GRAYWATER HANDBOOKS

City of Malibu

Department of Environment, Building and Safety
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A manual for design, construction, installation, operation and maintainance of graywater systems for the City of Malibu

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Handbook #1
GRAYWATER SYSTEMS IN THE CITY OF MALIBU

Graywater Defined

Graywater has no rigid definition. It is definitely not toilet wastewater (called blackwater) and rarely does it include the kitchen sink. The most common sources of graywater are washing machines, baths and showers. In 1992, Malibu already had numerous graywater systems — about 8% of the beachfront homes and 33% of the inland homes surveyed had some form of graywater system. However, these systems were considered "outlaw" systems because the County had no laws allowing them. In 1994, both the City of Malibu and the State of California passed laws that will allow graywater systems that meet certain standards in order to prevent any health risks and to help citizens save and reuse water, grow plants, protect their homes from fire and beautify their homescapes.

What are the Best Uses for Graywater in Malibu?

• To provide *irrigation water and some fertilizer* to your landscape. If you use the right soaps and cleansers, graywater is actually a mild fertilizer.

• To reduce your *water bill*. You use water once for washing and a second time for irrigation—two uses with one flow.

• To partially *reduce wastewater loads* to septic tank systems, especially for homes on small lots. Most homes can reduce "peak" pulses by redirecting the washing machine flow to the graywater system. Reducing the wastewater load to the septic tank can help homes on clay soils and homes with high groundwater tables.

• To reduce and *eliminate deep percolation* of wastewater into landslide masses. Instead, shallow irrigation redirects graywater to plants.

• To improve the *distribution of wastewater effluent* disposal on properties with difficult soils or geometry.

• To reduce the wastewater loads to *package plants* or small treatment plants (Trancas, Maison de Ville, Latigo Shores) which improves treatment, saves energy costs, eases disposal through soils, and prolongs system life.

• To feel good from wiser use of California's water resources. Your conservation effort hopefully leaves more water in California and Colorado rivers for fishing, boating, swimming, rafting and wildlife.

The City of Malibu wants to encourage water conservation both within your home and the reuse of graywater and treated septic tank effluent outside your home. You pay for the water. Conservation and reuse gives you the maximum benefit.

New Homes and Major Renovations of Home Plumbing

Graywater systems are <u>not</u> required. But, **in new homes and extensive renovations of home plumbing, it is required to install a diversion valve for the washing machine, if (and only if) the washing machine is adjacent to an exterior wall.** The cost is minimal, requiring a simple valve installed during plumbing your home. The diversion valve will allow you or a future owner to divert the washing machine to a graywater system without the added expense of breaking through the wall or cement slab. It is very low cost "preventative" medicine-- to save future expenses in case of a malfunction in your septic tank system or a desire to irrigate your landscape with graywater. The requirement is only for new homes or major renovations of plumbing.

The City suggests that you review the costs of diversion valves for <u>all</u> graywater appliances adjacent to exterior walls such as bathtubs. You might even consider "dual-plumbing." Dual-plumbing is least costly when you build a new home. You install separate pipes for graywater and separate pipes for blackwater. Dual-plumbing may help you with your irrigation plans and all the other best uses we have mentioned. If you want to install additional diversion valves or dual-plumbing, discuss the costs with your contractor or visit the City and discuss the benefits with staff.

Graywater Permits

Graywater systems are not for every home. **Handbooks 1, 2** and **3** will help you decide if you want a graywater system and, if you do, how to get the right one.

There are four kinds of graywater permits:

- Diversion valve permit (no fee);
- The washing machine or single-fixture permit;
- The multiple fixture or dual-plumbing permit;
- The upgrade permit for already installed graywater systems.

The legal requirements can be obtained from the City Building and Safety Department. Permits and fees are summarized in **Table A** for easy use.

The easiest home permit is for a single-fixture, usually a washing machine or a bathtub. If you want, you can perform soil tests, design and installation as a homeowner. The Handbooks provide complete instructions.

The more elaborate permit for multiple fixtures will require City inspection. It is also for homes on landslides, beachfronts, homes with large numbers of residents (usually greater than four) or more complex design situations. The fee includes inspection and staff review.

For innovative and demonstration systems, the fee will be set by the City depending on monitoring and peer review requirements.

Graywater systems for multiplex apartments, condominium, and other institutional or business buildings are considered wastewater systems by the City (Appendix I of UPC). Apply as if they were septic tank systems.

Note: For single-fixtured graywater systems, the required soil test for texture is in **Handbook 5**. For single fixture systems, if you do not wish to test your soil, you can assume that the soil will absorb about two gallons per square foot per day of graywater. Only sidewalls of the trench or drainfield hole will

be considered if the soil test is waived. For more complex systems, the City can require professional soil analysis. If you already have a septic tank system, remember to look at your home-site sewage system application. It should have all the soil information required for your graywater system.

Note: If you decide to reuse all graywater from your home for irrigation, it may be cost effective to redesign your septic tank system. Irrigating with effluent from your septic tank systems gives you the benefit of both graywater and blackwater reuse. These total reuse systems require filters and pumps and shallow trenches. They may include buried emitters for a drip system. They are described in the City's On-Site Wastewater Management Program.

The Graywater Quiz

Attached are two "Graywater Quiz" sheets. The first will help you decide if you want a graywater system: "yes" or "no". **Handbook 2** may also help you to decide. The second quiz sheet will help you decide *which kind* of graywater system is best suited to your needs. **Handbook 3** is designed to help you with this quiz. Please look over **Handbooks 2** and **3** before quizzing yourself about installing a graywater system.

If you still can't make up your mind, talk to staff or the contractor. Costs, landscape needs, mechanics, and soils may bring you to a final decision.

WHAT TO DO NEXT

All homeowners, renters, contractors and household help should read **Handbook 2: Understanding Graywater.**

All new homes or major renovations must install a graywater valve for their washing machine if it's adjacent to an exterior wall.

All new homes or major renovations should consider additional graywater valves or dual-plumbing.

You are now ready to read the handbooks that apply to your custom-designed graywater system. They will guide you through planning, building, and permitting.

TABLE A
GRAYWATER FEES AND PROCEDURES

Contact Environmental and Building Safety Department for current permit procedures, fees and policies.

Telephone: (310)456-2489
Hours: Monday through Friday, 8:30 A.M. to 12:30 P.M.

SHOULD MY HOME HAVE A GRAYWATER SYSTEM? YES OR NO

	YES	NO
We want to reuse graywater to irrigate plants, conserve water and lower water costs.	___	___
Our home has enough clearance under the house and exposed pipes, so installing a graywater system is easy.	___	___
All our pipes are cemented under or in the house slab and it's probably very expensive to break through the cement (many 1950's and 1960's homes).	___	___
There is no easy access to the washing machine or bathroom pipes without a pump or breaking through the wall.	___	___
We think we have problems with the septic tank system when the washing machine is in operation or there is party or peak use.	___	___
We may have too much household water for the size of the drainfield and water conservation doesn't help enough.	___	___
Our home is on a landslide and we want to reduce deep percolation. But, renovation of the septic tank system is not necessary or too costly. We can afford to reuse the graywater.	___	___
We live on a landslide and need to reuse both the graywater and blackwater in order to reduce deep percolation. A separate graywater system is not necessary.	___	___
Our washing machine or bath and shower drains to a part of the yard that is far from the septic tank system. We want a separate landscaping area.	___	___
We have a large parcel with plenty of room to irrigate.	___	___
We live in a beachfront home and have a reserve area or extra room alongside the house that could be used for a graywater system.	___	___
Our lot is so small that there is no room to install a graywater system (rare).	___	___
Our soils are so sloped, have such heavy clay, or such shallow soils above bedrock that we don't think it's possible.	___	___
We feel that it's too complicated, especially automated drip irrigation or pump systems and we don't want to bother with the maintenance or can't afford to hire a landscaper to service the system. (If you check this statement, remember there may be a low maintenance, simple system you like.)	___	___

WHICH KIND OF GRAYWATER SYSTEM DO WE NEED?

If you still want or can accommodate a graywater system, check the appropriate handbooks:

•We want all the wastewater (black and graywater) reused to irrigate or to prevent deep percolation.

We want to build or rebuild our septic tank and drainfield.

—— On-Site Wastewater Handbooks

•We live on a landslide.

We know it's best to reuse all the wastewater and prevent deep percolation, but at the moment we are not building or replacing the septic tank system. In the meantime we want to reuse the graywater for shallow irrigation.

—— Handbooks 3 and 5-8

•We live on a beachfront and/or pure sand soils.

We just want to dispose of the washing machine and/or bathtub graywater with no irrigation.

—— Handbooks 3, 5, 9

We want to irrigate trees with the graywater.

—— Handbooks 3, 5, 6, 7, 9

We want to irrigate trees and shallow rooted plants with the graywater from many fixtures.

—— Handbooks 3, 5, 6, 7, 9

We want to irrigate trees and shallow rooted plants with the graywater by means of an automated drip irrigation system.

—— Handbook 8

•We live in an inland home or have clays and shallow bedrock soils.

We want to dispose of the washing machine and/or bathtub graywater only. Irrigation is a secondary concern.

—— Handbooks 3 and 5

We want to irrigate trees with the graywater.

—— Handbooks 3, 6, 7

We want to irrigate trees and shallow rooted plants with the graywater.

—— Handbooks 3, 6, 7

We want to irrigate trees and shallow rooted plants with the graywater and an automated drip irrigation system.

—— Handbook 3, 6, 8

SUMMARY OF HANDBOOKS

Handbook 1:	Graywater Systems in the City of Malibu
Handbook 2:	Understanding Graywater
Handbook 3:	The Design of Graywater Systems
Handbook 4:	Graywater, Detergents, and Washing Machines
Handbook 5:	A Simple Washing Machine Graywater System
Handbook 6:	Constructing Surge Tanks, with & without Pumps
Handbook 7:	Irrigation Systems Using Gravity
Handbook 8:	Drip Irrigation Graywater Systems
Handbook 9:	Beachfront Home Graywater Systems
Handbook 10:	Demonstration and Larger Volume Systems
Handbook 11:	Access to Equipment, Books and a Glossary
Handbook 12:	Spanish Language Handbook N/A

Handbook #2
UNDERSTANDING GRAYWATER

Graywater Defined

Graywater has no rigid definition. It is definitely not toilet wastewater (called blackwater) and rarely does it include the kitchen sink. The most common sources of graywater are washing machines, baths and showers. **Table A** lists acceptable sources of graywater. **Table B** lists unacceptable graywater sources without special treatment.

Is Graywater Safe To Use?

When care is taken, graywater can be safely used, especially for near surface irrigation. Despite thousands of graywater users, no case of any water borne disease has ever been traced to graywater use.

The health risks of graywater itself are hotly debated. Some experts believe graywater is basically benign and can be discharged above ground if kept out of the way and kept from puddling. Other experts believe graywater to be almost as dangerous as blackwater. Currently, despite extensive reuse of graywater above, near the surface, and below ground during the California droughts, no illness has been traced to graywater. Nevertheless, above ground disposal or reuse of graywater is illegal and systems using above ground disposal will remain "outlaw" until the debate is settled.

The City of Malibu allows near surface irrigation. In these systems, the irrigating hose must be covered by at least 9 inches of mulch/soil.

Why Must Care Be Taken When Graywater Is Used?

Health hazards can occur when the *dosage* of the harmful organism is large enough to infect us and we are actually *exposed* to a harmful microbe, *and* your current state of health prevents your body from dealing adequately with the disease organism. The dosage of harmful organisms in graywater varies from zero to perhaps 10% of the dosage in regular blackwater. But, if you or a child is sick, dosages of harmful viruses and bacteria may be found in bathtub/shower or washing machine wastewater. No illness has ever been traced to graywater. Nevertheless, some health experts feel that dosages are high enough to cause concern.

Do's and Dont's of Graywater Use

Obviously toilet wastewater is prohibited from a graywater system. The family who washes its baby diapers is on an honor system. As a precautionary measure, it is best to wash diapers in water destined for a sewer or septic tank system or package plant. Of course, you should never drink graywater or allow children access to graywater. Surge tanks should be relatively inaccessible to children and reasonably childproof. To reduce exposure, all the graywater systems allowed by the City will require a layer of soil and/or mulch above the subirrigation piping. No spray irrigation or misting is allowed. Eliminating "daylighting" eliminates exposure.

Table A: Acceptable Residential Graywater Sources

Graywater for irrigation underground:

- Bathtubs
- Showers
- Bathroom sinks
- Washing machines
- Wet bar sinks (without garbage grinders and well-isolated from the kitchen sink)

"Wastewaters" that can be used directly above-ground:

- Condensation pans, refrigerators and air conditioners
- Reverse-osmosis filters
- Hot tub and jacuzzi drains
- Freshwater pond, pool, fountain and aquarium drains
- Cistern drain
- Outdoor showers and faucets for removing sand

Table B: Unacceptable Residential Graywater Sources (divert to septic tank or sewer)

- Toilets
- Bidets
- Urinals
- Kitchen sinks
- Laundry room sinks, when used for wastes other than washing machine
- Utility sinks: in garage, shop or patio if used for toxic chemical disposal
- Garden and greenhouse sinks
- Water softener backflush (too many salts)
- Saltwater aquarium drains
- Floor drains: garage, porch, and tennis (sports) courts, if washed with chemical cleansers
- Swimming pools drains (total dissolved solids and acids too high for irrigation)

Warning: Grimes and Toxics

Most simple graywater systems rapidly shunt household graywater into the soil for disposal or irrigation. The lack of extended treatment means that certain household fixtures cannot be part of graywater reuse. They are unacceptable for health and safety reasons, for prevention of grimey plumbing and to avoid poisoning your plants.

The garbage grinder is prohibited because its ground food parts cannot be treated long enough before entering the soil and will clog the soil. The kitchen sink itself produces too many organic bits and pieces and too much oil, fat and grease. The oils can also clog the drain pipes. Utility sinks that may have strong or toxic chemicals should not be part of the graywater system. Water softeners discharge a liquid too salty to nourish plants.

Warning: Use Friendly Detergents

Because you are taking responsibility for recycling your graywater, you will have to choose carefully your detergent and other products for your washing machine. Some detergents are too salty. None are perfect. **Handbook 4** lists some graywater-friendly brands. As you will see, they are not hard to find.

Warning: Drains, Spouts, and Patio Runoff

Don't connect storm drains to the graywater system. It's too big a flood for the system to handle and the soil is usually wet already. Make sure roof drains, sidewalks, patios and other hard surfaces don't cause puddling over the area you irrigate with graywater.

Common Uses of Graywater

Irrigation is by far the most common and most desired use of graywater. Graywater can be used to irrigate:

- Fruit trees and ornamental trees and shrubs
- Flowers and other ornamental ground cover
- Lawn

GRAYWATER DO'S AND DONT'S

- No spraying or misting.
- No drinking.
- If diapers are in washing machine, better to divert to sewer.
- Prevent ponding.
- Oils, grease and certain detergents can harm plants. Chose household products with care.
- Make graywater tanks child-proof.
- Screen vents or openings to prevent fly breeding.

Handbook #3
THE DESIGN OF GRAYWATER SYSTEMS

Introduction

In **Handbook 1**, we asked the question "Do you want a graywater system?" If your answer was "yes," read on for the answers to the following questions:

- What are the major components of a graywater system?
- How do I size the system?
- How do I fit it onto my property?
- Which subirrigation method is best for my needs?

Even though you desire a graywater system, a few preliminary obstacles remain:

- In an old house, can I get to the plumbing? How many fixtures can I reasonably connect to the graywater system?
- In a new home, how many graywater fixtures do I want to plumb for graywater reuse?
- On any lot, is there room to irrigate? During the winter rains, will the soils absorb and disperse the graywater?

Overview

The graywater system consists of graywater household fixtures that feed a surge tank that feeds a subirrigation and/or disposal field (**Figure A**).

Between the plumbing for the graywater fixtures and the surge tank is a *switching valve* (**Figure B**) to allow the homeowner to switch the graywater flow either to the graywater system or the septic/sewer system. The switching valve is a safety feature that allows the home resident to switch from subirrigation to disposal when there are exceptionally intense rains that saturate the soils or to repair and replace the graywater system.

After the surge tank, a *distribution valve* (**Figure C**) is usually installed to control the distribution of graywater to various areas of your landscape and prevent soil clogging. The valve can be hand-operated or automatic. The distribution valve rotates the graywater through two or more irrigation zones. This allows one or more zones to drain and to breathe in fresh air. The soil's beneficial bacteria and microbes prefer well aerated soil to consume the graywater particles, nutrients, and potential health hazard microbes.

Note: Malibu's inland "tight" soils and soils of some kinds of artificial fill are most prone to clogging and should always have a distribution valve and two rotating irrigation zones. Beachfront and inland sands or custom-designed fills will not clog (unless abused) and may use only one irrigation zone for graywater reuse or disposal with a settling tank (**Figure D**) and City approval.

Note: Consider installing treatment tanks (**Figure D**). They will increase the lifespan of your drainfield.

Note: If the irrigation zones are uphill from the surge tank, then a pump will be necessary (**Figure E** and **Handbook 6**).

Note: If subirrigation is by a drip system, then filtering and other modifications are necessary (**Handbook 8**).

In summary, your graywater system looks like this: plumbing + switching valve + surge tank + distribution valve + subirrigation/ disposal field. Further details are provided below and in referenced handbooks.

Graywater Plumbing: New Homes

New homes can plan their graywater plumbing. New homeowners *must* install a valve for any washing machine adjacent to an exterior wall (**Handbook 5**).

New homeowners *may* decide to add other valves to such fixtures as the bathtub or utilities sink that are also adjacent to exterior walls. It will save you money if you install these valves while building to avoid the expense of retrofitting.

New home builders may decide they can dual-plumb their home (**Figure F**). In dual-plumbed homes, all graywater fixtures (not just those near an exterior wall) will drain to their own separate plumbing. They can feed a near surface irrigation system and reuse up to 60% of their water. All inappropriate fixtures such as toilets and kitchen sinks (described in **Handbook 2**) will drain to the septic tank or sewer. Dual-plumbing can add $1,000 or more to your construction costs. But, in the long-term, you may save both water and money because you use up to 60% of your water twice. For dual-plumbing regulations, consult the City desk or the Uniform Plumbing Code.

Graywater Plumbing: Homes Built after 1994

Homes built after 1994 will have an already-installed valve to any washing machine which sits adjacent to an exterior wall. There may be a graywater system in place which should have been included in the building plans submitted to the City. If the previous homeowner didn't use the washing machine graywater system, simply look for the stubbed-out plumbing on the exterior wall near the washing machine. Remove the stub and connect the graywater system! If you want to add more than the washing machine, read about retrofitting pre-1995 homes.

Retrofitting Plumbing in Pre-1995 Homes

To retrofit your home, you will need to survey your pipes and foundations to see if you can gain access to graywater fixtures and drainpipes without excessive expense.

Surveying Your Home's Pipes and Foundation

The first place to look is the **laundry area**. If the washing machine is next to an exterior wall, in the garage, or below a window, then this important source of graywater can be readily tapped. Washing machines in interior rooms or with an exterior masonry wall may be more difficult to access, unless there is a wood-framed floor and enough space (at least 18 inches) beneath the floor (called the crawl space) to work and add graywater pipes.

Next, consider the **flooring** of your house. If the entire floor is concrete on top of the ground, then you're out of luck. The slab-on-grade type of flooring is common in modern Californian construction. Such flooring is a permanent obstacle since all graywater sources, except the washing machine, are entombed within the concrete slab. There's no cost-effective way to get to the encased discharge pipes. (An exception is a shower stall next to an exterior wall. A new artificial floor can be built 6 to 12 inches above the existing stall floor to house a new water trap with a pipe to the exterior wall.)

Third, look at the **foundation** and the **crawl space**. Many homes have a continuous perimeter foundation with vertical wooden framing to the level of the floor. If the crawl space beneath the floor's wooden joists is less than 18 inches you may not be able to conveniently replumb, although a practiced plumber may be used to such constraints (**Figure F**).

Next, check to see how the **pipes** can be plumbed so the graywater can drain downhill by gravity *and* get out above or beneath the concrete footing of the foundation. Graywater pipes must drop 1/4 inch for every foot of length. Sometimes, the length of the graywater pipe is such that the required drop-per-foot means the pipe would be exiting right through the middle of the concrete foundation.

To check the amount of drop over the length of the proposed graywater pipe, use a 2 or 4 foot level tied to a 10 foot wooden 2X4. Or, under the house's flooring, simply measure the total length of the proposed graywater pipe, multiply 1/4 inch for each 1 foot of distance (ie., 12 1/2 inches per 100 feet) and measure this total down from the bottom of the floor joist (**Figure G**). While it is possible to drill a hole through a concrete foundation, it can be difficult and expensive. In this case, routing the graywater pipe through an existing air vent or beneath the foundation wall may be more acceptable.

Also, note any internal **concrete foundation walls.** Some new houses and older homes with additions may have footings criss-crossing beneath the house which can play havoc with the convenient drainage of the graywater pipes. Again, use the same 1/4 inch for each foot of distance rule and a level to check for clearance above or beneath the foundation. If you have many internal concrete foundation walls, it's possible to pump from one section of the foundation to another, but it's more expensive and you'll be flirting with at least twice as many plumbing problems. Such complications may not be worth the potential maintenance troubles.

If physically possible, make sure the location of the surge tank allows for the automatic **overflow pipe** to a **sewer or septic tank pipe (Figures C and E)**. Sounds simple. But many existing homes have their plumbing arranged in a way that was convenient for the floor plan and the plumber, not for the sake of a graywater system retrofit. In some cases, there's no way to drain the graywater system to a conveniently-placed surge tank *and* still be able to drain the tank's overflow safely to the sewer or septic tank. In these cases, make the surge tank large enough to accomodate two or three times your expected graywater flow or put two surge tanks in sequence as shown in **Figure D**. An alarm system will be required.

Basements are rare in the Malibu area. If you are fortunate enough to have a basement, adding a graywater system may be simple. However, many houses are built on steep slopes with one side of the foundation at ground level, but the opposite side of the house well above both the slope and the perimeter foundation. Hillside houses with open foundations are the easiest homes to replumb to a graywater system.

Make use of the information gathered in surveying your foundation to evaluate which graywater sources can be reasonably replumbed. If you have a crawl space, you can trace the maze of pipes back to their sources by having a friend turn on the water faucets one by one or by taking a floor plan sketch under the house to guide you to individual fixtures. Some fixtures can be joined together to plumb a graywater system. Make a list of the sources you'll be using so the daily and peak flow rates can be determined.

A word of caution: One of the smartest things a homeowner can do is to know when *not* to have a graywater system. Any complexity in construction or design can increase the potential for additional maintenance and for things to go wrong. When an existing house's plumbing presents difficult circumstances, think twice before installing a graywater system.

Estimating Your Graywater Production

You'll need to develop a pretty reasonable estimate of how much graywater you will generate on a daily basis to design an effective graywater system. An accurate projection of graywater generation is especially important when designing a graywater system with an emphasis on efficient irrigation. With irrigation systems, knowing the daily amount of graywater will help you anticipate how much of your landscape can be watered. If you're planning to have a disposal system, anticipating the average daily graywater flow is required in order to plan the size of the shallow leachfields.

Water bills in Malibu are of little help. There is too much variation between inside and outside use, number of bathrooms, amount of time the homes are occupied, and kinds of fixtures. Graywater can be 40 to 60% of the total water use of a home or as little as 10% for a single fixture.

Determine your graywater flow by understanding the flows from fixures in your home. The numbers will be very fuzzy because they depend not just on the fixtures but your usage and the water pressure in your pipes. Remember, bathtubs don't use water. People do. You can neutralize the importance of a lowflow showerhead by simply taking a longer shower or doubling the number of baths per day.

Measuring the Actual Flow from a Home Fixture

To calculate your graywater, a worksheet has been provided. Use "typical" fixture flows unless you're sure the manufacturer will guarantee a smaller or larger number or you actually measure the flows. Look at the manufacturer's claims for the washing machine or dishwasher. You can measure the water coming from the faucet or the exit hose from the dish washer or washing machine with a 1 gallon bucket and a watch. Determine gallons per minute.

Don't reduce your estimates on the worksheet even if you have water conservation devices. These estimates provide a safety factor for "abusive" use by guests or kids or anyone else.

Remember: Calculate flows just for the fixtures going to the graywater system!

The Surge Tank

All graywater pipes drain by gravity to a tank, usually a 55 gallon, high-quality plastic drum. While this looks like a small storage tank, it only holds water for a short period of time, minutes or a few hours. If graywater is being generated faster than the drain openings can shunt it to the backyard, the surge tank allows for the temporary backup of water.

A surge tank may simply drain out the bottom to the landscape. This is called a gravity system. A gravity graywater system works when the soil or landscape is significantly below the level of the bottom of the surge tank (**Figures A, G, H and I and Handbook 5**). Otherwise a pump must be installed to lift the water to any landscape above the surge tank (**Figure E**).

Note: Surge tanks do not treat graywater. No treatment increases the chances of soil clogging. To treat graywater you must construct a mini-septic tank, or holding tank, that allows the solids to settle and the floatables to sit near the surface. Treatment tanks for graywater are a bit more complex but better in the long-term (**Figure D**).

Note: Pre-filters can prolong drainfield life but require maintenance (**Figure H** and **Handbook 6**).

Note: All surge tanks require vents, either above-roof or with activated carbon filter (**Figure I** and **Handbook 6**).

General Estimates of Each Fixture Use

Fixture/Appliance	Gal/Load	Range	Typical
Automatic home-type washing machine	gal/load	20-50	30
Automatic home-type dishwasher	gal/load	4-10	6
Bathtub	gal/use	20-30	24
Shower (5/8", 25' head)	gal/use	10-25	18
Washbasin	gal/use	0.75-2	1.25

WORKSHEET: TOTAL DAILY GRAYWATER FLOW

Appliance	# Fixtures to Graywater	Uses/Day*	Total Gal
Washing Machine			
Dishwasher			
Bathtub(s)			
Shower(s)			
Washbasin(s)			

Total/Day: ______

Peak Safety Factor (multiply by 1.5): ______

*Be generous. Assume all bedrooms occupied and you wash your hands 3 to 5 times each day. If you frequently do double loads or do one load of wash each day, use twice the gallons. Remember to only include those fixtures and appliances going to graywater system.

High or Low Water Flow Fixtures (use is up to you)

Appliance	High Rate	Low Rate
Shower head	3.5-7	2.5
Sink faucet	3.5	0.5 - 2.5
Washing machine	30-40 per load	20/load
Dishwasher	9-12/load	5/load

Surveying Your Property

To begin the design process, take out the map of your property. You may obtain a copy from the City's Building Department or the County Health Department. Make a few photocopies. In various colors, sketch the plantings you would like to subirrigate and where you plan to have the surge tank.

If you live on a smaller or oddly shaped parcel or a parcel with steep slopes or other ecologically difficult areas, you may have to roughly measure your property to fit in all the parts of the graywater system. If you don't meet these setback distances (see **Tables A** and **B**), adjust your initial concept and make more sketches to see where each component might be located. If you still can't meet the setback criteria you can submit a basic plan if you think you can show that your soil or circumstances are different enough to allow for a waiver.

The homes on beachfront parcels have, by mutual agreement, different setbacks from inland homes. The inland and beachfront setback requirements are in **Tables A** and **B**. The beachfront parcels may also use the "reserve area" if the homeowner is willing to sign a statement that, should the reserve be needed, they will move the graywater system and replace the sand used in the graywater drainfield

Drainfields

Graywater disposal systems are near the surface to maximize irrigation of plant life. The gravity-fed systems are best for deep-rooted plants like trees and certain shrubs. They come in a variety of shapes and sizes:

- mulched watering moats;
- gravel mini-leach pits with "upside-down flower pots" as inlets;
- rectangular shallow drainfields for longer stretches;
- pumped drip irrigation;
- a special beach sand drainfield (**Handbook 9**).

Unlike most septic leachfields, a graywater system leachfield is very shallow, 10 inches deep and as close as 9 inches to the surface.

Note: If you are just reusing washing machine graywater, you will want a gravity disposal/irrigation system. Drip irrigation is too expensive and requires too much maintenance for just the washing machine alone.

Handbook 7 describes each subirrigation system in detail. Here, we simply introduce you to some of your choices. The benefits and limitations of each are outlined in the final page of this handbook. **Handbook 9** describes drainfields for beach sands.

Mulched Watering Moats

Where there isn't much graywater to disperse, a pair of heavily-mulched watering moats around two trees may be the best solution. A simple 18 inch deep ditch is dug beneath the outside edge of the tree's foliage or canopy (often called the dripline), a permanent dedicated hose or pipe brings the graywater to the moat and, to prevent daylighting, the moat is filled with a rough bark or wood chip mulch (**Figure J**).

Gravel Mini-Leach Pits with Flower Pot "Emitters"

A simple homemade disposal system can be made from a number of upside-down flower pots, or other hollow containers, placed over a pocket of gravel-like crude "emitters" (**Figure K**).

Table A: Beachfront Setbacks (number of feet)

Site	Surge Tank	Irrigation/Dispersal Area
Building/House*	0	0
Foundation	0	2
Property Line	0	5
Well	100	100
Mean High Tide Line	5	5
Existing Leachfield	5	5
Septic tank	0	0
Drinking Water Line	0	5
Water Main	5	5

*For above-ground tanks only.

Table B: Inland Soil Zone (number of feet)

Site	Surge Tank	Irrigation/Dispersal Area
Building/House*	0	0
Foundation	0	2
Property Line	5	10
Well (Drinking)	100	100
Stream/Lake/Pond	50	50
Existing Leachfield & Expansion	5	10
Septic Tank	0	0
Drinking Water Line	5	10
Water Main	5	10

*For above-ground tanks only.

Shallow Leachfields

Shallow leachfields are similar to a conventional septic leachfield (**Figure L**). The graywater is distributed via a perforated pipe surrounded by a trench of gravel. A graywater system leachfield is very shallow, 10 inches deep compared to 2X6 feet deep for a conventional septic leachfield.

Drip Irrigation for an Irrigation Graywater System

Drip irrigation systems require filters to prevent clogging and pumps to insure equal flows in all the drip irrigation lines.

Drip irrigation involves a series of black plastic tubing installed with small gizmos, called emitters, which carefully control the flow of water to a small dribble. It is a near-surface irrigation system usually covered by 9" of mulch or soil. A drip irrigation system is the most efficient way to water plants and the best way to irrigate for spreading plants.

The emitters, however, have tiny holes and passages to regulate the flow of water. The lint, dirt and oils in graywater look like large logs, huge boulders, and oil slicks to the tiny opening in an emitter. Graywater *must* be filtered to work with a drip irrigation system. Some systems filter the graywater with a fine-meshed filter bag, some with canisters of clean sand and others use paper cartridge chambers. Some systems require cleaning of the filter medium, others have automatic flushing of the filter.

Carefully consider the pluses and minuses of a drip system before committing yourself to this more complex approach (**Handbook** 8).

Amount of Plant Life to Be Irrigated

The purpose of near surface graywater systems is to reuse as much water as possible for irrigation. Some graywater will escape use by the plant roots, especially in the winter when rain is plentiful and temperatures are cooler. The City of Malibu has designed your system for this "worst case" season of rain and low temperatures.

In general, without a drip system, consider the root zone within two feet of the drainfield. This is the area irrigated by graywater. In addition, any roots from more distant trees and shrubs that enter the drainfield will also use graywater.

Next Steps

You have figured which graywater fixtures you will connect to your graywater system, the type of drainfield, and the approximate area you want to irrigate. You are now ready for details of design, construction and installation:

- **Handbook 5:** for washing machine only.
- **Handbook 6:** for construction and installation of the surge tank.
- **Handbook 7:** for subirrigation design, construction and installation.
- **Handbook 8:** for drip systems.
- **Handbook 9:** for beachsand systems.
- **Handbook 10:** for innovative demonstration systems or systems requiring waivers.

Mulched Watering Moats

- **Benefits** - easy to install; no heavy gravel to haul in; no fancy plumbing; easy to spot watering problems; works well downhill from a gravity system; simple to remove/change.
- **Limitations** - works only on flat areas or level yards; bi-weekly to monthly maintenance; not very efficient use of graywater; can daylight if not well-monitored; won't water very many trees; inappropriate for annuals, lawns and ground covers; graywater not secure from animals/pets.

Gravel Mini-Leach Pits with Flower Pot "Emitters"

- **Benefits** - Fairly simple to construct; upside-down flower pot creates an air gap between the graywater hose and the gravel so that roots won't grow back into the irrigation hose; more even distribution of graywater than a mulched moat; spreads graywater to more plants; can be used with shrubs and trees; doesn't require much gravel to be hauled in; fairly simple to add to an existing planting; works well downhill from a gravity system and works on gentle slopes.
- **Limitations** - Some gravel to cart in; takes time to adjust the ball-valves to equalize the distribution of the graywater; any above ground tubing is unsightly and can be eaten by dogs; gophers may eat below ground tubing; more susceptible to clogging than a water moat or a shallow leachfield; inappropriate for lawns and most ground covers.

Shallow Leachfields

- **Benefits** - Simple to operate; doesn't readily clog; easy to clean out in the rare case it does clog; fairly simple to install in a new landscape (prior to planting); works well downhill from a gravity system; best suited to water trees and shrubs; some people find gravel-filled leaching trenches easiest to install in a new planting.
- **Limitations** - Awkward to install among existing plants in a mature landscape; inefficient distribution of water to the landscape; waters a small, limited area (each length of perforated pipe should be no more than 10 feet long); not evenly pressurized so plants at the beginning of the perforated pipe get more of the water (until that portion of the gravel gets clogged); perforated pipe must be installed level to function correctly and is not easily installed on slopes; inappropriate for lawns and most ground covers.

Drip Irrigation for an Irrigation Graywater System

- **Benefits** - The most efficient and direct way to irrigate. Promotes the healthiest plants, the best growth, the greatest amount of blossom and, with edible plants, the highest yields. Spreads graywater over the largest possible area, to the largest number of plants and with the greatest amount of control. Allows for slow percolation of graywater into the soil and is the most practical way to apply graywater to slopes, heavy clay soils, and land subject to sliding or creeping. Applies graywater close to the soil's surface for the most aerobic "digestion" of its organic matter and nutrients. Can be automatically operated for simple distribution to various zones. A thickly-mulched drip system provides a virtually weed-free, low maintenance landscape.
- **Limitations** - Complicated for do-it-yourself installations. More costly than most dispersal methods such as shallow leachfields, upside-down flower pot "emitters" and mulched watering moats. Prone to clogging if filtration is inadequate or cleaning of the filter is irregular. A failed filter can permanently ruin the entire drip system in a matter of minutes. Requires more maintenance and energy use than gravity and dispersal systems. Above ground and below ground rodents may chew through the drip irrigation tubing. Not well-suited to most gravity systems. May require duplicate drip system for potable water.

