structures must be included to accommodate extreme flood flows. However, these structures should provide energy dissipation, as outlined above.

The design processes addressed in the technical publications on BMP performance are technical in nature and require significant technical expertise to ensure that these considerations are incorporated into actual design and construction. For this reason, designs should be performed by qualified engineers, who are licensed to practice in the State of Texas and are experienced in the design of structural BMPs for controlling storm water. In addition to the need to have qualified personnel design these systems, it is also important that the personnel reviewing these designs on behalf of the public have similar qualifications and experience. This review will provide an additional level of protection.

[112] For example, a BMP with no significant operational component having a published removal effectiveness of 125 milligrams per liter (mg/L) at the Event Mean Concentration (EMC) should be considered to have a removal effectiveness of 100 mg/L (125/1.25). A BMP with a significant operational component having a published removal effectiveness of 75% should be considered to have a removal effectiveness of 50% (75/1.50).

[113] Reference Note 107.

9.7.2.2. Design Considerations Unique to the Planning Region

The unique aspects of the Barton Springs Zone make many of the standard structural BMPs unsuitable for use in the Planning Region without modification. In most instances, these BMPs serve to concentrate pollutants in the vicinity of the device, and then either control or remove the pollutants, and retain the water prior to release. The characteristics of the Barton Springs Zone of the Edwards Aquifer make it undesirable for this pollutant laden water to be allowed to recharge. It is important that any BMP utilized in the Recharge Zone be modified or augmented to prevent direct infiltration/recharge from the BMP.

9.7.3. Strategy for Identifying BMPs for Use in the Planning Region

For the purposes of the Plan, several different types of structural BMPs have been recommended for implementation in the Planning Region. Extensive background information on the design, construction and operation of these BMPs exists in readily available literature. The descriptions of the recommended BMPs are not intended to be exhaustive, but to describe their general nature and function. They are presented in order of preference. Additional information can be obtained on these BMPs from the literature citations provided in the Technical Reference List in Attachment 6. Where modifications to the standard application of a BMP due to the unique nature of the Edwards Aquifer are appropriate, these have been noted. The purpose of the structural BMPs presented is to control the effects of storm water discharges from the developed portions of tracts complying with the non-structural measures (e.g. location restrictions, buffer zones, impervious cover limits, etc.) for the tract as a whole.

The BMPs recommended for use in the Planning Region are broken down into two (2) categories: primary and secondary. Technical background data on all the listed BMPs has been evaluated by the consulting team. Based on that evaluation, the consulting team has determined that the primary BMPs presented, working alone within their documented operating range, should meet the objective of "no net increase" of pollutants, as presented in the section "Strategy for Selection of Watershed Management and Water Quality Protection Measures". The specific primary BMPs selected have also been identified as appropriate for use in complying with the TCEQ's Edwards Aquifer regulations, under both existing[114] and proposed[115] guidelines. The secondary BMPs presented may not meet the objectives working alone, but may be useful working in conjunction with other measures. Regardless of the type, number and sequencing of structural BMPs selected for use, they should all be addressed and evaluated through the comprehensive site planning and design process, presented previously.

[114] "Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices", Regulatory Guidance Document No. 348, Texas Natural Resource Conservation Commission, June, 1999.
[115] PROPOSED - "Edwards Aquifer Technical Guidance Manual", TCEQ, December, 2004.

9.7.4. Primary Structural BMPs

9.7.4.1. Retention/Irrigation Systems

Retention/Irrigation systems provide storm water capture for subsequent irrigation. This capture is accomplished using structures such as wet ponds or basins with adequate capacity to prevent discharge and retain captured storm water until it can be land applied for irrigation. The goal of these systems is to model natural normal infiltration/evapo-transpiration processes. These systems are very effective at controlling a wide variety of pollutants, including both suspended and dissolved constituents, and can approach one hundred percent (100%) pollutant removal efficiency. However, these systems also require routine maintenance to ensure that the irrigation system is performing properly. If the irrigation system is not operational, the performance of the system is significantly diminished. By minimizing the total pollutant loadings from developed portions of the site, these systems should achieve the objective of no increase in pollutant loadings from the entire site.

There are special considerations necessary for use of this BMP in any location where direct recharge to useable groundwater may occur, including the Recharge Zone. To prevent recharge from the retention pond, an appropriate barrier should exist. This could include an artificial lining or an evapo-transpiration bed of sufficient depth to prevent recharge even during extended wet periods. The same requirement applies to the area where the collected storm water is irrigated. A sufficient depth of soil profile (for evapo-transpiration) is necessary to prevent unintended recharge of pollutants. Application rates should also be controlled to prevent runoff, and irrigation should take place only on upland areas and not areas that may be subjected to concentrated flow. The design strategy presented below in the section on Wastewater Management, should be followed for areas receiving irrigation of retained storm water. For the application areas to be considered as pervious cover, the establishment of the hydraulic loading rate and the corresponding safety factors in the Wastewater Management section must be respected.

9.7.4.2. Bio-retention/Bio-filtration Systems

Bio-retention systems are similar to retention/irrigation systems in that they capture storm water for subsequent reuse. However, this reuse takes place inside the retention system through the support of vegetation and benthic and aquatic organisms. Capture is accomplished using structures such as wet ponds or basins with adequate capacity to prevent discharge. These systems are also very effective at controlling a wide variety of pollutants, including both suspended and dissolved constituents. By minimizing the total pollutant loadings from developed portions of the site, these systems should achieve the objective of no increase in pollutant loadings from the entire site.

There are special considerations necessary for use of this BMP in any location where direct recharge to useable groundwater may occur, including the Recharge Zone. To prevent

recharge, an appropriate barrier or evapo-transpiration bed should exist beneath the retention structure.

9.7.4.3.Constructed Wetland System

Similar in design and concept to bio-retention systems, Constructed wetland systems capture storm water to support wetland vegetation and aquatic organisms. These systems incorporate the natural functions of wetlands to aid in pollutant removal from storm water.

Constructed wetlands can also provide for quantity control of storm water by providing a significant volume of ponded water above the permanent pool elevation. A water balance must be performed to determine the availability of water to sustain the aquatic vegetation between runoff events and during dry periods. In addition sediment fore bay or some other pretreatment provision should be incorporated into the wetland system design to allow for the removal of coarse sediments that can degrade the performance of the system. Also, construction sediment should be prevented from entering constructed wetlands, as the resulting sediment loading can severely degrade the performance of the system. Constructed wetlands are particularly appropriate where ground water levels are close to the surface because ground water can supply the water necessary to sustain the wetland system.

9.7.5. Secondary Structural BMPs

9.7.5.1.Infiltration System

An infiltration system can be designed to capture a volume of storm water and infiltrate this water into the ground over a period of several hours or even days, thereby maximizing the infiltrative capacity of the BMP. Infiltration systems include an infiltration basin, porous pavement and infiltration trenches or wells. Infiltration increases the recharge capacity of underlying aquifers thereby increasing the base flow level of nearby streams. Infiltration removes pollutants as water percolates through the soil and dissolved constituent particles can be filtered out. Infiltration may not be appropriate in areas where ground water is a primary source of drinking water due to potential for contaminant migration. This is especially true if the runoff is from commercial or industrial areas where the potential for contamination by organics or metals is present.

9.7.5.2.Detention/Sedimentation Systems

Detention/Sedimentation systems also capture storm water, but subsequently release it following a certain residence time. The residence time varies but is usually only for relatively short durations, typically measured in some multiple of the duration of the storm runoff event. During extended dry periods, these systems do not retain water. While these systems have lower recharge potential, they are also less effective at removing or sequestering pollutants. They are most effective at removing suspended constituents such as sediment. Depending on the design and operational parameters, detention sedimentation systems can remove up to approximately eighty percent (80%) of suspended solids. However, these systems are much less effective at removing dissolved constituents, in some

instances accomplishing almost no removal. Since these systems discharge, their design and operation should also control the rate, volume and characteristics of discharge to avoid altering the hydrologic regime of the receiving stream. Even though the recharge potential is lower, when constructed in the recharge zone, these systems should also include an appropriate barrier beneath the structure. Given the removal efficiency of these systems, they should be sized to accomplish adequate removal from the portion under their control to meet the objective of no net increase in pollutant loadings from the entire site. Detention/Sedimentation Systems may also be used in conjunction with existing systems to

9.7.5.3. Sand Filtration Systems

Sand filtration systems are designed to remove suspended particles from storm water runoff and provide very little, if any detention. As with sedimentation ponds, these systems have lower recharge potential, and are much less effective at removing or sequestering pollutants than wet ponds. As with sedimentation ponds, they can remove up to approximately eighty percent (80%) of suspended solids. Sand filtration systems provide almost no removal of dissolved constituents. As with sedimentation ponds, the design and operation of sand filtration systems should also control the rate, volume and characteristics of discharge to avoid altering the hydrologic regime of the receiving stream. Even though the recharge potential is lower, when constructed in the recharge zone, these systems should also include an appropriate barrier beneath the structure. Given the removal efficiency of these systems, they should be sized to accomplish adequate removal from the portion under their control to meet the objective of no net increase in pollutant loadings from the entire site.

9.7.5.4. Vegetative Filter Strips

As their name implies, vegetative filter strips are areas of land where storm water is discharged for the purpose of utilizing the vegetation to trap sediment and other pollutants. As stand alone BMPs, vegetative filter strips are limited in that they can only accommodate sheet flow and not concentrated flow. If concentrated flow is discharged to a vegetated filter strip, adequate provisions should be incorporated to dissipate the energy and properly distribute the flow. The removal efficiency of these strips varies depending on the pollutant loading and the size of the strip, but they generally provide partial removal of suspended constituents and limited removal of dissolved constituents. Even though the recharge potential is lower with vegetative filter strips, when constructed in the recharge zone, their design should include recharge limitation features. In most instances, vegetative filter strips are intended to work in series with other structural BMPs.

9.7.5.5. Vegetated Swales

Vegetated swales are broad, shallow channels with a dense stand of vegetation covering the side slopes and channel bottom. Vegetated swales are designed to slowly convey storm water runoff, and in the process trap pollutants, promote infiltration and reduce flow velocities. Swales are very effective in removing Total Suspended Solids (TSS) and adsorbed metals. Wet swales can be used where standing water does not create a nuisance problem and where

the ground water level is close enough to the surface to maintain the permanent pool in inter-event periods.

9.7.6. Operations, Maintenance and Funding of Structural BMPs

Another important consideration for structural BMPs is their on-going operation and maintenance. Numerous studies by the EPA, the TCEQ and other organizations acknowledge the necessity of proper operation and maintenance for the proper long-term function of structural BMPs. In accordance with Stakeholder Guiding Principal No. 6, the use of any structural BMP as a water quality measure within the Planning Region will require a long-term operations, maintenance and funding plan. This plan should identify the requirements and responsibilities for operations and maintenance of the BMP and for funding of these tasks.

9.8. Local Enforcement of Construction Site Controls

As outlined in the discussion on Water Quality Threats, the Stakeholder Committee and consulting team have determined that the failure to use the appropriate measures and controls for storm water discharges from construction sites poses a significant threat to water quality. For this reason it is recommended that local jurisdictions request delegation of the review, inspection and enforcement of construction site storm water controls under the TCEQ's Edwards Aquifer rules and the TPDES Storm Water Construction Site program. The procedures for establishing local control of these programs are described in more detail in the Implementation Section.

Another mechanism for ensuring local enforcement of construction site storm water controls is by requiring that they be submitted and reviewed by the local jurisdiction in conjunction with the development review process. While local requirements may not be less stringent than the TCEQ's rules cited above, local controls may certainly be more restrictive, if warranted. In addition to ensuring that the construction site storm water controls have been reviewed and approved by the TCEQ, the local jurisdiction should require the following items in conjunction with a construction site storm water control plan:

- A demonstration that the estimated sediment capturing capacity of each type of control measures is capable of handling the expected sediment loading rate (using the NRCS Universal Soil Loss Equation[116], or similar evaluation).
- A demonstration that control measures for concentrated flow are suitable for the quantity and rate of flow expected at their respective location.

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The review of these items should be incorporated into the development review and construction plan approval process, as identified in the Implementation section. Instituting these requirements will also require appropriate technical expertise on behalf of the reviewing entity during the review process.

In addition to incorporating storm water controls into the site design review, the inspection of storm water controls should also be incorporated into other inspection activities conducted by the local

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jurisdictions. This will require incorporating the requirements into existing inspection guidance documents or forms and providing appropriate training to inspectors.

9.9. Wastewater Management

While the improper management of wastewater can pose a significant threat to water quality, the proper management of wastewater can be of great benefit in maintaining and enhancing water quality. When properly treated and reused with appropriate precautions, wastewater can become a valuable resource for the Planning Region. The primary threats result from unintended discharges or inadequate treatment. Depending on the management scheme selected, different water quality protection measures will be required to address these various threats.. Water quality protection measures are outlined below for the prevailing existing management strategies as well as alternative management strategies.

9.9.1. Centralized Collection and Treatment Systems

A widely used strategy for the management of domestic wastewater is centralized collection and treatment. Due to the limitations on the surface discharge of treated wastewater imposed by the TCEQ's Edwards Aquifer rules[117], the primary means of discharge of treated wastewater from centralized collection and treatment systems in the Planning Region is through land application, utilizing either irrigation or evapo-transpiration. The following water quality protection measures are recommended for centralized collection and treatment systems.

9.9.1.1.Centralized Collection Systems

Due to the significant water quality threats posed by unintended discharges from centralized wastewater collection systems, these systems should be designed, installed, inspected and operated to prevent the discharge of untreated wastewater. The TCEQ's Edwards Aquifer rules currently require the systems to be designed and installed under the supervision of a professional engineer licensed to practice in the state of Texas, and that the systems be inspected regularly. [118] Systems constructed after 1990 in the Recharge Zone are required to be inspected every five years.

As noted previously, approximately 85% of the recharge to the Barton Springs Segment of the Edwards Aquifer comes from streams which originate in the Contributing Zone and cross the Recharge Zone. Given the sensitivity of the Recharge zone and potential impact on Barton Springs, the consulting team has concluded that an increased inspection frequency will be more protective of water quality. Local jurisdictions should implement a plan to conduct full television monitoring of all centralized wastewater collection systems on a three year basis for both the Recharge and Contributing zones. In addition to adopting this water

[117] New wastewater discharges and increases in the capacity of existing discharges are prohibited in the Recharge Zone [30 TAC§213.6(a), "Wastewater Treatment and Disposal Systems, General"]. New wastewater discharges and increases in the capacity of existing discharges in the Contributing Zone must meet certain quality standards [[30 TAC§213.6(c), "Wastewater Treatment and Disposal Systems, Discharge Upstream from the Recharge Zone"

[118] 30 TAC§213.5(c), "Required Edwards Aquifer Protection Plans, Notification, and Exemptions, Organized Sewage Collection Systems"

quality protection measure, local jurisdictions should also incorporate into their ordinances the other requirements of the TCEQ's Edwards Aquifer rules for collection systems. These measures will help address the water quality threat from unintended discharges of untreated wastewater.

9.9.1.2.Adequate Treatment

Another previously identified water quality threat is the inadequate treatment of domestic wastewater. Inadequate treatment fails to adequately reduce pathogens and remove oxygen demanding constituents and nutrients from the wastewater. If discharged without adequate treatment, wastewater with excessive pathogens, oxygen demanding constituents or nutrients can adversely impact surface water or groundwater. Treatment requirements for domestic wastewater are specified in the TCEQ's Edwards Aquifer and Texas Pollutant Discharge Elimination System (TPDES) rules.[119] These rules specify that treated domestic wastewater that is to be land applied, must meet secondary treatment standards.[120] The requirement for treatment facilities to be designed and operated in accordance with these regulations should be incorporated in to local ordinances. These measures will help address the water quality threat from improperly treated domestic wastewater.

9.9.1.3.Treated Wastewater Discharge Through Land Application

Wastewater that is treated to meet the land application requirements specified in the TCEQ rules is not necessarily suitable for direct surface discharge. Any discharge of treated wastewater effluent from an irrigation site to either surface water or groundwater is prohibited by TCEQ rules.[121] For this reason, it is imperative that the land application be designed and operated so that the applied wastewater is incorporated into the soil profile and allowed to either assimilate or be consumed through evapo-transpiration. There are a number of different techniques use to accomplish this land application, with the most common being surface spray irrigation or subsurface drip irrigation. The design considerations presented below apply to either practice.

There are several factors that must be addressed to ensure that the irrigation practices are consistent with the limitations of the receiving site. These factors include the surface characteristics of the receiving site, the characteristics of the vegetation, the depth of the soil profile, the infiltration characteristics of the soil present, the application rate for the treated wastewater, and the mechanics of the irrigation system.

The surface characteristics of the receiving site should be evaluated to determine how they will respond to the irrigation practices. Irrigation on slopes steeper than ten percent (10%) should be avoided. Given the same soil characteristics, the effective infiltration capacity of

[119] The TCEQ Edwards Aquifer rules are codified in 30 TAC§213, and the TPDES regulations are codified in 30 TAC §307-309, §311, §312, §314, §315, and §317.
[120] 30 TAC §213.6, "Wastewater Treatment and Disposal Systems" and 30 TAC §309.20, "Land Disposal of Sewage Effluent"
[121] 30 TAC §309.20(b)(2)(A)

sloped areas is inherently lower than flat areas since the rainfall to runoff fractions increase proportionately to increasing slope. In addition to avoiding slopes areas, the receiving site should not be intersected by concentrated stormwater flow channels. While irrigation is not intended to occur during rainfall events, any erosion or scour occurring from stormwater flow could disturb or disrupt the vegetation and/or soil profile. This would result in localized areas with significantly different infiltration characteristics than the rest of the site. These surface characteristics need to be addressed in the evaluation of the irrigation receiving site.

The vegetation is a major factor in determining the effectiveness of the irrigation site to assimilate the irrigation. Vegetation utilizes both water and nutrients. As the assimilative hydraulic capacity of the vegetation increases, this reduces the amount of infiltration that must occur through the soil profile. The vegetation also assimilates nutrients, which are not normally assimilated well into the soil profile. Soil profile depth is also an important factor in the design of an irrigation area. A soil profile with inadequate depth will not allow adequate sequestering/filtering of remaining pollutants through the soil matrix. This is particularly important to address metals and organic constituents that are not well assimilated through vegetation. Soil profiles with effective infiltration rates that are lower than the actual application rate will limit the amount of infiltration occurring and cause the excess wastewater applied to run off. If the application rate is set to the saturated infiltration rate of the soil profile, this allows no margin of error for changes in antecedent moisture content that may drastically affect effective infiltration. This could result in a direct surface discharge of treated wastewater in violation of existing rules. It is important that all of these factors be adequately evaluated in the design of a land application site for treated wastewater.

There are a number of current technical procedure manuals and regulatory guidance documents addressing the mechanics of the irrigation process.[122] It is important that these components be properly designed to ensure that they function properly, and are adequately designed. By following existing design standards for the irrigation mechanics and performing a thorough evaluation of the receiving site, the land application of treated wastewater through irrigation can be protective of water quality.

There are a number of existing evaluation and design procedures in use within the Planning Region. Current TCEQ rules require a site specific evaluation of the soil's infiltration characteristics, as well as an assessment of the evapo-transpiration capacity of the receiving site. Due to the necessity to prevent runoff from land application areas, realistic estimates for these parameters are required. For land application sites within the Planning Region, a wastewater irrigation plan shall be included with the comprehensive site design. This plan shall be developed by a licensed professional engineer, licensed geoscientist, or licensed sanitarian with knowledge of the soils in the Planning Region. Due to the uncertainty of effective infiltration rates and antecedent moisture conditions, a safety factor of 1.50 shall be applied to the measured hydraulic infiltration rate to determine the design application rate. This provision has been included to ensure that the irrigation application area is considered

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[122] "Nonpoint Source Pollution Control Technical Manual", LCRA, July 1998, and TCEQ regulations at 30 TAC §213.

pervious cover, as discussed previously. The TCEQ design standards and these additional measures should be incorporated by the local jurisdictions into their ordinances.

9.9.2. On-site Sanitary Sewer Facilities

Another widely used strategy for the management of domestic wastewater is on-site sanitary sewer facilities (OSSFs). OSSFs are currently regulated by the TCEQ's OSSF rules.[123] These systems are typically used for individual tracts of land with a single residence or for residences in larger lot subdivisions. OSSFs rely on infiltration and evapo-transpiration for discharge of the treated wastewater. The following water quality protection measures are recommended for centralized collection and treatment systems.

