Rainwater Harvesting Potential and Guidelines for Texas

Report to the 80th Legislature

Submitted by

Texas Rainwater Harvesting Evaluation Committee
Texas Water Development Board
Texas Commission on Environmental Quality
Texas Department of State Health Services
Texas Section of the American Water Works Association
Conservation and Reuse Division

Published by
Texas Water Development Board
Austin, Texas

November 2006

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Executive Summary

The Texas Water Development Board (TWDB) established the Texas Rainwater Harvesting Evaluation Committee pursuant to the passage of House Bill 2430 by the 79th Texas Legislature in 2005. In accordance with House Bill 2430, membership of the Texas Rainwater Harvesting Evaluation Committee consists of representatives from the TWDB, the Texas Commission on Environmental Quality, the Texas Department of State Health Services, and the Texas Section of the American Water Works Association Conservation and Reuse Division.

House Bill 2430 directs the Texas Rainwater Harvesting Evaluation Committee to evaluate the potential for rainwater harvesting in Texas and to recommend

(a) minimum water quality guidelines and standards for potable and non-potable indoor uses of rainwater;
(b) treatment methods for potable and non-potable indoor uses of rainwater;
(c) ways, such as dual plumbing systems, to use rainwater harvesting systems in conjunction with existing municipal water systems; and
(d) ways that the state can further promote rainwater harvesting.

In addition, House Bill 2430 directs the Texas Commission on Environmental Quality to establish recommended standards for the domestic use of harvested rainwater, including health and safety standards. It also directs them to develop standards for collection methods for harvesting rainwater intended for drinking, cooking, and bathing. The legislation requires the Texas Commission on Environmental Quality to adopt these recommended standards by December 1, 2006.

The Texas Rainwater Harvesting Evaluation Committee has concluded its evaluation of the potential for rainwater harvesting in Texas, has formulated its recommendations regarding minimum water quality guidelines, standards, and methods of treatment for the safe use of water for indoor purposes, ways in which to incorporate rainwater harvesting with existing public water systems, and the state's role in promoting rainwater harvesting.

This report represents the fulfillment of the committee's obligation under House Bill 2430 to submit its evaluation and associated recommendations in a report to the Texas Lieutenant Governor and Speaker of the Texas House of Representatives by December 1, 2006.

In this report, the Texas Rainwater Harvesting Evaluation Committee presents a narrative discussion, associated maps, and other illustrations relating to the potential benefits and advantages that may be derived from rainwater harvesting. In addition, the committee respectfully submits the following key findings and 10 key recommendations:

Key Findings and Recommendations

Potential for Rainwater Harvesting in Texas

- **Key Finding**

There is a significant untapped potential to generate additional water supplies in Texas through rainwater harvesting, particularly in urban and suburban areas.

In most areas of the state, rainfall is sufficient to make rainwater harvesting a reliable and economical source of water even during short-term droughts. Because rainfall is generally harvested in the same location where it will be used, the need for complex and costly distribution systems is eliminated. An estimated 2 billion gallons of water could be generated annually in a large metropolitan area the size of Dallas if 10 percent of the roof area were used to harvest rainwater. Approximately 38 billion gallons of water would be conserved annually if 10 percent of the roof area in Texas could be used for rainwater harvesting.

- **Recommendations**

The legislature should consider expanding the state's role in promoting rainwater harvesting by:

1. *Directing new state facilities with 10,000 square feet or greater in roof area (and smaller facilities, when feasible), to incorporate rainwater harvesting systems into their design and construction. Harvested rainwater at these locations may be used for restroom facilities and/or landscape watering*.

2. *Developing incentive programs to encourage the incorporation of rainwater harvesting systems into the design and construction of new residential, commercial, and industrial facilities in the state.*

3. *Considering a biennial appropriation of $500,000 to the Texas Water Development Board to help provide matching grants for rainwater harvesting demonstration projects across the state.*

Guidelines, Standards, and Regulations

- **Key Finding:**

With the application of appropriate water quality standards, treatment methods, and cross-connection safeguards, rainwater harvesting systems can be used in conjunction with public water systems.

Harvested rainwater may be the only source of water supply for many rural and remote households where no other water supply is available. In urban and suburban environments, rainwater harvesting could help public water systems reduce peak demands and help delay the need for expanding water treatment plants. Rainwater harvesting can reduce storm water runoff, non-point source pollution, and erosion in urban environments. Rainwater is valued for its purity and softness and is generally superior for landscape purposes to most conventional public water supplies. Rainwater harvesting can be used for both indoor and outdoor purposes in residential, commercial, and industrial applications.

- **Recommendations**

The legislature should consider:

4. *Directing the Texas Commission on Environmental Quality and other state agencies to continue to exempt homes that use rainwater harvesting as their sole source of water supply from various water quality regulations that may be required of public water systems. Guidelines are provided in this report to assist homeowners in improving and maintaining the quality of rainwater for potable and non-potable indoor uses.*

5. *Directing the Texas Commission on Environmental Quality and other state agencies to require those facilities that use both public water supplies and harvested rainwater for indoor purposes to have appropriate cross-connection safeguards, and to use the rainwater only for non-potable indoor purposes.*

6. *Appropriating $250,000 to the Texas Department of State Health Services to conduct a public health epidemiologic field and laboratory study to assess the pre- and post-treatment water quality from different types of rainwater harvesting systems in Texas, and to submit a report of findings to the next session of the legislature.*

7. *Directing Texas cities to enact ordinances requiring their permitting staff and building inspectors to become more knowledgeable about rainwater harvesting systems, and allow such systems in homes and other buildings, when properly designed.*

Training, Education, and Certification

- **Key Finding**

There is a need to develop training and educational materials on rainwater harvesting to help design appropriate systems and to realize the full potential of rainwater harvesting in Texas.

Successful and widespread integration of rainwater harvesting systems with public water systems requires a commitment on the part of state and local governments to develop professional programs and opportunities for education, training, and certification on rainwater harvesting systems. In Texas, there are currently no licenses or certifications required to design, install, or maintain a rainwater harvesting system. In addition, the current training conducted by the Texas State Board of Plumbing Examiners for licensed plumbers and water utility operators does not include any information regarding rainwater harvesting systems.

- **Recommendations**

To help improve the professional service capabilities of rainwater harvesting consultants, contractors, and local governments, the legislature should consider:

8. *Directing a cooperative effort by the Texas Commission on Environmental Quality and the Texas State Board of Plumbing Examiners to develop a certification program for rainwater harvesting system installers, and provide continuing education programs.*

9. *Directing Texas Cooperative Extension to expand their training and information dissemination programs to include rainwater harvesting for indoor uses.*

10. *Encouraging Texas institutions of higher education and technical colleges to develop curricula and provide instruction on rainwater harvesting technology.*

Chapter 1 - Introduction

The population in Texas is expected to more than double between the years 2000 and 2060, growing from almost 21 million to about 46 million. That population growth will result in twice the municipal water demand, which is projected to increase from about 4 million acre-feet per year in 2000 to 8.2 million acre-feet per year in 2060. However, during that same time period, the total water supply in Texas is projected to decrease by 3.2 million acre-feet per year from 17.8 million acre-feet in 2010 to about 14.6 million acre-feet in 2060 due to various factors, such as reservoir sedimentation and reduced aquifer yields. Faced with a growing population and a diminishing water supply, Texas will need to develop new water supplies and encourage alternative technologies such as rainwater harvesting, to supplement available water sources.

The Texas Legislature and state water agencies have promoted the use of rainwater harvesting through several actions in the past (Krishna, 2005). In 1993, Proposition 2 was passed in Texas, providing property tax relief to commercial and industrial facilities that use rainwater harvesting and pollution control measures. Senate Bill 2, passed in 2001 by the 77th Legislature, allows local taxing entities the authority to exempt all or part of the assessed value of the property on which water conservation modifications, such as rainwater harvesting, are made. Senate Bill 2 also provides sales tax exemptions for rainwater harvesting equipment. House Bill 645, passed in 2003 by the 78th Legislature, prevents homeowners' associations from implementing new covenants banning outdoor water conservation measures, such as rainwater harvesting. A rainwater harvesting and water recycling task force submitted a report to the Texas Residential Construction Commission in 2005 (TRCC, 2005) recommending development of resource information and encouraging builders to incorporate rainwater harvesting systems. This report provides the needed resource information and water quality guidelines for rainwater harvesting systems.