A Simple Gravity Disposal Graywater System

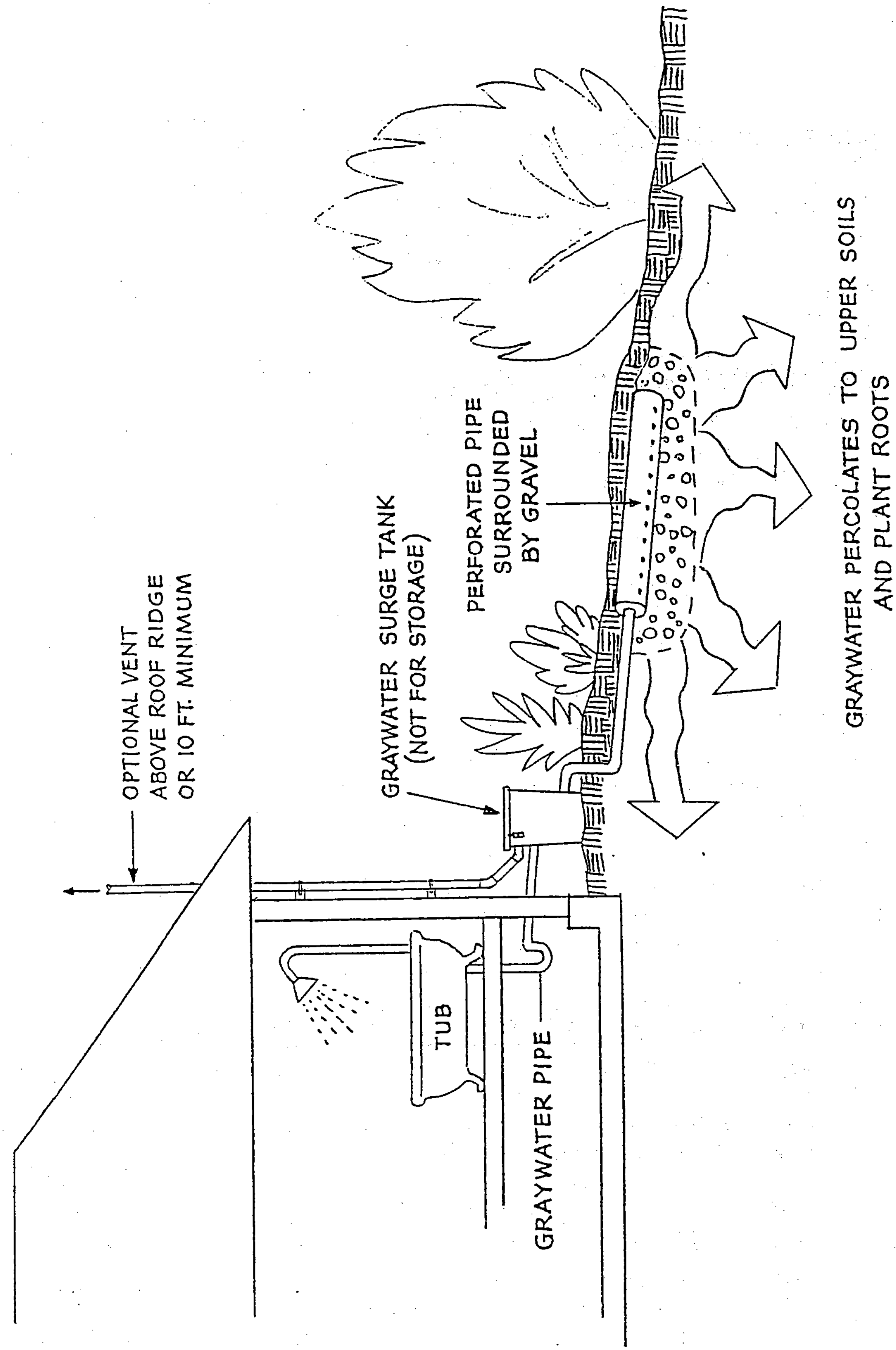


FIGURE A

Switching Valve for a Laundry Graywater System

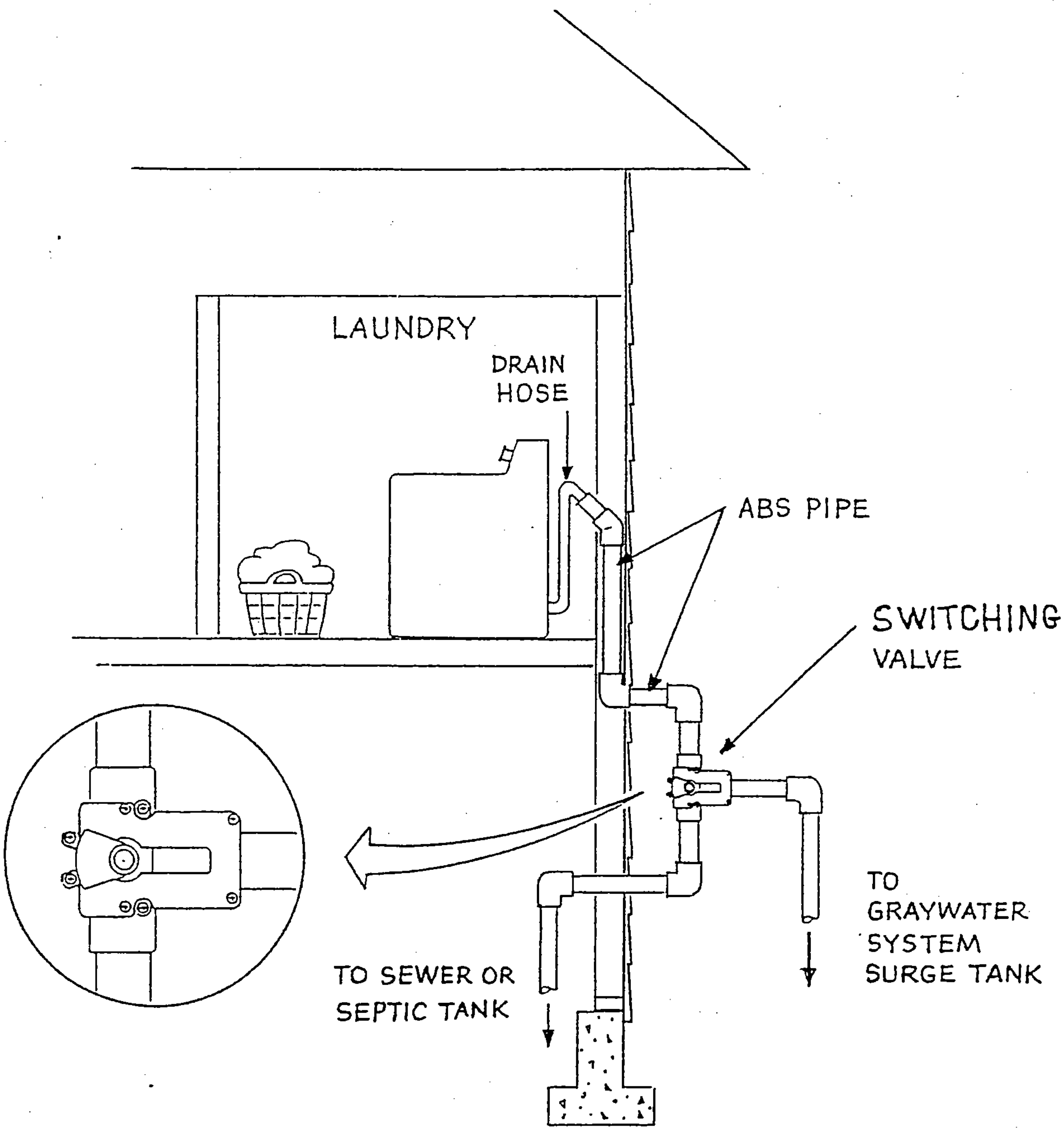


FIGURE B

A Simple Gravity Disposal Graywater System

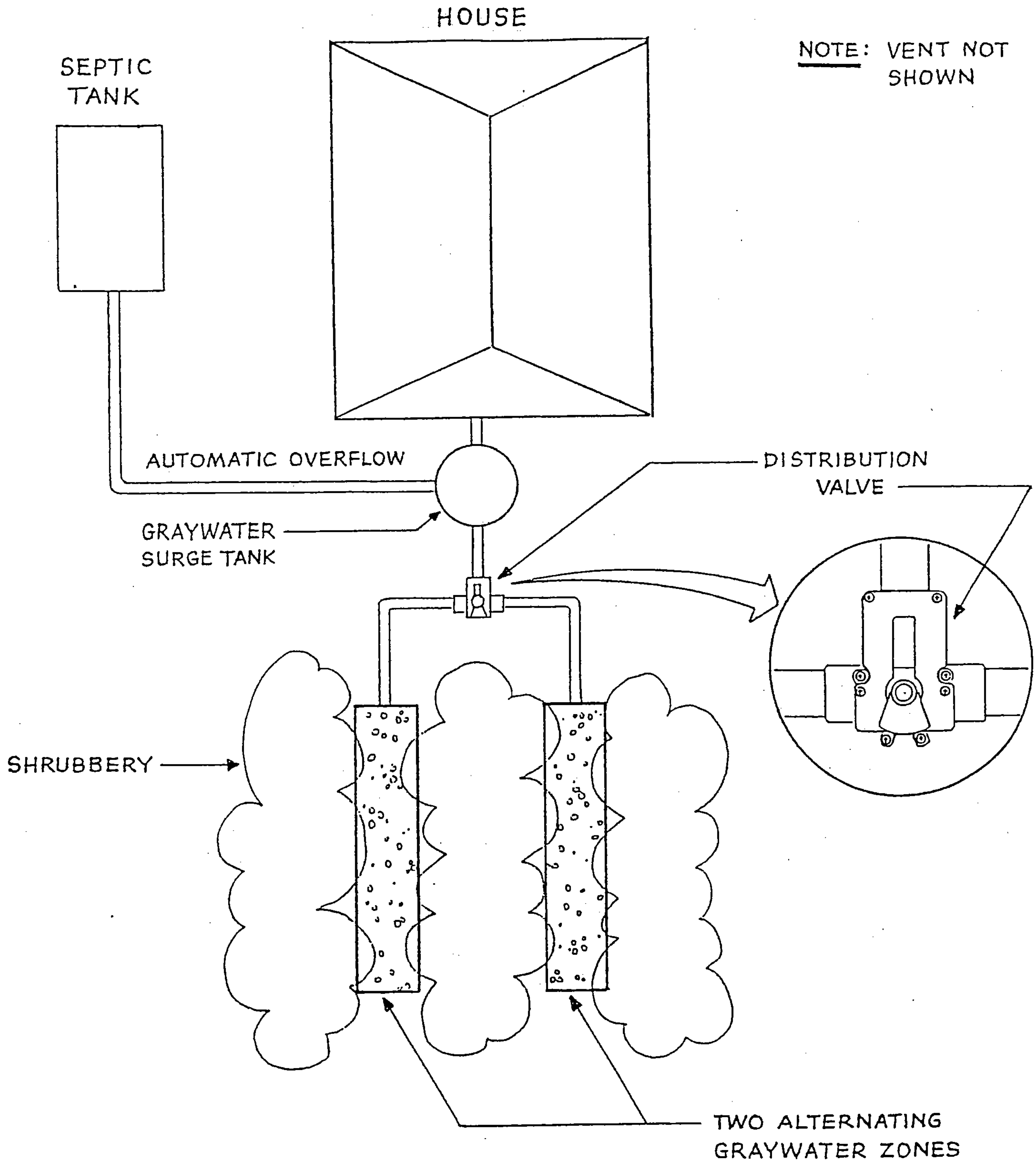
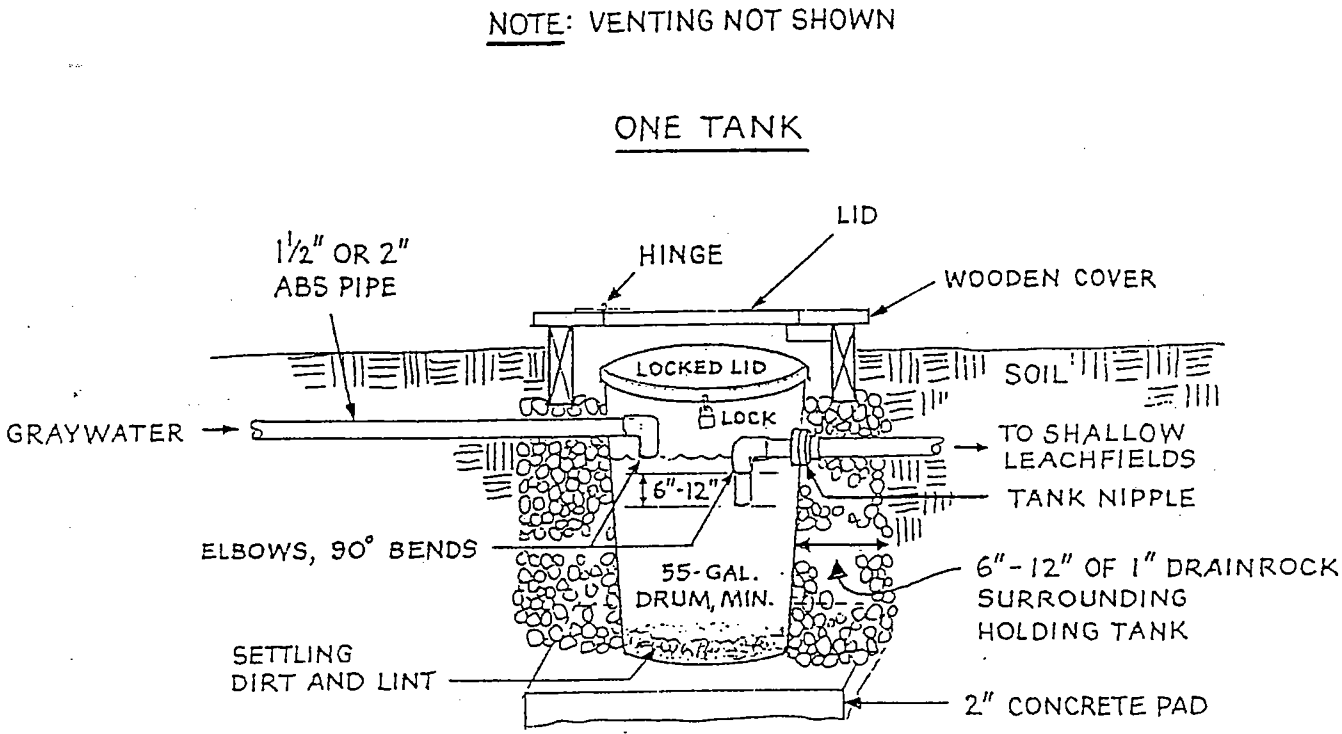


FIGURE C

Near Surface Holding Tanks



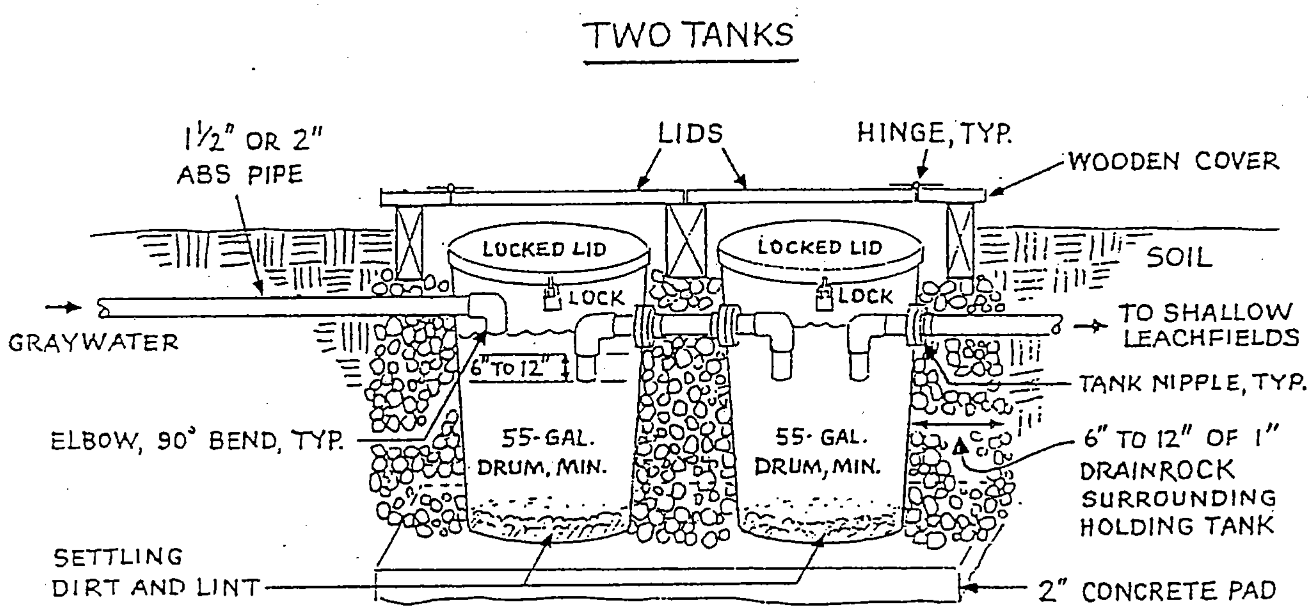
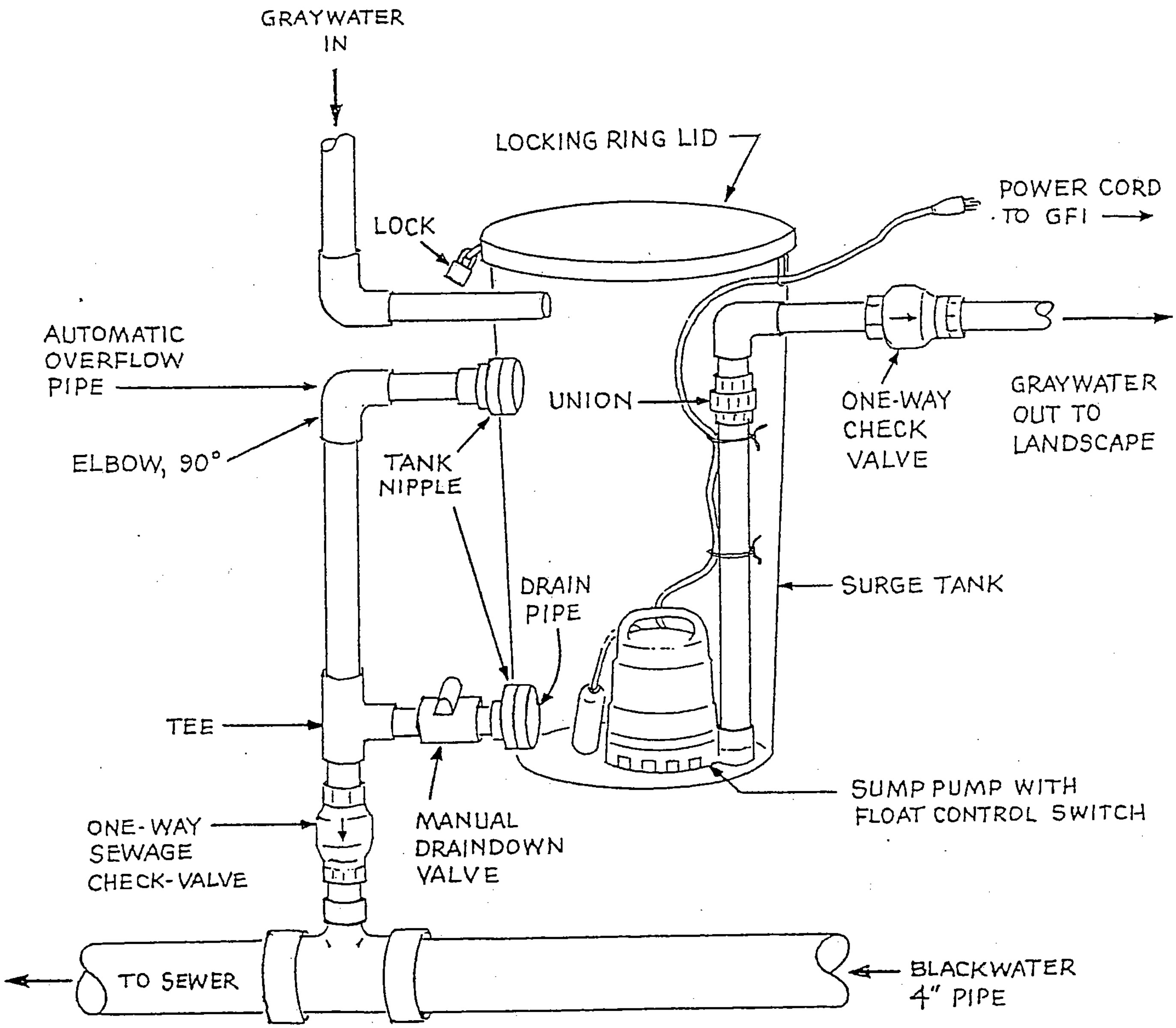


FIGURE D

Graywater Surge Tank with a Sump Pump



NOTE: VENT AND OPTIONAL ACTIVATED CARBON AIR FILTER NOT SHOWN

FIGURE E

Basic Components of a House Replumbed for a Graywater System (with a sump pump)

NOTE: VENT NOT SHOWN

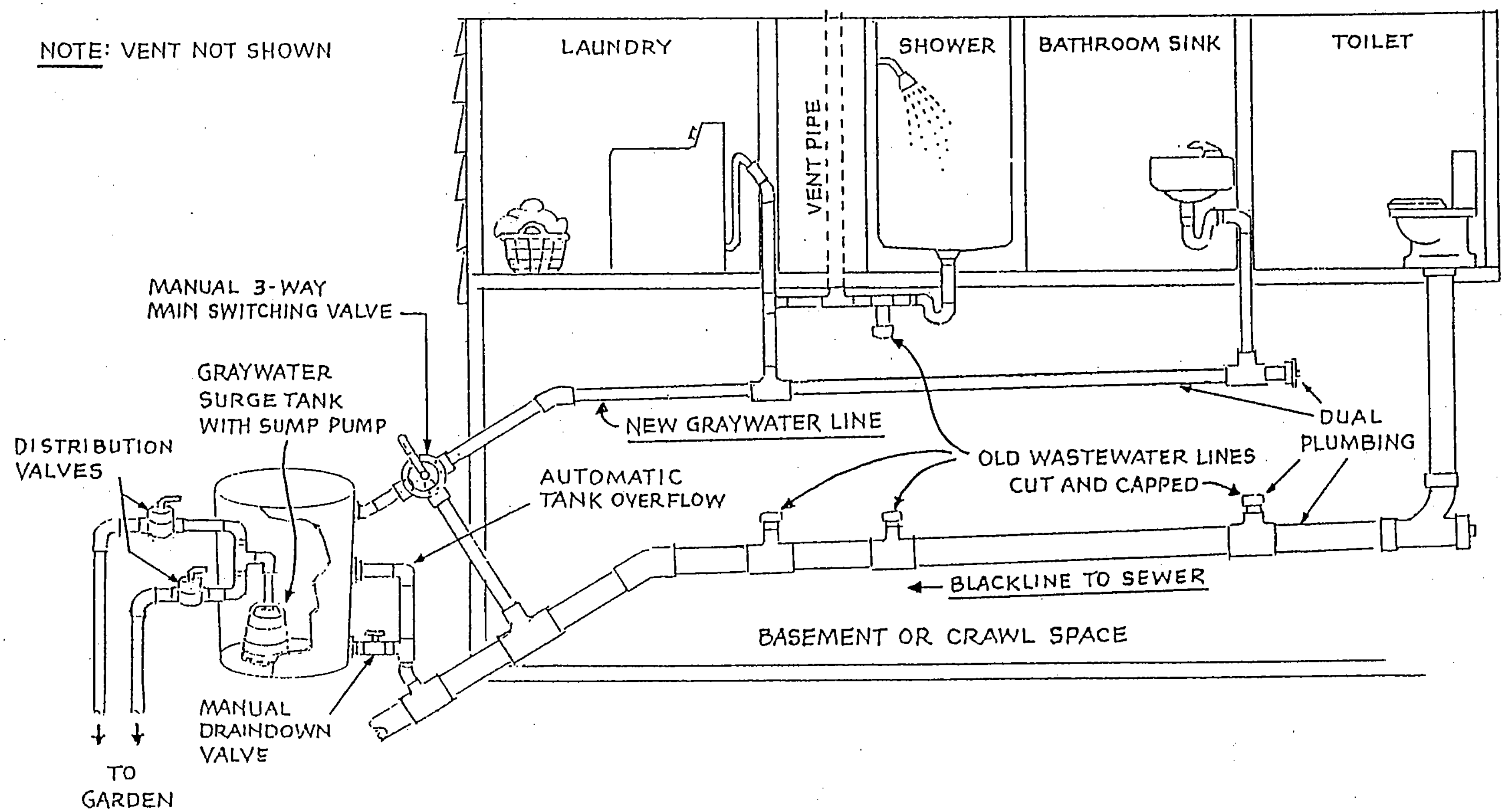


FIGURE F

Checking the Slope of Graywater Pipes

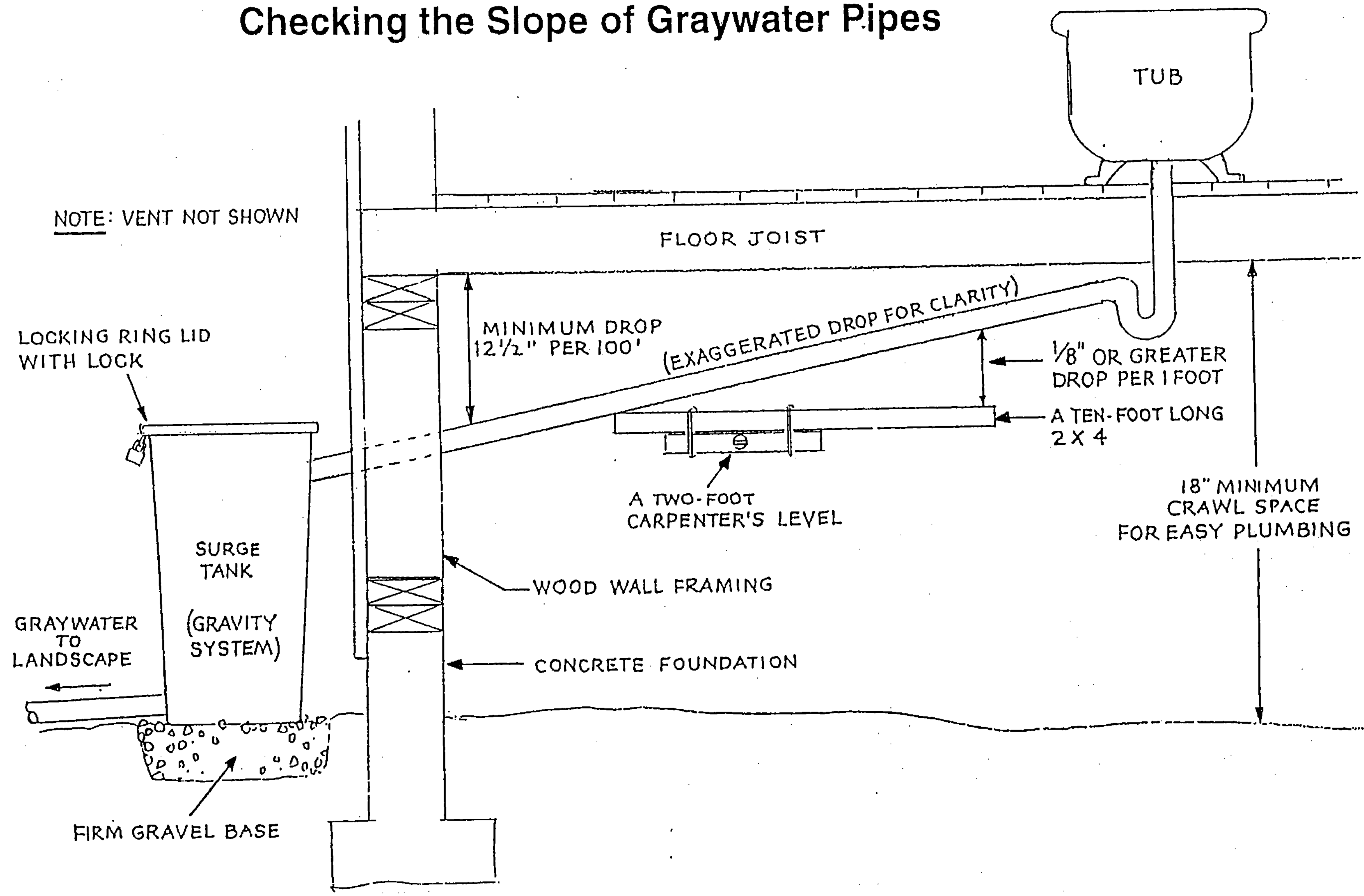


FIGURE G

Two Simple Graywater System Pre-Filters

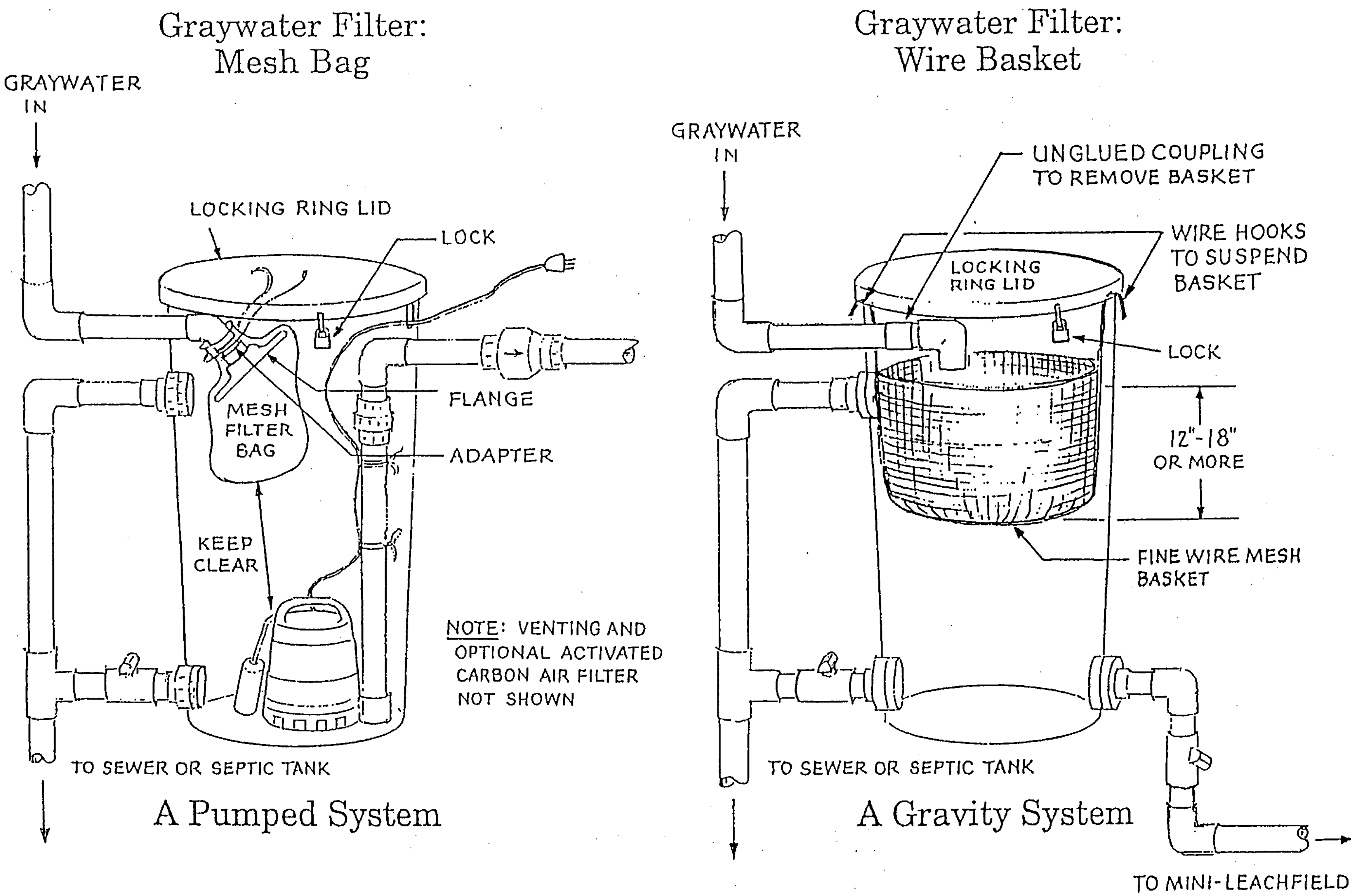


FIGURE H

Venting a Graywater System

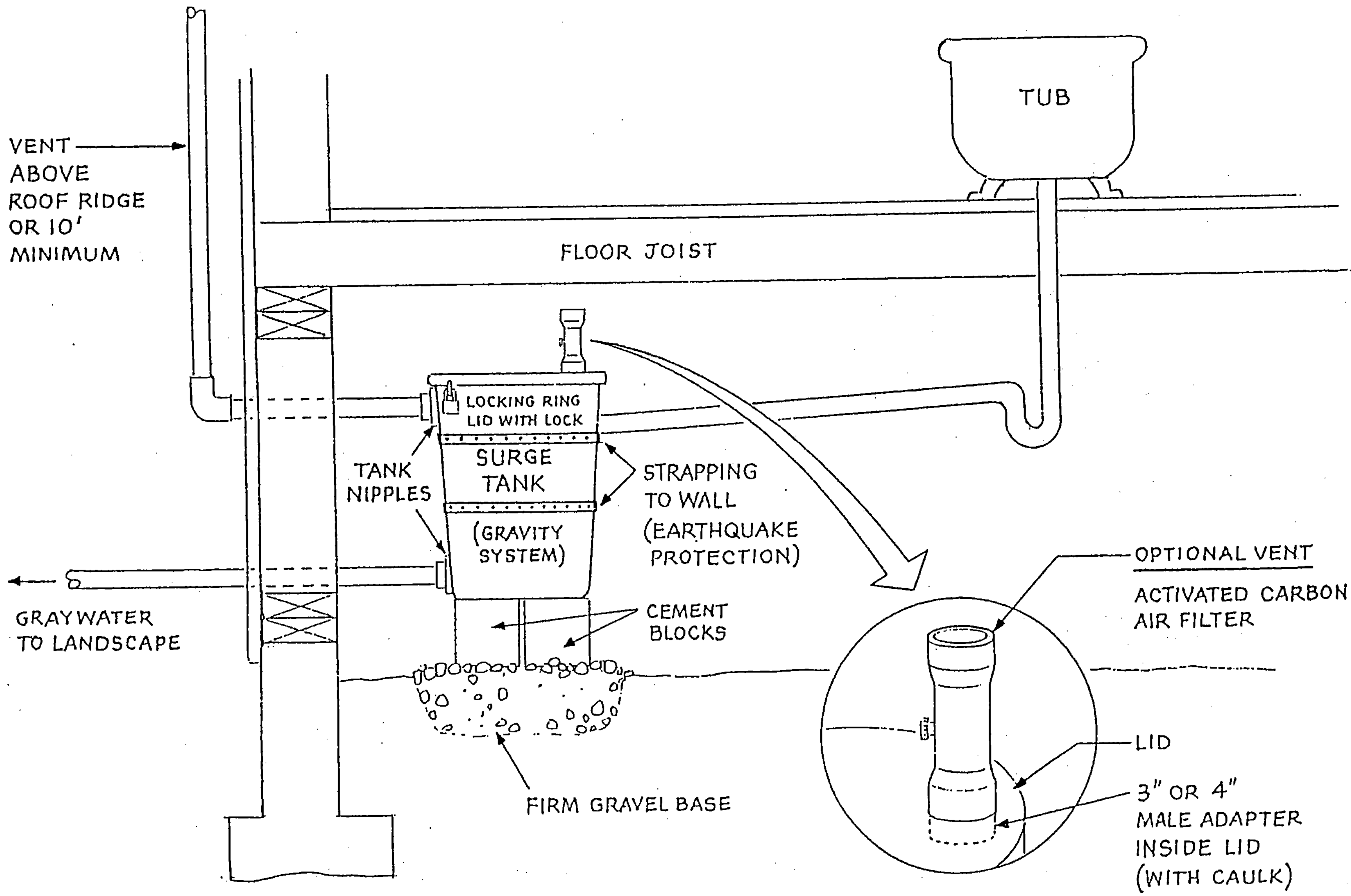


FIGURE I

A Graywater Mulched Watering Moat

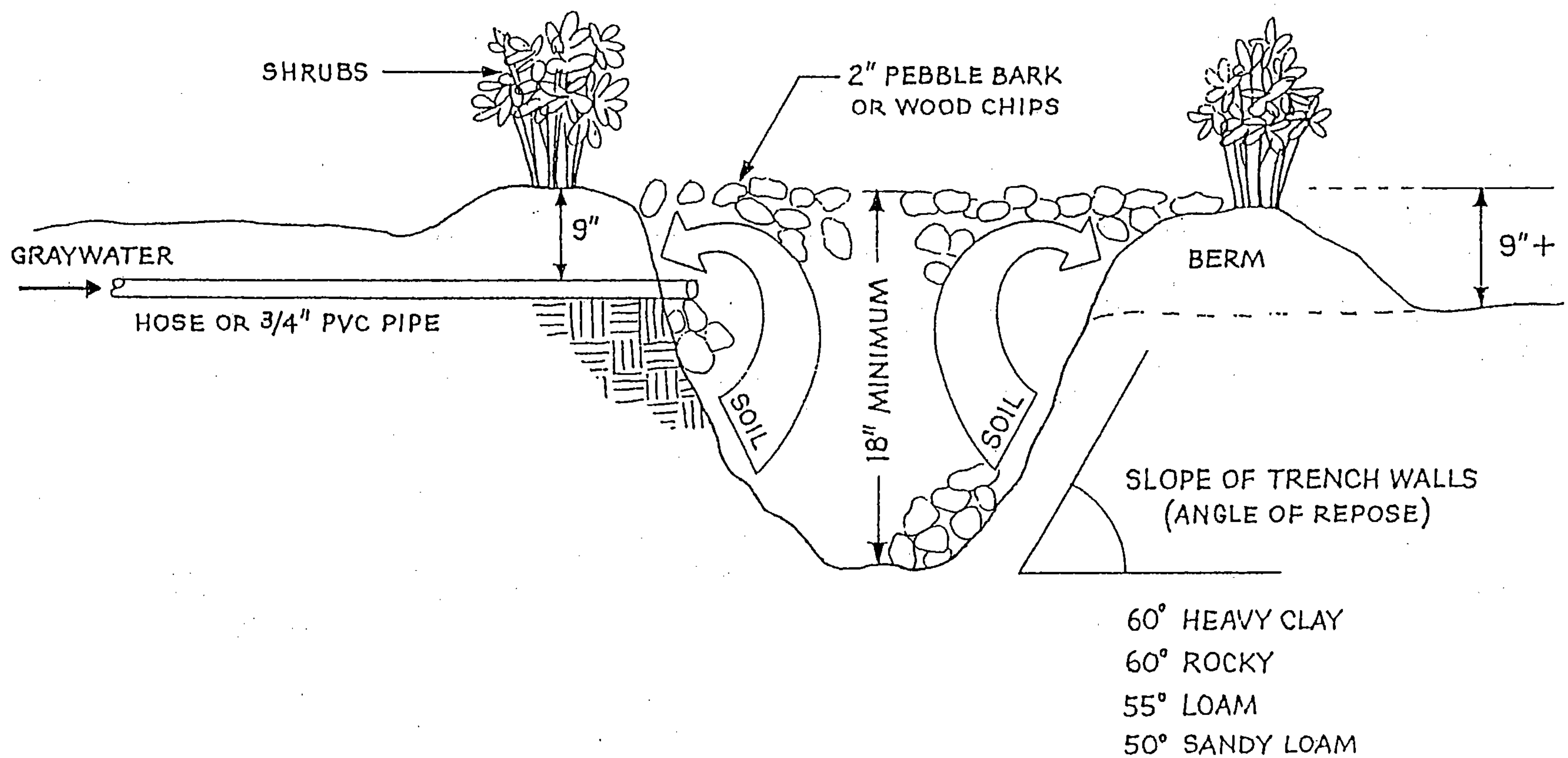


FIGURE J

A Flower Pot "Emitter"

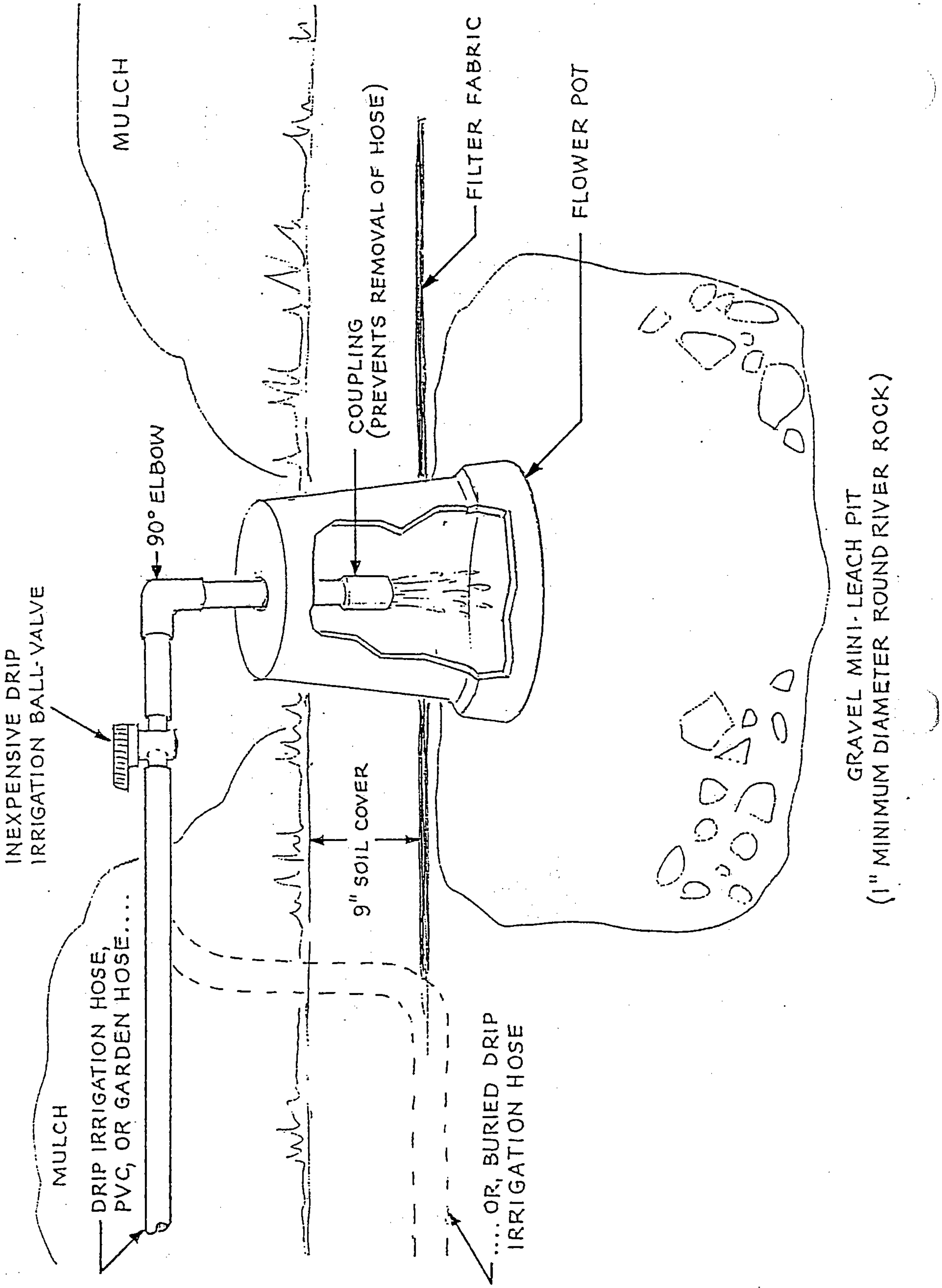
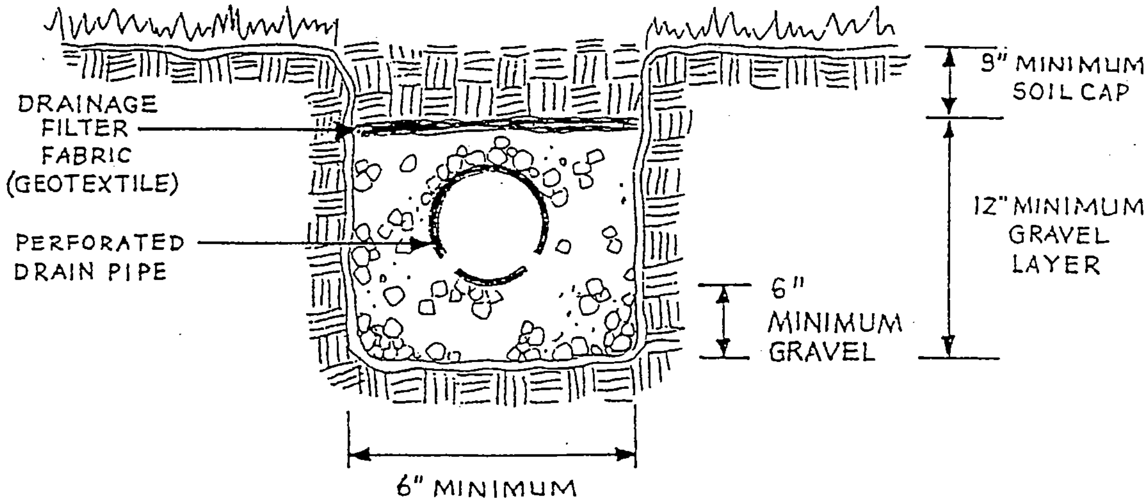


FIGURE K

A Shallow Leachfield



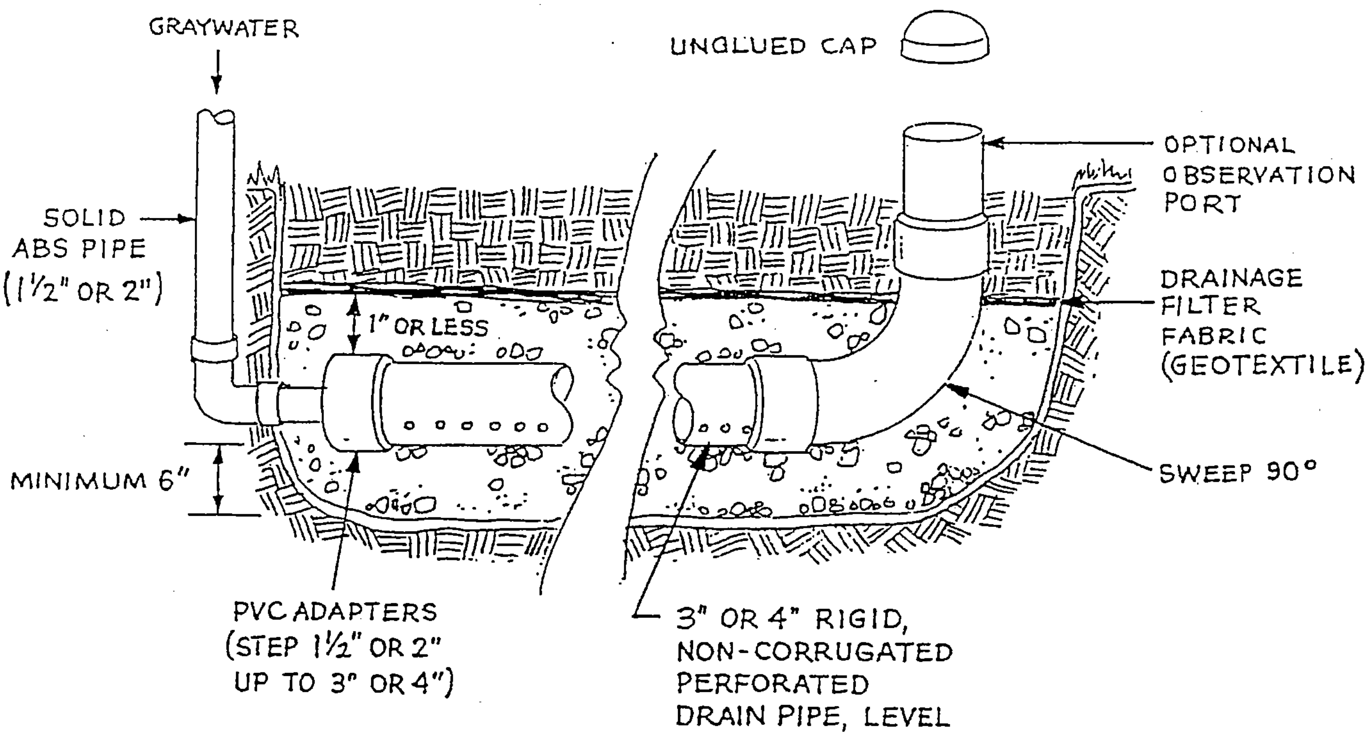


FIGURE L

Handbook #4
GRAYWATER, DETERGENTS, AND WASHING MACHINES

Garden-Friendly Detergents

Graywater can be friend or foe to plants. Its quality changes with the dirt on your hands and clothes; the detergents, soaps, softeners, whiteners, shaving cream, and toothpaste you prefer; and the pipes in your plumbing. Since most homes will connect their washing machine to the graywater system, laundry detergents are one of the most controllable additives.