9.9.2.1. Proper Design and Installation

The presence of a suitable soil profile, with known infiltration characteristics is critical to the proper design and installation of an OSSF. As with surface irrigation, a soil profile with inadequate depth will not allow adequate sequestering/filtering of remaining pollutants through the soil matrix and could result in the introduction of these pollutants into the groundwater. Soils with infiltration rates that are lower than the design rate of the system could result in surface accumulations of untreated wastewater, with the excess being discharged as runoff. This could result in a direct surface discharge of untreated or partially treated wastewater in violation of existing rules. It is important that all of these factors be adequately evaluated in the design of an OSSF.

As with the other water quality protection measures recommended, utilizing realistic design constraints is necessary to achieve the intended outcome of protecting water quality. Soil profile depths and types and infiltration rates should be addressed as part of the geologic assessment of the site. The use of "default" infiltration rates can lead to inadequate designs, which can correspond to inadequate function. The design procedures utilized should comply with established technical guidance documents, such as the LCRA's On-Site Sewage Facilities Program.[124] These designs should also respect existing regulatory requirements regarding lot size, including a minimum one (1) acre lot size in the recharge zone under the TCEQ's OSSF rules[125], and other existing local regulations.

In addition to proper design, proper installation is also necessary. Local public entities should inspect each OSSF system located within the recharge and contributing zone to assure that they have adequate soil depth, soil type, and that they are being installed in accordance with their design.

[123] The TCEQ OSSF rules are codified in 30 TAC §285, "On-Site Sewage Facilities"
[124] "Construction Standards for On-Site Sewage Facilities", LCRA, September, 1997
[125] 30 TAC 285, Subchapter E, "Special Requirements for OSSFs Located in the Edwards Aquifer Recharge Zone"

9.9.3. Alternative Systems

A wide variety of wastewater management systems are available as alternatives to centralized collection systems or on-site systems. These alternatives can include hybrid systems with centralized collection, but on-site reuse. Alternative systems can also include centralized collection, but wastewater discharge through various means, including evapo-transpiration through the soil matrix instead of surface irrigation. Due to the number and potential variety of these systems, specific designs are not included in this Plan. However, the other water quality protection measures presented in this Plan are intended and should be construed to encourage the beneficial reuse of treated wastewater.

9.9.4. Operations, Maintenance and Funding of Wastewater Management Systems

As discussed above with structural BMPs, the proper operation and maintenance of wastewater management systems is necessary to ensure that they are protective of water quality. In accordance with Stakeholder Guiding Principal No. 6, wastewater management systems within the Planning Region will require a long-term operations, maintenance and funding plan. This plan should identify the requirements and responsibilities for operations and maintenance of the wastewater management system and for funding of these tasks.

9.10. Alternative Water Sources/Uses and Conservation

9.10.1. Rainwater harvesting

Rainwater harvesting holds the potential to provide both an alternative water supply as well as being used as a BMP for water quality protection. The Texas Guide to Rainwater Harvesting notes that "Rainwater harvesting also lessens local erosion and flooding caused by runoff from impervious cover … Thus, stormwater run-off, the normal consequence of rainfall which picks up contaminants and degrades our waterways, becomes captured rainfall which can then fulfill a number of productive uses."[126] Rainwater tends to be very soft and contain almost no dissolved minerals and salts. Total dissolved minerals and salt levels average about 10 mg/l and total dissolved solids can range as high as 50 mg/l and as low as 2 mg/l. This compares to city tap water in Texas which is typically 200 to 600 mg/l.[127] A rainwater harvesting system consists of six basic components including:

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- Catchment Area/Roof which is the surface on which the rain falls;
- Gutters and Downspouts which transport the water from the catchment area to storage;
- Leaf screens and Roof washers which are used to filter out debris;
- Cisterns or Storage Tanks where collected rainfall is stored;
- Conveyance, which is the method of delivering the water either by gravity or pump; and

[126] "Texas Guide to Rainwater Harvesting", Second Edition, Texas Water Development Board, Center for Maximum Potential Building Systems, 1997, pg. 2
[127] Ibid. p.4

- Water Treatment which include filters and equipment that are used to settle, filter, and disinfect the water if it is to be used for drinking water.

Catchment areas are usually roofs of buildings. However, they can also be channeled gullies along driveways. Swales in yards can also serve as catchment areas. If these areas are used as a catchment area the water is diverted to a French drain or bermed detention area. Rainwater yield varies with the size and texture of the catchment area. Smoother, cleaner and more impervious roofing material will increase the yield. Losses tend to be negligible with a pitched metal roof but concrete and/or asphalt roofs average just less than 10% loss and tar and gravel roofs average a maximum of 15% loss. Regardless of roofing materials used, designers assume up to a 25% loss on annual rainfall due to the roofing material texture, evaporation, and inefficiencies in the collection process.[128]

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Gutters and downspouts are typically made of seamless aluminum and are sized to match the size of the catchment area. Typically, downspouts are designed to handle 1.25 inches of rainfall during a 10 minute period. Roof washing is the collection and disposal of the initial flush coming off the catchment area. These systems are typically a standpipe made from PVC pipe which extends from the gutter to the ground with the top of the pipe sealed so water will not flow out of the top. Once the pipe has filled the rest of the water will not flow out the top. These systems should be designed so that at least 10 gallons of water are diverted for every 1,000 square feet of collection area. The first flush can be used for irrigation or other non-potable uses. Many of the commercial roof washers which also contain filter or strainer boxes are available. Storage tanks may be made of several different materials including concrete or masonry, ferrocement, stone, fiberglass, metal or wood. The conveyance system is typically PVC pipe and pumps that assist in pressure maintenance. Water treatment includes the use of filters as well as disinfection if the water is to be used for potable uses.

Design criteria are based on precipitation in the area. One square foot of collection area equals approximately 600 gallons collected per inch of rainfall on 1,000 square feet of collection areas. Collection efficiencies will vary based on the storage availability and anticipated usage. Collection efficiencies of 75%-90% are often used by installers depending on the specific design if the system is to be used for in home use or for large scale irrigation. For small systems designed for supplemental irrigation collection factors of below 50% are common because it is not economic to install the large storage required to gain a higher percentage.[129]

A rainwater harvesting system is generally more cost effective if it is designed and integrated as part of new construction. Retrofitting existing buildings can often be significantly more expensive. If there is a potable supply of water available, using rainwater harvesting as a supplemental supply is usually the most cost effective method of implementing a rainwater harvesting project. In general the cost to install a rainwater harvesting system in new construction is approximately $1/gallon of collection capacity.[130] The City of Austin currently

[128] "Texas Guide to Rainwater Harvesting", Second Edition, Texas Water Development Board, Center for Maximum Potential Building Systems, 1997, pg. 7
[129] Ibid, pg. 22
[130] Ibid, pg. 33

offers financial incentives for both residential and commercial water customers to use rainwater harvesting as a water conservation measure. These incentives can be up to $500 per system and a short application form is required to be submitted to the Water Conservation Division at the City of Austin.[131] The City has identified the following sites as demonstration sites:

- Lady Bird Johnson Wildflower Center
- American Botanical Council
- Summit Elementary School
- Pickle Elementary School
- Feather and Fur Animal Hospital
- Parque Zaragoza Recreation Center
- The Natural Gardener
- Westwood High School
- Robert E. Lee Elementary School
- HEB Grocery at William Canon and Brodie Lane

The Texas Water Development Board also identified rainwater harvesting systems around the state, the vast majority of which were in Travis and Hays Counties serving households with both potable water and water for irrigation and other non-potable uses.

Additionally, the State of Texas created a sales tax exemption for equipment used in water conservation including rainwater harvesting, water recycling and reuse, reduction or elimination of water use, desalination, brush control, precipitation enhancement, and water and wastewater system improvements.

While rainwater harvesting has traditionally been considered a water conservation tool, it does have potential for being used as a water quality BMP, both for both residential and commercial development within the planning region.

9.10.2. Water Conservation

While some may argue that water conservation is not directly linked to water quality, this is not the case in areas where there is significant reliance on the use of groundwater, such as in the Planning Region. Particularly given the water quality threats posed by excessive groundwater pumping as established by the BSEAC Study, water conservation that reduces groundwater usage is directly linked to water quality.

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Water conservation practices have long been advocated in Texas, and in recent years, the Texas legislature has passed a number of mandatory water conservation measures. These measures include the requirement that all new fixtures (especially toilets and shower heads) sold in the state must include water conserving features. The Legislature has also mandated that all regional water plans include water conservation practices and drought management measures that are at least as stringent as those required under water rights permitting statutes.

[131] Rainwater Harvesting Incentive Program, City of Austin, October, 2004.

There is a wealth of information available on proven water conservation measures. Among other sources, the Texas Water Development Board has numerous publications on water conservation techniques, many of which are available over the internet.[132] The following water conservation measures are recommended for implementation in the Planning Region. These measures should be implemented as mandatory, through water suppliers, and voluntarily, in conjunction with the recommended public education measures.

9.10.2.1. Water Conservation Rate Structures

The concept of conservation water rates is based on the idea that the quantity of water demand clearly decreases with increasing water prices. There are four generally accepted conservation rate structures:

- Uniform Rates - the same rate applies to all water users.
- Inverted Block Rates - a schedule of rates applicable to blocks of increasing usage in which the usage in each succeeding block is charged at a higher unit rate than in the previous blocks.
- Seasonal Rates - based on the cost of service variations with respect to system season requirements. For example, a higher unit rate for water many be charged in the summer than for the rest of the year.
- Marginal Cost Rates - the cost of water is based on the cost of providing the next unit of production such as an increment of plant capacity and supply. Example: If a water utility needed to develop a new source of supply at considerable expense, the charge for all water sold should reflect that cost even though the average could be less.

9.10.2.2. Drought Management

Drought management includes short-term measures enacted during times of water shortage. Drought management allows for essential water needs to be met during water-short periods while other potential uses of water, that are not as high a priority, are curtailed. Those measures provide the ability to stretch water supplies to avoid running out of water during drought conditions. It is important to have drought contingency measures in place in case they are needed, and they are a required component of good water resource management.

9.10.2.3. Water Conservation Regulations

The following are examples of regulations that could establish water conservation requirements or encourage the more efficient use of water:

- Retrofit of Plumbing fixtures on Resale - When buildings or houses are sold, all plumbing fixtures would be retrofitted in order to meet current plumbing standards.
- Irrigation Permitting - Require all new underground irrigation systems to obtain a permit, ensuring that the system is constructed in the most water efficient manner including the installation of a rain shut off switch, wind sensor, check valves, or other water saving equipment.

[132] http://www.twdb.state.tx.us/assistance/conservation/pubs.asp

- Separate Irrigation Meter Requirements - Require all commercial properties including duplexes, triplexes, and four-plexes to install separate irrigation meters so that the property owner could effectively monitor outdoor water use.
- Waste of Water Regulations - Regulation or ordinances could be passed prohibiting the waste of water such as running an irrigation system with broken heads, heads directed over paved areas, allowing water to run down the street or pond in a parking lot, or other similar events.
- Landscape Ordinance - A landscape ordinance could be adopted requiring the use of water efficient plants, irrigation systems that have rain shut-off switches, etc. Additionally, the ordinance could require that parking lot medians and buffer areas be at least 8 feet wide to prevent water waste.

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9.10.2.4.Xeriscaping

Xeriscaping is a method of landscaping which includes the use of native and/or naturally drought resistant plants, landscape renovation to reduce water use, and more efficient irrigation. Xeriscaping of public parks and landscape areas represents an opportunity for local governments to reduce water demand.

9.10.2.5.Irrigation Techniques

The use of low-pressure drip irrigation instead of high-pressure spray irrigation offers a more efficient means of irrigating crops. This concept can also be applied in conjunction with the irrigation of wastewater effluent or retained storm water, as discussed in other sections.

9.11. Characteristics of Development

There are varying potential threats to water quality that depend on the specific characteristics of the development. These threats need to be addressed through a number of water quality protection measures unique to the type of development occurring.

9.11.1. Commercial/Institutional

Commercial developments are generally accompanied by large parking areas. The typical construction materials used for parking lots generally result in higher unit runoff rates than those generated from other types of impervious cover. This characteristic tends to concentrate both storm runoff and pollutants. To address this characteristic, parking lots should be designed to avoid large contiguous areas of impervious cover. By concentrating large numbers of parked vehicles, parking lots can accumulate residuals from automobiles, including leaked fluids, organic rubber constituents and metals. These residuals contain a variety of parameters which can adversely impact water quality. In addition to automobile residuals, commercial parking lots serve as accumulation points for litter. In terms of water quality parameters, these pollutants are best represented by oil and grease, dissolved metals, and floatables. The design of parking lots for commercial areas, and their associated BMPs, should address these parameters. These structural measures are necessary to protect water quality. Other design features for commercial development should incorporate the other water quality protection measures included in this Plan.

9.12. Land-use restrictions

Land-use restrictions involve developing laws and ordinances restricting certain activities with the ability to adversely impact water quality.

9.12.1. Land-use restrictions

As outlined in the current Edwards Aquifer rules, there are a number of land-uses that are currently prohibited in the Recharge Zone:[133]

- Waste disposal wells (disposal of liquid wastes by underground injection)
- New feedlot/concentrated animal feeding operations
- Land disposal of Class I industrial wastes (landfills or land application sites)
- Sewage holding tanks as part of an organized sewage collection system
- Municipal solid waste landfill facilities
- New municipal and industrial wastewater discharges.

Local jurisdictions should develop land-use restrictions to prohibit these activities.

In addition to these prohibitions, local jurisdictions should also develop restrictions on industrial facilities. Industrial facilities concentrate operations and chemicals which pose a serious threat to water quality given the unique conditions of the Recharge Zone. New industrial facilities would typically be restricted through their need to obtain a wastewater discharge permit, which is prohibited under the Edwards Aquifer rules. However, local jurisdictions should be explicit in prohibiting industrial land-uses in the Recharge Zone. These land-use restrictions will serve as non-structural measures to protect water quality.

9.12.2. Zoning/Use limitations

In addition to certain land-use prohibitions, local jurisdictions should also restrict the location of certain activities through zoning and/or use-limitations. These zoning/use limitations should address for the Contributing Zone the activities prohibited in the Recharge Zone, as outlined above. Due to their characteristics, these facilities also pose a water quality risk when located in the Contributing Zone.

As outlined above, commercial activities can also pose water quality threats. Due to their tendency to require large, contiguous areas of impervious cover, commercial activities should be located where they pose a lower risk to the environment. Since the EPA NPDES storm water regulations adopted a threshold of five (5) acres for differences in requirements for construction site runoff, this same threshold has been adopted in this Plan for restricting commercial development. Commercial developments exceeding five (5) acres in size should be restricted to preferred growth areas, as defined above. This threshold is intended to provide flexibility for implementation by local jurisdictions.

[133] 30 TAC §213.8, "Prohibited Activities"

9.13. Restrictions on Use, Storage and Disposal of Potentially Harmful Materials

Restrictions on the use, storage and disposal of potentially harmful materials help address the threats posed by these substances to water quality. These types of restrictions are non-structural water quality protection measures. Restrictions are most effective when coordinated with the Public Education measures outlined later in the Plan.

9.13.1. Hazardous Materials

The improper handling, use and disposal of hazardous materials can have an adverse impact on water quality. Water quality protection measures addressing the disposal of wastes resulting from hazardous materials are included elsewhere in the Plan. Restrictions on the use of pesticides and nutrients are also incorporated elsewhere in the plan. The following additional restrictions on other types of hazardous materials should be implemented:

9.13.1.1.Concentrated Storage

The concentrated storage of hazardous materials poses a significant threat to water quality. Current programs in the state dealing with the concentrated storage of hazardous materials require most facilities to register and file public reports. The TCEQ currently requires all facilities that handle industrial waste to file certain notifications.[134] A program under the Department of State Health Services (DSHS) also requires facilities that store more than certain threshold quantities of specified hazardous materials to register and file public reports. [135] While neither of these programs prohibits these facilities, they do record their location and the type and quantity of materials stored. Local jurisdictions with zoning authority should restrict the concentrated storage of hazardous materials to those areas determined to pose a lower threat to water quality and the environment.

9.13.1.2.Transportation Incidents

One significant identified threat is the release of hazardous materials during transportation incidents. Current programs in the state dealing with the release of hazardous materials during transportation focus primarily on risks to public safety. Incidents involving the release of hazardous materials can also pose threats to water quality and the environment. Due to the amount of public infrastructure already in place, local jurisdictions should coordinate with existing hazardous materials (HAZMAT) response programs to ensure that water quality protection measures are incorporated into those programs. This measure can be accomplished through providing water quality training to HAZMAT responders, including the importance of initial response actions to contain and recover the released materials. Ordinances addressing the clean-up of released hazardous materials should also be reinforced

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[134] 30 TAC §335.6, "Notification Requirements".
[135] The notification requirements are established under legal authority of the Texas Health and Safety Code, are administered by the Department of State Health Services, are codified in 25 TAC §295, "Occupational Health", Subchapter H, "Hazardous Chemical Right-to-know" (25TAC §295.181-§295.183).

to include requirements to perform proper assessment, and to use proper waste characterization and disposal methods.

9.13.1.3. Use of Certain Petroleum Products

Certain hazardous materials used in specific applications pose significant threats to water quality in the Planning Region. As identified previously, the use of paving materials containing "coal tar" have been linked to the occurrence of PAH compounds in storm water runoff. Materials containing these "coal tars" are used as overlays on previously paved areas, such as parking lots, roadways and driveways. PAH compounds are a serious threat to certain aquatic species and specifically to the Barton Springs Salamander. Due to these threats, the use of "coal tar" sealants containing leachable PAH compounds should be prohibited in the Planning Region. Local jurisdictions should incorporate this use restriction into laws and ordinances governing development, public projects, and to the extent allowed by law the sale and use of these items by the public.

9.13.2. Wastes

Numerous waste management measures are included in existing state and federal regulations. Most of these regulations are intended specifically to protect water quality from the improper management of disposal of wastes. Local jurisdictions should incorporate into their laws and ordinances restrictions on waste management activities consistent with these state and federal regulations. Jurisdictions with zoning authority should restrict waste management activities to those areas determined to pose a lower threat to water quality and the environment. These activities have previously been described in the section on Existing Water Quality Regulatory Programs.

9.13.3. Pesticides and Nutrients

To avoid the adverse impacts associated with pesticides and excessive nutrients, integrated management programs should be implemented by all entities that utilize pesticides and/or nutrient supplements. This includes both public and private entities and individuals in the Planning Region. A number of sources describe integrated management programs. The U.S. Department of Agriculture, (USDA) Natural Resource Conservation Service (NRCS) has developed an integrated nutrient management program for agricultural activities.[136] Both the existing[137] and proposed[138] guidelines for use in complying with the TCEQ's Edwards Aquifer rules include an integrated pesticide and nutrient management strategy. Integrated management strategies serve as non-structural measures to protect water quality.

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[136] "Nutrient Management", Conservation Practice Standard Code 590, U.S. Department of Agriculture, Natural Resource Conservation Service, October, 2003.

[137] Section 2.3, "Pesticide and Fertilizer Management", "Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices", Regulatory Guidance Document No. 348, Texas Natural Resource Conservation Commission, June, 1999.

[138] PROPOSED - Section 2.3, "Pesticide and Fertilizer Management", "Edwards Aquifer Technical Guidance Manual", TCEQ, December, 2004.

9.14. Proper Vegetative Management

While undeveloped land left in a natural state can be an effective measure for maintaining water quality, other activities occurring on undeveloped land can have adverse impacts on water quality. As previously identified, the majority of these potential impacts are associated with improper management of vegetation. Good vegetative ground cover slows and filters surface sediment from storm runoff, prevents erosion, and improves infiltration of water into the soil. More sediment is deposited on the land rather than carried into streams or water impoundments, and more water is retained in the riparian zone for slow release to the streams as base flow. Various scientific studies have confirmed the relationship between proper vegetative cover, decreased sediment yield and increased infiltration.[139]

The following measures are recommended to minimize adverse water quality impacts from improper vegetation management. Additional information is available from the U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS).

9.14.1. Vegetative/forestation practices

Proper vegetative practices will help ensure good water quality on undeveloped land. Practices such as removing invasive/noxious brush and weeds and propagating/re-establishing native plant communities will provide storm water runoff quality similar to undeveloped land in its natural state. As indicated in the section on Water Quality Threats, the excessive propagation of juniper can abstract a significant amount of water that would otherwise contribute to plant growth, runoff or recharge. Those who own and/or manage undeveloped land should institute programs to control the propagation of juniper and replace this growth with native trees and/or grasses. Information from the USDA NRCS indicates that brush and noxious weed removal may make additional water available to sustain healthy streamflow and aquifer recharge, ranging from approximately 30,000 to 100,000 gallons per acre per year.[140] Other studies have indicated that an vegetative canopy coverage of approximately fifteen percent (15%) is optimal.[141]

However, the management of juniper should be approached with caution and consideration of endangered species (particularly the Golden Cheek Warbler) and the overall diversity of habitat composition. This kind of consideration has been given to vegetative management in other preserves and conservation easements in the study area, including endangered species preserves and the City of Austin Water Quality Management Properties Protection Lands (Prop 2 Lands).

