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Pipeline

National Small Flows Clearinghouse

Small Community Wastewater Issues Explained to the Public

EVAPOTRANSPIRATION SYSTEMS

Evapotranspiration (ET) systems use an alternative onsite treatment technology suitable for areas where risks of groundwater and surface water contamination might exist.

ET systems employ the combined effects of evaporation from soil and transpiration from plants to dispose of wastewater effluent. Wastewater flows from a septic tank or aerobic unit into a vegetation-covered distribution and storage area. (*See figure 1.*)

From this storage area, moisture is wicked up to plant roots and to the soil surface. The plants use the moisture in their growing processes and subsequently transpire the excess through their leaves. Moisture that migrates up to the soil surface evaporates into the atmosphere as relatively clean water.

These systems function most effectively in areas where annual evapotranspiration rates exceed the loading rate of the system from rainfall and wastewater. In other words, arid climates with minimal rainfall provide the best conditions for an ET system's operation.

Individual dwellings, small housing clusters, and commercial or institutional establishments may find ET systems appropriate to their sites. But large surface area requirements for distribution/storage may make ET systems impractical for bigger facilities.

Pretreatment adjustments to effluent also may be necessary, depending on its source. Restaurants must have a grease trap installed, for example, before wastewater runs into a septic or aerobic tank for eventual ET dispersal.

Two types of ET systems are presently used. The lined ET system disposes of wastewater without permitting effluent to move into the soil. The evapotranspiration/absorption (ETA) system is similar, but is constructed without a liner to permit a very slow rate of seepage (absorption) into the ground.

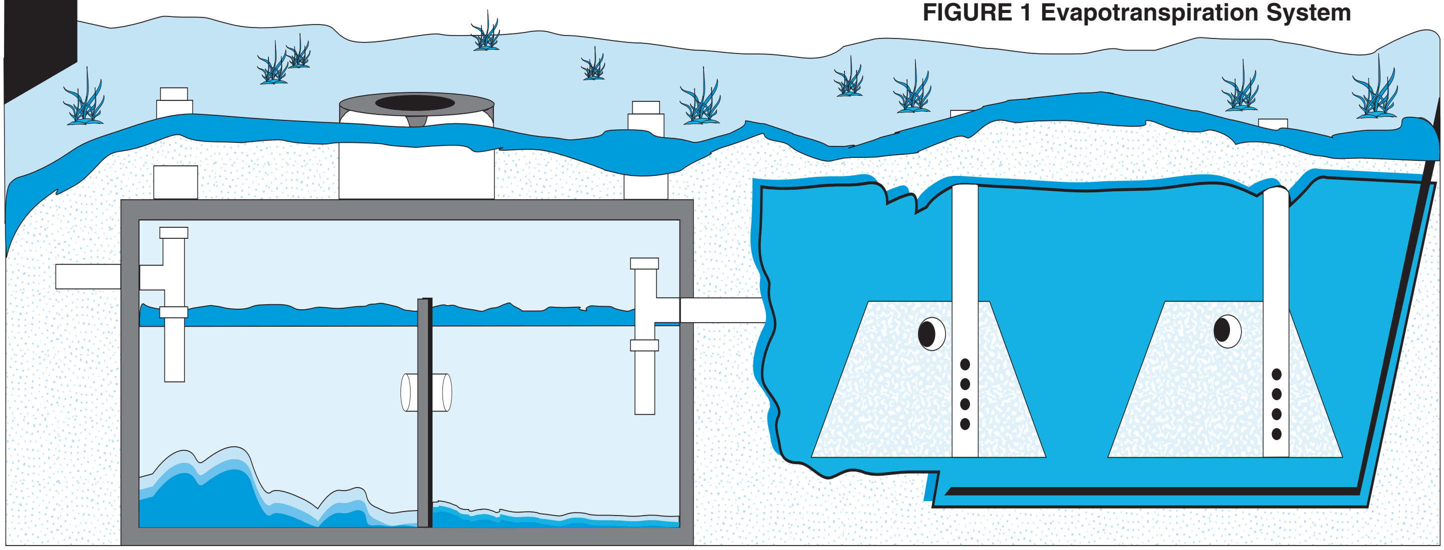
This issue of *Pipeline* focuses on these two versions of the ET system, how they are designed, how they treat wastewater effluent, and what climate and soil situations warrant their use. Listed advantages and disadvantages of ET systems demonstrate whether this type of wastewater treatment works for a particular site.

Is an ET System Right for Your Site?

