TEXAS GUIDE TO RAINWATER HARVESTING

Texas Water Development Board
in Cooperation with the
Center for Maximum Potential Building Systems

Second Edition

1997
AUSTIN, TEXAS

SECOND EDITION ACKNOWLEDGMENTS

This is the second edition of this publication. In this edition, the staff of the Texas Water Development Board have added several significant new pieces of information and have modified others as more information becomes available in this rapidly changing field. This has resulted in a text which differs somewhat from the original text written by the Center for Maximum Potential Building Systems. As new information becomes available, the Board staff will make appropriate changes in future additions as time and funds permit. In addition to the recognition of contributors presented in the original acknowledgment below, the Texas Water Development Board staff would like to recognize Matthew Bachardy, Harley and Pam Rose, Peter Pfeiffer, Kate Houser, Duncan Echelson, Jeff Reich, and others who helped contribute to the second edition's technical content.

ORIGINAL ACKNOWLEDGMENTS

The *Texas Guide to Rainwater Harvesting* was developed by the Center for Maximum Potential Building Systems, Austin, Texas, under the direction of Gail Vittori, with funds provided by the Texas Water Development Board Contract #95-483-136. The *Guide* was researched and written by Wendy Price Todd, AIA and Gail Vittori, and edited by Bill Hoffman, P.E., Ken Heroy and Janie Hopkins. Graphic design and production was provided by Worldwise Design Creative Director Harrison Saunders. Spanish translation by Cristina Villarreal.

The Center for Maximum Potential Building Systems, established in 1975 and based in Austin, Texas, is a non-profit education, research, and demonstration organization dedicated to sustainable planning, design and development. For more information on the Center's activities, contact us at 8604 F.M. 969, Austin, TX 78724, 512-928-4786.

The authors would like to thank the following agencies and individuals for their valuable assistance: Laurence Doxsey, City of Austin Green Builder Program; Marcia Roberts, Lower Colorado River Authority; Mike McElveen; Mary Sanger, Texas Center for Policy Studies; Hugo Gardea, Texas Historical Commission; Ron Bearden and Wendi White, Texas Natural Resource Conservation Commission; Dennis J. Lye, U.S. Environmental Protection Agency; Yu-Si Fok, University of Hawaii; Phillip S. McClay, Water Filtration Company; Joe Henderson, Water Quality Association; the contractors listed in the Resource section; and the participants in the Case Studies.

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IS RAINWATER HARVESTING FOR YOU?

The *Texas Guide to Rainwater Harvesting* is a primer of the basic principles of captured rainfall, with an emphasis on residential and small-scale commercial applications. If you are considering rainwater harvesting as a partial or total source of your water supply for new construction or remodeling, this *Guide* and accompanying videotape provide the essential information to enable you to design a system that meets your needs.

Most Texans have not had to operate their own water system. Your utility has done that for you. If you plan to use a rainwater harvesting system for your source of drinking water and for other direct human purposes, you must be willing to make a commitment to its long term, proper operation and maintenance, or you could endanger your family's and friends' health. Your local health department and city building code officer should also be consulted concerning safe, sanitary operations and construction of these systems.

As you read this manual, seriously consider what you want your system to do and how you will provide back-up water if you are designing the system as a supplemental water source, or in the event of severe drought. The case studies, covering several dozen installations operating in Texas, provide an excellent snapshot of current systems.

What makes rainwater harvesting the preferred water source for some Texans today? While large, sophisticated systems are not cheap, some Texans have devised innovative approaches that are both effective and affordable. Rainwater catchment systems provide a source of soft, high quality water, reduce reliance on wells and other water sources, and, in many contexts, are cost-effective. Systems can range in size from a simple rain barrel to a contractor designed and built system costing thousands of dollars. However, rainwater harvesting systems are inherently simple in form, and can often be assembled with readily available materials by owner-builders with a basic understanding of plumbing and construction skills. If you plan to use the water for human consumption, it is wise to consult or employ experts. Texans with the time and the inclination to build their own system can save a significant portion of costs associated with labor. Regardless of whether you intend to hire a contractor or build a system yourself, we recommend that you read through the entire manual before starting a catchment system of your own.

INTRODUCTION

For centuries in Texas and throughout the world, people have relied on rainwater harvesting to supply water for household, landscape, livestock, and agricultural uses. Before large, centralized water supply systems were developed, rainwater was collected from a variety of surfaces—most commonly roofs—and stored on site in tanks known as cisterns. With the advent of large, reliable community treatment and distribution systems and more affordable well drilling equipment, rain harvesting systems have been all but forgotten, even though they offer a source of pure, soft, low sodium water. A renewed interest in this time-honored approach has emerged in Texas and elsewhere due to:

- the escalating environmental and economic costs of providing water by centralized water systems or by well drilling;
- health concerns regarding the source and treatment of polluted waters;
- a perception that there are cost efficiencies associated with reliance on rainwater.

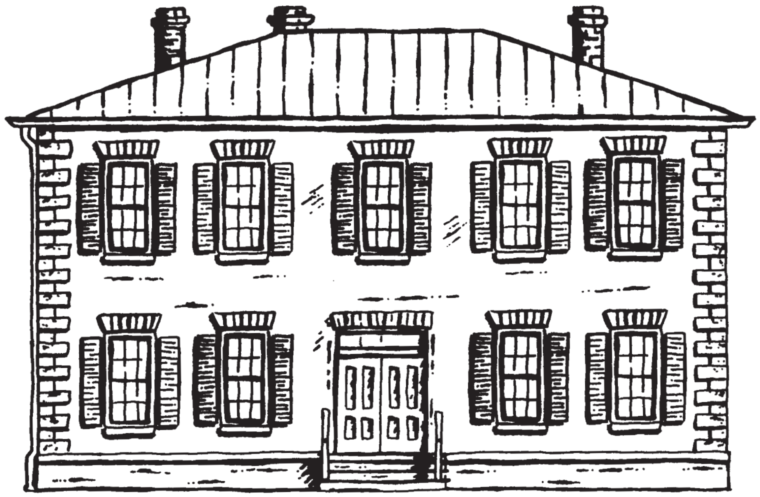
From rock cisterns to hollowed out tree trunks, historical precedents abound that trace people's reliance on rainwater collection. The Hueco Tanks in west Texas are natural rock basins that trapped rainwater for the native dwellers, from the archaic hunters to the Mescalero Apaches, and later became a stopping point for stagecoach travelers. In south Texas and the Rio Grande Valley, central plazas were often not only the place where the townspeople congregated for social affairs, but also were the collection surfaces for vast underground tanks that collected and stored water for use by adjacent shops and homes. Such notable historic structures as the Stillman House in Brownsville, the Fulton Mansion near Rockport, the Freeman Plantation near Palestine and the Carrington-Couvert House in Austin collected rain from their roofs, and then guttered and piped the water into an above-ground tank or cellar cistern. While many of these systems are no longer in use, they signify the importance that early Texas settlers placed on captured rainfall for sustenance.

Today, island states such as Hawaii and entire continents such as Australia promote rainwater harvesting as the principal means of supplying household water. In Bermuda, the U.S. Virgin Islands and other Caribbean islands where rainwater is the most viable water supply option, public buildings, private houses, and resorts collect and store rainwater. And in Hong Kong, skyscrapers collect and store rainwater to supply the buildings' water requirements.

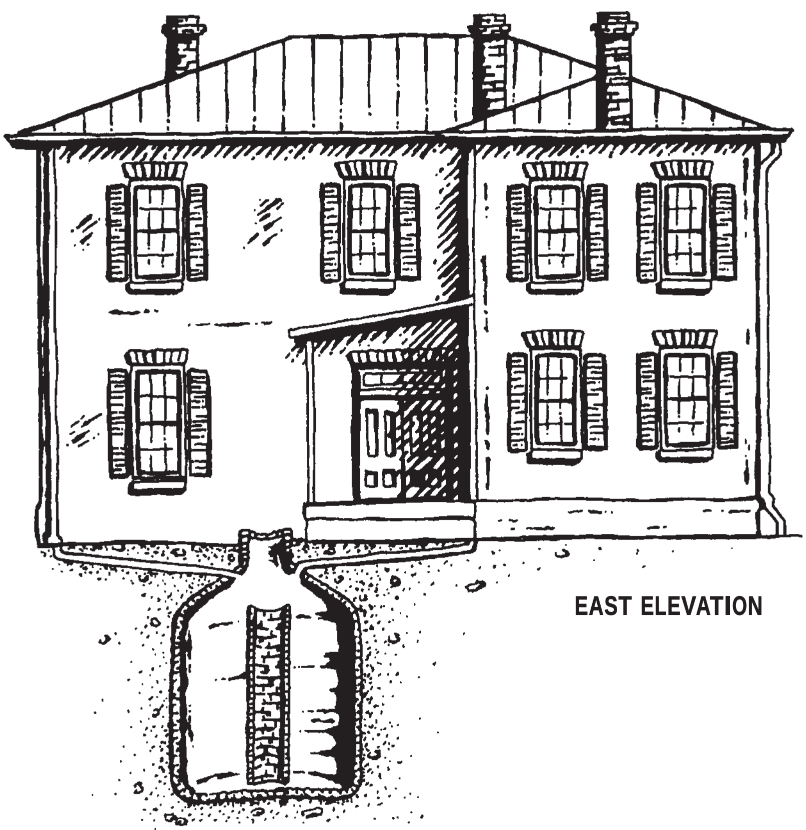
As with other natural systems, rainfall maintains its own cycles and patterns as evidenced by the severe droughts that devastated the Texas landscape in the 1950's, as well as the floods of 1981 and 1993 that ravaged east, south, and central Texas. These extremes underscore the importance of designing your rainwater catchment system with a thorough understanding of the basic principles and essential information contained in this Guide.

As you will see in the following pages, many Texans today are putting their dollars behind a life-long investment in a rainwater harvesting system over other options. A decision to reduce household water consumption to live within your means is a commitment that may not be for everyone, but it may be for you.

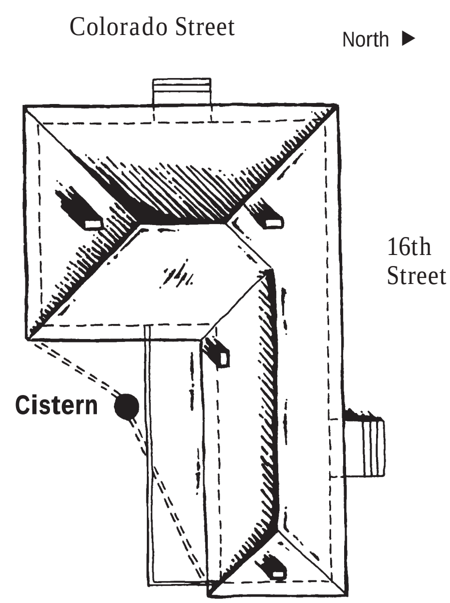
THE CARRINGTON-COUVERT HOUSE
(1857)
Colorado Street, Austin, Texas



WEST ELEVATION



EAST ELEVATION

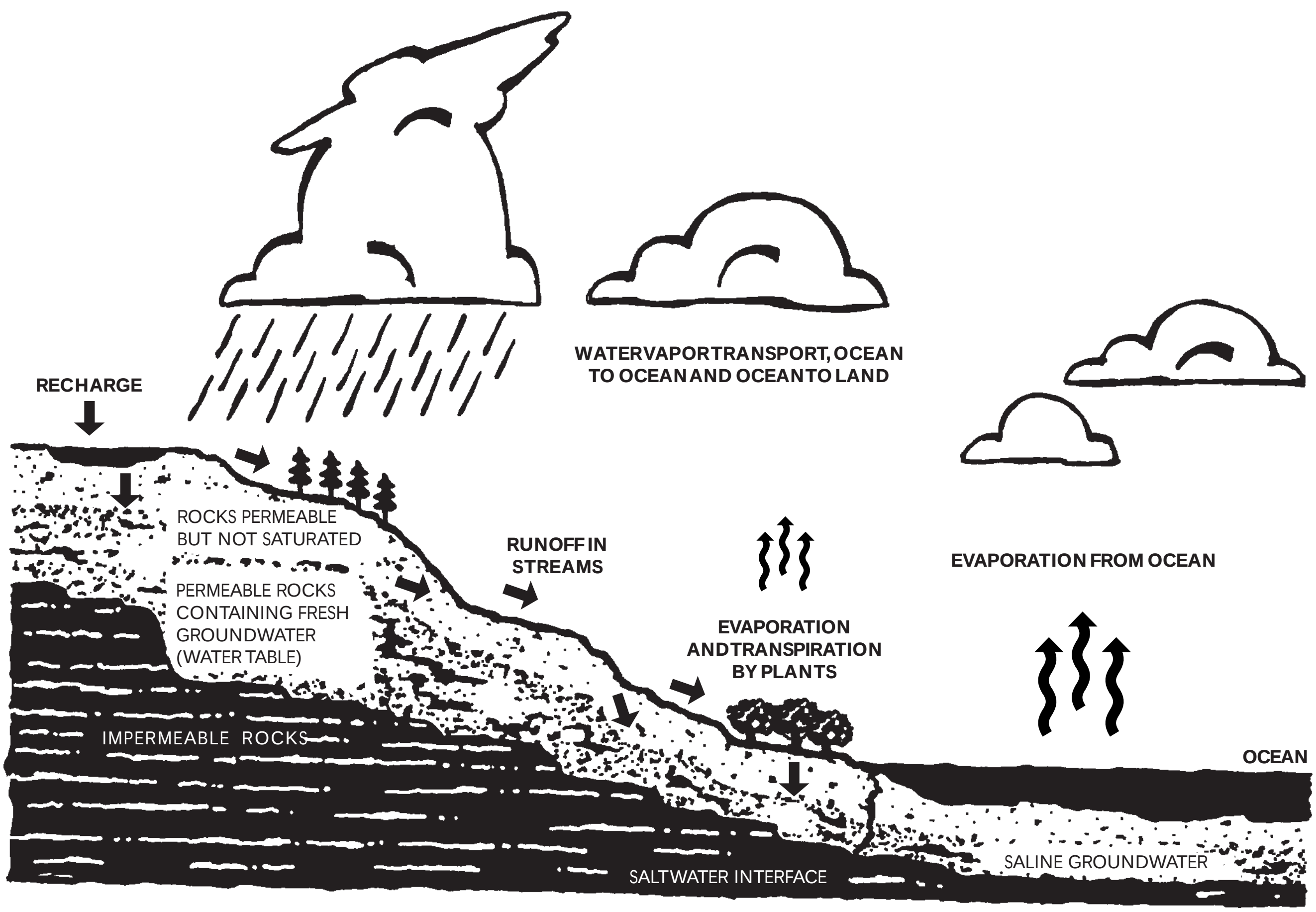


ROOF PLAN

I. THE WATER CYCLE

The never-ending exchange of water from the atmosphere to the oceans and back again is known as the hydrologic cycle. This cycle is the source of all forms of precipitation (hail, rain, sleet, and snow), and thus of all water. Precipitation stored in streams, lakes, and soil evaporates while water stored in plants transpires to form clouds which store the water in the atmosphere.

Currently, about 75% to 80% of conventional water supplies from lakes, rivers, and wells are developed and in use in Texas. Making the most efficient use of our State's limited and precious resources is essential. This includes using appliances and plumbing fixtures that conserve water, not wasting water, and taking advantage of alternative water sources such as greywater reuse and rainwater harvesting.



II. ADVANTAGES OF RAINWATER

For some Texans, rainwater's environmental advantages and purity over other water options make it their top choice, even with their knowledge that precipitation cycles can fluctuate from year to year.

ENVIRONMENTAL ADVANTAGES

Collecting the rain that falls on a building to be used nearby is a simple concept. Since the rain you harvest is independent of any centralized system, you are promoting self-sufficiency and helping to foster an appreciation for this essential and precious resource. Collecting rainwater is not only water conserving, it is also energy conserving since the energy input required to operate a centralized water system designed to treat and pump water over a vast service area is bypassed. Rainwater harvesting also lessens local erosion and flooding caused by runoff from impervious cover such as pavement and roofs, as some rain is instead captured and stored. 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. Policymakers may wish to reconsider present assumptions regarding impervious cover and consequent run-off management strategies when rainwater harvesting systems are installed.

QUALITATIVE ADVANTAGES

A compelling advantage of rainwater over other water sources is that it is one of the purest sources of water available. Indeed, the quality of rainwater is an overriding incentive for people to choose rainwater as their primary water source, or for specific uses such as watering houseplants and gardens. Rainwater quality almost always exceeds that of ground or surface waters: it does not come into contact with soil and rocks where it dissolves salts and minerals, and it is not subject to many of the pollutants that often are discharged into surface waters such as rivers, and which can contaminate groundwater. However, rainwater quality can be influenced by where it falls, since localized industrial emissions affect its purity. Thus, rainwater falling in non-industrialized areas can be superior to that in cities dominated by heavy industry, or in agricultural regions where crop dusting is prevalent.

Rainwater is soft and can significantly reduce the quantity of detergents and soaps needed for cleaning, as compared to typical municipal tap water. Additionally, soap scum and hardness deposits disappear, and the need for a water softener, often an expensive requirement for well water systems, is eliminated. Water heaters and pipes will be free of deposits caused by hard water and should last longer. Rainwater's purity also makes it an attractive water source for certain industries for which pure water is a requirement. Thus, industries such as computer microchip manufacturing and photographic processing may also wish to examine this source of water.

III. WATER QUALITY CONSIDERATIONS

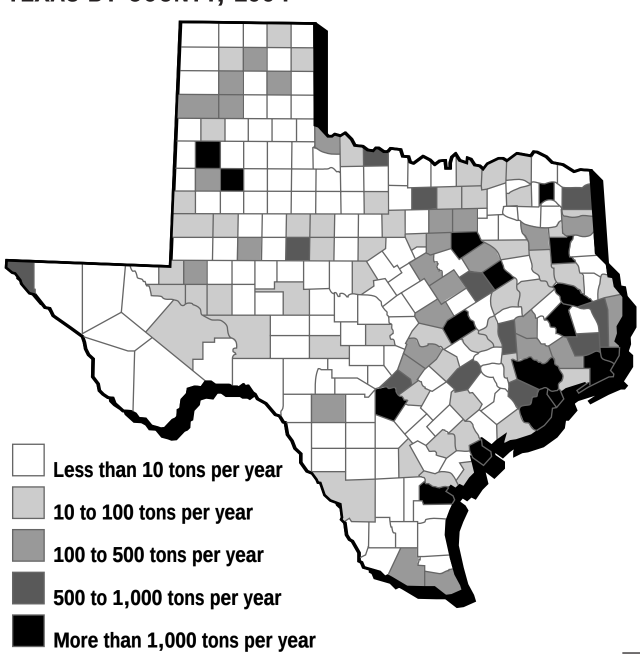
People who relied on rainwater systems 30 to 40 years ago may well recall contamination as a serious concern. Because the construction methods and materials used to build many of the rural cisterns were not in compliance with today's standards, and because of inadequate treatment procedures, illnesses associated with drinking unhealthful water were not uncommon. However, rainwater can provide clean, safe, and reliable water so long as the collection systems are properly built and maintained, and the water is treated appropriately for intended uses.