Rainwater and snowmelt are the primary sources for all fresh water on the planet. The practice of collecting runoff from rainfall events can be classified into two broad categories: land-based and roof-based. Land-based rainwater harvesting occurs when runoff from land surfaces is collected in furrow dikes, ponds, tanks and reservoirs. As its name implies, roof-based rainwater harvesting refers to collecting rainwater runoff from roof surfaces. Roof-based rainwater harvesting results in a much cleaner source of water and provides water that can be used both for landscape watering and for indoor purposes. Roof-based rainwater harvesting is the focus of this report.

Before the advent of large-scale public water systems, capturing rain in cisterns for residential and various commercial purposes had been a relatively common practice in Texas in the 19th century. Since the mid-1990s, there has been renewed interest in rainwater harvesting as a low-cost technology that produces water of relatively good quality. In Central Texas alone, it is estimated that at least 500 residential rainwater harvesting systems have been installed in the past 10 years. Homes in remote areas with no access to other sources of water supply depend on rainwater for all their needs. In addition to residential use, there are many examples of rainwater harvesting systems being used in commercial and industrial applications (TWDB, 2005). Public facilities, such as schools and community centers have started harvesting rainwater to conserve water supplies. The City of Austin has encouraged the use of rainwater as a supplemental source of water for residential and other applications.

Surveys of various state agencies suggest that there may be as many as 100,000 rainwater harvesting systems in use in the United States (Lye, 2003). Portland, Oregon, and the State of Washington have developed guidelines for designing and installing rainwater harvesting systems. Santa Fe, New Mexico requires the installation of rainwater harvesting systems on all new residential structures greater than 2,500 square feet. Tucson, Arizona, has instituted requirements for rainwater harvesting in its land use code to provide supplemental water for on-site irrigation as well as for floodplain and erosion control. In Hawaii, up to 60,000 people depend on rainwater harvesting systems for their water needs (Macomber, 2001).

Rainwater harvesting systems have also been popular in other countries. Several countries in Western Europe use them to conserve municipal water supplies, as does Australia. Some states in India have made rainwater harvesting mandatory in all new buildings. Rainwater harvesting is required by law in the U.S. Virgin Islands and many other Caribbean islands

There are numerous potential benefits and advantages from rainwater harvesting (Krishna, 2003). Rainwater harvesting systems can

- provide a source of free water—the only costs would be for storage, treatment and use;
- provide water if there is no other source of water;
- augment or replace limited quantities of groundwater;
- provide good-quality water if groundwater quality is unacceptable;
- provide water if tap charges are too high for water supply connection;
- reduce storm water runoff;
- reduce non-point source pollution;
- reduce erosion in urban environments;
- provide water that is naturally soft (no need for water softeners);
- provide water that is pH neutral/slightly acidic;

- provide water that is sodium-free, important for those on low-sodium diets;
- provide good quality water for landscape irrigation;
- provide water for non-potable indoor uses;
- provide safe water for human consumption, after appropriate treatment;
- help utilities in reducing peak demands in the summer;
- help utilities in delaying the expansion of water treatment plants;
- provide water for cooling and air-conditioning plants;
- reduce the demands on groundwater;
- provide water for fire protection; and
- save money for the consumer in utility bills.

Rainwater harvesting also provides several additional benefits. It can reduce scaling build-up in hot water heaters, plumbing, faucets, and showerheads. Rainwater requires less soap and detergent than most public water supplies because of its natural softness. In particular, use of rainwater can be valuable for the hotel industry, helping them reduce their use of municipal water supplies and the amount of detergents used for their daily laundry.

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Chapter 2 - The Potential for Rainwater Harvesting in Texas

Rainwater harvesting has considerable potential as a source of alternate water supply in Texas if the systems that collect the rainwater are properly designed and implemented. The amount of rainwater that can be collected is a function of roof area and rainfall. In order to determine the potential benefits from rainwater harvesting in Texas, statewide rainfall data and roof area information from nine representative cities across the state were obtained. The average annual rainfall in Texas is approximately 28 inches, and the total roof area in the state is estimated to be approximately 22.5 billion square feet.

According to the Texas Rainwater Harvesting Evaluation Committee's analysis, approximately 2 billion gallons of water could be generated annually in a large metropolitan area the size of Dallas if 10 percent of its roof area were used to harvest rainwater. If 10 percent of all the roof area in the state were used to harvest rainwater, an estimated 38 billion gallons of water could be generated annually in Texas. This is equivalent to producing about 104 million gallons per day of new water. In general, for every 1 percent of total roof area in the state used to harvest rainwater, approximately 11,650 acre-feet per year of additional water could be generated.

The Texas Rainwater Harvesting Evaluation Committee also estimated how much water could be collected from just residential buildings (homes and apartments) by examining census data and other information on housing units. The total residential roof area in the state was estimated at 15.7 billion square feet. By collecting rainwater from 10 percent of the residential roof area in the state, an estimated 27 billion gallons of water could be conserved.

In addition to its potential to generate considerable quantities of water, rainwater harvesting results in a process of collecting water that is decentralized and therefore, relatively less vulnerable than conventional public water supplies to natural disasters or terrorism. Another advantage of rainwater harvesting is that its systems are generally cost-competitive with well drilling and it provides water that is naturally soft, eliminating the need for water softeners. In some cases, rainwater harvesting is less expensive than the costs associated with obtaining a tap connection from water supply corporations.

Rainwater Harvesting Feasibility in Texas

With respect to the feasibility of using rainwater harvesting systems in Texas, it is important to realize that rainwater harvesting may be the only option in many rural areas where there is no other source of water supply. Also, rainwater can be used as a sole source of water supply or in conjunction with other water sources such as surface water or groundwater. The Texas Rainwater Harvesting Evaluation Committee examined to what degree rainfall patterns in different regions of the state affect the viability of this alternative water supply option. After reviewing rainfall and runoff data, and the evidence presented by a number of individuals who have successfully practiced rainwater harvesting in the state, the Texas Rainwater Harvesting Evaluation Committee has concluded that rainwater harvesting systems, if properly designed, can provide adequate water supplies in most regions of the state even during periods of short-term drought. It is, however, necessary to practice water conservation to ensure the success of rainwater harvesting, especially when it is the sole source of water supply.

According to the Handbook of Water Use and Conservation (Vickers, 2001), the average indoor water use in a water-conserving home in the United States is 45.2 gallons per capita per day; clothes washers and toilets consume about 40 percent of this amount (approximately 18 gallons per capita per day). However, most homeowners who rely solely on rainwater harvesting systems routinely use between 30-40 gallons per capita per day for indoor purposes, that includes about 14 gallons per capita per day for clothes washers and toilets. This level of indoor water consumption is based on the use of water-conserving showerheads and faucets and high-efficiency flush toilets, clothes washers, and dishwashers.

The maps and discussion in this chapter are intended to provide information regarding the suitability of rainwater harvesting technology in various rainfall zones throughout the state. Annual rainfall in Texas ranges from less than 10 inches in West Texas to more than 50 inches in East Texas (Figure 1). In most areas of the state, rainy seasons occur during the months of April-June and again in September-October, with a relatively dry period during the interim months of July and August.

In general, rainwater harvesting will be successful if sufficient rainwater can be captured and stored to satisfy needs during those dry periods, and dry periods increase from 50 days in East Texas to 120 days in West Texas (Figure 2). In other words, rainwater harvesting systems would need to provide adequate water storage to meet the needs during those relatively dry periods. In Central Texas, for example, that would mean water storage for an 80-day period.

Assuming a rainfall collection efficiency of 80 percent, a rainwater harvesting system using 2,000 square feet of roof area will generate approximately 1,000 gallons of water for every inch of rainfall. This mathematical relationship holds true in all regions of Texas. For example, in the Austin area (south central Texas) where the average annual rainfall is 33 inches, one would expect to collect approximately 33,000 gallons of rainwater annually from a 2,000 square foot roof (Figure 3). In the San Angelo area (west central Texas), where the average annual rainfall is 19 inches, one would expect to collect approximately 19,000 gallons of rainwater annually from a 2000 square foot roof. The amount of water that can be collected from a typical 2,000 square foot roof generally ranges from about 12,000 gallons per year in areas of West Texas to about 60,000 gallons per year in areas of East Texas.

To determine the rainwater harvesting potential at any location, the following equation may be used: Annual Rainwater Harvesting Potential (Gallons) = Average annual rainfall (in inches) * 0.62 * 0.80 * Collection area (in square feet). If the average annual rainfall is not known, a location's longitude could be used to estimate the average annual rainfall as shown below.