The most garden-friendly detergents will:
- be a liquid, not a powder (less sodium);
- have zero sodium or additives with sodium (sodium trypochlorite);
- have zero boron (or borax and sodium trypochlorite);
- have zero water softeners (vs. clothes softeners);
- have zero chlorine from bleach;
- have zero aklylbenzene or other petroleum distillates.

CHEMISTRY FOR CONSUMERS

Boron

Boron is beneficial in very tiny amounts but can be poisonous (if not lethal) in even small amounts. Most soils have enough boron to meet plant needs. Adding any boron (in the form of borax, sodium perborate or other "bor-" compounds) is asking for trouble.

Chlorine

Chlorine shouldn't be used in washing machines whose graywater irrigates plants. It blocks normal metabolism and can release sodium to the soil which also damages plants.

Phosphates

Phosphates are beneficial to plant growth and can be found in all fertilizers. They are a pollutant in streams but can be mildly beneficial to garden soils. Some phosphates in detergents can't be readily used by plants, so don't try to substitute detergent for fertilizer unless you know the detergent's phosphate will help your plants.

Sodium

Low sodium is perhaps the most important quality for graywater. High sodium can destructure soils, rendering them unfit for good root aeration and absorption of water. It turns clays greasy or slick, obstructing good drainage. Recovery of the damaged soil is difficult. Only beachfront homes that dispose of their graywater will have no sodium problems.

Alkalinity

Certain salts make your water more "caustic" or "basic." These alkaline salts release sodium that interfere with plant nutrition and metabolism. In addition, the carbonates, sulfates, and chlorides from detergents can be toxic to many stages of plant life. Alkalinity ranges from Chlorox 2 (1420 mg/l) to Shaklee (6.5 mg/l). In general, the lower the better for plant life.

Conductivity

Conductivity is a general measure of salts and minerals in water. Very high conductivities indicate too many salts (Chlorox-2). Low conductivities are not harmful to plants (e.g., Shaklee, All Regular, Oasis, Ivory Snow).

TABLE A
DETERGENTS, CLEANING & GRAYWATER

Product Name	P or L	Sodium	Boron	Alkalinity	Conductivity	Phosphate	Cleaning Power*
Distilled/Deionized Water	n/a	<	<<	3.78	2.03	<<<	
Oasis	L	<	<<	16.2	89.6	<<<	
Alfa Kleen	L	3.71	<<	16.8	25.6	<<<	
Yes	L	6.40	<<	10.3	42.5	<<<	
Shaklee	L	6.48	<<	12.1	19.0	<<<	40
Bold	L	9.74	<<	68.6	46.7	<<<	
Ecovcover	L	24.3	<<	63.7	132	<<<	
ERA Plus	L	26.3	<<	15.3	102	<<<	52
All Regular	L	39.3	<<	29.8	116	<<<	
Tap Water (Tucson, AZ)	n/a	42.7	0.042	118	317	<<<	
Wisk Advanced Action	L	56.8	7.41	72.4	221	<<<	66
Ivory Snow	P	70.8	<<	219	258	NT	
White King	P	74.0	1.83	165	266	NT	
Tide Regular	L	93.8	0.030	61.2	291	<<<	73
Cheer Free	L	94.7	<<	80.3	307	<<<	
Tide with Bleach	L	95.0	2.30	58.3	329	<<<	82
Fab 1-Shot	Pkt	109	<<	09	501	5.26	64
Fresh Start	P	132	0.026	106	510	8.28	
Cheer Ultr	P	171	0.076	149	710	<<<	71
Gain Ultra	P	180	0.058	300	792	<<<	
Dreft Ultra	P	189	9.75	328	737	<<<	
Amway	P	227	<<	310	939	4.00	
Shaklee Basic L	P	230	<<	285	1030	<<<	55
Purex Ultra	P	231	<<	278	1010	<<<	
Dash	P	238	2.14	482	1060	<<<	
Woolite	P	239	0.17	22.3	1040	<<<	
Tide Ultra	P	243	0.098	236	959	10.7	71
Surf Ultra	P	249	<<	302	989	13.7	
Oxydol Ultra	P	272	11.3	501	1030	<<<	62
White Magic Ultra	P	273	0.035	194	1140	18.5	
Ariel Ultra	P	280	0.030	247	1020	10.8	
Ajax Ultra	P	292	0.040	219	1130	11.2	
Wisk Power Scoop	P	319	<<	360	1160	9.77	
Sun Ultra	P	335	<<	653	1490	1.58	
Valu Time	P	371	0.034	460	1650	1.79	
Bonnie Hubbard Ultra	P	377	0.036	617	1560	<<<	
Greenmark	P	395	<<	568	1690	1.67	
Fab Ultra	P	443	<<	199	1140	21.7	
All	P	492	0.10	659	2030	NT	46
Par All Temperature	P	529	0.049	431	2350	2.67	
Arm and Hammer	P	572	<<	1160	2450	<<<	34
Sears Plus	P	635	<<	1200	2500	<<<	29
Chlorox 2	P	672	11.2	1430	2880	<<<	
Calgon Water Softener	P	359	<<	345	1290	22.9	
Downy Fabric Softener	L	<	<<	NT	6.37	<<<	
Snuggle Fabric Softener	L	<	<<	NT	2.60	<<<	

Legend: P: Powder L: Liquid
<: Less than the sodium detection limit of 1.0 mg/l.
<<: Less than the boron detection limit of 0.025 mg/l.
<<<: Less than the phosphate detection limit of 1.2 mg/l.
NT: Testing of sample not possible.

*Detergent Ratings by Consumer Reports
100 = Best

Handbook #5
A SIMPLE WASHING MACHINE GRAYWATER SYSTEM

Introduction

The most simple graywater reuse system can be a "washing machine only" system. This handbook describes what to do if you want to reuse your washing machine "wastewater."

Measuring Graywater from a Washing Machine:

Gallons/Person/Day (gpd)	13
Flow Rate (gpm)	12-20
Gallons per Load	30-40

Preliminaries

The City will require you to register your washing machine-only graywater system. You must fill out a simple permit at the counter and take home the appropriate handbooks and a **Do's and Don'ts** list which you should post near your washing machine. On the permit you must specify how you will subirrigate or dispose of the graywater: flower-pot emitters, shallow leachfields, mulched moats or beachsand drainfield.

- For single-fixture graywater systems only, you can perform your own soil tests (**Soils Appendix**) to determine how big a subirrigation area you need.
- Read the handout on garden-friendly detergents (**Handbook 4**).
- Read **Handbook 6** if you need a sump pump.
- Read **Handbook 9** if your home is on beachsand.
- Read **Handbook 7** if you have an inland home.

Design

Be sure to follow setback specifications listed in **Tables A** and **B**. The measurements from your graywater system to each of the items in the setback chart must appear on the sketch for the Planning Department.

Plumbing: The Main Switching Valve

A switching or diverter valve is required to allow the homeowner to alternate between the graywater system and the septic tank or sewer as desired (**Figure A**). The switching valve is used when the ground is saturated with rainwater, when someone is ill with an infectious disease, or when you have an exceptional number of loads.

Switching the Laundry Drain Hose

The simplest way to divert graywater to either the sewer/septic tank or to the landscape is to add a second drain pipe for the flexible rubber drain hose with the hooked end (installed with each washing machine) (**Figure B**). Make the second drain pipe opening just as high above the floor as the existing drain pipe (clearly marked **Danger - Don't Drink**). Plumb a second trap to this new drain pipe to keep the graywater surge tank's fumes from backing up into the laundry room.

Table A: Beachfront Setbacks (number of feet)

Site	Surge Tank	Irrigation/Dispersal Area
Building/House*	0	0
Foundation	0	2
Property Line	0	5
Well	100	100
Mean High Tide Line	5	5
Existing Leachfield	5	5
Septic Tank	0	0
Drinking Water Line	0	5
Water Main	5	5

*For above-ground tanks only.

Table B: Inland Soil Zone (number of feet)

Site	Surge Tank	Irrigation/Dispersal Area
Building/House*	0	0
Foundation	0	2
Property Line	5	10
Well (Drinking)	100	100
Stream/Lake/Pond	50	50
Existing Leachfield & Expansion	5	10
Septic Tank	0	0
Drinking Water Line	5	10
Water Main	5	10

*For above-ground tanks only.

The new graywater drain can exit through any convenient wall, or the pipe may drop through the floor to a crawl space or basement below. The trap can be located beneath the laundry room floor. To send graywater to the landscape, simply lift the washing machine's drain hose over and into the new drain pipe.

Note: This simple switching system doesn't protect the laundry room from flooding if there is a clog anywhere between the washing machine and surge tank. For the most protection from clogging, install a three-way diverter valve with passive overflow pipe. This valve is the simple to install and the most convenient to use (**Figure A**).

An electro-mechanical valve, such as a 24VAC spa-type three-way diverter valve, should be used if the diverter valve is to be located at the surge tank or any other position not adjacent to the washing machine.

The Surge Tank

A washing machine's internal pump can easily pump to a nearby surge tank, usually a 55-gallon, high-quality plastic drum. The washing machine can surge water at a rate much faster than a gravity graywater system can handle the water and usually faster than most cost-effective sump pumps can distribute it. Therefore, a surge tank is required to allow for the temporary backup of water. Construction instructions for surge tanks are in **Handbook 6**.

Surge tanks must have an automatic overflow pipe near the top of the tank in case something clogs downstream from the tank or the sump pump fails (**Figure C**). The overflow port must be connected by gravity-flow to the existing septic or sewer line or adequate storage volume with an overflow alarm must be provided for problem flows.

Note: A basket filter requires maintenance, but will catch lint and help ensure a working drainfield (**Figure D**).

Note: Each surge tank should also have a manual drain-down valve plumbed to the sewer or septic line to allow for cleaning and draining the tank. Install a protective one-way check valve. You can often plumb the tank so one check valve services both the overflow and the draindown functions (**Figure D**).

Note: With heavy use of your washing machine, a holding tank may serve your drainfield better by postponing clogging (**Figure E** and **Handbook 6**).

A Sump Pump for Hilly Sites

The washing machine pump may not be strong enough to pump the graywater far enough or high enough. An additional pump, usually a sump pump, to repressurize the water is required when the landscape you want to irrigate is level with the surge tank but more than 20 feet away, or if all the plants are uphill.

Important Warning: Protecting Your Washing Machine

Note: This warning applies only to systems with a sump pump or mesh bag pre-filter. Gravity feed surge tanks can skip this section.

If any lint should clog a filter or sump pump downstream from the washing machine, the machine will pump against itself until the motor burns up. To prevent this problem, a simple passive overflow port will relieve the pressure and divert the machine's discharge to the normal washing machine wall-mounted drain pipe.

With a three-way diverter valve (manual or electric), plumb a tee fitting in the graywater system pipe prior to the valve. From the tee, add solid pipe or flexible tubing in a loop 3 feet higher than the top of the machine and back down into the existing waste port, usually a black ABS 2-inch pipe (**Figure C**). If lint should clog the diverter valve, the water will simply surge back up-and-over the loop and safely discharge into the sewer or septic tank.

The Distribution Valves

After the surge tank, a series of two or more manual or automatic valves can control the application of graywater to various zones of the landscape (**Figure F**). For the sake of the plant's health, the graywater should be alternated between two or more separate zones. This rotation allows a resting time so the soil can drain and treat the graywater's lint and particulates.

Next Steps

Read handbooks on disposal or irrigation:

- **Handbook 6: Constructing Surge Tanks**
- **Handbook 7: Irrigation Systems Using Gravity**
- **Handbook 9: Beachfront Home Graywater Systems**

SOILS APPENDIX: Soil Texture Test for Single-Fixture Graywater Systems

Note: This test can be used for washing machine or bathtub-only graywater systems. Systems with more fixtures may require lab analysis. Consult with the City if your graywater system drains more than one fixture.

- Use soil sample from actual layer of soil to receive graywater. Do not use top 6-9 inches of topsoil.
- If soil layers have more than one color you must test each separately. Report how much of each layer you'll use in drainfield trench or hole (e.g., 3 inches of sandy loam and 9 inches of clay).
- Below the top layer of soil (usually brown or black), the color may be grayish, bluish or greenish. This indicates seasonal groundwater. You must indicate the presence of these colors in your application.
- Look at the soil closely to see if it has blotches or "mottles" of a different color than the body of soil. If you think there is mottling, indicate its presence on the application. Mottling may or may not indicate a seasonal groundwater elevation.
- If you don't feel comfortable with your assessment, it,s best to hire someone with experience (a professional soil scientist, a landscaper, a geologist).The Natural Resources Conservation Service (formerly the Soil Conservation Service) may confirm or analyze the soil samples for you.
- Fill out the form below and return it with your application.

Attach to Application for Single-Fixture Graywater Permit

Topsoil (6-9 inches) texture ______________________
Subsoil (9-24 inches) texture ______________________
Depth to bedrock (if less than 3 1/2 feet) ______________________
Presence of bluish, greenish or grayish colors ______________________
Presence of blotches or mottles in soil layer ______________________
Presence of gravel or fractured bedrock in soil ______________________

I have performed the "texture test" on the soil layers to the best of my ability. They accurately represent the soils in the graywater drainfield area that will be used to disperse, dispose or subirrigate. I have sized my drainfield according to the texture test results and the presence of limiting layers (seasonal groundwater, bedrock, and clay). A city inspector may confirm these results by entering my property by appointment.

Name ______________________
Signature ______________________
Application Number ______________________
Date ______________________

How to Name Your Soil

You must test each soil sample from each layer of soil. Here are the steps for the moist soil sample text.

Step 1: Fill the palm of your hand with dry soil.

Step 2: Moisten the soil enough so that it sticks together and can be worked with the fingers. *Don't saturate it into a runny mud.* If the soil sticks to your fingers, it's too wet to test. Add more dry soil.

Step 3: Knead the soil between your thumb and fingers. Take out pebbles. Crush all the clumps or aggregates. You may need to add a little more water. Continue working the soil until you crush all the clumps.

Step 4: Determine the sand in the soil by grittiness, feeling for sand grains. This sand "feel test" will allow you to estimate how sandy your sample is:

- More than 50%—Sand dominates. In describing the soil, use the word *sandy*.
- 20 to 50%—Sand is noticeably present, but not dominant. The texture is most likely *loam* or *clay loam*, though *silt loam* or *clay* are possible.
- Less than 20%—Silt and clay dominate. In describing the soil, use the words *silt loam*, *silty clay loam*, or *clay*.

Step 5: Form a cast with the sample by squeezing it in your palm. The ability of the soil to keep its shape is a test for both sandiness and clayiness (**Table A**).

Step 6: Squeeze the moist soil between your thumb and the second knuckle of your index finger. Try to work a "ribbon" out of the soil sample by pushing it further and further away from your hand. See if you can make the ribbon protrude1-3 inches from your index finger. This is the test for clay content (**Table A**). You may also note how sticky the soil feels and how dirty it makes your hands (**Table B**).

- Less than 27%—The ribbon is less than 1 inch long. In describing the soil, use the word *loam* but not the word *clay*.
- 27 to 40%—The ribbon is 1 to 2 or 2 1/2 inches long. In describing the soil, use the words *clay* and *loam*.
- More than 40%—Clay dominates. The ribbon is more than 2 1/2 inches long. In describing the soil, use the word *clay* but not the word *loam*.

Step 7: Combine your "sand" words and "ribbon" words as shown below. Use **Table A** to come to more accurate conclusions.

		SAND >50	SAND 20-50	SAND <20
CLAY	>40	Sandy clay	Clay	Clay Silty clay
CLAY	27-40	Sandy clay loam	Clay loam	Silty clay loam
CLAY	<27	Sandy loam Loam sand Sand	Loam	Silt loam

Sands, sandy loams, loamy sands, sandy clays, and loams can all be designed to receive 4 to 5 gallons of graywater per square foot of trench or other shaped hole. Use the sidewalls only in sizing your drainfield, not the bottom area. Count the top of the sidewall from the top of the subirrigation pipe.

If the soil texture is a clay, clay loam, silty clay, silt loam or silty clay loam, then use a maximum of 2 gallons of graywater per square foot of trench, sidewalls only.

Table A
Clues to the Feel of Textural Classes

Sand

__ Moist sample collapses after squeezing.
__ Your hands don't get dirty working the sample.

Loamy sand

__ Sample has very little body.
__ Moist soil barely stays together after squeezing.
__ Just enough silt and clay to dirty your hands.

Sandy loam

__ Sand dominates noticeably.
__ Enough silt and clay to give the sample body.
__ Moist soil stays together after squeezing.
__ Hardly forms any ribbon at all.

Sandy clay loam

__ Feels gritty and sticky.
__ Forms ribbon 1 to 2 inches long.

Sandy clay

__ Feels definitely sandy.
__ Forms ribbon 2 to 3 inches long.

Loam

__ Sand noticeably present, but doesn't dominate.
__ Sample works easily between thumb and fingers.
__ Contains enough silt and clay to give sample good body.
__ Sample only forms short, broken ribbons.

Silt loam

__ Feels smooth, like flour or corn starch.
__ Tends to be nonsticky.
__ Only forms short, broken ribbons.

Clay loam

__ Noticeably gritty, but sand doesn't dominate.
__ Noticeably sticky.
__ Noticeably hard to work between thumb and fingers.
__ Forms ribbons 1 to 2 1/2 inches long.

Silty clay loam

__ Feels smooth and sticky.
__ Contains very little sand.
__ Forms ribbons 1 to 2 1/2 inches long.

Clay and silty clay

__ Dry sample absorbs a lot of water before it is moist enough to work.
__ Sample very hard to work between thumb and finger.
__ Forms ribbon 2 1/2 to 4 inches long.

Switching Valve for a Laundry Graywater System

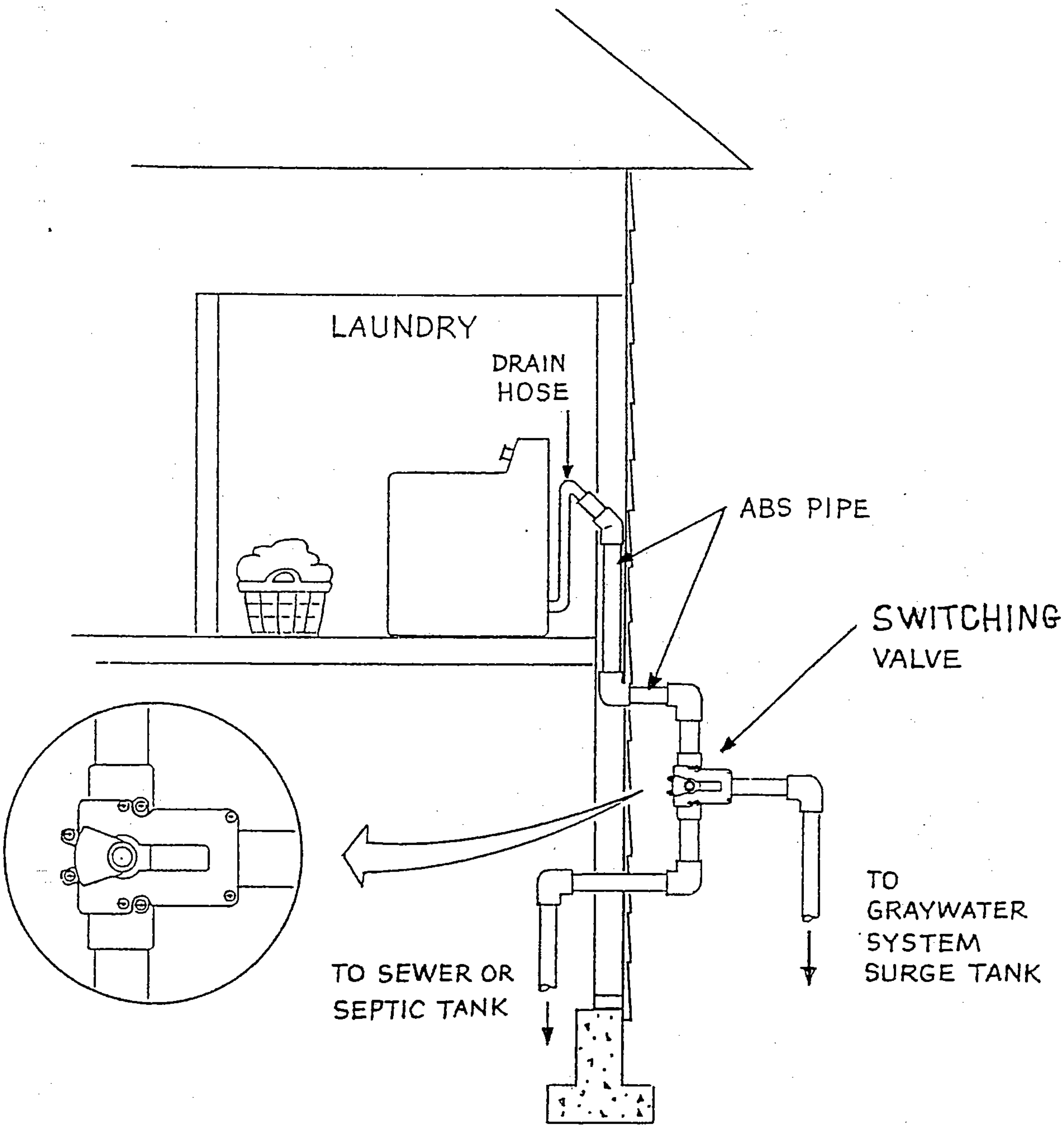


FIGURE A

Switching the Laundry Drain Hose from Graywater to Septic/Sewer

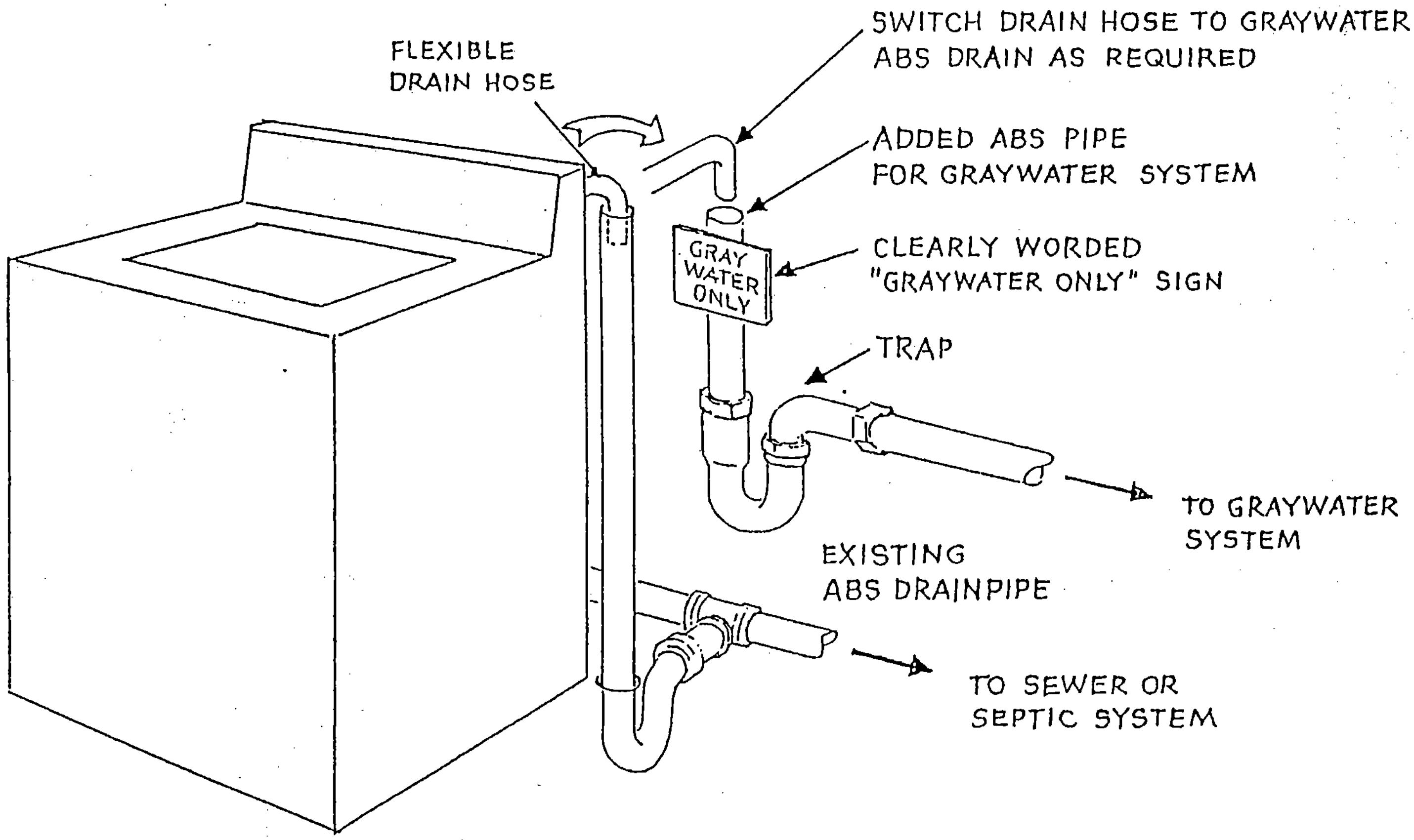


FIGURE B

Passive Overflow Protection for the Laundry

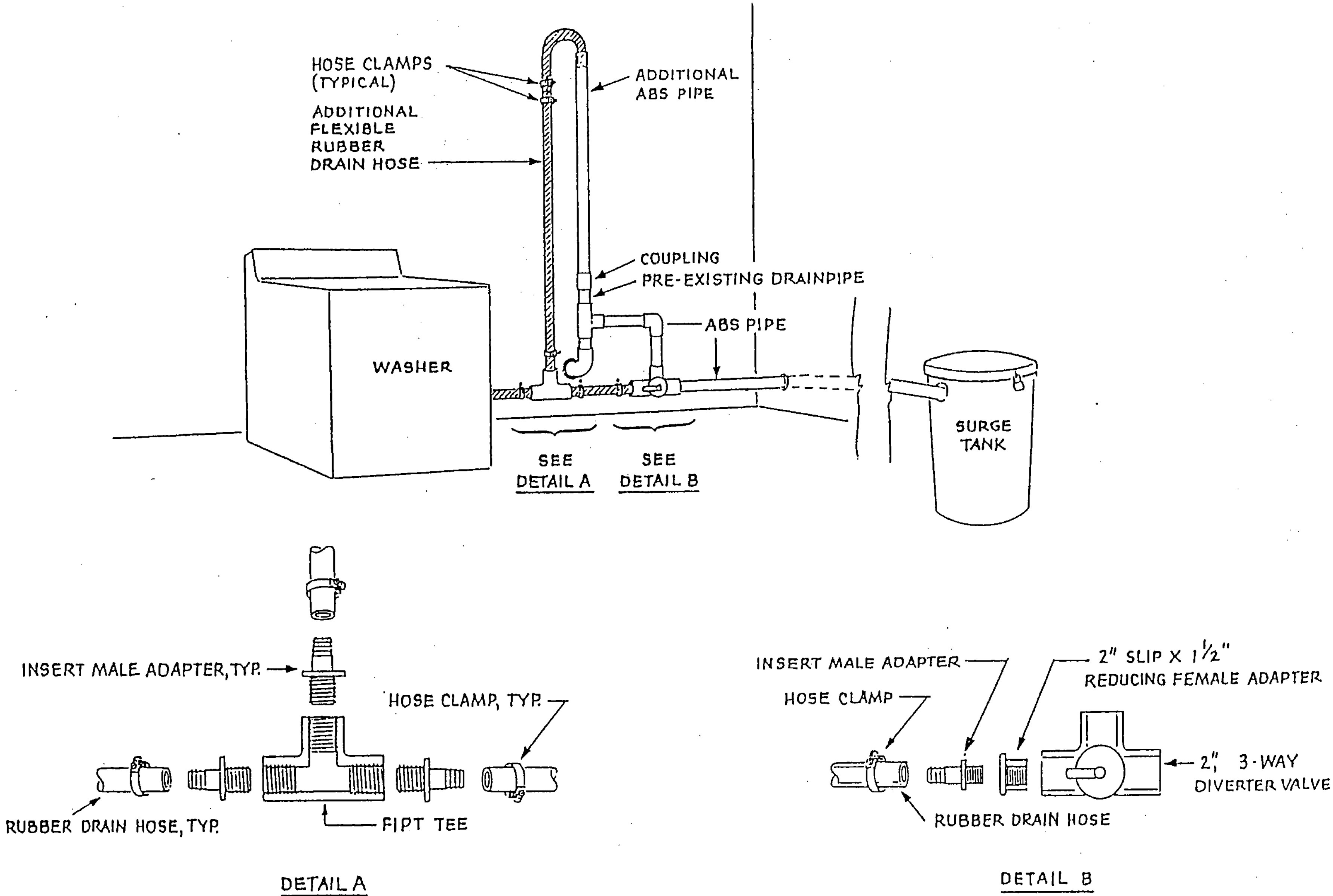


FIGURE C

A Gravity Surge Tank

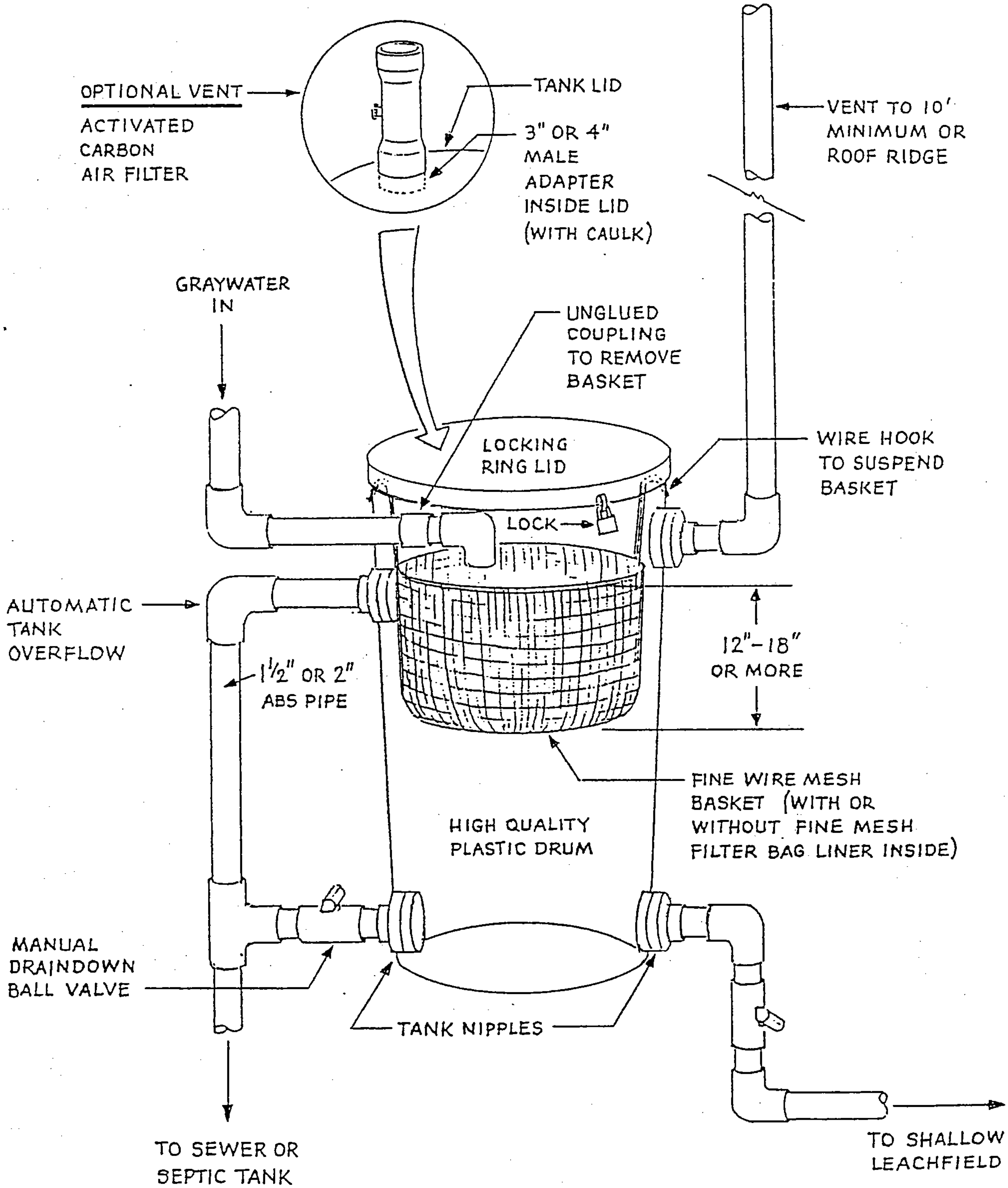
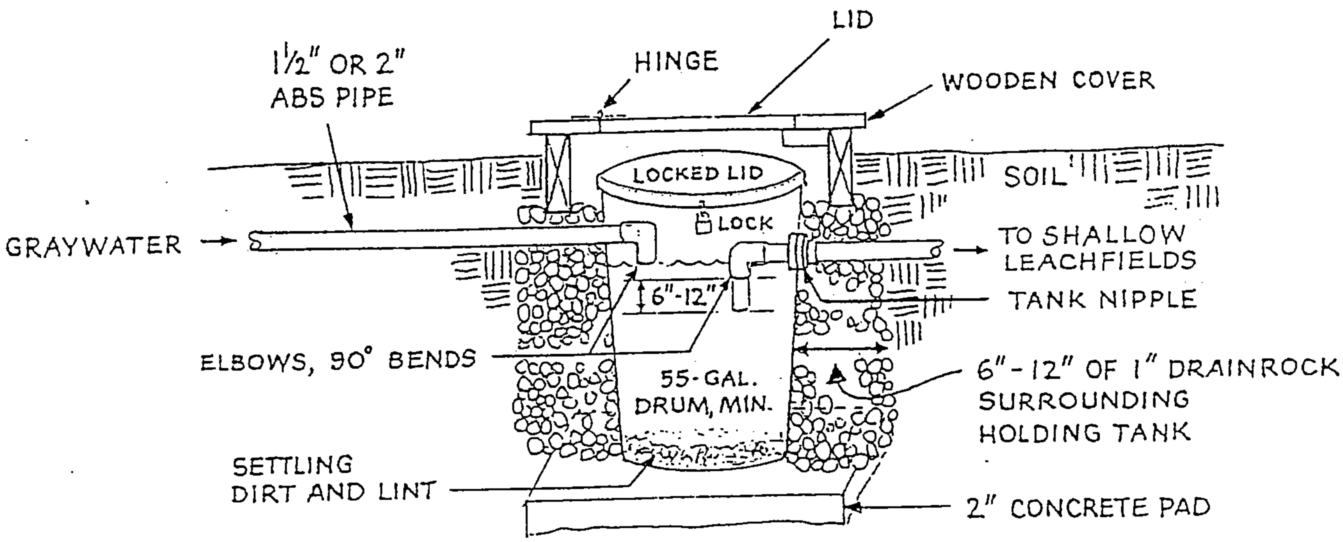


FIGURE D

Near Surface Holding Tanks

NOTE: VENTING NOT SHOWN

ONE TANK



TWO TANKS

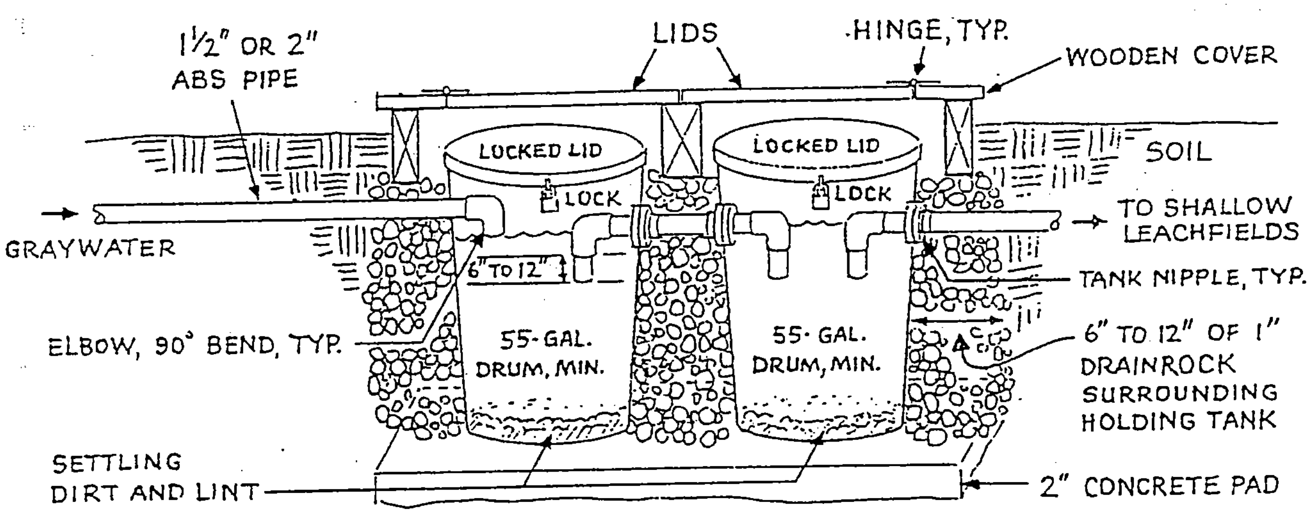


FIGURE E

A Simple Gravity Disposal Graywater System

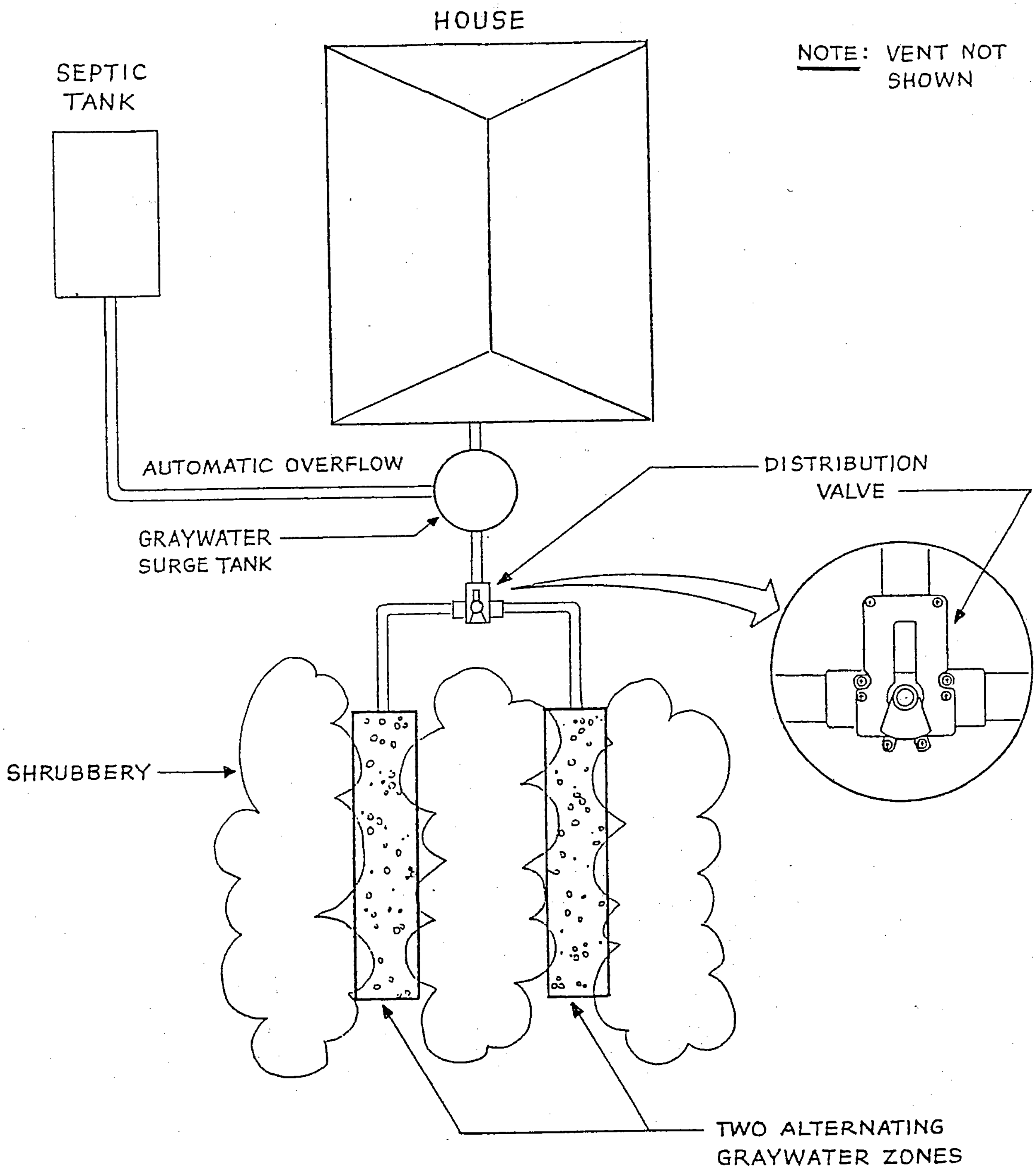


FIGURE F

Handbook #6
CONSTRUCTING SURGE TANKS With and Without Pumps

Introduction

The surge tank is usually a high quality, 55-gallon drum that receives graywater flowing from your home. While it looks like a small storage tank, it only holds graywater for a short period (minutes to a few hours). When graywater surges from your home faster than the soil can absorb it, the surge tank allows for a temporary backup (**Figure A**).