PRIMARY WATER QUALITY CRITERIA – HEALTH CONCERNS

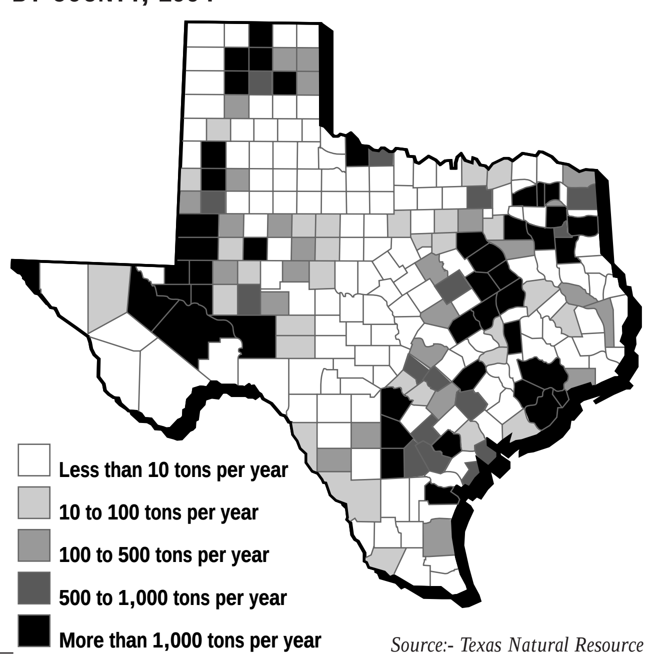
Once rain comes in contact with a roof or collection surface, it can wash many types of bacteria, molds, algae, protozoa and other contaminants into the cistern or storage tank. Indeed, some samples of harvested rainwater have shown detectable levels of these contaminants. Health concerns related to bacteria, such as salmonella, e-coli and legionella, and to physical contaminants, such as pesticides, lead, and arsenic, are the primary criteria for drinking water quality analysis. Falling rain is free of most of these hazards. Common sense takes a lot of the guess work out of proper treatment procedures.

For example, if the rainwater is intended for use *inside* the household, either for potable uses such as drinking and cooking or for non-potable uses including showering and toilet flushing, appropriate filtration and disinfection practices should be employed. If the rainwater is to be used *outside* for landscape irrigation, where human consumption of the untreated water is less likely, the presence of

ANNUAL PARTICULATE MATTER (PM_{10}) EMISSIONS IN TEXAS BY COUNTY, 1994



ANNUAL SULFUR DIOXIDE (SO_2) EMISSIONS IN TEXAS BY COUNTY, 1994



Source:- Texas Natural Resource Conservation Commission contaminants may not be of major concern and thus treatment requirements can be less stringent or not required at all.

Depending on where the system is located, the quality of rainwater itself can vary, reflecting exposure to air pollution caused by industries such as cement kilns, gravel quarries, crop dusting, and a high concentration of automobile emissions.

SECONDARY WATER QUALITY CRITERIA – AESTHETIC CONCERNS

Aesthetic concerns such as color, taste, smell, and hardness comprise the secondary testing criteria used to evaluate publicly supplied water. When assessed according to these characteristics, rainwater proves to be of better quality than well or municipal tap water. Inorganic impurities such as suspended particles of sand, clay, and silt contribute to the water's color, and smell. Proper screening and removal of sedimentation help to decrease problems caused by these impurities.

Rainwater is the softest natural occurring water available, with a hardness of zero for all practical purposes. In central and west Texas, dust derived from limestone and alkaline soils can add as much as one or two milligrams per liter (mg/L) of hardness to the water, although these amounts are negligible compared to the average hardness (about 200 to 400 mg/L) of groundwater in some areas. As mentioned above, a benefit of the soft water is that faucets and water heaters last longer without the build-up of mineral deposits.

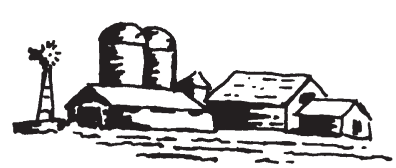
Rainwater contains almost no dissolved minerals and salts and is near distilled water quality. Total dissolved minerals and salts levels average about 10 milligrams per liter (mg/L) across Texas. Total Dissolved Solids (TDS) can range as high as 50 mg/L and as low as 2.0 mg/L. These values are very low when compared to city tap water across Texas, which typically is in the 200 to 600 mg/L range, making rainwater virtually sodium free. For people on restricted salt diets, this represents a decisive advantage over other water sources.

The pH of rainfall would be 7.0 if there were nothing else in the air. However, as rain falls through the air, it dissolves carbon dioxide that is naturally present in the air and becomes slightly acidic. The resultant pH is 5.6; however, any sulfates or nitrates dissolved from the air will lower this number below pH 5.6. According to National Atmospheric Deposition Program data, the pH of rainfall in Texas ranges from 4.6 in east Texas to 5.6 or above

WATER QUALITY PROPERTIES RELATED TO SPECIFIC USES

DOMESTIC	INDUSTRIAL	IRRIGATION
Taste	pH	Boron
Odor	Acidity	Alkalinity
Poisons	Alkalinity	Sodium-Calcium Ratio
Flouride	Silica	Dissolved solids
Nitrate	Hardness	
Iron	Sediment	
Hardness	Dissolved solids	
Sediment		
Dissolved solids		





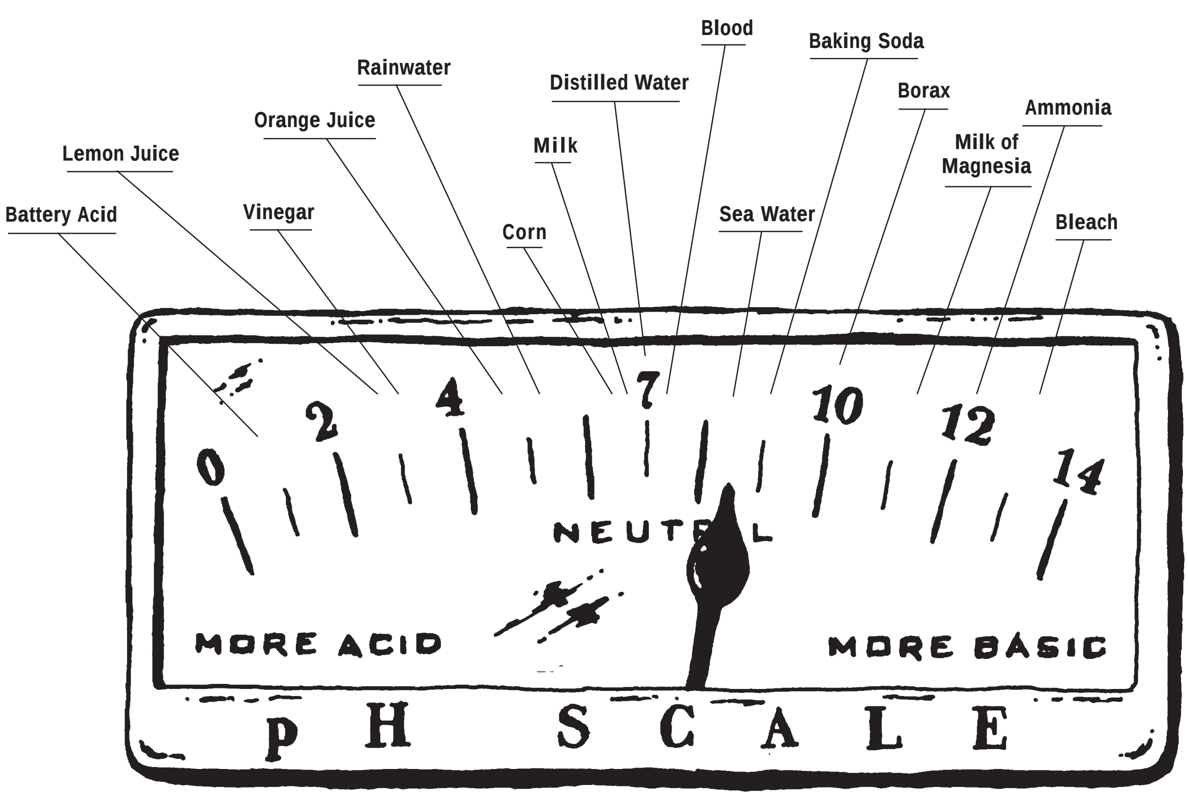
in west Texas. While northeast Texas experiences an even lower pH than found in other parts of the state, acid rain is still not considered a serious concern throughout Texas.

Although the pH of rain is below neutral, it is only slightly acidic, and the smallest amount of buffering can neutralize the acid. The low total dissolved salts and minerals levels found in rainwater permit even very small amounts of something like baking soda (one level tablespoon per 100 gallons) to adjust the pH to near neutral.

The Texas Natural Resource Conservation Commission (TNRCC) monitors municipal water quality and has adopted Drinking Water Standards in accordance with the Federal Safe Drinking Water Act. If you plan to use your harvested rainfall for drinking water, have the water tested by a laboratory certified by the Texas Department of Health (TDH) or Environmental Protection Agency (EPA). A list of drinking water testing criteria can be obtained from TNRCC or TDH. The Texas Department of Health performs tests for coliform bacteria for a nominal fee at locations around the state. At least 100 ml. of water are required to perform the test; results are available within five days.

PH SCALE FROM BASIC TO ACID

pH is the measure of acidity or alkalinity. In a scale from 0 to 14, 7 is neutral, values less than 7 represent more acid conditions, values greater than 7 represent more basic or alkaline conditions. The determination of whether water is acidic, neutral, or basic, is referred to as pH, which is a measure of the hydrogen ion concentration in water. The desired pH of potable water is pH 7, while the scale ranges from values of less than pH 7 down to pH 1 as increasingly acidic and greater than pH 7 up to pH 14 as increasingly basic. Soda pop and vinegar have a pH of about 3.0.



IV. HOW DOES A RAINWATER HARVESTING SYSTEM WORK?

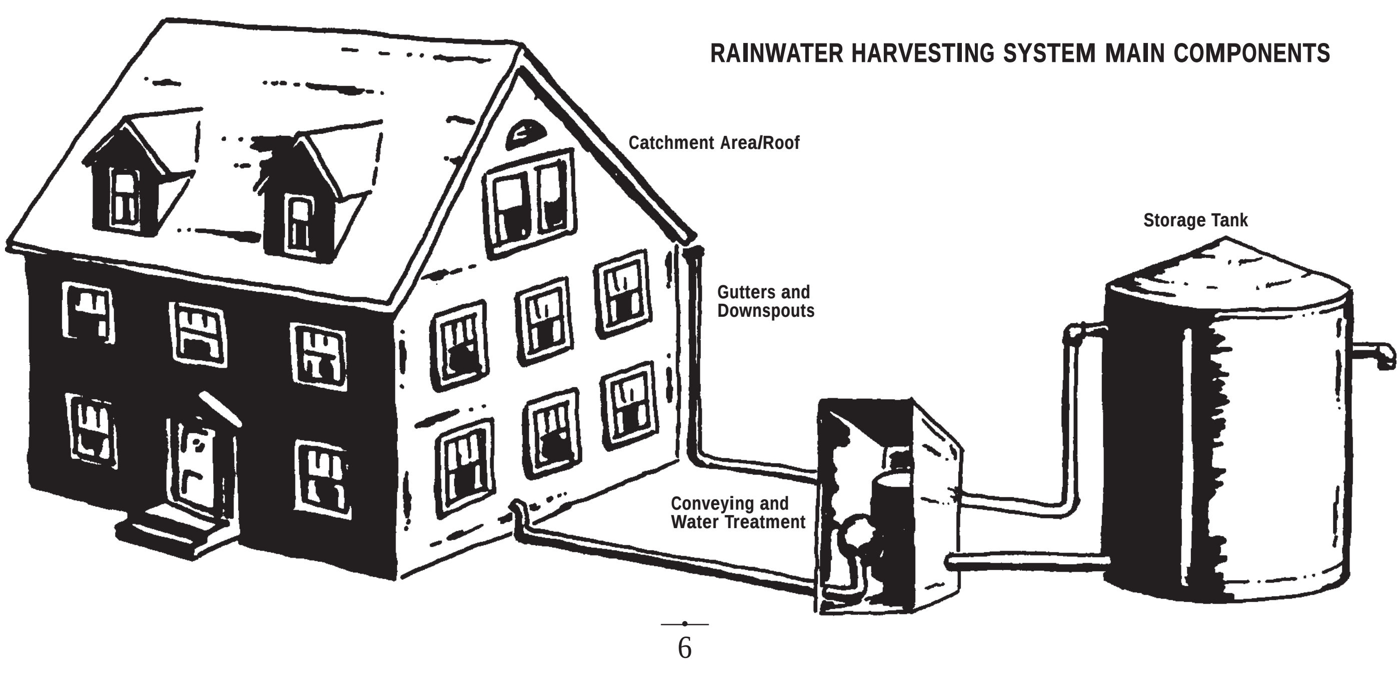
SYSTEM COMPONENTS

Whether the system you are planning is large or small, all rainwater harvesting systems are comprised of six basic components:

A. **Catchment Area/Roof,** the surface upon which the rain falls;
B. **Gutters and Downspouts,** the transport channels from catchment surface to storage;
C. **Leaf Screens and Roofwashers,** the systems that remove contaminants and debris;
D. **Cisterns or Storage Tanks,** where collected rainwater is stored;
E. **Conveying,** the delivery system for the treated rainwater, either by gravity or pump; and
F. **Water Treatment,** filters and equipment, and additives to settle, filter, and disinfect.

A. CATCHMENT AREA

The catchment area is the surface on which the rain that will be collected falls. While this Guide focuses on roofs as catchment areas, channeled gullies along driveways or swales in yards can also serve as catchment areas, collecting and then directing the rain to a french drain or bermed detention area. Rainwater harvested from catchment surfaces along the ground, because of the increased risk of contamination, should only be used for lawn watering. For in-home use, the roofs of buildings are the primary catchment areas, which, in rural settings, can include outbuildings such as barns and sheds. A “rainbarn” is a term describing an open-sided shed designed with a large roof area for catchment, with the cisterns placed inside along with other farm implements.



Rainwater yield varies with the size and texture of the catchment area. A smoother, cleaner, and more impervious roofing material contributes to better water quality and greater quantity. While loss is negligible for pitched metal roofs, concrete or asphalt roofs average just less than 10% loss, and built up tar and gravel roofs average a maximum of 15% loss. Losses can also occur in the gutters and in storage. Regardless of roofing material, many designers assume up to a 25% loss on annual rainfall. These losses are due to several factors: the roofing material texture which slows down the flow; evaporation; and inefficiencies in the collection process.

WHAT TYPE OF ROOFING MATERIAL?

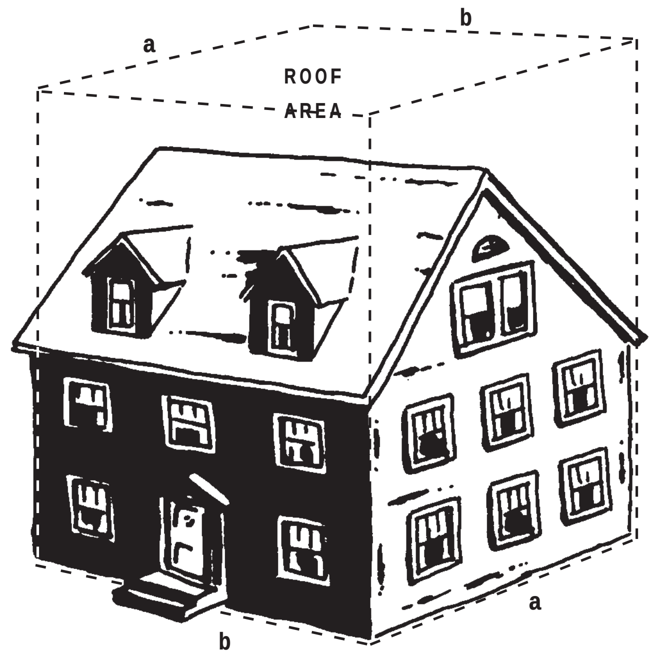
If you are planning a new construction project, metal roofing is the preferred material because of its smooth surface and durability. Other material options such as clay tile or slate are also appropriate for rainwater intended to be used as potable water. These surfaces can be treated with a special painted coating to discourage bacterial growth on an otherwise porous surface. Because composite asphalt, asbestos, chemically treated wood shingles and some painted roofs could leach toxic materials into the rainwater as it touches the roof surface, they are recommended only for non-potable water uses.

For systems intended as potable water sources, no lead is to be used as roof flashing or as gutter solder as the slightly acid quality of rain can dissolve the lead and thereby contaminate water supply. Existing houses and buildings should be fully examined for any lead content in the planning stages of any rainwater collection project.

CATCHMENT AREA SIZE

The size of a roof catchment area is the building's footprint under the roof. The catchment surface is limited to the area of roof which is guttered. To calculate the size of your catchment area, multiply the length times the width of the guttered area (See Chapter VI for more detail).

CALCULATING CATCHMENT AREA



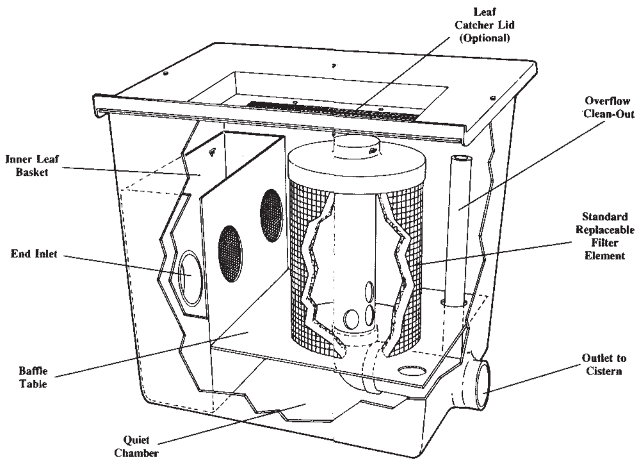
B. GUTTERS AND DOWNSPOUTS

These are the components which catch the rain from the roof catchment surface and transport it to the cistern. Standard shapes and sizes are easily obtained and maintained, although custom fabricated profiles are also available to maximize the total amount of harvested rainfall. Gutters and downspouts must be properly sized, sloped, and installed in order to maximize the quantity of harvested rain.

MATERIALS AND SIZES.

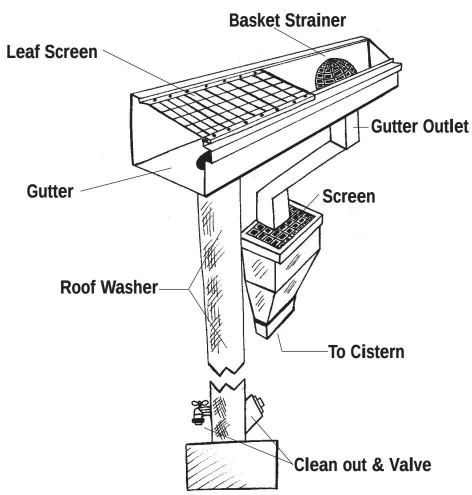
The most common material for off-the-shelf gutters is seamless aluminum, with standard extrusions of 5 inch and 6 inch sections, in 50 foot lengths. A 3 inch downspout is used with a 5 inch gutter and a 4 inch downspout is used with a 6 inch gutter. Galvanized steel is another common material which can be bent to sections larger than 6 inches, in lengths of 10 feet and 20 feet. A seamless extruded aluminum 6 inch gutter with a 4 inch downspout can handle about 1,000 square feet of roof area and is recommended for most cistern installations. For roof areas that exceed 1,000 square feet, larger sections of gutters and downspouts are commonly fabricated

EXAMPLE OF A COMMERCIALLY AVAILABLE ROOF WASHER WITH FILTER SYSTEM



Courtesy of Water Filtration Company

EXAMPLE OF A STANDPIPE TYPE ROOF WASHER



from galvanized steel or the roof area is divided into several guttered zones. Downspouts are designed to handle 1.25 inches of rainfall during a 10 minute period.

Copper and stainless steel are also used for gutters and downspouts but at far greater expense than either aluminum or galvanized steel. Downspouts are typically the same material as the gutters but of a smaller cross section. The connection between the downspout to the cistern is generally constructed of Schedule 40 PVC pipe.

To keep leaves and other debris from entering the system, the gutters should have a continuous leaf screen, made of 1/4 inch wire mesh in a metal frame, installed along their entire length, and a screen or wire basket at the head of the downspout. Gutter hangers are generally placed every 3 feet. The outside face of the gutter should be lower than the inside face to encourage drainage away from the building wall. Where possible, the gutters should be placed about 1/4 inch below the slope line so that debris can clear without knocking down the gutter.