Before deciding on buying property or building a particular type of onsite watewater treatment system, contact local health officials to find out:

1) whether any onsite treatment system is appropriate for that particular site,
2) minimum lot sizes and other site conditions that dictate onsite systems,
3) how to apply for an onsite system permit,
4) the types of onsite systems allowed in your area,
5) who may design, install, and inspect onsite systems, and
6) who is responsible for maintaining onsite systems, and what must be done if a system malfunctions.

FIGURE 1 Evapotranspiration System

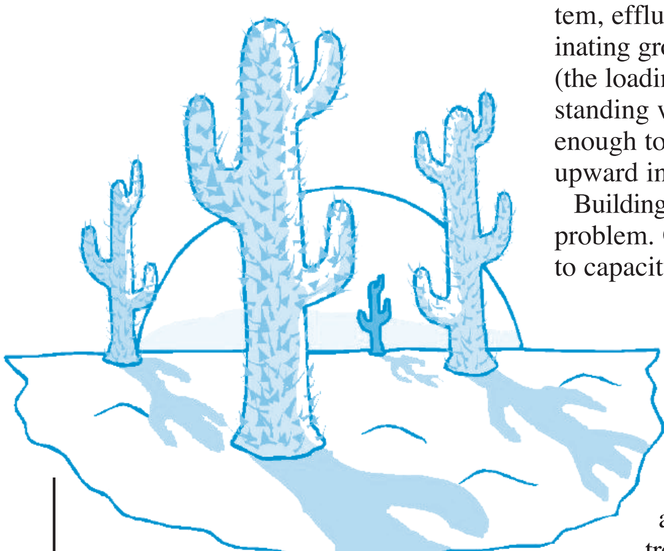


Why Use an ET System?

Very porous soils, like those composed of fill dirt, karst limestone, fractured bedrock, or sites with a shallow water table depth, make traditional absorption systems unsuitable. ET systems are one of a number of alternative technologies appropriate for sites where effluent could quickly migrate to surface or groundwater supplies. The lined ET system is also sometimes used to allow for a closer proximity to water wells (50 feet) as opposed to the 100-foot setback needed for soil absorption drainfields.

When deciding which system, the ET or the ETA, might be better for a site, sites with a percolation rate of less than five minutes per inch need to have the lined ET system installed. If using a soils classification approach rather than percolation testing, a slowly permeable soil (Class IV) would not require a liner unless seasonal groundwater tables are within two feet of the excavation. Check local regulations to be certain.

The ET system relies on the evapotranspiration capabilities of the bed's surface and its plantings in that particular environment. The impermeable liner covering the bottom and sides of the distribution area contains the effluent, storing it until it is absorbed up through the sand layer and into the roots of plants growing on the surface of the bed.



Several factors control the evaporation rate in an area: precipitation, solar radiation, humidity, wind speed, and temperature. Bright, hot sunlight causes evaporation of moisture. The drying effect of regular, brisk winds also increases transpiration in plants. High humidity, shading, and/or periods of plentiful rainfall, on the other hand, lessen the transpiration rate, making an ET system a poor choice in a climate with those conditions.

So, a rapid exchange of moisture from the plants and soil surface to the air is key to successful operation of the ET system. Weather conditions change on a daily, seasonal, or yearly basis. These regional climate factors must be considered to insure adequate system performance. *(See U.S. map on page 5.)*

Use of the ET system might be feasible for summer homes in temperate regions with relatively dry summers. But long-term storage of effluent plus additional water from rainfall, especially during times of no net evaporation (high humidity or during rains), make the system unsuitable for year-round use in areas with frequent or heavy winter precipitation.

By the same token, the hydraulic loading rate must also be considered for proper bed functioning. If too much household wastewater enters the system, effluent may overflow, contaminating groundwater; if not enough (the loading rate is too low), then the standing water level may not be high enough to be effectively absorbed upward into the plants' roots.

Building two beds helps alleviate this problem. One bed's storage area fills to capacity while the other bed rests.

ETA's More Versatile Design

An ETA system's performance depends on both soil characteristics and climate conditions. This treatment system is unlined and designed for use where soils are fairly impenetrable, but not entirely so. The ETA system disposes of wastewater in the same evaporation/transpiration manner, but also allows effluent to trickle slowly into the underlying ground.

The loading rate for an ETA system is generally more than that of an ET system in the same climate. And, an ETA system can be used in a wider range of climate conditions. As with any soil absorption system, the general rule stands that wastewater must travel through two to four feet of unsaturated soil for adequate treatment before reaching groundwater.