Surge tanks do *not* treat the graywater. They allow all the lint from clothes, the soap and oils from bathing, and hair to pass into the soil. The treatment, hopefully, occurs in the soil. You must give the soils a chance to break down graywater solids. You can do this by rotating graywater drainfields. While one works, the other dries and treats graywater solids and nutrients. If you do *not* use two drainfields, you must treat the graywater as shown in **Figure B** or use a filter. This will avoid frustrating back-ups and odors.

You can have the best of both worlds by installing a pre-filter in your surge tank (**Figures A and C**). If you use an in-take filter you must clean it (once every two weeks during heavy use periods). If you are someone who doesn't like maintenance, then avoid filtering.

Surge tanks feed the subirrigation drainfields. The graywater can flow by itself to the drainfields (gravity-fed) or can be pumped. If the slopes and distances are favorable, gravity-fed surge tanks are much easier to install and maintain than surge tanks with a sump pump. Sump pumps are necessary on:

- hilly sites;
- when the washing machine pump is not strong enough to pump the graywater uphill;
- when you need to lift your graywater to the area that you want to irrigate;
- when the landscape you want to irrigate is level with the surge tank but more than 20 feet away;
- when you want to drip irrigate.

This handbook will first present the purchase and installation of the surge tank without a sump pump, then a surge tank with a sump pump. For washing machines requiring pumping, a simple sump pump is all that is needed (described below and in **Handbook 5**). For larger systems, uphill irrigation or drip irrigation, you must choose between a sump pump, a centrifugal pump and an Orenco pump (**Handbook** 8).

BUYING A SURGE TANK

For surge tanks with or without pumps, the process of choosing the actual tank is the same. Buy heavy-weight, rigid plastic, polyethylene or fiberglass drums. The surge tank is usually a 55-gallon plastic, polyethylene or fiberglass drum, with a full-

head, locking-ring lid. The best quality drums are made for the transport of hazardous waste. These should obviously be purchased new, not recycled. These high-density, high-molecular weight polyethylene drums will have embossed markings such as a DOT 21C/E-7768 rating or the equivalent.

Make sure you buy a drum with sides as straight as possible, especially where the sides meet the bottom. Many drums have two or more convex bulges, like fake barrel bands, around their circumference and pronounced curves at the top and bottom of the drum. The manual and automatic overflow outlet pipes can't be attached through a curved area. The manual draindown pipe must be installed above the curved wall. If the curve is large enough, there will be a considerable amount of standing graywater in the drum at all times which may turn septic and smell awful.

When possible, purchase a drum with a flat or partially-flat bottom. Many drums have bulging bottoms which make it somewhat difficult to position the sump pump level and secure. If you're planning to drain graywater out the bottom with a gravity system, a flat bottom is essential.

Avoid drums with narrow openings and buy one with a full-head lid as wide as the drum or with a lid as wide as possible. A wide lid is important for more ready access during construction and during routine maintenance and cleaning. The best drums have a full-head lid with a locking-ring clamp so the top can be locked against wayward kids and wild animals.

Warning: Do not buy an uncoated metal drum unless it's stainless steel. Do not use metal or plastic garbage cans for above-ground surge tanks because they will either rust or bulge and possibly split open.

Buying a Used Surge Tank

Many people make their tank from a used, recycled barrel or drum. As admirable as this may be, there are potential risks. For a safe, properly-functioning tank, consider all the design factors described above for a used tank. Buy only tanks or drums which were previously used to store food, food-grade products, water or consumable liquids. Avoid drums used for petroleum-based products. Clean the drum thoroughly and air-dry before installation.

Stabilizing Surge Tanks

All surge tanks must be strapped to prevent spillage during earthquakes. Follow the same guidelines as provided for water heater tanks: When the surge tank is on a firm floor or pad and next to a wall, secure the tank with metal plumber's tape around the tank's circumference and as high on the tank as practical. Bolt directly to the wall's structural members with lag screws. When the surge tank is not on a pad but on a platform, secure the tank with metal plumber's tape at two points around the tank's circumference, as high on the tank as possible and one-fourth of the height of the tank above the platform. Again, use lag screws to secure the plumber's tape to a structural member. If the surge tank is not next to a wall, install a wooden 4X4 support between two structural members and secure the tank with plumber's tape.

After the Surge Tank

After the surge tank, a series of two or more manual or automatic valves can control the application of the graywater to various portions or zones of the landscape (**Figure D**). For the sake of the plant's health and to prevent clogging, the graywater must be alternated between two or more separate zones. This rotation allows a resting time so the soil's pores can drain and breathe in fresh air (**Handbooks 7** or **8**).

CONSTRUCTING YOUR OWN GRAVITY-FED SURGE TANK WITHOUT A SUMP PUMP

If the slopes, distances, and piping from your home are appropriate, a gravity-fed graywater system is much easier to install than one with a sump pump. The process of choosing a drum is identical, the materials list varies slightly and the process is streamlined.

> **Materials Lingo**
>
> In plumbing lingo, an "X" doesn't mean multiplication, it stands for "to be attached to." For example, "fipt X slip" stands for "a female iron pipe thread to be attached to a slip-and-glued fitting."

Materials List:

1 Tank, usually a 55-gallon plastic, polyethelyne or fiberglass drum, with a full-head, locking-ring lid.

Parts for Downdrain and Overflow Assembly:

2 Tank nipples with slip (glued) female fittings. Match the ABS pipe's diameter (1.5 to 2 inches).

2 ABS male adapters to match the tank nipples above (mipt X slip).

1 ABS tee (sized to graywater outlet and overflow pipes).

1 ABS elbow (sized to graywater outlet and overflow pipes).

1 Sewage check valve (sized to graywater outlet and overflow pipes). Option: appropriate mipt X slip ABS fittings if the check valve has fipt openings.

Tools and Helpers:

1 Hole saw, about 1/8 inch greater in diameter than outside diameter ABS pipe. For example; for 2 inch ABS pipe, a 2 1/2 inch diameter bi-metal hole saw hole drill bit is required (the kind that cuts a hole with a circular saw blade).

1 Electric drill, chuck key and electric extension cord.

1 Small can of ABS glue.

1 Small can of ABS-to-PVC glue.

1 Can or roll of Teflon™ paste or tape sealant.

1 Pair of latex solvent-resistant gloves to protect your hands from the toxic polyvinyl chloride (PVC) solvents in the glues.

Sandpaper to smooth cut ABS pipe.

Some rags to clean the pipe before gluing.

CONSTRUCTING THE GRAVITY-FED SURGE TANK (Figure A)

Step 1

Locate and drill a hole for the ABS graywater inlet pipe. The hole should be as high on the drum's side as possible, but beneath the lip of the closed lid and lower than the vent outlet. This hole doesn't have to be water-tight because it is above all other holes, including the automatic overflow pipe. (No tank nipple is needed.) To keep out insects, the hole should be close to the outside diameter of the inlet pipe. For instance, for a 2 inch ABS pipe, use a 2 1/2 inch bi-metal hole saw. (After the tank is installed, use a piece of fiberglass insulation fiber or some other waterproof wrapping to plug the gap around the ABS pipe.)

Step 2

Locate and drill the manual draindown hole. This hole must be as close to the bottom of the drum as possible, but still on a flat, not curved, surface of the drum's wall. The hole through the drum's wall should be as close as possible to the outside diameter of the threads of the mipt nipple. For instance, for a 2 inch tank nipple, a 3 1/2 inch bi-metal hole saw drill bit is required. File or sand the hole smooth to eliminate all burrs.

> **Tank Nipples**
>
> There are a number of less costly ways to get through the drum's wall compared to plumbing nipples, but most end up leaking and require tedious repair. There are many types of tank nipples. Two common types use attachments by (1) screwing threaded parts, or (2) gluing parts that slip together. The most common type with threads has three main parts: the body with a male iron pipe thread (mipt), the locknut with female threads inside it (fipt), and a gasket which sits against the shoulder (**Figure E**). The non-thread types (**Figure F**) require a firm sliding of parts together with glue. A 2 inch tank nipple will cost $20 to $25.

Step 3

Add a tank nipple to the draindown port. Place the tank nipple's body and gasket inside the surge tank. Push the nipple through the hole in the surge tank wall. Attach the lock nut.

Note: For thread-type tank, tighten snugly with a pipe wrench (but not too tight), then screw in the adapter for a 1 1/2 inch or 2 inch ABS pipe.

Note: For slip-type fitting, the ABS pipe is simply pushed and glued into the tank nipple.

Test the surge tank by filling the drum half full with potable water. (Hand fit a slip cap on a length of ABS pipe. Press the uncapped end into the slip end of the male adapter to temporarily seal the outlet—do not glue!)

If the tank nipple leaks, drain the drum, remove the lock nut, pull the tank nipple back into the drum, dry all surfaces around the hole, reinsert the nipple, add a 1/4 inch bead of silicon rubber caulk to the inner third of the flat side of the body's shoulder which will seat against the drum's wall. Tighten till snug, not tight. Test with water again.

Step 4

Locate and drill a hole for the automatic overflow pipe. The top of this hole should be 4 to 6 inches below the bottom level of the graywater inlet. Note that this overflow port is in a line directly above the draindown port.

Step 5

Install a tank nipple at the automatic overflow port. Follow the directions for Step 3. You'll have to fill the drum higher to test this tank nipple's seal.

Step 6

Glue the draindown pipe to the manual draindown ball valve. Use a custom-cut length of ABS pipe and a coupler. Be sure to use the special glue made to join ABS to PVC parts to join the draindown valve to the tee.

Step 7

Glue the automatic overflow pipe to the draindown pipe and the manual draindown ball valve. Use ABS glue only to join the ABS pipes to connect the elbow and the tee. Use ABS-to-PVC glue to join the pipe to the tank nipple and to the ball valve.

Step 8

Place surge tank in its final, level position. It must be on firm, level ground or on a platform. Now that the drum is plumbed and installed, it becomes an official "surge tank."

Step 9

Glue a coupler and a length of ABS pipe to the graywater outlet port of the ball valve and adapt to the appropriate pipe and fittings to get the graywater to the landscape.

Step 10

Install the one-way sewage check valve. You will need to cut into the 4 inch blackwater pipe at some point lower than the bottom of the surge tank, the lower and more downstream, the better.

Use the appropriate fittings to connect the surge tank's drain pipe to the sewer or septic. You can buy a single 4 inch tee with a 2 inch or 1 1/2 inch inlet port to make the conversion easier.

Warning: Be sure to thoroughly wash yourself and your tools after working with the blackline.

Note: make sure <u>no</u> fixtures are going to be used or automatically discharge (washing machines) while you're working on the blackline, or it'll be a day you'll <u>never</u> forget!

Note: If you cannot divert graywater back to the septic tank because of complex plumbing or slopes, you must use two holding tanks (**Figure B**).

Step 11

Test the graywater surge tank and system with potable water.

Step 12

Reward yourself for a job well done.

CONSTRUCTING A SURGE TANK WITH A SUMP PUMP (Figure G)

Sump Pumps

As mentioned in **Handbook 3**, sump pumps are designed to be submerged in water and to automatically turn on when the water reaches a predetermined level. Each pump has the capacity for moving the graywater a maximum height and distance—measured as the head (the vertical lift) and the run (the horizontal length). The flow rate of each sump pump is rated in gallons-per-minute (gpm) or gallons-per-hour (gph).

Warning: The pump must be wired with grounded direct-burial wire to a ground-fault-interrupt outlet located inside the house or nearest building. All electrical work must be done by an electrical contractor and meet UBC guidelines.

Warning: The sump pump must be rated for water heated up to 130° F.

- Sump pumps are the most convenient pumps for homeowners to install. These pumps are waterproof and designed to prevent electrical shock.
- Sump pumps are basically designed to evacuate a large amount of water as quickly as possible. Sump pumps can move lots of water in a short period of time, but they often can't lift the water very high (they have a low head). To lift wastewater read about other kinds of pumps for drip and larger graywater systems (see **Handbook 8**).
- You should set the float control on the sump pump to drain the tank to as close to empty as possible. The less graywater left to turn septic in the surge tank, the fewer pungent odors there will be. Sump pumps with intakes above the pump's "legs" are not allowed because they sit too far off the bottom of the tank.

- All sump pumps must be constructed primarily of metal parts and have metal housing. (Plastic-bodied pumps often must have 4 or more inches of standing water at all times to keep the pump from overheating.) The slotted or perforated grate for the intake of the graywater and the impeller which ejects the water out through the pump may be plastic.
- Sump pumps have one of two types of automatic switches for level control: a round or cylindrical mercury-float switch tethered to an electrical cord or a vertical path float switch with a float that slides up-and-down a vertical pin passing through a vertical channel in the float. With a mercury-float switch, make sure the tether doesn't get caught on any of the pipes or pump.
- Washing machines upstream from a sump pump may require overflow protection to prevent a clogged line from burning out the motor (see **Handbook 5** and **Figure A**).
- The vertical pipe from the sump pump should be as large as the pipe or tubing from the washing machine.

Choosing the Right Sump Pump

The horse-power rating of the pump is the least important specification. The important pump ratings are the head (in feet) and the flow rate in gallons-per-minute (gpm) or gallons-per-hour (gph.) To choose the right sump pump for uphill pumping, you'll need to know the desired head (see **Chart** on facing page).

Typically, the head is the gross difference in elevation. As a safety factor, the head for a graywater system is determined by adding the total changes in the elevation, both up and down, from the surge tank to the point of dispersal. Don't expect your pump to last long if it's always pumping at the uppermost limit of its rated capacity. To the head add at least 15% more feet for a measure of protection. (In other words, if the total change in the elevation from the tank to the uphill shallow leachfields is 13 feet then the sump pump must be rated at least a 15 foot head.)

You should verify how much water can be pumped at the required head from the manufacturer's chart of lift vs. flow rates. Many pumps can discharge a huge volume of water when the point of release is just a foot or two higher than the pump, but the gpm drop off rapidly with increased elevation.

Washing machines discharge a lot of water very quickly. To prevent losing graywater via the surge tank's overflow port, make sure the sump pump can discharge enough graywater at your required elevation to keep up with the maximum discharge (in gpm) of the washing machine, or make sure the surge tank is large enough to hold the peak flow.

CONSTRUCTING A SURGE TANK WITH SUMP PUMP

Materials List:

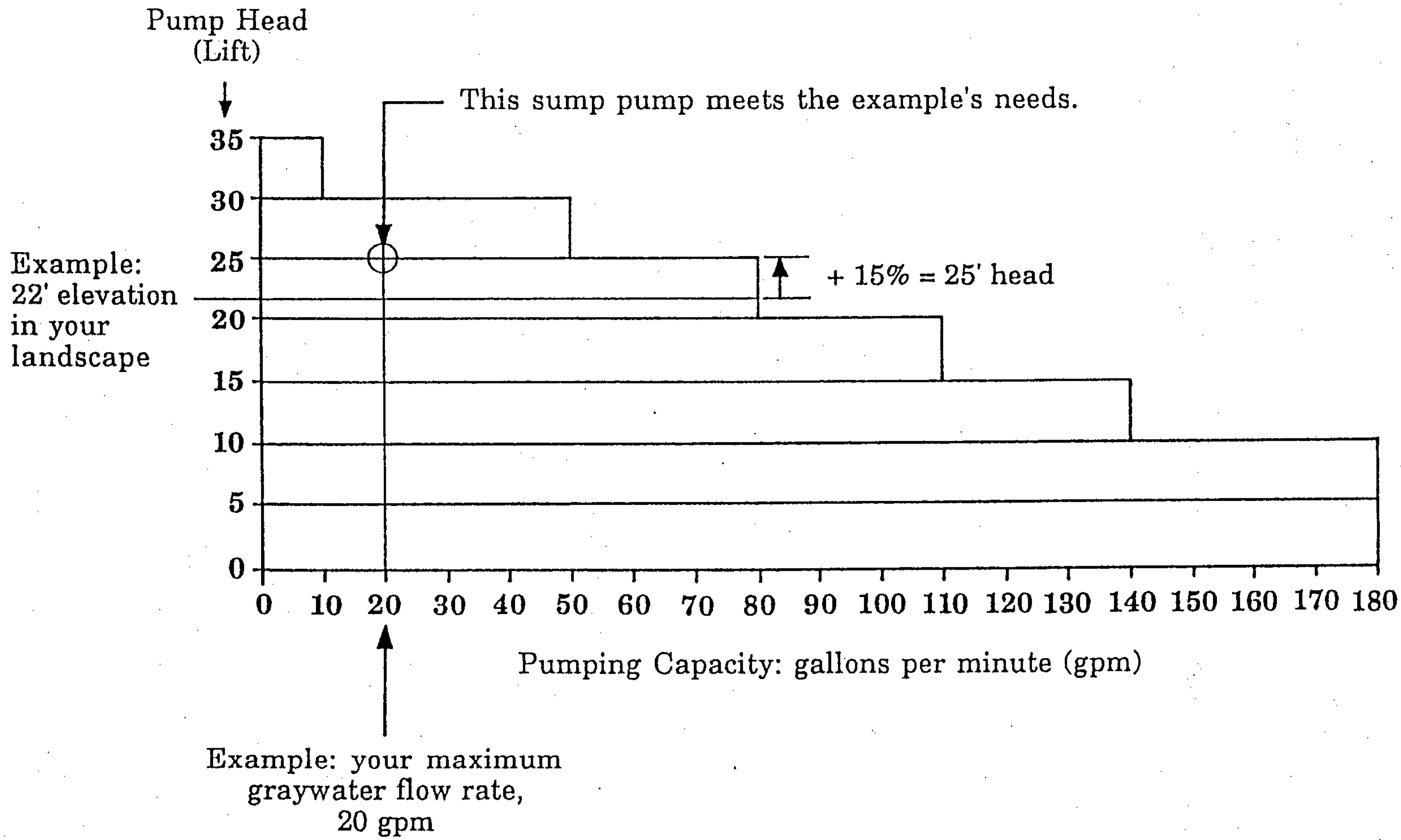
1 Tank, usually a 55-gallon plastic, polyethylene or fiberglass drum, with a full-head, locking-ring lid (see "Buying a Surge Tank").

1 Sump pump with float switch, with no legs or short legs and a waterproof electric cord.

For overflow and draindown assembly:

1 ABS cap (sized to match draindown pipe; used to test water-holdng abilities of surge tank; usually a slip attachment).

Selecting a Sump Pump



2 Tank nipples with slip (glued) female fittings. Match to ABS pipe's diameter, usually 1 1/2 to 2 inches.

2 ABS male adapters to match the tank nipples (mipt X slip).

1 ABS tee (sized to match the graywater outlet and overflow pipes diameter).

1 ABS elbow (sized to match the graywater outlet and overflow pipes diameters).

1 PVC manual or automatic draindown valve (ball-valve) with female slip openings to match the ABS pipe size.

1 Sewage check valve to match the graywater outlet and overflow pipes. (Plus appropriate mipt X slip ABS fittings if the check valve has fipt openings.)

Tee with 4 inch pipe and 1 1/2 inch to 2 inch inlet port for connection of draindown pipe and overflow to sewer.

For discharge from pump to drainfield:

1 Length of ABS pipe (sized to match graywater outlet pipe and discharge from sump pump, probably 1 inch or 1 1/2 inch).

1 PVC one-way check valve, sized to match the diameter of the sump pump discharge pipe (fipt X fipt).

1 Nipple (Schedule 80) sized to match outlet port of pump (often 1 inch or 1 1/2 inches). Select a nipple—with male iron pipe threads (mipt) on both ends—long enough to reach from the pump's outlet port to 2 or 3 inches below the lid on the drum's wall.

1 Union (Schedule 80) with female iron pipe threads (fipt), sized to match the pump nipple's diameter.

1 Elbow (Schedule 80) with fipt to match pump's outlet nipple.

1 Close nipple, 3/4 inch long.

1 Nipple (Schedule 80), 8 inch.

1 Male adapter (Schedule 80, mipt X s), 1 inch or 1 1/2 inch.

1 Male adapter (Schedule 40, mipt X s), 1 inch or 1 1/2 inch to be attached to check valve.

Tee with 4 inch pipe and 1 1/2 inch to 2 inch inlet port for connection of draindown pipe and overflow to sewer.

Tools and Helpers

1 Hole saw, the kind of drill that cuts a hole with a circular saw blade. Sized about 1/8 inch greater in outside diameter than the outside diameter of the ABS pipe. For example, for 2 inch ABS pipe, a 2 1/2 inch diameter bimetal hole saw is required.

1 1/2 inch screw machine-steel drill bit.

1 Electric drill, chuck key and electric extension cord.

1 Fine-toothed hand, key-hole or miter saw.

1 Small can of ABS glue.

1 Small can of ABS-to-PVC glue.

1 Can or roll of Teflon™ paste or tape sealant.

1 Pair of latex solvent-resistant gloves to protect your hands from the toxic poly-vinyl chloride (PVC) solvents in the glues.

Sandpaper to smooth cut ABS pipe.

Some rags to clean the pipe before gluing.

Reminders

Note: Do not use spring-loaded check valves. Use "flapper" check valves.

Note: Look carefully at the illustration in order to know the names of parts. See the glossary if you become confused.

Note: The float control(s) on the sump pump must be set to allow the pump to drain the tank as close to empty as possible—less than 1 inch. The less graywater left behind, the less chance of septic odors. Sump or sewage ejector pumps with intake ports above the pump's legs will not be allowed as they sit too far off the bottom of the tank.

The pump's intake openings (the impeller housing) must be as large as possible. They should be equal to or larger than the smallest internal opening in the rest of the graywater system (downstream), usually the holes in the perforated drain pipe. A vertically-slated impeller housing may be less likely to clog than perforated or mesh-type housing.

The pump's impeller should be able to pass spherical solids equal to at least half the diameter of the surge tank's graywater inlet pipe, or larger—the larger, the better.

The larger the diameter of the sump pump's discharge pipe, the safer your system will be. The discharge port must be at least a 1 inch pipe.

Note: Through the tank's wall, the discharge pipe must be PVC Schedule 80 pipe or iron pipe. (PVC pipe outside of the tank can be Schedule 40.)

Note: Repair or cleaning of the pump will be facilitated if the discharge pipe has a union somewhere between the check valve and the sump pump **(Figure G)**.

Note: The check valve going to your landscape must have the same diameter as the discharge pipe from the sump pump. This will prevent any water from siphoning back into the surge tank.

Note: Only use threaded fittings within the surge tank.

Construction Steps for the Pumped Surge Tank (Figure G)

Step 1

Locate and drill a hole for the graywater inlet pipe. The hole should be as high on the drum's side as possible, but beneath the lip of the closed lid and lower than the pump outlet pipe. This hole doesn't have to be water-tight (no tank nipple is needed) and is above all other holes, including the automatic overflow pipe. To keep out insects, the hole should be as close as possible to the outside diameter of the inlet pipe. For a 2 inch inlet pipe, use a 2 1/2 inch hole saw. After the tank is installed, use a piece of fiberglass insulation or some other waterproof wrapping to plug the gap around the inlet pipe to exclude insects.

Step 2

Locate and drill a hole for the exit of the sump pump's electrical cord, making sure the 1/2 inch screw machine steel drill bit is as wide, or wider, than the cord. Locate the hole opposite the graywater inlet pipe for an extra measure of electrical safety. Make sure the hole is lower than the closed lid, or the cord will be pinched. After drilling the hole, use a fine-toothed hand, key-hole or miter saw to cut straight down from the top of the rim to the outer edge of the hole to make a slot. Again, any gap around the cord should be stuffed with fiberglass insulation or other waterproof wrapping to exclude insects.

Step 3

Locate and drill the manual draindown hole. This hole must be as close to the bottom of the drum as possible, but still on a flat, not curved, surface of the drum's wall. The hole through the drum's wall should be as close as possible to the outside diameter of the threads of the mipt nipple. For a 2 inch tank nipple, a 3 1/2 inch bi-metal hole saw drill bit is required. File or sand the hole smooth to eliminate all burrs.

Step 4

Add a thread-type tank nipple to the draindown port. A tank nipple is required for a water-proof seal. Unthread the flange from the nipple. Place the nipple's flange, with gasket, inside the drum and out through the hole. Attach the fipt locking ring and tighten snugly, but not too tight, with a pipe wrench. Thread the male adapter to the tank nipple's fipt orifice. Use Teflon paste or tape sealant to seal the threads.

Test by filling the drum half-full with potable water. Hand fit the slip cap on a length of ABS pipe and press the other end into the slip end of the male adapter to temporarily seal the outlet—do not glue!

If the tank nipple leaks, drain the drum, remove the locking ring, pull the tank nipple back into the drum, dry all surfaces around the hole, reinsert the nipple, add a 1/4 inch bead of silicon rubber caulk to the inner third of the flat side of the shoulder which will seat against the drum's wall. Thread and tighten till snug, not tight, with a pipe wrench. Test with water again.

Step 5

Locate and drill a hole for the automatic overflow pipe. The top of this hole should be 4 to 6 inches below the bottom of the graywater inlet pipe. This allows for a surge area above the overflow. Follow the drilling directions in Step 3.

Step 6

Install a tank nipple at the automatic overflow port. Follow the directions in Step 4. You'll have to fill the drum higher to test this tank nipple's seal.

Step 7

Glue the manual draindown valve to the draindown port. Use custom-cut lengths of ABS pipe to join the male adapter to the ball valve and to the tee. Be sure to use the special glue which is made to join ABS-to-PVC plastic parts.

Step 8

Glue the automatic overflow port to the elbow and tee connecting to the ball valve and draindown port. Use ABS glue only to join the pipe from the male adapter to the elbow and then to the tee. Depending on the site, you may have to customize the tee connection or the turns of the pipe after the tee.

Step 9

Locate the sump pump discharge hole. The pump discharge hole does not need to be sealed. It must higher than both the automatic overflow pipe and the graywater inlet pipe, but lower than the power cord outlet slot. To locate the hole, you must first pre-assemble the pump's discharge assembly to make sure everything is at the proper level.

Step 10

Precut the sump pump discharge assembly. Thread the Schedule 80 nipple into the sump pump. Hand thread the 8 inch nipple into the fipt elbow. Use the close nipple (the stubby or short-end) to join the elbow to the union. Add the male adapter to the bottom of the union, then hold this assembly inside the drum at the level where you expect the pipe to pass through the wall. Mark the pump's discharge nipple where it will insert into the male adapter. Now mark the drum's wall for the exit hole.

Step 11

Drill the sump pump discharge hole. Use the appropriate bi-metal hole saw to leave little space around the discharge pipe. Sand any burrs.

Step 12

Install the sump pump with discharge pipe. Use Teflon paste or tape to seal the nipple's threads when attaching to the pump. Tighten with a pipe wrench. Thread the male adapter to the union so that the flange with the O-ring will be facing up. Thread the close nipple and the elbow to the top of the union. Use a pipe wrench to tighten these parts.

Insert the 8 inch nipple through the drum's wall and thread into the elbow. Tighten. Use a PVC glue rated for Schedule 80 pipe to join the male adapter on the bottom of the union to the pump's nipple. Rotate back and forth slightly while the glue is wet to insure a good glue joint.

Step 13

Add the check-valve to the 8 inch nipple. Using a sealant, thread the check-valve onto the end of the 8-inch nipple. Add a Schedule 40 male adapter (with sealant) to the other end of the check-valve. Tighten all three fittings with a pipe wrench. Fill in any gaps around the discharge pipe with insulation to eliminate insects.

Note: Make sure the arrow on the check-valve faces toward the landscape to be irrigated and away from the drum.

Step 14

Place surge tank in its final, level position. It must be on firm, level ground or on a platform. Sometimes it is easier to place the sump pump inside the drum after it is installed in its final working position. Now that the drum is plumbed and installed, it becomes an official "surge tank."

Step 15

Glue the check valve's Schedule 40 male adapter to appropriate pipe and fittings to get the graywater to the landscape.

Step 16

Install the one-way sewage check valve to the draindown pipe. You will need to cut into the 4 inch blackwater pipe at some point lower than the bottom of the surge tank—the lower and more downstream, the better.

Note: Make sure no fixtures are going to be used or automatically discharge (washing machines) while you're working on the blackline, or it'll be a day you'll never forget!

Note: When connecting the draindown pipe to the sewer, use the appropriate fittings. You can buy a single 4 inch tee with a 1 1/2 inch or 2 inch inlet port to make the conversion easier.

Step 17

Test the graywater surge tank and system with potable water. Check to make sure the float switch on the sump pump doesn't get hung up on anything in the tank. Also, adjust float switch to drain the tank to as close to empty as possible.

Step 18

Reward yourself for a job well done and a graywater that's good for the environment and your plants.

A Gravity Surge Tank

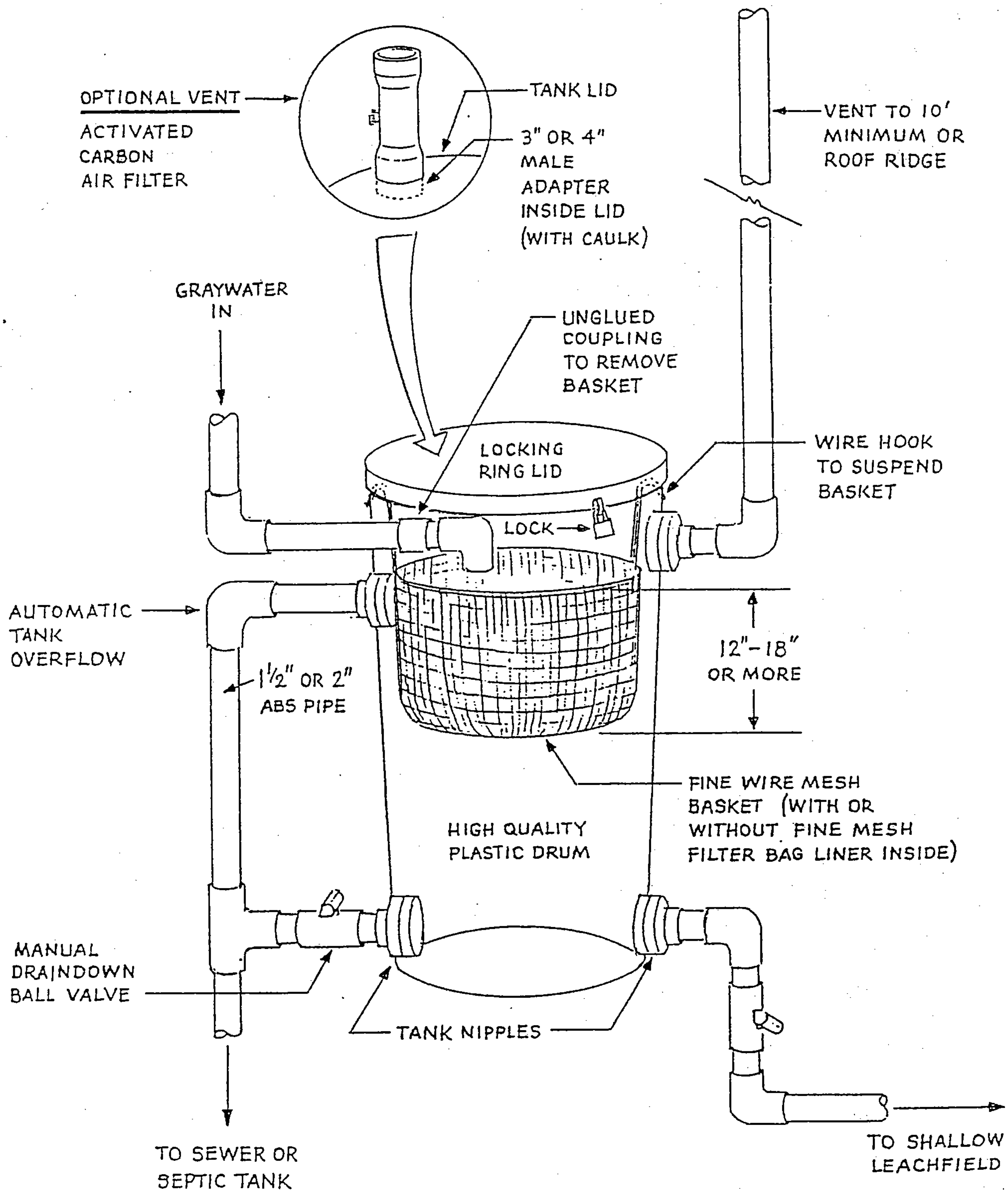
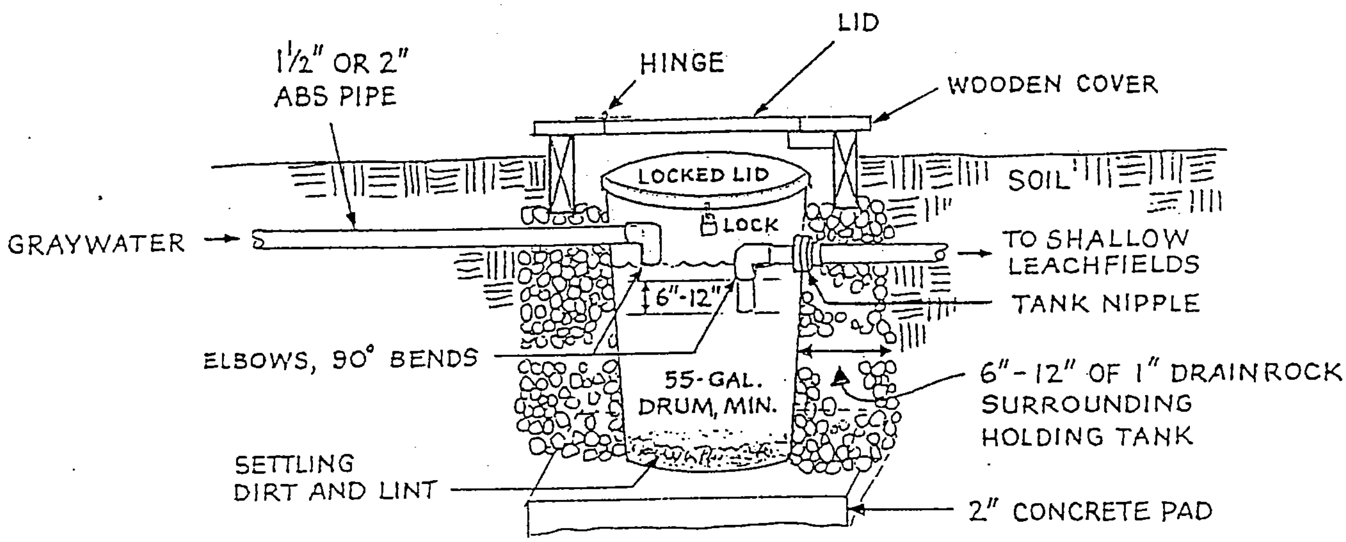


FIGURE A

Near Surface Holding Tanks

NOTE: VENTING NOT SHOWN

ONE TANK



TWO TANKS

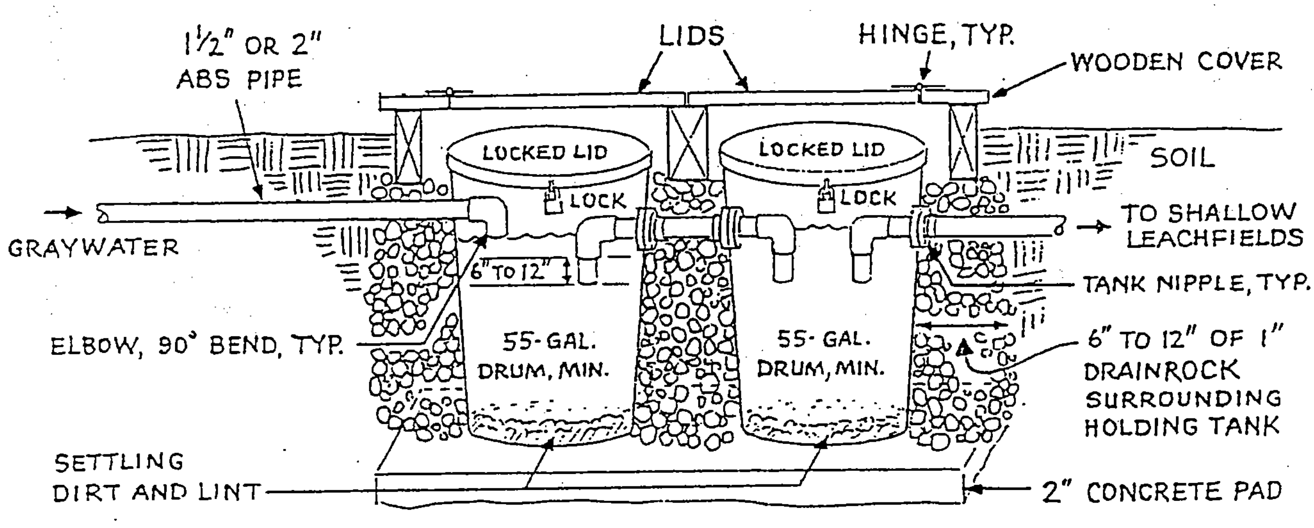


FIGURE B

Two Simple Graywater System Pre-Filters

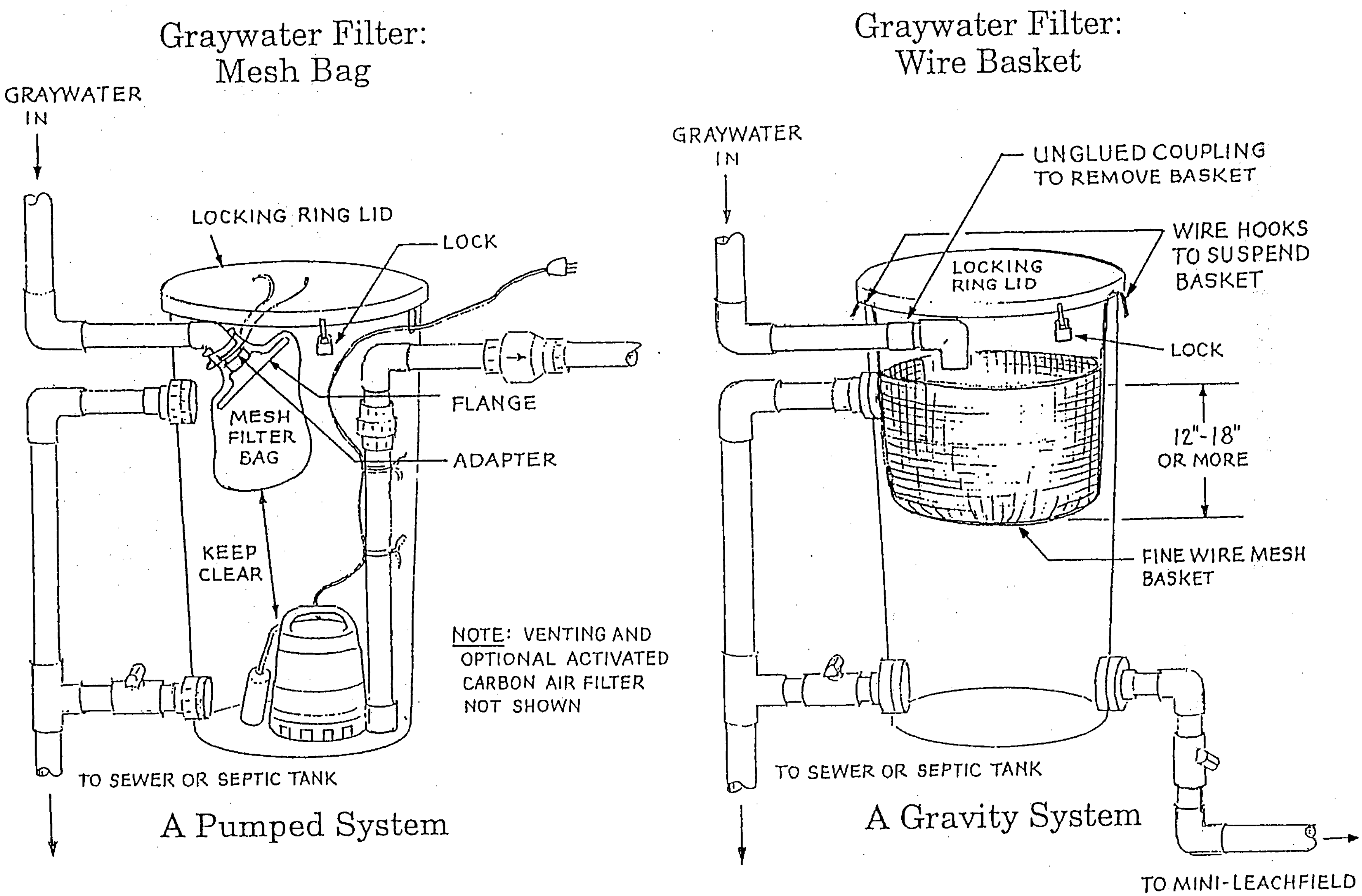


FIGURE C

A Simple Gravity Disposal Graywater System

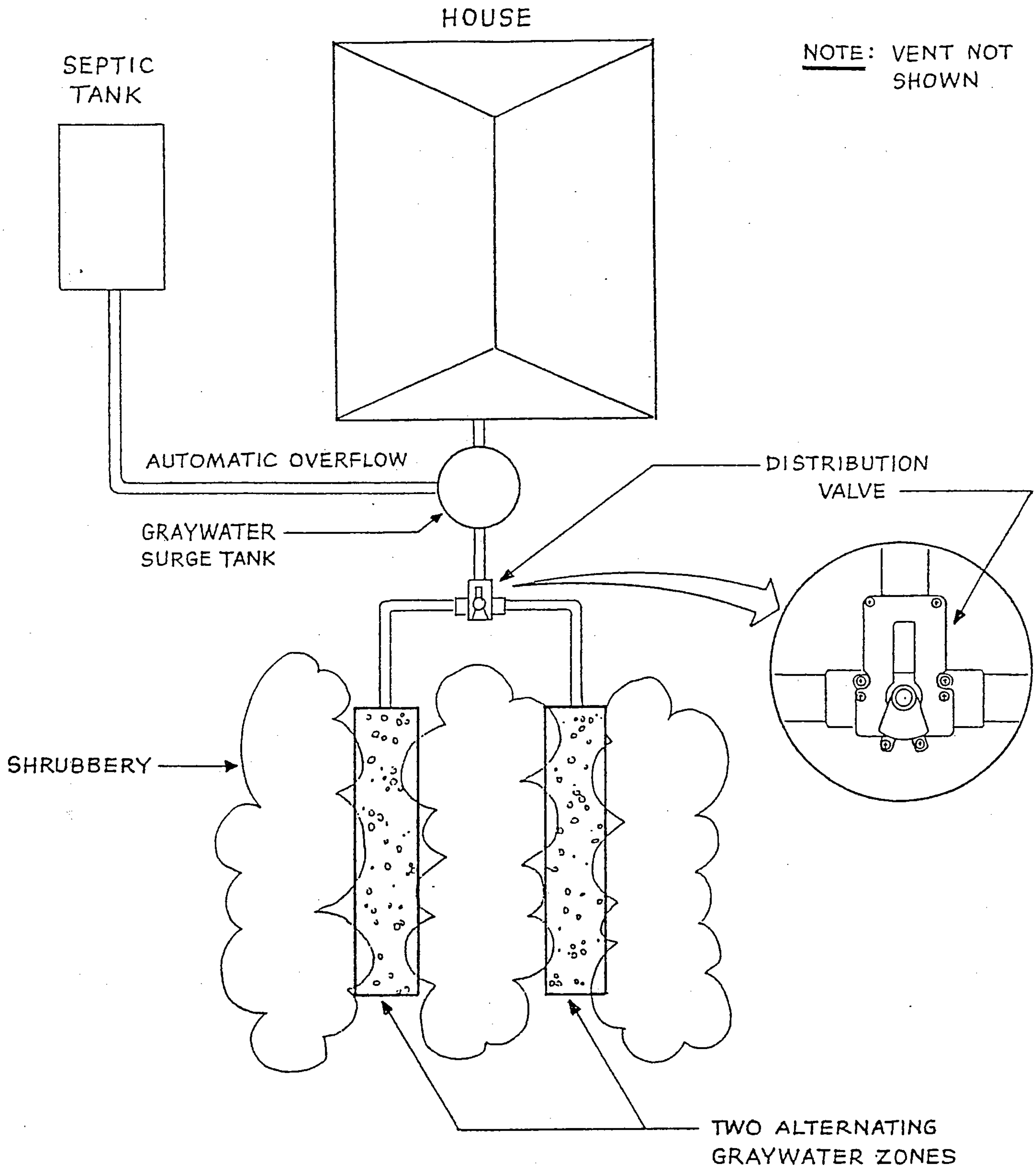
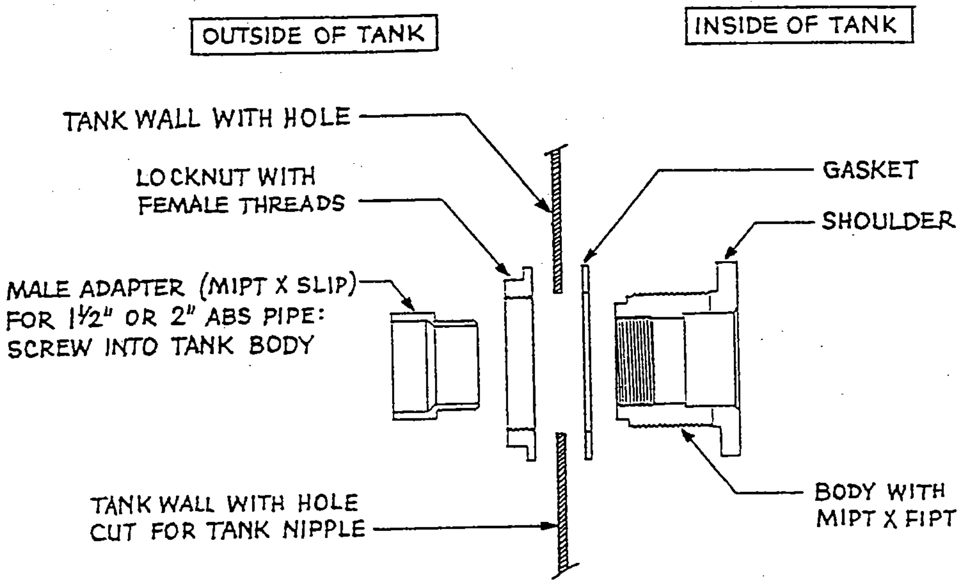