As with the catchment surface, it is important to ensure that these conduits are free of lead and any other treatment which could contaminate the water. Check especially if you are retrofitting onto older gutters and downspouts that may have lead solder or lead-based paint.

ROOF WASHERS

Roof washing, or the collection and disposal of the first flush of water from a roof, is of particular concern if the collected rainwater is to be used for human consumption, since the first flush picks up most of the dirt, debris, and contaminants, such as bird droppings that have collected on the roof and in the gutters during dry periods. The most simple of these systems consists of a stand pipe and a gutter downspout located ahead of the downspout from the gutter to the cistern. The pipe is usually 6 or 8 inch PVC which has a valve and clean out at the bottom. Most of these types of roofwashers extend from the gutter to the ground where they are supported. The gutter downspout and top of the pipe are fitted and sealed so water will not flow out of the top. Once the pipe has filled, the rest of the water flows to the downspout connected to the cistern. These systems should be designed so that at least 10 gallons of water are diverted for every 1000 square feet of collection area. Rather than wasting the water, the first flush can be used for non-potable uses such as for lawn or garden irrigation. Several types of commercial roof washers which also contain filter or strainer boxes are available.

Consider trimming any tree branches that overhang the roof. These branches are perches for birds and produce leaves and other debris.

C. STORAGE TANKS

Other than the roof, which is an assumed cost in most building projects, the storage tank represents the largest investment in a rainwater harvesting system. To maximize the efficiency of your system, your building plan should reflect decisions about optimal placement, capacity, and material selection for the cistern.

SITING

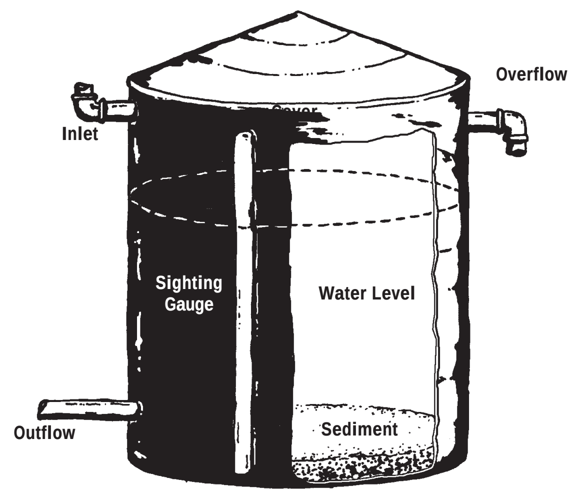
In Texas, recently installed cisterns are placed both above and below ground. While above ground installations avoid the costs associated with excavation and certain maintenance issues, cisterns that are below ground benefit from the cooler year-round ground temperatures. To maximize efficiency, cisterns should be located as close to both the supply and demand points as possible. And, to facilitate the use of gravity or lower stress on a pump, the cistern should be placed on the highest level that is workable.

While the catchment area (roof) should not be shaded by trees, the cistern can benefit from the shade since direct sunlight can heat the stored rainwater in the tank and thereby encourage algae and bacterial growth, which can lower water quality.

Texas does not have specific regulations concerning rainwater systems; however, to ensure a safe water supply, cisterns should be sited at least 50 feet away from sources of pollution such as animal stables, latrines, or, if the tank is below ground, from septic fields.

Tank placement should also take into consideration the possible need to add water to the tank from an auxiliary source, such as a water truck, in the event your water supply is depleted due to over-use or drought conditions. For this reason, the cistern should be located in a site accessible to a water truck, preferably near a driveway or roadway, and positioned to avoid crossing over water or sewer lines, lawns or gardens.

A TYPICAL STORAGE CISTERN



DESIGN FEATURES

Regardless of the type of tank material you select, the cistern should have a durable, watertight exterior and a clean, smooth interior, sealed with a non-toxic joint sealant. If the water is intended for potable use, the tank should be labeled as FDA-approved (Food and Drug Administration), as should any sealants or paints used inside the tank. A tight-fitting cover is essential to prevent evaporation, mosquito breeding, and to keep insects, birds, lizards, frogs and rodents from entering the tank. If the cistern is your only water source, an inflow pipe for an alternate water source is advisable. All tanks, and especially tanks intended for potable use, should not allow sunlight to penetrate or algae will grow in the cistern. A settling compartment, which encourages any roof run-off sediment that may enter the tank to settle rather than be suspended in the tank, is an option that can be designed into the bottom of the cistern.

Designing a system with two tanks provides some flexibility that may be of value. In most cases, an additional tank represents added cost, regardless of whether it represents increased capacity. This is because two smaller tanks of, for example, 1,500 gallons each are generally more expensive than a single 3,000 gallon tank. The primary benefit of a multi-tank system is that the system can remain operational if one tank has to be shut down due to maintenance or leaking.

Regardless of tank type chosen, regular inspection and proper maintenance are imperative to ensure reliability and safe, efficient operation. Remember that water is heavy. A 500 gallon tank of water will weigh more than two tons, so a proper foundation and support are essential.

MATERIALS

Tanks are available in a range of materials and sizes, new and used, large and small, to accommodate your system design and budget. For small installations, readily available new and used tanks, including whiskey barrels, 55-gallon drums, and horse troughs can be fashioned into supplemental do-it-yourself systems. If used tanks are selected, be sure that they did not contain any toxic substances which could affect water quality for many, many years. For large installations, many options exist for manufactured and site-built systems, as described below.

Concrete and Masonry

Concrete. Reinforced concrete tanks can be built above or below ground by a commercial contractor or owner-builder. Because of their weight, they are usually poured in place to specifications and are not portable. However, concrete tanks can also be fashioned from prefabricated components, such as septic tanks and storm drain culverts, and from concrete blocks. Concrete is durable and long-lasting, but is subject to cracking; below-ground tanks should be checked periodically for leaks, especially in clay soils where expansion and contraction may place extra stress on the tank. An advantage of concrete cistern chambers is their ability to decrease the corrosiveness of rainwater by allowing the dissolution of calcium carbonate from the walls and floors.

Ferrocement. Ferrocement is a term used to describe a relatively low-cost steel-mortar composite material. Its use over the past 100 years has been most prevalent in developing countries in a range of low-cost applications, such as water tanks. It has also gained popularity among do-it-yourselfers in Texas and throughout the U.S. Although it is a form of reinforced concrete, its distinctive characteristics relative to performance, strength, and flexible design potentials generally warrant classification of ferrocement as a separate material. Unlike reinforced concrete, ferrocement's reinforcement is comprised of multiple layers of steel mesh (often chicken wire), shaped around a light framework of rebar, that are impregnated with cement mortar. Because its walls can be as thin as 1", it uses less materials than conventional poured-in-place concrete tanks, and thus can be less expensive. Ferrocement lends itself to low-cost construction projects, since it can take advantage of self-help labor and prevalent, low-cost raw materials such as rebar, chicken wire, cement and sand. Ferrocement tanks are likely to require greater ongoing maintenance than tanks constructed of other materials. Small cracks and leaks can be easily repaired with a mixture of cement and water, and also applied where wet spots appear on the tank's exterior. Some sources recommend that it is advantageous to paint above-ground tanks white to reflect the sun's rays, reduce evaporation, and keep the water cool. Though ferrocement is most commonly a site-built method, commercially available ferrocement tanks are available in some parts of Texas. Check to be sure that the ferrocement mix does not contain any toxic compounds which may make the water unfit for use.

Stone. Across the Texas Hill Country and other parts of the state with abundant rock, site-built stone cisterns were historically a logical approach to tank fabrication since the materials were locally available. The mass of the stone walls helps to keep interior water temperature cool, and the tanks can be designed to blend in with adjacent buildings. Some recent installations, such as the National Wildflower Research Center in Austin, have continued the tradition of stone cisterns. As with cement tanks, these installations are permanent. Construction procedures should be careful to exclude any compounds which may be toxic, such as some types of mortars and sealants, especially if the system is planned for potable water.

Plastic

Fiberglass. Fiberglass tanks are lightweight, reasonably priced, and long lasting, making them one of the most popular tanks in contemporary installations. As with the polyethylene and galvanized tanks, fiberglass tanks are commercially available throughout the state and easy to transport. They are available in a wide range of sizes and can be specified for potable water. Fiberglass tanks should be coated or constructed to prevent penetration of sunlight into the tank.

Plastic Liner. Plastic liners are sometimes used to line concrete tanks or tanks that have developed leaks. These liners can also be used to line low-cost, temporary collection tanks constructed of materials such as plywood. Plastic liners that are specified for potable use are commercially available. It is important to remember when using liners that they must be fully supported since they have no structural strength of their own. If a wooden form is used, remember that it should be protected from the elements since it will tend to rot quickly.

Polyethylene. These tanks are commercially available in a variety of sizes, shapes, and colors, and can be constructed for above or below ground installations. Polyethylene tanks are gaining popularity due to

ROUND CISTERN CAPACITY

DEPTH (feet)	6 FOOT DIAMETER (gallons)	12 FOOT DIAMETER (gallons)	18 FOOT DIAMETER (gallons)
6	1,266	5,076	11,412
8	1,688	6,768	15,216
10	2,110	8,460	19,020
12	2,532	10,152	22,824
14	2,954	11,844	26,628
16	3,376	13,536	30,432
18	3,798	15,228	34,236
20	4,220	16,920	38,040

CISTERN TYPES

MATERIAL	FEATURE	CAUTION
PLASTICS		
Garbage Cans (20-50 gallon)	commercially available, inexpensive	use only new cans
Fiberglass	commercially available, alterable and moveable	degradable, requires interior coating
Polyethylene/Polypropylene	commercially available, alterable and moveable	degradable, requires exterior coating
METALS		
Steel Drums (55 gallon)	commercially available, alterable and moveable	verify prior use for toxics, corrodes and rusts, small capacity
Galvanized Steel Tanks	commercially available, alterable and moveable	possible corrosion and rust
CONCRETE AND MASONRY		
Ferrocement	durable, immoveable	potential to crack and fail
Stone, Concrete Block	durable, immoveable	difficult to maintain
Monolithic/Poured in Place	durable, immoveable	potential to crack
WOOD		
Redwood, Douglas Fir, Cypress	attractive, durable	expensive

their relatively low cost and long life expectancy—they are considered slightly more durable than fiberglass with comparable life expectancy. Their light weight makes them easy to transport and relocate, if needed, while their smooth interior surface makes them easy to clean. Repairs are relatively easy to carry-out—use heat to soften the plastic and reshape as necessary. To ensure their long-life, polyethylene tanks should be chosen which have ultra-violet (UV) inhibitors for outdoor use, or can be placed in an enclosure or painted with a protective surface to provide protection from the sun. Black tanks have the greatest UV resistance, with a life expectancy of 25 years, though will tend to absorb heat and thus can affect water quality. Painting or shading the tank will minimize the effects of UV light and is recommended. Again, light penetration will promote algae growth. If you intend to use the tank for potable water, be sure that it is FDA approved.

Metal

Galvanized Steel. Steel tanks were a predominate choice by those early Texans who did not have stone nearby, and continue to be a popular choice in Texas today. Galvanized steel tanks are commercially available and reasonably priced. They are noted for their strength, yet are relatively lightweight and easy to move. Corrosion can be a problem if exposed to acidic conditions; some suppliers provide an inside liner to guard against this problem. In addition, high and low pH water conditions can result in the release of zinc. As with other tank materials, be sure that any galvanized metal tank used as a potable water source is FDA approved. If salvaging an old metal tank, be aware that these were generally soldered with lead and should not be used as a potable water source.

Wood

Redwood and Cypress. Redwood is considered one of the most durable woods for outdoor use, though is uncommon in Texas since it is not a native wood species. Cypress is a native Texas wood with many of the same properties as redwood. Although cypress was used to construct cisterns in Texas in the early 1900's, cypress tanks are not commercially available today. Redwood has a reputation as durable water storage tank material, and is attractive because it has no resins that could affect the odor or taste of water, has high levels of tannin, a natural preservative which makes the tank resistant to insects and decay, and has a cellular construction which allows for complete saturation from capillary and direct pressure and enhances its capacity to retain moisture. In addition, redwood is an efficient insulator, which keeps water cooler in summer and protects it from freezing temperatures in winter, does not rust or corrode and requires no painting or preserving. Redwood tanks have an average life expectancy of 50 years, with some known to last as long as 75 years.

D. CONVEYING

Remember, water only flows downhill unless you pump it. The old adage that gravity flow works only if the tank is higher than the kitchen sink accurately portrays the physics at work. The water pressure for a gravity system depends on the difference in elevation between the storage tank and the faucet. Water gains one pound per square inch of pressure for every 2.31 feet of rise or lift. Many plumbing fixtures and appliances require 20 psi for proper operation, while standard municipal water supply pressures are typically in the 40 psi to 60 psi range. To achieve comparable pressure, a cistern would have to be 92.4 feet (2.31 feet X 40 psi = 92.4 feet) above the home's highest plumbing fixture. That explains why pumps are frequently used, much in the way they are used to extract well water. Pumps prefer to push water, not pull it.

To approximate the water pressure one would get from a municipal system, pressure tanks are often installed with the pump. Pressure tanks have a pressure switch with adjustable settings between 5 and 65 psi. For example, to keep your in-house pressure at about 35 psi, set the switch to turn off the pump when the pressure reaches 40 psi and turn it on again when the pressure drops down to 30 psi.

E. WATER TREATMENT

Before making a decision about what type of water treatment method to use, have your water tested by an approved laboratory and determine whether your water will be used for potable or non-potable uses.

The types of treatment discussed are filtration, disinfection, and buffering for pH control. Dirt, rust, scale, silt and other suspended particles, bird and rodent feces, airborne bacteria and cysts will inadvertently find their way into the cistern or storage tank even when design features such as roof washers, screens and tight-fitting lids are properly installed. Water can be unsatisfactory without being unsafe; therefore, filtration and some form of disinfection is the minimum recommended treatment if the water is to be used for human consumption (drinking, brushing teeth, or cooking). The types of treatment units most commonly used by rainwater systems are filters that remove sediment, in consort with either an ultraviolet light or chemical disinfection.

FILTERS

Filtration can be as simple as the use of cartridge filters or those used for swimming pools and hot tubs. In all cases, proper filter operation and maintenance in accordance with the instruction manual for that specific filter must be followed to ensure safety.

Once large debris is removed by screens and roofwashers, other filters are available which help improve rainwater quality. Keep in mind that most filters on the market are designed to treat municipal

TREATMENT TECHNIQUES

METHOD	LOCATION	RESULT
SCREENING		
Strainers and Leaf Screens	Gutters and Leaders	Prevent leaves and other debris from entering tank
SETTLING		
Sedimentation	Within Tank	Settles particulate matter
FILTERING		
In-Line / Multi Cartridge	After Pump	Sieves sediment
Activated Charcoal	At Tap	Removes chlorine*
Reverse Osmosis	At Tap	Removes contaminants
Mixed Media	Separate Tank	Traps particulate matter
Slow Sand	Separate Tank	Traps particulate matter
DISINFECTING		
Boiling / Distilling	Before use	Kills microorganisms
Chemical Treatments		
(Chlorine or Iodine)	Within Tank or At Pump (liquid, tablet or granule)	Kills microorganisms
Ultraviolet Light	Ultraviolet light systems should be located after the activated carbon filter before trap	Kills microorganisms
Ozonation	Before Tap	Kills microorganisms

* Should only be used after chlorine or iodine has been used as a disinfectant. Ultraviolet light and ozone systems should be located after the activated carbon filter but before the tap.

water or well water. Therefore, filter selection requires careful consideration.

Screening, sedimentation, and prefiltering occur between catchment and storage or within the tank. A cartridge sediment filter, which traps and removes particles of five microns or larger is the most common filter used for rainwater harvesting. Sediment filters used in series, referred to as multi-cartridge or in-line filters, sieve the particles from increasing to decreasing size.

These sediment filters are often used as a prefilter for other treatment techniques such as ultraviolet light or reverse osmosis filters which can become clogged from large particles.

Unless you are adding something to your rainwater, there is no need to filter out something that is not present. When a disinfectant such as chlorine is added to rainwater, an activated carbon filter at the tap may be used to remove the chlorine prior to use. Remember that activated carbon filters are subject to becoming sites of bacterial growth. Chemical disinfectants such as chlorine or iodine must be added to the water prior to the activated carbon filter. If ultraviolet light or ozone is used for disinfection, the system should be placed **after** the activated carbon filter. Many water treatment standards require some type of disinfection after filtration with activated carbon. Ultraviolet light disinfection is often the method of choice. All filters must be replaced per recommended schedule rather than when they cease to work; failure to do so may result in the filter contributing to the water's contamination.

DISINFECTION

Ultraviolet Light (UV) water disinfection, a physical process, kills most microbiological organisms that pass through them. Since particulates offer a hiding place for bacteria and microorganisms, prefiltering is necessary for UV systems. To determine whether the minimum dosage is distributed throughout the disinfection chamber, UV water treatment units should be equipped with a light sensor. Either an alarm or shut-off switch is activated when the water does not receive the adequate level of UV radiation. The UV unit must be correctly calibrated and tested after installation to insure that the water is being disinfected. Featured in the case studies are several systems which utilize ultraviolet light.

Ozone is the disinfectant of choice in many European countries, but it has not been used in American water treatment facilities until recently. Ozone is a form of oxygen (0_3) produced by passing air through a strong electric field. Ozone readily kills microorganisms and oxidizes organic matter in the water into carbon dioxide and water. Any remaining ozone reverts back to dissolved oxygen (0_2) in the water. Recent developments have produced compact ozone units for home use. Since ozone is produced by equipment at the point of use with electricity as the only input, many rainwater catchment systems owners use it to avoid having to handle chlorine or other chemicals. Ozone can also be used to keep the water in cisterns "fresh". When used as the final disinfectant, it should be added prior to the tap, but after an activated carbon filter, if such a filter is used.

Chlorine or iodine for disinfecting. Private systems do not disinfect to the extent of public water systems where the threat of a pathogenic organism such as e. coli can affect many households. If the harvested rainwater is used to wash clothes, water plants, or other tasks that do not involve direct human consumption or contact, treatment beyond screening and sedimentation removal is optional. However, if the water is plumbed into the house for general indoor use such as for drinking, bathing, and cooking, disinfection is needed.

While filtering is quite common in private water systems, disinfection is less common for these reasons: the Safe Drinking Water Act is neither enforced nor applicable to private systems; chlorine is disliked due to taste, fear associated with trihalomethanes (THMs), and other concerns. Chlorine is the most common disinfectant because of its dependability, water solubility, and availability.

Granular or tablet form is available (calcium hypochlorite), but the recommended application for rainwater disinfecting is in a liquid solution (sodium hypochlorite).

Household bleach contains a 5.0% solution of sodium hypochlorite, and is proven to be reliable, inexpensive and easily obtained. A dose is one liquid ounce of bleach for each 100 gallons (one and a quarter cups of bleach per 1,000 gallons) of rainwater collected will most likely be sufficient to disinfect the collected rainwater. When disinfecting, never overdose with bleach. Mixing occurs naturally over a day or so, but a clean paddle may be used to accelerate the process.

When chlorine bleach is added directly to the storage tank or cistern as described above, the chlorine will have a longer time to kill bacteria thus achieving a better rate of disinfection. Chlorine feed pumps which release small amounts of solution while the water is being pumped can also be used. Chlorine metering pumps inject chlorine into the water only at the time of use.

Chlorine concentrations are easily measured with a swimming pool test kit. A level of between 0.2 mg/L (milligrams per liter) and 1.5 mg/L is recommended. If the level is below 0.2 mg/L, add one liquid ounce of chlorine bleach per 100 gallons of the volume of water in storage (one and a quarter cups per 1,000 gallons) if you are using bleach or adjust the chemical feed pump in accordance with the pump's instructions.