Proper vegetative practices should also be integrated into other areas of the plan. Stream buffers or adjacent uplands taken out of agricultural use and preserved as stream buffers or open space conservation easements should be subjected to proper vegetative management practices. This

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[139] Reference Figure 2, "Rangeland Hydrology and Water Quality in the Texas Coastal Bend", D. Lynn Drawe, Coastal Coordination Council, National Oceanic and Atmospheric Administration, August 2002.
[140] "Grazing Lands" A Valuable Resource for All Texans", U.S. Department of Agriculture, Natural Resource Conservation Service.
[141] "Improved Rangeland Management: Prospects for Improved Water Quantity and Quality from the Proposition 2 Lands in Austin, Texas", M. Hollon, Glenrose Engineering, Inc., et al, Austin, Texas

will maximize water quality/quantity functions and values. Management may be needed to restore the land to a more ideal composition of woody plant and native grass cover, or to restore areas disturbed during the development process.

9.14.2. Restoration Following Construction/Development

There are a number of practices that should be utilized to re-establish proper vegetation and minimize erosion and sedimentation following disturbance by construction and/or development. A series of proposed practices for proper restoration has been developed by the City of Austin to maximize the establishment of appropriate native vegetation following land disturbance.[142] These practices address:

- Identification of species, sources, mixtures, and rate of application of seeding, specifically the relationship of cool season vegetation to warm season vegetation.
- Type of mulch and compost.
- Watering requirements
- Management practices for establishment of vegetation.

These practices should be followed in all areas of the Planning Region for the re-establishment of vegetation following land disturbance.

9.15. Proper Agricultural Practices

The following measures are recommended to minimize adverse water quality impacts from improper agricultural practices. Additional information is available from the U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS).

9.15.1. Livestock/Range Practices

There are a number of practices that can be utilized to minimize the impact from livestock grazing and range practices. Some of these practices have been summarized below.

- Controlled Grazing – utilizing structural fencing and administrative rotation practices to evenly distribute grazing activity across the property, to avoid concentrating animal byproducts and vegetative disruption in the same areas over the long-term. This practice is also intended to balance forage consumption by grazing animals with plant biomass production in a manner that provides a portion of of the plant resources for conservation purposes and maintenance of a healthy plant community.
- Distributed Watering – similar to controlled grazing, the objective is to distribute watering activities around the property to avoid concentrating animal activity and byproducts in the same areas over the long-term.
- Topsoil/Nutrient Maintenance and Enrichment – ensuring that the topsoil and grasses have adequate nutrients to support grazing and prevent the adverse impacts of over-grazing.
- Weed/Invasive Plant Control – managing and controlling the propagation of weeds/invasive plants to ensure that soil nutrients are available for grasses and minimizing the need for supplemental nutrient application.

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[142] "Native Grassland Seeding and Planting for Erosion Control", City of Austin Standard Specification Manual 609S.

9.15.2. Cropland Practices

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There are a number of practices that can be utilized to minimize adverse water quality impacts from cropland:

- Select crops which can be sustained from natural precipitation, and avoid the need for irrigation or additional water application.
- Minimize the use of pesticides and nutrients, and use proper application procedures when they are used.
- Use conservation practices (e.g. contour farming,[143] hedgerow planting,[144] crop rotation,[145] etc.) to minimize erosion/sedimentation.

9.16. Protection of Endangered and Threatened Species

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Scientific evidence obtained from the City of Austin supports the conclusion that the combined effects of changes in springflow, sedimentation, turbidity, and pollutant loading adversely affect the Barton Springs Salamander. Minimum target spring flows will be identified with associated aquifer management strategies as part of the development of the Barton Springs Habitat Conservation Plan (HCP) currently being developed by the Barton Springs Edwards Aquifer Groundwater Conservation District. Dissolved oxygen concentrations are also being investigated to determine overall habitat requirements and suitability. Effects of non-point source pollution including nutrient loading (chemical compounds comprised of phosphates and nitrates that cause excessive growth of vegetation that degrades habitat for aquatic animals), and contamination from pesticides and polycyclic aromatic hydrocarbons (PAHs) are of concern.

Species protection imposed by federal law and/or water quality threshold criteria determined by additional scientific studies that are on-going or identified by future studies in the Barton Springs HCP may supplant current TCEQ standards. The sensitivity of the Barton Springs ecosystem to changes in both water quantity and quality suggests establishment of critical water quality parameters that may include other components not listed in or having different thresholds than the current TCEQ Water Quality Standards.

9.17. Public Education/Outreach

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Public education and outreach is a major factor in the success of many water quality protection measures. Through public education, people gain an understanding of how their actions can affect water quality and become more informed about water quality issues in their community. When the public is aware of the impacts that they have on their surroundings, they develop a greater sense of responsibility for those actions. Public education, awareness and acceptance are crucial for the political and financial sustainability of water quality protection measures implemented by local

[143] "Contour Farming", Conservation Practice Standard Code 330, U.S. Department of Agriculture, Natural Resource Conservation Service, February, 2000.
[144] "Hedgerow Planting ", Conservation Practice Standard Code 422, U.S. Department of Agriculture, Natural Resource Conservation Service, October, 2003.
[145] "Conservation Crop Rotation ", Conservation Practice Standard Code 328, U.S. Department of Agriculture, Natural Resource Conservation Service, February, 2000.

governments. Public Education is also the primary driver for the voluntary implementation of water quality protection measures.

As a part of its Phase II Storm Water program, the U.E. EPA has adopted Public Education as one of the minimum control measures to be implemented to control storm water pollution. The public education component of this Plan is based on the EPA's minimum control measure strategy. To the extent possible, this effort should be coordinated with other public education activities.

9.17.1. Awareness/Support of the Regional Plan

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Ensuring that the public is aware that the Plan exists is a major step in facilitating its implementation. This should be accomplished through public notices made by the implementing entities, and should include an outline of the water quality threats and the protection measures included in the Plan to address those threats. While other parts of this Plan incorporate elements to inform the individuals and entities requesting permission for certain regulated activities, the measures recommended for voluntary implementation have few inherent notification mechanisms. Specific emphasis should be placed on voluntary measures and those measures directed toward individual citizens.

9.17.2. Public Education/Outreach for Homeowners

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Public education/outreach directed to Homeowners should include the following topics:

- Lawn and Garden Activities - Programs that encourage composting, decreased fertilizer and pesticide use, water use efficiency, practical turf areas, appropriate plant selection, and soil analysis/improvement.
- Water Conservation Practices for Homeowners - Programs that encourage water conservation in the home including reduced consumption, looking for leaks, and efficient lawn watering.
- Proper Disposal of Household Hazardous Wastes - Programs that educate citizens on impacts of hazardous household materials and alternatives to toxic chemicals. Also initiatives to provide disposal opportunities for paints, paint thinners, solvents, motor oil, and other chemicals.
- Pet Waste Management - Education and possibly ordinances to encourage pet owners to collect and properly dispose of their animal's waste.
- Trash Management – Programs that educate citizens on impacts of garbage and control measures, including source reduction (alternative packaging, waste reduction, alternative chemicals, recycling etc,) and community clean-up programs

9.17.3. Education/Outreach for Commercial Activities

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Public education/outreach directed to Commercial Activities should include the following topics: pollution prevention activities at businesses, education for employees, and recognition programs for businesses that participate.

9.17.4. Outreach Programs to Minority and Disadvantaged Communities and Children

Programs that are bilingual, community organization based; and/or directed at children through school, scouts, and other groups.

- K-12 programs in the classroom, lab, or "hands-on" in the field. Storm Water Educational Materials
- Mail, door-to-door, businesses, organizations, public places, presentation, conferences, and media distribution of materials and information.

9.17.5. Public Outreach Programs for New Development

Public education/outreach directed to new development should be addressed to those who are involved in planning and constructing, and those who will occupy the new development. This should include the following topics:

- The importance of a comprehensive site design
- Low Impact Development
- Outreach encouraging pollution prevention with residential and commercial developers and owners.

9.17.6. Public Assistance with Problem Identification and Enforcement

An informed public can help identify potential water quality problems and assist the agencies charged with enforcing the water quality protection measures. This can be accomplished by informing the public about the processes for reporting and providing information on water quality problems. In addition, publicizing the consequences of enforcement actions can also serve as a deterrent for future water quality violations.

9.17.7. Public Education Outreach Avenues

Public education/outreach should utilize a combination of avenues to ensure that all segments of the population are reached. These avenues can include:

- Educational displays and informational material (e.g. pamphlets, booklets, brochures, etc.) on water quality that are made available at public locations and events including conferences, seminars, libraries, schools, and community events.
- Special events (e.g. festivals, proclamations, tours, seminars, etc.) designed to raise awareness of water quality issues.
- Notification through regulatory approval processes (e.g. development approvals, building permits, etc.)
- Coordinated distribution of informational material on water quality issues (e.g. coordinated with utility or service billings, real estate/property transactions, construction materials suppliers, etc.)
- Public service announcements through various media outlets (e.g., newspapers, magazines, radio, internet, and television)

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10. IMPLEMENTATION, ENFORCEMENT AND ACCOUNTABILITY

In any endeavor, planning only gets you part of the way to the solution. A well planned strategy requires execution to be successful. This Regional Plan is no different. The best of all possible plans will provide no real water quality protection if it is not implemented. During the Stakeholder meetings and discussions, much emphasis was placed on the importance of implementation, specifically including enforcement and accountability. The following sections outline the general implementation strategy and address specific implementation mechanisms.

10.1. Implementation Principles: Voluntary, Mandatory or Both?

For the types of measures identified in this Plan, there are two possible implementation strategies: 1) mandatory, and 2) voluntary. Obviously, all of the measures outlined can and should be implemented on a voluntary basis. However, a completely voluntary implementation strategy would provide uncertain and disparate implementation. For this reason, a number of the water quality protection measures are identified as recommended for mandatory implementation. Among the measures recommended for mandatory implementation, there are several for which more than one agency has existing regulatory authority. In a few cases, there are measures for which no existing entities have the legal authority to implement. These potential impediments to implementation are addressed in a separate section below.

10.2. Legal Authority of Existing Entities

There are a number of different types of governmental and quasi-governmental entities that have existing legal authority for implementing certain parts of the Plan. The benefits of utilizing existing authority in existing entities include shorter implementation time and the ability to amend existing ordinances instead of adopting new ones. The disadvantages of using existing entities include potential funding limitations and institutionalized cultures that are not sensitive to water quality concerns. Strategies to take advantage of the benefits and compensate for the disadvantages are outlined in later sections. The various types of entities and their general powers to implement water quality protection measures are outlined below. For a more detailed presentation of the existing legal authorities of these entities, please refer to Attachment 7, "Existing Authorities Matrix for Governmental Entities in the Planning Region".

10.2.1. Texas Commission on Environmental Quality

Under the Texas Water Code, the TCEQ was designated by the Texas Legislature as the agency with "primary responsibility for implementation of water quality management functions, including enforcement actions, within the state."[146] Under this broad authority, the TCEQ can implement any water quality regulations that it can demonstrate are necessary and do not conflict with other state legislation. The TCEQ may also delegate these responsibilities to local governments through cooperative agreement.[147]

[146] Texas "Water Code", Title 2, Chapter 26, "Water Quality Control", §26.0136(a).
[147] Texas "Water Code", Title 2, Chapter 26, "Water Quality Control", §26.175.

10.2.2. Home Rule Municipality

In Texas, Home Rule (or Chartered) municipalities are subdivisions of the state vested with the full power of local self government through the adoption of a charter conforming to the requirements of the Texas Constitution.[148] Home Rule municipalities have relatively broad powers to enact rules and ordinances to protect public health and water quality within their Municipal Boundaries (i.e. City Limits) and their Extra-Territorial Jurisdiction (ETJ). Zoning restrictions can also be adopted and enforced by Home Rule municipalities within their municipal boundaries, but not within their ETJ. The Home Rule municipalities in the Planning Region are the City of Austin and the City of Kyle.

Home rule municipalities have generally attempted to incorporate water quality protection measures as part of their plat and subdivision approval process as authorized under Chapter 212 of the Texas Local Government Code[149]. Home rule municipalities also have legal authority to regulate water quality through the Texas Water Code[150]. Under this section, a municipality may establish a water pollution control and abatement program for areas within the municipal limits and it's ETJ. Although such a program generally entails water quality monitoring, sampling and inspection requirements for waste dischargers, the program may also include "reasonable and realistic plans for controlling and abating pollution or potential pollution" from non-point sources such as storm sewer discharges and urban rainfall runoff. Once the plan is developed it must be submitted to the TCEQ for its review and approval and any requirement under the program may be appealed to TCEQ or the district court. Under the Texas Water Code, home rule municipalities may also request delegation of water quality functions from the TCEQ.

A home rule municipality is also given the authority to "prohibit the pollution or degradation of, and may police, a stream, drain, recharge feature, recharge area, or tributary that may constitute or recharge the source of water supply of any municipality." A home rule municipality may also provide for the protection of and may police any watersheds. This authority may be exercised in the municipality's ETJ, except that the authority to protect recharge features and groundwater aquifers in the ETJ may only be exercised by a municipality with a population of over 750,000 and only if that groundwater constitutes more than 75% of the municipality's source of water.[151]

10.2.3. General Law Municipality

In Texas, General Law municipalities are also subdivisions of the state incorporated in accordance with the Texas Local Government Code.[152] General Law municipalities are vested with less local self government power than Home Rule municipalities, but can still enact certain rules and ordinances to protect public health and water quality within their municipal limits and

[148] Texas "Local Government Code", Title 2, "Organization of Municipal Governments", §5.004, §51.072-§51.079.
[149] Texas "Local Government Code", Title 7, "Regulation of Land Use, Structures, Businesses and Related Activities", Chapter 212, "Municipal Regulation of Subdivisions and Property Development", §212.004-§212.903.
[150] Texas "Water Code", Title 2, Chapter 26, "Water Quality Control", §26.175 and §26.177.
[151] Texas "Local Government Code", Title 13, "Water and Utilities", Chapter 401, "Water Control by Municipalities", §401.003, "Protection of Streams and Watersheds by Home-Rule Municipality".
[152] Texas Local Government Code, Title 2, "Organization of Municipal Governments", §5.001-§5.003.

their ETJ. Like Home Rule municipalities, General Law municipalities can adopt and enforce zoning restrictions within their municipal boundaries, but not within their ETJ. The General Law municipalities in the Planning Region are:

- Village of Bear Creek
- Village of Bee Cave
- City of Buda
- City of Dripping Springs
- City of Hays
- Village of Lakeway
- City of Mountain City
- City of Rollingwood
- City of Sunset Valley
- City of West Lake Hills

As with home rule municipalities, general law municipalities are also authorized to incorporate water quality protection measures as part of their plat and subdivision approval process under the Texas Local Government Code[153], and to regulate water quality under the Texas Water Code[154]. General law municipalities may establish a water pollution control and abatement program for areas within the municipal limits and the ETJ and may also request delegation of water quality functions from the TCEQ.

10.2.4. Counties

Counties are subdivisions of the state created under the Texas Constitution or by act of the Texas Legislature,[155] but have no specific authority granted by virtue of their existence. The Planning Region includes portions of the Counties of Blanco, Hays and Travis. Through various acts of the Texas Legislature, counties have been given some powers to regulate the subdivision of land through the platting process. They also have been given some authority to own and operate some public infrastructure, including water, wastewater, drainage and waste disposal facilities. Counties may also institute civil actions and prosecute criminal actions under the Texas Water Code and the Texas Health and Safety Code.

Under Senate Bill (SB) 873[156] the Texas Legislature gave Travis and Hays Counties[157] the authority to adopt regulations governing plats and subdivisions of land in unincorporated areas of the county if the regulations promote the "health, safety, morals, or general welfare of the county and the safe, orderly, and healthful development of the unincorporated area of the county."[158] However, SB 873 specifically prohibits the county from regulating certain elements, usually regulated by municipalities through zoning. These elements include:[159]

[153] Texas "Local Government Code", Title 7, "Regulation of Land Use, Structures, Businesses and Related Activities", Chapter 212, "Municipal Regulation of Subdivisions and Property Development", §212.004-§212.903.
[154] Texas "Water Code", Title 2, Chapter 26, "Water Quality Control", §26.175 and §26.177.
[155] Texas Constitution, Article IX, Section 1, "Creation of Counties".
[156] Senate Bill 873, An Act of the Legislature of the State of Texas, Amending Title 7, Chapter 232 and a portion of Title 7, Chapter 242, of the Texas "Local Government Code", 77th Regular Legislative Session, May, 2001.
[157] Texas Local Government Code, Title 7, Chapter 232, "Infrastructure Planning in Certain Urban Counties", §232.100, applicable to counties with a population greater than 700,000 or counties adjacent to a county with a population of 700,000 and within the same metropolitan statistical area.
[158] Texas Local Government Code, Title 7, Chapter 232, "Infrastructure Planning in Certain Urban Counties", §232.101(b)(1)-(4).
[159] Texas Local Government Code, Title 7, Chapter 232, "Infrastructure Planning in Certain Urban Counties", §232.101(a).

- The use of any building for a particular purpose (e.g. residential, business, or industrial).
- The bulk, height, or number of buildings constructed on a particular tract of land.
- The size of a building including the ratio of the square footage of the building's floor space to square footage of the land.
- The number of residential units per acre of land.

Given the broad charge to promote health, general welfare, or safe and orderly and healthful development it would appear that Counties affected by SB 873 may enact water quality regulations as part of the platting process as long as they do not restrict these specific items. While this interpretation, like any other, would be subject to legal review if challenged, the current construction would prohibit the outright regulation of impervious cover limits and dwelling unit densities.

10.2.5. Special Purpose Districts

The Texas Constitution allows for the creation of special purpose districts[160] as subdivisions of the state. There are several different types of districts authorized under current legislative authority. The types of districts identified as potentially relevant to the implementation of the Plan, and examples of these types of districts within the Planning Region, are presented below.

10.2.5.1. Municipal Utility Districts

Municipal utility districts (MUDs) can be created by either the Commissioners Court of the county in which they are located or by the TCEQ at the request of fifty percent (50%) of the landowners located within the proposed MUD. The Texas Legislature may also create a MUD during the legislative session. MUDs are authorized to own and operate facilities inside and outside their district boundaries to facilitate service within their boundaries. They have the ability to levy taxes for payment of debt service as well as operations and maintenance and to enter into contracts and interlocal agreements with other political subdivisions. There are no active MUDs in the Blanco or Hays County portions of the Planning Region, but there are several active MUDs in the Travis County portion.[161] Current MUD boundaries are shown on Figure 5, on the following page. Active MUDs in the Travis County portion of the Planning Region include:

- Lost Creek
- Northwest Travis County MUD No. 3
- Northwest Travis County MUD No. 4
- Northwest Travis County MUD No. 5
- Northwest Travis County MUD No. 6
- Northwest Travis County MUD No. 7
- Northwest Travis County MUD No. 8
- Northwest Travis County MUD No. 9
- Shady Hollow
- Sienna Hills

[160] Texas Constitution, Article III, Section 52, "Counties, Cities or Other Political Corporations or Subdivisions" and Article XVI, Section 59, "Conservation and Development of Natural Resources and Parks and Recreational Facilities; Conservation and Reclamation Districts".
[161] "2004 Appraisal District Directory", No. 016 Blanco County, No. 105 Hays County and No. 227 Travis County, Texas Comptroller of Public Accounts, 2004.

If a MUD is to be formed within the ETJ of a city, the city must grant permission allowing the formation of the district.[162] If a MUD is formed outside the ETJ of a city the TCEQ is required to notify the County Commissioners Court of any proposed bond issue and projects that are to be funded by those bond issues. The County has thirty (30) days after notification to examine all information on file and submit a written opinion from the Commissioners Court stating any findings, conclusions, or other information that the Commissioners Court considers important to the TCEQ making a final determination. If a written opinion is submitted the TCEQ is obliged to consider the written opinion before taking final action.[163]

MUDs have traditionally been used to facilitate development in the area under their jurisdiction and are regulated under Chapter 54 of the Texas Water Code. A MUD is given specific authority to act for "the protection, preservation, and restoration of the purity and sanitary condition of water within the state; and the preservation of all natural resources of the state."[164] Based on this authority the MUD may adopt and enforce water quality regulations within their jurisdiction.