Factors that affect the performance of the ET and ETA systems:

- Climate
- Hydraulic loading
- Sand capillary rise characteristics
- Depth of free water surface in the bed
- Cover soil and vegetation
- Construction techniques
- Salt accumulation (ET only)
- Soil permeability (ETA only)

Design and Construction

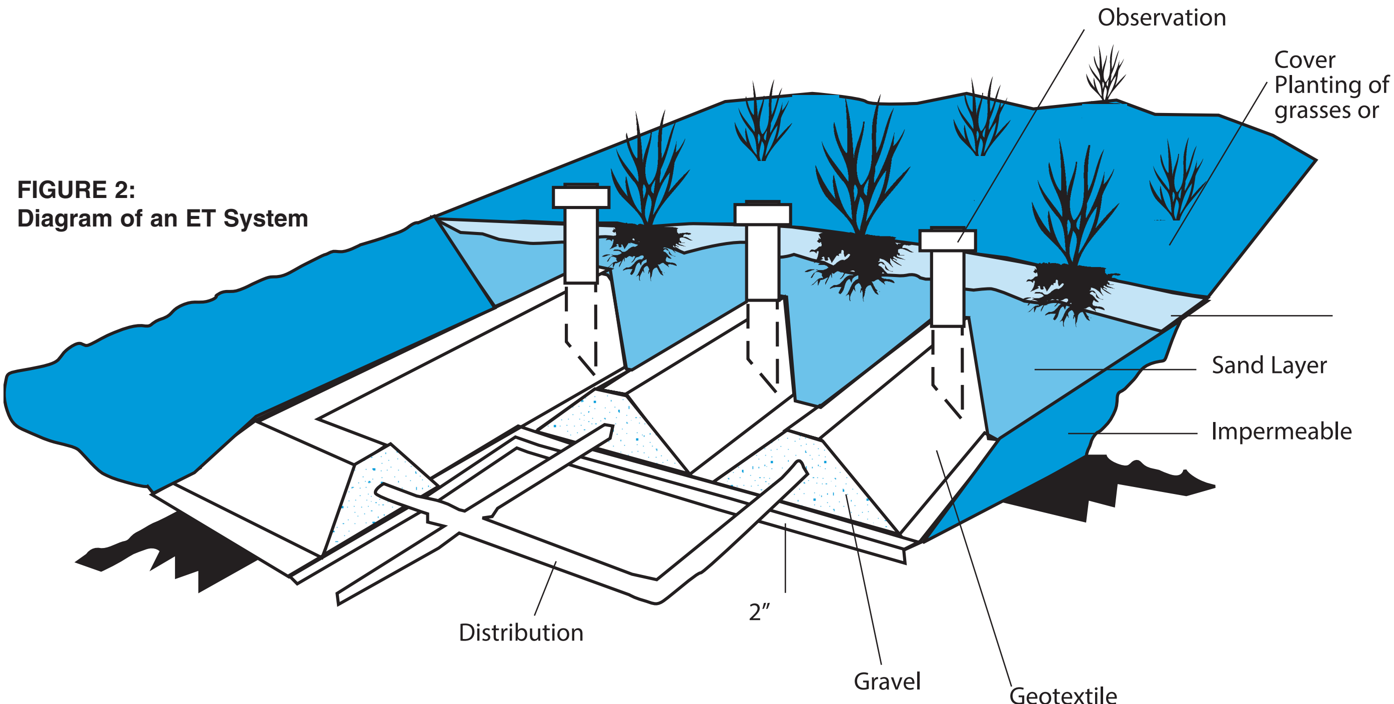
Little has changed in basic ET system technology in the last 25 years, except for regional adaptations. (*See Texas Designers . . . on page 6.*)

The ET system needs to be located in an area out of the way of runoff from structures or sloped land and should be built on as level ground as possible. If the terrain is not level, terracing or concrete retaining walls can be constructed to provide a suitably level distribution area and to contain the system.

Household wastewater first collects in a single- or double-compartment septic tank to separate solids from the effluent. From the septic tank, the effluent flows into the distribution pipes of the water storage area of the system.

Two separate ET beds are recommended to prevent overloading the system. A valve connects the two beds and controls the flow. As one

FIGURE 2:
Diagram of an ET System



NOT TO SCALE

bed becomes saturated, the effluent is directed to the other bed. This strategy requires occasional monitoring of the water level within the distribution system through the observation pipes installed down through the layers of soil, sand, and stone.