Swimming pool test kit chemicals are toxic and should never be allowed to mix with cistern water. Testing should occur outside the tank.

Chlorine is more effective at higher water temperatures and lower pH levels than iodine. Iodine is another water disinfectant that is less soluble than chlorine although it is effective over a pH range of 5 to 9 and displays greater antibacterial activity in water temperatures of 75 to 98.6 degrees Fahrenheit.

Prolonged presence of chlorine where organic matter may be present may cause the formation of chlorinated organic compounds. If chlorine is used as a disinfectant, be sure to screen all organic material from the tank.

BUFFERING

Baking soda for buffering. The composition and pH of rainwater differs from chemically treated municipal water and mineral rich well water. Controlling the pH of rainwater by buffering can be easily accomplished by adding one level tablespoon of baking soda to the storage tank for each 100 gallons of water collected. (About four ounces by weight of baking soda for every 1,000 gallons of water collected.) An easy method is to mix this amount of baking soda in a jar of water and pour it into the tank. Mixing will occur naturally over a day or two or a clean paddle may be used to hasten the process, but avoid disturbing materials that have settled at the bottom of the cistern.

OTHER TREATMENT

There are a number of other treatment devices available on the market. When selecting additional treatment devices, always ask yourself what is it that you are trying to remove, does it need to be removed, and does this water source contain that contaminant. Commercial and public test laboratories can help in this regard.

Some of the types of treatment available include reverse osmosis (RO) and nano-filtration, and several other "membrane" processes and distillation equipment that are designed primarily to remove dissolved materials such as salts or metals, but rainwater contains extremely low dissolved salts or hardness levels. For the most part, systems such as RO would be redundant and expensive to use. Besides, most home RO units waste three to five gallons of water for every gallon of water produced.

As a word to the wise, consult your local health department before purchasing such devices. Some devices are actually dangerous if used incorrectly.

V. HOW MUCH WATER DO YOU USE?

Assessing your indoor and outdoor water needs will help determine the best use for the rainwater. If you are already connected to a municipal water system, then a rainwater harvesting unit designed to fulfill outdoor requirements such as lawn and garden irrigation may be most cost-effective. If you have already invested in a well-water system, rainwater could augment or enhance the quality of mineralized well water for purposes such as washing, or provide back-up water when underground water sources are low. Some people are installing a full-service rainwater system designed to supply both their indoor and outdoor water needs. If you are considering this option, it is imperative that you employ best conservation practices to ensure a year-round water supply. Three variables determine your ability to fulfill your household water demand: your local precipitation, available catchment area, and your financial budget.

If you are accustomed to simply turning on a tap to get your water and then paying a bill at the end of the month, the switch to a rainwater system will require some adjustment. While the associated tasks are not difficult, they are important to keep your water safe and your family in good health. These responsibilities include regular inspections of all the previously discussed components, including

HOUSEHOLD WATER DEMAND CHART

FIXTURE	USE	FLOW RATE	# OF USERS	TOTAL
Toilet	# flushes per person per day	1.6 gallons per flush (new toilet)*		
Shower	# minutes per person per day (5 minutes suggested max.)	2.75 gallon per minute* (restricted flow head)		
Bath	# baths per person per day	50 gallons per bath (average)		
Faucets	bathroom and kitchen sinks (excluding cleaning)	10 gallons per day	not applicable	
Washing Machine	# loads per day	50 gallons per load (average)	not applicable	
Dishwasher	# loads per day	9.5 gallons per load	not applicable	
			Total	# gallons / day
			multiply (x) 365	# gallons / year

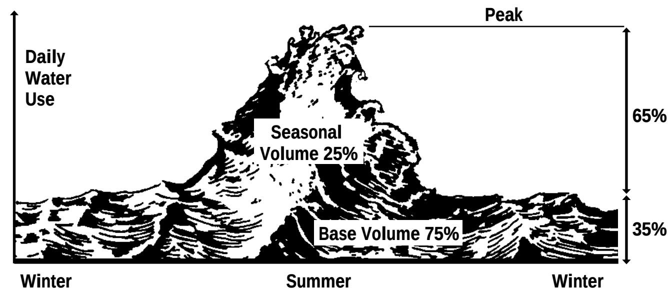
*All of the flow rates shown are for new fixtures. Older toilets use from 3.5 to 7 gallons per flush, and older shower heads have flow rates as high as 10 gallons per minute.

pruning branches that overhang roof, keeping leaf screens clean, checking tank and pump, replacing filters, and testing the water. A maintenance schedule and checklist based upon your particular system are recommended to ensure proper performance.

HOUSEHOLD WATER BUDGET

An easy way to calculate your daily water consumption is to review previous water bills, if you presently receive municipal water. Another method is to account for every water-using activity, including shower, bath, toilet flush, dishwashing run, washing machine load. A conserving household that has low-flow plumbing fixtures such as 1.6 gallon-per-flush toilets and 2.75 gallon-per-minute shower heads, now required by the Texas Plumbing Standards, might use 55 gallons or less of water per day per person and very conservative minded households might be able to reduce water use to as low as 35 gallons per person per day. However, for the purposes of designing a rainwater system, an estimate of 75 gallons per person per day for indoor use is advised to ensure adequate year-round indoor water supply – unless you are sure that all of your

BASE AND SEASONAL WATER USE IN TEXAS

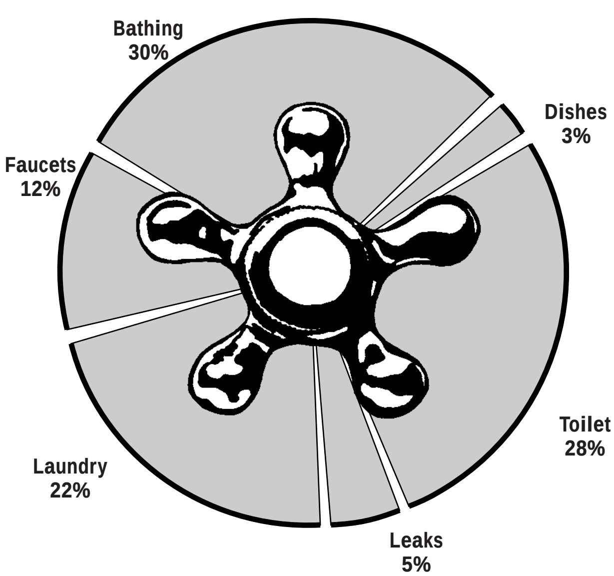


fixtures are the newer, more efficient ones and you plan to follow strict conservation practices. Complete the Household Water Consumption Chart on page 16 to see how your household's water consumption compares with the recommended design allowance. See page 18 for outdoor use estimates.

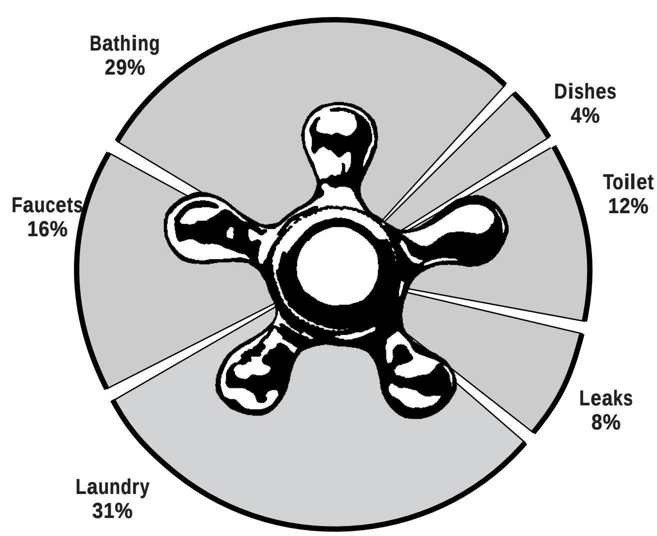
While inside water use remains relatively level throughout the year, total water demand increases during the hot, dry summers due to increased lawn and garden watering, and decreases during the cool, wet winters when the garden is fallow and the lawn needs little attention. To determine your daily water budget, multiply the number of persons in the household times the average water consumption. Estimates of indoor household water use range from less than 55 gallons per person a day in a

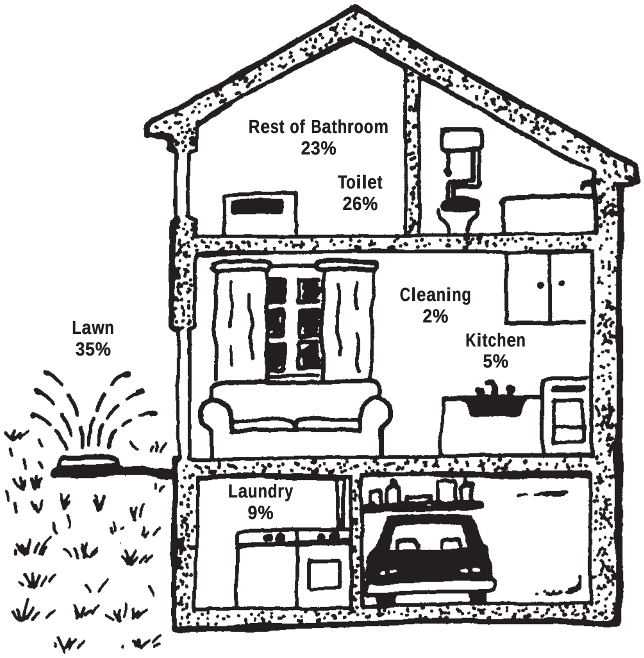
HOME INDOOR WATER USE

Homes with older fixtures use about 75 gallons per person per day (GPCD)



Homes with water-saving fixtures use about 55 gallons per person per day (GPCD)





HOME WATER USE, INDOOR AND OUTDOOR

conservation minded household to well over 75 gallons per person a day in non-conserving households.

LANDSCAPE WATER BUDGET

In order to calculate a water budget for a conventional lawn, you must determine the grass type, the square footage of your lawn, and your annual rainfall. If the average annual rainfall for your area is higher than the required water demands listed below, your annual rainfall is sufficient. If your annual rainfall is lower than the required inches based on grass type, you will need to complete the following chart to determine your lawn watering requirements in order to properly size your cistern.

WATER CONSERVATION TECHNIQUES

While rainwater collection can function well as a stand alone system, its efficiency can be enhanced by working in concert with other water conservation practices. Reducing your water demand results in lowering the up front cost of your rainwater harvesting system.

SAVING WATER INSIDE YOUR HOUSE

If your water budget or water bill indicates usage beyond your collection capacity, common sense water conservation practices might help you to recover those extra gallons. The repair of dripping faucets and leaking toilets, frequently the source of much lost water, is a good start. Installing low-flow showerheads, faucet aerators and toilet dams are other steps that pay for themselves in less than a year through water savings. Water conserving dish washers and clothes washing machines that operate with half as much water as conventional appliances

LANDSCAPE WATER DEMAND CHART

GRASS TYPE AND THEIR WATER DEMAND

St. Augustine	50 inches per year	Bermuda	40 inches per year	St. Augustine / Bermuda Mix	45 inches per year
Buffalo Grass	25 inches per year	Zoysia	45 inches per year		

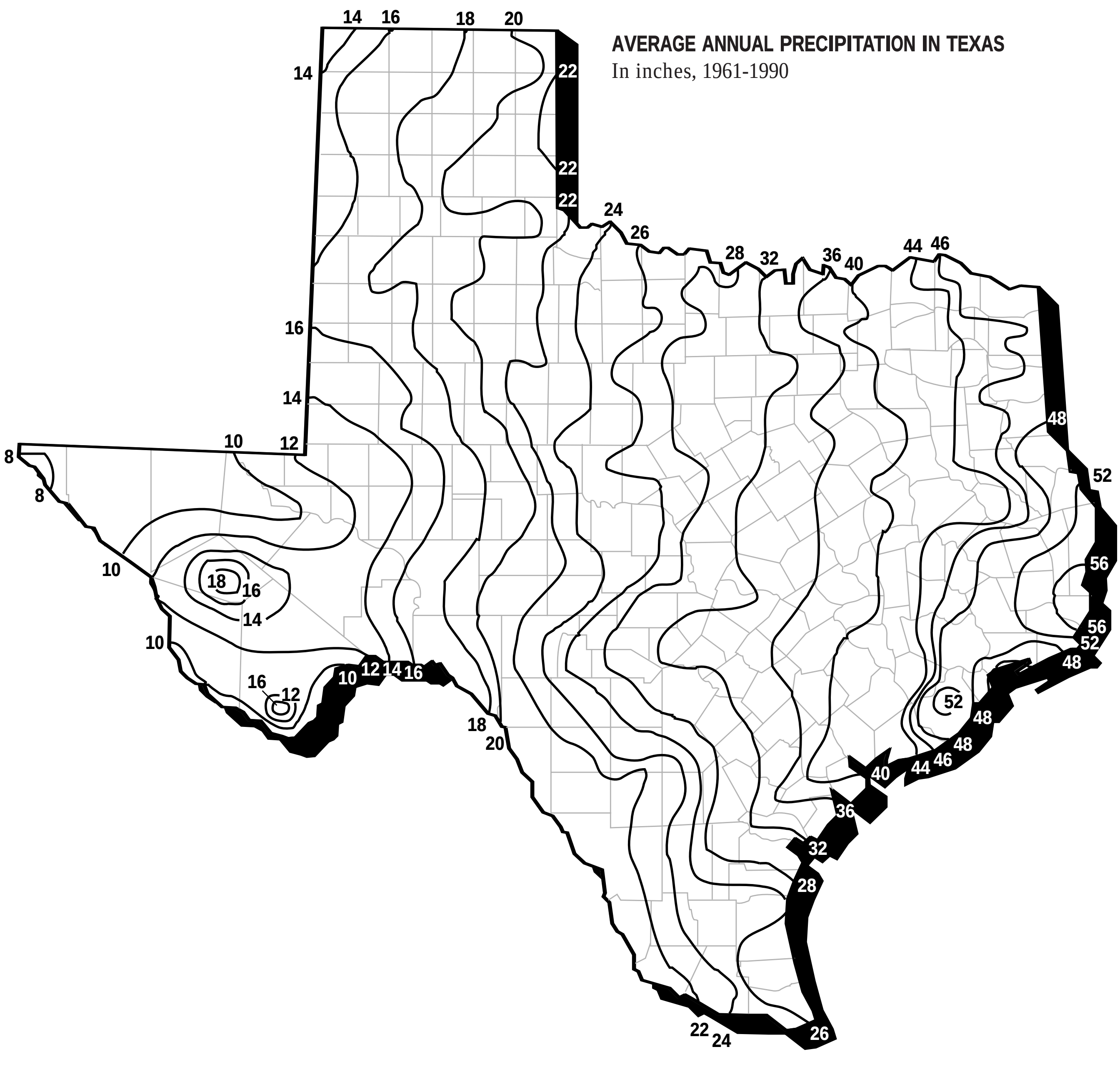
1. Multiply the water demand (inches per year) times your lawn size (square feet) and divide by 12. This will give you the cubic feet of of water demand per year. __________ cu. ft.
2. Multiply the number cubic feet of water demand per year (line 1) times a conversion factor of 7.48. This gives you the number of required gallons of water per year. __________ gal.
3. Multiply the inches of natural rainfall for your area (see page 20) times your lawn size (square feet) and divide by 12. This gives you the cubic feet of water supplied by natural rainfall. _________cu. ft.
4. Multiply the cubic feet of natural rainfall times a conversion factor of 7.48. This gives you the gallons of natural rainfall per year. __________ gal.
5. Subtract the gallons of natural rainfall (line 4) from the required water demand for your grass type (line 2). This gives you the gallons required. __________ gal.

are also available. The Texas Water Development Board and your local water utility have more information on ways to conserve water in your bathroom, kitchen, and laundry.

SAVING WATER OUTSIDE YOUR HOUSE

Landscape irrigation accounts for about one-quarter of all municipal water use in Texas. The most intensive time to irrigate is the summer growing season, which is when temperatures are highest and rainfall is lowest. Rainwater becomes particularly precious during these hot, dry months. Indeed, rainwater used for summer irrigation must be captured earlier in the year. Therefore, a landscape that requires minimum watering, especially in the summer, is most appropriate for rainwater harvested irrigation. The use of regionally-adapted drought tolerant and low water use plants is also a major help.

Drip Irrigation. Trickle or drip irrigation is the frequent, low pressure application of small amounts of water to the soil area directly surrounding the plant roots. A constant level of soil moisture is maintained, even though up to 60% less water



AVERAGE ANNUAL PRECIPITATION IN TEXAS
In inches, 1961-1990

than conventional watering is used by this method. The efficiency and uniformity of a low water flow rate reduces evaporation, run-off, and deep percolation. A common soaker hose, usually installed below ground, is one of the simplest ways to drip irrigate shrub beds, gardens and young trees.

To obtain more information about Water Wise landscaping, drip irrigation, and indoor water conservation techniques, contact the Texas Water Development Board at Conservation, P.O. Box 13231, Austin, TX 78711-3231 or the Texas Department of Agriculture, city utility, river authority, or your county agriculture extension agent.

Greywater Reuse. In urban areas, public policy and health codes generally mandate the centralized collection and treatment of household wastewater. Policy discussions relating to greywater reuse are underway, reflecting concern to maximize water use options brought on by droughts, water shortages, and development impacts on existing wastewater treatment facilities. Greywater reuse, which relies on separating the greywater from the blackwater, has many environmental and economic benefits on both the building and regional scales. Because greywater is relatively benign, it can be directed to a number of secondary uses such as toilet flushing and irrigation, thus displacing the need to use higher quality water.

Greywater is household wastewater generated by clothes washing machines, showers, bathtubs, and bathroom sinks. Wastewater from kitchen sinks is excluded from this category since it contains oil, fat, and grease which are difficult to filter, clog distribution pipes, have unpleasant odors, and are likely to attract pests.

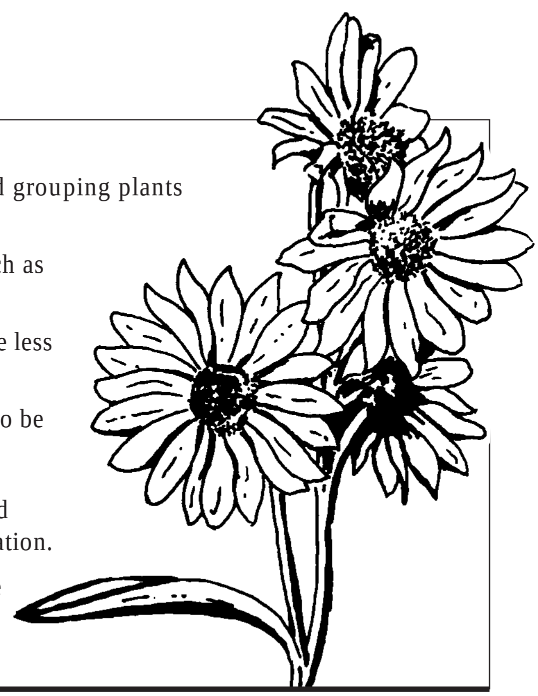
Blackwater is the water flushed down toilets and urinals and also includes the discharge from kitchen sinks due to the reasons stated above. If a sanitary sewer connection is not available, blackwater must be treated on site by a septic tank, drain field, or a permitted on-site wastewater treatment system.

Greywater can contain harmful bacteria and therefore also requires filtration and disinfection prior to reuse. Once the greywater is properly treated, it can be reused for irrigation and used to supplement higher quality rainwater. Always consult your local health department.

If you plan to incorporate a greywater system, check with your local health department officials since certain restrictions regarding installation and reuse apply. For example, greywater systems with overflows to public sewer systems cannot be connected to rainwater systems.