The potential for rainwater harvesting as a water resource was estimated through a regression analysis that was performed on historic rainfall for 13 major Texas cities geographically scattered across the state. The following equation can be used by water resource planners to estimate the average annual rainfall for any particular community in Texas, using longitude. Average annual rainfall (in inches) = 352.2 - (3.27 * Longitude).

The Texas Rainwater Harvesting Evaluation Committee is of the opinion that rainwater harvesting technology is applicable to all areas of Texas, however, its greatest potential for indoor uses may be in the yellow, green and blue zones that range in average annual rainfall from about 20 inches to over 50 inches. Together, these rainfall zones encompass approximately 75 percent of the state's total area. To meet household needs in the red zone, a larger surface area may be needed for rainwater collection, along with a back-up or alternate source of water supply to cover extended dry periods.

Potential Impact of Rainwater Harvesting on Streamflow

To examine the potential impact of rainwater harvesting on streamflow in the state, the Texas Rainwater Harvesting Evaluation Committee determined the amount of rainfall that would be captured if 10 percent of the total roof area in the state were equipped with rainwater harvesting systems. That value was compared with total rainfall and mean annual streamflow discharged into the Gulf of Mexico by the state's rivers and streams.

Assuming a statewide average precipitation of 28 inches per year, the Texas Rainwater Harvesting Evaluation Committee determined that capturing rainfall on 10 percent of the total roof area in the state over the course of one year would generate approximately 120,000 acre-feet of water. The committee compared this value to the 396 million acre-feet of water resulting from the 28 inches of rainfall over the entire state and found that the rainfall intercepted by rainwater harvesting amounted to only 0.03 percent of the statewide rainfall total.

The combined mean streamflow discharged by the state's rivers and streams into the Gulf of Mexico totals approximately 40 million acre-feet per year. The committee compared this value to the estimated 120,000 acre-feet of water conserved annually by capturing rainfall on 10 percent of the total roof area in the state, and determined that the rainwater captured represents only 0.3 percent of total streamflow entering the Gulf of Mexico via our state's rivers and streams. Therefore, if a goal of capturing up to 10 percent of the total roof area in the state via rainwater harvesting is achieved, it is reasonable to conclude that this level of rainfall diversion would have little or no impact on total streamflow in the state. Rainwater harvesting may even provide a measure of relief from demands placed on surface waters in the state, ultimately increasing overall streamflow.

Average Annual Rainfall in the State of Texas
For the Climatological Period 1971 - 2000.

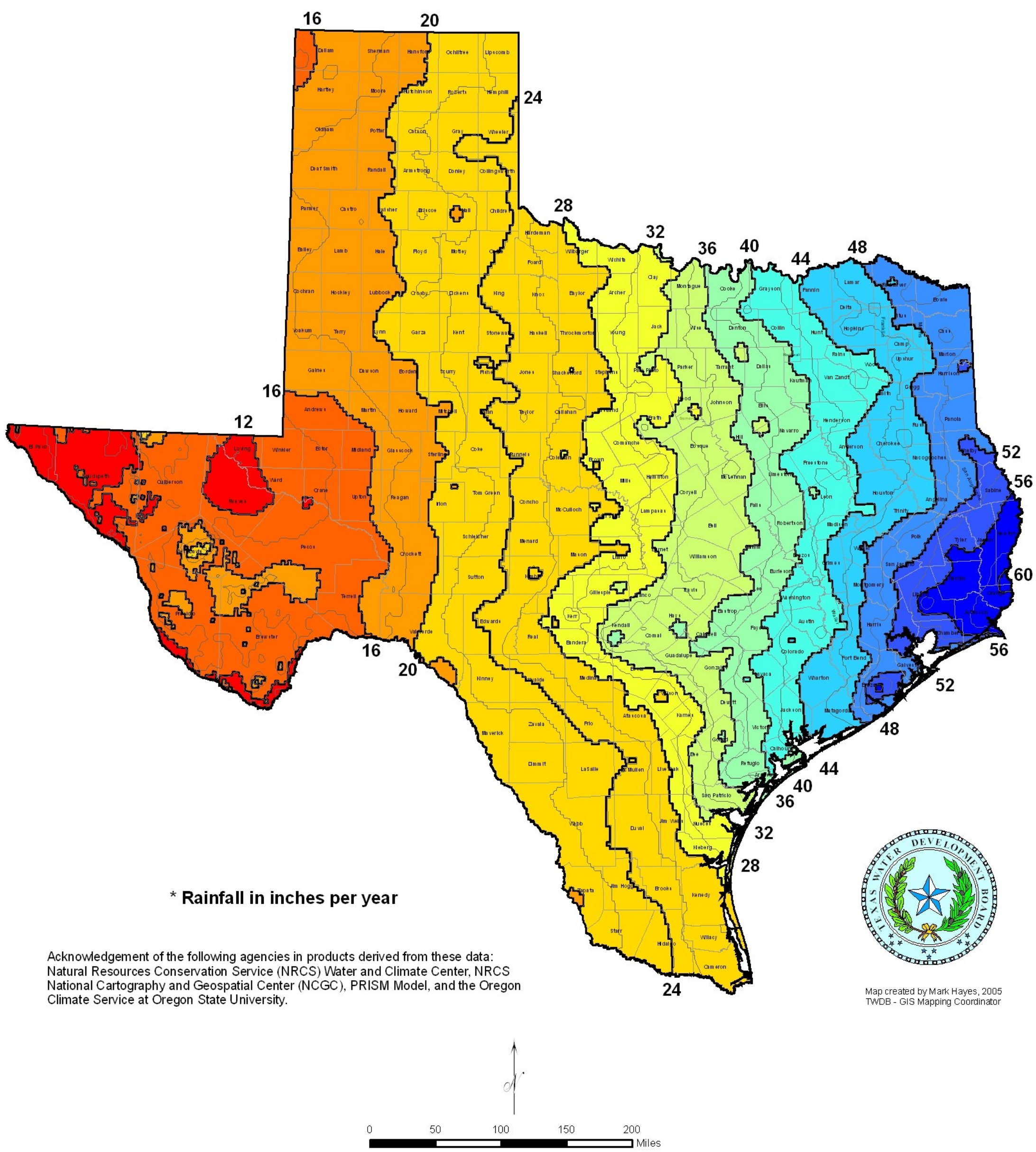

Figure 1. Average annual rainfall in Texas (in inches).