10.2.5.2. Water Control and Improvement Districts

Like MUDs, Water Control and Improvement Districts (WCIDs) can be created by either a County Commissioners Court or the TCEQ at the request of fifty percent (50%) of the landowners located within the proposed WCID, or by the Texas Legislature. While formed in the same manner, WCIDs do not possess all of the powers of MUDs. WCIDs are authorized to use any practical means to protect, preserve and restore the purity and sanitary condition of water.[165] They can adopt rules to preserve the sanitary condition of water controlled by the district and to prevent waste or unauthorized use of water.[166] Like MUDs, WCIDs are authorized to own and operate facilities inside and outside their district boundaries to facilitate service within their boundaries. They can levy taxes for payment of debt service as well as operations and maintenance and can enter into contracts and interlocal agreements with other political subdivisions. If a WCID is formed in a city's ETJ, there are notification procedures very similar to those for MUDs.[167]

[162] Texas "Water Code", Title 4, Chapter 54, "Municipal Utility Districts", §54.016.
[163] Texas "Water Code", Title 4, Chapter 54, "Municipal Utility Districts", §54.5161(a)-(b).
[164] Texas "Water Code", Title 4, Chapter 54, "Municipal Utility Districts", §54.101(7)-(8).
[165] Texas "Water Code", Title 4, Chapter 54, "Water Control and Improvement Districts", §51.121.
[166] Texas "Water Code", Title 4, Chapter 54, "Water Control and Improvement Districts", §51.122.
[167] Texas "Local Government Code", Title 2, Chapter 42, "Extraterratorial Jurisdictions of Municipalities", §42.042.

There are no active WCIDs in the Blanco County portion of the Planning Region, but there are several active WCIDs in the Hays and Travis County portions.[168] Current WCID boundaries are shown on Figure 5. Active WCIDs in the Planning Region include:

- Hays County WCID No. 1
- Hays County WCID No. 2
- Travis County WCID No. 10
- Travis County WCID No. 14
- Travis County WCID No. 19
- Travis County WCID No. 20

10.2.5.3.Groundwater Conservation Districts

Groundwater Conservation Districts (GCDs) are subdivisions of the state created by the Texas Legislature or under the authority of the Texas Water Code.[169] GCDs are authorized to "provide for the conservation, preservation, protection, recharging, and prevention of waste of groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence."[170] Under the Texas Water Code, GCDs are authorized to "make and enforce rules, including rules limiting groundwater production based on tract size or the spacing of wells, to provide for conserving, preserving, protecting, and recharging of the groundwater or of a groundwater reservoir or its subdivisions in order to control subsidence, prevent degradation of water quality, or prevent waste of groundwater."[171] The GCDs with jurisdiction in the Planning Region are the Barton Springs Edwards Aquifer Conservation District, the Blanco Pedernales Groundwater Conservation District, and the Hays Trinity Groundwater Conservation District.

10.2.5.4.Public Improvement Districts

Under the Texas Local Government Code, a municipality or county may form a Public Improvement District (PID) upon the submission of a petition filed by the landowners of 50% in value of the land to be included in the PID.[172] A PID is intended as an alternative financing mechanism to pay for improvement projects that confer special benefits on a definable part of a municipality or a county. Examples of improvements that may be financed through a PID include water, wastewater, drainage facilities, parks, landscaping, lighting, sidewalks, pedestrian malls, artwork, libraries, parking facilities, mass transportation facilities, and projects similar to these listed projects. A PID has the power to levy a tax, called an assessment, on the property in the district to pay for the improvements which benefit the land subjected to the assessment. While water quality protection is not specifically included as a similar project, if structural and non-structural BMP's are part of the design criteria for drainage or flood control, streets and roadways, and parks and open space there is a potential that a PID could be used to finance construction and operations and maintenance. The PID is not intended to be a property-owning entity in its own right so the

[168] "2004 Appraisal District Directory", No. 016 Blanco County, No. 105 Hays County and No. 227 Travis County, Texas Comptroller of Public Accounts, 2004.
[169] Texas "Water Code", Title 2, Chapter 36, "Groundwater Conservation Districts", §36.011.
[170] Texas "Water Code", Title 2, Chapter 36, "Groundwater Conservation Districts", §36.0015.
[171] Texas "Water Code", Title 2, Chapter 36, "Groundwater Conservation Districts", §36.101.
[172] Texas "Local Government Code", Title 12, Chapter 372, "Improvement Districts in Municipalities and Counties", §372.002.

title to the improvements and responsibility for the operations and maintenance of the improvements is vested in the entity within whose jurisdiction the improvements are located.

10.2.6. Authorities

Authorities are subdivisions of the state created by act of the Texas Legislature with the specific powers granted to them through their enabling legislation. Since each Authority in the State of Texas is individually created, their powers and duties vary widely. Authorities with water quality powers and/or duties in the Planning Region include the Edwards Aquifer Authority, the Lower Colorado River Authority, and the Guadalupe Blanco River Authority.

10.2.6.1. The Lower Colorado River Authority

The Lower Colorado River Authority (LCRA) was formed by the Texas legislature under Article XVI, Section 59 of the Texas Constitution as a conservation and reclamation district. The boundaries of the LCRA include Blanco, Burnet, Llano, Travis, Bastrop, Fayette, Colorado, Wharton, San Saba and Matagorda counties. Under its enabling legislation the LCRA has broad powers including storage of water, generation of water power and electric energy, own and operate water and wastewater facilities, operate parks, conserve and protect the waters of the basin and enter into contracts. The authority was also expressly authorized to adopt water quality regulations and penalties as found in Section 222.004(q) of the water code. This section allows the LCRA to adopt rules that provide for the control of both artificial and natural pollution, including organic and thermal, of all groundwater or surface water of the Colorado River and its tributaries within the boundaries of the LCRA. The LCRA has adopted water quality rules and regulations for those areas that drain directly into Lake Travis.

10.2.6.2. The Edwards Aquifer Authority

The Edwards Aquifer Authority (EAA) was formed by the Texas Legislature under Article XVI, Section 59 of the Texas Constitution as a conservation and reclamation district.[173] The boundaries of the EAA include all or part of Atascosa, Bexar, Caldwell, Comal, Guadalupe, Hays, Medina, and Uvalde counties. The EAA's jurisdiction in Hays County encompasses a small portion of the Planning Region.

10.2.6.3. The Guadalupe Blanco River Authority

The Guadalupe Blanco River Authority (GBRA) was formed by the Texas Legislature under Article XVI, Section 59 of the Texas Constitution as a conservation and reclamation district.[174] The boundaries of the GBRA include all or part of Caldwell, Calhoun, Comal, Dewitt, Guadalupe, Gonzales, Hays, Kendall, Refugio and Victoria counties. The GBRA's jurisdiction in Hays County encompasses a small portion of the Planning Region.

[173] Senate Bill 1477, An Act of the Legislature of the State of Texas, 73rd Regular Legislative Session, 1993.
[174] An Act of the Legislature of the State of Texas, 44th Regular Legislative Session, 1935.

10.3. Existing Entities within the Planning Region

As presented above, Texas law gives varying degrees of authority to each of these political subdivisions to regulate water quality within their jurisdictions. Additionally, in Travis County the LCRA has been granted authority to regulate water quality and the LCRA currently has water quality regulations for areas around their reservoirs. Other special purpose units of government such as MUDs and WCIDs have limited authority to regulate water quality within their jurisdictions. However, state law does impose certain limits on general law cities and counties as to how they can enforce their water quality regulations. Home Rule cities, such as Austin, have the greatest flexibility in enforcing water quality ordinances. Table 13, below, lists the municipalities and counties within the planning area, the estimated area within their municipal boundaries and areas of Extra Territorial Jurisdiction (ETJ).

Table 13 – Approximate Areas Under the Jurisdiction of Local Entities Within the Planning Region[175]

LOCAL ENTITY	Area (Ac.)	% of study area
City of Austin (Incorporated)	22,384	9.31
City of Austin (Limited Purpose ETJ)	5,470	2.28
City of Austin (2 mile ETJ)	23,587	9.81
City of Austin (5 mile ETJ)	17,836	7.42
Village of Bear Creek (Incorporated)	739	0.31
Village of Bee Cave (Incorporated)	1,200	0.50
Village of Bee Cave (1 mile ETJ)	5,582	2.32
City of Buda (Incorporated)	91	0.04
City of Dripping Springs (Incorporated)	2,536	1.05
City of Dripping Springs (ETJ)	69,335	28.84
City of Hays (Incorporated)	2,539	1.06
City of Kyle (ETJ) [Estimated]	100	0.04
Village of Lakeway (Incorporated)	119	0.05
Mountain City (Incorporated)	157	0.07
Mountain City (0.5 mile ETJ)	840	0.35
City of Rollingwood (Incorporated)	441	0.18
City of Sunset Valley (Incorporated)	154	0.06
City of Sunset Valley (0.5 mile ETJ)	724	0.30
City of West Lake Hills (Incorporated)	763	0.32
SUB-TOTAL	**154,598**	**64.31**
Blanco County (Unincorporated)	3,304	1.37
Hays County (Unincorporated)	73,540	30.59
Travis County (Unincorporated)	8,952	3.72
SUB-TOTAL	**85,796**	**35.69**
TOTAL	**240,394**	**100.00**

Figure 6, below shows the location of these areas municipalities and their ETJ within the Planning Region.

[175] Base data taken from "Northern Hays and Southwestern Travis Counties, Water Supply System Project Environmental Impact Study", BIO-WEST, Inc. and LCRA, June 2002. Data supplemented with information provided directly by local entities.

10.4. Recommended Implementation Strategy

The successful implementation of this Plan will depend on a number of factors, including: the type of growth and development that local governments want to encourage, the adoption of water quality ordinances and orders that will complement platting and subdivision regulation, effective operations and maintenance of facilities and educating the public on the importance of managing their activities to minimize the potential for adversely impacting water quality.

The implementation recommendations presented in the plan are both long term and short term. The short term recommendations have been developed to rely solely on local jurisdictions involved in the planning process, working strictly within their existing legal authority. There are several reasons for taking this approach. The first is that these entities have demonstrated initiative in instituting this planning process and have expressed a desire to commit to implementation of the resulting plan. Secondly, these entities can act within their own existing authority, without relying on an outside entity over which they have no control. Thirdly, by working within these constraints, the timing for implementation can be substantially reduced over that required for actions by outside entities, such as the TCEQ or the Texas Legislature. Fourthly, the implementation approach presented here incorporates local mechanisms for funding the implementation. Using this approach, the local jurisdictions have the means to successfully implement the Plan.

During the planning process, there has been much stakeholder input stressing the need for consistent implementation of the recommended measures to provide effective water quality protection. The objective of consistent implementation could certainly be achieved more effectively with one entity than with multiple entities. However, this one entity would need both the legal authority to implement the measures as well as a funding mechanism to support implementation. No local governmental entity has legal authority in all areas of the Planning Region. A number of existing regional entities (e.g. the EAA, the LCRA, the GBRA, the BSEACD, etc.) have jurisdiction over larger portions of the Planning Region, but they do not currently have the legal authority to implement all of the recommended protection measures. While the TCEQ currently has the legal authority to regulate all aspects of water quality anywhere in the State, (including the Planning Region) they do not have a long-term, reliable funding mechanism to implement the water quality protection measures. The Texas Legislature could certainly remedy these impediments through the establishment of a new entity or through the expansion of powers or funding base for an existing entity. However, due to the time required and the uncertainty in outcome for these types of actions, the establishment of a single implementing entity has been incorporated as an alternative, long term objective.

As shown in the previous section, the Planning Region consists of portions of eleven cities and three counties with a combined area of approximately 240,000 acres. The unincorporated area of Hays County accounts for 30.7% of the Planning Region, while the City of Dripping Springs and its ETJ accounts for 29.7%; the City of Austin accounts for 28.8%, and the unincorporated area of Travis County accounts for 3.7%. These four entities have approximately 93% of the Planning Region within their jurisdictional boundaries.

As noted earlier in this Plan, water quality management is multi-faceted. The recommendations developed in the Plan include design criteria to ensure the incorporation of appropriate water quality protection measures, as well as regulatory and contractual arrangements to ensure the implementation, maintenance and enforcement of the water quality protection measures. Depending on the approach taken to accomplish water quality objectives using structural BMP's, non-structural BMP's or a combination of the two there are many questions and policy decisions that have to be made as to who pays for capital improvements, land acquisition, and ongoing operations and maintenance as well as land management techniques. This is also complicated by the varying degrees of development regulation authority between local jurisdictions and the role of the TCEQ.

The water quality protection measures identified in this Plan are intended for implementation through all local jurisdictions within the Planning Region. It is recommended that, at a minimum, the local jurisdictions adopt the water quality protection measures outlined in this Plan. However, it is the local jurisdiction that will ultimately be responsible for the long term implementation of these measures, even if they are funded through another source. As noted in previous sections, the geologic, topographic and environmental features of the planning area do not necessarily facilitate a "one-size" fits all approach to water quality assessment. Each of the local jurisdictions involved must make a fundamental decision as to whether they intend to adopt the measures recommended in this Plan, or adopt measures that the local jurisdictions believe are more protective of water quality than those presented here. However, for this Plan to function as a true regional plan, it is imperative that there be consistent implementation to ensure a consistent level of water quality protection throughout the Planning Region.

Since a small number of the local governments control the vast majority of the Planning Region, the initial (short-term) implementation strategies have been developed focusing on municipalities and counties. Other types of entities, whose establishment is within the powers of existing local jurisdictions, can be utilized to supplement this implementation. Additional long-term alternatives have been suggested by the Stakeholder Committee and are presented in subsequent sections.

10.5. Implementation Mechanisms for All Jurisdictions

Many of the water quality protection measures can be implemented directly by all existing jurisdictions. The following specific measures are common to all the previously listed types of public entities.

10.5.1. Incorporate Water Quality Protection Measures into Existing Design Criteria

The water quality protection measures presented in the Plan should be incorporated into existing design criteria for roads, streets, utilities, drainage structures and site design. Many of the water quality management strategies and BMPs that are identified in this Plan can be effectively integrated into drainage and flood control design while also meeting the water quality management objectives. As outlined above, local jurisdictions may adopt measures that they deem to be more protective of water quality than those provided here. For example, if lower density development is desired (less impervious cover) and more stringent non-structural BMPs

are utilized, there is the potential that long term operations, maintenance and monitoring costs will be lower than if higher density and structural BMPs are utilized. In addition, the capabilities of the entity performing the long term operations, maintenance and monitoring should be considered as part of the design criteria.

10.5.2. Pre-Development Review Process

Pre-development reviews, of varying level of detail, are conducted by almost all local governments. Traditionally, the first step in approving a development project begins with the submission and approval of a preliminary plat. This preliminary plat identifies generally how the property is to be divided between different land uses, such as residential lots, roadways, utilities, easements, parks, floodplains, etc. While local jurisdictions issue an approval on preliminary plats, they are not the final authorization. Following the approval of the preliminary plat, most jurisdictions require the preparation and approval of a final plat. This final plat provides detailed dimensions and locations for how the property is to be divided between different land uses, as outlined above. However, final plats must be completed with sufficient detail to serve as the basis for the sale of individual lots and for the dedication of road rights-of-way, easements, parks, etc. Once a final plat is approved and recorded, detailed construction plans are typically required before construction authorization (typically a building permit) is issued. The water quality protection measures included in this Plan are intended to fit within this typical pre-development review process.

10.5.2.1. Preliminary Plat

In conjunction with the general layout of the proposed development typically shown on the preliminary plat, the local jurisdiction should require that the developer submit a preliminary site characterization and development plan. The site characterization should include identification of streams, critical environmental features, areas with steep slopes, and a preliminary soils assessment, identifying the approximate soil types and depths across the site. The preliminary development plan should identify the areas of the site to be developed, the areas to be used for buffer zones, proposed storm water and wastewater management strategies, the approximate development density that will result from the development, and the proposed transportation and utility plan for the development. This information should be reviewed by the local jurisdiction during the preliminary platting process and any corresponding deficiencies noted. As with other aspects of the preliminary platting process, if these deficiencies were not satisfactorily corrected, the preliminary plat would be rejected.

10.5.2.2. Final Plat

In conjunction with the detailed layout of the proposed development typically shown on the final plat, the local jurisdiction should require that the developer submit a detailed site development plan. The site development plan should include water quality protection measures for all aspects of the site development, including:

- A detailed characterization of streams and drainage ways (physical and hydrologic) and identification of associated buffer zones.

- A detailed characterization of critical environmental features and identification of associated buffer zones.
- A detailed soils assessment, identifying the soil types and depths in all areas of steep slopes and areas proposed for storm water and/or wastewater irrigation, or below grade discharge of wastewater.
- A detailed intensity evaluation based on the gross site area method, demonstrating compliance with the applicable impervious cover limits.
- A detailed evaluation of proposed storm water and wastewater management strategies, including estimated quantities, runoff rates, storage volumes, application rates, infiltration rates, discharge rates, etc. This evaluation should also identify all structural water quality protection measures and include pollutant loading calculations to demonstrate compliance with the goals and objectives.
- A proposed transportation and utility plan for the development, including any water quality protection measures associated with this infrastructure (e.g. procedures for protection of stream crossings, etc.)
- An operations, maintenance, monitoring and funding plan identifying responsibilities for on-going operations, monitoring, maintenance and inspection.
- Evidence of suitable potable water supply.
- A listing of other water quality related permits and/or regulatory approvals required for the development.
- Evidence of coordination with the TCEQ and other applicable jurisdictions (e.g. groundwater conservation districts).

This information should be reviewed by the local jurisdiction during the final platting process and any corresponding deficiencies noted. As with other aspects of the platting process, if these deficiencies were not satisfactorily corrected, the final plat would be rejected.

10.5.2.3.Construction Plan Approval

In conjunction with the review of the final construction plans, the local jurisdiction should require that the developer submit a final site development plan. This final site development plan should address all of the items required in the development plan submitted with the final plat, along with any updates or modifications required. In addition to the final development plan, the developer should submit the following documentation:

- Evidence of construction site storm water permit coverage, including a copy of the Storm Water Pollution Prevention Plan (SW3P), copies of all Notices of Intent (NOIs) submitted for the site, and copies of any regulatory responses to the SW3P or NOI.
- Evidence of regulatory approval for the wastewater management strategy.
- Evidence of obtaining all water quality related permits and/or regulatory approvals required for the development.
- A final operations, maintenance, monitoring and funding plan for all water quality protection measures.

- Evidence of financial assurance for the operations and maintenance period identified in the funding plan.

During the development of this Plan, standardized checklists have been developed to assist in the coordination and implementation of the pre-development review throughout the Planning Region. Copies of these checklists have been included in Attachment 8.

10.5.3. Construction Inspection

An important element of successful water quality protection is inspections during construction. These inspections can ensure that the water quality protection measures are being implemented in accordance with their approved design. Each implementing jurisdiction should incorporate inspections into their development review process. This will provide an additional level of water quality protection.

10.5.4. Incorporating Water Quality Protection Measures into Public Projects

All jurisdictions should adopt the water quality protection measures outlined in the Plan for their own public projects. This should include new and expanded facilities as well as significant retrofit projects. In acquiring park land or open space/natural areas, water quality protection measures should be incorporated into the design of amenities and the acquisition of properties. Jurisdictions should consider the potential for leveraging public funds by partnering with conservation organizations, private landowners, developers, and other political subdivisions for land acquisition for park and open space/natural area properties as well as providing for public recreational opportunities. There are many instances where cooperative agreements have been reached not only for the acquisition and development of parks and open space/natural areas, but also agreements for management and operations and maintenance of the properties. This approach offers several advantages to all parties by broadening the pool of funds available, and can provide water quality protection and environmental preservation through the acquisition of additional open space/natural areas.

10.5.5. Requesting Delegation from TCEQ for Local Enforcement

Throughout this planning process, concern has been expressed by the stakeholders that the TCEQ does not have the resources necessary and does not adequately enforce many of its rules. Public entities within the Planning Region have a vested interest in assuring that the TCEQ rules are followed since the water quality protection measures required under these rules (both construction and post-construction) will directly impact the public entity when it is given title to the infrastructure. Local jurisdictions in the Planning Region should consider requesting delegation from TCEQ for local enforcement of several water quality related programs. Delegation of these authorities to local jurisdictions is already authorized under the Texas Water Code.[177] The following programs should be considered for delegation:

- Edwards Aquifer program

[177] Texas "Water Code", Title 2, Chapter 26, "Water Quality Control", §26.175, "Cooperative Agreements".