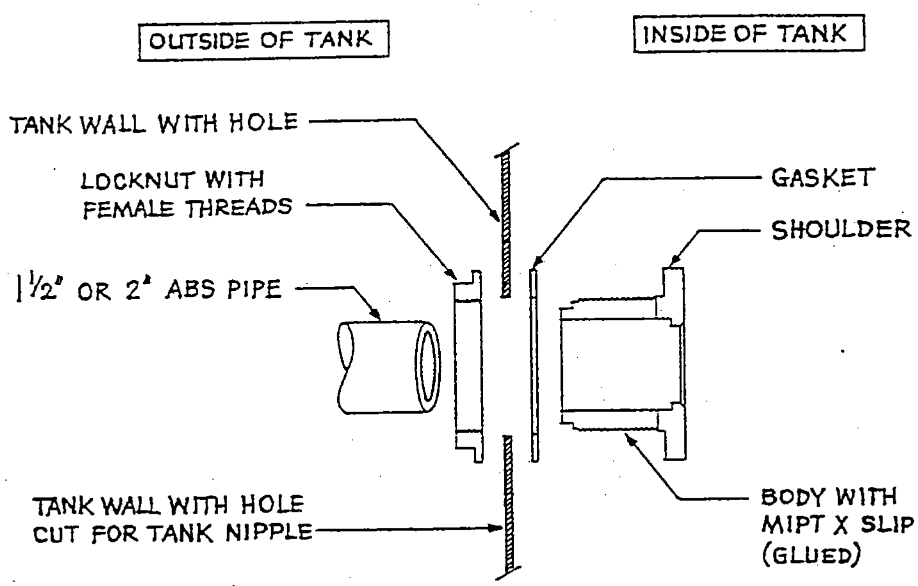
FIGURE D

Tank Nipple — Threaded Detail



1½" OR 2"
TANK NIPPLE
WITH FEMALE THREADS

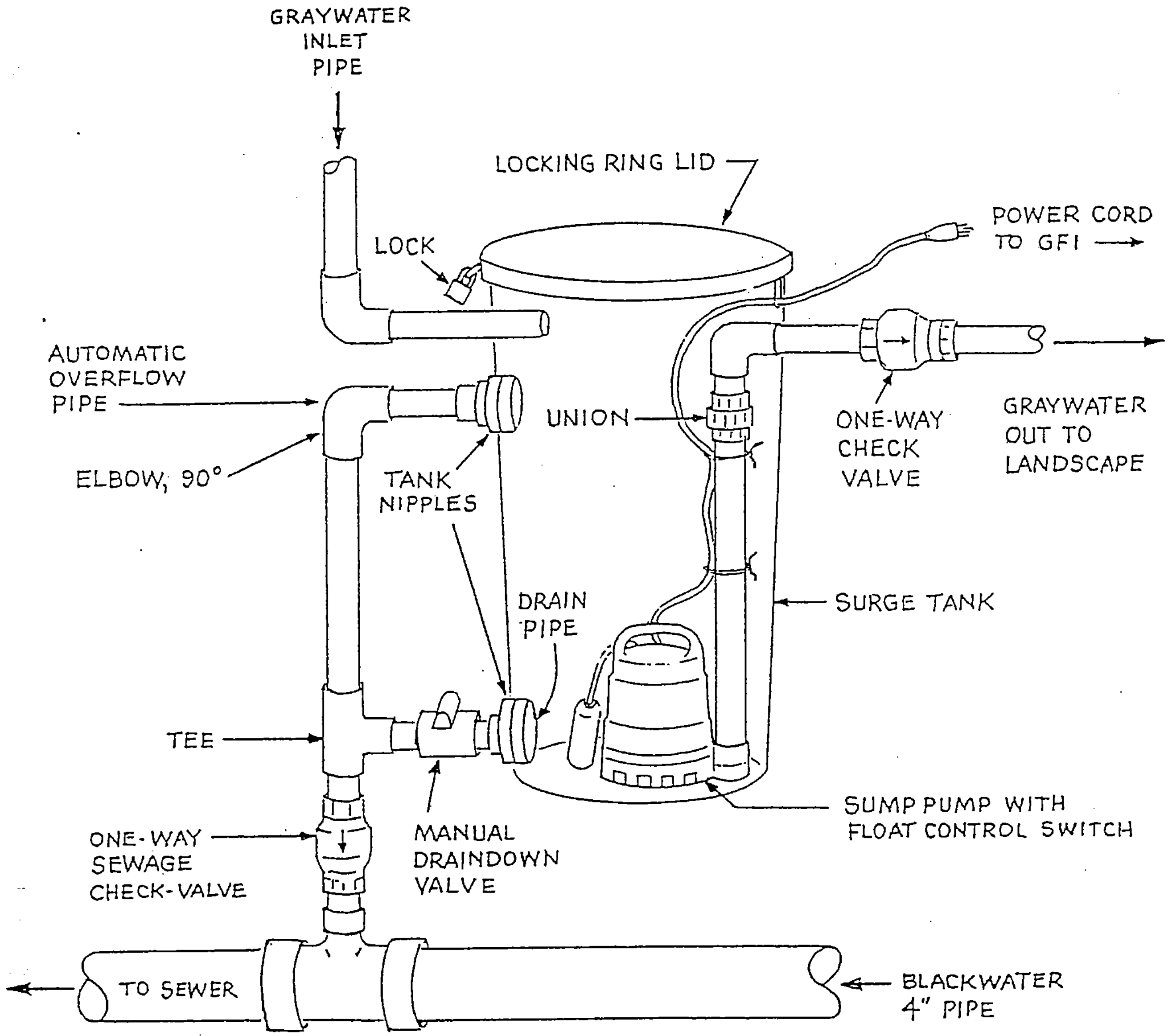
Tank Nipple — Slip-Fitting Detail



1½" OR 2"
TANK NIPPLE
WITH FEMALE SLIP

FIGURES E and F

Graywater Surge Tank with a Sump Pump



NOTE: VENT AND OPTIONAL ACTIVATED CARBON AIR FILTER NOT SHOWN

FIGURE G

Handbook #7
IRRIGATION SYSTEMS USING GRAVITY

Introduction

This handbook covers the mulched watering moat, the mini-leachfield with flower pot inlets, and the gravel-filled leachfield as well as providing a description of soil characteristics accepted by the City.

- For sump pumps and drip irrigation systems, see **Handbooks 7 and 8.**
- For a washing machine only system, see **Handbook 5.**
- For beachsand drainfields, see **Handbook 9.**
- For soil test for single-fixture graywater systems, see **Handbook 5.**

MULCHED WATERING MOAT

Note: The mulched watering moat is for small volumes of graywater such as the washing machine alone or a single bathtub and is only allowed for single fixture uses. It requires monthly attention, a compost pile or inaccessible area on your property, and renewed purchases of mulch. You will need to sign a statement that you will be responsible for maintenance and fill out the City's permit form. Moats are not allowed in sand and sandy loams as the sidewalls collapse.

Materials

- A fixed pipe or a dedicated hose with a minimal diameter of 3/4 inch.
- A surge tank or holding tank as described in **Handbook 6.**
- A renewable supply of bark/chips.

Design

- You must design for two moats of equal size and alternate use of moats to meet irrigation schedule and prevent soil clogging.
- The surge tank or holding tank should be designed as outlined in **Handbook 6.**
- Calculate the average amount of daily graywater to be generated from **Handbook 3.**
- The depth of the moat must be at least 18 inches deep in the middle.
- The moat must have sloped sides to prevent the collapse or erosion of soil into the moat. The depth should always be greater than the sloped sides (**Figure A**).

Size of the Moat

The most conservative approach is to assume 1 gallon of graywater requires 4 square feet of moat sidewall. All clay loams, silty clays and clay soils require 4 sq ft per gallon. The sidewall can be calculated as follows:

Sidewall req'd = vol. of graywater X 4 = __ sq ft.

For loams (remember, moats will not work in sands), assume 1 gallon of graywater requires 2.5 square feet of moat sidewall. Calculate as follows:

Sidewall req'd = vol. of graywater X 2.5 = __ sq ft.

The length of each moat can be calculated by:

Running feet of moat = total sidewall req'd/2 X trench depth.

Note: Trench depth is measured from bottom of pipe to bottom of moat.

Construction/Installation

- Each moat must be on level ground, sloping no more than 1 inch in every 10 feet.
- If you draw an imaginary circle around a tree with a circumference approximating the dripline, the moat can be placed anywhere between an inner circle with a radius two-thirds the distance from trunk-to-dripline and an outer circle with a radius one and one-half the distance from trunk-to-dripline (**Figure B**). Moats between these "circles" will best irrigate the roots.
- The solid hose must be buried from the house to the moat and as it passes through the berm.
- The top of each moat must have a berm which is 6 inches above the existing grade, or higher. (Soil excavated to make the moat can be used for the berm.)
- The moat must be filled to the top of the berms with either pebble-bark or wood chips. (The larger and "chunkier" the mulch, the better because there will be more cavities for the graywater.)
- The mulch level must be maintained to the top of the berms at all times and the graywater pipe must be at least 9 inches below the surface of the mulch.

O & M

- As the mulch decomposes, remove the rotted material with a shovel and bury it or add it to an active compost pile. If possible, lift the graywater pipe and remove all the mulch. If the sidewalls have collapsed, reshape them with a deeper bottom and longer side slopes. Raking the side slopes may open up clogged spots in the soil.

Note: Allow moat to completely dry out before removing mulch.

GRAVEL MINI-LEACH PITS WITH FLOWER POT "EMITTERS"

Note: Flower-pot emitters are best for homeowners who have a specific tree or group of trees that they wish to irrigate with graywater. The submission of a graywater permit is required, including how soil type was determined. Flower-pot emitters require switching the flow of graywater to maintain soils and proper irrigation (**Figure C**).

Materials

- Gravel (1 inch minimum diameter round river rock), flower pots, 3/4 inch hose or pvc, ball valves, compression couplings (optional), filter fabric (geotextile).
- Either buried rigid PVC pipe or dedicated garden hoses can be used to deliver the graywater to each mini-leach pit.
- Each mini-leach pit must have an individual inexpensive drip irrigation ball valve to regulate the flow of graywater on slopes and long runs.
- The upside-down flower pot may be of any plastic or clay material, and be any similar hollow vessel.

Design

- The surge tank or holding tank should be designed as illustrated and described in **Handbook 6.**
- At least two separate mini-leach pits with an equal number of cubic inches of gravel are required. The total volume can be divided by any number of mini-leach pits to disperse the graywater for landscaping.
- Calculate the amount of graywater from **Handbook 4.**

Size of the Mini-Leach Pits

The amount of sidewall of the mini-leachfield is 4 square feet of sidewall times the amount of daily graywater. This provides for 4 square feet of soil to absorb every gallon of graywater. This is a requirement for clay and silt soils. If you want to avoid testing the soil, you may use this calculation.

Sandy and Sandy Loam Soils:

- The amount of sidewall area for the mini-leachfield is 2.5 square feet of sidewall times the amount of graywater. This provides for 2.5 square feet of soil to absorb every gallon of graywater.
- For single fixtures, a soil can be determined by homeowner (see **Handbook 5**). For two fixtures, the City Health Specialist may allow the homeowner test. For more than two fixtures, a professional soils analysis is required. The Natural Resources Conservation District (formerly the Soil Conservation Service) may perform this analysis for you if you bring them proper samples.
- The leach pit holes can be of any dimension. Sidewall areas (narrow and deeper) are preferred because the bottom of the pit clogs quickly. The sidewalls of each set of mini-leachfields must total your total sidewall requirements. For instance, if you have a graywater discharge of 75 gpd and you choose the conservative method, then you need 4 X75, or 300 square feet, of sidewall for the mini-pits. This could become five or six mini-pits about 2 feet deep, 10 feet long and 2 feet wide. Don't worry about super-precision. Soils in Malibu vary so much that super-precision will not improve absorption of the wastewater, but make your estimates close.

Installation and Construction

- In digging the mini-pits, try not to break too many tree roots.
- If the sidewalls of the pit look slick or smeared, scrap them with a rake or another tool so they become rough.
- The ball-valve must not be buried and must remain readily accessible. You will need to adjust the individual ball-valve (**Figure C**) at each mini-leach pit to equalize the distribution of graywater to each zone.
- Insert the irrigation hose through the hole in the flower pot. Attach the compression coupling to the end of the hose. This will stop children from pulling the hose out of the flower pot.
- For aesthetic reasons, the top of the flower pot need not be above ground, just the ball-valve.
- The top of the gravel must be covered by at least 9 inches of soil, but can be deeper.
- To prevent the soil from silting-up the gravel below, a single sheet of filter fabric (geotextile) is required over the top of the gravel, with a hole cut out for the bottom of the flower pot (formerly the top).

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- Adjust ball valves to insure equal flow to all flower-pot emitters.
- Switch between the dual-leachfields to insure irrigation of both areas of plants and give the soil a rest.

SHALLOW LEACHFIELD

Note: Shallow leachfields work well when you have a straight line of plants needing irrigation. They require presentation of a completed form, including how you determined what type of soil you have. The shallow leachfields require switching from one subirrigation zone to another (**Figures D** and **E**).

Materials

- Diverter or switch valves.
- Rigid non-corrugated perforated drain pipe or slotted effluent pipe (3 inches in diameter).
- Minimum of 1.5 inch river rock.
- Filter fabric.
- Optional observation ports with 90 degree sweep.

Design

- Remember, there must be at least two separate shallow leachfield zones for safe disposal.
- At a minimum, each zone must be able to hold an entire day's graywater in the gravel leachfield.
- Be sure this design can meet all the setback requirements.
- Manual or electric ball-valves or diverter-valves must be installed to allow for convenient switching between zones.
- The only approved electrical valve for unfiltered graywater is a spa-type 2-way or 3-way swing-diverter valve with a 24VAC actuator. Install with no-hub connectors or an approved ABS-to-PVC glue.
- Each shallow leachfield must be installed topographically level, but a series of leachfields can be on different levels if connected by a special overflow design. On slopes, leachfields must run on the contour and be level (**Figure F**).
- The rigid, non-corrugated perforated PVC drain pipe must be no larger in diameter than 4 inches. Currently, the smallest diameter perforated drain pipe is 3 inches. Where the uniform irrigation of plants is the goal, a smaller diameter is preferred. Slotted effluent pipe starts at 1 1/2 inches in diameter.
- Use rigid PVC, non-corrugated perforated drain pipe or slotted effluent pipe, both with the holes or slots facing down (**Figure E**).
- While not required, it's recommended that the end of each leachfield have a sweep 90 degree fitting up to the soil's surface with a removable cap to be used as an observation port to monitor the field's performance and roto-root any roots that enter the pipe (**Figure E**).
- The solid pipe from the surge tank to each zone must be the same diameter as the pipe entering and leaving the surge tank.
- The smallest interior orifice of any distribution valve must be no smaller than the interior of the distribution pipe from the surge tank or pump.
- The leachfield trench must be at least 10 inches deep and 6 inches wide.
- Use 1 1/2 inch or greater diameter washed round river rock for the leachfield. Place at least 4 inches of the rock under the perforated drain pipe.
- The recommended maximum length of each zone, if you want to provide reasonably balanced irrigation to plants along a length of rigid 3 inch perforated pipe, is approximately 10-15 feet. A shallow leachfield longer than 10-15 feet may prevent equal distribution of the graywater along the leachfield's length.

To determine the total lineal footage of the shallow leachfield based upon its daily supply of graywater, assume the recommended gravel backfill has a void equal to 50% of its gross volume. Calculate the total peak gallons (greatest possible volume) of graywater generated per day. (Each gallon of water fills a volume of 231 cubic inches.)

Sizing the Mini-Leachfield

The length and shape of the mini-leachfield can be determined by either of two techniques: (1) calculating the volume of the leachfield required to hold a single day's above-average load of graywater; (2) calculating the amount of sidewall area of the mini-leachfield that can absorb a daily dosage of graywater. Either method is acceptable, but the City may require the more conservative size to be used.

By the Volume of the Leachfield

This method starts with the design of the mini-leachfield shape, its depth and width, for a typical foot-long length. You then calculate how much volume this typical foot-long length can hold and, knowing your daily volume, determine the total length required (**Figure G**).

For shallow rooted plants a typical depth is 8 inches below cover. For deeper rooted trees and shrubs, the depth must be 18 to 30 inches. The width should be no less than 6 inches (hard to dig that narrow) and no wider than 12 inches. The calculation is done in cubic inches because its easier.

- **Step 1:** Decide on the dimensions of your typical mini-trench.
- **Step 2:** Multiply for a typical foot-long section. Length X width X depth = volume of a typical foot-long section of your mini-trench. Remember: Do this all in inches so your answer is in cubic inches.
- **Step 3:** Divide. The volume (Step 2) ÷ 231 = the number of gallons in your typical foot-long mini-trench. The "231" is the number of cubic inches per gallon of water.
- **Step 4:** Divide again. The number of gallons in your mini-trench (Step 3) ÷ 2 = the holding capacity of the mini-trench after the drainrock has been added. Drainrock fills up half the space. This number is in gallons.
- **Step 5:** Divide one last time. The expected daily volume of graywater (**Handbook 4**) ÷ the holding capacity (Step 4) = the total length of mini-leachfield trench required.

Remember: You are required to have two rotating mini-leachfields of equal size in order to allow one to rest.

By the Soil Absorption Capacity

This technique starts with your determination of the kind of soils in your mini-leachfield. For single fixtures, a soil can be determined by homeowner (**Handbook 5**). For two fixtures, the City Health Specialist may allow the homeowner test. For more than two fixtures, a professional soils analysis is required. The Natural Resources Conservation District (formerly the Soil Conservation Service) may perform this analysis for you, if you bring them proper samples.

If the soil is clay or clayey or silty, you are required to provide 4 square feet of sidewall area for each gallon of graywater discharged daily. If you do not want to bother with the soil test, you may also use 4 square feet per gallon. If you anticipate using the graywater system through the winter rains, you might consider 4 square feet per gallon even with more permeable soils. The calculation is simple: Volume of graywater X 4 = total amount of sidewall required. The length of trench = sidewall ÷ 2.

If your soil is a loam then you are required to provide 2.5 square feet of sidewall area for each gallon of graywater produced daily. The calculation is simple: Daily volume of graywater X 2.5 = total amount of sidewall required. The length of trench = sidewall ÷ 2.

Remember that you are required to have two alternating mini-leachfields of equal size in order to allow one to rest.

Note: The bottom of the trenches do not count in calculating the length of trench, only the side walls of the trench.

Installation/Construction

- After the gravel has been added to cover the perforated pipe, cover the entire gravel layer with geotextile or filter fabric. The use of straw, building paper or insulation is not permitted.
- Cover the geotextile or filter fabric with at least 9 inches of soil.

O & M

- Alter the irrigation schedule to ensure both areas are subirrigated. In summer droughts, one or both areas may need supplemental irrigation. In winter, alternating prevents damage to the soils.

A Graywater Mulched Watering Moat

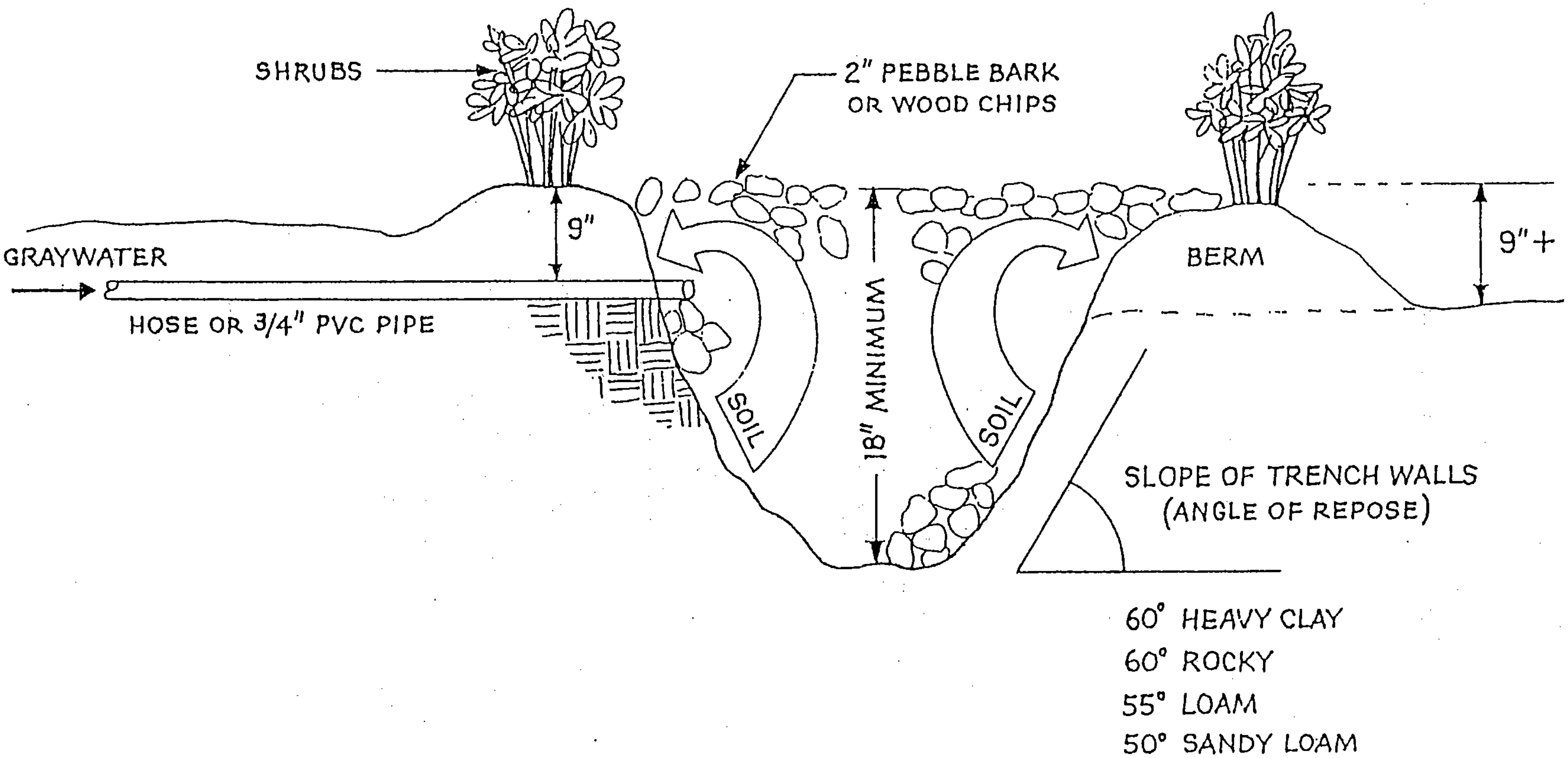


FIGURE A

Optional Locations of Tree Moats

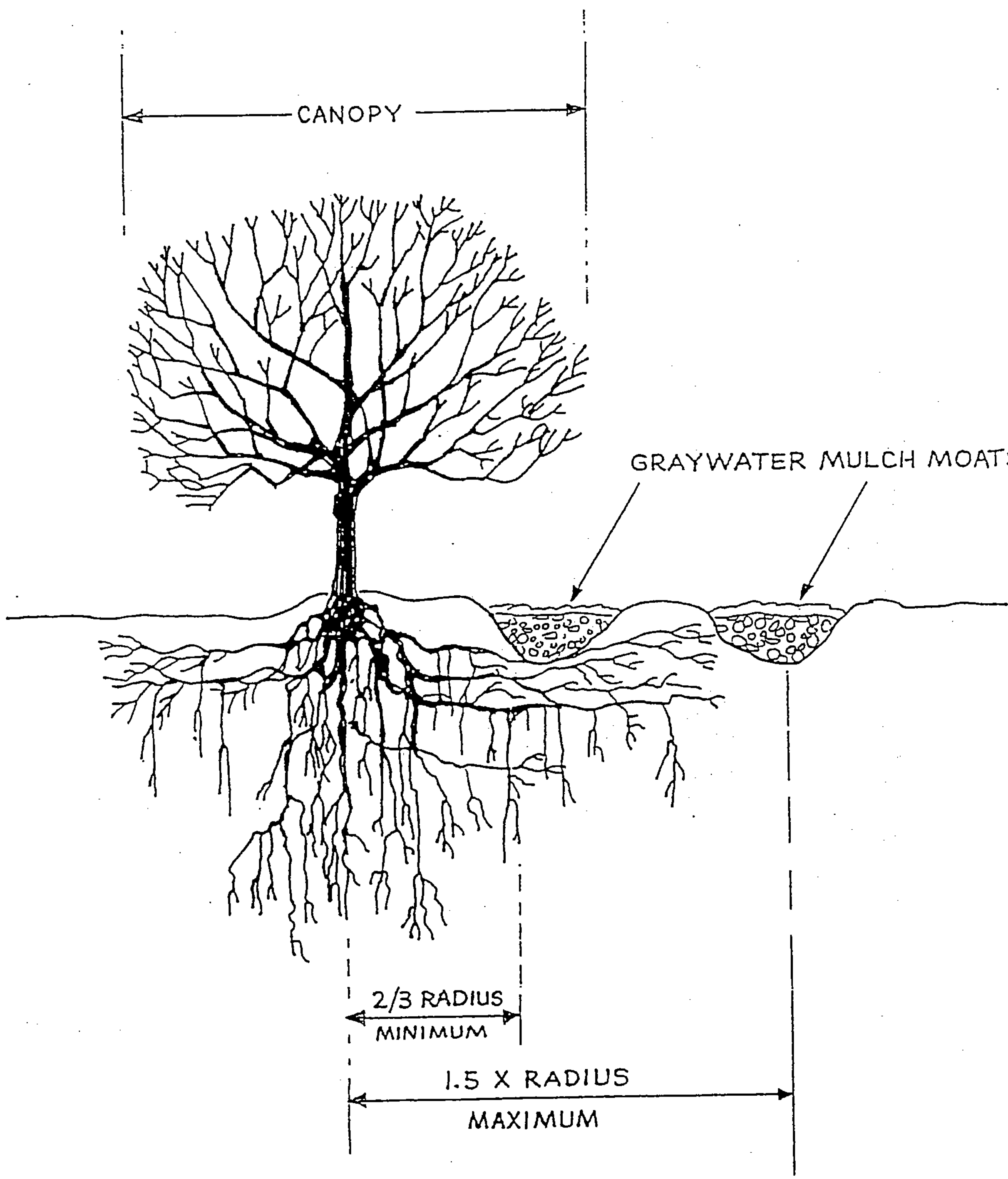


FIGURE B

A Flower Pot "Emitter"

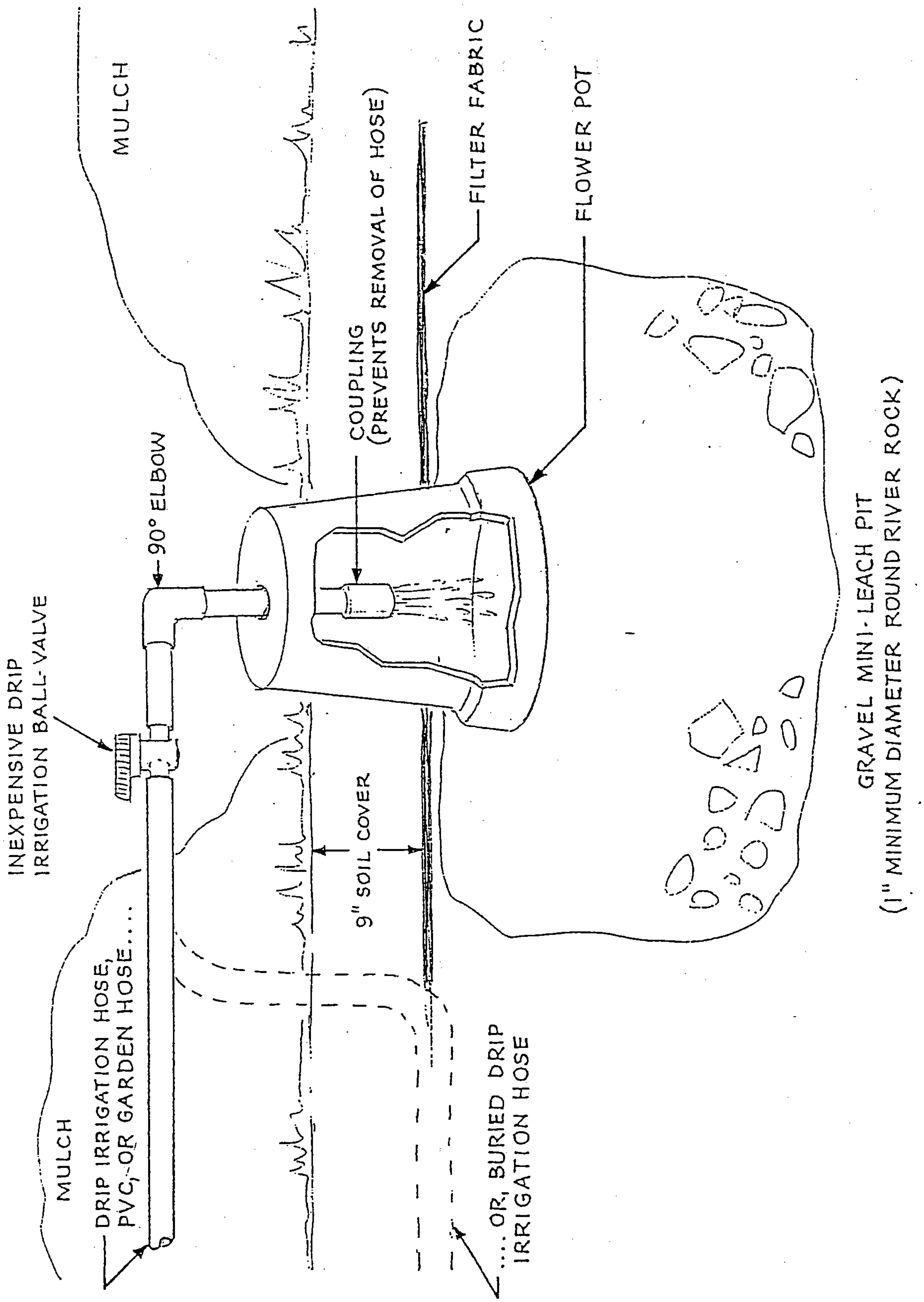


FIGURE C

A Simple Gravity Disposal Graywater System

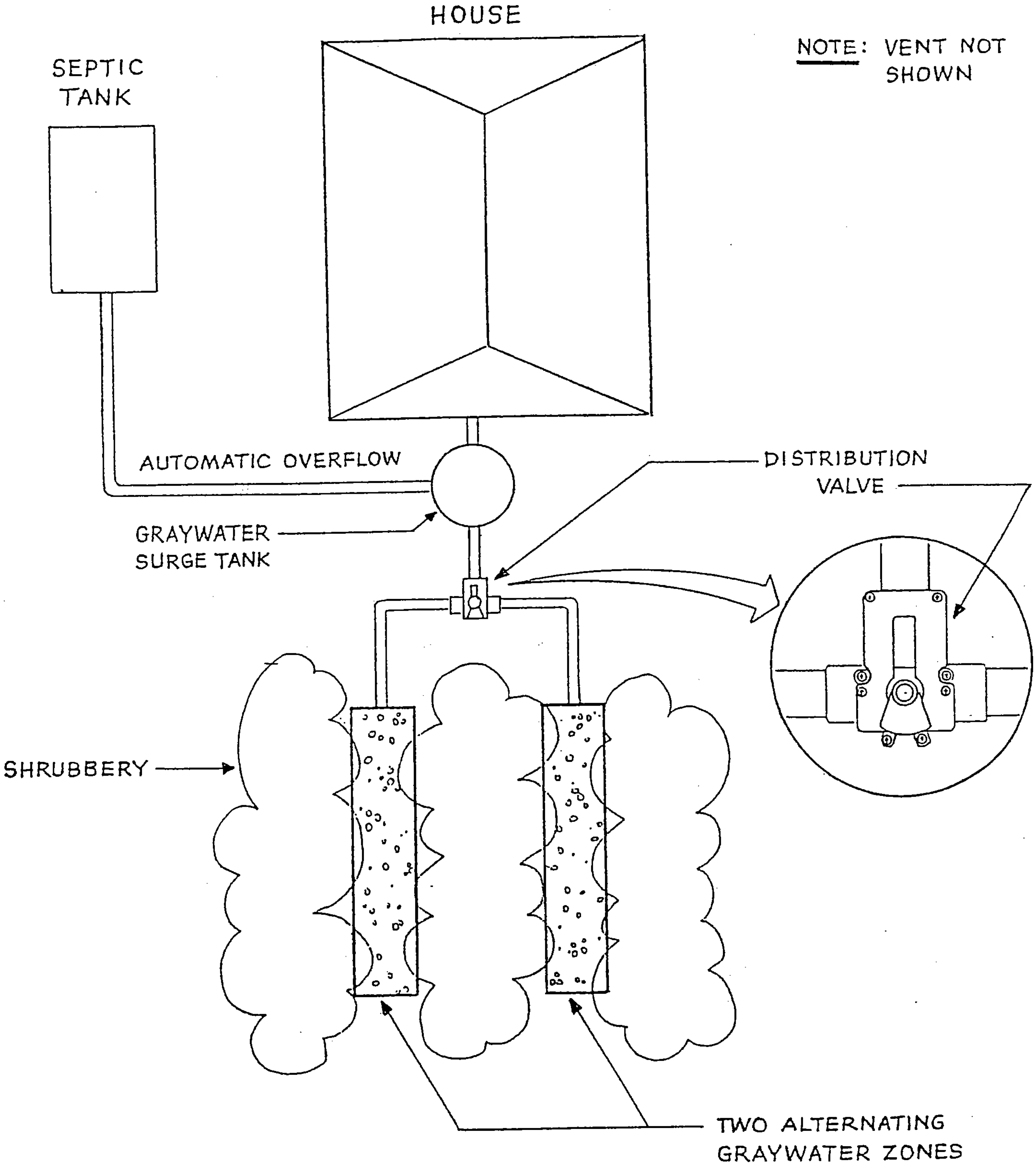
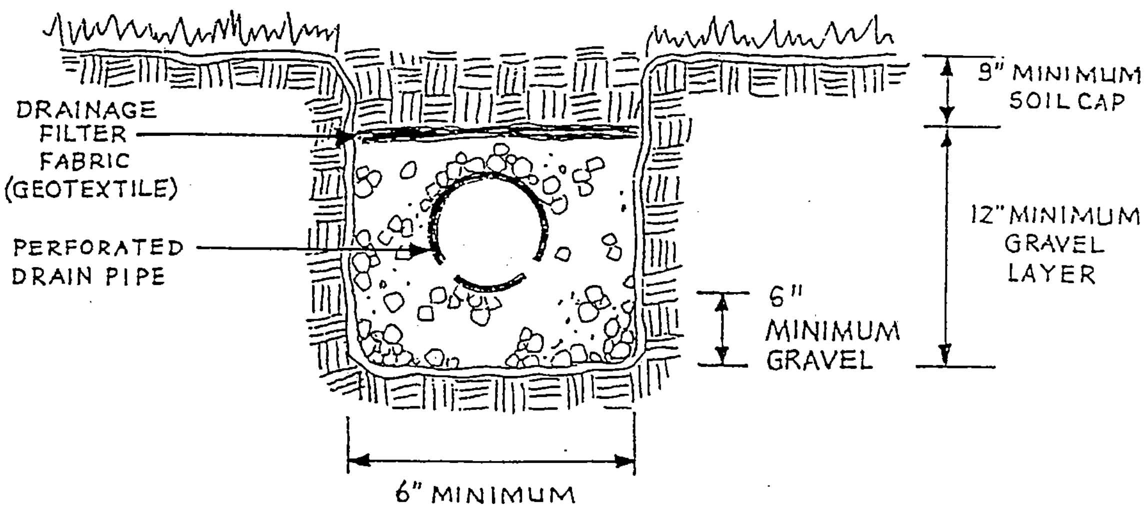