7 WATER WISE PRINCIPLES

1. Planning & Design that considers topography, existing vegetation, and grouping plants and grasses by their watering needs.
2. Soil Improvement to prevent erosion and adding organic material, such as compost, to promote water penetration and retention.
3. Appropriate Plant Selection such as native and adapted plants that use less water and are more resistant to diseases and pests.
4. Practical irrigated turf and landscaped areas in appropriate locations to be separately irrigated.
5. Efficient Watering by avoiding watering until absolutely necessary and never watering in the heat of the day or on windy days to avoid evaporation.
6. Use of Mulches to cover and shade soil, minimize evaporation, reduce weed growth and soil erosion.
7. Lower Maintenance by the decreased use of pesticides and fertilizers.



Other Water Reuse Options

Under new rules from the Texas Natural Resources Conservation Commission (TNRCC), water from on-site sewage facilities, such as septic systems, can now be reused for landscape irrigation after proper secondary treatment and disinfection. Contact your local health department or the TNRCC at P.O. Box 13087, Austin, Texas 78711-3087. The applicable rule is 30 TAC285. You can also download the rule from the TNRCC's web site at http://www.tnrcc.state.tx.us.

VI. HOW MUCH RAINFALL CAN YOU COLLECT?

Now that you have a better understanding of the principles of rainwater catchment, the next questions are, how much rain can you expect to collect in your location and how reliable is this rainfall. The simple answer to the first question is that one inch of precipitation (1/12 foot) on one square foot of collection area equals 0.6233 gallons. Many simply round this off to 600 gallons collected per inch of rain on 1,000 square feet. From this basic rule of thumb (600 gallons per inch on 1,000 square feet) the analysis shifts to (1) how efficiently can this rainfall be collected, and (2) how reliable is the rainfall on your specific area. Once these questions are answered, you will need to balance the amount of rainfall than can be collected with the amount of water that will be used. You may be surprised to learn that even with the strictest water conservation measures, rainfall collection can only provide a fraction of the amount of water you use.

The answer to these questions also depends in part on what the harvested rain will be used for. If it is to provide supplemental water for the yard, the answer will be different than if the system will be the sole source of water for a household. One should also keep in mind that the efficiency of the collection system can change depending on design while the question regarding precipitation reliability depends on where you are located.

Collection Efficiency. How efficiently the rainfall can be collected depends on several considerations. Many first assume that "I can collect all of it," but this is never the case. First, there is always a small loss to rainfall needed to wet the roof area and water collected by the roof washer. This is usually a small percentage of the rainfall and will range from about 3/100's to 1/10th of an inch *per rainfall event*, depending on the roof material and the volume the roof washer diverts. Built-up flat roofs can retain as much as half an inch of water depending on their condition and design. Overshot of gutters and spillage during very intensive rainfall events will occur.

Spills and rate of rainfall can also make a difference. If filter type roof washers are used, they will "spill" the excess flow once the filter flow through capacity is exceeded. Finally, you can collect only as much rainfall as your storage system will hold. Depending on your design, most cisterns will become full during especially rainy periods and any additional rainfall collected will spill. Collection efficiencies of 75% to 90% are often used by installers depending on the specific design if the system is to provide water for in-home use. For small systems designed for supplemental plant watering, collection factors of below 50% are common because it is not economic to install the large storage that would be required to increase this factor.

Rainfall Reliability. The reliability of precipitation requires a closer look. The first and simplest parameter to consider is average precipitation. The map on page 19 shows average precipitation for Texas. The first step one should take is to use the average rainfall for your area to determine how much water would be generated from your roof area. The calculation is the roof catchment area times the average rainfall times 600 gallons divided by 1,000.

$$\frac{\text{Area (ft}^2\text{) X Average Rainfall (inches) X 600}}{1{,}000}$$

If you are only interested in supplemental water for plant watering, this may be sufficient knowledge, but if rainwater is to be your sole source of water, you need to know what precipitation rate you can rely on in more detail. Once your system is in, you will need to know the amount of rainfall you can expect from one month to the next.

The figure on page 24 shows annual precipitation for seven cities from across Texas. The annual rainfall is arranged in rank order from the lowest to the highest for each city. This graph also shows the percent of time that rainfall of that magnitude will not be exceeded. For example, the graph shows that in Wichita Falls, rainfall will be greater than 30 inches per year about 35% of the time or lower than 30 inches per year 65% of the time. The graph also indicates that annual rainfall in Wichita Falls will fall between 17 inches but below 37 inches 90% of the time.

As a rule-of-thumb in Texas, if one divides average annual rainfall by two, the resulting answer will be near the 5% percentile rainfall. For example, Austin receives an average of 32 inches a year and only 5% of the time is rainfall less than 17 inches a year. This can help give a quick method of determining if enough rainfall will occur to provide water during very low periods based on annual precipitation. An expample of how annual data can be used is shown below.

The monthly distribution of rainfall is also important information for sizing a system. Using annual data does not tell you how much water one can expect from one month to the next or just as important, once in operation, how much rainfall can one expect in any one given month. These statistics are presented in “Rainfall Data for Selected Communities Across Texas” on page 27.

The use of these data is twofold. First, the 10%, 25% and 50% (median) monthly data present the percent of times that rainfall is less

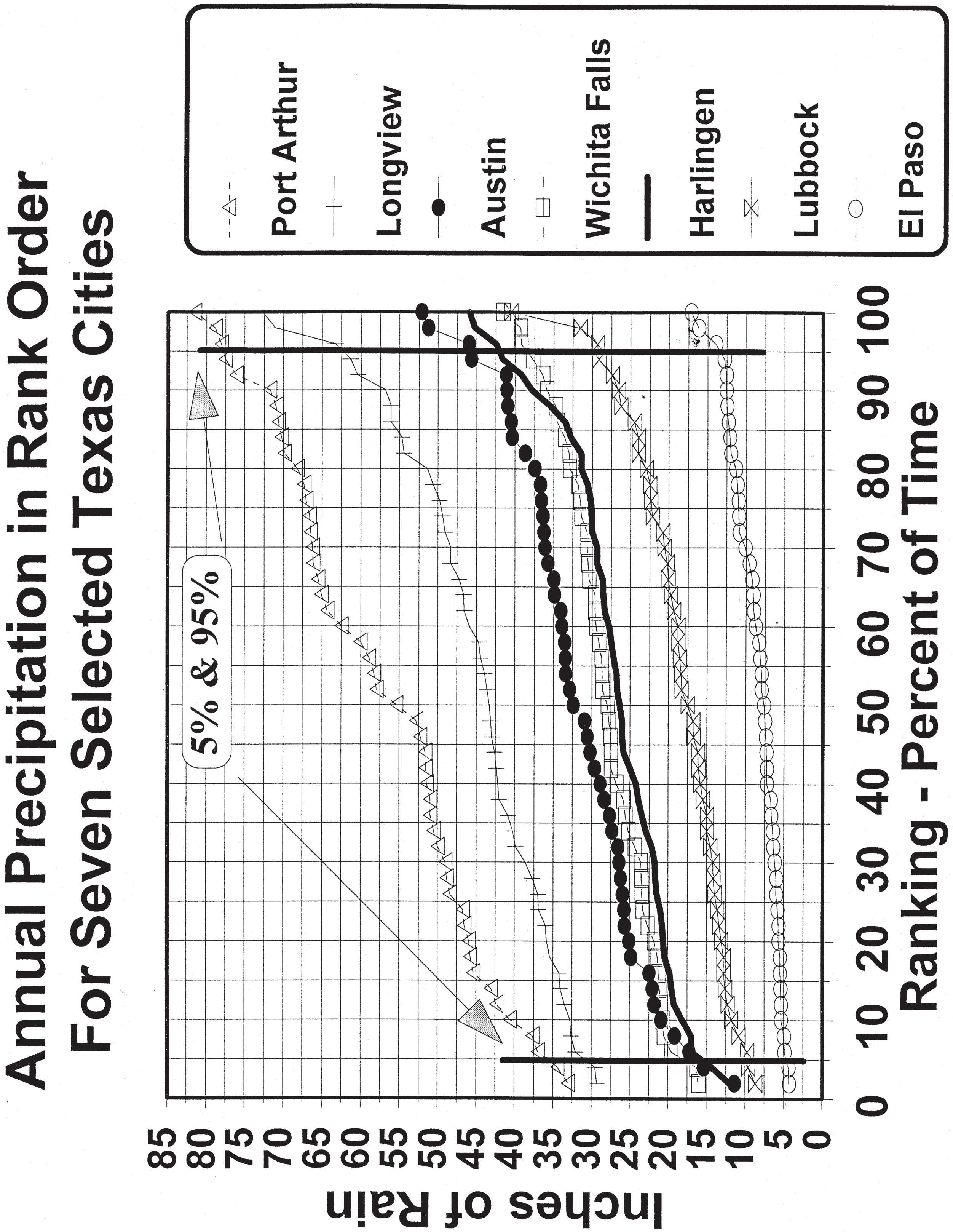
BASIC METHOD USING ANNUAL DATA

1. Calculate Roof Catchment Area (see page 7)
2. Multiply the collection area in square feet by 0.6 gallons per square foot per inch of rain times the collection factor times the average annual rainfall and half of the average annual rainfall.

   For example, if you have 2,500 square feet of collection area and live in Austin, where the average annual rainfall is 32 inches a year and the collection efficiency factor is 80%, the average amount of rain you can collect is:

   2,500 X 0.6 X 0.8 X 32 = 38,400 gallons per year

3. Dividing this by 365 days a year, the supply would be 105 gallons per day.
4. Using the rule-of-thumb that half of the average rainfall will provide a close estimate of the low expected rainfall for the area, in an extremely severe drought year, approximately 19,700 gallons could be collected. This would result in a supply of only 53 gallons a day.


Annual Precipitation in Rank Order
For Seven Selected Texas Cities
5% & 95%
Inches of Rain
85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
Ranking - Percent of Time
0 10 20 30 40 50 60 70 80 90 100
Port Arthur
Longview
Austin
Wichita Falls
Harlingen
Lubbock
El Paso

than that value. Examination of the data also shows that the 50% values are lower than the average values. This is because the arithmetic average is skewed by a few abnormally high rainfall events such as those occurring during hurricane. While the median represents the rainfall that, when all historic rainfall values for that month are ranked from lowest to highest, is in the middle.

The way to use these data on a monthly basis is that for any given month, you can expect to get at least the median rainfall half of the time, the 25% rainfall 75% of the time, and the 10% rainfall 90% of the time. The sum of the twelve monthly median values is lower than the annual average as explained above. In Texas, the sum of the medial values provides a rainfall that can be relied on for 65% of the time or more. For example, the total for Austin is 25 inches which occurs 80% of the time in any given year and the 25% monthly value annual total is 12 inches which occurs over 95% of the time.

This information can also be used to develop monthly balances of demand and storage as shown on the following page using Austin data. In this example, the median (50%) and 25% monthly rainfall were used. The purpose is to determine how much storage capacity is needed and the level of demand that can be sustained.

Different storage volumes, roof sizes (if this is an option), and monthly demands are tried. In the example case, the roof size is 3,000 square feet, the collection efficiency is 80%, and the storage volume is 10,000 gallons. It is assumed that the year begins with 3,000 in storage; monthly demands of 2,000 gallons, 3,000 gallons, and 4,000 gallons are used. The calculation is done by following the steps below.

MONTHLY BALANCE CALCULATIONS

1. Determine January rainfall for both the 50% and 25% levels. For example, at the 50% rainfall level of 1.23 inches for January it is:

   3,000 X 0.8 X 1.23 X 0.623 = 1,839 gallons collected

2. Add the volume already in storage (3,000 gallons) to the gallons collected and subtract the monthly demand. For the 2,000 gallons a month demand example and 50% rainfall level, this is:

   1,839 + 3,000 - 2,000 = 2,839 gallons in storage at the end of the month

   This is repeated, but note that if the storage is zero or less at the end of the month, use zero for the next month; if the amount in storage at the end of the month is greater than the capacity of the cistern (10,000 gallons in this example) use the storage capacity for the end of the month storage. The end result is that for the 10,000 gallon storage capacity an anverge use of 3,000 gallons / month, but not 4,000 gallons / month, could be supported.

   Many professionals use 50 to 100 years of actual monthly rainfall data in a program which performs the same series of calculations as described above to determine the optimum system size.

EXAMPLE MONTHLY WATER BALANCE CALCULATIONS

Month	Monthly Use (gal/mo)	50% rain (inches)	Rainfall Collected (gallons)	End of Mo. Storage (gallons)	25% rain (inches)	Rainfall Collected (gallons)	End of Mo. Storage (gallons)
				3,000			3,000
1	2,000	1.23	1,839	2,839	0.60	897	1,897
2	2,000	2.28	3,409	4,248	1.13	1,690	1,587
3	2,000	1.66	2,482	4,730	0.81	1,211	798
4	2,000	2.18	3,260	5,990	1.38	2,063	861
5	2,000	3.89	5,816	9,806	1.60	2,392	1,254
6	2,000	2.63	3,932	10,000	1.51	2,258	1,511
7	2,000	1.01	1,645	9,645	0.44	658	169
8	2,000	1.19	1,779	9,424	0.60	897	0
9	2,000	3.15	4,710	10,000	1.50	2,243	243
10	2,000	2.78	4,157	10,000	0.87	1,301	0
11	2,000	1.71	2,557	10,000	0.74	1,106	0
12	2,000	1.24	1,854	9,854	0.74	1,106	0
	24,000	25.04	37,440		11.92	17,823	
1	3,000	1.23	1,839	1,839	0.60	897	897
2	3,000	2.28	3,409	2,248	1.13	1,690	0
3	3,000	1.66	2,482	1,730	0.81	1,211	0
4	3,000	2.18	3,260	1,990	1.38	2,063	0
5	3,000	3.89	5,816	4,806	1.60	2,392	0
6	3,000	2.63	3,932	5,738	1.51	2,258	0
7	3,000	1.01	1,645	4,383	0.44	658	0
8	3,000	1.19	1,779	3,162	0.60	897	0
9	3,000	3.15	4,710	4,872	1.50	2,243	0
10	3,000	2.78	4,157	6,029	0.87	1,301	0
11	3,000	1.71	2,557	5,586	0.74	1,106	0
12	3,000	1.24	1,854	4,440	0.74	1,106	0
	36,000	25.04	37,440		11.92	17,823	
1	4,000	1.23	1,839	839	0.60	897	0
2	4,000	2.28	3,409	248	1.13	1,690	0
3	4,000	1.66	2,482	0	0.81	1,211	0
4	4,000	2.18	3,260	0	1.38	2,063	0
5	4,000	3.89	5,816	1,816	1.60	2,392	0
6	4,000	2.63	3,932	1,749	1.51	2,258	0
7	4,000	1.01	1,645	0	0.44	658	0
8	4,000	1.19	1,779	0	0.60	897	0
9	4,000	3.15	4,710	710	1.50	2,243	0
10	4,000	2.78	4,157	867	0.87	1,301	0
11	4,000	1.71	2,557	0	0.74	1,106	0
12	4,000	1.24	1,854	0	0.74	1,106	0
	48,000	25.04	37,440		11.92	17,823	

RAINFALL DATA FOR SELECTED COMMUNITIES ACROSS TEXAS

This chart contains monthly rainfall data from 40 weather stations across Texas. The statistics are based on 50 years of recorded rainfall, from 1940 through 1990. For each station, six monthly precipitation values are given:

- **MIN.** The minimum recorded occurrence is the lowest recorded rainfall in 50 years.
- **10%** The 10% occurrence level indicates that 90% of the time monthly rainfall is higher.
- **25%** The 25% occurrence level indicates that 75% of the time monthly rainfall is higher.
- **50%** The 50% (median) occurrence level describes monthly rainfall for half the time.
- **AVE.** The average monthly (mean) occurrence level factors in precipitation extremes and is higher than the 50% (median) data.
- **MAX.** The maximum recorded occurrence is the highest recorded monthly rainfall in 50 years.

Refer to the map below to see if there is a data set for your town. If you live between weather stations, average the monthly precipitation values for the closest town to the north and to the south, since precipitation patterns in Texas run from the north to south/southwest. (See map of Average Annual Precipitation in Texas, page 19.)

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Abernathy						
January	0.00	0.00	0.09	0.35	0.57	3.75
February	0.00	0.01	0.12	0.45	0.67	2.28
March	0.00	0.01	0.17	0.44	0.72	3.13
April	0.00	0.13	0.37	0.88	1.11	3.96
May	0.31	0.68	0.98	1.81	2.47	6.32
June	0.32	0.52	1.56	2.84	3.03	8.36
July	0.00	0.46	1.20	2.38	2.44	9.68
August	0.10	0.45	0.83	1.96	2.34	8.54
September	0.05	0.34	0.74	1.81	2.27	6.43
October	0.00	0.00	0.28	1.00	1.67	7.41
November	0.00	0.00	0.05	0.37	0.61	2.08
December	0.00	0.01	0.09	0.31	0.57	2.22
Abilene						
January	0.00	0.00	0.10	0.79	0.98	4.29
February	0.02	0.10	0.35	1.02	1.08	3.57
March	0.02	0.13	0.41	0.79	1.08	5.08
April	0.00	0.44	0.97	1.87	2.10	6.76
May	0.14	0.70	1.44	2.98	3.36	13.11
June	0.00	0.35	1.46	2.19	2.80	9.55
July	0.00	0.23	0.86	1.71	2.16	7.11
August	0.00	0.34	0.74	1.60	2.31	8.18
September	0.00	0.50	1.23	2.31	2.79	10.97
October	0.00	0.35	1.01	2.08	2.51	10.64
November	0.00	0.00	0.33	0.76	1.23	4.55
December	0.00	0.01	0.18	0.74	1.05	6.22

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Ackerly						
January	0.00	0.00	0.00	0.37	0.56	2.17
February	0.00	0.00	0.09	0.44	0.63	3.20
March	0.00	0.00	0.00	0.48	0.75	3.91
April	0.00	0.00	0.23	0.74	1.14	7.15
May	0.00	0.53	1.10	2.04	2.58	12.61
June	0.00	0.00	0.87	2.05	2.13	7.22
July	0.00	0.10	0.59	1.79	2.25	8.30
August	0.00	0.10	0.60	1.21	1.78	5.53
September	0.00	0.00	0.99	1.99	2.60	10.53
October	0.00	0.00	0.49	1.10	1.67	6.49
November	0.00	0.00	0.00	0.20	0.59	2.89
December	0.00	0.00	0.01	0.46	0.65	3.84
Albany						
January	0.00	0.00	0.11	0.87	1.27	8.06
February	0.15	0.32	0.60	1.01	1.54	6.51
March	0.06	0.15	0.51	0.99	1.42	4.31
April	0.00	0.58	1.11	2.16	2.58	10.12
May	0.24	1.22	2.20	3.58	3.94	10.46
June	0.06	0.32	1.18	2.26	2.87	9.42
July	0.00	0.12	0.66	1.79	2.26	11.52
August	0.11	0.36	0.71	1.41	1.99	6.53
September	0.00	0.22	1.62	2.69	3.35	13.40
October	0.00	0.23	0.89	2.24	2.74	1.01
November	0.00	0.00	0.36	0.81	1.43	6.07
December	0.01	0.07	0.32	1.12	1.42	8.62