- TPDES construction site storm water permit program
- OSSF program

As a result of delegation, the public entity will have its own inspectors and engineers keeping track of construction progress and conformance with the design criteria that the public entity enforces. Local public entities delegated the authority from TCEQ for enforcement could provide much closer inspection and could respond more quickly if violations were noted and reduce the risk of potential water quality impacts. If this delegation is requested and approved it will significantly streamline the regulatory process and allow local control of decisions and implementation. Conversely, if the local governments do not perform, they are much more readily accountable to the local public than is a larger, state-wide agency. If the local government was not performing satisfactorily, the delegation could be revoked.

An important element in delegation is how the implementation of the delegated TCEQ rules would be financed. Public entities would need to ensure that development permit and/or review fees would cover the cost of inspections and enforcement in new development during construction and use other sources of funds as noted earlier for ongoing inspection and enforcement. Additionally, these fees could be used for on-going monitoring of the site to determine compliance. The cost of this delegation would be incremental and could be recovered by assessing a fee when a development plan is submitted for review.

10.5.6. Development Agreements

Where necessary to ensure compliance with certain measures, local jurisdictions may enter into development agreements to clearly define the responsibilities of the developer and the local jurisdiction for the installation, operation, maintenance, monitoring and funding of the water quality protection measures. While these types of agreement are not necessarily self-enforcing, they do establish specific responsibilities that can serve as the basis of enforcement using other means. Due to the differences between the types of items that can be covered in development agreements between municipalities, counties and other special purpose districts, the recommended details for these development agreements are discussed in more detail in the individual sections below.

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During the discussions on developer agreements within the stakeholder process, there was considerable concern that development agreements might be utilized by local jurisdictions to supersede or circumvent the water quality protection measures outlined in the Plan. As indicated previously, the success of the Plan is dependent upon the uniform implementation of the Plan. The use of development agreements to circumvent the intent of the Plan would be inconsistent with the intent to implement the Plan consistently throughout the Planning Region. For this reason, development agreements should be utilized as an optional means for certain local jurisdictions (e.g. counties) to encourage compliance with and not circumvent the water quality protection measures presented in the Plan.

10.5.7. Financial Assurance/Long-Term Funding

Local jurisdictions should adopt ordinances outlining the specific requirements for providing financial assurance in instances where the jurisdiction determines that it is necessary to satisfy operations, maintenance, and monitoring of water quality protection measures. This financial assurance should be sufficient to cover all anticipated future costs associated with the condition assured. The TCEQ has specific regulations regarding financial assurance[178] for many types of environmental controls, including water quality protection measures. The financial assurance mechanisms allowed under TCEQ regulations should provide equivalent financial assurance to local jurisdictions. In addition to these available financial assurance mechanisms, long-term funding for operations, maintenance and monitoring may be secured through the levying of taxes or through user fees. Specific long-term funding mechanisms for the differing types of local jurisdictions are presented below.

10.5.8. Cooperative Agreements with Other Political Subdivisions

Local jurisdictions that determine they are not in a position to perform a specific function for which they are currently authorized may enter into cooperative agreements with other political subdivisions. Cooperative agreements with other political subdivisions would provide a method of coordination in plat and construction plan review, subdivision regulations, drainage, flood control, water quality protection measures, monitoring, park and open space acquisition and development, and other related development issues. Given the diverse number and types of political subdivisions and utility providers that are involved in the Planning Region there is the potential for certain overlaps and gaps when water quality measures are involved. Complicating this situation is turnover at all levels in terms of elected officials and city/county/district professional staff that means loss of institutional knowledge as well as technical support. A coordinated effort between political subdivisions regarding development issues and how they affect water quality will help ensure a consistent approach to protecting water quality throughout the Planning Region.

Cooperative agreements provide the framework and process to address these issues and provide a forum so that the decisions of one unit of government do not adversely affect another political subdivision. This is an important step in facilitating continuity and consistency in planning, review of measures, and responsibility for implementation and operations and maintenance. This coordination should allow each participant to evaluate the impact of a particular land use issue on water quality within their jurisdictions. Additionally, the cost of monitoring, operations and maintenance and other water quality issues could potentially place a significant financial burden on smaller entities. As part of this strategy local political subdivisions should evaluate the potential of joining together to take advantage of economies of scale to reduce costs. One measure that could be considered is identifying one group or contracting out with a private vender to provide periodic inspections to facilities to assure that they are functioning properly for all or part of the group. Additionally, this type of arrangement could be used for coordination of mitigation banking in conjunction with the transferable development rights.

[178] Title 30, Texas Administrative Code (TAC), Chapter 37, "Financial Assurance". [30 TAC §37.1-§37.9085]

10.5.9. Public-Private Partnerships with Conservancy Groups

All jurisdictions should consider entering into public-private partnerships with conservancy groups to identify potential opportunities to acquire property by purchase or negotiated conservation easements for water quality protection and enhancement. Public entities are in a unique position to partner with conservation groups to leverage funding from multiple sources to acquire land and/or conservation easements. As an example, a public entity could apply for state and federal funds for this purpose and combine those resources with those from a non-profit conservancy group.

10.6. Implementation Mechanisms for Municipalities

10.6.1. Adoption of Water Quality Protection Measures

The water quality protection measures and land use restrictions (e.g. location restrictions, density restrictions, and other zoning related items) recommended in this plan should be incorporated into each municipality's local development ordinances. Municipalities can incorporate these measures under existing legal authority. This will implement these water quality protection measures for all new development. Other new improvements within existing developments (e.g. streets, drainage, flood control, parks or open space acquisition) performed by the municipality should incorporate the same water quality measures in the design and operations and maintenance water quality protection measures outlined in the development ordinances.

10.6.2. Development Agreements

Municipalities may enter into development agreements based on their adopted water quality protection ordinances which also identify specific financial assurance and funding mechanisms. The broad authority of municipalities often facilitates reaching development agreements between the municipality and the developer or special district. As part of this agreement it must be decided who will be responsible for the initial cost of implementing the water quality protection measures.

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10.6.3. Financial Assurance/Long-Term Funding

There are several possible mechanisms for municipalities to secure financial assurance and/or long-term funding for on-going operations, maintenance and monitoring for new development. The simplest mechanisms are paid-in trusts or cash accounts, fully funded by the developer or property owner, under the fiscal control of the local jurisdiction. These mechanisms are not in wide-spread current use and will likely not be preferred by developers and/or property owners due to the up-front cash requirements. Another mechanism is to establish a taxing entity to provide the long-term funding.

As noted earlier, municipalities generally have authority to regulate water quality protection measures within their municipal boundaries and ETJ. Municipalities also have significant authority in the formation of taxing entities (special districts) including MUDs, WCIDs and PIDs. Of the available mechanisms, the most advantageous to municipalities is the PID. The

formation of a PID creates a taxing authority associated with definable infrastructure, but does not physically create a separate regulatory entity, with the ability to own infrastructure. Conversely, MUDs and WCIDs are separate regulatory entities, with the ability to own and operate infrastructure. For municipalities, the use of PIDs for water quality protection measures provides a funding mechanism specific to the property benefited by the measures, but allows the municipality to collect the revenue to own, operate, maintain and monitor the improvements, without the creation of a new regulatory entity.

10.6.4. Operations, Maintenance and Monitoring

Another important issue for municipalities is performing the long-term operations, maintenance and monitoring of the water quality protection measures. In order to avert a potential conflict of interest, the entity responsible for inspection and monitoring should not be the same entity that is responsible for operations and maintenance. If a PID is utilized for long-term funding, the municipality should normally assume the responsibility for all aspects. However, the inspection and monitoring should be performed by another entity through a cooperative agreement. Municipalities could enter cooperative agreements with a special district (e.g. the LCRA), a county or another municipality to conduct the inspection and monitoring. If desired, the municipality could also enter a cooperative agreement for operations and maintenance, as long as it was not the same entity performing the monitoring.

If a MUD or WCID is utilized to provide long-term funding for the water quality protection measures, the municipality should normally assume the responsibility for inspection and monitoring. The MUD or WCID would then be responsible for operations and maintenance. Since the MUD or WCID would be collecting the tax revenue, a cooperative agreement would be necessary to fund the municipalities inspection and monitoring functions from the tax revenue generated by the improvements.

In general, it is not appropriate for the landowner or a Home Owners Association to be responsible for the long-term operation, maintenance or monitoring of water quality protection measures. While this approach may seem initially cost effective, it can quickly become a financial burden on the land owner or association, with judicial action as the only way to enforce performance. While third-party financial assurance mechanisms may help bridge this gap, the preferred method of funding these activities is through a taxing entity.

10.7. Implementation Mechanisms for Counties

Due to their differences in authority, the implementation mechanisms for counties are different from those of municipalities. The following strategies are not intended to be stand alone but as part of larger policy decisions made by the Commissioners Court in addressing development issues.

10.7.1. Adoption of Water Quality Protection Measures

The water quality protection measures and land use restrictions (e.g. location restrictions, intensity restrictions, and other zoning related items) recommended in this plan should be incorporated into each county's local development ordinances to the extent allowed under

current law. Counties may currently regulate the design and construction of roadways and drainage improvements in unincorporated areas of the county. This allows the county to enact a variety of regulations to reduce and control stormwater runoff which is generally recognized as a major source of non-point pollution. Within the context of regulating these activities the county can require water quality measures to be incorporated in the plans and specifications for the improvements and can require that they be included as part of the overall operations and maintenance of the roads and stormwater management system. This approach should be taken by counties in incorporating the water quality protection measures outlined into their existing storm water (drainage) and roadway management ordinances and rules. Additionally, a county may require that a developer provide a bond in order to ensure compliance with road and drainage regulations. A county also has authority to regulate on-site wastewater facilities as well as regulate minimum lot frontages on county roads and buildings and set back lines on public roads in unincorporated areas outside of a municipal boundary or ETJ. Counties also have the authority to own and operate parks and recreational facilities as well as public open space and nature areas. Using an integrated management approach as part of the regulatory requirements, it is possible to include water quality management parameters as part of the roadway and drainage improvements and to use park and open space areas as part of a water quality management strategy.

If counties desire the full implementation of the water quality protection measure recommended in the Plan, the option is available to establish another regulatory authority (e.g. a MUD or WCID) to implement these measures. On its own authority, the County Commissioners Court may establish either a MUD or a WCID in the unincorporated areas of the county outside the ETJ of any municipality. Establishing a MUD or WCID which covered any part of a municipality or its ETJ would require a cooperative agreement with that municipality. The MUD or WCID could then adopt the water quality protection measures outlined in this Plan.

10.7.2. Development Agreements

Counties may enter into development agreements based on their adopted water quality protection ordinances, with the purpose of identifying specific financial assurance and funding mechanisms. A contractual agreement would provide several benefits for each party including clearly defining the roles and responsibilities for: initial construction costs, operations and maintenance, compliance with rules and regulations, financial assurances that facilities will function as they were intended, and budgeting of long term operations and maintenance. A development agreement could also facilitate cooperation in identifying land and easements for parks, open space and conservation easement acquisition that could aid and/or enhance drainage, flood control and water quality protection measures.

Under current authority, the county could not incorporate into development agreements any restriction on the elements they are prohibited from regulating under SB 873,[179] including

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- The use of any building for a particular purpose (e.g. residential, business, or industrial).

[179] Texas Local Government Code, Title 7, Chapter 232, "Infrastructure Planning in Certain Urban Counties", §232.101(a).

- The bulk, height, or number of buildings constructed on a particular tract of land.
- The size of a building including the ratio of the square footage of the building's floor space to square footage of the land.
- The number of residential units per acre of land.

While these agreements do define responsibility for some aspects, they can not be used to directly regulate these items. The regulation of these items would be required through a cooperative agreement with another entity.

10.7.3. Financial Assurance/Long-Term Funding

There are several possible mechanisms for counties to secure financial assurance and/or long-term funding for on-going operations, maintenance and monitoring for new development. County tax revenues should not be used to accomplish these objectives because the costs are not county wide and affect only the Planning Region. As with municipalities, the simplest mechanisms are paid-in trusts or cash accounts, fully funded by the developer or property owner, under the fiscal control of the county. While a PID addresses the financial assurance and funding issues, it does not broaden the regulatory powers of the county. As outlined above, these mechanisms still do not give the county the ability to regulate certain prohibited items. However, counties can form MUDs or WCIDs.

MUDs and WCIDs are separate regulatory and taxing entities, with the ability to own and operate infrastructure. For counties, the use of MUDs or WCIDs for water quality protection measures provides a funding mechanism specific to the property benefited by the measures, but vests the responsibility for operations, maintenance and monitoring with a separate entity.

10.7.4. Operations, Maintenance and Monitoring

Another important issue for counties is performing the long-term operations, maintenance and monitoring of the water quality protection measures. In order to avert a potential conflict of interest, the entity responsible for inspection and monitoring should not be the same entity that is responsible for operations and maintenance. If a MUD or WCID is utilized for long-term funding, that entity should normally assume the responsibility for all aspects. However, the inspection and monitoring should be performed by another entity through a cooperative agreement. Counties could enter cooperative agreements with the MUD or WCID to conduct the inspection and monitoring, with appropriate funding provided by the MUD or WCID. As with municipalities, it is not appropriate for the landowner or a Home Owners Association to be responsible for the long-term operation, maintenance or monitoring of water quality protection measures.

10.8. Implementation Mechanisms for Special Purpose Districts/Authorities

As previously noted, special purpose districts will play an important role in implementing a regional water quality plan because of the authority they have been given by the Texas Legislature as well as their role as water and wastewater provider in the area.

10.8.1. Lower Colorado River Authority

The LCRA should consider and adopt water quality regulations within unincorporated areas of Travis County that are outside of a city ETJ.

- The LCRA has been granted the authority to develop water quality regulations within its original jurisdiction, which includes Travis County. In fact, the LCRA has had an ongoing water quality regulatory program for those areas generally surrounding Lake Travis. This program was developed and adopted by the LCRA Board of Directors in 1990 and updated in 2004. The ordinance requires a water quality permit and establishes performance standards. Additionally, a Non-Point Source Pollution Control Technical Manual has been developed which includes design standards as well as Best Management Practices that should be considered.
- Given the limited authority that counties have in water quality regulations, the LCRA is in a position to enforce water quality regulations in unincorporated areas of Travis County outside of a city's ETJ. For this authority to be extended to the portion of Hays County in the Colorado River basinm legislative action would be required.
- As a regional water supplier, the LCRA is in the unique position to be able to include water quality parameters as part of long term water supply contracts as well as where they provide retail water supplies. The LCRA has regulatory authority in unincorporated areas of Travis County outside of a city ETJ and should consider adopting and enforcing water quality regulations consistent with the regional plan in these areas.
- In Hays County, consider including provisions within wholesale and retail water service agreements that require compliance with water quality ordinances of the cities and counties and that there be a plan in place and a development agreement between the purchaser and appropriate city or county jurisdiction for the development and implementation of water quality measures.

10.8.1.1. Other Special Districts

- Work with local governments and other interests to determine opportunities where water quality protection can be enhanced and cost effective measures of monitoring and operations can provide water quality protection for the planning region.
- Work with wholesale customers such as MUD's and WCID's to reach development agreements with cities and to comply with and enforce water quality measures in a cost effective and efficient manner.
- Another alternative for the implementation of a regional water quality plan would be the establishment of a regional entity that would have the authority to implement a regional plan. While County Commissioners Courts and the TCEQ may establish a special purpose district for providing public services, a special purpose district focused on water quality issues would need to be established by the Texas Legislature. Several issues would have to be addressed including jurisdictional boundaries, authority to regulate within a city's ETJ, and how the regulations would be incorporated into the platting process by cities and counties. Administrative issues include how the district would be governed through an appointed board or an elected board, how the district would be

funded either through taxes, fees or a combination, and if a confirmation election by the voters in the proposed district would be required.

10.9. Natural Area Conservation and Transferable Development Rights

Natural area/open space conservation was previously identified as an important water quality protection measure. While the voluntary conservation of natural areas was recommended, several elements of the Plan provide for natural area conservation in exchange for flexibility in other areas. To implement this exchange, the implementation of transferable development rights (as presented previously) is essential.

There was extensive discussion with the Stakeholder Committee regarding the implementation of TDRs. While the concept of TDRs received consensus acceptance, there were also significant concerns expressed. Instituting TDR's in the Planning Region was often characterized as "coining a new currency". Because the use of TDRs is a relatively new and untested concept in Texas and in the Planning Region, there are many uncertainties about how they would be accepted, traded and enforced. These uncertainties and the potential for unintended consequences is discussed in more detail below. The process to implement both voluntary and mandatory natural area conservation, including the TDR concept, is presented below.

10.9.1. Voluntary Conservation

All entities and individuals inside and outside the Planning Region should be encouraged to voluntarily conserve natural areas/open space. As discussed previously, this water quality protection measure was consistently considered among the most important objectives of the Plan. There are many benefits to the public and the environment from the voluntary conservation of natural areas. However, if these areas are to provide these benefits in perpetuity, their conservation must be ensured by preventing their future development. It is strongly recommended that any individual or entity committed to the voluntary conservation of natural areas under this measure secure the future development rights for the property using the procedures outlined below.

10.9.2. Natural Area Conservation and the Effects of Prior Development

As presented in Stakeholder Guiding Principal No. 7, the issue of equity in the implementation of water quality protection measures was considered an important issue for the stakeholders. One recurring issue during stakeholder deliberations was the "fairness" of requiring significant water quality protection measures for new development while ignoring the adverse water quality impact of prior development with few or no water quality protection measures. In most instances, this existing development has occurred at intensities which significantly exceed the uniform intensities recommended in this Plan. The stakeholders determined that one way to address the equity issue was to recommend that local public jurisdictions secure conservation easements in an attempt to bring the "as-built" impervious cover in the Planning Region closer to the uniform development intensities presented in this Plan.

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As indicated in the discussion on the impacts of impervious cover (see Table 10), there are several watersheds within the Planning Region, where the estimated "as-built" development intensities exceed the uniform development intensities specified for future development. In being consistent with the equity principle, the stakeholders have recommended that natural area conservation be implemented in an amount sufficient to offset these excess intensities. While this will not necessarily address any current water quality impact issues within these watersheds, it will achieve a distribution of development intensity across the Planning Region that is closer to the intensities presented in this Plan as protective of water quality. Table 14, below, provides a quantification of the amount of natural area conservation necessary to achieve a net of ten percent (10%) impervious cover for these watersheds.

Table 14 – Amount of Natural Area Conservation Necessary to Achieve a Net 10% IC for Watersheds with an Estimated As-built IC exceeding 10%

Watershed	Area in PR (Ac)	Est. As-Built IC	Est. IC (Ac.)	Addn. Ac. for 10%
Bee Creek	1,920	15.37%	295	1,031
Little Bee Creek	640	20.05%	128	643
Eanes Creek	2,560	27.25%	698	4,416
Williamson Creek*	15,872	20.28%	3,219	16,316
Slaughter Creek*	16,401	11.65%	1,911	2,706
Total	37,392		6,250	25,112

Based on this evaluation, the plan recommends that a minimum of 20,000 acres of natural area conservation be implemented within the Planning Region to address the equity issues with prior development. To accomplish this objective, each of the local jurisdictions in the Planning Region would be responsible for assessing the intensity of existing development within its boundaries and determining the quantity of conservation easement required to reach this recommended quantity. Once this quantity is allocated among the jurisdictions, a process for identifying target tracts should be developed. This process should focus on maximizing the benefits obtained. One way to maximize the water quality benefit of these acquisitions is to secure tracts for which prior development approvals have been issued which allow construction to occur with fewer water quality protections than those specified in this Plan. Utilizing this strategy in effect purchases more water quality benefit that simply securing the development rights from undeveloped land which would otherwise be required to comply with this Plan. Once target tracts have been identified, a funding plan and acquisition schedule should be developed.

Funding for the acquisition and long-term care of these conservation easements could be provided by several different mechanisms. The specifics of the funding mechanisms would vary based on the type of entity, and have been previously presented. To qualify as conservation easement under the Plan, the local jurisdiction must secure the future development rights for the property using the procedures outlined below.

10.9.3. Conservation Easements Used to Secure Transferable Development Rights

The concept of using conservation easements to secure transferable development rights was previously discussed as a means to allow significant flexibility in the application of water quality protection measures in the Planning Region. Individuals or entities wishing to utilize this flexibility bear the responsibility for satisfying the requirements of the local public entity having jurisdiction over the developed tract and for securing sufficient transferable development rights to comply with the other sections of this Plan. In general, the amount of additional transferable development rights will be determined and verified by the local public entity during the development review process. If these rights are to be secured through conservation easements, the party responsible for the site to be developed must secure the identified quantity of conservation easement in compliance with the terms of this Plan and the requirements of the applicable local jurisdiction. Documentation that the restrictive mechanisms outlined below have been applied to the property from which the transferable development rights were obtained, must be provided before that property can be accepted by any of the local public jurisdictions implementing this Plan. The local public jurisdictions should ensure that this documentation is provided and that the other requirements of this program have been met before issuing the final development approval.