Sizing the ET Drainfield

The amount of surface area needed for the ET drainfield can be determined using this formula:

$$A=Q/ET-Pr$$

where

- A= total bed surface in square feet (or square meters)
- Q= annual flow in cubic feet per year (cubic meters/year)
- ET= annual potential evapotranspiration rate in feet per year (meters/year)
- Pr= annual precipitation rate in feet per year (meters/year)

If using an ETA system, the formula adds a factor for the annual percolation rate (P) of the soil in feet per year: $A=Q/ET-Pr+P$.

The Lining Makes the System

The impermeable liner containing the ET system rests on two inches of sand for stability and protection from underlying stone. (*See figure 2.*) A cushion layer of sand should also be placed on top of the liner to prevent punctures from the rock media. This step is vital to maintaining the integrity of the liner.

A 12-inch layer of uniformly sized gravel, ranging from three-quarters of an inch to two-and-a-half inches in diameter, covers the bottom of the system. This gravel layer acts as the storage area for the effluent. The bottom of the storage area needs to be as level as possible to assure even distribution of the water.

Distribution piping is positioned at the surface of the gravel. These pipes should be no more than 12 feet apart and no less than three feet from the walls of the bed. Closer spacing ensures that the wastewater fills the entire storage area, making it readily available for uptake by the adjacent sand.

The sand extends down through the depth of the gravel layer to the bottom of the ET bed. These sand extensions (called "wicks" by some installers) should be uniformly spaced throughout the bed between the rock-covered distribution piping.

The effluent storage area (gravel layer) is covered with geotextile filter fabric, a water-permeable soil barrier, to prevent infiltration of sand into the gravel. A layer of sand 24 to 30 inches deep is then placed over the fabric to within two inches of the top of the ET bed. This sand must be fine enough to enable capillary action, drawing the effluent from the distribution area upward to the plant roots near the surface of the bed.

Monitoring pipes for periodically observing water depth should be positioned vertically down through the layers of the bed to the base of the distribution area. These pipes also provide access in case emergency pumping becomes necessary. Removable covers on the pipe openings prevent accidents and keep insects and rodents out of the system.

Surface Plants Finish the Process

Sandy loam is used to finish filling the top two inches of the bed. The bed surface should be covered with this rich soil mix and mounded from the center at a two to four percent grade to encourage runoff of rainwater.

Plant vegetation that can withstand a wide range of soil moisture levels on the surface of the bed. Maintain the plants in good health to maximize their transpiration capabilities.

Salts may build up in the soil of the bed as moisture evaporates. Salts accumulate most heavily during

continued on page 4

Evapotranspiration Systems: Advantages and Disadvantages

Advantages

- ET systems can be used where physical and geological conditions prohibit using subsurface waste water disposal methods.
- Lined ET systems reduce or eliminate the risk of groundwater contamination.
- Costs for an ET system compare with other alternative onsite systems.
- ET can supplement absorption on sites with highly impermeable soils.
- ET systems provide a workable alternative in arid regions.
- ET systems may be appropriate for summer homes or recreation areas where evaporation and transpiration exceed rainfall.
- The system's surface can be planted with shallow-rooted ornamentals to enhance the landscape.

Disadvantages

- Climate conditions—precipitation, windspeed, humidity, solar intensi ty, and temperature—determine the effectiveness of ET systems.
- The systems can't be used where land is limited or the surface is highly irregular.
- Storage capacity is limited, so the system may not be able to hold-over winter wastewater for summer disposal.
- Precipitation potentially may over-load the system.
- The bed liner must be watertight to prevent leakage into groundwat-er.
- Evapotranspiration must exceed rainfall by at least 24 inches for the system to be effective.
- Transpiration and evaporation rates decline in the winter when vegetation is dormant.
- Salt and the accumulation of other elements may eventually be harmful to vegetation, thus dimin-ishing the effectiveness of the system.

continued from page 3

periods of dry weather, but are then redistributed throughout the bed with rainfall. Occasional monitoring for excessive salts is necessary, since these substances may injure plant tissue over time. If injury is severe, the grass (or other vegetative cover) may need to be re- placed with a more salt tolerant species.

The ET bed should be planted with a vegetative cover that allows for maximum transpiration for the region. Bermuda grass or St. Augustine grass placed over the soil as sod is most effective. Seeding grass directly on the soil bed may be ineffective if rainfall washes out the mounded soil before the grass plants become established. Larger plants that tolerate a broad range of moisture conditions and that have shallow root systems could also be used to fulfill the evapotranspiration process.