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Alpine						
January	0.00	0.01	0.13	0.45	0.54	1.82
February	0.00	0.00	0.03	0.24	0.47	3.04
March	0.00	0.00	0.03	0.18	0.35	1.66
April	0.00	0.01	0.07	0.25	0.51	3.60
May	0.00	0.18	0.43	1.06	1.19	3.41
June	0.00	0.41	0.89	1.76	2.04	6.93
July	0.05	0.60	1.39	2.66	2.93	9.30
August	0.05	0.84	1.52	2.27	2.64	8.15
September	0.01	0.49	1.00	2.21	2.61	11.08
October	0.00	0.11	0.28	0.98	1.28	4.39
November	0.00	0.00	0.00	0.37	0.47	3.19
December	0.00	0.00	0.09	0.28	0.52	2.56
Amarillo						
January	0.00	0.00	0.11	0.42	0.53	2.30
February	0.00	0.03	0.20	0.48	0.55	1.76
March	0.00	0.02	0.26	0.59	0.88	3.93
April	0.00	0.19	0.40	0.85	1.03	2.75
May	0.01	0.74	1.40	2.47	2.69	9.76
June	0.00	1.00	1.70	3.15	3.44	10.62
July	0.11	0.79	1.46	2.50	2.77	7.50
August	0.26	1.20	1.68	2.87	2.99	7.45
September	0.02	0.31	0.68	1.59	1.84	4.95
October	0.00	0.12	0.45	0.99	1.34	4.78
November	0.00	0.00	0.14	0.39	0.60	2.23
December	0.00	0.02	0.15	0.27	0.52	4.46
Anahuac						
January	0.63	1.15	2.12	4.33	4.09	10.02
February	0.00	0.90	1.77	2.81	3.36	10.93
March	0.05	0.59	1.20	2.03	2.90	8.34
April	0.09	0.86	2.02	2.97	3.84	12.53
May	0.62	1.11	1.89	3.79	4.53	10.00
June	0.26	0.77	1.82	3.55	5.16	20.25
July	0.39	1.69	2.82	4.43	4.59	13.32
August	0.30	1.78	2.57	3.08	4.68	17.15
September	0.05	0.76	2.32	5.45	5.51	16.44
October	0.00	0.23	1.33	3.19	4.05	19.02
November	0.50	1.21	2.10	3.44	4.10	10.74
December	0.63	1.56	2.13	3.39	4.33	13.46
Austin						
January	0.02	0.35	0.60	1.23	1.79	9.14
February	0.23	0.59	1.13	2.28	2.40	6.48
March	0.00	0.25	0.81	1.66	1.84	5.97
April	0.03	0.53	1.38	2.18	2.89	9.85
May	0.77	1.17	1.60	3.89	4.40	9.90
June	0.00	0.66	1.51	2.63	3.41	14.87
July	0.00	0.11	0.44	1.10	1.75	10.50
August	0.00	0.25	0.60	1.19	2.03	8.84
September	0.09	0.80	1.50	3.15	3.22	7.41
October	0.00	0.56	0.87	2.78	3.50	12.25
November	0.00	0.32	0.74	1.71	2.05	7.28
December	0.00	0.32	0.74	1.24	2.18	14.05

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Bakersfield						
January	0.00	0.00	0.02	0.31	0.61	4.24
February	0.00	0.00	0.10	0.40	0.62	4.33
March	0.00	0.00	0.02	0.22	0.42	1.83
April	0.00	0.00	0.11	0.54	0.82	3.58
May	0.00	0.43	0.89	1.30	1.76	4.56
June	0.00	0.00	0.18	1.20	1.40	6.00
July	0.00	0.03	0.14	0.81	1.21	6.23
August	0.00	0.03	0.40	1.17	1.46	4.73
September	0.05	0.22	0.60	1.64	2.49	23.41
October	0.00	0.12	0.32	1.38	1.83	13.30
November	0.00	0.00	0.00	0.35	0.57	2.61
December	0.00	0.00	0.00	0.23	0.54	2.92
Brady						
January	0.00	0.02	0.17	0.71	1.13	6.36
February	0.09	0.34	0.70	1.33	1.57	5.19
March	0.00	0.11	0.39	0.81	1.19	3.44
April	0.26	0.52	1.08	1.88	2.13	6.45
May	0.11	1.36	1.90	3.31	3.69	7.88
June	0.00	0.42	0.81	1.89	2.60	8.24
July	0.00	0.02	0.17	1.15	1.96	13.99
August	0.07	0.28	0.63	1.34	2.08	11.12
September	0.00	0.57	1.41	2.55	3.19	10.41
October	0.01	0.18	0.64	1.78	2.47	7.68
November	0.00	0.12	0.40	1.10	1.28	3.77
December	0.00	0.05	0.14	0.76	1.29	8.16
Brownsville						
January	0.00	0.13	0.36	1.07	1.37	4.74
February	0.00	0.05	0.35	1.00	1.43	10.21
March	0.00	0.01	0.11	0.33	0.60	3.44
April	0.00	0.00	0.23	0.88	1.65	10.33
May	0.00	0.25	1.14	1.95	2.50	9.05
June	0.00	0.06	1.34	2.20	2.80	8.45
July	0.00	0.10	0.31	1.06	1.63	9.35
August	0.00	0.12	0.88	2.10	2.52	9.47
September	0.05	1.43	2.79	4.71	5.35	20.09
October	0.33	0.63	1.26	2.79	3.17	17.03
November	0.00	0.09	0.51	0.86	1.48	7.63
December	0.00	0.02	0.14	0.71	1.09	3.91
Cameron						
January	0.00	0.55	0.96	1.73	2.28	8.94
February	0.44	0.85	1.63	2.84	2.78	7.38
March	0.07	0.48	0.96	1.74	2.20	7.29
April	0.01	1.31	1.62	2.53	3.54	11.58
May	0.57	0.88	2.96	4.12	4.36	9.74
June	0.00	0.46	1.13	2.54	3.01	8.61
July	0.00	0.00	0.20	1.01	1.50	9.23
August	0.00	0.08	0.36	1.21	1.66	5.71
September	0.01	0.72	1.17	3.28	3.54	12.49
October	0.00	0.58	1.32	2.40	3.54	11.49
November	0.00	0.58	1.18	2.51	2.73	7.60
December	0.18	0.51	1.16	2.06	2.64	11.64

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Childress						
January	0.00	0.00	0.12	0.32	0.60	3.43
February	0.00	0.05	0.28	0.62	0.85	2.89
March	0.00	0.11	0.38	0.84	1.11	4.47
April	0.00	0.11	0.58	1.26	1.69	7.29
May	0.07	1.17	1.86	2.70	3.33	8.11
June	0.10	0.59	1.40	2.66	3.00	7.50
July	0.09	0.25	0.72	1.88	2.06	6.73
August	0.07	0.27	0.74	1.57	1.88	5.74
September	0.05	0.18	0.56	1.89	2.25	6.68
October	0.00	0.05	0.49	1.37	2.02	9.88
November	0.00	0.01	0.15	0.73	0.89	4.24
December	0.00	0.01	0.20	0.59	0.79	3.86
College Station						
January	0.21	0.54	1.24	2.23	2.87	15.53
February	0.10	0.87	1.52	2.68	2.89	9.72
March	0.26	0.61	1.30	1.96	2.43	6.03
April	0.04	0.94	1.71	3.32	3.73	12.44
May	0.21	1.63	2.20	4.50	4.73	11.30
June	0.07	0.53	1.47	2.75	3.78	12.56
July	0.00	0.09	0.74	1.93	2.19	7.05
August	0.00	0.19	0.60	1.83	2.29	10.61
September	0.31	0.66	2.12	4.08	4.37	12.06
October	0.00	0.36	1.79	3.16	3.74	12.84
November	0.17	0.84	1.70	2.87	3.12	8.30
December	0.23	0.93	1.67	2.56	2.93	8.57
Corpus Christi						
January	0.01	0.13	0.35	1.20	1.61	10.71
February	0.00	0.20	0.92	1.39	1.91	8.06
March	0.00	0.05	0.15	0.66	1.12	4.76
April	0.00	0.05	0.35	1.52	2.06	8.01
May	0.00	0.57	1.25	2.70	3.17	9.34
June	0.02	0.28	0.73	2.41	3.20	13.31
July	0.00	0.01	0.30	1.10	1.93	11.86
August	0.10	0.45	0.80	2.45	3.09	14.74
September	0.46	0.88	2.00	4.19	5.36	20.27
October	0.00	0.17	0.86	2.55	3.20	10.97
November	0.00	0.10	0.41	1.11	1.51	5.17
December	0.00	0.08	0.41	0.88	1.54	9.68
Cotulla						
January	0.00	0.05	0.17	0.62	0.99	5.44
February	0.00	0.05	0.37	1.08	1.31	3.81
March	0.00	0.02	0.13	0.60	0.83	5.83
April	0.00	0.30	1.01	1.66	2.10	9.35
May	0.05	0.27	0.85	2.11	2.70	7.60
June	0.00	0.35	1.16	2.08	2.67	11.53
July	0.00	0.00	0.14	0.70	1.27	6.12
August	0.00	0.10	0.40	1.19	2.00	13.17
September	0.02	0.46	0.95	2.10	2.77	9.52
October	0.00	0.10	0.80	2.08	2.99	12.86
November	0.00	0.00	0.25	0.86	1.14	3.73
December	0.00	0.00	0.19	0.79	1.15	4.10

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Dalhart						
January	0.00	0.00	0.05	0.34	0.43	1.69
February	0.00	0.00	0.05	0.31	0.42	1.73
March	0.00	0.00	0.15	0.56	0.83	2.92
April	0.00	0.10	0.36	0.62	1.08	3.53
May	0.19	0.81	1.67	2.77	2.73	6.38
June	0.00	0.38	1.01	2.01	2.29	6.94
July	0.23	0.73	1.51	2.46	3.10	8.85
August	0.01	0.42	1.40	2.51	2.72	9.66
September	0.01	0.18	0.48	1.19	1.56	8.33
October	0.00	0.06	0.16	0.59	1.09	5.94
November	0.00	0.00	0.05	0.27	0.57	3.19
December	0.00	0.00	0.12	0.26	0.42	1.91
Dallas						
January	0.00	0.29	0.85	1.81	1.91	8.36
February	0.24	0.79	1.20	2.17	2.33	5.65
March	0.12	0.49	1.23	2.40	2.88	9.05
April	0.02	0.89	1.94	3.62	3.99	15.37
May	0.52	1.53	3.03	4.31	5.11	13.66
June	0.28	0.65	1.49	2.98	3.43	10.83
July	0.00	0.18	0.58	1.63	2.17	8.49
August	0.01	0.12	0.62	1.71	2.07	5.92
September	0.00	0.71	1.50	2.58	3.08	10.64
October	0.00	0.41	1.06	2.96	3.97	16.00
November	0.14	0.40	1.01	1.89	2.29	7.50
December	0.03	0.28	0.86	1.54	2.22	9.20
Dekalb						
January	0.20	0.94	1.60	3.20	3.35	10.36
February	0.61	1.31	2.55	3.74	3.74	7.46
March	0.58	1.23	2.36	4.13	4.28	11.02
April	0.51	1.10	2.35	3.44	4.56	14.11
May	0.12	1.78	2.29	4.23	5.41	16.39
June	0.07	0.77	1.24	2.83	3.75	9.55
July	0.12	1.24	2.62	3.91	4.21	8.79
August	0.05	0.53	1.12	2.28	2.76	10.62
September	0.07	0.45	1.57	3.54	3.79	12.94
October	0.14	0.55	1.43	3.29	4.32	13.90
November	0.47	0.87	1.71	3.69	4.46	12.05
December	0.12	0.69	1.97	3.90	4.33	12.57
Eagle Pass						
January	0.00	0.02	0.13	0.49	0.78	3.33
February	0.00	0.09	0.27	0.59	1.05	6.23
March	0.00	0.02	0.13	0.34	0.65	3.09
April	0.00	0.06	0.31	1.41	1.87	11.65
May	0.00	0.43	1.32	2.90	3.12	7.09
June	0.00	0.01	0.61	1.84	2.64	14.61
July	0.00	0.00	0.23	1.12	1.99	13.15
August	0.00	0.14	0.31	1.12	2.08	8.70
September	0.07	0.26	1.11	2.46	2.92	11.74
October	0.00	0.04	0.34	1.61	2.21	9.43
November	0.00	0.00	0.08	0.62	0.79	3.98
December	0.00	0.01	0.15	0.39	0.77	3.86

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
El Paso						
January	0.00	0.01	0.14	0.30	0.42	1.75
February	0.00	0.00	0.05	0.36	0.40	1.61
March	0.00	0.00	0.02	0.18	0.29	2.24
April	0.00	0.00	0.00	0.07	0.20	1.39
May	0.00	0.00	0.02	0.14	0.33	4.08
June	0.00	0.00	0.00	0.25	0.62	3.12
July	0.03	0.18	0.71	1.14	1.55	5.47
August	0.00	0.25	0.48	1.08	1.46	5.50
September	0.00	0.01	0.15	0.91	1.36	6.58
October	0.00	0.00	0.17	0.52	0.70	3.08
November	0.00	0.00	0.03	0.18	0.33	1.60
December	0.00	0.00	0.07	0.36	0.59	3.23
Falfurrias						
January	0.05	0.14	0.30	0.84	1.26	9.76
February	0.00	0.07	0.61	1.12	1.62	6.17
March	0.00	0.01	0.11	0.57	0.71	2.71
April	0.00	0.08	0.33	1.01	1.35	5.36
May	0.09	0.81	1.41	2.56	2.96	12.31
June	0.00	0.13	0.79	2.77	3.21	12.95
July	0.00	0.06	0.24	1.02	1.59	11.51
August	0.01	0.10	0.53	1.46	2.39	12.83
September	0.39	1.05	1.63	3.42	4.63	32.76
October	0.00	0.27	0.63	1.81	2.64	7.16
November	0.00	0.06	0.23	0.76	1.06	5.17
December	0.00	0.06	0.25	0.83	1.18	4.90
Galveston						
January	0.16	1.15	1.52	3.14	3.32	10.69
February	0.07	0.46	1.14	2.00	2.54	8.27
March	0.03	0.22	0.77	1.47	2.15	9.39
April	0.00	0.33	0.78	1.89	2.50	10.35
May	0.00	0.44	1.30	2.69	3.34	10.92
June	0.21	0.74	1.58	3.36	3.92	14.74
July	0.00	0.34	1.21	2.67	3.59	17.38
August	0.14	0.60	1.76	3.20	4.14	15.20
September	0.27	1.20	2.84	4.44	5.34	15.36
October	0.00	0.21	1.13	2.25	2.75	9.02
November	0.45	0.68	1.35	2.39	3.05	10.74
December	0.48	1.28	1.95	2.67	3.32	8.94
Gonzales						
January	0.00	0.37	0.84	1.56	2.08	7.78
February	0.13	0.37	1.33	2.08	2.36	8.64
March	0.01	0.20	0.77	1.39	1.76	4.84
April	0.16	0.68	1.10	2.75	3.38	10.43
May	0.26	1.44	2.22	3.45	4.53	15.15
June	0.00	0.90	1.59	2.53	3.90	20.18
July	0.00	0.15	0.39	1.19	1.53	5.29
August	0.12	0.35	0.65	1.38	2.09	17.01
September	0.16	0.85	1.82	3.05	3.73	18.79
October	0.00	0.50	0.96	2.31	3.18	13.08
November	0.01	0.50	0.97	1.81	2.37	7.16
December	0.00	0.38	0.77	1.43	2.13	9.57

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Harlingen						
January	0.00	0.17	0.30	0.96	1.46	5.07
February	0.00	0.14	0.40	1.18	1.66	9.45
March	0.00	0.03	0.19	0.60	0.92	3.91
April	0.00	0.07	0.34	0.92	1.98	17.13
May	0.01	0.41	1.08	2.06	2.84	11.90
June	0.00	0.14	0.93	2.30	2.69	7.46
July	0.00	0.18	0.41	0.89	1.65	8.59
August	0.00	0.30	0.94	2.01	2.69	11.21
September	0.08	1.14	2.23	4.38	5.06	17.57
October	0.00	0.46	1.03	2.17	2.59	10.63
November	0.01	0.23	0.42	1.09	1.45	4.26
December	0.00	0.06	0.23	0.84	1.21	4.25
Houston						
January	0.15	1.11	2.13	3.44	3.70	9.49
February	0.09	0.65	1.90	3.23	3.48	11.20
March	0.03	0.71	1.16	2.00	2.71	11.38
April	0.04	0.89	1.37	2.76	3.49	10.41
May	0.46	1.16	2.46	3.81	4.84	14.76
June	0.17	1.52	2.16	4.25	5.85	17.28
July	0.05	0.82	2.02	3.43	4.29	17.22
August	0.35	1.07	2.07	3.17	4.23	15.97
September	0.14	0.63	1.87	4.53	4.85	15.30
October	0.00	0.62	1.64	3.09	4.76	22.20
November	0.16	1.09	1.50	2.99	4.02	10.15
December	0.47	1.11	1.59	3.17	3.55	9.69
Hunt						
January	0.00	0.17	0.30	1.01	1.31	6.88
February	0.00	0.35	0.91	1.50	1.82	6.14
March	0.00	0.10	0.40	1.10	1.48	4.70
April	0.07	0.52	1.11	1.74	2.32	9.25
May	0.48	1.18	2.09	3.16	3.81	10.10
June	0.00	0.50	1.44	2.41	2.80	10.47
July	0.00	0.18	0.50	2.00	2.34	10.35
August	0.00	0.00	0.63	1.57	2.66	20.01
September	0.20	0.80	1.43	3.08	3.40	12.26
October	0.00	0.10	0.75	2.39	3.12	9.00
November	0.00	0.00	0.36	1.19	1.52	4.84
December	0.00	0.00	0.24	0.83	1.45	10.11
Karnack						
January	0.05	0.91	1.92	3.22	3.74	12.58
February	0.54	1.86	2.69	3.61	4.09	8.99
March	0.00	1.18	2.45	3.92	3.98	9.36
April	0.00	1.57	2.54	3.59	4.40	13.97
May	0.00	2.10	2.75	4.65	5.02 1	4.05
June	0.00	1.10	1.64	3.66	4.46	14.47
July	0.00	0.46	1.47	3.08	3.17	9.17
August	0.11	0.47	0.87	1.99	2.52	7.45
September	0.23	0.65	1.35	2.43	3.57	11.87
October	0.00	0.52	1.25	2.98	3.80	12.65
November	0.18	1.29	2.91	4.66	4.69	11.11
December	0.00	1.82	2.61	3.66	4.32	10.39

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Longview						
January	0.12	0.82	1.80	3.76	3.68	8.40
February	0.51	1.86	2.87	3.62	3.90	7.83
March	0.48	1.62	2.26	3.68	3.84	11.61
April	0.20	1.24	1.50	4.20	4.49	15.25
May	0.42	1.46	2.40	4.68	5.18	12.46
June	0.38	0.99	2.09	3.76	4.36	14.35
July	0.00	0.28	1.02	2.07	3.14	12.36
August	0.10	0.43	1.03	2.06	2.43	9.96
September	0.07	0.77	1.94	3.61	3.93	11.13
October	0.00	0.72	1.60	2.64	3.75	14.03
November	0.23	0.97	2.55	4.16	4.31	9.30
December	0.45	1.36	2.04	3.71	4.17	12.69
Lubbock						
January	0.00	0.00	0.05	0.31	0.50	3.98
February	0.00	0.02	0.14	0.36	0.61	2.46
March	0.00	0.02	0.15	0.54	0.75	3.12
April	0.02	0.10	0.33	0.85	1.05	3.44
May	0.06	0.66	1.34	2.41	2.62	7.77
June	0.00	0.49	1.37	2.25	2.84	7.91
July	0.00	0.23	0.75	2.03	2.20	7.14
August	0.03	0.29	0.68	1.75	2.06	8.77
September	0.00	0.14	0.63	1.74	2.22	6.82
October	0.00	0.01	0.47	0.95	1.80	10.77
November	0.00	0.00	0.02	0.31	0.59	2.67
December	0.00	0.01	0.07	0.32	0.51	2.19
Lufkin						
January	0.22	1.08	1.97	2.53	3.73	13.09
February	0.89	1.40	1.74	2.87	3.38	9.87
March	0.19	0.99	1.70	3.19	3.18	7.19
April	0.28	0.70	2.36	3.45	3.83	8.77
May	0.59	1.36	3.37	4.52	5.00	12.07
June	0.33	1.15	1.45	3.21	3.70	13.93
July	0.00	0.58	1.51	2.29	2.67	6.94
August	0.13	0.68	1.14	1.90	2.59	8.46
September	0.09	0.74	2.02	2.43	3.44	11.19
October	0.00	0.46	1.26	2.68	3.60	15.45
November	0.76	1.10	2.06	3.17	3.79	12.86
December	0.58	1.67	2.17	3.69	4.04	10.01
Midland						
January	0.00	0.00	0.07	0.37	0.54	3.57
February	0.00	0.07	0.17	0.35	0.60	2.52
March	0.00	0.00	0.02	0.20	0.46	2.83
April	0.00	0.00	0.09	0.60	0.75	2.40
May	0.06	0.33	0.91	1.84	2.11	7.58
June	0.00	0.33	0.71	1.39	1.53	3.94
July	0.00	0.05	0.32	1.12	1.86	8.47
August	0.12	0.22	0.62	1.21	1.65	4.36
September	0.07	0.15	0.68	1.56	2.12	9.64
October	0.00	0.11	0.39	1.04	1.62	7.38
November	0.00	0.00	0.01	0.25	0.56	2.30
December	0.00	0.01	0.15	0.25	0.52	3.22