Since the use of transferable development rights to allow additional development intensity will generally be directed by private for-profit interests, sufficient safeguards must be incorporated into the process to protect the public interest. These safeguards must include transfer of undivided ownership interest and control, free of liens and encumbrances, to a governmental or non-profit entity acceptable to the local public jurisdiction accepting the conservation easement as part of the transfer. These conservation easements must also comply with the procedures for assuring conservation, as outlined below.

10.9.4. Procedures for Assuring Conservation

There are several different aspects to the process for ensuring that future development of designated natural area/open space conservation easements is prohibited. While the specific aspects may vary from property to property, each aspect should be investigated and appropriate restrictive mechanisms put in place before establishing an area as a conservation easement. Specific restrictions or requirements for these mechanisms have been presented in the preceding sections.

10.9.4.1. Ownership

The most important aspect of long-term conservation is controlling ownership interests. In Texas, current law allows surface ownership interests to be separated from sub-surface mineral ownership interests. In some instances, property whose ownership has been tightly controlled (e.g. generally family transfers only) may have common ownership of surface and sub-surface interests. However, in many instances, the surface interests and sub-surface interests have previously been severed and are under separate ownership. To ensure long-

term preservation of property, control of both surface and sub-surface ownership interests is imperative.

The most straightforward mechanism for securing ownership interests of conservation easements is through direct purchase or donation, with title transfer to a conservator using appropriate legal instruments (e.g. warranty deeds, quit-claim deeds, etc). Sole ownership is the preferred mechanism for conservation easements used to secure transferable development rights under the Plan. An alternative mechanism of securing a controlling ownership interest is by purchase or donation of a majority undivided interest. However, this encumbers the majority ownership with the interests of the minority ownership. Regardless of the mechanism used, the control of ownership interests is critical to long term conservation.

In instances where a conservation easement is being secured by a governmental entity, the property will benefit from the public interest protection inherent in the operation of the governmental entity. The property secured as a conservation easement will also receive all the protections of public property. Cooperative ventures to secure conservation easements often have significant merit. Ventures between multiple governmental entities should be pursued where possible to maximize public benefit and minimize costs. Non-profit organizations can also provide good partnering opportunities to governmental entities for conservation purposes, if appropriate safeguards are incorporated. An appropriate safeguard from the aspect of ownership is to ensure that the ownership interest and control of the conservation easement reverts to a public entity if the non-profit entity becomes insolvent or incapacitated. Cooperative ventures with for-profit entities are often problematic due to competing interests, and should generally be avoided. If utilized, cooperative ventures with for-profit entities must incorporate strict safeguards to protect public interests.

10.9.4.2.Legal Mechanisms to Prohibit Future Development

Instituting legal mechanisms to prohibit future development is another important aspect of assuring the protection of conservation easements. There are several different mechanisms available to prohibit future development. For conservation easements located within the jurisdiction of public entities having zoning authority, zoning restrictions are an effective legal mechanism for prohibiting future development. A zoning designation should be selected which allows little to no development of the property. Any future attempts to develop the property would encounter administrative safeguards through the zoning process. Another legal mechanism to control future development is through the granting and filing of a dedicated easement to the public. While this mechanism does not directly prohibit future development, it would serve as a recurring reminder of the public easement during any future title research on the property. Another available legal mechanism is the incorporation of restrictive covenants into the deed records. Since these covenants are contained within the text of the deeds, they are sometimes not as readily visible in the public record as are zoning restrictions and easements to the public. Legal mechanisms to restrict future development should generally be utilized to supplement and not substitute for the control of ownership.

10.9.4.3.Physical Barriers

Another aspect of assuring preservation of property is incorporating physical barriers to future development. Physical barriers include fencing, signage and other types of physical notification that the property is protected and restricted. These mechanisms are limited in their ability to prevent future development and they require long-term maintenance and upkeep. Physical barriers can only supplement and can not substitute for either the control of ownership or the use of legal mechanisms.

10.9.4.4.Long-term Custodial Management

Another aspect of assuring the long term protection of conservation easements is by the appointment of a conservator responsible for long-term custodial management of the property. Since little or no development will be allowed in preserves, the maintenance of physical systems will be minimal. However, to ensure their proper function, conservation easements should be subjected to active management in accordance with the water quality protection measures presented in the Plan for undeveloped land. This active management will include controlling human activity on the property, vegetative management, protection of the property from exterior physical threats (e.g. vandalism, fire, impacts from adjacent development, etc.), and on-going evaluation to ensure that the preserve is meeting its objectives. To accomplish this on-going active management, a conservator will be required. This conservator must be under the direct control of the entity with controlling ownership interests in the conservation easement, and should possess the necessary resources to effectively perform the on-going active management. If the entity with controlling ownership interests delegates the role of conservator to another party, sufficient safeguards (e.g. minimum qualifications, financial assurance, insurance, etc.) should be required to ensure that the conservator performs the management properly.

10.9.4.5.Long-term Funding

Long-term funding is another key aspect to assuring conservation. An assured source of long-term funding will allow the conservation easement to be properly managed and protected. The entity establishing or owning the controlling interest in the preserve is responsible for establishing this long-term funding source and ensuring that it is sufficient for reasonably anticipated future expenditures. If the establishing entity arranges with another entity to provide long-term funding, the establishing entity is required to demonstrate the long-term financial stability to ensure the long-term custodial care of the property.

10.9.5. Transferable Development Rights Secured by Retrofitting Prior Development

The concept of securing transferable development rights by retrofitting prior development was discussed during the stakeholder process as a means to allow significant flexibility in the application of water quality protection measures in the Planning Region. However, as discussed previously, there was some concern about how to quantify the capabilities of various structural water quality protection measures. Some quantification of these capabilities would be necessary

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to determine the corresponding amount of TDRs that could be obtained by retrofitting prior development with these measures. In instances where there is a net reduction in impervious cover obtained through the retrofitting process, this can provide some tangible quantification of water quality benefit. As a result of the stakeholder discussions, the recommended strategy for securing TDRs through retrofitting was to allow credits only for net reductions in impervious cover. In practice, the net quantity of impervious cover removed could be transferred to a new development utilizing TDRs. The adaptive management process recommended for implementation of the Plan, should evaluate case studies of retrofit projects to quantify any future TDR credits that may be obtained, if it is deemed appropriate.

Individuals or entities wishing to utilize this flexibility bear the responsibility for satisfying the requirements of the local public entity having jurisdiction over the developed tract and for securing sufficient transferable development rights to comply with the other sections of this Plan. The party responsible for the site to be developed must perform the retrofit in compliance with the terms of this Plan and the requirements of all applicable local jurisdictions. The retrofit must comply with the same design standards used in conjunction with the water quality protection measures presented in this Plan.

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If the retrofit is to be performed by the party performing the development, it must be completed prior to the local jurisdiction issuing the final development approval. If the local jurisdiction has a program in place to evaluate the adequacy of financial assurance, a local jurisdiction may accept an appropriate, irrevocable financial assurance mechanism[180] posted by the responsible party in lieu of the retrofit being performed prior to final development authorization. Local jurisdictions may also establish a retrofit program which allows developers to make a cash payment in lieu of the required retrofit.

10.9.6. Uncertainties and the Fear of Unintended Consequences

As with any new venture, even a thorough evaluation of the concepts and strategies may not always identify and avoid uncertainty and unintended consequences. It is absolutely imperative that the institution of the concept of TDRs be evaluated by each entity and be an evaluation factor during the adaptive management process. The outcome intended for TDRs in this Plan is to bring equity to the development process and prevent early projects from exceeding protective intensities at the expense of later development that would have to be further restricted beyond protective levels. Given this understanding of the purpose and intended outcome of the use of TDR's, the following restrictions should be incorporated into the implementation process:

- TDRs are a voluntary component intended to create a market for flexibility in development intensity and can not be secured through the used of eminent domain or the right of condemnation. Entities with the right of eminent domain should be encouraged to use TDRs, where appropriate or desirable, but must secure them through an open market and not through the use of eminent domain.

[180] See the discussion on financial assurance mechanisms in the Implementation Section for local jurisdictions.

- TDRs are not intended to have an independent or inherent taxable value. In accordance with established Texas law and tax policy, the tax status, including any exemptions, for all property should be based on the use of that property and not on the status of the TDRs.

10.10. Compliance with the EPA's Phase II Municipal Storm Water Regulations

The EPA's Phase II Municipal Storm Water Regulations are part of the EPA's NPDES program, as presented in the section on existing regulatory programs. In Texas, this program is being implemented by the TCEQ. As discussed previously, these regulations apply to all municipal separate storm sewer systems (MS4s) owned or operated by governmental entities within designated urbanized areas. The water quality protection measures addressed in the Plan have been developed to be consistent with the EPA's Phase II Municipal Storm Water Regulations for urbanized areas. While there are additional requirements of this program that are not incorporated into this Plan, the adoption of the water quality protection measures included in the Plan will satisfy a good portion of the Minimum Control Measures required under that program. These measures can result in significant reductions in non-point source pollution, as required under that program.

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10.11. On-going Monitoring Program

Most of the water quality protection measures included in the Plan have been based to varying degrees on monitoring data. As outlined in the strategies for achieving Objectives No. 7, the ability to monitor and assess performance of these measures is essential to the success of the Plan. The primary mechanism for assessing the effectiveness of the plan will be an on-going monitoring program. This monitoring program should correspond to the historical monitoring database so that it can be compared to the historical data. This comparison will serve as the basis for assessing the effectiveness of the water quality protection measures implemented.

This on-going monitoring program should be a cooperative venture between the local jurisdictions involved. Cooperative efforts with entities that are currently performing monitoring should be pursued.

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10.12. Public Education

A comprehensive and coordinated public education program should be included as a part of implementing these measures. While each entity involved has the responsibility to conduct public education as a part of its implementation activities, significant opportunities for cooperation with other entities exist. Cooperative ventures can be more effective through combined effort and can reduce overall costs. Due to the of the public education efforts outlined in the proposed measures, a coordinated regional public education program should be adopted by all jurisdictions in the Planning Region. This coordinated effort could be accomplished by identifying one coordinating entity that executed the public education efforts through cooperative agreement with the public entities. Entities with a larger geographic focus (e.g. authorities, groundwater conservation districts, etc.) would be the logical choices for fulfilling this responsibility of the plan.

10.13. Alternative Implementation Mechanisms

There are several alternatives to the implementation mechanisms presented above. In some instances, these alternative mechanisms can supplement the current recommendations, while in other instances they would replace them entirely. Three alternatives are presented and discussed.

10.13.1. Creation of a New Regulatory Entity to Implement the Plan

This alternative would involve the creation of one legal entity to be responsible for the implementation of the Plan. During the identification of issues by the stakeholders, the concept of a single regional entity to implement the Plan was consistently popular and considered important by many stakeholders. Such an entity would have several distinct advantages, including consistency of implementation across the entire Planning Region, eliminating replicated administration and overhead, and the economies of scale typically associated with larger entities. However, this type of new entity would also have several disadvantages. The principal disadvantages would be the extended time frame required to start up this type of entity, the requirement for multiple political jurisdictions to agree on its establishment and how to integrate the water quality criteria into the platting and subdivision regulations of local political subdivisions as well as design criteria for drainage and flood control. Other issues that would need to be addressed include identifying who would be responsible for enforcement, ongoing operations and maintenance of the water quality measures that are implemented, and for future capital improvements associated with the improvements. Due to the legal authority required for such an entity, it could only be created by the Texas Legislature. This requirement places the establishment of a new entity beyond the direct control of the existing local jurisdictions within the Planning Region.

As a part of its establishment, this entity would require the legal authority to regulate all aspects of water quality protection within the Planning Region. The Legislature has at its disposal multiple legal mechanisms to establish an entity with the necessary powers, including a conservation and reclamation district or a water control and improvement district. There are also several important inter-jurisdictional issues that would have to be resolved. The first of these issues would be how the powers of the new entity relate to the TCEQ; specifically how the TCEQ's existing powers would impact the new entity, and how the new entity's powers would impact the TCEQ. A second issue would be how the powers of this new entity interacted with the existing powers of other governmental entities, including municipalities and counties. A third issue would be how the powers of this new entity interacted with other special purpose districts that have already been established in the Planning Region.

In most cases when the legislature establishes a special purpose district a confirmation election is held to validate the establishment of the district. If the confirmation election were to fail, there is a potential that the legislature would have to take up the enabling legislation again during the next legislative session. A related issue is how the governing body of the new entity would be selected. Options include having a general election of governing members from within the boundaries of the entity at large or forming single member districts. Another option is to have

the governing board for the new entity selected by the governing bodies of political subdivisions that have platting and subdivision control within the boundaries of the new entity.

In addition to the inter-jurisdictional issues, the issue of funding would need to be addressed. Since the implementation of water quality protection does not typically result in the transfer of a commodity, (e.g. the sale of water or electricity) funding this type of entity through service fees is more difficult to implement. For this new entity to be funding using service fees, a utility system would have to be established. While this is one funding possibility, the lack of the ability to couple this service to another essential commodity (e.g. water or electricity) leaves significant doubts about the financial feasibility of the service fee approach. Given the role and function of a new entity to implement this plan, the preferred funding mechanism is through ad valorem taxes. However, a significant impediment to the collection of ad valorem tax revenue is the necessity for voter approval prior to instituting the tax. Even if an entity is established and empowered, it cannot begin implementation until it has secured a long term funding source. The establishment and funding of a new regional taxing authority can be expected to take several years.

The issues outlined above could be significant impediments to the establishment and operation of a single new regional entity to implement the plan. There are many complex issues that must be resolved, requiring political consensus and initiative. It is anticipated that several years will be required to establish a new entity. Additional time (likely several additional years) will be required for the entity to have secured funding, obtain resources, and set up infrastructure to implement the Plan. Due to the complexity of the issues involved and the extended time required for actual implementation, this alternative should be considered a possible long-term goal.

10.13.2. Expanding the Authority of An Existing Entity to Implement the Plan

This alternative would involve expanding the authority of an existing entity and assigning that entity the responsibility for implementation of the Plan. As identified in the previous alternative, the concept of a single regional entity to implement the Plan was consistently popular and considered important by many stakeholders. There are several existing entities whose current boundaries, powers and authority could be expanded to allow implementation of the Plan, including the EAA, the LCRA, the GBRA, the BSEACD and the HTGCD. This expanded, single entity would have most of the same advantages and disadvantages of a new entity. Due to the nature of the changes required to expand the authority of any of these entities, the change would have to be instituted by the Texas Legislature, again removing the process from the direct control of the existing local jurisdictions within the Planning Region. This expanded entity would also require the legal authority to regulate all aspects of water quality protection within the Planning Region.

The funding mechanisms available to these potential entities are currently limited to the assessment of fees. None of the entities has taxing authority. The EAA, BSEACD, or HTGCD do not own or operate a utility system and are limited to raising funds through permit and

operation fees. Neither the GBRA nor LCRA has taxing authority and must rely on revenues generated through the sale of electricity, water and wastewater service. The LCRA currently is providing surface water to areas outside the city limits of Austin. Given the limited availability of groundwater in the planning area it is anticipated that surface water will be used instead of groundwater for new development and growth within existing developments. The LCRA has also been actively involved in regulating water quality in the Lake Travis watershed since 1990 and has developed the Lake Travis Nonpoint-Source Pollution Control Ordinance and a Nonpoint-Source Pollution Control Technical Manual. As part of this ordinance the LCRA has established a permit procedure, fees for inspection during construction, enforcement actions, and financial security for implementing water quality measures in the event that a developer would not be able to perform in accordance with the permit. As a policy measure, the LCRA Board of Directors has determined that the Highland Lakes are the first priority in establishing programs for the control and prevention of nonpoint-source water pollution. As part of their ordinance the LCRA encourages municipalities within the Planning Region that do not have a water quality ordinance at least as strict as the LCRA ordinance, to enter into an interlocal agreement or MOU with the LCRA stating that they will adopt and administer the LCRA ordinance within their jurisdiction for new development. Currently the LCRA has the authority to implement water quality measures in Travis County but not in Hays County. If the LCRA were to become the regional water quality entity the legislature would have to expand its authority into the Hays County portion of the planning area. Since the LCRA is providing water service to much of the undeveloped portion of the planning region a potential source of revenue would be to add a water quality component to the wholesale water rate to cover these costs.

The process for accomplishing this expansion would require resolving the same inter-jurisdictional and funding issues as establishing a new entity. However, it would also involve the selection of one existing entity over the other potential agencies. This process would require significant political consensus and would correspondingly have several potential political pitfalls. While the expansion of an existing entity could likely be completed more quickly than creation of a new entity, it is likely that several years would still be needed for full implementation. Due to the complexity of the issues involved and the extended time required, this alternative should also be considered a possible long-term goal.

10.14. Adaptive Management

Adaptive management is a process allowing for periodic evaluation and adjustment of programs. The concept of adaptive management will be applied to assessing the effectiveness of the water quality protection measures implemented, determining their effectiveness, and recommending and implementing solutions for measures determined to be ineffective. The adaptive management process should include all aspects of the plan in all jurisdictions. To do this, a standing committee should be maintained to oversee the adaptive management process. This committee should be a public process and should include representatives of the entities responsible for implementing the plan, the entities responsible for enforcing the plan, and representation from members of the public. A process similar to the current stakeholder involvement process, and possibly continuing the existing Stakeholder Committee, would fulfill these conditions.

The committee overseeing the adaptive management process should perform an annual evaluation to assess the effectiveness of the Plan. The adaptive management process recommended for the Plan has several different elements.

10.14.1. Review and Evaluation of Monitoring Data

As outlined in the Goals and Objectives, the purpose of this plan is to provide water quality protection. The effectiveness of these measures will be reflected in the data collected as a part of the on-going monitoring. The committee reviewing this monitoring data should be assisted by technically competent individuals. This review and evaluation of the monitoring data should be summarized in a written report.

10.14.2. Review of the Implementation Process

In addition to the technical review of the monitoring data, the committee should also review the performance and function of the implementation system. This review should include all elements of the implementation process including the legal status of water quality protection measures, the development review process, actual case studies of selected development projects, implementation funding, and enforcement activities. The results of this review should be presented in a written report.

10.14.3. Development of Recommendations

Based on the technical evaluation of the monitoring data and the performance review of the implementation measures, the committee should develop recommendations for any necessary response actions and modifications needed to the implementation system. These recommendations should include an implementation strategy, identification of funding sources for implementation, and an economic evaluation of the recommendations. These recommendations should be summarized and presented in a written report.

10.14.4. Implementation by Local Jurisdictions

At the conclusion of the evaluation process, the committee should deliver the written report containing the evaluation and recommendations, to the local jurisdictions. The jurisdictions implementing the Plan will be responsible for implementing the recommendations developed by the committee.

10.15. Implementation Obstacles

10.15.1. Incorporating Water Quality Controls in Existing Development

One of the issues raised during the stakeholder process has been the need to incorporate water quality controls in existing development. However, there are many complicating factors which make identifying workable solutions for this issue difficult. The EPA has evaluated this issue

and acknowledged the difficulty of retrofitting existing development with water quality protection measures:[181]

> ***In highly urbanized and densely populated cities, little opportunity exists for retrofitting storm drainage systems with BMPs to provide water quantity control due to flooding considerations. The large area of impervious surfaces in heavily urbanized areas produce large quantities of runoff. Rapid conveyance by the storm drain system is frequently the only option that exists in order to prevent flooding of yards, streets and basements. In these areas, the most appropriate BMPs are those that limit the generation of pollutants or remove pollutants from the urban landscape.***

In contrast to the recognized authority of a municipality to regulate water quality through its land development authority in it's ETJ for proposed new development, it would be problematic for a municipality to attempt to impose water quality controls on existing development. For example, any attempt by a city to require existing ETJ development to comply with a new set-back requirement would undoubtedly be challenged as an unconstitutional taking of property, especially if complying with the ordinance meant having to tear down or re-construct existing development. Supreme Court Justice Craig Enoch alluded to this legal issue of a city's regulation of ETJ development in his concurring opinion in the *Quick* case. Justice Enoch expressed concern that a city exercising land use control authority in its ETJ disenfranchises a class of citizens because the residents of the ETJ are subjected to regulations yet have no right to vote in city council elections or otherwise participate in the city's electoral process. An attempt to impose new water quality controls on existing development would probably implicate the sort of constitutional concerns described by Justice Enoch in the *Quick* case. A detailed discussion on the takings issues is provided in a subsequent section.