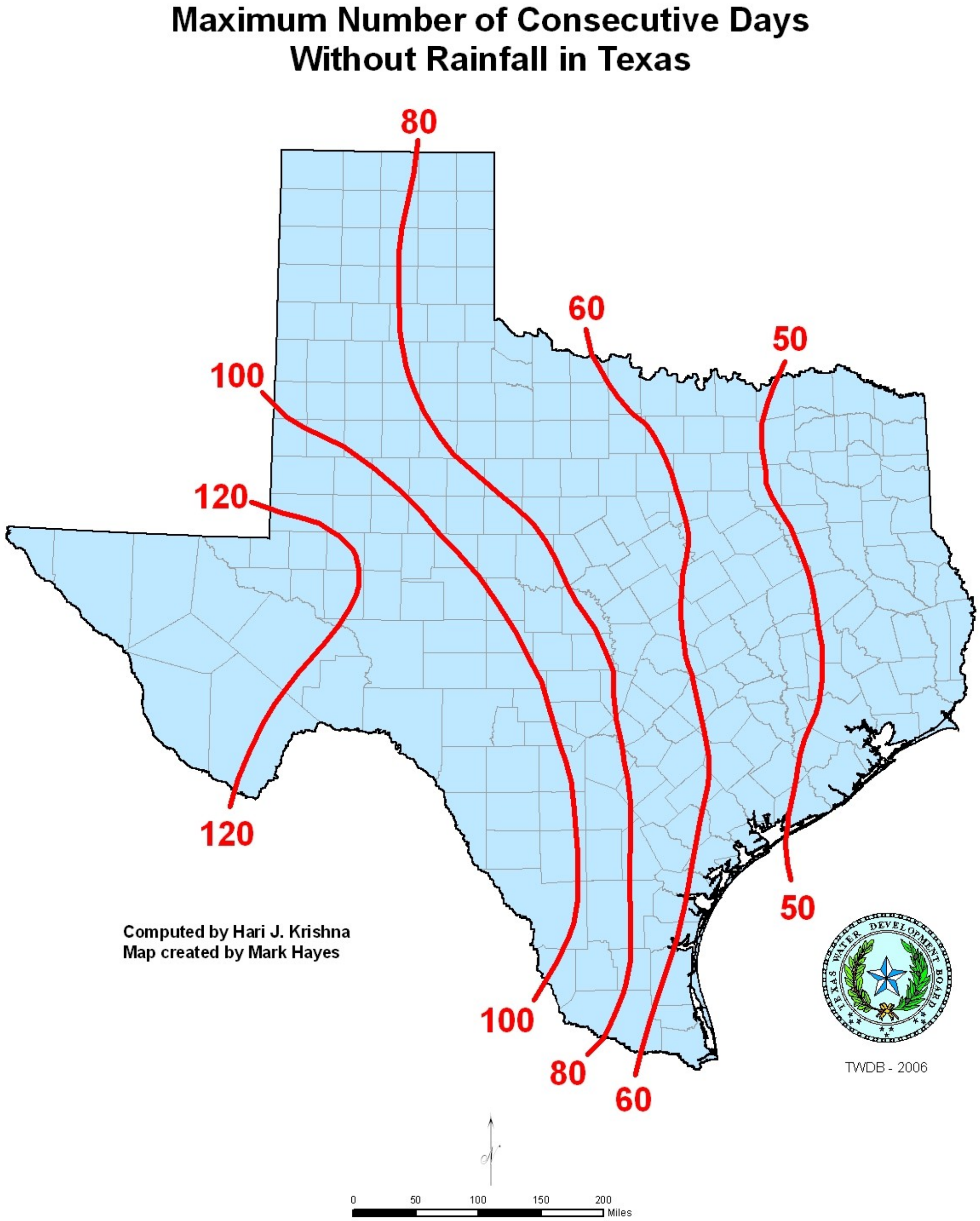

Figure 2. A map of Texas with isolines showing the maximum number of consecutive days without rainfall (Krishna, 2003; TWDB, 2005).

Average Annual Runoff from 2,000 square feet of Roof Area

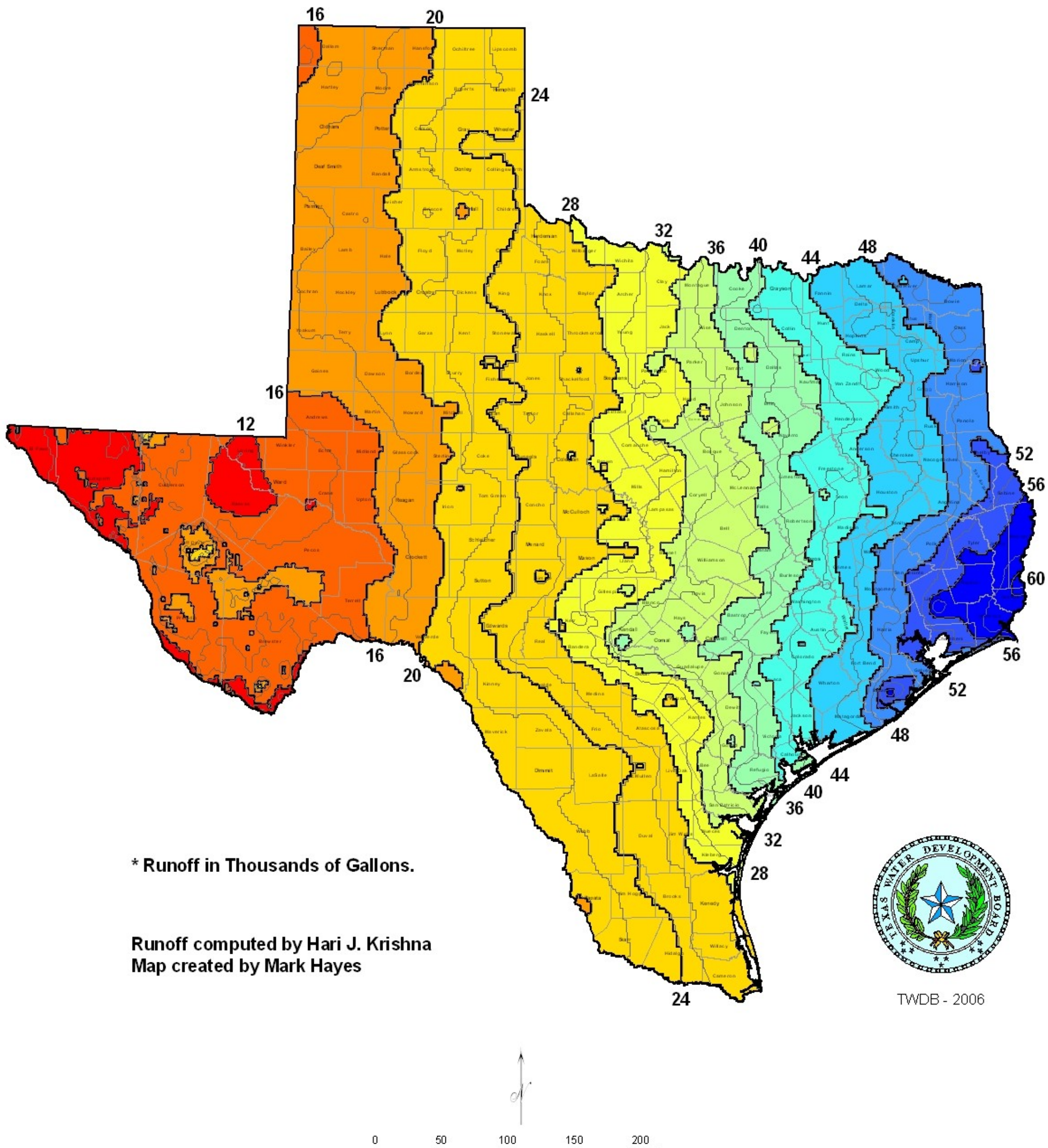

Figure 3. Map of Texas showing isolines of average annual runoff (in thousands of gallons) that can be expected from 2,000 square feet of roof area.

Conclusions:

- Rainwater harvesting is the only source of water supply in many rural communities where there is no other source of water.
- Under average rainfall conditions, a considerable amount of water (approximately 120,000 acre-feet per year) can be generated through rainwater harvesting systems from just 10 percent of the roof area in Texas.
- Rainwater harvesting provides a decentralized system of water supply that would be less vulnerable to natural disasters or terrorism.
- A color-coded map of Texas has been specifically developed for this report which shows that the average annual roof runoff can range from about 12,000 gallons in West Texas to about 60,000 gallons in East Texas from a typical 2,000 square foot roof.
- Rainwater can be used for indoor and/or outdoor purposes, in homes, and in commercial and industrial facilities.
- Rainwater can be used as a sole source of water supply or in conjunction with other sources of water supply such as groundwater and surface water.
- Evidence has been presented to the Texas Rainwater Harvesting Evaluation Committee to indicate that rainwater harvesting systems are practical and cost-competitive with well water systems, and also in relation to the costs associated with obtaining a tap connection from water supply corporations in some areas.
- The quantity of water that could be collected through rainwater harvesting would constitute less than 1 percent of the state's streamflow and will therefore have little impact on the water that flows in the rivers and streams of the state.

Chapter 3 - Minimum Water Quality Guidelines for Indoor Use of Rainwater

Although rainwater is one of the purest forms of water, it is still necessary to establish minimum water quality guidelines for its use, because the water can become contaminated during the rain harvesting process. House Bill 2430 requires the Texas Commission on Environmental Quality to establish “recommended standards” related to the domestic use of harvested rainwater. Since these are to be recommended standards and not regulations, the Texas Commission on Environmental Quality will adopt these standards in the form of guidelines, and they will be published as regulatory guidance documents. This chapter will discuss water quality considerations and establish coliform guidelines for the safe use of rainwater.

From a regulatory standpoint, the Texas Commission on Environmental Quality considers rainwater harvesting systems that provide water to individual homes to be similar to the regulatory status of private domestic wells that serve individual homes in Texas. There are no statutes or regulations at the state or federal level currently that regulate the potable and non-potable indoor uses of domestic well water systems. Therefore, the Texas Commission on Environmental Quality will also not regulate the potable and non-potable indoor use of rainwater systems in individual homes if those homes are not connected to any public water systems.

Minimum Water Quality Guidelines for Non-Potable Indoor Use of Rainwater (Residential and Commercial Facilities):

Typical non-potable indoor uses for rainwater would include washing clothes and flushing toilets. If a public water system is to be used as a back-up source of water, the non-potable rainwater must not be allowed to contaminate the public water supply. This can be accomplished by providing an air gap in the storage tank for the backup water supply. Alternately, a mechanical device referred to as a reduced pressure zone back flow preventer must be used. Chapter 5 will include a further discussion of the conjunctive use of rainwater with public water systems.