Maintaining ET Beds

The ET system needs very little routine maintenance. The septic tank should be pumped out periodically, and the grass planted on the beds should be mowed regularly.

Since healthy vegetative growth is an integral part of this wastewater dis-posal system, the plants that facilitate the evapotranspiration must continually be actively growing. If the grass or other vegetation goes through a win-ter dormancy period, an alternative cold-season grass cover needs to be overseeded to continue the transpi-ration process. Shallow-rooted ever-greens may also be planted on the ET system to provide a more attractive landscape.

The most important considerations in keeping an ET system functioning properly are selecting sand for the absorption layer that provides max-imum capillary rise and installing a heavy liner of impervious rubber or plastic at a thickness of 20 mils or greater. Reinforced concrete, gunite, or compacted and tested clay, one foot thick or more, may also be used as liner material.

How much does an ET system cost?

Determining the total costs for an ET system depends on several factors, such as the site, characteris-tics of the wastewater, and the size and type of facility from which the wastewater originates. The total sur-face area of the ET beds, which is a function of the design loading rate, determines construction cost.

Further considerations include the type and thickness of the system liner, the availability of appropriately fine sand, whether retaining walls will be needed, and the vegetation that will be used to cover the surface of the beds.

Figures of approximately $10,000 or higher are typical for a three-bed-room home's septic tank and ET system.

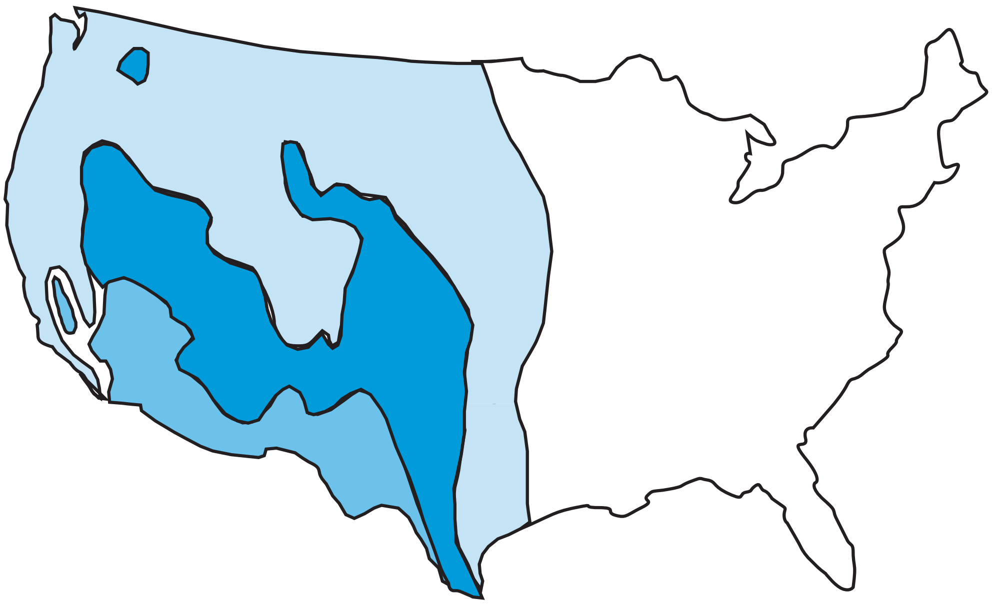
Keeping Your ET System Working

Maintenance of the ET system is minimal except for surface vegetation. The grasses or other plants growing on the beds need to be kept healthy, because they provide the vital step of transpiration in the disposal process.

Grass must be mowed regularly to eliminate excess growth. But if the plants go dormant in the winter, some other cool-season grass must be over- seeded on the bed to ensure the system's continued operation.

Excessive water from rain or run-off needs to be diverted around the system. Mounding the surface of the beds helps prevent too much water from entering the storage area and overloading the system.

Salts accumulate in the ET system and will be transferred into the growing vegetation on the surface. Salt-tolerant grasses may offer a good choice for cover plantings, because some of the salts will be removed from the sys-tem when the grass is mowed and the clippings are removed from the area.



- Light Blue - Minimal ET suitability
- Middle Blue - More suitable
- Dark Blue - Most suitable

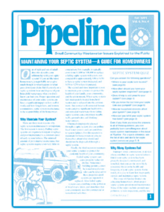
Regions Appropriate for Evapotranspiration Systems
Colored areas represent climates most suitable for ET systems.