10.15.2. Enforcing Impervious Cover Limits in Unincorporated Areas of a County

Another obstacle to implementation is the enforcement of impervious cover limits in unincorporated areas of a county. As discussed in the Implementation Mechanisms outlined above, there are several alternatives for implementing these measures. The recommended procedure is for the county to establish a MUD or WCID to enforce these provisions.

10.16. Water Quality Protection Measures as Regulatory "Takings"

In any consideration of water quality protection measures to be adopted by local governmental entities, it is necessary to consider whether or to what extent such measures may be vulnerable to legal challenges on the grounds that they may constitute a prohibited "regulatory taking." A regulatory taking is a governmental action which regulates a private property interest to such a degree that it violates the Constitutional prohibition on the taking of private property without just

[181] "Preliminary Data Summary of Urban Storm Water Best Management Practices", Publication No. 821-R-99-012, U.S. Environmental Protection Agency, August, 1999.

compensation.[182] One form of a taking is a physical taking where a governmental entity physically takes or occupies private property (e.g., a city condemning an easement to expand a roadway across private property).

A more difficult-to-define form of taking is a regulatory taking which is a governmental regulatory requirement which has the effect of reducing the economic usefulness and value of private property to such an extent that it constitutes a taking of private property. Water quality protection measures such as the impervious cover and setback requirements of this Plan are good examples of potential regulatory takings. Another example of a potential regulatory taking is where a governmental entity imposes a dedication requirement or "exaction" on a landowner as a condition for granting a governmental approval (e.g., a county conditioning its approval of a subdivision plat on the dedication by the developer of right-of-way for road expansion or lands for public parks).

10.16.1. General Principles in the Law of Regulatory Takings

The U.S. Supreme Court and the Texas Supreme Court have struggled to formulate a standard for determining when a governmental regulation of private property goes so far as to become a taking. At present the U.S. Supreme Court and Texas Supreme Court have adopted the following basic legal principles concerning the law of regulatory takings:

- Possible remedies for a regulatory taking are to invalidate the offending regulation or to make the governmental entity liable for monetary damages.[183]
- In defending a challenge to a regulation, the governmental entity must show that the regulation actually substantially advances a legitimate state interest.[184] A legitimate state interest has been liberally interpreted to include even such things as protecting residents from the "ill effects of urbanization" and the preservation of desirable aesthetic features.[185]
- A compensable regulatory taking occurs when a land use regulation either (1) denies the landowner all economically viable uses of the property, or (2) unreasonably interferes with the owner's right to use and enjoy his property.[186] The Texas Supreme Court has held that a land use regulation denies a landowner all economically viable uses of the property if the regulation renders the property valueless.[187]
- In determining whether a governmental regulation unreasonably interferes with an owner's right to use and enjoy his property, a court must evaluate two factors: (1) the economic impact of the regulation (i.e., comparing the value that has been taken from the property with the value that remains), and (2) the extent to which the regulation interferes with "distinct

[182] The 5th Amendment of the U.S. Constitution states that "private property [shall not] be taken for public use without just compensation." Similarly, Article I, Section 17 of the Texas Constitution provides that no "person's property shall be taken, damaged, or destroyed for or applied to public use without adequate compensation being made…."
[183] *First English Evangelical Lutheran Church v. County of Los Angeles*, 482 U.S. 304 (1987).
[184] *Nollan v. California Coastal Commission*, 483 U.S. 825 (1987).
[185] *Agins v. City of Tuburon*, 447 U.S. 255 (1980); *Penn Central Trans. Co. v. City of New York*, 438 U.S. 104 (1978).
[186] *Lucas v. South Carolina Coastal Council*, 505 U.S. 1003 (1992). In this case, the landowner was prohibited from using any part of his beachfront property for the construction of any structure and this was held to constitute a regulatory taking because of the extreme deprivation of the uses to which the property could be put.
[187] *Mayhew v. Town of Sunnyvale*, 964 S.W.2d 922, 935 (Tex. 1998).

investment backed expectations" of the landowner.[188] A regulation that interferes with existing or already-permitted land uses is more likely to be considered a regulatory taking than a regulation which interferes with speculative uses or the landowner's asserted entitlement to the highest and most valuable use of every piece of his property.

- In the case of governmental exactions, the required dedication for public use or of public facilities must be roughly proportional to the actual need for those public facilities which is generated by the proposed development.[189] For example, the amount of roadway required to be dedicated by the developer must be reasonably commensurate to the amount of traffic generated by the new development.

10.16.2. The Texas Real Property Rights Preservation Act

In response to widespread concerns about governmental intrusions on private real property rights in the mid-1990's (sometimes referred to as the "Take Back Texas" movement), the Legislature enacted the Texas Real Property Rights Preservation Act which is codified in Chapter 2007 of the Texas Government Code. The overriding purpose of the Act was to ensure that governmental entities in Texas take a "hard look" at the effects on private real property rights of the regulations they adopt.

10.16.2.1. Lawsuit to Invalidate a Governmental Taking.

The Act allows landowners whose property is significantly impaired by governmental regulations to sue the governmental entity to invalidate the regulation.[190] As an alternative to invalidation of the governmental action, the governmental entity may elect to pay the landowner compensation for the loss in value of the property interest.[191] The Act is generally applicable to any governmental action (e.g., adoption of an ordinance, regulatory requirement or policy, or a governmental exaction) that restricts or limits the landowner's rights in the real property and that causes a reduction of 25% or more in the market value of the property. Any lawsuit by an affected real property owner against the governmental entity must be filed within 180 days after the owner knew or should have known of the governmental action.[192] The prevailing party in the lawsuit against the governmental entity is entitled to recover reasonable and necessary attorneys fees and court costs from the losing party.[193]

10.16.2.2. Governmental Actions Exempted From the Act.

The Act does not apply to an annexation of land by a city nor to a city's regulation of its ETJ if the same regulation applies to all other areas within the city. Other governmental actions exempted from coverage under the Act include (1) actions reasonably taken to fulfill an obligation mandated by federal or state law; (2) regulation of public or private nuisances; (3)

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188 *Mayhew v. Town of Sunnyvale*, 964 S.W.2d 922, 936 (Tex. 1998).
189 *Dolan v. City of Tigard*, 512 U.S. 374 (1994).
190 §§ 2007.021 - 2007.023 Tx. Gov't Code.
191 § 2007.024 Tx. Gov't Code.
192 § 2007.021(b) Tx. Gov't Code.
193 § 2007.026 Tx. Gov't Code.

governmental actions necessary to prevent a grave and immediate threat to life or property; (4) exercise of the power of eminent domain; (5) regulation of construction in a floodplain; (6) regulation of onsite sewage facilities; (7) regulations to prevent waste of groundwater or to protect groundwater rights holders; (8) actions taken in response to a real and substantial threat to public health and safety; and (9) actions designed to significantly advance public health and safety.

10.16.2.3. Requirement to Prepare Takings Impact Assessment

In addition to the risk of a lawsuit to invalidate a taking by a governmental entity, all governmental entities in Texas are required to prepare an evaluation (called a "takings impact assessment") of any proposed regulation that may impair private real property interests and to provide public notice of the takings impact assessment.[194] If a governmental entity fails to prepare a required takings impact assessment, an affected real property owner may bring suit to invalidate the governmental action and recover attorneys fees and court costs.[195]

10.16.3. Conclusion: Reasonable Water Quality Protection Measures Do Not Constitute a Regulatory Taking

It appears that reasonable water quality protection measures, such as impervious cover limits and setback requirements from critical environmental features, are not of such an extreme character as would constitute a regulatory taking. First, the goal of protecting water quality would clearly appear to qualify as a legitimate state interest since prior U.S. Supreme Court rulings have held that governmental regulations addressing the "ill effects of urbanization" and the preservation of desirable aesthetic features are legitimate state interests.[196] It has also been expressly held by the Supreme Court that governmental restrictions on the use of only limited portions of a parcel of land such as setback ordinances are not considered regulatory takings.[197]

Moreover, in the latest U.S. Supreme Court case on regulatory takings, the Court was faced with the question of whether a temporary moratorium on all development around Lake Tahoe constituted a regulatory taking *per se*. The Supreme Court held that such a moratorium did not constitute a *per se* taking and that various factors must be analyzed to determine whether a moratorium constitutes a taking. In so ruling, the Court referred to a set of Lake Tahoe water quality protection ordinances enacted in 1972 which restricted impervious cover and established setback limits. These measures preceded the establishment of the development moratorium at issue in the case. Since the moratorium was held not to be a *per se* regulatory taking, **it is very doubtful that traditional water quality protection measures such as impervious cover limits and set back requirements would be considered a regulatory taking if crafted to accomplish the purpose of water quality protection while still allowing the landowner to reasonably use and enjoy his property**.

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[194] §§ 2007.041 - 2007.045 Tx. Gov't Code.
[195] § 2007.044 Tx. Gov't Code.
[196] See Footnote 4.
[197] *Gorieb v. Fox*, 274 U.S. 603 (1927).

This conclusion is consistent with the guidelines adopted by the Texas Attorney General's Office. The Attorney General publishes these guidelines to help local governmental entities meet their responsibilities under the Texas Private Real Property Rights Preservation Act. The Attorney General's guidelines provide as follows:

> ***"Accordingly, government may abate public nuisances, terminate illegal activity, and establish building codes, safety standards, or sanitary requirements generally without creating a compensatory 'taking.' Government may also limit the use of real property through land use planning, zoning ordinances, setback requirements, and environmental regulations."***[198]

These guidelines further indicate that traditional water quality protection measures may qualify for the exemption from the Texas Private Real Property Rights Preservation Act as regulatory actions which protect public health and safety.[199] Based on the concepts outlined above, the imposition of reasonable water quality protection measures is consistent with Stakeholder Guiding Principals Nos. 2 and 3.

10.16.4. Limitations

While this analysis does represent a general presentation of the status of current law, it is not intended to provide specific legal advice for any particular jurisdiction or entity. It is the responsibility of each jurisdiction within the planning region to obtain specific legal advice on proposed actions and to conduct a thorough takings impact assessment prior to adopting regulatory measures and/or rules as prescribed by Texas state law.

10.17. Obligation of Development to Avoid Offsite Impacts

While the imposition of reasonable water quality protection measures does not constitute a public regulatory taking of private property, it is also the obligation of development to prevent or mitigate offsite impacts resulting from that development, to prevent a private taking of public or other private property. This concept is also consistent with Stakeholder Guiding Principals Nos. 2 and 3.

10.18. Implementation Mechanisms

As outlined in the preceding sections, the implementation of the Plan will require that each jurisdiction adopt new or amend existing ordinances and rules. To aid in implementation, model ordinances have been developed. One set of model ordinances has been developed for a municipality, with another set developed for counties. Copies of these model ordinances have been included in Attachment 9.

[198] See § 1.32 of the Attorney General's Private Real Property Rights Preservation Act Guidelines.
[199] See § 1.33 of the Attorney General's Private Real Property Rights Preservation Act Guidelines.

11. IMPLICATIONS

There are many implications of the implementation of the water quality protection measures presented in this Plan. These include social, political, economic and environmental impacts. While it is not possible to provide a detailed quantitative evaluation of each potential impact, the following sections address attempt to address the major issues from a qualitative perspective, supplemented with quantitative information where available.

11.1. Economic Impacts

There are numerous potential economic impacts associated with the water quality protection measures included in the Plan. Some of them will require fundamental changes in the way certain activities are conducted, resulting in addition costs. Others will require new expenditures for which no source currently exists. Still others will impose limits of on activities that some perceive to be a restriction of rights. However, the economic impacts of the water quality protection measures must be gauged against the value of the resources they are designed to protect.

11.1.1. The "No Action" Alternative

The potential adverse economic impacts of the "No Action" alternative are staggering. As recognized in Stakeholder Guiding Principal No. 1, this "no action" alternative is unacceptable. The threats to water quality and environmental resources in the Planning Region have already been established. In addition, the value of the unique, "one of a kind" resources to both public and private interests is also unquestioned. The groundwater and surface water resources within the Planning Region are irreplaceable. Should these resources be damaged, impaired or destroyed, the economic damages would be incalculable.

11.1.2. Economic Impacts of the Proposed Water Quality Protection Measures

The economic impacts of the proposed water quality protection measures will vary significantly depending on their location and the nature of the activities requiring the incorporation of protective measures. Another factor affecting the economic impact is identifying the true basis for assessing the incremental cost of the new proposal. The following discussion focuses on several key areas of economic impact.

11.1.2.1. Land Value/Costs

It is difficult to assess the direct impact of the proposed water quality protection measures on land values and/or costs in the Planning Region. This is particularly true of the concept of value. Land in the Planning Region not only derives its value from development potential, but also for recreational potential and its inherent aesthetic attributes. In accordance with the Stakeholder Guiding Principles, it is important to protect these recreational and aesthetic values from losses resulting from the degradation of water quality.

No specific studies assessing the impacts of the proposed measures have been performed. In addition, there is very little scientific data available assessing the economic impact on land values of the types of water quality protection measures proposed. However, some basic correlations between before and after land values can be assessed. Based on information obtained from the stakeholders in the process, land values/costs in the Planning Region run from approximately $5,000 to $20,000 per acre. Assuming similar "salable tract" sizes, before and after the implementation of the proposed measures, a basic correlation between the cost of undeveloped land and the final cost of the developed land can be established. For illustration purposes, it will be assumed that current development is represented by approximately twenty percent (20%) impervious cover. Using an approximation of 4,350 square feet of impervious cover per unit, this 20% impervious cover corresponds to 2 units per acre (43,560 square feet). Correspondingly, at fifteen percent (15%) and ten percent (10%) impervious cover, this corresponds to 1.5 and 1 unit per acre, respectively. By dividing the land cost by the number of salable tracts (units), the land cost component of the salable tract can be determined. Table 15, below illustrates the correlation for the noted impervious cover percentages to varying land costs.

Table 15 – Correlation Between Percentage of Impervious Cover and Land Cost Component of Salable Tracts

Land Cost ($/Ac)	Salable Tract (Units/Ac)	Land Cost Component ($/Unit)	Salable Tract (Units/Ac)	Land Cost Component ($/Unit)	Salable Tract (Units/Ac)	Land Cost Component ($/Unit)
5000	2	$2,500	1.5	$3,333	1	$5,000
10000	2	$5,000	1.5	$6,667	1	$10,000
15000	2	$7,500	1.5	$10,000	1	$15,000
20000	2	$10,000	1.5	$13,333	1	$20,000

While the land cost component of the salable tracts varies significantly based on the land value, this analysis indicates a clear increase in the land cost component associated with the magnitude of reductions in impervious cover proposed in this Plan.

11.1.2.2.Costs of Structural BMPs

The EPA has conducted a number of studies attempting to assess the costs of structural BMPs. However, due to the number of different types and the variability of BMPs from region to region, and from site to site, their studies concluded that there was insufficient data to develop estimates of costs in sufficient detail to compare to corresponding benefits.[200] However, these studies do provide some examples of the costs for specific BMPs. As presented below, there are two elements to the cost of structural BMPs: 1) initial construction, and 2) long-term operations and maintenance.

Initial capital costs for BMPs vary significantly depending on the type and the value of the underlying land. Unit costs quoted in one EPA study ranged from $0.50 to $5.00 per cubic

[200] "Preliminary Data Summary of Urban Storm Water Best Management Practices", Publication No. 821-R-99-012, U.S. Environmental Protection Agency, August, 1999.

foot of capacity, or from $10,000 to $125,000 per installation, standardized to five (5) acres of development.[201] This translates to an approximate installation cost of between $2,000 and $25,000 per acre. Using the same salable tract densities used in the land value analysis presented above, this would correspond to capital cost allocations of $1,333 to $16,667 per salable tract for 15% IC and $2,000 to $25,000 per salable tract for 10% IC.

Operations and maintenance (O&M) costs for structural BMPs can be a significant burden to the entity or organization charged with carrying out these tasks. Regular maintenance of the structural BMPs is critical to ensuring that water quality within the planning region is being maintained or enhanced. Most structural BMPs will require routine maintenance to keep them functional and to maintain the pollutant removal level capabilities of the BMP. Structural BMPs that will require routine maintenance include retention/irrigation systems, sedimentation/filtration ponds, bio-retention/bio-filtration systems, detention/sedimentation systems, and vegetative filter strips.

O&M costs for structural BMPs can be found for communities throughout the country. Due to the variable nature of personnel costs, local cost information is most useful in determining the actual O&M costs that will be incurred by the communities. Recent City of Austin data indicates that the average, annual maintenance cost for their water quality ponds was approximately $3,500 per pond, not including the initial acquisition of maintenance equipment (backhoes, trucks, etc…). Local information for on-going maintenance of bio-retention/bio-filtration systems and vegetative filter strips has not been obtained. On-going operational costs for BMPs such as a retention/irrigation system, where power costs for pumps and more-intensive maintenance of the pumps and sprinkler system may be require, will tend to increase the annual per pond cost for such systems.

For comparison purposes, the O&M cost presented above was allocated at $1,000 per acre per year. Using an interest rate of ten percent (10%) per year, extended over an infinite time frame, the present value of this amount would be $10,000. Using the same salable tract densities used in the land value analysis presented above, this would correspond to O&M cost allocations of $6,667 per salable tract for 15% IC and $10,000 per salable tract for 10% IC.

11.1.2.3.Costs of Non-Structural BMPs

As stated previously non-structural BMPs encompass a variety of different institutional and pollution-prevention type practices designed to prevent pollution from entering storm water runoff or reduce the volume of storm water requiring management. Non-structural BMPs include, but are not limited to the following: natural area and open space conservation; conservation easements; stream buffer zones; CEF offsets; land-use restrictions; low-impact development (LID); public education and outreach; restrictions on use, storage, and disposal of potentially harmful materials.

[201] Ibid. Table 6.1 and 6.2.

Due to the varied nature of non-structural BMPs, the determination of on-going O&M costs is difficult. However, annual costs will be incurred for on-going program management for personnel costs, material costs, and possibly equipment costs for maintenance of natural areas and conservations easements. The costs associated with these on-going activities can fluctuate dramatically from community to community due to the variable level of implementation between communities.

11.1.2.4.Illustrative Summary of Cost Allocations

Any illustration of the potential cost impacts of the proposed water quality protection measures must be based on some scenario. The outcome of the illustration will depend significantly on the starting point. For example, a comparison of the Plan's measures to a proposed development with no limit on intensity and no water quality protection measures would of course show a very significant corresponding increase in costs. However, in most locations in the Planning Region, this is not a relevant comparison. In many locations, the terrain and physical features of the property will dictate maximum development intensities. As presented previously, analysis of developments occurring prior to the requirement for significant water quality protection measures generally ranges from twenty to twenty five percent (20-25%) impervious cover. In addition, significant areas of the Planning Region are subject to existing water quality protection measures. For example, areas under the jurisdiction of the City of Austin are subjected to the SOS ordinance or other similar land development codes that incorporate water quality protection measures. In addition, from a practical standpoint, developments occurring in Hays County and in western Travis County outside of the City of Austin's jurisdiction, will likely require the use of surface water to be furnished by the LCRA. Under this scenario, the developments would be subjected to water quality measures agreed to between the LCRA and the USFWS. Even beyond these areas, any other developments within the Planning Region would require compliance with the TCEQ's Edwards aquifer rules. For illustration purposes, four (4) general scenarios have been developed for evaluation purposes, with each being compared to the basic Plan measures for the Recharge Zone (10% impervious cover) and the Contributing Zone (15% impervious cover):

- The City of Austin SOS Ordinance
- The USFWS 2000 measures presented in the Memorandum of Understanding with the LCRA and others
- The cooperative optional measures included in the TCEQ's Edwards Aquifer program for avoiding take of the Barton Springs salamander, as approved by the USFWS
- The TCEQ's Edwards Aquifer rules, with base development intensity at 20%

The results of the evaluation of these scenarios (incremental costs only) are presented in Figure 7, below.