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Palacios						
January	0.23	0.50	1.25	2.62	2.82	10.19
February	0.15	0.61	1.10	2.77	2.85	9.36
March	0.12	0.31	0.66	1.40	2.18	9.22
April	0.00	0.36	1.10	2.33	2.71	9.21
May	0.02	0.68	1.50	3.29	4.41	13.15
June	0.00	0.49	1.47	3.03	4.38	15.49
July	0.08	0.25	0.89	2.31	3.56	12.79
August	0.06	0.39	0.94	2.77	3.52	13.59
September	0.43	0.81	2.22	4.26	5.64	23.66
October	0.00	0.50	1.14	2.72	4.53	24.21
November	0.07	0.49	1.10	2.47	3.03	9.13
December	0.28	0.76	1.12	2.34	3.11	9.02
Port Arthur						
January	0.54	1.60	2.07	4.67	4.82	14.79
February	0.14	0.70	2.01	3.92	3.97	13.07
March	0.05	0.58	1.27	2.61	3.20	10.16
April	0.24	0.88	1.85	3.13	3.93	15.28
May	0.08	0.60	2.71	4.60	5.29	13.08
June	0.74	1.12	1.94	3.91	5.43	18.82
July	0.60	2.02	3.29	4.62	5.37	18.59
August	0.89	1.65	2.49	3.93	5.08	17.17
September	0.50	1.03	2.40	4.10	5.62	21.92
October	0.00	0.07	1.66	3.09	4.24	15.05
November	0.14	1.38	2.60	3.89	4.35	10.81
December	1.27	2.01	2.87	4.03	5.01	17.93
San Angelo						
January	0.00	0.00	0.06	0.55	0.82	3.61
February	0.00	0.12	0.34	0.62	0.98	4.44
March	0.00	0.03	0.22	0.46	0.82	4.96
April	0.05	0.27	0.71	1.06	1.62	5.09
May	0.23	0.52	1.45	2.43	2.85	11.18
June	0.05	0.15	0.65	2.11	2.17	5.98
July	0.00	0.15	0.30	0.78	1.23	7.09
August	0.00	0.15	0.45	1.34	1.63	8.07
September	0.00	0.25	1.14	2.66	2.97	10.93
October	0.00	0.07	0.42	1.88	2.28	8.63
November	0.00	0.00	0.21	0.55	0.87	3.53
December	0.00	0.00	0.05	0.31	0.77	3.91
San Antonio						
January	0.02	0.24	0.56	1.12	1.64	8.40
February	0.01	0.39	0.85	1.73	1.92	6.34
March	0.00	0.11	0.53	1.16	1.59	6.06
April	0.08	0.47	1.22	2.03	2.61	9.25
May	0.16	0.93	1.73	3.05	4.08	12.77
June	0.00	1.00	1.58	2.68	3.59	11.89
July	0.00	0.02	0.22	1.25	1.93	8.22
August	0.00	0.13	0.62	1.96	2.44	11.09
September	0.47	0.74	1.05	2.23	3.15	13.03
October	0.00	0.44	1.09	2.71	3.19	9.74
November	0.00	0.12	0.69	1.88	2.17	5.99
December	0.02	0.15	0.37	1.00	1.65	13.86

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Waco						
January	0.02	0.42	0.74	1.34	1.70	5.79
February	0.17	0.48	1.31	1.92	2.21	6.25
March	0.02	0.58	0.82	2.18	2.25	5.53
April	0.10	1.16	1.57	2.74	3.23	13.26
May	0.61	1.47	2.17	3.92	4.62	14.89
June	0.26	0.44	0.94	2.14	2.86	12.02
July	0.00	0.07	0.25	0.74	1.81	8.53
August	0.00	0.16	0.53	0.90	1.61	8.83
September	0.00	0.31	0.73	2.53	3.07	7.24
October	0.00	0.86	1.25	2.40	3.20	10.43
November	0.12	0.29	0.81	2.08	2.26	6.19
December	0.03	0.40	0.50	1.71	2.00	8.34

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Weatherford						
January	0.00	0.13	0.34	1.45	1.68	6.20
February	0.04	0.56	0.95	1.69	2.15	5.41
March	0.23	0.66	1.04	1.82	2.27	7.14
April	0.30	1.22	1.70	2.61	3.34	11.65
May	0.49	1.87	2.80	4.45	4.79	16.31
June	0.00	0.91	1.48	2.91	3.39	9.45
July	0.00	0.16	0.83	1.90	2.15	11.07
August	0.02	0.23	0.97	1.66	2.09	8.46
September	0.00	0.27	1.31	2.74	3.16	8.61
October	0.00	0.51	0.97	1.98	3.54	14.88
November	0.00	0.28	0.86	1.57	1.84	5.51
December	0.00	0.24	0.49	1.40	1.80	10.98

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Wichita Falls						
January	0.00	0.12	0.23	1.02	1.04	4.41
February	0.00	0.20	0.61	1.05	1.34	4.47
March	0.00	0.42	1.07	1.70	1.86	5.29
April	0.30	0.62	1.53	2.37	2.78	8.44
May	0.00	1.01	2.23	4.05	4.48	13.07
June	0.22	0.87	1.65	2.86	3.39	8.55
July	0.02	0.20	0.70	1.44	1.98	11.74
August	0.03	0.18	0.55	1.82	2.12	7.55
September	0.00	0.04	1.41	2.28	3.25	10.16
October	0.00	0.34	0.99	2.07	2.74	7.81
November	0.00	0.02	0.28	0.86	1.36	5.66
December	0.01	0.10	0.39	0.85	1.41	6.86

MONTH	MIN.	10%	25%	50%	AVE.	MAX.
Wink						
January	0.00	0.00	0.05	0.12	0.43	3.04
February	0.00	0.00	0.04	0.25	0.42	1.63
March	0.00	0.00	0.00	0.10	0.35	2.96
April	0.00	0.00	0.10	0.36	0.72	4.74
May	0.05	0.25	0.42	0.85	1.20	8.61
June	0.00	0.04	0.31	1.18	1.45	4.84
July	0.00	0.25	0.59	1.34	1.84	5.83
August	0.00	0.14	0.37	1.13	1.27	3.71
September	0.00	0.08	0.49	1.19	1.76	9.04
October	0.00	0.00	0.18	0.93	1.38	5.59
November	0.00	0.00	0.00	0.15	0.46	2.34
December	0.00	0.00	0.05	0.14	0.40	3.04

VII. COST CONSIDERATIONS

A rainwater harvesting system designed as an integrated component of a new construction project is generally more cost-effective than retrofitting a system onto an existing building. This is because many of the shared costs (roof and gutters) can be designed to optimize system performance, and the investment can be amortized over time. As described above, a system can be designed as a full-service or supplemental water source, each having specific costs and paybacks. While costs for the same system are equivalent regardless of whether there is access to a municipal water supply, *payback* (the amount of time it takes to recoup the investment relative to dollars saved) varies depending on other available water supply options. For example, based on current water rates, payback on a system where the only option is drilling a well is better than if municipal water supply is available, since the cost of drilling a well and associated annual maintenance and treatment costs are often higher than annual costs of a municipal water supply. Other variables which affect system economics include choice of tank and filtration. In general, maximizing storage capacity and minimizing water use through conservation and reuse are important rules to keep in mind.

For buildings outside a municipal water service area, rainwater harvesting systems designed to fulfill all water requirements can be as costly, and frequently more expensive, than the cost of drilling a conventional well. However, there is evidence that with careful planning and design, the cost of a rainwater system can be less than the cost of a well in many cases – especially if the well water must be softened and treated to remove dissolved minerals, and the rainwater system is owner-built, which is a viable option for people with available time and basic skills. Factoring in the full costs of drilling and operating a well are necessary to understand comparative costs. For example, costs of drilling a well vary depending on soil type and water availability, and range from about $6.00 to $15.00 per linear foot of depth. In addition, wells require a pump and possibly a water softener and filter, depending on water quality. Monthly costs including operations, maintenance, appliance replacement, are estimated to be as much as $120. In addition, reliance on well water has the potential uncertainties of long term water supply and water quality. And, if salt is added to well water, a related environmental cost is the resulting negative impact on soil quality, which can make the soil sterile.

Around the state, city-supplied water is relatively inexpensive, though does not always reflect the "full" cost of water including costs of treatment and pumping. For new construction, many cities require a tap to be installed before a Certificate of Occupancy will be issued. The tap fee is generally in the range of $1,500 to $2,900, depending on rates for particular cities. Because of these factors, the return of a full-service rainwater harvesting system where city water is available is rarely less than 30 years and can be as high as 90 years, assuming about present values for municipal water and approximate construction costs of $1.00 per gallon of collection capacity for a rainwater harvesting system.

Although difficult to quantify, an important consideration for some people when comparing options is the value of water *quality,* which varies tremendously depending on source. Some rainwater harvesters in Texas believe rainwater to be the highest quality water available, and therefore worth the added expense to harvest.

Understanding water quality relative to available water sources may be an important consideration for you in determining what water source to rely on.

Hardness and high mineral content in some parts of Texas make municipal and private well water less desirable because of deposits that build-up on pipes and appliances, poor taste, and possible negative health effects. Therefore, the value of the rainwater due to its high quality may offset the added expense if the alternative is high mineral content city-water, especially if additional costs of bottled water for cooking and drinking, a water softener, and increased soap use are factored in. In parts of the state where city-supplied water is satisfactory, a rainwater system as a supplemental water source may be most practical. For example, a system sized just for drinking and cooking, or just for garden irrigation, can be significantly smaller than a full-service system, but provide the benefits that have particular value to the user.

Conventional financing for stand alone rainwater harvesting systems has been provided for just a few new homes in Texas. While this has not become standard practice, such precedents will help to educate the financial community of the viability of rainwater harvesting. However, until this practice is better understood, appraisers may underestimate the value of a rainwater system, and insurance underwriters may require a back-up water source such as an on-demand supply contract with a local water hauler.

The term “stand alone system” refers to rainwater harvesting systems that do not have municipal or well water back-up.

VIII. CODE AND SAFETY ISSUES

The Texas Natural Resource Conservation Commission (TNRCC) regulates municipal and well water, not rainwater. The Texas Department of Health (TDH) regulates mosquito hazards and greywater. Check with local authorities since no agency authorizes or inspects private rainwater collection systems. The Texas Plumbing Code does not allow double trenching wastewater and potable water lines. In Austin, for example, an airgap wider than the municipal line must exist between the public water and rainwater to keep the rainwater from entering the supply outlet.

The State of Ohio Department of Health and the State of Virginia Bureau of Sewage and Water Services regulate rainwater systems. Since the State of Texas does not presently inspect or enforce any guidelines regarding captured rainfall, you may want to consider some specifications from these other states when designing your system.

- A cistern may not be located closer than 50 feet from a source of contamination, such as a septic tank.
- A cistern must be located on a grade lower than the roof washer to ensure that it can fill completely.
- A rainwater system must include installation of an overflow pipe which empties into a non-flooding area.
- Inlets to cisterns must be designed to dissipate pressure of influent stream and minimize the stirring of any settled solids.
- An above-ground roof washer or filtering device shall be provided on all cisterns.
- The water intake for a pump in a cistern shall be attached to a flotation device and be located a minimum of 4 inches below the surface of the water.
- Overflow from rainwater systems cannot flow into wastewater systems.
- Cisterns shall be accessible for cleaning.
- All openings into the cistern shall be screened.
- Cisterns cannot be relied upon to provide potable water without adequate treatment consisting of roofwashing and continuous disinfection.

The following case studies are organized by material (masonry, cast in place concrete, ferrocement, fiberglass, polyethylene, steel, and composite systems utilizing more than one material) and capacity (from smallest to largest). With the exception of a few installations identified by a proper name, these systems are found on buildings throughout the state, with a majority in central Texas.

MASONRY AND CONCRETE

MASONRY

County:	Gillespie
Number of People in Household:	2
Roofing Material:	Galvanized Steel
Gutter and Downspout Material:	Galvanized Steel
Preliminary Filters:	Inlet Screen
Above or Below Ground Storage:	Below
Cistern Materials:	Masonry
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	1,200 Gallons
Installation Date:	1889
Cost:	Unknown
Potable or Non Potable	Potable only Water Supply
Treatment:	Coal at top of cistern to filter incoming rain
Integrated with Greywater System:	No
Additional Comments:	In last 47 years of continuous use, only one repair of replastering a crack.

CAST IN PLACE CONCRETE

County:	Travis
Number of People in Household:	3
Roofing Material:	Galvanized Steel
Gutter and Downspout Material:	Seamless Aluminum
Preliminary Filters:	Screen Basket
Above or Below Ground Storage:	Below
Cistern Materials:	Concrete
Site Built or Shop Fabricated:	Poured in Place
Number of Cisterns:	1
Storage Capacity:	25,000 Gallons
Installation Date:	1992
Cost:	$18,000
Potable or Non Potable Water Supply:	Both
Treatment:	15 Micron Sediment Filter
Integrated with Greywater System:	House is plumbed for black and greywater reuse but recovery system is not in place

CAST IN PLACE CONCRETE

County:	Travis
Number of People in Household:	3
Roofing Material:	Galvanized Steel
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Leaf Screens and Roof Washer
Above or Below Ground Storage:	Above
Cistern Material:	Concrete
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1 Rain Cistern, 1 Greywater Tank
Storage Capacity:	25,000 Gallons Rain, 2,500 Gallons Greywater
Installation Date:	1994
Cost:	$30,000
Potable or Non Potable Water Supply:	Both
Treatment:	5 Micron Sediment Filter, Carbon Cartridge, Ultraviolet Light and Reverse Osmosis
Integrated with Greywater System:	Yes

GUNNITE

County:	Travis
Number of People in Household:	3
Roofing Material:	Galvalume
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Inlet Screens and Roof Washer
Above or Below Ground Storage:	Below
Cistern Material:	Gunnite
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	25,000 Gallons
Installation Date:	1995
Cost:	$7,000
Potable or Non Potable Water Supply:	Potable
Treatment:	Sediment Filter and Ultraviolet Light
Integrated with Greywater System:	No
Additional Comments:	Cistern built like a swimming pool with domed concrete cover.

FERROCEMENT

County:	Hidalgo
Number in Household:	6
Roofing Material:	Mineralized Asphalt
Preliminary Filters:	Manual Roofwashing Prior to Rainfall
Above or Below Ground Storage:	Above
Cistern Material:	Ferrocement
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	600 Gallons
Installation Date:	1992
Cost:	$100
Potable or Non Potable Water Supply:	Potable (Cooking and Drinking only)
Filters:	None
Integrated with Greywater System:	Yes. Also rainwater diversion system that irrigates 19-tree orchard with 24,000 gallons per year
Additional Comments:	While the asphalt roofing is not recommended for potable water supply, no significant levels of any contaminant have been detected. The only objection to the mineralized asphalt roofing is its texture which makes cleaning the catchment area prior to a rain event more difficult than it would be on a smoother surface such as metal.

FERROCEMENT

Location:	Travis
Number of People in Household:	3
Roofing Material:	Metal
Gutter and Downspout Material:	Seamless Metal
Preliminary Filters:	Screen over Downspouts
Above or Below Ground Storage:	Above
Cistern Material:	Ferrocement
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	20,000 Gallons
Installation Date:	1995
Cost:	$6,790 for Cistern Only
Potable or Non Potable Water Supply:	Both
Treatment:	20 and 5 Micron Sediment Filters and Ultraviolet Light
Integrated with Greywater System:	No

FERROCEMENT

Location:	Travis
Number of People in Household:	3
Roofing Material:	Galvanized Sheet Metal
Gutter and Downspout Material:	Seamless Aluminum
Preliminary Filters:	Roof Washer
Above or Below Ground Storage:	Above
Cistern Materials:	Ferrocement
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	20,000 Gallons
Installation Date:	1995
Cost:	$9,000
Potable or Non Potable Water Supply:	Both
Treatment:	None
Integrated with Greywater System:	No

FERROCEMENT

County:	Williamson
Number of People in Household:	5
Roofing Material:	Galvalume
Gutter and Downspout Material:	Aluminum / PVC
Preliminary Filters:	Manual Wash Box
Above or Below Ground Storage:	Above Ground
Cistern Material:	Ferrocement
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	25,000 Gallons
Installation Date:	1995
Cost:	$8,000
Potable or Non Potable Water Supply:	Potable
Treatment:	Ultraviolet Light and 400 micron Cartridge Filter
Integrated with Greywater System:	No
Additional Comments:	Daily per capita water use for family of 5 averages 150 gallons per day but can be reduced to 120 gallons per day.

FERROCEMENT

County:	Travis
Number of People in Household:	6
Roofing Material:	Tin
Gutter and Downspout Material:	Tin
Preliminary FIlters:	Screen at Cistern Inlet
Above or Below Ground Storage:	Above and Below
Cistern Material:	Reinforced Concrete
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	26,000 Gallons
Installation Date:	1994
Cost:	$20,000
Potable or Non Potable Water Supply:	Both
Treatment:	Ultraviolet Light
Integrated with Greywater System:	Yes. Both black and greywater pass through a sand filter then are reused in a drip irrigation system around the house. FERROcement

FERROCEMENT

County:	Hays
Number of People in Household:	3
Roofing Material:	Metal
Gutter and Downspout Material:	Seamless Metal
Preliminary Filters:	20 and 5 Micron Sediment Filters
Above or Below Ground Storage:	Partially Below Ground
Cistern Material:	Reinforced Concrete
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	28,000 Gallons
Installation Date:	1995
Cost:	$9,400
Potable or Non Potable Water Supply:	Both
Treatment:	Ultraviolet Light
Integrated with Greywater System:	No
Additional Comments:	Unusual 32 feet long by 15 feet wide by 5 feet high rectangular shape.