Even though bacterial contamination of water for indoor non-potable use is not as critical as that used for potable purposes, total coliform and fecal coliform sampling can be used to evaluate a general level of acceptable microbial contamination for non-potable water. The acceptable level of total coliform for non-potable water should be less than 500 cfu/100 ml, and fecal coliform levels should be less than 100 cfu/100ml. Testing is recommended on an annual basis (Lye, 2005).

Minimum Water Quality Guidelines for Potable Use of Rainwater (Residential):

In addition to drinking water, potable uses for harvested rainwater typically include shower or bath as well as kitchen uses, such as dishwashing and food preparation. Rainwater collected from roofs is not subject to the same level of contamination as surface water such as streams, rivers and lakes, but if it is to be used for potable purposes, it needs to be both microbiologically and chemically safe.

Rainwater for potable use should meet a higher level of requirements for turbidity and microbiology than non-potable rainwater. The presence of suspended material in water, such as finely divided organic material, plankton, clay, silt, and other inorganic material, is indicated through turbidity, measured as NTU (nephelometric turbidity units). High turbidity also interferes with disinfection. Turbidity in water from surface water sources is currently regulated by the Safe Drinking Water Act to be less than 1 NTU (AWWA, 2006). This same level of turbidity is recommended for rainwater used for potable purposes in private homes.

Filtration is essential to control particulates, and homeowners must be diligent in cleaning and changing their filters to ensure that turbidity levels are controlled. The filters need to be replaced regularly in accordance with manufacturers' recommendations. A further discussion of filtration and other treatment requirements will be presented in Chapter 4.

It is also important that the water be free of microbiological contaminants. Thus, both the total coliform and fecal coliform levels in treated rainwater for potable use should be maintained at zero. In addition, there should be no protozoan cysts (such as *Giardia Lamblia* and *Cryptosporidium*) and no viruses. Testing for total coliform and fecal coliform or e.coli at least on a quarterly basis will help monitor the water quality.

Minimum Water Quality Guidelines for Potable Use of Rainwater (Community and Public Water Systems)

State and federal drinking water regulations that apply to public water systems establish the "gold standard" for ensuring the safety of drinking water. A public water system is one that is defined as a water system that serves fifteen connections or 25 people for at least 60 days of the year. These are further broken down into community and non-community water systems. Community water systems are those that serve residential connections, whereas non-community water systems serve nonresidential connections, such as businesses, restaurants, highway rest areas, parks, churches, and schools.

It is necessary that rainwater for potable use in public water systems meet the same health protection goals as other sources of water used in public water systems. Potable rainwater systems that meet the definition of a public water system will be required to meet all applicable public water system regulations set by the Texas Commission on Environmental Quality, under Title 30, Texas Administrative Code, Chapter 290.

Federal and state standards have established a turbidity level of 0.3 NTU as the standard for potable water used in public water systems. The Texas Commission on Environmental Quality requires filtration to provide this same level of turbidity if the rainwater is used for public water supply. Turbidity needs to be monitored at least on a quarterly basis. Monthly monitoring of total coliforms and fecal coliforms is required to ensure that they are both absent in public water supplies. In addition, there should be no protozoan cysts (such as *Giardia Lamblia* and *Cryptosporidium*) and no viruses.

The regulations that apply to public water systems require extensive monitoring and require construction and operation practices as prescribed under the regulations. Those same standards would apply to any rainwater harvesting operation that provides water to a public water system. However, because of the unique characteristics of rainwater, alternate methods for meeting the filtration and disinfection requirements are acceptable, but must be approved under the Texas Commission on Environmental Quality's innovative/alternate treatment provisions under Title 30, Texas Administrative Code, Chapter 290.42(g).

Table 1 provides a summary of the minimum microbiological guidelines for indoor use of rainwater, both for private homes and for public water systems. In addition to testing for microbiological indicators, users of rainwater for potable purposes may have their water tested for possible chemical contaminants too, at many water testing laboratories.

Water Testing Laboratories

Water samples can be routinely analyzed at many health department, water utility, and river authority laboratories. However, not all of these entities perform analyses which enumerate the level of coliforms. Many labs only analyze for presence or absence of total coliforms and fecal coliforms. Laboratories that are accredited by the Texas Commission on Environmental Quality can be found on their website at:

http://www.tceq.state.tx.us/compliance/compliance_support/qa/env_lab_accreditation.html

Table 1. Minimum Water Quality Guidelines for Indoor Use of Rainwater

Category of Use	**Rainwater Quality for Non-Potable Indoor Use**	**Rainwater Quality for Potable Uses**
Single Family Households	Total Coliforms <500 cfu / 100 ml Fecal Coliforms <100 cfu / 100 ml Water testing recommended annually	Total Coliform - 0 Fecal Coliform - 0 Protozoan Cysts – 0 Viruses – 0 Turbidity < 1 NTU Water testing recommended every 3 months
Community or Public Water System	Total Coliforms <500 cfu/100 ml Fecal Coliforms <100 cfu/100 ml Water testing recommended annually	Total Coliform - 0 Fecal Coliform - 0 Protozoan Cysts - 0 Viruses - 0 Turbidity < 0.3 NTU Water testing **required** monthly *In addition, the water must meet all other public water supply regulations and water testing requirements per Texas Commission on Environmental Quality guidance document(s)**

* Please visit www.tceq.state.tx.us for more information.

Conclusions:

- Rainwater is not subject to the same level of contamination as surface water supplies, especially when proper care is taken during the rain harvesting process.
- The Texas Commission on Environmental Quality does not regulate the use of rainwater for indoor uses in private homes that use rainwater as their sole source of water supply (not connected to a public water system).
- For rainwater to be used indoors for non-potable purposes, total coliforms should be less than 500 cfu/100 ml and fecal coliforms should be less than 100 cfu/100 ml; testing is recommended on an annual basis.
- For potable use, rainwater should undergo adequate filtration to maintain turbidity below 1 NTU. A level not exceeding 0.3 NTU is required if the rainwater is used in conjunction with a community or public water system. In addition, proper disinfection is needed to maintain a level of zero coliforms and no *Giardia, Cryptosporidium,* or viruses.
- Water testing is recommended on a quarterly basis for individual residences, and monthly for community and public water systems. Public facilities providing rainwater for drinking will be subject to the same health protection goals and requirements as other public water systems.
- The Texas Commission on Environmental Quality will allow alternate methods of filtration and disinfection for rainwater systems under their innovative/alternate treatment methodologies.
- Water samples can be analyzed for microbiological and chemical contaminants at many health department, water utility, and river authority laboratories. Laboratories accredited by the Texas Commission on Environmental Quality for this analysis can be found on their website.

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Chapter 4 - Treatment Methods for Indoor Use of Rainwater

A number of steps can be taken to help ensure the successful use of rainwater for indoor purposes. First, any tree branches and vegetation that overhang roof surfaces should be removed so that contamination caused by birds and rodents on the branches is not washed down to the roof. Gutters may be screened or leaf-guards installed to prevent larger objects from washing down from the roof.

The impact of any impurities, such as dust and bird or animal droppings from the roof surface, can be minimized by using first-flush diverters that drain the first few gallons of water. As a rule of thumb, first-flush diverters should be capable of diverting at least 10 gallons per 1,000 square feet of roof area. A description of various types of first flush diverters and roof washers (pre-filters) is provided in Chapter 2 of the Texas Manual on Rainwater Harvesting (TWDB, 2005).

The manual can be accessed online at
http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf
or hard copies may be ordered from the TWDB, by calling (512) 463-7955.

The next step in the treatment process is filtering the water to remove fine particulates. The level of filtration and disinfection required for rainwater depends on the quality of the collected water and the purpose for which it will be used. In addition to filtration, rainwater for indoor use should undergo disinfection to remove any microorganisms.

Treatment Methods for Non-potable Indoor Use of Rainwater

Storage

After passing through the roof washer indicated above, rainwater for non-potable indoor uses may be stored in any leak-proof tank or cistern. Tanks should be kept tightly covered to inhibit mosquitoes and keep out other contaminants, and protected from light to control the growth of algae, and to. A more complete discussion of storage tanks is provided in the Texas Manual on Rainwater Harvesting (TWDB, 2005).

Filtration

Cartridge filters may be placed on the discharge side of the pump, which provides pressure to the plumbing system. To ensure adequate flow and pressure of the water supply, the filters need to be sized to the intended use of the water. A number of different filters can be used to provide the particulate removal necessary to address adequately non-potable water uses. In general, a nominal 5 micron (um) filter is sufficient for non-potable indoor uses. Filters of different sizes and from numerous manufacturers are commercially available. The Texas Rainwater Harvesting Evaluation Committee recommends the use of filters certified by the National Sanitation Foundation (NSF).