FIGURE D

A Shallow Leachfield



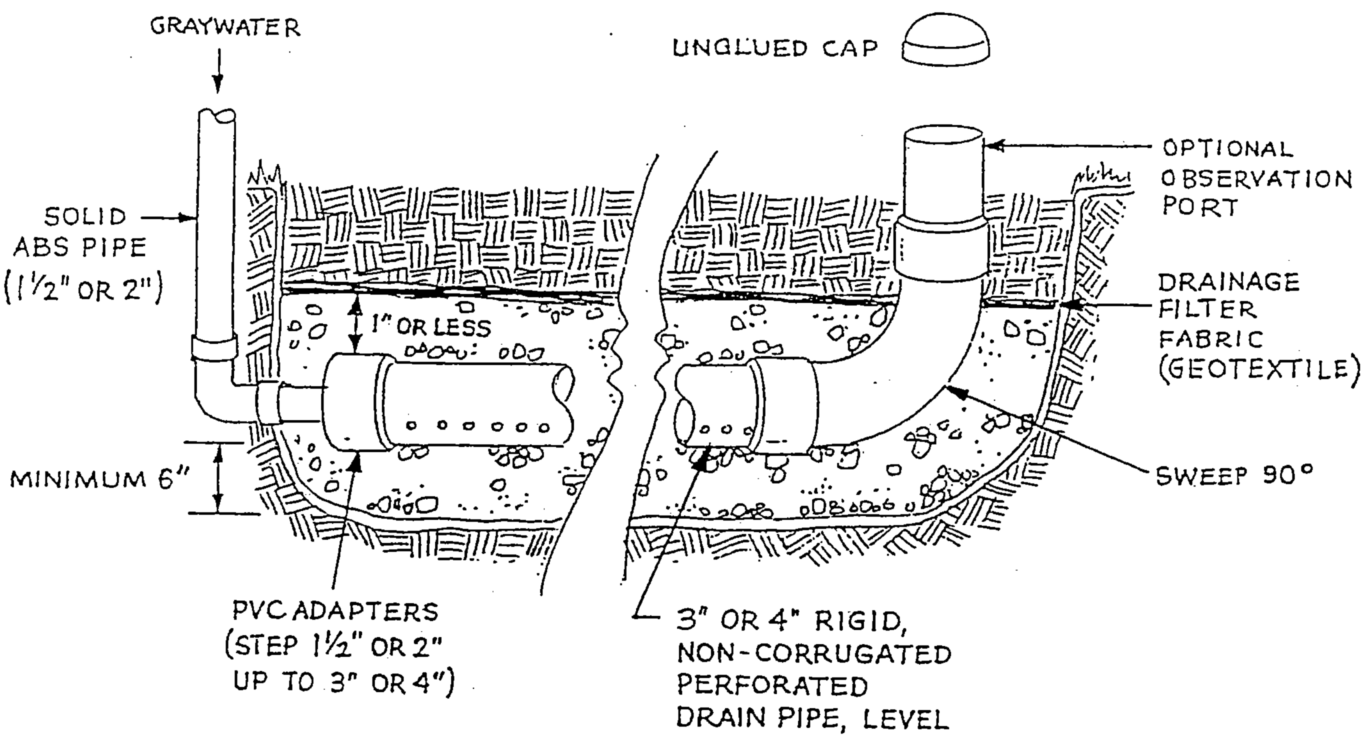


FIGURE E

Flow Control Switch on Slopes

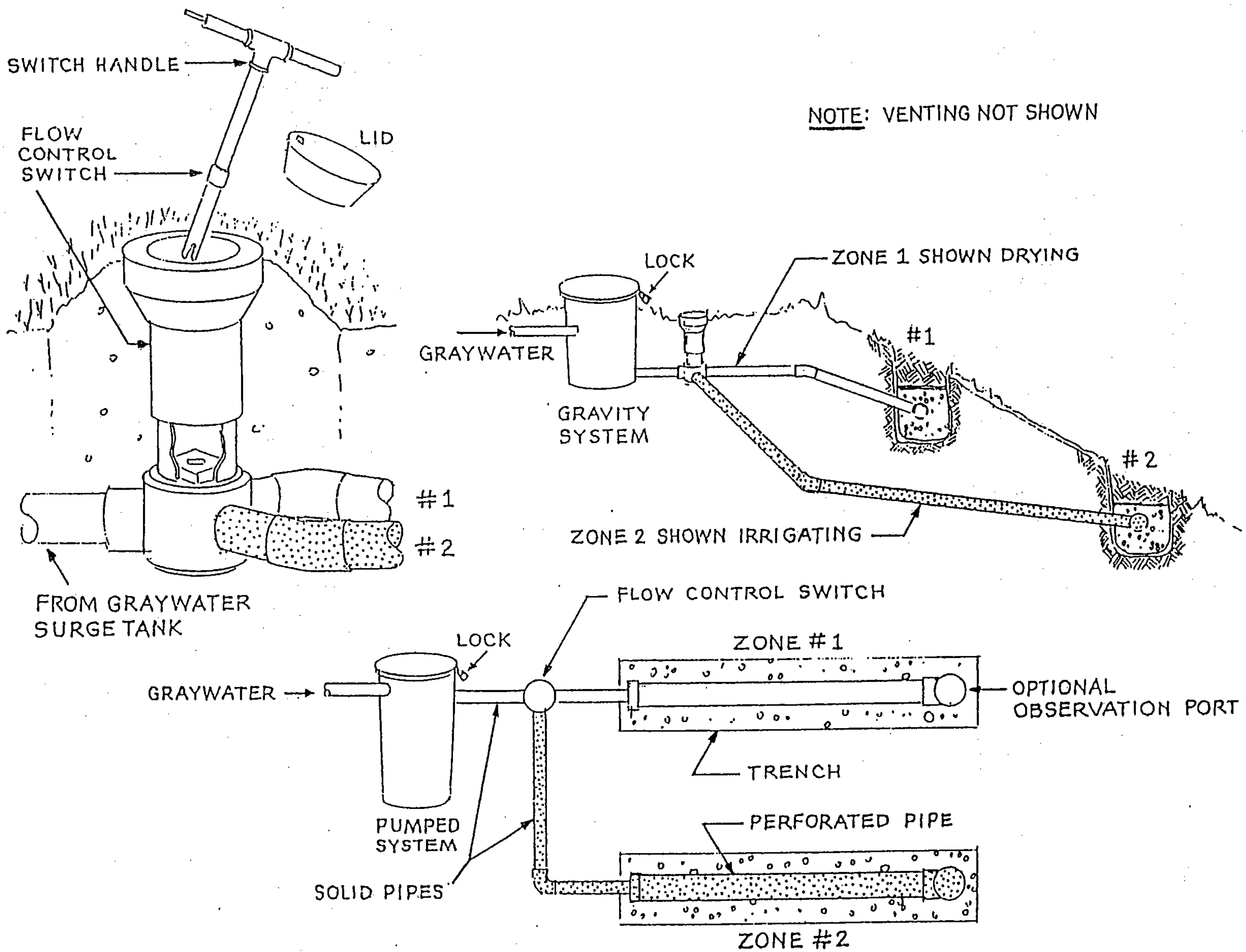
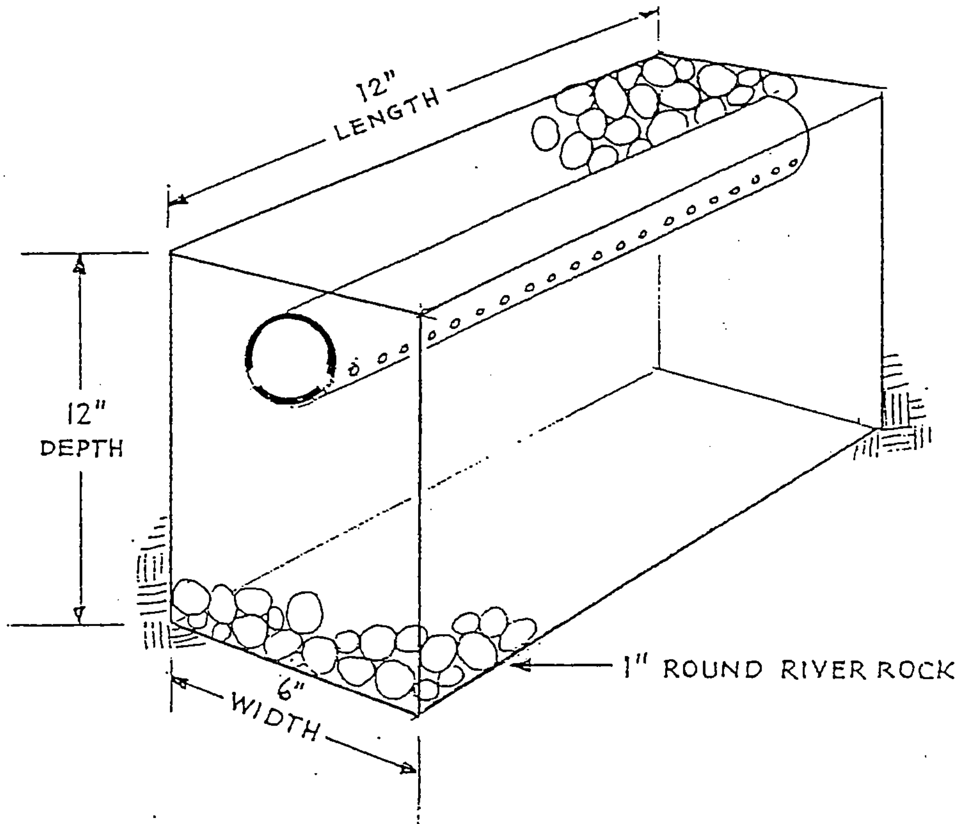


FIGURE F

Calculating Shallow Leachfield Holding Capacity



Sample Calculation:

If: D = 12" (minimum) W = 6" (minimum, 12" maximum)

L = 12" (Per lineal foot, can be up to 20 feet.)

Then: 12 X 6 X 12 = 864 cubic inches (cu. in.)

864 cu. in. divided by 231 cu. in. per gallon = 3.74 gallons

3.74 X .5 (50% void) = 1.87 gallons holding capacity per lineal foot

If: 2 people = 74 gallons of graywater per day

74 gallons per day divided by 1.87 gallons =

39.57 lineal feet of shallow leachfield per day.

FIGURE G

Handbook #8
DRIP IRRIGATION GRAYWATER SYSTEMS

Defining an Irrigation Graywater System

The most effective way to apply graywater for the plant's growth and the soil's health is via drip irrigation tubing beneath a thick protective layer of mulch (**Figures A** and **B**). Such a system uses the slow, gradual release of the filtered graywater through drip irrigation emitters or similar devices. Because the filtered graywater dribbles out of the emitters so slowly, the graywater doesn't flood much of the soil's pores, stays in the soil's upper, more aerobic layers, doesn't daylight and is less likely to move down a steep slope. The mulch insures the tubing is hidden from view, the plastic is protected from damaging UV light, and that the graywater remains safely out-of-touch.

Drip Irrigation Basics

Drip irrigation involves a series of black, plastic tubing installed with small gizmos, called emitters, which carefully control the flow of water to a small dribble at a rate of either 1/2, 1 or 2 gallons per hour (gph). A drip irrigation system promotes the best growth and bloom with ornamental plants.

The emitters have tiny holes and passages to regulate the flow of water (**Figure C**). The lint, dirt and oils in graywater look like large logs, huge boulders and extensive oil slicks to the tiny opening in each emitter. Graywater *must* be fully filtered to work with a drip irrigation system. This doesn't mean the graywater must be purified to equal drinking water. Purifying graywater is very costly and eliminates its most important value—the mild fertilizing effects of the dirt, soap and detergents and other so-called "filth." The goal is to trap only the particles large enough to clog the emitters. Some systems pre-filter the graywater with a fine-meshed filter bag or with canisters of clean sand, while others use paper cartridge filters.

Some systems require cleaning of the filter medium, others have automatic flushing of the filter. Even this filtering doesn't clean up the graywater enough to use with old-fashioned soaker hoses, porous pipe (which, like soaker hoses, oozes water from micro-pores along the entire hose), Laser™ tubing (with tiny holes pierced at regular intervals), or certain old-fashioned emitters.

Carefully consider the pluses and minuses of a drip system before committing yourself to this more complex approach. A summary of the risks and benefits follows:

Benefits to Drip Irrigation

- The most efficient and direct way to irrigate.
- Promotes the healthiest plants, the best growth, the greatest amount of blossom and, with edible plants, the highest yields.
- Spreads the graywater over the largest possible area, to the largest number of plants and with the greatest amount of control.
- Allows for the slow percolation of graywater into the soil and is the most practical way to apply graywater to slopes, heavy clay soils, and land subject to sliding or creeping.

- Applies graywater close to the soil's surface for the most aerobic "digestion" of its organic matter and nutrients.
- Can be automatically operated for simple distribution to various zones.
- A thickly-mulched drip system is virtually weed-free and supports a low maintenance landscape.

Limitations to Drip Irrigation

- Complicated for do-it-yourself installations.
- More costly than most dispersal methods such as shallow leachfields, upside-down flower pot "emitters" and mulched watering moats.
- Prone to clogging if filtration is inadequate or cleaning of the filter is irregular.
- A failed filter can permanently ruin the entire drip system in a matter of minutes.
- Requires more maintenance and energy use than gravity and dispersal systems.
- Above ground and below ground rodents may chew through the drip irrigation tubing.
- Not well-suited to most gravity systems.
- May require duplicate drip system for potable water.

City Requirements

The City understands that technology is rapidly changing and improving. It will allow demonstration graywater drip systems but will require strict operations, maintenance, and City installation inspection. In general, the City must approve the site plan, drip irrigation hardware and landscaping plants, and inspect before it is covered over. There will be an annual inspection of pumps and laterals or a requirement that laterals are cleaned annually with an acid solution.

Locating the Area to be Drip Irrigated

Figuring out the size of the area of a drip irrigation graywater system is a bit complicated and covered in greater length in the sections that follow. For the sake of considering this option, you can begin with a few assumptions and general numbers. Basically, the safest system prevents daylighting with the use of 1/2 gallon-per-hour (gph) emitters. This is the slowest rate for almost all emitters and allows even clayey soils and slopes to readily absorb the graywater without daylighting or runoff. With sandy soils, it's certainly possible to place one emitter every 14 inches in a staggered grid, or one emitter for every square foot of the landscape. In heavy clay soil, one emitter for every 2 square feet is a good guideline (**Figure D**).

Assuming an average of 37 gallons of graywater per day per person, each day's drip irrigation system can water up to 74-148 square feet for one hour, depending if you have sandy or clayey soil respectively. This is a maximum figure and will be reduced by the specifics of your plant's needs, the soil and the weather. Use these ballpark figures as a starting point to determine how much of your landscape may be watered with your graywater.

In reality, irrigation rates should be based upon the weather and species of plant. With a set amount of daily graywater, plants exhale water vapor and incorporate some of the water into their plant bodies. The amount absorbed depends on the activity of the plant, its age, and the heat from the sun. To disperse all your graywater, a much larger area must be irrigated in the winter when the soil is moist or wet, compared to a smaller area during the heat of summer. Calculating these details is too complicated for this scale of wastewater reuse. Instead, we assume winter, the worst case.

Filtering Graywater for Drip Irrigation

The three most important concepts when using graywater for a drip irrigation system are: filter, filter and filter. Graywater is completely different from city or well water and requires thorough filtration to keep from clogging the emitters. Graywater contains much more than just particulates, sand and sediment to screen out. An irrigation graywater system must deal with a small universe of oils, greases, chemicals, fats, soaps, detergents, lint, hair and bodily exudates. Some of these compounds can pass through fine filters and then coagulate into emitter-clogging globs. Nonetheless, drip irrigation is such an efficient way to apply a limited amount of graywater that many homeowners prefer the increased cost or hassle to install a drip irrigation graywater system. To begin with, you'll need a pre-filter to catch most of the offending lint, hair and particulates before they enter the surge tank. Then you'll install a pump to pressurize the graywater. Finally, you'll filter all the graywater once again just before it goes to the drip irrigation system in the garden (**Figures A** and **B**).

Selecting Drip Irrigation Hardware: Pre-Filter Specifications

- A pre-filter is required with all drip irrigation systems.
- The pre-filter must be located at a convenient and readily-accessible location, either in a small tank prior to or within the main surge tank.
- The pre-filter can be either a mesh bag made of PVC, polyethylene or plastic screen; shade "cloth"; a polyethylene woven-mesh bag; a fiber or paper canister filter; or a stainless-steel wire-mesh strainer.
- The surface area of the pre-filter should be at least 2 square feet so it doesn't quickly clog. The bigger the pre-filter, the better—up to a point. (Remember, water is heavy. If a pre-filter bag is completely saturated on the inside with lint and hair it will hold water weighing 8.33 pounds per gallon. For example, a saturated 4.4 sq. ft. pre-filter bag, 7 inches in diameter and 30 inches long, holds about 4.6 gallons and weighs 38.3 pounds when full! Make sure you can easily lift a clogged and full pre-filter bag.)
- The pre-filter tank or the surge tank must have an easily-removed lid for convenient access to the pre-filter. A locking ring lid which is nearly the full diameter of the tank is recommended for easy cleaning of the interior.
- Gloves for the safe handling of the pre-filter must be kept nearby.
- In case the pre-filter is not cleaned often enough and becomes saturated or clogged, the pipes must be plumbed so that any water backing up from the clogged lint filter automatically dumps to the sewer/septic tank (**Figure E**).
- If you place the pre-filter in its own tank, the outlet must be at the tank's bottom. The outlet pipe must continue by gravity to the surge tank at a slope of at least1/8 inch per 10 feet of pipe.
- No pre-filter tank can be plumbed to any potable water supply (to prevent a cross-connection).
- If you place the pre-filter in its own tank, the tank must be a high-quality plastic, stainless steel, polyethylene or fiberglass (or equivalent), either new or recycled. Recycled tanks must have been previously used only to store potable water or food products—not petrochemicals, poisons or other toxic compounds.
- To allow for quick removal for inspection and cleaning, no port or pipes can pass through the tank's lid.

- Use unions or no-hub fittings on the inlet and outlet pipe of the tank so it can be easily removed without cutting any pipe.
- Like a water heater tank, an in-line graywater pre-filter tank must be secured or strapped to either a joist, a wall or a level base, to limit swaying during an earthquake.

Note: Do not confuse this "pre-filter" with the "drip irrigation filter" (usually a Y-filter). Both are required.

Selecting Drip Irrigation Hardware: Pumps

Most drip irrigation systems need at least—at the absolute *bare* minimum—11 pounds-per-square-inch (psi) pressure to operate as intended and to automatically flush the emitters. This means most gravity systems will not develop enough pressure unless the total drop in elevation is over 26 feet. (Multiplying head—total drop in elevation—times .44 gives you pressure.) Therefore, some form of pump is required to re-pressurize the graywater after it has entered the surge tank. The three main options are a sump pump, a centrifugal pump or a submersible high-head effluent pump.

- Most drip irrigation fittings must be kept at, or below, 25 psi to prevent failure. While some in-line tubing can withstand 70 psi, the fittings which join the tubing together can't. Make sure your pump doesn't exceed 25 psi or add a pressure regulator after the final filter to each irrigation line.
- With a centrifugal pump combined with a diaphragm pressure tank or submersible high-head effluent pump, be sure to install 25 psi pressure regulators after the filter and before the first drip irrigation fittings.

Selecting Drip Irrigation Hardware: Emitters

The most important criteria for selecting an emitter is its resistance to clogging. There are four generic classifications for emitters: orifice, vortex, diaphragm and tortuous path (also called turbulent and complex labyrinth) (**Figure C**). There are hybrids of these basic forms, such as the combination of a short tortuous path with a flexible diaphragm to make a pressure-compensating emitter. For graywater systems, only the tortuous path type emitter has a proven track record and is required. The many turns in this emitter's internal labyrinth forces the water to remain

Converting Inches, Mesh and Microns

Inches to...	Inches (in decimals) to...	Mesh to...	Microns
1/16	.0625	70	210
3/64	.0469	100	150
1/32	.0308	140	104
1/33	.0315	150	106
1/50	.02	200	75
1/64	.016	270	50

in a sideways vortex (like a tornado) which keeps all particles suspended in the middle of the stream.

Within the tortuous path emitter classification, there are individual emitters which can be punched in drip tubing as desired and emitters pre-installed at regular intervals, called in-line emitter tubing. Some manufacturers of acceptable tortuous path emitters include Agrifim and Geoflow. If you choose to use any other type of emitter, be sure to thoroughly research their application with graywater before submitting a permit application.

- Porous pipe (also called Leaky Pipe™ and soaker hose) or Laser™ Tubing cannot be used—these quickly fail because their orifices are too small.
- Emitters are usually rated at 1/2, 1, and 2 gph, sometimes even higher. To prevent daylighting, use the lower rated emitters. On slopes or heavy soils, only 1/2 gph emitters are permitted. Sandy soils in the beachfront and inland zones can use the highest flow emitters.

Selecting Drip Irrigation Hardware: The Drip Irrigation Filter

No matter how good the emitters are and how thorough any pre-filtration is, one more filter is required just before the graywater enters emitter tubing. A 3/4 inch or larger Y-filter with a flushing ball-valve is recommended. These filters have screens with a large surface area, and last longer between cleaning. The ball-valve allows for easy manual or automatic flushing of the screen on a regular basis. A metal screen is highly recommended as it stands up to scrubbing better.

Typically, a Y-filter has either a 140- or 150-mesh screen with municipal water or a 200-mesh screen with well water. It's more accurate to determine the smallest internal orifice of the emitter you plan to use and select a filter screen with at least a 50% safety factor. Use the conversion chart on the preceeding page.

As an example, consider the Netafim 1/2 gph non-pressure compensating in-line emitter tubing (distributed by Toro). According to the manufacturer, the smallest internal passage is .043- by .046-inches, or about equal to a 100 mesh/150 micron filter screen. Multiply the inches, in decimals, by .5 for a 50% safety factor (e.g., .0469 X .5 = .02345, or approximately a 200 mesh/75 micron filter). This means the filter will take out everything down to particles one-half the size of the emitter's internal passage. Most emitters will need final filtration equal to at least a 200 mesh screen, or 75 microns.

Selecting Drip Irrigation Hardware: Maximum Length of Tubing

Each drip irrigation system must have two or more zones. Each zone is composed of one or more sub-assemblies. The pattern of the sub-assembly will be described below. But the total length is determined by the manufacturer's specifications. At any one operating pressure, there is a maximum number of feet of tubing per sub-assembly before the pressure drops, due to resistance, too far for equal distribution.

Chart A shows the maximum effective lengths of some products for even distribution of water and the corresponding maximum flow rate in gph. (The PSI column gives suggested maximum psi for each material.) Each listing has a "fudge factor" built in to compensate for pressure loss due to tees, elbows and other fittings. Instead of using complicated formulas for pressure loss, simply look up the tubing and see the total length each zone or sub-assembly should have.

TUBING or PIPE		PSI	MAX. GPH	MAXIMUM LENGTH ON FLAT GROUND
SOLID DRIP HOSE	3/8" (400)	25	110	(120')
	1/2" (700)	25	235	(240')
	3/4" (900)	25	475	(300')
SOLID SCH 40 PVC PIPE	1/2"	40	250	(200')
	3/4"	40	480	(300')
	1"	40	780	(300')
	1 1/4"	40	1200	(300')
GEOFLOW™ INPIPE EMITTER TUBING	1/2 gph 12"cntrs.	25	.5/ft.	(180')
	1 gph 12" cntrs.	25	1.0/ft.	(130')
	1/2 gph 18" cntrs.	25	.5/ft.	(250')
	1 gph 18" cntrs.	25	1.0/ft.	(170')
	1/2 gph 24" cntrs	25	.5/ft.	(300')
	1 gph 24" cntrs.	25	1.0/ft.	(210')

DO NOT DESIGN SYSTEM FOR BOTH MAX. FLOW RATE AND MAX. LENGTH

Scale: 10 20 30 40 50 100 200 300 400

CHART A

Note: These figures are for a level garden. Any significant uphill slope will *decrease* the length. Don't expect good results if you try to get away with both the maximum length, or a bit more, and the maximum flow rate. Check with your supplier for the specifics for the emitters

Selecting Drip Irrigation Hardware: Valves

- With graywater, each time the system is turned off, the nutrients in the water cause a microbial mat to grow which can clog emitters. Two devices, an air relief valve and a line flushing valve, can help prevent this problem (**Figure B**).
- At the beginning of each sub-assembly or just after the filter, install an air relief valve. Make sure the air relief valve is in a protected spot above the soil and mulch. Each time the system turns on, the air relief valve shuts under pressure. Each time the system turns off, the air relief valve opens to draw air into the drip tubing. Whenever air replaces water in the tubing, any developing slime or algae growth quickly dries out and dies.
- At the end of each sub-assembly install a line flushing valve. Each time the system comes on, the line flushing valve will purge one or more gallons of water from the line, taking with it any sediment which may have started to accumulate at the end of the sub-assembly. When the system shuts off, the line flushing valve opens and all the water which can drain by gravity leaves the tubing. Because there's an air relief valve at the beginning of the system, no vacuum is created and the water drains freely. The goal is to suck as much drying, desiccating air into the tubing as possible to arrest the growth of any emitter-clogging grunge. Because the line flushing valve must drain, be sure to place it above a gravel-filled dry well large enough to hold the surplus water until it drains into the soil.

Selecting Drip Irrigation Hardware: Staking and Mulch

- The drip irrigation tubing can be staked on top of the soil, but in order to prevent daylighting it must be covered with at least 9 inches of a fibrous, interlocking mulch, such as shredded—not chipped—bark (sometimes called "Angel's hair") or straw, or 9 inches of a nonstringy, noninterlocking mulch, such as tree chips, pea gravel or lava rock.
- On slopes greater than 20 degrees, only a fibrous, interlocking mulch is allowed.
- On slopes steeper than 45 degrees, the tubing with 1/2 gph emitters must be staked every 4 feet, 4 inches of an interlocking, fibrous mulch held in place with landscape erosion netting stapled on a 3 foot by 4 foot staggered row pattern and the netting covered with 2 more inches of mulch. Or, all 6 inches of the mulch can be placed under the netting.

Drip Irrigation Layout and Zones

Chart A gives the maximum length of tubing or pipe for a number of common materials, and your task is to divide and conquer. Sketch your entire irrigation plan, double-check the flow rates for each sub-assembly or lateral, divide the laterals or sub-assemblies into more sub-assemblies if the recommended maximum length was exceeded, then double-check the supply pipe to make sure they can pass enough water to satisfy all the laterals or sub-assemblies if turned on at the same time. Finally, increase the size of the supply pipes if required or add another supply pipe to a portion of the garden.

Drip Irrigation Based on Evapotranspiration

For the sake of graywater irrigation, there are two seasons: the dry season only or the entire year. The toughest design situation is the year-round application of graywater, even during rainy months. If possible, switch your graywater to the sewer or septic tank during the rainy season to simplify your graywater system design and management.

In either case, you'll be basing the length and extent of drip tubing based upon the evapotranspiration (ET) rates for Malibu. The ET rate combines the amount of moisture lost from the soil's surface (evapo-) and the foliage (evapo- and -transpiration.) It represents the amount of water a plant uses, regardless of the method of application, and is determined with a formula which factors the temperature, wind speed, humidity and percentage of ground covered by foliage. The ET rate is equal to the minimum rate of irrigation for a good-looking landscape. (Many drought resistant plants can survive with less than ET-based irrigation, or no supplemental water whatsoever, but will almost always look more attractive with some irrigation.) **Chart B** shows the ET rates for each month, in the total number of inches for the month and per day, for Malibu.

One inch of evenly spread water equals 0.63 gallons per square foot of landscape. Looking at the chart, the month of January is usually quite cool, overcast and rainy and the total ET is only 2.2 inches (compared to 5.5 inches in July), which equals .07 inches per day (2.2 inches divided by 30 days) or .0448 gallons per square foot per day. This means that for each gallon of graywater to be distributed in January you will need 22 square feet of landscape—divide 1 gallon by .0448 gallons per square foot per day. By comparison, during the hot and dry month of July you will only need 9 square feet to distribute the same amount of graywater.

For either approach—all year or just the dry season—you can start by multiplying the estimated amount of daily graywater times the lowest monthly ET rate for the period. This will give the largest area required for each zone to absorb the daily graywater. For example, if you're only irrigating with graywater from April through October and the daily graywater amount is 150 gallons, each zone of drip tubing must be at least 2206 square feet (150 gallons divided by .068 gallons per square feet). By comparison, this same amount of water needs only 1364 square feet to be absorbed during July. (It is possible to distribute much more than these amounts of graywater in the dry season, over much smaller areas, but you run the risk of having some of the graywater percolate below the root zone, effecting the landslide potential of the subsoils.)

Always design for the largest area of landscaping possible, based on the ET rate. For protection, make sure the planting is well-adapted to drought and local environmental conditions. Any supplemental irrigation must be done via another, redundant, drip irrigation system so that there is no risk of the graywater contaminating the potable water supply due to a cross-connection.

Irrigating the Entire Root Zone

Next, fit the drip tubing to each zone. The simplest approach is to use in-line emitter tubing (or drip tubing with punched-in tortuous path emitters) with emitters every 14 inches. Each row of tubing can be placed topographically across any slopes on 14 centers. Stagger each line so that the emitters don't line up from row to row. These parallel lines, with staggered emitters, irrigate the entire root zone of the landscape. The wet spots on the ground will not fill in the entire surface area, but 9 inches below the ground the wet spots merge to provide continuous root zone irrigation (**Figure D**).

Malibu ET, 6-21-94

DAILY MALIBU EVAPOTRANSPIRATION RATES FOR ANNUAL GRAYWATER APPLICATION

LANDSCAPE PLANT MATERIAL	ET %	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Monthly Evapotranspiration Rates (in Inches) Used to Determine Daily Rates, in gallons		2.2	2.7	3.4	3.8	4.9	4.7	5.5	4.9	4.1	3.4	2.4	2
Daily Evapotranspiration Rates, in gal/sq ft.		0.04	0.05	0.07	0.075	0.98	0.89	0.12	0.98	0.09	0.07	0.045	0.037
Per Square Foot													
Perennial food plants	1.20	0.048	0.06	0.084	0.09	1.176	1.068	0.144	1.176	0.108	0.084	0.054	0.0444
Lawns	1.00	0.04	0.05	0.07	0.075	0.98	0.89	0.12	0.98	0.09	0.07	0.045	0.037
Shrubs, Grnd. Covers	0.80	0.032	0.04	0.056	0.06	0.784	0.712	0.096	0.784	0.072	0.056	0.036	0.0296
Drought-Resistant Trees	0.40	0.016	0.02	0.028	0.03	0.392	0.356	0.048	0.392	0.036	0.028	0.018	0.0148
Native Oaks	0.20	0.008	0.01	0.014	0.015	0.196	0.178	0.024	0.196	0.018	0.014	0.009	0.0074
Per 100 sq. ft.													
Perennial food plants	1.20	4.8	6	8.4	9	117.6	106.8	14.4	117.6	10.8	0.084	5.4	4.44
Lawns	1.00	4	5	7	7.5	98	89	12	98	9	0.07	8200	3.7
Shrubs, Grnd. Covers	0.80	3.2	4	5.6	6	78.4	71.2	9.6	78.4	7.2	0.056	3.6	2.96
Drought-Resistant Trees	0.40	1.6	2	2.8	3	39.2	35.6	4.8	39.2	3.6	0.028	1.8	1.48
Native Oaks	0.20	0.8	1	1.4	1.5	19.6	17.8	2.4	19.6	1.8	0.014	0.9	0.74
Per 1000 sq. ft.													
Perennial food plants	1.20	48	60	84	90	1176	1068	144	1176	108	84	54	44.4
Lawns	1.00	40	50	70	75	980	890	120	980	90	70	45	37
Shrubs, Grnd. Covers	0.80	32	40	56	60	784	712	96	784	72	56	36	29.6
Drought-Resistant Trees	0.40	16	20	28	30	392	356	48	392	36	28	18	14.8
Native Oaks	0.20	8	10	14	15	19.6	178	24	196	18	14	9	7.4

CHART B

Adjust the emitter spacing to your soil type. The closest spacing of 12 X 12 inches is best for sandy and sandy-loam soils. The heavier the soil, the further apart the emitters can be placed. Clay-loam or silty-loam soils only need emitters at an 18 X 18 inch interval. The heaviest clay soils can have emitters at 24 inch spacings.

Warning: The only way to determine the best emitter interval is by this simple test. Punch a hole near the bottom of an empty plastic 1 gallon milk jug and insert an emitter. Fill the jug with water and place it on a dry spot in the garden. After the milk jug is empty (which may take 24 hours or more because it's not under pressure), dig a small trench next to the plastic jug to see the shape of the wet spot on your soil. Put the jug in several places in the garden to see how different soils affect the shape of the moist spot.

Drip Irrigation Valving

With a graywater system, scheduling the watering times is quite simple. Since storage of the graywater is discouraged, the graywater must go to the landscape as it's generated in the house. This means that one valve to one zone of drip irrigation must be open at all times. The valves for the drip system can be either manual or automatic. For manual valves, use only ball-valves for switching to each zone. The only approved electrical valve for graywater is a spa-type two-way swing-diverter valve with a 24VAC actuator. Install with the appropriate adaptor fittings and an approved ABS-to-CPVC glue.

Multi-Station Digital Controllers

If you're going to automate your graywater system, use a multiple-station timer or controller. Pick a controller that is easy to program. Make sure it can be programmed to keep one valve open at all times—not many controllers can do this. The least expensive models must be mounted indoors in a protected spot and close to a 110VAC outlet. With all controllers, the wires can run up to 1500 feet, depending upon the wire's thickness or gauge, from the controller out to wherever the two-way diverter valves are located.

Warning: The stand-alone battery powered units often found on an individual hose-bib can't be programmed to be on for 24 hours.

Drip Operating and Maintenance

All your investment in a graywater drip irrigation system will be for nothing if you don't perform some routine maintenance. Unlike a simple mini-leachfield, drip irrigation requires periodic attention.

Flush Your Troubles Away

The kingpin of drip maintenance is flushing. During installation, the drip irrigation hose should have been flushed when first buried in the soil, again after any tees or 90s are added to the tubing and before the ends of each line are capped. Each line or zone in the graywater system should be flushed at the beginning of every irrigation season and at least once during the season, and at least twice during the year if using graywater year round. As with the original installation, open the ends of all the lines, run the water for several minutes, begin closing the lines at the surge tank or pump or the highest point in the lines and work your way progressively away from the surge tank and downhill.

Keep the Ends Flushing

A line flushing valve acts as an automatic flushing device. It utilizes the same tortuous path technology as used with in-line emitter tubing. Each time the drip system is turned off, the line flushing valve allows water to

drain out of the lines, again removing some of the wayward sediment. The lack of standing water in the lines prevents the buildup of algae scums and bacterial slimes, both of which can clog emitters. The line flushing valve is best placed inside a purchased or homemade valve box over a pocket or sump of gravel. Periodically check to make sure the line flushing valve is free of clogs and that the gravel sump isn't daylighting graywater.

Clean the Filters Regularly

The Y-filter, or any filter, will rapidly accumulate sediment, lint and crud which may slip through the pre-filter or a surge tank filter.

Flush each Y-filter at least once a month, and more often if experience indicates rapid clogging.

With an electronic irrigation controller and 24VAC solenoid valves, you can automate the flushing of a Y-filter with a ball-valve for flushing on its filter chamber. At the end of the filter's flush ball-valve, install an irrigation solenoid. Leave the filter's flushing ball-valve in the open position. Wire the solenoid to your electronic irrigation controller, but to a separate "program" from the irrigation lines. Then you can set the controller to turn on that program once a week for a few minutes to flush the filter automatically.

No matter how much you flush your Y-filter with a ball-valve, the water streaming by will not strip everything off the metal screen, especially algae and other unrecognizable slimy stuff. So, at the beginning of every graywater irrigation season and at least once each summer, take the Y-filter apart, remove the metal screen cylinder and scrub well with an old toothbrush and a strong solution of bleach.

Give Your System the Acid Treatment

Despite all these precautions, some buildup may occur on the emitters, especially with graywater. Particles, oils and fats build up on the interior surfaces of the emitter, like hardening of the arteries. Once a year, or as needed, you can dissolve mineral, slime and sludge buildup by pumping a dilute solution of acid through your graywater drip irrigation system.

You'll need to plumb into your system a special gizmo called an injector, or proportioner. This device suctions a concentrated solution from a bucket while the drip system is running and proportions a dilution of acid into the stream of water in the drip hose. You must purchase a low-volume type of injector/proportioner. The inexpensive proportioners sold at many hardware stores are designed to function with the flow of a regular garden hose and oscillating sprinkler (5 gpm) and will not work at the low flow rates of a typical drip irrigation system. Each proportioner requires a minimum flow rate to begin the suction of liquid concentrate into the system. Check the box or instructions to make sure the proportioner will operate at the flow rate, in gpm or gph, of your graywater system.

The proportioner must be plumbed in between the surge tank and the filter. Placing the proportioner before the filter (upstream) allows the filter's screen to catch any wayward dirt, sediment or undissolved chemicals or fertilizers.

To flush your drip system, you simply mix up a solution of any one of the emitter cleaners on the market, pour the solution into the bucket and turn on the drip system. Follow the manufacturer's instructions for both the dilution rate and the length of flushing. This is best done during the dormant season or during a heavy rain to mitigate the effect of the acids on the soil.

Winterize Your Drip System

This applies only to those living in the Malibu canyon bottoms which get heavily frosted on occasion. If your graywater drip system is only for the summer months, shut off your system at a point inside the house where the valve is protected from freezing. Outdoors, loosen all unions at each main assembly to drain all water out of the pipes, filters and pressure regulators. Make sure you don't lose the O-ring which seals each union. Be sure to open the flush ball-valve on the Y-filter so the filter chamber doesn't crack.

Tidy Tips for Your Drip System

Every piece of rigid PVC pipe which shows above ground should have been painted with a quality exterior latex paint right after installation to protect the pipe from the degrading effects of sunlight. Besides protecting the pipe, you'll help disguise it.

- Make sure the pump's lift capacity exceeds the height of the surge tank or the distance from the bottom of the tank to the pump, whichever is greater. (The lift is usually in the range of 12-20 feet, sufficient for most installations.)
- The size of the diaphragm pressure tank is determined by how long the irrigation system can run before the centrifugal pump comes on to repressurize the tank. The longer the interval between pump starts, the more energy you'll conserve.
- There must be a flapper check valve installed on the discharge port of a straight through pump to prevent any water from siphoning back into the surge tank.
- All pipes within the surge tank must be PVC Schedule 80 pipe or iron pipe. (PVC pipe on the outside of the tank nipple can be Schedule 40.)
- Repair or cleaning of the pump will be facilitated if the intake pipe has a union somewhere after the surge tank and before the pump as well as after the discharge port. Only use threaded fittings within the surge tank.

PUMPING SYSTEMS FOR DRIP IRRIGATION

Most drip irrigation systems need at the absolute *bare* minimum 11 psi pressure to operate as intended and to automatically flush the emitters. This means most gravity systems will not develop enough pressure unless the total drop in elevation is over 26 feet. Therefore, some form of pump is required to repressurize the graywater after it has entered the surge tank. The three main options are a sump pump, a centrifugal pump or a submersible high-head effluent pump.

Sump Pumps

A sump pump is designed to be submerged in water, to automatically turn on when the water reaches a predetermined level and to pump the water a certain maximum height and distance, at a specific rate, measured in gpm or gph.

Most inexpensive sump pumps ($95-125) don't develop pressure above 11 psi (a 26-foot head) and can service a small, level drip irrigation system. The sump pumps which develop more than 11 psi cost from $800 -1500. (A centrifugal pump with a pressure tank or submersible high-head effluent pump can develop considerable pressure for less money.)

For drip irrigation systems, you must know how much pressure the sump pump develops in psi. You must get the manufacturer's chart showing the psi for the range of gpm/gph and head for the pump.

For many emitters, the minimum operating pressure is 10 psi. Check with your supplier for

the minimum operating psi suggestions. With graywater's relative dirtiness, the higher the pressure, up to a maximum 25 psi, the better the self-cleaning.

Centrifugal Pump

- Centrifugal pumps, combined with a diaphragm pressure tank, allow for all the pressure and control over pressure you'll ever need with a drip irrigation system.
- The centrifugal pump is installed outside the surge tank, but the centrifugal pump and diaphragm pressure tank should be housed in or under a weatherproof structure.
- All centrifugal pumps must be constructed of metal parts, with a metal housing.
- These pumps must be wired with grounded wire and plugged into a GFI outlet located inside the nearest building. All electrical work must be done by an electrical contractor and meet UBC guidelines.
- The surge tank's intake pipe should be as large as the threaded inlet port on the pump.
- Make sure all pipes entering or exiting the surge tank pass through the tank's walls, not the lid.
- The bottom of the intake pipe must be near the bottom of the tank to have a draw down to nearly empty.
- Centrifugal pumps are either self-priming or straight through. A straight through pump requires the bottom of the surge tank to be above the level of the impeller. A self-priming pump can suck water up to a certain limit and then through the pump. A self-priming pump works better when a check valve is installed at the bottom of the intake pipe to keep graywater in the intake pipe to prime the pump.
- To choose the proper size pump, follow the same guidelines as described for sump pumps to match the head, psi and gpm/gph to your situation and application.

Submersible High-Head Effluent Pumps

A 4 inch diameter submersible turbine pump made of stainless steel and high-quality thermoplastics can be specifically for pumping wastewater system effluent. The only submersible turbine pump with UL approval is a special product from Orenco Systems, Inc. (**Handbook 11**).

- To select a pump, refer to **Figure F**. Once you know the maximum flow rate of your entire drip irrigation system, in gpm, you can pick the pump which will give at least 25 psi at that flow rate. For example, if your drip system passes 480 gph, or 8 gpm, trace up the vertical line. The OSI 05 HH pump curved line of pressure crosses the 8 gpm line at 150 foot head, or 66 psi. In this example, the pump develops plenty of pressure and would require a 25 psi pressure regulator at the beginning of each drip irrigation sub-assembly.
- This pump requires a minimum of two mercury float switches to control the on-and-off function. (A third float switch can control an overflow alarm if desired.) They are illustrated in the manufacturer's instructions.
- Rreset the level controls to drain the graywater no lower than 3 inches above the intake port of the pump. Make sure the pump doesn't create a vortex at the intake which can suck air and overheat the pump. Adjust the float switches accordingly. Since the motor is in the bottom half of the pump and the inlet is in the middle, this will leave a fair amount of graywater in the surge tank at all times.