FERROCEMENT

County:	Travis
Number of People in Household:	3
Roofing Material:	Cement Shingles
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Leaf Screens
Above or Below Ground Storage:	Below Ground 6 Feet, Above Ground 3 Feet
Cistern Material:	Ferrocement
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	1
Storage Capacity:	33,000 Gallons
Installation Date:	1995
Cost:	$6,800
Potable or Non Potable Water Supply:	Potable
Treatment:	5 Micron Sediment Filter
Integrated with Greywater System:	No
Additional Comments:	Unusual 35 foot long kidney shaped tank covered with earth and terraced with limestone

PLASTIC

FIBERGLASS

County:	Bexar
Number of People in Household:	1
Roofing Material:	Asbestos Shingles
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Leaf Screens
Above or Below Ground Storage:	Above
Cistern Materials:	Fiberglass
Site Built or Shop Fabricated:	Prefabricated
Number of Cisterns:	2
Storage Capacity:	1,000 (2 @ 500 Gallons)
Installation Date:	1993
Cost:	$5,000
Potable or Non Potable Water Supply:	Non Potable
Treatment:	None
Integrated with Greywater System:	No

FIBERGLASS

County:	Travis
Number of People in Household:	3
Roofing Material:	Concrete Tile
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Leaf Screens
Above or Below Ground Storage:	Above
Cistern Material:	Fiberglass
Site Built or Shop Fabricated:	Shop Built
Number of Cisterns:	1
Storage Capacity:	5000 Gallons
Installation Date:	1993
Cost:	$4,200
Potable or Non Potable Water Supply:	Potable
Treatment:	5 Micron Sediment Filter, Carbon Cartridge Filter, and Ultraviolet Light
Integrated with Greywater System:	No

FIBERGLASS

County:	Hays
Number of People in Household:	2
Roofing Material:	Galvalume
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Leaf Screens
Above or Below Ground Storage:	Above
Cistern Material:	Fiberglass
Site Built or Shop Fabricated:	Shop Fabricated
Number of Cisterns:	1
Storage Capacity:	5,000 Gallons
Installation Date:	1995
Cost:	$9,000
Potable or Non Potable Water Supply:	Potable
Treatment:	Ultraviolet Light and Cartridge Filter
Integrated with Greywater System:	No

FIBERGLASS

County:	Travis
Number of People in Household:	2
Roofing Material:	Metal
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Leaf Screens
Above or Below Ground Storage:	Above
Cistern Material:	Fiberglass
Site Built or Shop Fabricated:	Shop Fabricated
Number of Cisterns:	1
Storage Capacity:	8,500 Gallons
Installation Date:	1995
Cost:	$8,500
Potable or Non Potable Water Supply:	Potable
Treatment:	Ultraviolet Light and Cartridge
Integrated with Greywater System:	No
Additional Comments:	Retrofit system with water well as back-up supply.

FIBERGLASS

County:	Hays
Number of People in Household:	2
Roofing Material:	Metal with Baked Enamel Finish
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Leaf Screens
Above or Below Ground Storage:	Above
Cistern Material:	Fiberglass
Site Built or Shop Fabricated:	Shop Fabricated
Number of Cisterns:	3
Storage Capacity:	13,000 Gallons Total
Installation Date:	1995
Cost:	$5,500
Potable or Non Potable Water Supply:	Potable
Treatment:	30, 5, and 1 micron Filters, Chlorine, Reverse Osmosis for Kitchen Tap
Integrated with Greywater System:	No
Additional Comments:	Rainwater system less expensive than well.

FIBERGLASS

County:	Bastrop
Number of People in Household:	6
Roofing Material:	Galvalume
Gutter and Downspout Material:	Seamless Aluminum
Preliminary Filters:	Leaf Screens, 20 Gallon Roof Washer
Above or Below Ground Storage:	Above
Cistern Material:	Fiberglass
Site Built or Shop Fabricated:	Shop Fabricated
Number of Cisterns:	2
Storage Capacity:	16,000 Gallons (10,000 Gallon and 6,000 Gallon Tanks)
Installation Date:	1994
Cost:	$12,500
Potable or Non Potable Water Supply:	Potable
Treatment:	Prefilter, Sediment Filter, Ultraviolet Light, and Carbon Filter
Integrated with Greywater System:	No
Additional Comments:	Owner built house with system designed during construction. Freestanding garage also collects rainwater in smaller of two tanks. To reduce water consumption, the house contains two composting toilets, one that uses low water and another that uses no water.

FIBERGLASS

County:	Travis
Number of People in Household:	3
Roofing Material:	Galvanized Metal
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Screens, Roofwasher
Above or Below Ground Storage:	Above
Cistern Material:	Fiberglass
Site Built or Shop Fabricated:	Shop Fabricated
Number of Cisterns:	2
Storage Capacity:	20,000 Gallons, 2 @ 10,000 Gallons
Installation Date:	1994 first tank, 1996 second tank
Cost:	$6,390 first tank + $4,032 second tank (includes tank, pad, and plumbing) = $10,422 total
Potable or Non Potable Water Supply:	Potable
Treatment:	Ultraviolet Light, Sediment Cartridge Filter, and Carbon Filter
Integrated with Greywater System:	Yes, greywater from sinks, shower, and washing machine is reused.
Additional Coments:	Pole barn planned to be added over tanks.

FIBERGLASS

County:	Hays
Number of People in Household:	3
Roofing Material:	Galvalume
Gutter and Downspout Material:	PVC
Preliminary Filters	Leaf Screen
Above or Below Ground Storage:	Above
Cistern Materials:	Fiberglass
Site Built or Shop Fabricated:	Prefabricated
Number of Cisterns:	1
Storage Capacity:	20,000 Gallons
Installation Date:	1995
Cost:	$12,000 (Includes 3,200 square foot water barn)
Potable or Non Potable Water Supply:	Both
Treatment:	Ozonation
Integrated with Greywater System:	No

FIBERGLASS

County:	Travis
Number of People in Household:	2
Roofing Material:	Concrete Tile
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Leaf Screens, Buffer Tank Screens, Sand Prefilter
Above or Below Ground Storage:	Buffer Tanks Below, Storage Tanks Above
Cistern Material:	Buffer Tanks are Concrete, Storage Tanks are Fiberglass
Site Built or Shop Fabricated:	Shop Fabricated
Number of Cisterns:	4 Buffer Tanks, 3 Storage Tanks
Storage Capacity:	25,000 Gallon Storage Tanks, 4,000 Gallon Buffer Tanks
Installation Date:	1996
Cost:	$30,000
Potable or Non Potable Water Supply:	Potable
Treatment:	Sediment and Acti-vated Carbon Filters, Ultra-violet Light, and Reverse Osmosis (Kitchen only)
Integrated with Greywater System:	No

FIBERGLASS

County:	Hays
Number of People in Household:	3
Roofing Material:	Metal
Gutter and Downspout Material:	PVC, Copper
Preliminary Filters:	Leaf Screens, Roofwasher
Above or Below Ground Storage:	Above
Cistern Material:	Fiberglass
Site Built or Shop Fabricated:	Shop Fabricated
Number of Cisterns:	3
Storage Capacity:	25,000 Gallons
Installation Date:	1994
Cost:	$18,000
Potable or Non Potable Water Supply:	Potable
Treatment:	Ultraviolet Light and Cartridge
Integrated with Greywater System:	No

POLYETHYLENE

County:	Brewster
Number of People in Household:	2
Roofing Material:	Metal
Gutter and Downspout Material:	Metal
Preliminary Filters:	Continuous Leaf Screen, 30 Micron Sediment Filter before Pump
Above or Below Ground Storage:	Above
Cistern Material:	Polyethylene
Site Built or Shop Fabricated:	Shop Fabricated
Number of Cisterns:	4
Storage Capacity:	10,000 Gallons
Installation Date:	1995
Cost:	$3,500
Potable or Non Potable Water Supply:	Non Potable
Treatment:	5 Micron Sediment Filter
Integrated with Greywater System:	No
Additional Comments:	House is totally reliant on solar energy which powers a 24 volt pump with a pressure tank.

METAL

STEEL

County:	Travis
Number of People in Household:	2
Roofing Material:	Metal
Gutter and Downspout Material:	Metal
Preliminary Filters:	None
Above or Below Ground Storage:	Above
Cistern Material:	Galvanized Steel Horse Trough
Site Built or Shop Fabricated:	Prefabricated Trough with Custom Wood Cover
Number of Cisterns:	1
Storage Capacity:	230 Gallons
Installation Date:	1993
Cost:	$200
Potable or Non Potable Water Supply:	Non Potable, for garden irrigation only
Treatment:	None
Integrated with Greywater System:	No

STEEL

County:	Travis
Number of People in Household:	2
Roofing Material:	Asphalt Composition Shingles
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Screens at tank inlet pipes
Above or Below Ground Storage:	Above
Cistern Material:	Steel Drums (55 gallons each)
Site Built or Shop Fabricated:	Prefabricated Drums, Site Built Installation
Number of Cisterns:	2 Collection Systems comprised of 3 drums each, 6 drums total
Storage Capacity:	330 Gallons (2 @ 165 Gallons)
Installation Date:	1995
Cost:	$400 including gutters
Potable or Non Potable Water Supply:	Non Potable, for garden irrigation only
Treatment:	None
Integrated with Greywater System:	No
Additional Comments:	The tanks are stacked horizontally on wood supports.

STEEL

Project:	Park Place Gardens
County:	Travis
Roofing Material:	Asphalt Shingles
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Screen Basket
Above or Below Ground Storage:	Above
Cistern Material:	Galvanized Steel
Site Built or Shop Fabricated:	Shop Built
Number of Cisterns:	1
Storage Capacity:	650 Gallons
Installation Date:	?
Cost:	Not Available
Potable or Non Potable Water Supply:	Non Potable
Treatment:	None
Integrated with Greywater System:	No

STEEL

County:	Travis
Number of People in Household:	2
Roofing Material:	Galvalume
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Screen along Gutter and at Downspout
Above or Below Ground Storage:	Above
Cistern Materials:	Galvanized Steel
Site Built or Shop Fabricated:	Shop Built
Number of Cisterns:	1
Storage Capacity:	850 Gallons
Installation Date:	1995
Cost:	$1,350 (including foundation and rock base)
Potable or Non Potable Water Supply:	Non Potable
Treatment:	None
Integrated with Greywater System:	No
Additional Comments:	Gravity feed system for garden use only. Overflow drains to pond.

STEEL

County:	Houston
Number of People in Household:	4
Roofing Material:	Galvalume
Gutter and Downspout Material:	Metal
Preliminary Filters:	Screen at Downspout
Above or Below Ground Storage:	Above
Cistern Materials:	Steel with Swimming Pool Liner
Site Built or Shop Fabricated:	Site Built
Number of Cisterns:	2
Storage Capacity:	6,000 Gallons (2 @ 3,000 Gallons)
Installation Date:	1995
Cost:	$2,000
Potable or Non Potable Water Supply:	Both
Treatment:	Carbon and Ultraviolet Light
Integrated with Greywater System:	No

STEEL

Project:	Advanced Green Builder House, Center for Maximum Potential Building Systems
County:	Travis
Collection Surface:	Roof
Roofing Material:	Galvalume
Gutter and Downspout Material:	Galvanized Steel and ABS Pipe
Preliminary Filters:	Roof Washer
Above or Below Ground Storage:	Above Ground
Cistern Material:	Galvanized Steel
Number of Cisterns:	7
Site Built or Shop Fabricated:	Shop Fabricated
Storage Capacity:	13,970 Gallons
Number of People in Household:	Designed for Family of Four
Installation Date:	1996
Cost:	$12,000 (tanks only)
Potable or Non Potable Water Supply:	Both
Treatment:	Undecided Between Ultraviolet Light or Reverse Osmosis
Integrated with Greywater System:	Yes

COMPOSITE SYSTEMS

COMPOSITE

Project:	Cross Timbers Permaculture Institute at Fossil Rim Wildlife Center
County:	Sommervell
Number of People in Household:	3
Roofing Material:	Galvanized Sheet Metal
Gutter and Downspout Material:	Seamless Aluminum and PVC
Preliminary Filters:	8 Gallon Diversion Catchment, "P" Trap
Above or Below Ground Storage:	Above
Cistern Materials:	Ferrocement and Metal
Site Built or Shop Fabricated:	Site Built and Prefabricated
Number of Cisterns:	3
Storage Capacity:	13,300 Gallons
Installation Date:	1995
Cost:	$500 each for the ferrocement tanks
Potable or Non Potable Water Supply:	Potable
Treatment:	None
Integrated with Greywater System:	No.

COMPOSITE

County:	Travis
Number of People in Household:	4
Roofing Material:	Galvanized Sheet Metal
Gutter and Downspout Material:	Seamless Aluminum
Preliminary Filters:	Roof Washer, 5 Micron Sediment Filter
Above or Below Ground Storage:	Above
Cistern Materials:	Fiberglass, Rigid and Sheet Polyethylene, Galvanized Steel, and Plaster
Site Built or Shop Fabricated:	Site Built and Prefabricated
Number of Cisterns:	13
Storage Capacity:	35,700 Gallons
Installation Date:	Ongoing Since 1983
Cost:	Not Available
Potable or Non Potable Water Supply:	Both
Treatment:	Ultraviolet Light
Integrated with Greywater System:	Laundry water in summer months only.
Additonal Comments:	Swimming pool filled with 35,000 gallons of rainwater.

COMPOSITE

County:	Hays
Number of People in Household:	2
Roofing Material:	Galvanized Metal
Gutter and Downspout Material:	Aluminum
Preliminary Filters:	Roof Washer
Above or Below Ground Storage:	Above
Cistern Materials:	Concrete, Steel and Fiberglass
Site Built or Shop Fabricated:	Both
Number of Cisterns:	4
Storage Capacity:	40,000 Gallons
Installation Date:	Since 1993
Cost:	$25,00 (includes water barn)
Potable or Non Potable Water Supply:	Both
Treatment:	Reverse Osmosis
Integrated with Greywater System:	Yes

COMPOSITE

Project:	National Wildflower Research Center
County:	Travis
Collection Surfaces:	Central Courtyard and Roofs
Roofing Materials:	Galvanized Steel
Preliminary Filters:	10 Gallon Roofwasher
Above or Below Ground Storage:	Central Collection Below Ground Pumped to All Others Above Ground
Cistern Materials:	Concrete (Precast and Poured in Place), Galvanized Steel, Fiberglass
Site Built or Shop Fabricated:	Both
Number of Cisterns:	Central Collection (poured in place), Entry (stone clad precast concrete), Childrens's Discovery (galvanized metal), Tower, Irrigation (2 fiberglass)
Storage Capacity:	70,000 Gallons (underground)
Installation Date:	1995
Cost:	$250,000
Potable or Non Potable Water Supply:	Non Potable
Filters:	None
Integrated with Greywater System:	No
Additional Comments :	Gravity fed system from roofs and courtyard to underground tank which pumps harvested rain to above ground tanks. Rainwater is also used for an entry pond and central fountain.

IN PROCESS

Project:	Franklin High School, El Paso Independent School District (in process)
County:	El Paso
Collection Surface:	Roof and Courtyards
Roofing Material:	Galvalume
Gutter and Downspout Material:	Galvalume
Preliminary Filters:	No
Above or Below Ground Storage:	Below
Cistern Material:	Undetermined
Site Built or Shop Fabricated:	Undetermined
Number of Cisterns:	Undetermined
Storage Capacity:	300,000 gallon potential
Installation Date:	1995 for Gutters, Downspouts and Supply Lines Cistern Installation in Future
Potable or Non Potable Water Supply:	Non Potable
Integrated with Greywater System:	Separate Provisions for Future

Additional Comments: This system is not yet in operation. Downspouts and area drains in courtyards lead to planned central storage tank. Construction budget did not provide funds for cistern in this phase. Campus is planned to include xeriscape landscaping and greywater reuse as future budget allows.

APPENDIX

GLOSSARY

air gap: a vertical space between a water or drain line and the flood level of a receptacle used to prevent backflow or siphonage from the receptacle in the event of negative pressure or vacuum.

aquifer: an underground waterway that is replenished by precipitation.

backflow: flow of water in a pipe or water line in a direction opposite to normal flow.

backflow preventer: a device or system installed in a water line to stop backflow from a nonpotable source.

blackwater: as defined in Texas, the wastewater from toilets and kitchen sinks.

buffer: to shift pH to a specific value.

building footprint: the area of a building on the ground.

cistern: an above or below ground tank used to store water, generally made of galvanized metal, fiberglass, ferrocement or concrete.

disinfection: a process in which pathogenic (disease producing) bacteria are killed by use of chlorine or physical processes.

diverter: a mechanism designed to divert the first flush rainwater from entering the cistern.

erosion: the loss of topsoil that occurs as a result of run-off.

filtration: the process of separating particles of 2 microns or larger in diameter from water by means of a porous substance such as a permeable fabric or layers of inert material housed in a media filter or removable cartridge filter.

first flush: generally the first 10 gallons of rainwater per 1,000 square feet of roof surface that is diverted due to potential for contamination.

flow rate: the quantity of water which passes a given point in a specified unit of time, expressed in gallons per minute.

forcebreaker: an extension of the fill pipe to a point 1" above the bottom of the cistern, which dissipates the pressure of incoming rainwater and thus minimizes the stirring of settled solids.

greywater: as defined in Texas, the wastewater from residential appliances or fixtures except toilets and kitchen sinks.

groundwater: water found below ground that has seeped there through spaces in soil and geologic formations.

hardness: a characteristic of groundwater due to the presence of dissolved calcium and magnesium which is responsible for most scale formation in pipes and water heaters.

hydrologic cycle: the continual exchange of water from the atmosphere to the land and oceans and back again.

leaf screen: a mesh installed over gutters and entry points to downspouts to prevent leaves and other debris from clogging the flow of rainwater.

micron: a linear measure equal to one millionth of a meter, or .00003937 inch.

nonpotable water: water intended for non-human consumption purposes, such as irrigation, toilet flushing, and dishwashing.

pH: a logarithmic scale of values of 0 to 14 that measure of hydrogen ion concentration in water which determines whether the water is neutral (pH 7), acidic(pH 0-7) or basic (pH 7-14).

pathogen: an organism which may cause disease.

potable water: water which is suitable and safe for human consumption.

pressure tank: a component of a plumbing system that provides the constant level of water pressure necessary for the proper operation of plumbing fixtures and appliances.

rainwater harvesting: the principle of collecting and using precipitation from a catchment surface.

roof washer: a device used to divert the first flush rainwater from entering a cistern.

run-off farming: the agricultural application of harvested rainwater involving a system of terraces that directs the rainwater from higher to lower elevations.

sedimentation: the process in which solid suspended particles settle out (sink to the bottom) of water, frequently after the particles have coagulated.

total dissolved solids: a measure of the mineral content of water supplies.

xeriscape: a landscape practice which specifies regionally-adapted, drought-resistant plants and other water-conserving techniques.

ABBREVIATIONS

FDA Food & Drug Administration

mg/L milligrams / Liter

psi pounds per square inch

PVC Polyvinylchloride

TDH Texas Department of Health

TDS Total dissolved solids

THMs Trihalomethanes

TNRCC Texas Natural Resource Conservation Commission

TWDB Texas Water Development Board

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ORGANIZATIONS

American Rainwater Catchment Systems Association, P.O. Box 685283, Austin, TX 78768-5283

American Water Works Association, 6666 West Quincy Avenue, Denver, CO, 80235

Center for Maximum Potential Building Systems, 8604 F.M. 969, Austin, Texas 78724. (512) 928-4786.

Water Quality Association, 4151 Naperville Road, Lisle, IL 60532

COMPUTER PROGRAMS

Raincatch, developed by Commonwealth Scientific and Industrial Research Organization, Division of Tropical Crops and Pastures, Townsfille, Australia: enables a given roof and tank to be quickly tested over the entire period of historical rainfall records by computer, and can find the most economic means of achieving a desired reliability, or the greatest reliability for a given cost, from any starting point, with or without rationing. Program initially developed for an Australian project in Africa, but can be applied anywhere that rainfall, consumption, and cost data are available.

Rainwater System Simulator (RainSim) is a spreadsheet program developed by Rain Harvest, Inc. (now Sustainable Homesteads), that simulates the performance of a rainwater collection system. For every month of the simulation, it subtracts the water that is used and adds in any rainwater that was collected. The amount of water remaining in the cistern at the end of the month is output to a graph. The program uses historical rainfall records from the National Weather Service records for the years 1955-1984 recorded in Austin, Texas. A total of 100 years' rainfall data may be added to the program.

The following values are manipulated for simulation:

- the size of the collection area in square feet
- the number of gallons that will be used each month
- the total size of storage capacity in gallons
- the amount of water in storage at the beginning of the simulation, in gallons
- the amount, if any, of water that will be put into storage if it is empty.

A companion program, *RainCalc*, calculates water production and peak flow rate based on the collection area and peak design rainfall rates to be expected in this area once every 10 years. *RainCalc* is used to properly design the collection plumbing system to catch all rainfall flowing off the roof without losing any to system back-up.

RESOURCES- a list of Rainwater design, construction and equipment firms is available upon request. If you want your firm listed; send information to **Conservation, Texas Water Development Board, P.O. Box 13231, Austin, Texas 78711-3231**