Disinfection

Disinfecting non-potable rainwater for indoor use is desirable to control microbial growth which could cause fouling and affect the operation of plumbng fixtures. Disinfection can be accomplished by passing the water through ultraviolet light or by treating it with chlorine. Chlorination may be accomplished simply by adding bleach to storage tanks or cisterns on a regular basis. Readily available household bleach (6 percent sodium hypochlorite) may be applied to the cistern at the rate of 2 fluid ounces per 1,000 gallons of water to achieve disinfection. Alternatively, in-line disinfection using bleach can be accomplished by using an injection pump to dose the water and maintain a level of 0.2 parts per million of chlorine residual.

Treatment Methods for Potable Use of Rainwater

Harvested rainwater that is intended for potable use requires a higher level of treatment than that for non-potable uses. In addition, an extra measure of diligence is necessary to maintain the safety of the harvested rainwater during storage, filtration, and disinfection.

Storage

After the rainwater is pre-filtered through appropriate first-flush diverters and/or roof washers, it should be stored in a leak-proof tank or cistern that has been approved for potable use by the Food and Drug Administration, National Sanitation Foundation, or the U.S. Department of Agriculture. The storage tank must be kept tightly covered, properly vented, and protected from light to control the growth of algae and keep out contaminants. Additional discussion of storage tanks is available in the Texas Manual on Rainwater Harvesting (TWDB, 2005).

Filtration

Cartridge filters may be placed on the discharge side of the pump, which provides pressure to the plumbing system. A number of different kinds of filters can be used to provide the particulate removal necessary to adequately address potable water uses. A filter that is capable of removing at least 99 percent of the particles that are 3 microns or larger in diameter is recommended for potable water that is free of protozoan pathogens, and particles that may be harboring smaller microbes or that may interfere with the disinfection process. If necessary, an activated charcoal filter may also be added to improve the taste of drinking water. Filters of different sizes and types from several manufacturers are commercially available, but those certified by the National Sanitation Foundation are recommended.

Disinfection

Disinfecting potable harvested rainwater is necessary to inactivate potentially pathogenic microorganisms that are not physically removed by filtration. Readily available sodium hypochlorite bleach may be used for disinfection. In order to ensure that disinfection is taking place and that there is enough chlorine in the system, a chlorine residual of at least 0.2 mg/l must be maintained at all times in the distribution system. Chlorine residuals can be easily measured using a test kit. Because chlorine does not kill *Giardia* or *Cryptosporidium*, a cartridge or membrane filter (that removes at least 99 percent of the particles which are 3 microns are larger in diameter) is preferred, followed by ultraviolet light for disinfection.

Ultraviolet Disinfection

Ultraviolet disinfection has been used in the water and wastewater industry for many years in Europe. However, regulatory recognition of ultraviolet disinfection was accorded in the United States only recently by the Environmental Protection Agency's adoption of the Long Term Phase 2 Enhanced Surface Water Treatment Rule (LT2). This rule has established the benchmark for the use of ultraviolet light for disinfecting drinking water.

Previously an ultraviolet dose capable of producing an energy of at least 40,000 uwsec/cm2 (40 mJ/cm2) was recognized, based on a National Sanitation Foundation recommendation that was consistent with European standards for inactivating bacteria, parasitic cysts, and most viruses. Because some viruses, such as adenovirus, an agent in gastrointestinal illnesses in children, are more resistant due to the virus' double-stranded DNA, the Environmental Protection Agency is considering a higher ultraviolet dose of 186 mJ/cm2 to inactivate these viruses also. Current or new rainwater harvesting ultraviolet systems will be able to increase the ultraviolet dose by increasing the number of lamps and/or exposure time within their system, or by pre-treating with chlorine. Increased ultraviolet dosage, regular inspection, and certification for the new standard is recommended for small rainwater harvesting systems that are used for potable purposes, or for any larger public water system where ultraviolet is used as a disinfectant in place of chlorine.

The recommended treatment methods for potable and non-potable indoor uses of rainwater are shown in Table 2.

Table 2. Recommended Treatment Methods for Indoor Use of Rainwater

Treatment Methods for Non-Potable Indoor Use of Rainwater	**Treatment Methods for Potable Use of Rainwater**
<u>Pre-filtration</u> First flush, roof washer, and/or other appropriate pre-filtration method <u>Cartridge Filtration</u> 5 micron sediment filter <u>Disinfection</u> Chlorination with household bleach or Ultraviolet light	<u>Pre-filtration</u> First flush, roof washer, and/or other appropriate pre-filtration method <u>Storage</u> Storage of rainwater only in tanks or cisterns approved for potable use <u>Cartridge Filtration</u> 3 micron sediment filter, followed by a 3 micron activated carbon filter <u>Disinfection</u> A chlorine residual of at least 0.2 parts per million maintained in the distribution system at all times Or Ultraviolet light for disinfection with a dosage of 186 mJ/cm2 for virus inactivation *(Refer to the Texas Commission on Environmental Quality Guidance Documents for details)**

*Please visit www.tceq.state.tx.us for more information.

Conclusions:

- A number of precautionary steps can reduce contamination of rainwater even before it is collected in tanks or cisterns.
- A first-flush roof washer or other appropriate pre-filtration is recommended prior to storing rainwater in a tank or cistern.
- For non-potable indoor uses, a 5 micron filter may be used, followed by chlorination with bleach at the rate of 2 ounces per 1,000 gallons of water.
- For potable indoor uses, only tanks/cisterns and cistern liners that are approved for potable use by the Food and Drug Administration, Environmental Protection Agency, or National Sanitation Foundation should be used.
- For potable indoor uses, a 3 micron filter is recommended, followed by ultraviolet disinfection to inactivate bacteria, parasitic cysts, and most viruses.

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Chapter 5 - Using Rainwater Harvesting Systems in Conjunction with Public Water Systems

House Bill 2430 required the Texas Rainwater Harvesting Evaluation Committee to recommend ways such as dual plumbing systems, to use rainwater harvesting systems in conjunction with existing municipal water systems. The terms 'municipal water systems' and 'public water systems' are used synonymously in this report.

There are currently several examples in Texas where rainwater is being used in combination with public water systems for landscape irrigation, such as the Lady Bird Johnson Wildflower Research Center and the Wells Branch Municipal Utility District Office in Austin. Other examples include: the Hays and Kerrville County Extension offices in San Marcos and Kerrville, respectively; the New Braunfels Municipal Building; the Van Horn Courthouse; the Edwards Aquifer Authority Office in San Antonio; the Paint Rock High School in Paint Rock; and the Menard Grade School in Menard, Texas.

Rainwater is also being used in conjunction with public water systems for non-potable indoor uses. The J.J. Pickle Elementary School in Austin uses rainwater collected from its rooftop to provide cooling water for the air-conditioning system. The Austin Resource Center for the Homeless is using rainwater for toilet flushing, and the Lower Colorado River Authority is currently constructing an office building in Austin that will collect and use rainwater for toilet flushing and irrigation.

Other communities around the country are also using rainwater systems along with public water systems. For example, Portland, Oregon, the State of Washington, Santa Fe, New Mexico, and Tucson, Arizona, have included various requirements relating to rainwater use in their codes and guidelines.