- There must be a flapper check valve installed after the pump. This will prevent any water from siphoning back into the surge tank.
- Any discharge pipe inside the surge tank must be PVC Schedule 80 pipe or iron pipe. (PVC pipe on the outside of the tank nipple can be Schedule 40.)
- Make sure all pipes entering or exiting the surge tank pass through the tank's walls using a tank nipple, not via the lid.
- Repair or cleaning of the pump will be facilitated if the discharge pipe has a union somewhere after the check valve and before the tank nipple. Use only threaded fittings within the surge tank.
- The pump must be wired with grounded direct-burial wire to a GFI outlet located inside the nearest building. All electrical work must be done by an electrical contractor and meet UBC guidelines.
- The pump must have a pre-filter equal to a 50 mesh screen or about 300 microns (.0118 inches.)

A Drip Irrigation Graywater System

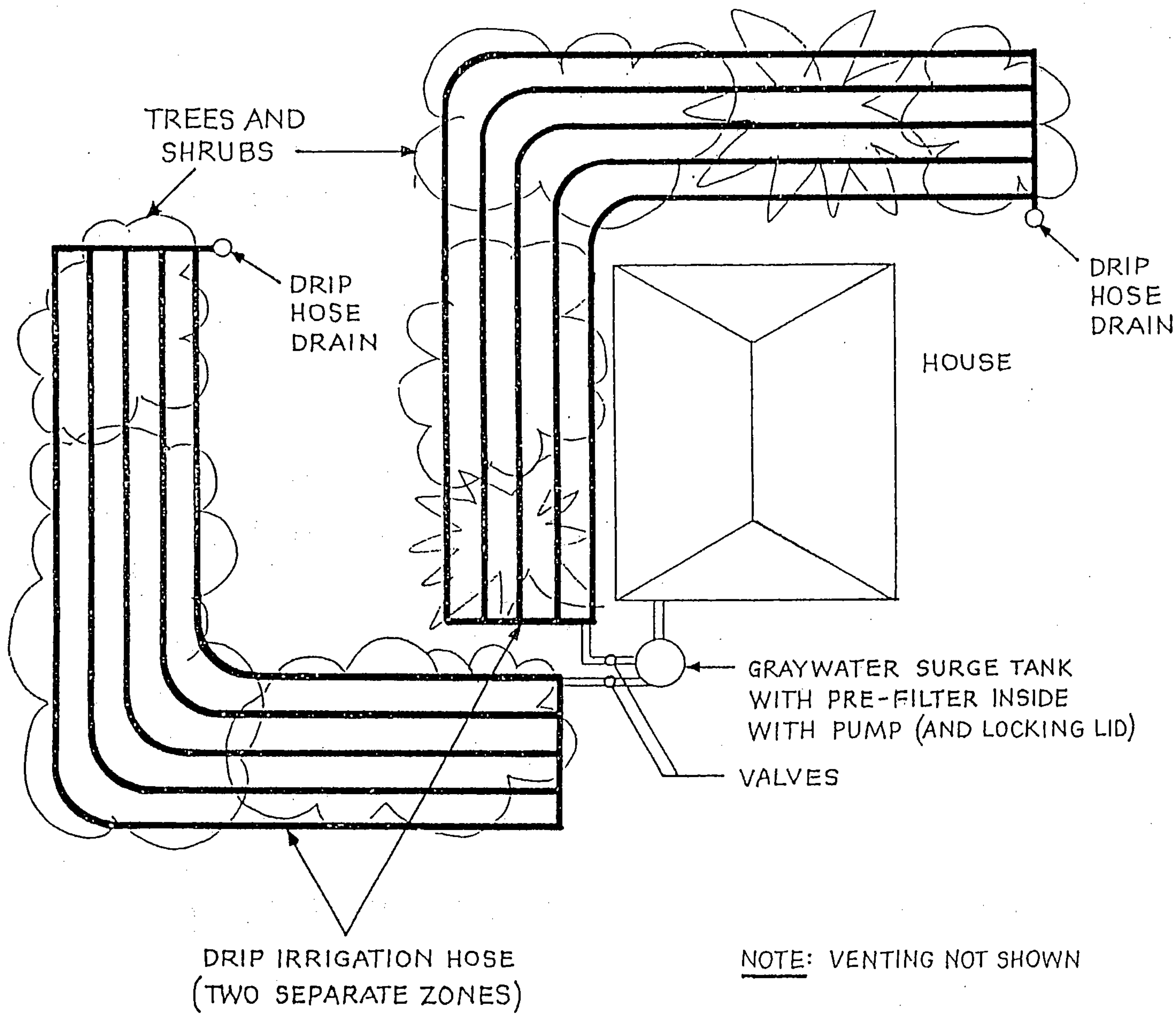


FIGURE A

Details for Installation of a Drip Irrigation Zone

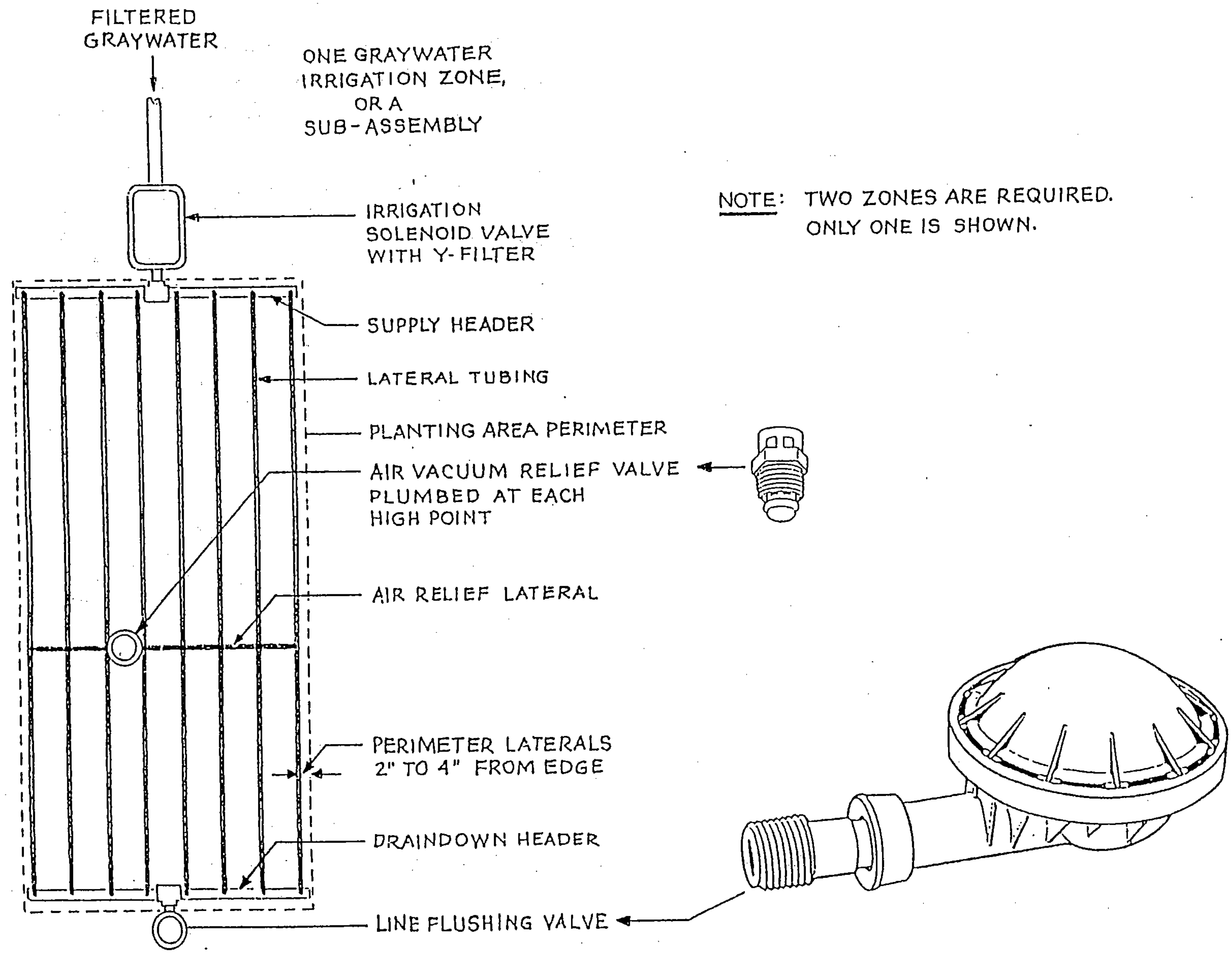


FIGURE B

Tortuous Path Emitters

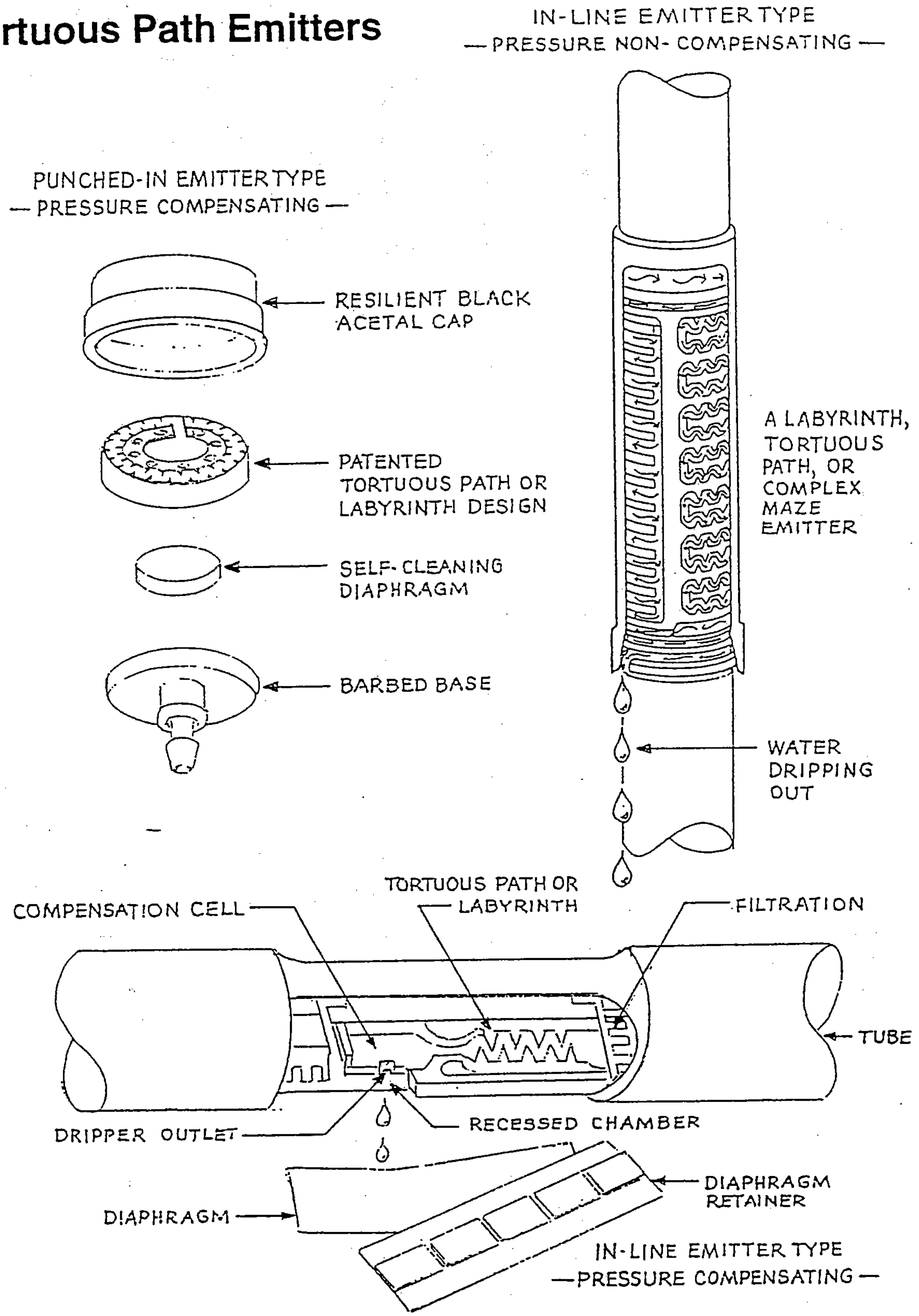
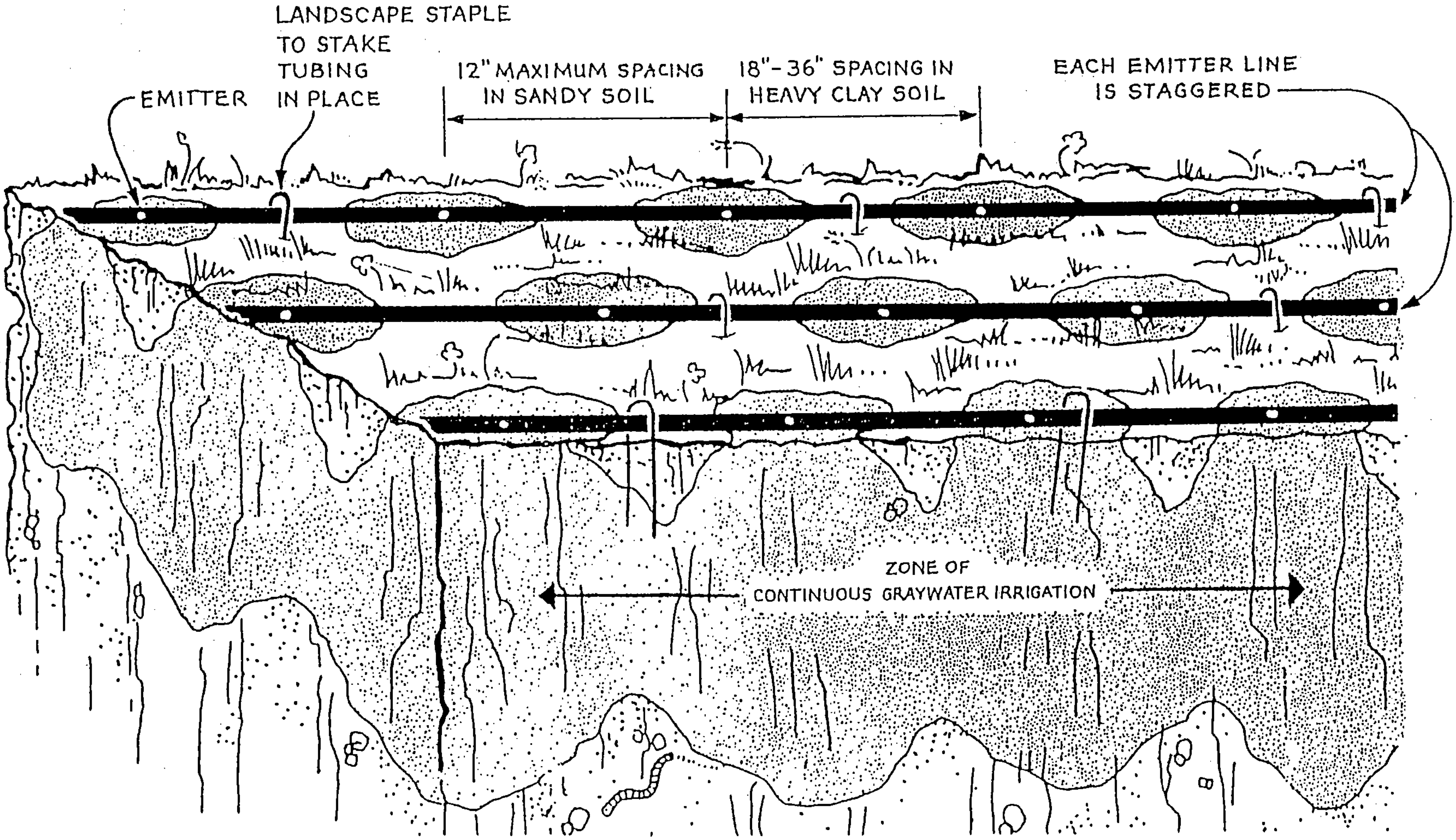


FIGURE C

Placing Emitters in an Irrigation Zone



37 GALLONS OF GRAYWATER IRRIGATES 74-148 SQ. FT. OF LANDSCAPE

— NOTE: MULCH REMOVED FOR CLARITY —

FIGURE D

Automatic Overflow for the Pre-Filter

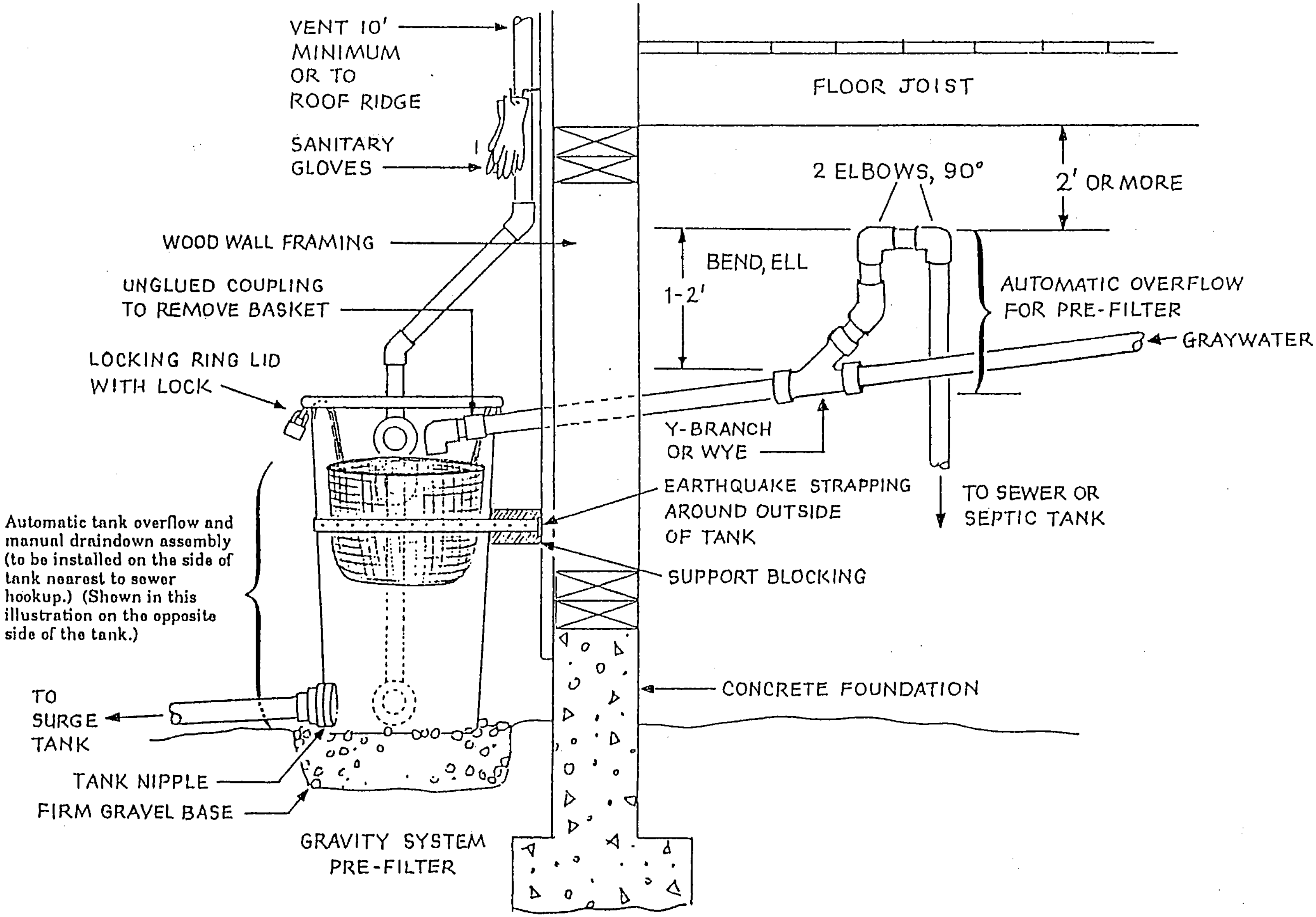
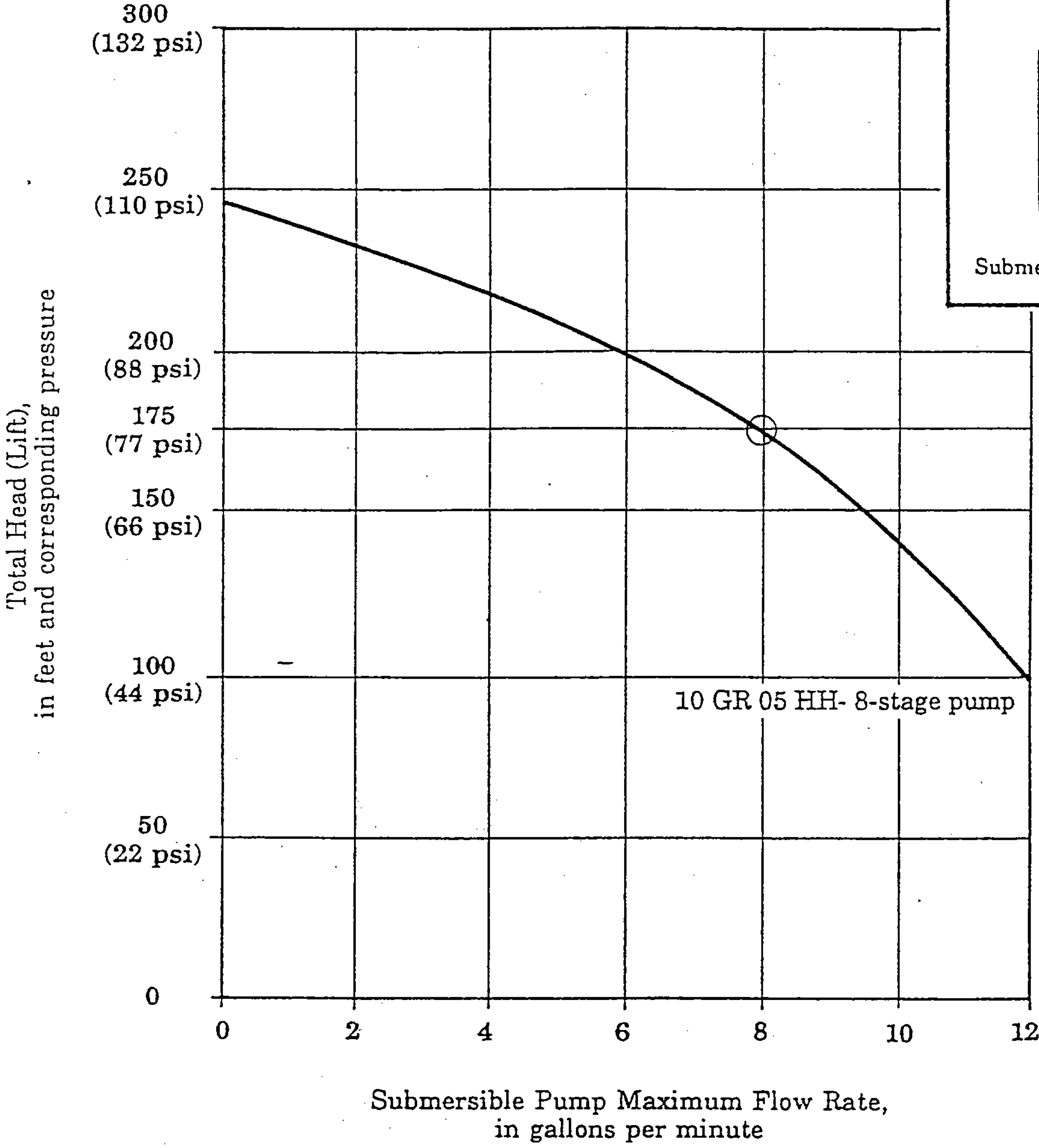
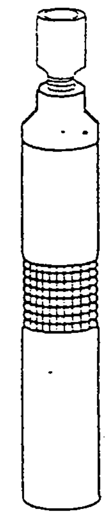


FIGURE E

Selecting a Submersible Pump





Submersible Pump

FIGURE F

Handbook #9
BEACHFRONT HOME GRAYWATER SYSTEMS

Introduction

Many beachfront homes differ from inland homes. They are easier to plumb for graywater systems than inland homes because the sand quickly accepts the graywater flow and many homes allow easy access to pipes. There are also some difficulties. There may not be room for plants (although many homes could plant but don't).The sand fills up the voids in a drainfield and makes them less useful. The sands may shift and cause pipes to snap off. The runoff from the home or street may wind up in the same area as the graywater system. This handbook outlines a simple system custom-designed for the beach sands. Other systems will work, including drip systems if you have enough area and plants to irrigate.

Most beachfront homes have areas on the side or front of their homes for small volume (washing machine only) graywater systems.

The underground systems may be installed under some patios or bricked areas, especially if there are plants within 10 feet, setbacks can be met, the foundation is not jeopardized, and runoff is properly managed. If you are installing under a patio or bricked area, the City will make the decision as to its safety and practicality.

You may use the area reserved for the future septic tank drainfield replacement if you are willing to record a covenant against your title so that any future buyer will know the reserve area contains a graywater system. To replace the drainfield, the existing drainfield may require excavation, removal, and replacement with new, imported sand as required by the City.

The 70 to 100 GPD Graywater System

This system will handle your washing machine plus a bathtub. See **Handbook 3** for retrofit and for calculating total graywater flow from your home.

The easiest graywater system is an above-ground surge tank (**Handbook 6**) with a beachfront drainfield. The surge tank can pass small solids like hair or lint. The solids shorten the life of the drainfield. To extend the life span of your graywater system, you can add a filter which requires cleaning or build a "mini-septic tank" which will remove lint and other floatables (**Figures A** and **B**).

TANKS

The surge tanks must have an overflow to the septic tank or sewer unless otherwise approved by the City.

The surge tanks or holding tanks should have a minimum volume of 55 gallons. If more than 70 to 100 gallons is generated on any one day of the week, then two holding tanks are required. The larger the volume of the tanks, the less chance of an operational mishap.

The surge tank should be a material that is resistant to salt corrosion.

The tanks must have a solid base. A concrete slab that is as wide as possible, but at least 6 inches wider than the tank, is required.

For details of attaching pipes to surge or holding tanks, see **Handbook 6**.

BEACHSAND DRAINFIELD

Warning: Do not place the tank or drainfield closer than 5 feet above the summer-time water table or the tank will sink and the drainfield collapse.

Warning: Make sure no runoff from street, patios, porches, roof drains, roofs, or other hard surfaces flows onto or adjacent to the graywater system.

The drainfield is custom-designed for beachsand (**Figures C, D, E and F**). Construction steps are given for square and circular holes.

CALCULATIONS FOR SMALL VOLUMES

For a washing machine with usual use of one load every day, one 3 foot diameter circular hole or one 3 foot square hole is acceptable.

For 70 to 100 gallons of graywater each day, here are square and circular dimensions:

Circular (using flexible plastic)

Two hole system. Each hole is a 3 foot diameter circle. Each requires 2 feet of gravel plus 2 feet of top cover, a total of 4 feet depth.

Single hole system. A 5 foot diameter circle with 2 feet of gravel and 2 feet of top cover, a total of 4 feet depth.

This is the minimal acceptable drainfield. A larger or deeper circle will improve graywater dispersal. Deeper is better.

Square (using thin plywood or equivalent)

A rectangle, at least 3 feet wide and 3 1/2 feet long. Depth must accommodate 2 feet of gravel plus 2 feet of top cover, a total of 4 feet depth.

This is the minimal acceptable drainfield. Any larger or deeper square or rectangle will improve graywater dispersal. Deeper is better.

CALCULATIONS FOR LARGE VOLUMES

For larger systems, calculate the size of the hole as follows. *Choose the larger of the two numbers.* These calculations must be presented to the City.

Calculation A

The size of the hole must accommodate the full volume of each day's graywater discharge. The hole must have about *twice* the volume as the discharge because the gravel fills about half the hole. Minimal hole size = 2 X daily volume. The hole itself must have an additional volume for the 2 feet of cover above the filter fabric. (The 2 feet is not part of the volume used to accommodate a full day's flow.)

Calculation B

This calculation is based on 5 gph infiltrating through 1 square foot of sidewall of the hole. Bottom area cannot be used in this calculation. The amount of sidewall required is daily flow (in gallons) ÷ 5.

Cylinder-shaped hole: Calculate the cylinder's sidewall by $S = 2\pi rh$, where S is sidewall; $\pi = 3.14$; r is the radius of the cylinder, and h is the depth. (In construction remember to add the 2 feet of cover for total hole depth. This cover is not to be included in sidewall calculation.)

Rectangular-shaped hole: Calculate the rectangle's sidewall by S = 4hw, where S is sidewall, h is depth, and w is width. (In construction, remember to add the 2 feet of cover for total hole depth. This cover is not to be included in sidewall calculation.)

CONSTRUCTION

Step 1

Using a box of plywood or a circular sheet of flexible fiberglass or plastic, frame the hole you need to excavate. Dig the hole, pushing the plywood or fiberglass downward as you dig to prevent the sand from backfilling the hole. These holes will be hard to hand dig unless they are 3 feet in diameter or more.

Step 2

When the hole is excavated, place an inner square of plywood or a cylinder of plastic or fiberglass sheeting within the hole. There should be about 12 to 18 inches between the outer frame and the inner frame. Fill the outer volume with pea gravel.

Step 3

Place 12 inch of pea gravel on the bottom of the inner framing. Install the perforated pipe and the right-angle bend. Fill in the remaining space with the 1 inch to 2 1/2 inches clean gravel. Move it around so it settles into the hole.

Note: The perforated pipe should be of 3 inch diameter and have holes on all sides. If holes are not on all sides, drill them. Pipe holes should continue up the pipe to the top of the gravel fill.

Warning: The gravel should have no fines (dirt or dust).

Step 4

Remove the frames. If settling occurs, cover the top with more gravel until all perforations are 6 or more inches below gravel.

Step 5

Cover the hole with landscaper's filter fabric. Place the fabric at least 2 feet beyond the outermost edge of gravel.

Step 6

Attach the bend on the perforated pipe to the pipe from the tank. Cover the filter fabric (and, if close to the ground, the pipe) with at least 24 inches of sand, preferably more. Mounding will help because the sand will sink or move around.

Optional: Place the plywood or plastic over the filter fabric before covering with sand. This will help prevent caving in from the top.

Two Simple Graywater System Pre-Filters

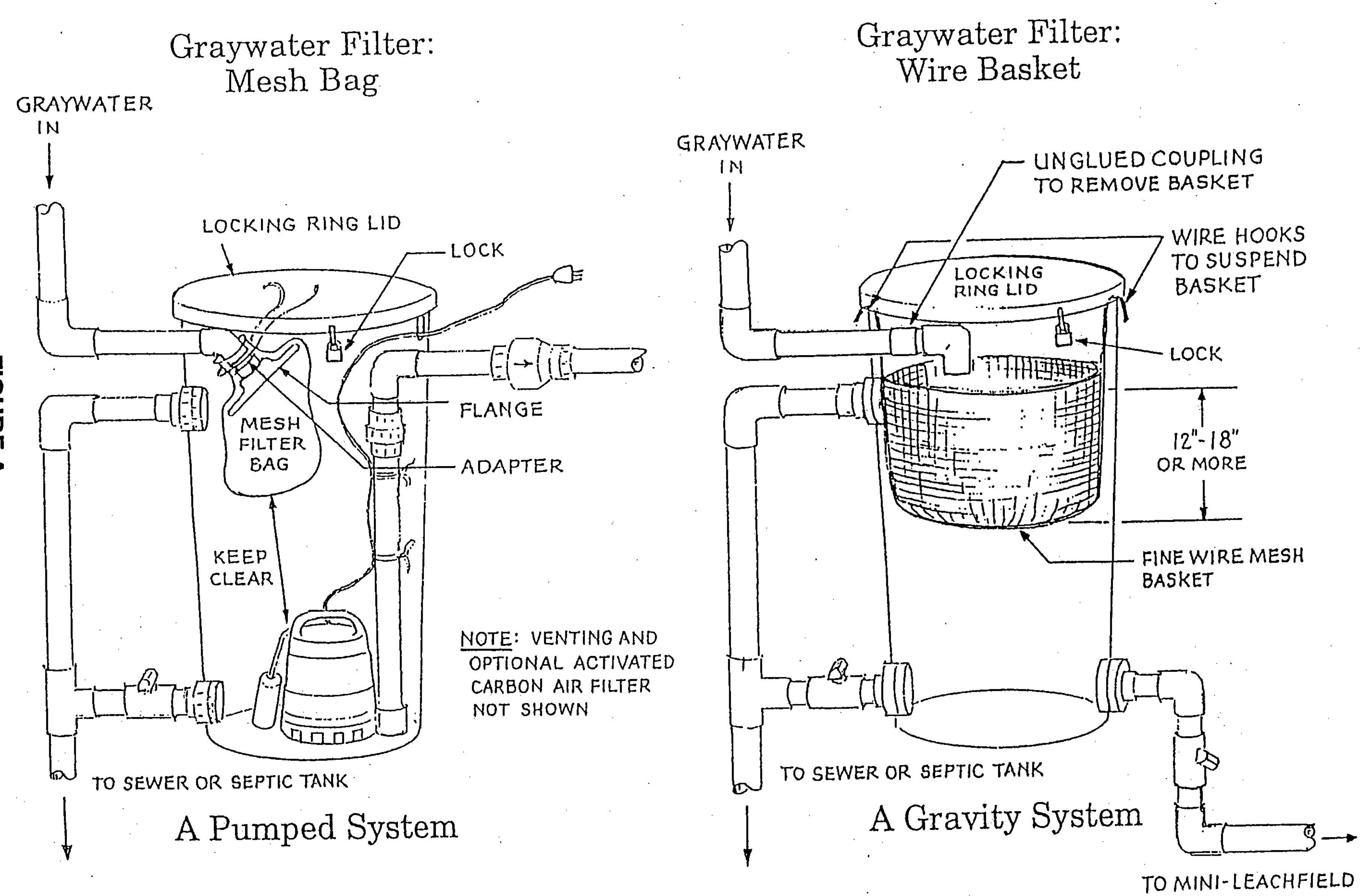
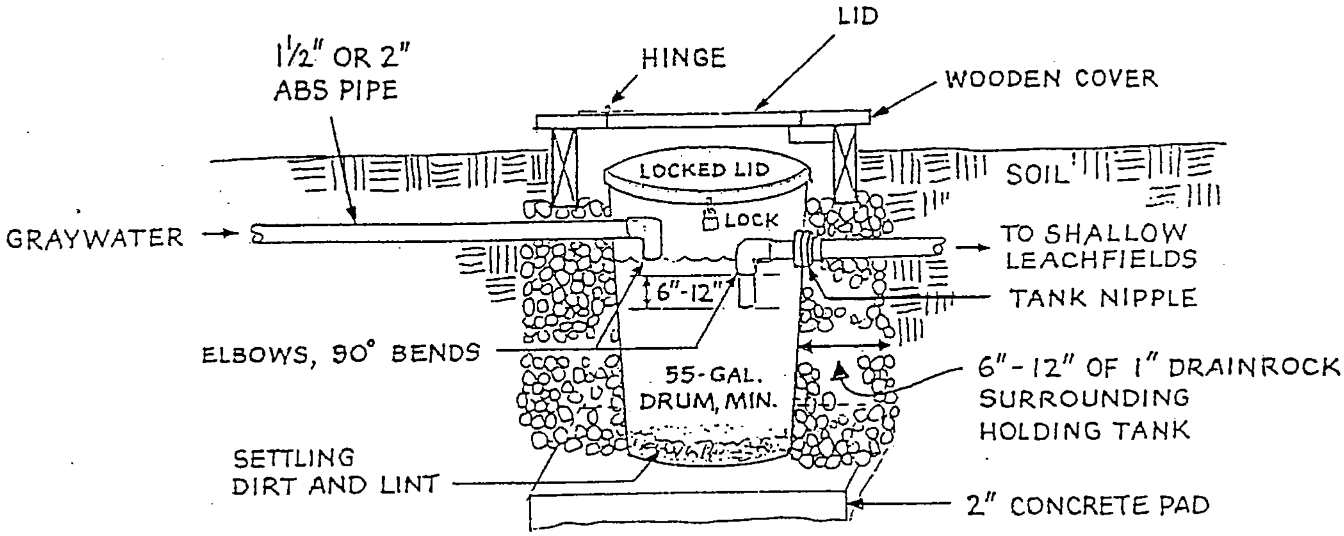


FIGURE A

Near Surface Holding Tanks

NOTE: VENTING NOT SHOWN

ONE TANK



TWO TANKS

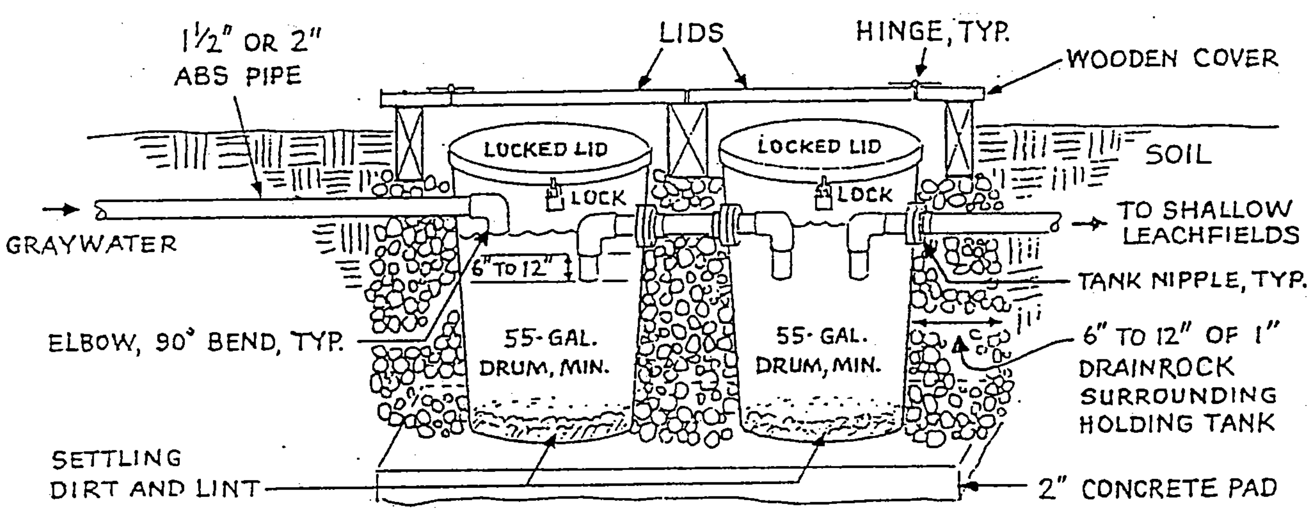
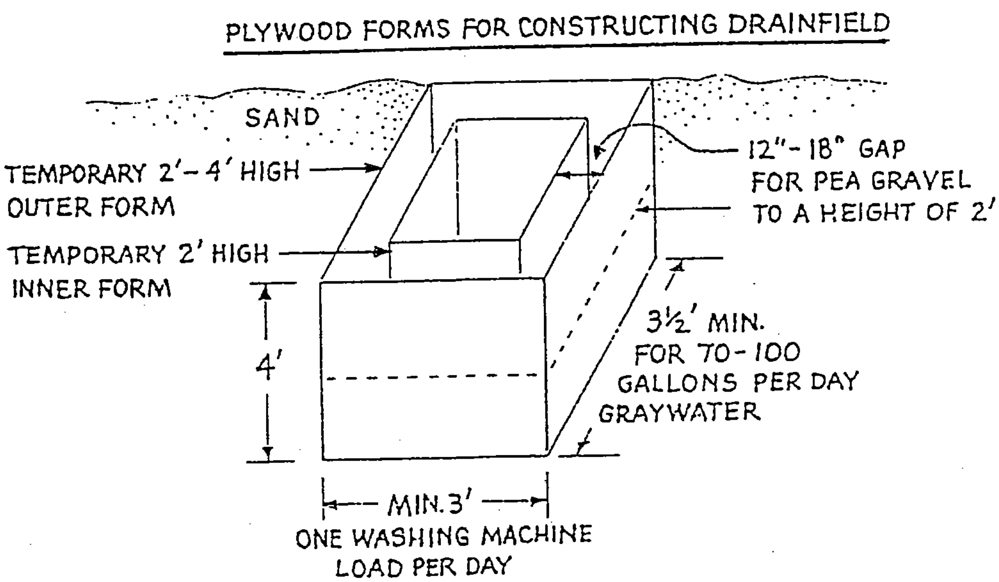