Septic Tanks Need Maintenance Too

An evapotranspiration system's performance depends on its pretreatment unit working properly.

Several back issues of *Pipeline* contain useful information about the siting, design, construction, installation, operation, and maintenance of septic tanks and aerobic units, two common pretreatment methods for ET systems.

Summer 1995: "Septic Tanks''



Fall 1995: "Septic Tanks Operation and Maintenance''

Winter 1996: "Aerobic Treatment Units''

ET System Information on the Internet

Up-to-date information about constructing an evapotranspiration system may be found at a number of sites on the World Wide Web. Questions may also be posted on the wastewater forum, "Septic Talk,'' hosted by Texas A&M University on issues concerning ET systems or other alternative treatment methods.

Austin City Connection
http://www.ci.austin.tx.us/wri/dis2.htm

Texas A&M University Extension Service
http://agpublications.tamu.edu/pubs/e8.pdf

Texas On-Site Wastewater Treatment Research Council
http://towtrc.tamu.edu/

National Onsite Wastewater Recycling Association's Onsite Insight Newsletter
http://nowra.org/news/news.shtml

U.S. Environmental Protection Agency
The EPA has a design manual of onsite wastewater treatment and disposal systems on the Web with a listing for evapotranspiration systems. The infor- mation is listed in the contents as beginning on page 300 of the document. To read or download that portion of the EPA document, type in page 318 in the "Go To''page space.
http://www.epa.gov/cgi-bin/claritgw

Texas Designers Alter ET Systems to Suit Their Needs

Photo courtesy of Bruce Lesikar, Texas

ET beds in sensitive environments ensure wastewater contaminants do not reach water supplies. This inspector for the Lower Colorado River Authority in Austin, Texas, inspects sand thickness before the system liner is installed.

The Texas Water Commission (TWC) found that previously approved sizing methods for evapotranspiration beds caused frequent system failures in that state. New formulas differ in that (1) they consider site specific data for evaporation and rainfall for the different regional climates of Texas, and (2) they incorporate specific information about the amount of wastewater generated from different sized houses and other facilities using ET technology.

The old method had separate formulas for single family residences and multiple family residences. The calculations were based on a standard sized area and the number of bedrooms divided by the mean overall evaporation rate and the rainfall rate.

The new recommendations use one formula for both individual homes, apartments and condominiums, restaurants, parks, and other areas. The formula is based on the estimated daily amount of wastewater generated in gallons per day and the net local evapotranspiration rate.

Similar to the previously mentioned formula A=Q/ET-Pr (*see page 3*), the TWC's recommendation includes a conversion factor of 1.6 (12 inches/foot divided by 7.48 gallons/cubic foot) making the formula A=1.6Q/ET-Pr.

Wastewater treatment system builders in Texas also found slight alterations to the basic ET system design appropriate for conditions there. The use of pure sand for the absorption layer has been exchanged in favor of a loamy soil/sand mix. Professionals there say that the absorption rate they get with this mix surpasses that of a straight sand layer.

Similarly, the wicks that run from the bottom of the rock media layer up to the soil/sand layer are made of loamy soil also.

ET systems in some parts of Texas are also being built with a greater number of distribution pipes laid in the beds to increase the dispersal of the effluent throughout the system. Piping is laid two feet from the walls and four feet apart instead of up to 12 feet apart.

Other kinds of media, like tire chips, are being used for the rock layer; and storage systems, such as leaching chambers (placed on four-foot centers and covered with loamy soil), have been found to provide effective storage for effluent.

The TWC recommends that one ET bed be open and the other closed and the flows alternated on a monthly basis so that one bed is always dry and rested. During wet weather, both beds should be opened to maximize evapotranspiration.

From the Texas Water Commission

Net evaporation rates for various areas of Texas demonstrate that the central and western part of the state have climates most condusive to using ET systems.

Area	Net Evaporation (inches per day)
Amarillo	0.19
Austin	0.10
Beaumont	0.00
Big Spring	0.17
Brownsville	0.08
Chillicothe-Vernon	0.12
Daingerfield	0.08
Dallas	0.13
El Paso	0.27
Fort Stockton	0.26
Houston	0.00
Lake Somerville	0.09
Laredo	0.24
Lubbock	0.19
Nacogdoches	0.00
San Antonio	0.10
San Angelo	0.25
Temple	0.09

Some information for this article was provided by the Texas Water Commission, Austin, Texas.