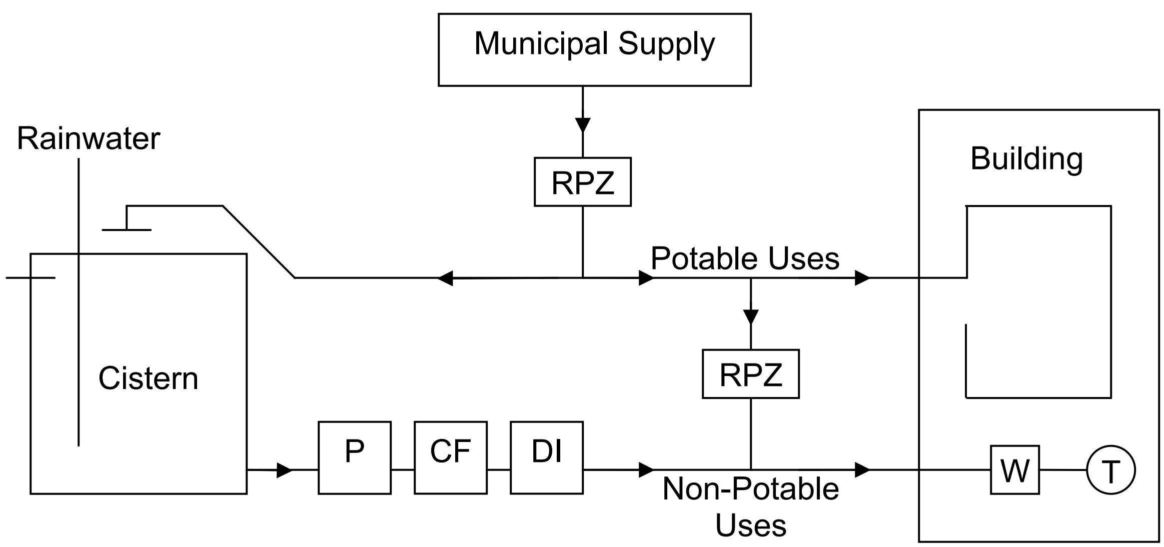
Rainwater harvesting systems are being used in Europe, Asia, Australia, and in the Caribbean. Germany has been a leader in promoting the widespread use of rainwater for domestic use, focusing mainly on non-potable uses such as irrigation, toilet flushing, and laundry use. France has recently enacted legislation to encourage the use of rainwater through tax credits. In New South Wales, Australia, the government is requiring a 40 percent reduction in water use, and some studies have shown that rainwater harvesting systems can reduce municipal water demand there significantly (Coombes, 2004). The U.S. Virgin Islands, the Bahamas, Bermuda, and other Caribbean islands, require cisterns to be included with all new construction.

There are numerous other examples around the world where rainwater harvesting is being promoted to conserve water and help reduce the demand on municipal water systems. Rainwater harvesting systems benefit both the public water systems and the homeowners.

The Texas Rainwater Harvesting Evaluation Committee believes that this is a great opportunity for Texas to take a lead in promoting rainwater harvesting systems in conjunction with existing public water systems, not only for residential purposes, but also for commercial and industrial applications. The hotel industry for example, can save a significant amount of water and money if they use rainwater for their laundry.

The Texas Rainwater Harvesting Evaluation Committee recommends that when used in conjunction with public water systems, harvested rainwater be used for outdoor (landscape) watering and indoor non-potable uses such as washing machines and toilets.

Toilets and washing machines consume about 40 percent of the water that is used inside the home (Vickers, 2001). If those two uses can be served with rainwater, a significant saving will result to the homeowner. It will also help utilities delay expansion of their water treatment facilities if rainwater can serve as a supplementary source. A typical schematic recommended for rainwater used in conjunction with a public water supply is shown below:



P=Pump; CF=Cartridge Filtration; DI = Disinfection; W=Washing Machine; T=Toilets;
RPZ = Reduced Pressure Zone Back Flow Preventer.

Figure 4. A schematic showing the conjunctive use of public water systems for potable uses, and rainwater for non-potable uses (washing machines and toilets).

Public water systems serve as a backup source for the cistern, with an air gap to prevent any cross-contamination. If at any time the cistern, pump, or other equipment becomes nonfunctional, the public water system could also serve the non-potable needs through a reduced pressure zone back-flow preventer valve.

A dual plumbing system used for rainwater harvesting in conjunction with a public water system in Australia is shown in Figure 5. To meet Texas standards however, such a system would be required to have a reduced pressure zone back flow preventer at the meter, and an air gap for public water supply entry into the storage tank.

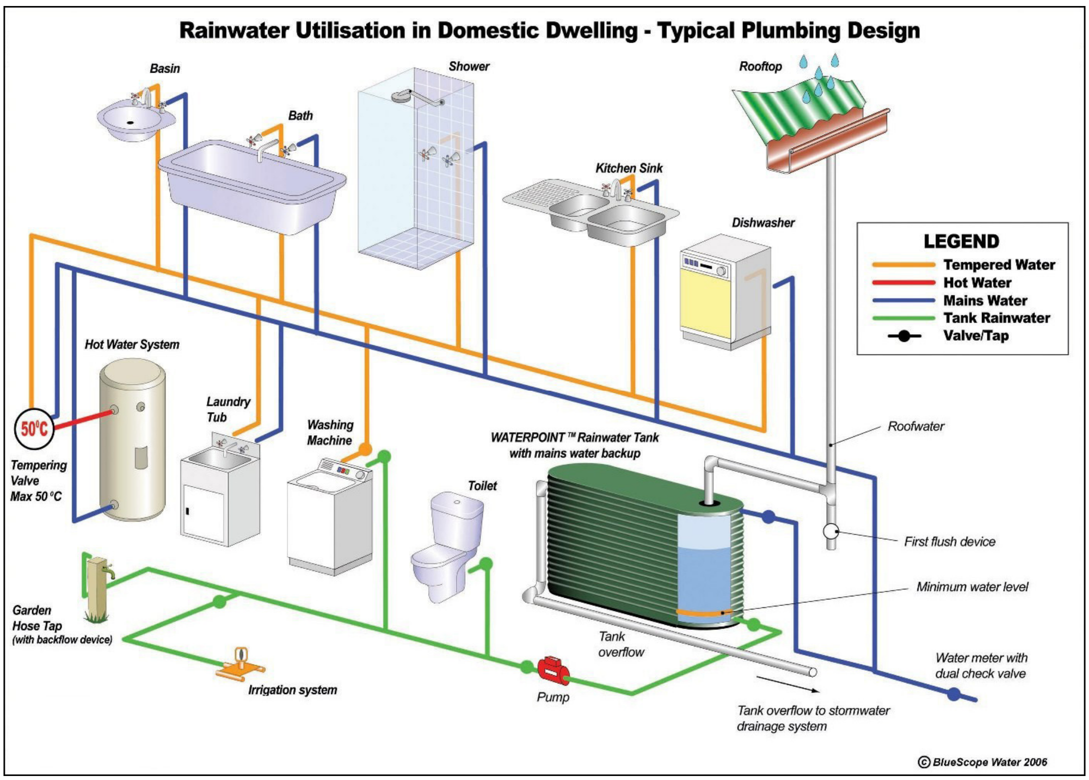


Figure 5. An example of a dual plumbing system used in Australia.

Rainwater System Components Used in Conjunction with a Public Water System

The system components being recommended in this report are consistent with state rules and recommendations to ensure the public's health and safety.

The guidelines for roof washers, cisterns, and water treatment found in Chapters 3 and 4 of this report should be met for any system that is using rainwater conjunctively with a public water supply. In addition, several system components must be addressed to protect both individual occupants and the public water system from contamination, including proper cross-connection control, system marking, and system maintenance.

Protection from Cross-Contamination

To keep rainwater from entering the public water system due to a drop in pressure in the utility's distribution system, an appropriate backflow prevention device or air gap should be used. This recommendation is based on the Texas Commission on Environmental Quality's rules for public drinking water systems that allow either an air gap or backflow prevention assembly, depending upon the type of potential hazard (Title 20, Texas Administrative Code, Chapter 290.44(h)).

Where non-potable rainwater pipe and public water system pipe are installed in the same trench, wall cavity, or other enclosed area, the pipes should be separated in accordance with local codes.

Pump

If a pump is used for rainwater in conjunction with a public water system, it is recommended that the pump and all other pump components be listed and approved for use with potable water systems. The pump should be capable of delivering a minimum residual pressure of 35 pounds per square inch, which is required by the Texas Commission on Environmental Quality rules (30 TAC Chapter 290.44(d)).

Piping and Labeling

If a rainwater harvesting system is used in conjunction with a public water system at any facility, the Texas Rainwater Harvesting Evaluation Committee recommends that the rainwater pipe be labeled for non-potable uses. The pipe should be painted in black lettering “RAINWATER – DO NOT DRINK” on a bright orange background. The lettering should be in bold and clearly visible. The label should be painted at two-foot intervals throughout the length of the pipe. If rainwater is mixed with other sources, such as air conditioning condensate or reclaimed water, purple pipe should be used.

Every toilet, urinal, hose bib, irrigation outlet, or other fixture that uses rainwater should be permanently identified as non-potable rainwater by the above labeling.

The pipe materials should meet the standards for domestic water. Fittings and other system components should be listed for use in residential construction. Both piping and fittings, as well as any other product used for the system, should be installed as required by applicable federal and state codes and standards.

Public Water System Issues

Public water system customers that also have rainwater harvesting systems must install a reduced pressure zone backflow preventer at the service meter. The public water system should also require the customer to meet all applicable health and safety standards per building and plumbing codes and provide a signed contract stating that all plumbing code requirements have been met. In addition, rainwater harvesting systems that are used in conjunction with a public water system should be recorded in the billing system. If the owner of a rainwater harvesting system either stops using or fails to maintain the system properly in accordance with public water system standards, the public water system should require that the rainwater harvesting system be abandoned, and this should be recorded in the public water system billing system.