FIGURE B

Rectangular Drainfield for Beachfront Graywater Disposal



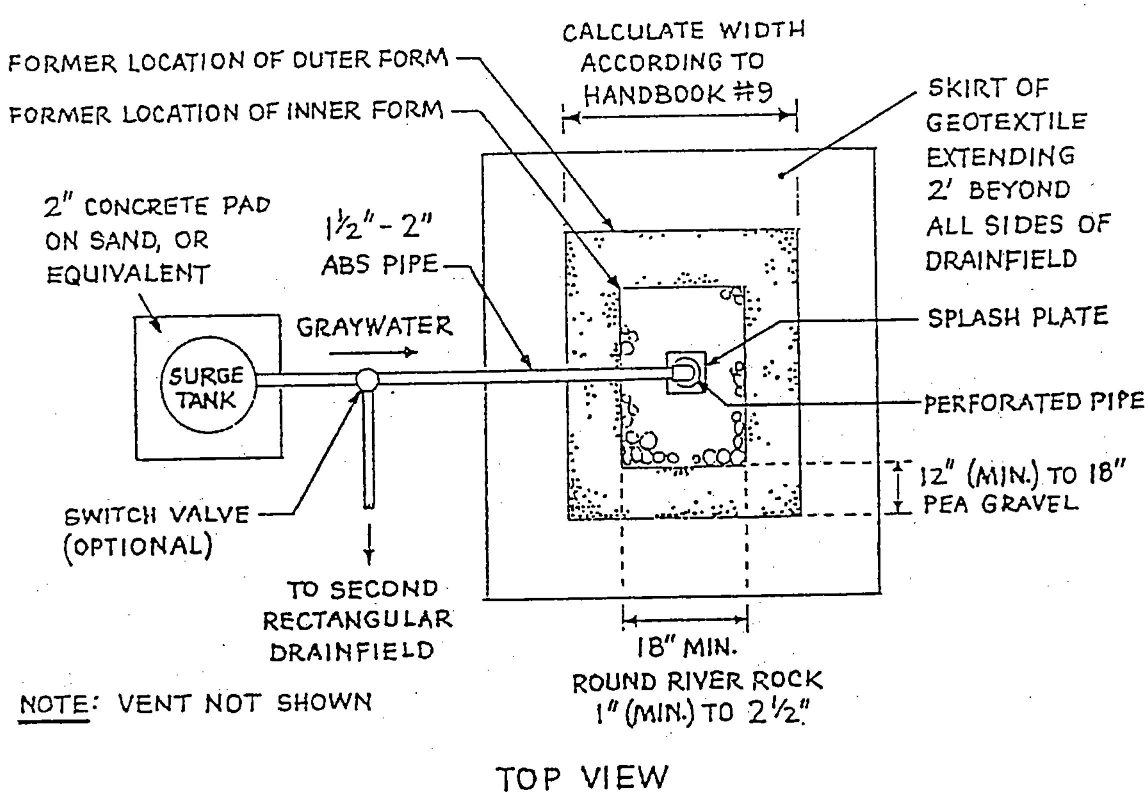
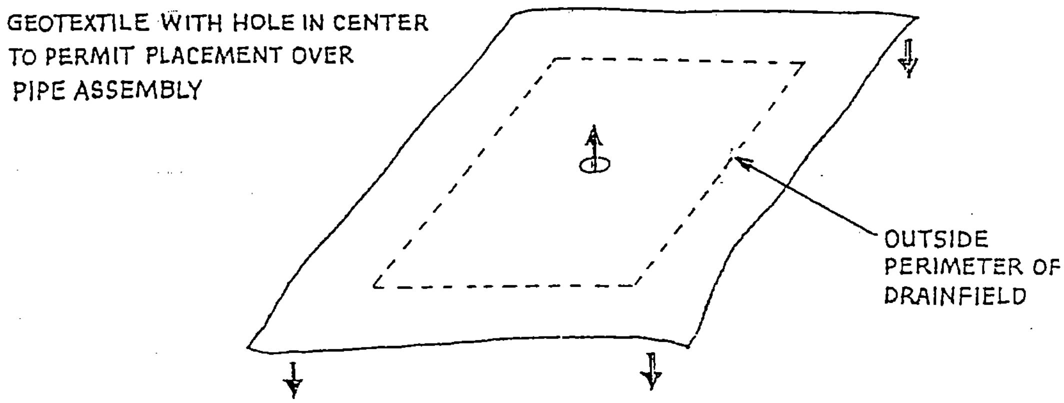
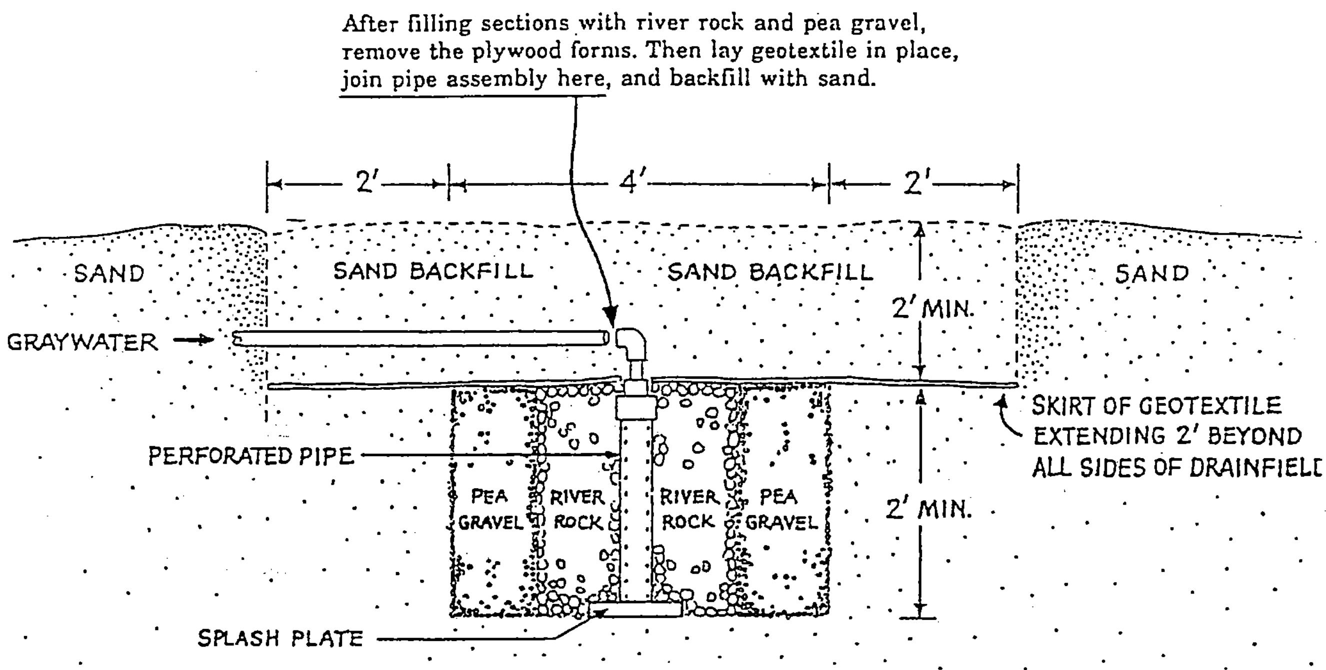


FIGURE C

Rectangular Drainfield for Beachfront Graywater Disposal





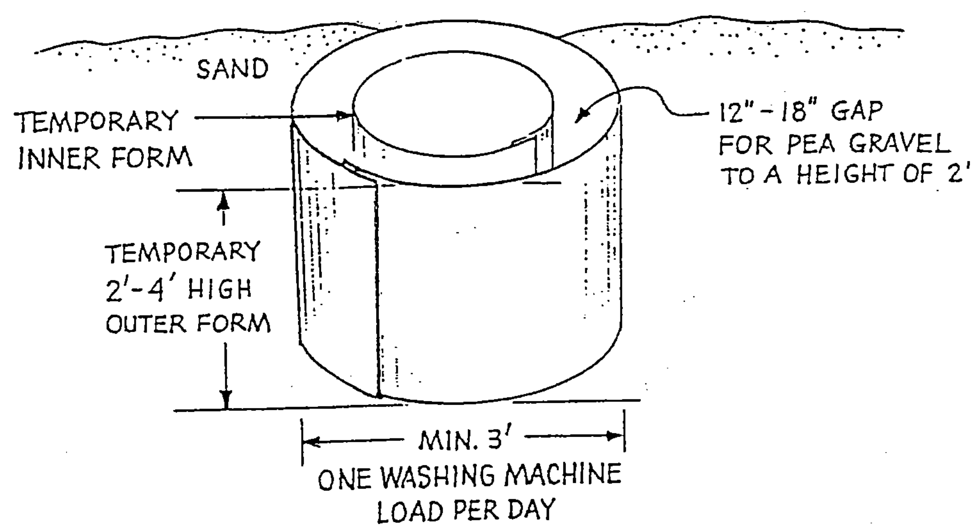
FRONT VIEW—CROSS SECTION

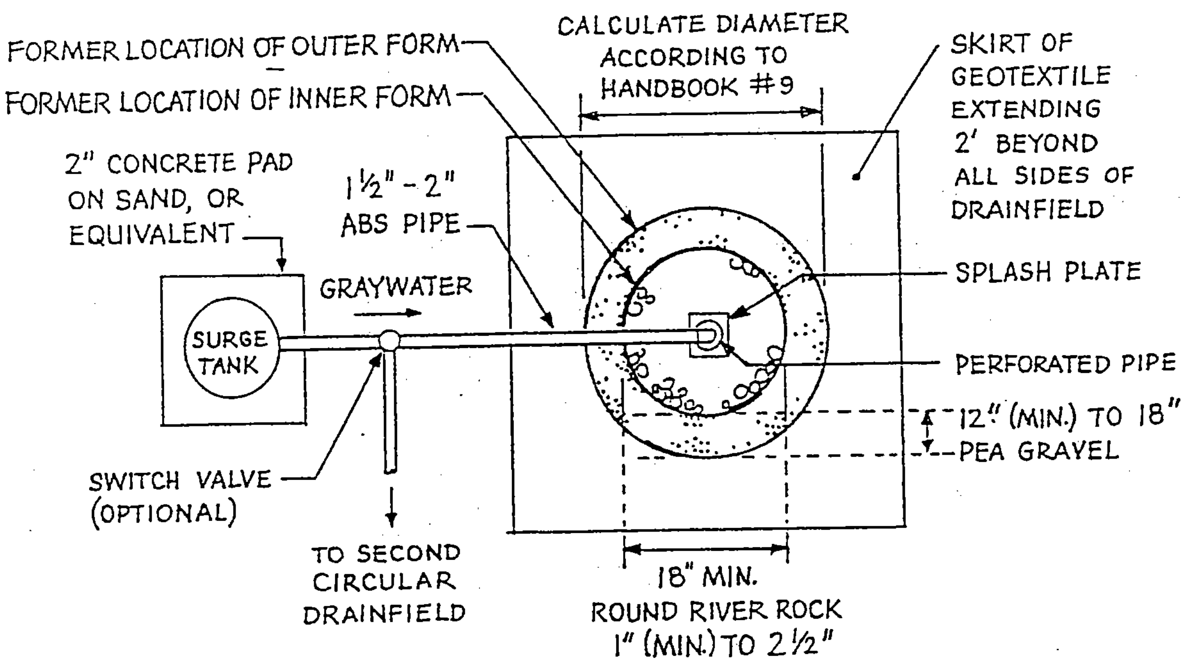
SHOWN AFTER REMOVAL OF FORMS

FIGURE D

Circular Drainfield
for Beachfront Graywater Disposal

FIBERGLASS FORMS FOR CONSTRUCTING CIRCULAR DRAINFIELD



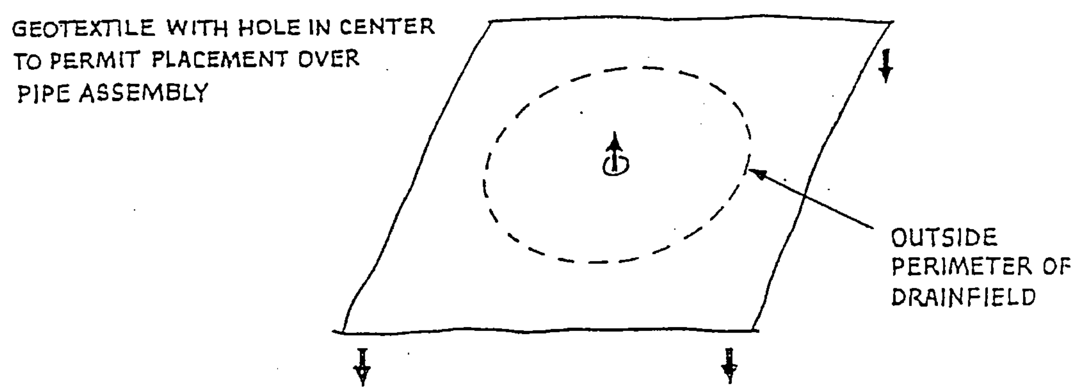


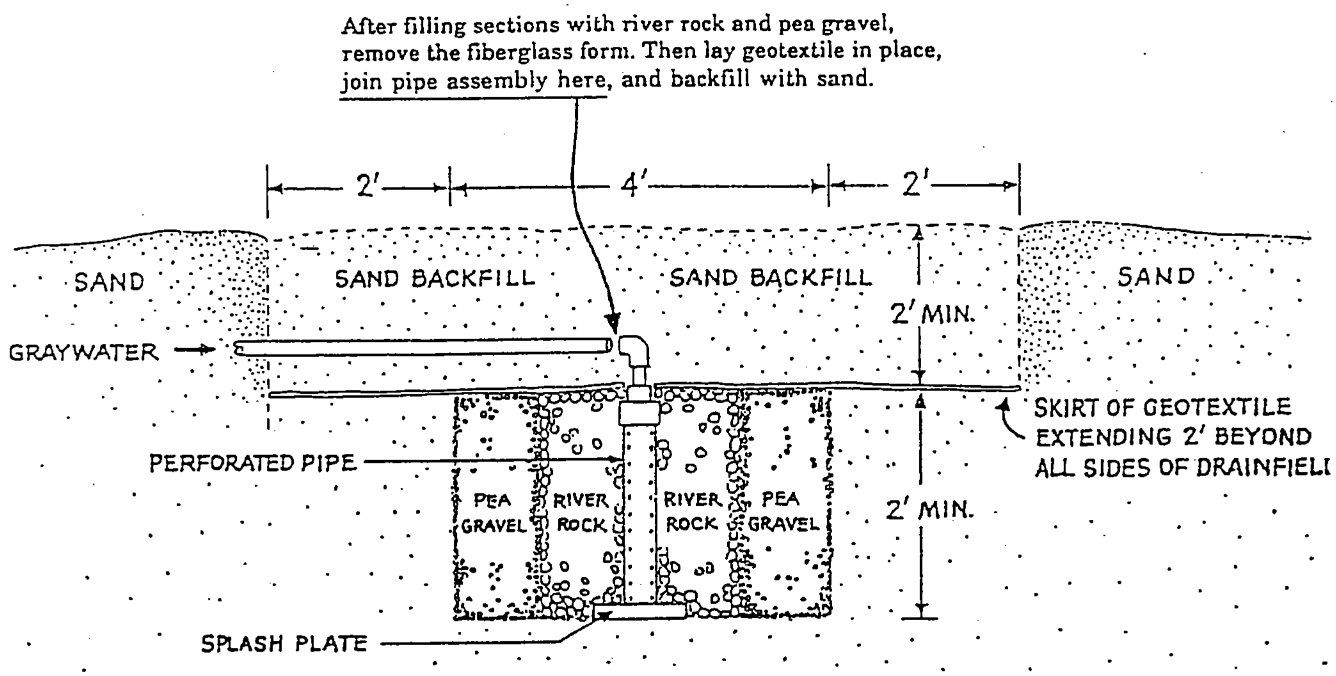
NOTE: VENT NOT SHOWN

TOP VIEW

FIGURE E

Circular Drainfield
for Beachfront Graywater Disposal





FRONT VIEW — CROSS SECTION

SHOWN AFTER REMOVAL OF FORMS

FIGURE F

Handbook #10
DEMONSTRATION & LARGER VOLUME SYSTEMS

Demonstration Systems

The City of Malibu would like to encourage demonstration systems for graywater reuse, especially water storage for fire protection and irrigation, but it must balance its responsibilities for public health and safety and City liability with the demonstration system proposed.

• A demonstration system is any system which has been successfully implemented or tested in other areas or tested in other areas but has never been used in the City. A system that has never been used before *in any other* location will probably meet with expensive monitoring peer review costs. In general, these review periods will last two winters to three years.

• To avoid gimmicks or miracle fixes that can greatly burden administrative time and may cause local nuisances, if not hazards, the City will accept only sound, well-engineered systems.

• The City will not sponsor its own program of testing demonstration graywater systems. It will accept applications from any home owners with a suitable location and reasonable plans.

• Constructing a demonstration system without notifying the City is a violation of City ordinances.

• Approval will be easier if the owner can divert the graywater back to a working septic tank system or package plant sewer. The septic tank system must be designed to take the increased load.

• Approval will require a careful operations and maintenance manual. This should be prepared before applying. If you expect monitoring to be required, design the monitoring program for review. Monitoring will usually be performed by a monitor certified by the City at the owner's expense.

• The designer, installer, and users of a demonstration system must agree, in writing, to hold the State of California, the County of Los Angeles, and the City of Malibu harmless of any loss or damage caused by the system. They must agree to replace, modify, repair or abandon the system if it operates unsatisfactorily.

• Disposal only systems will be required to follow City regulations.

Larger Volume Systems

Applicants who wish to reuse their graywater from large systems for irrigation, fire protection, reduction of deep percolation to groundwater or to benefit their on-site system are encouraged by the City. Within the limits of the City's health, safety, and liability requirements, the City will provide incentives to those large users who want to reuse graywater for beneficial purposes.

• A large system is actually any graywater system which differs significantly in strength, volume or quality from graywater produced by a single family home. Since home graywater is so variable, there are no rigid standards for what the City means by "differs significantly." Each situation may require testing or monitoring water volumes.

Large systems such as laundries, multiplex apartments, mobile home parks, or dual-plumbed motels in which the bathwater is to be treated separately will be treated as on-site wastewater systems (Appendix I, UPC) by the City. See "Demonstration Systems" in the **On-Site Wastewater** series of handbooks.

• The applicant must present a preliminary plan for the graywater system to the City. This application must include average daily flow, anticipated peak flows, design flow and storage, water conservation practices (if any), the sources of graywater, water quality estimates, a preliminary operations and maintenance schedule, as many safety (backup) alternatives as possible, and a preliminary discussion of what health or safety hazards might arise and how the applicant has mitigated them. The applicant should have on hand a competent professional experienced with wastewater. This consultant may be called upon by the City. Plans must not be finalized too soon as interaction with the City may require changes.

• A peer review process may be required at the City's discretion. An operation and maintenance manual is a requirement. Monitoring, especially of the drainfield, can be anticipated.

• Permit fees will be decided on a case-by-case basis. They will depend on the extent of peer review, number of site inspections, and monitoring requirements.

Handbook #11
ACCESS TO EQUIPMENT, BOOKS AND A GLOSSARY

Access to Graywater Equipment, Books and Other Resources

MAIL ORDER, General Outfitters:

Aqua-Flow Supply
453 Lopez Rd.
Goleta, CA 93117
805-967-2374 voice
805-967-5509 fax

Makes a simple graywater kit with drum and sump pump.

Oasis Biocompatible Products
5 San Marcos Trout Club
Santa Barbara, CA 93105-9726
805-967-3222 voice
805-967-3229 fax

Makes the only custom-designed detergents and soaps for graywater systems. Not toxic to soils or plants and helps promote plant growth. Call for local retail outlets.

Real Goods
966 Mazzoni St.
Ukiah, CA 95482-3471
800-762-7325 voice
707-468-9486 fax

For Oasis™ (a custom-designed detergent for graywater systems), 12 VDC pumps, water conservation gizmos, waterless toilets, manuals, books and some drip irrigation hardware.

Ted Adams, Fluid Systems
2800 Painted Cave Rd.
Santa Barbara, CA 93105
805-964-1211 voice and fax

Source of the useful but hard-to-find, two and three way diverter valves.

DRIP IRRIGATION:

AGWA Systems, Inc.
801 S. Flower St.
Burbank, CA 91502
818-562-1449 voice
818-843-7132 fax

Perhaps the best automated, filtered graywater-to-drip irrigation system on the market. Participated in the Los Angeles Graywater Pilot Program with one drip irrigated lawn and one shrubbery irrigated landscape. Both used highly filtered graywater and automatic backflushing of the filtering media. No maintenance of the graywater hardware is required. Has been installed on many properties in southern California.

Drip Irrigation Garden
16216 Raymer St.
Van Nuys, CA 91406
818-989-5999 voice

Drip irrigation supplies. Free catalog.

Harmony Farm Supply
PO Box 451, 4050 Ross Rd.
Graton, CA 95444
707-823-9125 voice
707-823-1734 fax

Complete mail order source of drip irrigation supplies. Ask for grower's supply catalog ($2).

The Natural Gardening Company
217 San Anselmo Ave.
San Anselmo, CA 94960
415-456-5060
415-721-0642

Sells kits with pressure-compensating, in-line emitter tubing and parts to extend kits to any size landscaped area. Provides free drip irrigation design to match your plans. Send for complete list of parts and prices.

The Urban Farmer Store
2833 Vincente St.
San Francisco, CA 94116
415-661-2204 voice, store
800-753-3747 mail order

Very complete mail order source of drip irrigation supplies. Ask for grower's supply catalog ($1).

BOOKS

Graywater Guide: Using Graywater in Your Home Landscape. 1994. California Department of Water Resources. Water Conservation Office. Marsha Prillwitz, PO Box 942836, Sacramento, CA 94236-0001.

Contains the full text of Appendix J (the California rules for graywater use and installation). Not as detailed as the **Malibu Handbooks**, but well written. Helps the homeowner figure out how to install a graywater system that meets the State's guidelines.

Create an Oasis with Graywater. 1994. Art Ludwig. Oasis Biocompatible Products. Available from Real Goods (see above).

Covers a wide-range of graywater systems with ideas on how to custom-design for your needs.

Gray Water Use in the Landscape. 1988. Robert Kourik. Santa Rosa, CA. Metamorphic Press. P.O. Box 1841, Santa Rosa, CA 95402.

The author is also co-author of the **Malibu Handbooks** and has installed graywater systems in Malibu. Written before California law changed the rules for installing graywater systems, this book places great emphasis on garden irrigation with graywater.

Malibu Wastewater Management Study: The Human Ecology of a New City. 1992. Peter Warshall and Associates and Philip Williams and Associates. 262 pp. Available at Malibu City Hall.

Malibu is the first American municipality to write a graywater ordinance and provide detailed handbooks with user-friendly guidelines. This is the background study that led to the writing of the **Malibu Handbooks.** Includes the most comprehensive overview of the ecology of Malibu, a description of "outlaw" systems, water use in Malibu, a discussion of health risks, water conservation, and design needs.

Manual for Judging Oregon Soils. Oregon State University. Extension Manual 6.

Although directly addressing Oregon soils, this manual is one of the best for learning how to identify your home soils for the purposes of accepting, treating, and dispersing or disposing of wastewater. Good photos. We have used their methods in **Handbook 5.**

A GLOSSARY FOR GRAYWATER AND IRRIGATION WORDS

adapter - Any plumbing or drip irrigation part which connects one size pipe or part to another. Often used to refer to the female fitting, whether glued or threaded, which joins different parts together.

actuator - A 24 VAC motorized valve, used to automatically control valves. Unlike a solenoid, this valve's opening and closing is powered by the motor, not the pressure in the pipe. Because it works without any water pressure in the pipes, it's the most practical valve for many graywater systems.

aerobic soil - A well-drained soil with sufficient pore space to allow plenty of air circulation. The pore space is usually dependent upon the texture (sand is most open) and a reasonable amount of organic matter and humus.

anionic surfactants - A cleaning agent, most commonly some form of sodium salt. Usually found in high sudsing detergents. (See sodium chloride.)

Appendix J - The rules passed by the State of California governing the installation of graywater systems in California.

ball-valve - A valve which has a globe-shaped rotating interior. The solid globe has a circular tunnel through it. When the handle of the valve is rotated, the solid portion of the ball cuts off the flow of water. Another rotation lines up the tunnel and water flows through the valve. Ball-valves are often found at the discharge port of quality y-filters. Because ball-valves shear off any contaminates and because they don't easily wear out like gate valves, they are the preferred valve for graywater and irrigation systems.

beachfront zone - Beachfront areas of Malibu with a sand profile versus a soil profile.

boron - A chemical found in some detergents, boron doesn't easily leach away once it has been added to the soil. Plants react negatively to it even at very low levels. While boron seldom actually kills plants, it does cause a very noticeable blackening or browning of the leaf margin. Found in detergents with boron listed on the label, even "environmentally-sound" and biodegradable versions.

buffer tank - See surge tank.

centrifugal pump - A pump installed outside the surge tank, not submersed in the graywater. The centrifugal pump along with a diaphragm pressure tank should be housed in or under a weatherproof structure.

check-valve - A backflow preventer which stops any water siphoning back toward the house. Often not legal as the only backflow preventer in a potable-water drip system. Must be coupled with some form of atmospheric vacuum breaker.

chlorine bleach - Chlorine bleach is a caustic cleanser or purifier. Non-chlorine bleaching agents and hydrogen peroxide can be used

to get whiter-whites without the damage of chlorine bleach.

close nipple - A short, 3/4 inch pipe nipple. Because the length is so short, close nipples are completely covered with all male iron pipe threads. (See nipple.)

compression fitting - A type of fitting used to join two pieces of drip irrigation hose together. The hose is forced inside a circular opening which has a barbed, ringed opening and can't be easily pulled back out once inserted due to the circular barb. Unlike other types of fittings, this fitting seals better as the water pressure increases because the swelling hose squeezes more tightly against the compression ring.

controller - An electronic device used to automatically turn irrigation valves on and off. Plugs into the home's 110 VAC power and steps the power down to 24 VAC to control the solenoid valves. Unlike a timer, controllers usually service more than one irrigation line or zone. Most modern controllers are operated by computer chips and have a digital readout. (See timer.)

coupler - Also called a coupling. Used to join two pieces of drip irrigation hose together.

cross-connection - When a dirty water supply, such as graywater, is plumbed with a fitting or valve to the fresh, potable water supply. Even with the valve(s) closed, contamination of the potable water is possible. It's tempting with a graywater system to connect to potable water to use the clean pressurized water to backflush the filter, but too risky. Not allowed with graywater systems.

crown - The crown is the upper 6 to 12 inches of the plant's root system. This is the zone most vulnerable to crown rot

daylighting - When graywater is exposed on the ground surface (sees the light of day). To be avoided at all costs.

diaphragm - Some emitters use a flexible internal diaphragm, usually some type of rubber-and-plastic combination, to modulate the flow of water and help purge the emitter of built-up sediment. Unreliable with graywater systems because chemicals in graywater can erode, harden or degrade the diaphragm so that it fails to regulate the water's flow.

disposal system - A disposal system, mini-leachfield, or shallow leachfield is more like a septic leachfield, but the graywater is applied much closer to the soil's surface. While shrub and tree roots may utilize all graywater in a disposal system, it is designed primarily to safely disperse the graywater while insuring it doesn't percolate up to the soil's surface.

distribution valves - One or more manual or automatic valves that control the application of the graywater to various portions of the landscape. For the sake of the plant's health, the graywater should be alternated between two separate watering areas (zones) or rotated through a number of zones. This rotation allows a resting time so the soil's pores can drain and breath in fresh air.

draindown header - The drip hose, whether solid or with in-line emitters, which collects the water at the end of all the laterals furthest from the supply header. A flushing or threaded end cap may be added to the draindown header making it easier to flush the hose and draindown water for winterization.

draindown valve - A valve plumbed from the surge tank to the sewer or septic line, with a protective one-way check valve, to allow for draining and cleaning the tank.

drip - A style or technology of irrigation where a tiny trickle of water is slowly applied to the soil.

drip hose adapter - The first fitting after the main assembly of a drip irrigation system. Almost always a fht (female hose thread) swivel X drip hose adapter. The female hose threads of the swivel go on to the male hose threads of a hose-bib or a transition nipple. The swivel action makes it easy to quickly add or remove this fitting. The other side of the adapter is either a slip (glue), compression, insert or Spin Loc™ part, depending upon the system.

drip line - A length of solid drip irrigation hose or in-line emitter tubing.

dripline - The width of a tree's or shrub's foliage, where water would drip off the edge of the canopy. Not an indicator of the width of the root system as roots grow from one half to three times wider than the dripline.

dual plumbing - A permanent separate set of pipes for all the graywater sources in the home.

elbow - A fitting which allows drip hose or pipe to make 90 degree turn.

emitter - The little gizmos attached or built in to solid drip irrigation hose which control the flow of water to the soil. There are many name-brand versions of emitters, but they basically fall into four generic styles or technologies: single diaphragm, double diaphragm, tortuous (or complex) path or simple orifice.

end cap - The fitting added at the end of a lateral to make it easy to open the tubing for draining or flushing. Has a female hose thread cap with a washer which threads on to the male hose thread fitting. The other end will be either a compression, insert or Spin Loc™ opening, depending upon what system you have.

ET - See evapotranspiration.

evapotranspiration (ET) - The loss of water from a plant or crop via transpiration (exhaling) by the foliage and evaporation from the plant's and soil's surface. The ET rate is influenced by humidity, rainfall, slope aspect, wind speed, temperature, plant care and soil.

figure eight end closure - A simple end closure which involves threading the end of the drip hose through one side of the figure eight, bending over the end of a drip hose and securing the bent end inside the other half of the figure eight.

filter - A device with a screen (cheap, poor-quality models have plastic screens) which is used to trap any particulates, dirt, or scum before it can enter the drainfield or clog the drip emitters. An essential component of all graywater drip irrigation systems. (See also pre-filters.)

fipt - Plumbing shorthand for a female iron pipe thread.

flapper check valve - A valve that prevents any water from siphoning back into the surge tank.

GFI - A ground fault interrupt outlet. All sump pumps must be plugged into a GFI outlet.

gph - Stands for gallons-per-hour.

graywater - Graywater is all untreated wastewater which hasn't been mixed with the water from a toilet (black water). The largest amount of daily graywater is the used water

from the shower, bathtub and washing machine. Rarely includes kitchen sink. Contains more nutrients than well or city water and is therefore more beneficial for plants.

head - A pump's head is the gross difference in elevation. As a safety factor, the head for a graywater system is determined by adding the total changes, both up and down, in the elevation from the surge tank to the point of disposal. To this figure add at least 15% more feet of the total head. (Don't expect your pump to last long if it's always pumping at the uppermost limit of its rated capacity.)

hose-bib - Another name for a garden faucet. The standard gizmo on the pipe sticking out of the house's exterior wall or on top of a metal water pipe in the yard and onto which the garden hose is attached.

hose shut-off valve - A small ball-valve which can be added at the end of a hose to control water without having to run back and forth to the hose-bib. With a few extra parts, this valve can be spliced into any drip hose and allow the gardener to exclude water from portions of a system. Often used to rotate graywater to different zones as needed.

in-line emitter hose - A more recent and effective type of drip irrigation hose where the emitters are manufactured inside the hose at regular intervals. The pre-spaced emitters use a tortuous path technology for water regulation without clogging. Water can be distributed at 1/2, 1 and 2 gph rates at many separate intervals ranging from 12 to 72 inches.

inland soil zone - Most of the inland areas of Malibu which contain loamy or clayey soil types, as opposed to the pure sands of the beachfront.

insert fitting - These fittings have male-shaped parts with barbed exteriors which insert inside the drip irrigation hose. As the water pressure increases, the fitting is more likely to fail because the swelling drip hose can bloat away from the barbed posts. Must use a ring clamp to secure the hose against too much pressure.

J-stake - A landscape pin used to secure drip irrigation hose, landscape netting and 12vdc wiring. Made like an upside down version of the letter "J" in the alphabet. Not as sturdy as the best U-stakes.

labyrinth - A complex, tortuous path inside certain emitters. The labyrinth of passages keeps any sediment in the water in suspension to pass out the emitter's orifice. All in-line emitter tubing uses some form of labyrinth to allow for a relatively large emitter orifice and to keep the emitter from clogging.

lateral - A lateral is a water-bearing pipe or drip hose which originates as an offshoot of a main supply pipe. Laterals are usually attached to the supply header via a tee.

leachfield - See shallow leachfield.

main assembly - The collection of parts at the beginning of a graywater system which filters the graywater to the drip emitters and regulates the water pressure to keep the drip system intact. Composed of a filter and pressure regulator plus the miscellaneous parts needed to connect everything together.

main switching valve - A main valve is required to allow the homeowner to alternate between the graywater system and the septic tank or sewer. Use the main valve when the ground is saturated with rainwater, when someone is ill with an infectious disease or the occupants don't want to use the graywater

irrigation system. The main valve, whether manual or electro-mechanical, is best plumbed near surge tank.

mesh - Most drip irrigation filters are rated by mesh size. The larger the mesh number, the better the filtration because smaller particles can be trapped. Many metal screen filters are either: 60 mesh (254 microns or .010 inches), 100 mesh (152 microns or .006 inches), 140 mesh (104 microns or .004 inches) or 250 mesh (61 microns or .0024 inches). Graywater systems should use a 200 mesh, or better, filter.

micron - A common measurement for irrigation parts. The bigger the micron number, the bigger the opening. A single micron equals one-millionth of a meter. It takes 254 microns to equal .010 inches, which equals a 60 mesh screen. Most graywater systems should have a 75 micron, or better, filter.

mipt - Plumbing shorthand for a male iron pipe thread.

mini-leachfield - See shallow leachfield.

mulched watering moats - A simple 18 inch deep ditch dug beneath the outside edge of the tree's foliage or canopy (the dripline). A permanent dedicated hose or pipe brings the graywater to the moat and, to prevent daylighting, the moat is filled with a rough bark or wood chip mulch.

nipple - Comes in plastic and iron versions with male iron pipe threads on each end. Plumbing nipples range in size from 3/4 inches long to 48 inches. Used to join two female iron pipe threads together.

overflow port (automatic) - An overflow pipe near the top of the tank dumps graywater to the sewer or septic tank in case something clogs the surge tank or the sump pump fails.

pathogens - Disease-causing organisms. To become infected, an individual must be exposed to a large enough dosage and be vulnerable to the pathogen. Most pathogens can reside out of the body of a host, in the soil, for a period of time, but each disease has a different life span in the soil.

percolation test - A test to determine the ability of the soil to accept graywater. The test is only required at the request of the City Health Officer. (See soil tests.) Percolation tests can be useful but they may not reflect long-term acceptance rates.

phosphates - Chemical often used to help soften laundry water. Phosphorous chemically inactivates calcium, magnesium, iron and manganese without making a precipitate. The chemical so many environmentalists and regulatory entities focused on in the 1970s. Famous for "ruining" lakes and rivers. It is, however, a good ingredient for a graywater system because roots utilize phosphorous like a fertilizer. Since a graywater system is managed for the improved growth of the plants, the more phosphates the better. Phosphates won't leach off your property to harm creeks or rivers.

phytophthora - Genus of various species of fungal diseases which attack the upper portion of the roots to destroy the bark's active layers of transport. Often called crown rot.

porous hose - Unlike an emitter, where the water dribbles out at select points; the water in porous drip hose oozes out through the entire surface area of the hose's walls. This genre of drip hose only works well with chlorinated city water because it's so prone to getting clogged by sediment and becoming sealed off internally due to the buildup of various types of algae slimes. Not recommended at all with graywater, no matter how well filtered.

potable water - Fresh drinking-quality water. City or pure well water.

pressure compensating emitter - A special type of emitter engineered so that the flow rate stays the same regardless of the length of the line (up to a point) and any change in elevation. Required when irrigating landscapes with a total elevation change of 20 feet or more.

pre-filter - Usually a basket or mesh bag which catches most of the offending lint, hair and pariculates before entering the surge tank. Its. filtering surface area should be at least 2 square feet so that it doesn't clog quickly. The bigger the pre-filter, the better. Must be used with a graywater drip irrigation system.

pressure regulator - A gizmo which reduces the water pressure in a graywater drip irrigation to 25 psi or lower to protect the subsequent drip irrigation fittings. Must be installed in every main assembly.

psi - Stands for pounds per square inch, the unit of measure for water pressure. Typical home water pressure is 40 to 80 psi. Drip irrigation systems generally operate at 11 to 25 psi.

PVC - A type of semi-rigid plastic made from polyvinyl chloride which is often used for garden plumbing. Some of the more common grades of this pipe (from the sturdiest to the weakest walls) are Schedule 80, Schedule 40, Class 200 and Class 120, which resist bursting up to, respectively, 800, 400, 200 and 120 psi.

saline water - Irrigation or ground water which is high in salt (sodium chloride). While saline water is useful in many medical applications, it is not healthy for many plants. Graywater can be particularly saline due to the salts in many detergents, especially powdered detergents. (See list of recommended low salt detergents in **Handbook 4**.)

sch - Shorthand for the word "Schedule." Used to denote the type or grade of PVC pipe and fittings.

shallow leachfield - A perforated pipe surrounded by a trench of crushed rock (gravel). Similar to a conventional septic leachfield, Unlike a septic leachfield, a shallow graywater leachfield is only 20 inches deep, compared to 4 to 6 feet deep for a traditional septic leachfield.

slip - A PVC fitting with an opening which requires glue, as opposed to threads with pipe dope, to "weld" the two parts together. Usually the end of the rigid PVC irrigation pipe and the fitting are moistened with PVC glue and the pipe is slipped into the wet, round opening of the waiting fitting.

sodium chloride (salt) - Destroys soil structure and kills soil bacteria, beneficial soil life, root hairs and plants. Found in detergents and soaps, especially in powdered detergents.

sodium carbonate - Caustic alkaline salt used in powdered detergents to soften water by precipitating the hard minerals (calcium, magnesium, iron and manganese) out of solution. Also called soda ash or washing soda.

sodium citrate - Chemical used in liquid detergents without phosphates to soften water and improve detergent's effectiveness.

sodium perborate - A non-chlorine bleach which is gentler than traditional chlorine bleaches. In powdered detergents, sodium carbonate is often added to help perborate work better. Releases active oxygen while it's cleaning. Effected by temperature, hot laundry water shortens the time required for bleaching.

sodium phosphate (actually, sodium tripolyphosphate) - The most important form of phosphorous and the first builder (cleansing enhancer) used in modern detergent fabrication and manufacturing. (See phosphates.)

sodium silicate - Chemical used in powdered and some liquid detergents. Acts as a buffering agent with hard water, inhibits corrosion of the washing machine and keeps dirt suspended in the wash water.

sodium sulphate - Found in most granular detergents. Mostly neutral as a cleaning agent, but essential in the manufacturing process to increase the powder's pourability, in making the granules and helping to keep all the separate detergent compounds evenly mixed.

solenoid - An electric valve used to control drip irrigation systems. The wires to the solenoid usually carry 24 volts of AC power. The irrigation controller has a transformer to step down the house current. Dependent on the static line pressure of the water supply to assist in the opening and closing of the valve, therefore they often can't be used with a graywater system unless the system is fully-pressurized at all times.

spaghetti tubing - A tiny or slender type of polyethylene tubing which can be used to distribute water to emitters or plants. Comes in 1/4 and 1/8 inch diameters. Because of this tubing's propensity to twist around itself it will make a tangled mess in the landscape. Can be controlled when used in container plantings.

Spin Loc™ - A series of fittings that allow for easy connection of drip irrigation hose. Utilizes a male post the drip hose fits over and a threaded ring that tightens down over outside of the hose.

sub-system - A branched system of drip irrigation laterals originating from a main supply line or header. Unlike a single lateral, a sub-system, also called a sub-main, has several subordinate lines all connected by tees in a pattern similar to the lines on sheet music.

submersible high-head effluent pump - A 4 inch diameter submersible turbine pump made of stainless steel and high-quality thermoplastics specifically for pumping wastewater effluent. A special product from Orenco Systems, Inc. Develops higher pressures than sump pumps. The only submersible turbine pump with UL approval.

sump pump - A pump designed to be submerged in water, to automatically turn on when the water reaches a predetermined level and to pump the water a certain maximum height and distance at a specific rate in gpm or gph. Installed in the surge tank.

supply header - The solid plastic pipe, solid drip hose or in-line drip irrigation hose which supplies one or more laterals.

surface - Refers to the top of a thick, permanent mulch covering the soil or the top of an un-mulched soil. Graywater must not daylight on the surface. (See daylighting.)

surge tank - Usually a 55 gallon, high-quality plastic drum which allows for the temporary backup of graywater if it is generated faster than the distribution system can disperse it. While it looks like a small storage tank, it only holds water for minutes or a few hours.

swivel - The rotating fitting that can be screwed onto another fitting. Usually refers to female hose threads which are threaded onto the end of a hose, hose-bibs or drip irrigation parts. Usually requires a rubber gasket in the swivel to prevent leaks.

tee - A fitting which joins a lateral line (solid PVC pipe, in-line emitter tubing or solid drip hose) to another water supply line. Tees come in compression, slip (glued), barbed-insert or Spin Loc™ models.

three-way swing-diverter valve - A spa-type swing-gate valve which comes in manual form or with a 24 VAC actuator for automatic control. Used to divert graywater flow from one zone to another zone.

timer - A battery-powered controller which controls one irrigation line. Attaches to the hose-bib and controls the flow of water to a hose or drip irrigation system.

tortuous path emitters - Drip irrigation emitters with a complex, tortuous or labyrinth path within the emitter which allows larger particles to flow through the emitter without clogging. Best emitter for use with graywater and one of the more recent developments in drip irrigation technology.

transition nipple - A plastic or metal fitting with a male hose thread and a male iron pipe thread used to connect conventional garden plumbing to drip irrigation fittings.

two-way swing-diverter valve - A spa-type swing-gate valve which comes in manual form or with a 24 VAC actuator for automatic control. Turns graywater flow on and off.

U-stake - A landscape pin used to secure drip irrigation hose, landscape netting and 12VDC wiring. Shaped like an inverted letter "U" in the alphabet. Much sturdier than a J-stake.

union - Related to a coupling, a union is a plumbing part which, after unthreading the locking ring, separates into two pieces and allows you to take a portion of any irrigation system (providing there is an union on each end of the section) out for repairs without having to cut the pipe. The use of unions allows for the quick reinstallation of the repaired section without having to re-glue with extra fittings.

water softeners - Sodium-based compounds which remove minerals from water, thus adjusting water hardness. Water softener wastewater should not be connected to graywater systems or be used to irrigate .

wet spot - The wet spot in drip irrigation has both depth and breadth, the extent of which is dependent upon the rate of the dribble (in gph), the duration of the trickle (in hours), the soil type, the slope of the land and the climate.

X - Plumbing symbol for the word "by." Used to denote a fitting's specifications.

Y-filter - The best type of filter for a graywater drip irrigation system. Easily identified by the filter chamber which is integrated into the filter at an obtuse angle. The best Y-filters have a metal-screen filter within the filter chamber and a ball-valve at the end of the chamber to make it easy to flush the screen.