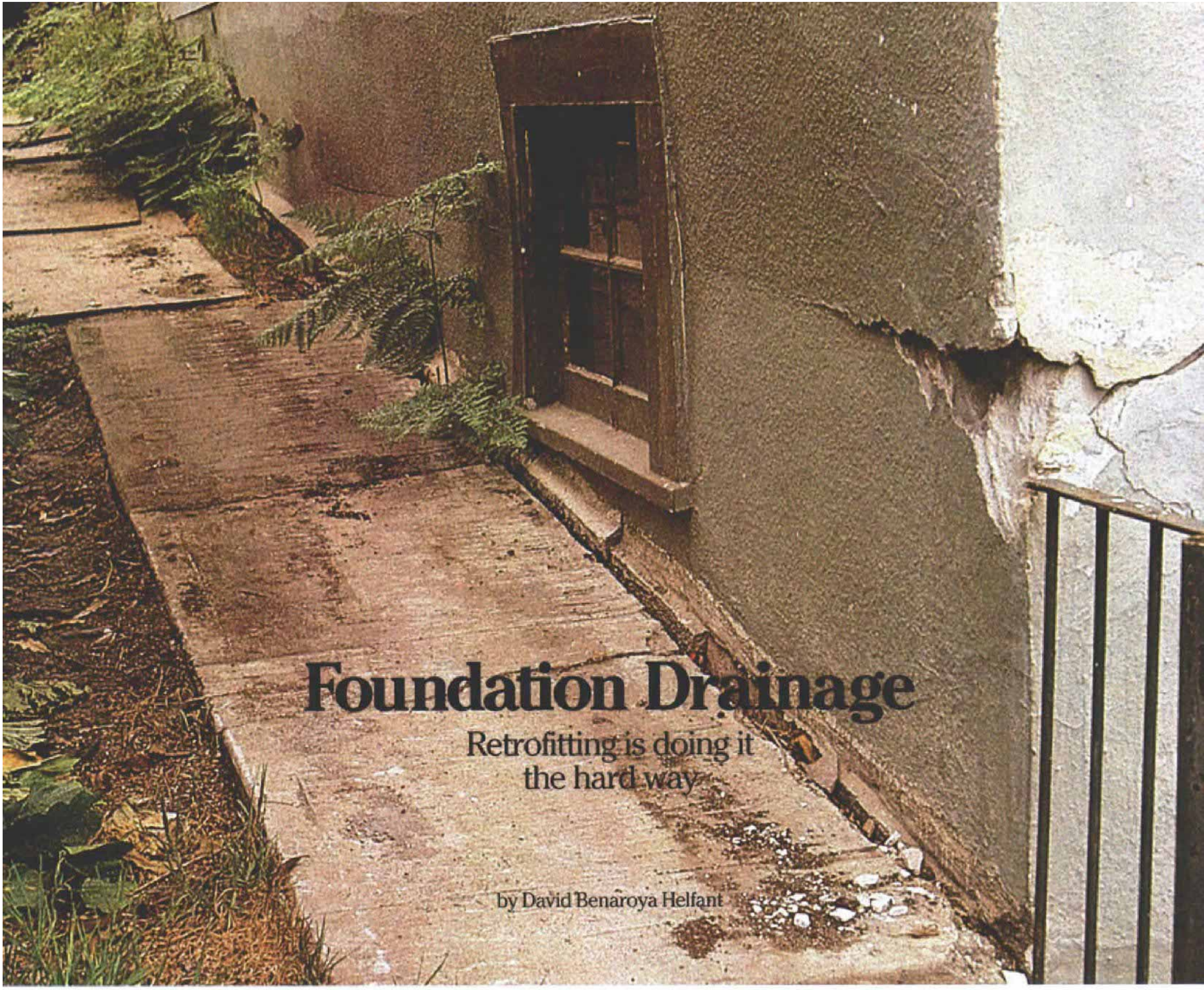


# Foundation Drainage

## Retrofitting is doing it the hard way

by David Benaroya Helfant

In a hillside community of homes I inspected recently, I found an interior stairway that rests on a "floating" concrete slab-on-grade. The owners of the house complained about the constant repairs needed to patch the drywall and baseboards that were connected to this stair. It seems that every time it rained, the stair would move up relative to the rest of the house. When the ground dried out, the stair sank.

The problem was that the stemwall foundation around the house was poorly drained, resulting in an inconsistent moisture content in the soil under the footings and allowing runoff to migrate beneath the slab some distance from the exterior stemwall. The slab was placed atop the undrained clay-laden soil, and there was negligible weight on the slab. Every time it rained, the clay expanded, taking the stairway for a short ride upward, tearing the drywall joints and wracking the baseboards, railings and casings out of alignment. The remedy to the situation was the placement of a drain uphill from the slab that diverted the water away from it.

The objective in designing and installing drainage systems around the perimeter of a foundation is to keep water from soaking into the soil and moving under the footings. Water initiates the undermining of a foundation by causing erosion beneath it, literally carrying away the soil upon which the footing bears. Often this is the prelude to building settlement. If the soils have a high clay content, poorly drained foundations can be cracked or rotated by forces exterted by the wet clay as it expands (photo above).

If the grade around a house is well-sloped, you may not need a subsurface drainage system. But if your house is on a hillside made up of soils that drain poorly, such as clay, subsurface drains can be essential to the long-term well-being of the structure.