The public water system operators should be knowledgeable about rainwater systems. While there are currently no licensing and certifications for rainwater system maintenance, it is recommended that the operators take any future training that becomes available regarding rainwater harvesting.

Codes and Regulatory Issues

The Texas State Board of Plumbing Examiners governs plumbing regulations for municipalities in Texas. Most communities follow one of two national plumbing codes - either the Uniform Plumbing Code or the International Plumbing Code. Rainwater harvesting is currently not addressed in either code.

Section 341.034 of the Texas Health and Safety Code regulates licensing and registration of persons who perform duties relating to public water systems, including backflow prevention and cross connection. The current training conducted by the Texas State Board of Plumbing Examiners for licensed plumbers and water utility operators does not include information regarding rainwater systems. Plumbers must complete six hours of continuing education credits every year to maintain their license, and rainwater harvesting systems should be included in their continuing education courses. Also, a rainwater harvesting component should be included in the Texas State Board of Plumbing Examiner's current “water supply protection endorsement”.

It is recommended that the state develop a certification program for consultants and contractors to properly design, install, and maintain rainwater harvesting systems. In addition to rainwater harvesting system design, this program needs to include some basic knowledge of plumbing and public water system requirements.

Finally, it is recommended that training on rainwater harvesting systems be added to the current training for city permitting staff, building inspectors, plumbers, and water utility operators.

Conclusions:

- Rainwater harvesting systems are already being used in conjunction with municipal or public water systems in other parts of the country, in Europe, Asia, and Australia.
- The Texas Rainwater Harvesting Evaluation Committee recommends that when used in conjunction with public water systems, rainwater be used for landscape watering and non-potable indoor uses only, such as washing clothes and toilet flushing.
- Toilets and washing machines consume about 40 percent of indoor water use, so if rainwater could be used for those purposes, it would constitute a significant saving to homeowners.
- Rainwater harvesting systems can help cities conserve water and possibly assist in delaying the expansion of their water treatment systems.
- Rainwater harvesting systems can help reduce peak discharge to storm sewers, especially during high-intensity storms.
- Rainwater harvesting systems can save the hotel industry a significant amount of money, if they use rainwater for their daily laundry requirements.
- Rainwater harvesting systems may be used in conjunction with public water supplies, if a reduced pressure zone back flow preventer is installed or an air gap maintained to prevent rainwater from coming into contact with public water systems.
- If a facility uses rainwater in combination with water from a public water system, the pipes and fixtures for conveying the rainwater should be labeled in a bright orange color, as explained in this report.
- If rainwater harvesting systems are used in conjunction with public water systems, the installers of such systems need to be certified or licensed.
- Rainwater harvesting system recommendations should be incorporated in all city building and plumbing codes.

Chapter 6 - Recommendations for Promoting Rainwater Harvesting in Texas

House Bill 2430 required the Texas Rainwater Harvesting Evaluation Committee to recommend ways in which the state can further promote rainwater harvesting. Members of this committee evaluated various aspects of rainwater harvesting systems and public water systems in developing these recommendations.

In addition, Texas members of the American Rainwater Catchment Systems Association were contacted to provide their suggestions as well. All suggestions and recommendations were evaluated and the following 10 key recommendations were selected (also included in the Executive Summary):

Key recommendations:

1. Directing new state facilities with 10,000 square feet or greater in roof area (and smaller facilities, when feasible), to incorporate rainwater harvesting systems into their design and construction. Harvested rainwater at these locations may be used for restroom facilities and/or landscape watering.

2. Developing incentive programs to encourage the incorporation of rainwater harvesting systems into the design and construction of new residential, commercial, and industrial facilities in the state.

3. Considering a biennial appropriation of $500,000 to the TWDB to help provide matching grants for rainwater harvesting demonstration projects across the state.

4. Directing the Texas Commission on Environmental Quality and other state agencies to continue to exempt homes that use rainwater harvesting as their sole source of water supply from water quality regulations that may be required of public water systems. Guidelines are provided in this report to assist homeowners in improving and maintaining the quality of rainwater for indoor uses.

5. Directing the Texas Commission on Environmental Quality and other state agencies to require those facilities that use both public water supplies and harvested rainwater for indoor purposes to have appropriate cross-connection safeguards, and to use the rainwater only for non-potable indoor purposes.

6. Appropriating $250,000 to the Texas Department of State Health Services to conduct a public health epidemiologic field and laboratory study to assess the pre- and post-treatment water quality from different types of rainwater harvesting systems in Texas, and to submit a report of findings to the next session of the legislature.

7. Directing Texas cities to enact ordinances requiring their permitting staff and building inspectors to become more knowledgeable about rainwater harvesting systems, and permit such systems in homes and other buildings, when properly designed.

8. Directing a cooperative effort by the Texas Commission on Environmental Quality and the Texas State Board of Plumbing Examiners to develop a certification program on rainwater harvesting and provide associated training in their continuing education programs.

9. Directing Texas Cooperative Extension to expand their training and information dissemination programs to include rainwater harvesting for indoor uses.

10. Encouraging Texas institutions of higher education and technical colleges to develop curricula and provide instruction on rainwater harvesting technology.

In addition to the above key recommendations, several other suggestions were submitted to and considered by the Texas Rainwater Harvesting Evaluation Committee; they are included as an appendix to this report.

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Appendix
Other Suggestions for Promoting Rainwater Harvesting

The following suggestions were submitted to and considered by the Texas Rainwater Harvesting Evaluation Committee:

1. Design and installation specifications for rainwater harvesting systems should be developed by state agencies, and included in the Texas Building Code and Energy Performance Standards.

2. The Texas Department of Transportation and the Texas Parks and Wildlife Department should consider rainwater harvesting for toilet flushing and/or landscape use at highway rest areas and state parks.

3. Under Senate Bill 2, passed in 2001, all local taxing entities in Texas should consider providing blanket exemption on the cost of rainwater harvesting equipment from being added to the value of any commercial, industrial, or residential property for property tax assessment.

4. All cities and local taxing entities should consider amending their land development regulations to exempt roof areas used for rainwater harvesting from being considered as impervious cover.

5. Cities, local communities, and Texas Cooperative Extension should provide more publicity on the sales tax exemption for rainwater harvesting equipment and supplies found in Tax Code Section 151.355.

6. Cities should organize local meetings and workshops to bring together their permitting staff, architects, engineers, builders, and mortgage lenders so that a communitywide effort can be made to promote rainwater harvesting for commercial, industrial and residential applications.

7. Regional water planners should give greater consideration to using rainwater harvesting as a source of alternate water supply.

8. Local economic development corporations in Texas should consider including rainwater harvesting projects for funding eligibility.

9. Cities should recognize and provide awards to local facilities that use the best rainwater harvesting techniques, in order to encourage others to practice rainwater harvesting.

Acknowledgements

The Texas Rainwater Harvesting Evaluation Committee wishes to acknowledge the assistance of the following Texas Water Development Board staff during the preparation of this report: Kevin Kluge, Yun-Jeong Cho, Mark Hayes, Miguel Pavon, and Felicia Retiz.

The committee greatly appreciates the technical material from Dr. Dennis Lye (U.S. Environmental Protection Agency, Cincinnati, OH), Dr. Peter Coombes (Australia), and Klaus Konig (Germany). The committee also appreciates the cooperation of Pioneer Water Tanks ~ a BlueScope Water Company in allowing us the use of their schematic to illustrate a dual plumbing system in Australia.

A draft of this report was reviewed by Bill Mullican, Jorge Arroyo, John Sutton, Dr. Sanjeev Kalaswad and Ruben Ochoa at the Texas Water Development Board, and by Patricia Macomber at the University of Hawaii, all of whom provided many useful comments.

The committee appreciates very much the information provided by the resource persons listed on the next page of this report, and the comments provided by Dr. Casey Barton, Billy Kniffen (Texas cooperative Extension), Dana Nichols (San Antonio Water System), Lisa Hill (Texas State Board of Plumbing Examiners), Dan McNabb and Danny Lytle (both from City of Austin), and Joseph Wheeler (Rainfilters of Texas, LLC).

During the public comment period, 30 comments were received and reviewed by the committee. We wish to thank all those who submitted their comments to us on the draft report.

Texas Rainwater Harvesting Evaluation Committee
Austin, Texas

November 2006

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Texas Rainwater Harvesting Evaluation Committee

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