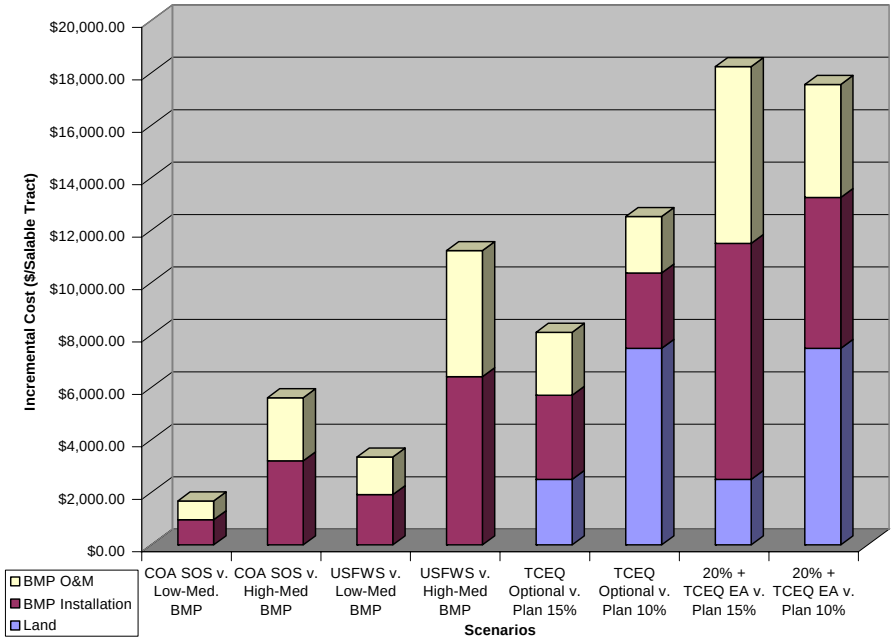

Figure 7 – Range of Estimated Incremental Costs for Water Quality Measures for Various Scenarios for a Typical Salable Residential Lot

11.1.2.5.Impact of Incremental Costs on Total Costs

As with the illustration of the potential incremental costs, the illustration of the impact of thes incremental costs on the total cost must also be based on some scenarios. In general, the higher the existing cost of a typical residential lot, the lower the impact of the incremental cost on the total cost. Conversely, the lower the existing cost of a typical residential lot, the more pronounced the impact of the incremental costs on the total cost. Data from 2004 un-built lot sales figures were obtained from the Austin Association of Realtors[202] for various areas across the Planning Region. The incremental costs developed for the various scenarios above, were combined with the published sales data. For illustration purposes, the following scenarios were used:

- Areas potentially subject to the City of Austin SOS Ordinance, both inside and outside the existing municipal limits
- Areas subject to the USFWS 2000 measures in southern and western Travis County and Hays County, through the memorandum of understanding with LCRA supplying surface water

[202] Information compiled from a printout of the Austin Association of Realtors Multiple Listing Service (MLS) for completed sales of lots with no habitable structures, for the period ended December, 2004. Median costs were used.

- Areas subject to the TCEQ's Edwards Aquifer rules in Travis and Hays Counties

The results of the evaluation of these scenarios are presented in Figure 7, below.

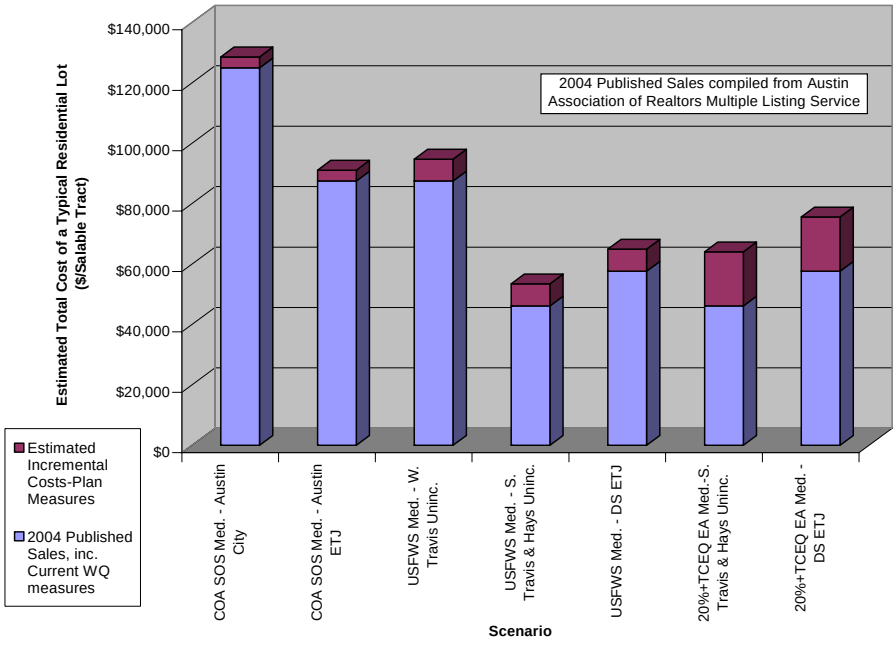

Figure 8 –Estimated Total Cost of a Typical Salable Residential Lot, Including the Plan Measures

As noted above, these comparisons are for illustrative purposes only, and are based on the scenarios outlined along with implementing the proposed water quality protection measures. While the analysis presented focused on residential development, the general influences on the costs of commercial tracts should follow the same general trends. In addition, this analysis addresses only "cost" and does not address "value". The analysis also does not address the "costs" of water quality impacts associated with unregulated development activities or attempt to relate these costs to the benefits of preserving water quality. As previously stated, the value of the resources at stake is incalculable.

11.1.3. Relationships Between Water Quality Protection Measures and Land Values

A significant economic issue raised by the SHC was the relationships between water quality protection measures and land values. While little hard data was available for land "values", there was limited data available on land "costs". Anecdotally, many stakeholders suggested that there was significant value attached to land that was located adjacent to natural areas and preserves. Conversely, many stakeholders suggested that there was a significantly decreased

value for land located adjacent to areas where the water quality had been significantly impact (e.g. a polluted creek). While "costs" are often straightforward to quantify and assess, "value" is much more difficult to quantify. In the truest sense, the value of instituting water quality protection measures is determined in the court of public opinion. The relationship between water quality protection measures and public policy is discussed in more detail below. However, the value of these measures will be assessed based on whether or not public and private entities are willing to bear the costs required to protect the resources in the Planning Region.

11.2. Funding

One of the critical areas identified by the Stakeholder Committee as well as the political subdivisions is identifying sources of revenue to provide for the initial capital improvements as well as ongoing operations and maintenance. There have been diverse viewpoints expressed in terms of both policy and implementation with some favoring that new development should bear the burden of both capital improvements and ongoing operations costs for the development while others feel that once capital improvements or buffer zones are dedicated to the local political subdivision, ongoing operational costs should be borne by local government. A related issue is how to incorporate water quality protection measures in existing developments that were not required to meet current standards. In all of these discussions one common factor is to identify an ongoing source of revenue that can be used to finance long term operations and maintenance.

11.2.1. Initial Implementation

Determining who is responsible for initial construction and the operations and maintenance of water quality protection measures is a critical issue. There has been little disagreement that the developer is responsible for installing the water quality protection measures for both commercial and residential development. In general, most of the water quality ordinances that are currently in effect require that commercial development be responsible for O&M of BMPs on their property as well as additional capital improvements if they are necessary. In some cases the property owner is required to obtain an annual certification from a professional engineer that the water quality measures meet specifications and are functioning properly. Residential development is usually treated differently with either a homeowners association or political subdivision responsible for the O&M. It has been suggested by some members of the stakeholder committee that the developer should bear the responsibility for O&M for the development. However, this approach has some very practical limitations. With commercial development there is a property owner that is subject to financial liability for non-compliance and the political subdivision has recourse to put a lien on the property if there is a bankruptcy or a refusal to make necessary repairs. A residential subdivision is very different in that once the development is sold out the developer would only own the water quality BMPs and if the developer were to go bankrupt the political subdivision would not be able to collect if an enforcement action were to take place. Another consideration is that many of the BMPs that are being recommended are non-structural in nature and would represent green space which could be used for public purposes. If the property were still in private hands the public could be excluded from access and use of the property. If O&M were to be handled by a homeowners association the only method of collecting revenue is to assess fees through the homeowners association. Previous experience

has shown that collecting these fees can sometimes be problematic and there is still limited recourse if there is an enforcement issue.

Local political subdivisions have two methods of raising funds for capital improvements. The first is to issue bonds which are supported from taxes, utility revenues, or a combination pledge of taxes and revenues. The second is to develop a capital improvement reserve fund which is capitalized over time using O&M taxes, utility revenues, or a combination pledge. If a bond issue is supported by a tax pledge the issue must be approved by the voters or if certificates of obligation are used a vote is not necessary can be subject to a referendum if certain requirements are met. Taxes must be levied on all property in the jurisdiction. There are two exceptions to this rule. The first is if a public improvement district is formed then taxes can be levied within the district to support certain improvements that benefit that district. The second is for Municipal Utility Districts that are larger than 2,000 acres. In those districts a "defined area" can be identified and a separate bond issue can be voted to construct improvements that benefit the defined area. The taxes that are levied to support the bond issue are then levied within the defined area along with any other taxes levied by the MUD. The following is a brief discussion on financing options available for water quality capital improvements as well as O&M.

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11.2.1.1. Municipalities

Municipalities can issue bonds for capital improvements which can include structural and non-structural BMPs and land acquisition. The pledge for these bonds can be either a tax pledge or a revenue pledge of surplus revenues of the utility system. If taxes are pledged the municipality would levy a debt service tax sufficient to cover annual debt service on all properties within the boundaries of the municipality. If revenues are used to cover the debt service the rates that are charged must be sufficient to make debt service payments along with a reserve fund capitalized over the first five years of the bond issue to protect bondholders. Using a revenue pledge has been used by municipalities over 100,000 to implement the federal stormwater permit requirements since voters have turned down the establishment of a separate stormwater utility where it was proposed. If a city were to make water quality capital improvements in their ETJ those improvements would have to be supported by taxes only from residents within the boundary of a municipality unless a Public Improvement District were formed and then they could be supported by debt service taxes from the PID. If surplus utility revenues were used for debt repayment it would have to be from all revenues paid into the system. However, if the municipality did not provide utility service to the area in the ETJ the revenues would have to be generated from their utility service area.

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11.2.1.2. Counties

Counties can issue bonds for capital improvements which can include water quality improvements if the BMPs are identified as part of a flood control/drainage program or for land acquisition if it is part of a open space or park plan. The county would either have to receive voter approval for the issuance of the bonds on a county wide basis or issue certificates of obligation. In all cases the bonds would be supported by a county wide tax for

debt service. Since most counties do not have utility revenues to fall back on the cost of debt service would strictly be taxes, unless a PID or other special taxing entity were formed by the county to levy a specific tax on an area for specific improvements.

11.2.1.3. Municipal Utility Districts/Water Control and Improvement Districts

A MUD or WCID may include water quality capital improvements as part of their overall bond package when being started as well as subsequent bond issues if the issuance is approved by TCEQ. If it were a new district the pledge for repayment would be secured by ad valorem taxes. Future improvements once the district was established could be secured by either taxes, utility revenues or a combination pledge. If a district were to be formed in a city's ETJ the district would need to receive an approval of the city. One of the requirements of that approval from the city could be that the district must adopt the city water quality standards and require that the district operate and maintain those improvements. If the district were to be established in an unincorporated area outside of a city ETJ, the developer would have to obtain approval of the plat as well as drainage plans and streets and roads from the county. While the county could not block the establishment of a district by the TCEQ or legislature, if water quality controls were incorporated into design criteria or a contractual agreement were entered into by the county, then the district water quality capital improvements could be addressed as part of that agreement. If the district were to be a wholesale customer for water and/or wastewater service from a regional entity, such as LCRA, the water and/or wastewater supply agreement could incorporate the regional water quality plan as part of the contractual obligation.

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11.2.1.4. Regional Authorities

If a regional water quality authority were formed by the legislature several issues would have to be negotiated between the authority and existing cities, counties and special districts over jurisdictional and financing issues for water quality capital improvements that would be required for new and future capital improvements required by the authority. Since a new authority would not have any utility sales or other revenues available it would have to depend on assessments from other entities within its jurisdiction or ad valorem taxes, if approved by the voters, to pay for capital improvements. As noted earlier, the LCRA has been granted authority to regulate water quality within Travis County and has had an active water quality ordinance for the watershed draining into Lake Travis. As part of this ordinance the LCRA requires that developers obtain a water quality permit and include appropriate water quality BMPs into their developments as a permit requirement. Currently, the LCRA has not expanded its water quality regulations to include any other parts of Travis County. While the LCRA currently does not have water quality management authority in Hays County, it is supplying the surface water to the area and has the ability to require that water quality measures be implemented by its wholesale customers as part of the wholesale water contract. A second option would be to request that the legislature expand the LCRA water quality authority to the planning region in Hays County and allow the LCRA to implement water quality measures and require development to install appropriate water

quality capital improvements. While the LCRA does not have taxing authority, it could require initial capital improvements be developed by developers and build into its wholesale water rate a capital component that could be made available for future capital improvements that were not covered by other political subdivisions.

11.2.2. On-going Operations and Maintenance

11.2.2.1.Municipalities

Municipalities typically have three methods of financing ongoing water quality O&M costs within their jurisdiction. The first is to levy an O&M tax, dedicate revenue from its general fund and the third is to use revenues from its utility system. While municipalities do have the ability to establish a stormwater utility that could include O&M costs for water quality O&M, these proposed utilities have proven very unpopular and the charges associated with them are sometimes referred to as a "rain tax" by opponents. If O&M taxes are used for ongoing operations and maintenance of the water quality protection measures a policy decision has to be made by the municipality if they are to provide O&M for just the municipal boundaries or include the ETJ. If the ETJ is included, only taxpayers within the municipal boundaries would have the tax levied against their property and could be subject to a roll back tax election. However, if a PID were formed O&M taxes could be assessed for the water quality protection only for the PID area to pay for ongoing O&M of those improvements within the PID. In the case of a MUD/WCID being established within the ETJ, they could levy a tax within the district or use revenues from their utility system to pay for ongoing O&M. If revenues from the utility system were to be used all users of the utility system would be contributing to the revenue stream.

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11.2.2.2.Counties

Counties can only finance ongoing O&M for water quality improvements as well as road and bridge funds through the levy of an O&M tax. This tax is levied county wide and is subject to the O&M rollback provisions under the tax code. If a MUD/WCID has been established and an agreement is in place for the district to provide O&M for water quality measures the district would be have to generate funds through their O&M tax or utility revenues.

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11.2.2.3.Municipal Utility Districts/Water Control and Improvement Districts

A district may provide funding for O&M through either an O&M tax or through revenues of its utility system. As previously mentioned the O&M tax is subject to rollback restrictions and in many cases the district is also restricted to a cap on an O&M tax rate. These restrictions typically can be included as part of the enabling legislation for the district or through voter approval of the creation of the district. The only way to raise this tax is to ask for voter approval. Utility revenues can also be used and in many cases are used for providing O&M for water quality protection measures.

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11.2.2.4. Regional Authority

If a new regional authority were to be established and would be responsible for O&M of water quality protection measures it would need to acquire taxing authority to accomplish this objective and be subject to the rollback requirements established in the tax code. Since the authority would not have utility revenues to draw upon the only other source of funding would be from voluntary assessments from other entities. If the LCRA were to assume the role of a regional authority for water quality purposes its only source of funding for ongoing O&M would be from its water sales within the planning area as well as potential assessments to other local governments.

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11.3. Enforcement and Oversight

The strategy presented in this Plan will only achieve true protection of water quality if it is enforced, with proper oversight from the implementing jurisdictions. As discussed in the implementation section, coordinated and comprehensive implementation is essential to providing this water quality protection. If the local jurisdictions are not coordinated in their implementation, future development will likely occur preferentially in areas with less stringent enforcement and oversight. It is important that each and every jurisdiction involved provide consistent levels of enforcement and oversight.

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11.4. Interaction of Population Growth and Protection Measures

One of the implications of the water quality protection measures is their interaction with projected population growth. A number of these measures (e.g. stream offsets and impervious cover limits) directly impact the quantity of development that can take place on a tract of land. Combined with the transferable development rights concept presented in the Plan, these measures establish a direct relationship between the amount of land remaining to be developed within the Planning Region, and the amount of development that can occur on that land. If population growth continues at or above the projected rates, the amount of land available for development will be consumed more quickly. Conversely, if the rate of development is controlled, this will in turn limit available population growth. In practice, the recommended water quality protection measures will impose certain limitations on the ultimate build-out the land in the Planning Region.

In order to assess the interaction of population growth with the implementation of the recommended water quality protection measures, the consulting team prepared an analysis of the build-out rates based on a set of established scenarios. The population projections presented in the section on Demographics, were used to estimate the number of single family residential structures, and the corresponding land area required, to accommodate these projects. This analysis has been simplified for illustration purposes and does not address relevant issues such as:

- the current real property vacancies that could be used to accommodate population growth with no additional construction
- the construction of multi-story, high occupancy residential structures that can accommodate a higher population density than low-rise single story construction with the same footprint

Given a current estimated population of approximately 122,954, the projected population for 2010 is approximately 159,393, resulting in an increase of approximately 36,439 people. Using the estimated average 2.63 persons per household, this would require the construction of approximately 13,855 single family residential dwelling units during that 10 year time frame, or 1,386 residential dwelling units per year. If each of these residential dwelling units occupies approximately 5,000 square feet of impervious cover, this represents an increase of approximately 6,930,000 square feet (or 159 acres) of impervious cover per year. Using a basin wide average impervious cover of approximately fifteen percent (15%), this represents approximately 1,060 acres of total development per year. This corresponds to an overall development density of approximately one dwelling unit for every 0.75 acres. If a basin wide average impervious cover of approximately ten percent (10%) is used, this represents approximately 1,590 acres of total development per year.

An analysis of several urbanized watersheds within the City of Austin (Waller, Shoal and East Bouldin) indicates that the approximate relationship between commercial, industrial and infrastructure land uses and residential land uses is approximately 1.4 to 1. Given this ratio, and that the other development will comply with the water quality protection measures, an approximate total land area required to support development can be correlated to the projected population growth. Table X, below presents the anticipated number of dwelling units and corresponding acres of development necessary to support the population projections, given the conditions established for the evaluation scenario.

Table 16 – Land Area Estimates Required to Sustain Population Growth with the Recommended Measures

Year	Population	Growth	Dwelling Units	Residential Area Required at 15% (Acres)	Total Area Required	Residential Area Required at 10% (Acres)	Total Addn. Area Required (Acres)
2000*	122,954	2.63 P		0.75 Ac	2.4 Ac	1.15 Ac	2.4
2010	159,393	36,439	13,855	10,391	24,938	15,933	38,239
2020	200,431	41,038	15,604	11,703	28,087	17,945	43,068
2030	240,545	40,114	15,252	11,439	27,454	17,540	42,096
2040	283,995	43,450	16,521	12,391	29,738	18,999	45,598
2050	335,142	51,147	19,448	14,586	35,006	22,365	53,676
2060	385,594	50,452	19,183	14,387	34,529	22,060	52,944
Total		262,640	99,863	74,897	179,752	114,842	275,621

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At a uniform limit of 15% impervious cover, and the corresponding relationship between residential land use and commercial land use, the Planning Region is approximately seventy five percent (75%) built out by 2060. At a uniform limit of 10% impervious cover and the corresponding relationship between residential land use and commercial land use, the projected growth in the Planning Region requires more land area than what is available.

11.5. Interrelation with Public Policies

Water quality protection measures are inherently linked to broader public policies. Environmental protection is primarily a public policy issue in that the governmental powers of the public are

focused on preventing and correcting those activities which might harm the environment. Specifically, the imposition of water quality protection measures in the Planning Region is a public policy decision that must be made to protect water quality. Most of the water quality protection measures presented in this plan must be adopted by local government jurisdictions, making them inherent public policy. If their implementation is to be successful, these measures must be adopted, accepted and enforced as public policy. But beyond their inclusion as public policy, the effectiveness of water quality measures can also be affected by other public policies.

Public policies that encourage human and economic activities are also inherently linked to water quality. These activities provide many benefits to society as a whole through gainful employment and economic empowerment of the population, which generally results in a higher quality of life. However, if not properly controlled, these activities may also have adverse water quality and other environmental impacts. While the importance of these economic activities is not the same across all elements of society, most agree that these activities can not go unchecked or they will result in harm to a valued public asset: the environment. This fundamental understanding of the relationship between human and activity and environmental protection should be recognized in all public policy.

To help the proposed water quality protection measures succeed, the following actions are recommended to ensure that these measures are integrated into larger scale public policy, and should be included into the adoption of the measures:

- Public entities should adopt broad policy statements regarding the need to integrate water quality protection measures into all public actions.
- Public entities should adopt broad policy statements regarding the need to integrate water quality protection measures into all regulated private actions.
- Public entities should also encourage non-regulated private actions to integrate water quality protection measures.

These recommendations should accomplish one of the expected outcomes of this Plan, which is to have coordinated public policies that encourage the protection of water quality.