In most cases, a structure won't be threatened with a terminal illness brought on by bad drainage, but it can suffer an abundance of minor maladies. A damp crawl space can cause mustiness, mold and mildew in a house, and fungus wood rot and termites thrive in this kind of environment. Soils under foundations that undergo dry/soggy cycles can bring on the familiar phenomenon of sticking doors and windows. While good site drainage may not solve all moisture problems (such as condensation), it can be effective in combatting cyclical changes, such as the floating-slab phenomenon described before.

**System basics**—An effective drainage system consists of two distinct systems: a subsurface drain to carry away the flow of ground, or subsurface water, and a surface drain to convey rain or snowmelt away from the building (drawing, facing page). The core of any subsurface drainage system is a network of perforated pipes laid at the bottom of trenches next to or near the foundations, and sloped to drain toward a suitable receptacle. The pipe is laid with the perforations pointing down, so that water seeping into the trench from below will rise into the pipe and be carried off. Above the perforated pipe is a run of unperforated pipe (photo right) that is used to transport runoff from roofs, patios, walkways and other paved surfaces. Typically, these pipes will lead to a dumping site 10 ft. to 20 ft. downhill from the house (more on this later).

You may ask, "Why can't I just run my downspouts into the subsurface drain, and do away with the surface drain?" Don't do it. Combining the two increases the potential for a clogged line, and it defeats the purpose of a subdrain by injecting water into the ground.

For most residential drain lines—both surface and subsurface—we use 3-in. dia. pipes. But if we're working on a hillside where we expect heavy flows, we'll install 4-in subsurface lines. If a large roof area is draining into a single downspout, we'll play it safe and install a 4-in. surface drain line to carry the runoff.

Pipes and fittings for drain lines are quite similar to those used for DWV (drain, waste and vent) work, but the fittings don't come in as many configurations and the pipes aren't as heavy. They also cost less—about 40% to 50% of what corresponding DWV materials cost.

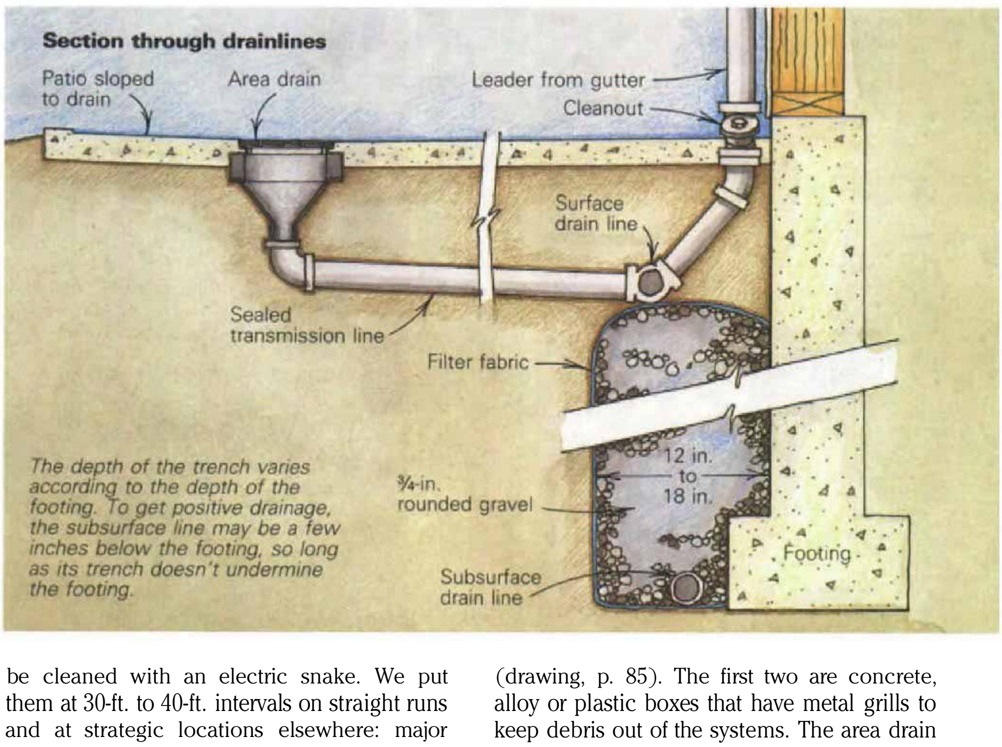
We prefer to use smooth-wall pipe and fittings made of polyethylene plastic for subsurface and surface lines. This is a fairly rigid pipe that can be cleaned by an electric snake without being diced up from the inside out. We specify pipe that is rated at 2,000 lb. of crushing weight. This is important because subsurface pipes are often buried well beneath the surface, and we usually compact the earth above them. Where the line passes under a sidewalk or a portion of a driveway that will carry traffic, we switch to cast-iron pipe and link the two materials with no-hub couplings.

When we can't get the polyethylene pipe, we use polystyrene pipe instead. But the crew doesn't like to work with this material because it's brittle, which makes it tougher to assemble the fittings and pipe sections. We never use clay-tile pipe, which comes in 12-in. to 15-in. sections that butt against each other. There are too many opportunities for sections to move differentially. Nor do we use the thin, corrugated polyethylene pipe, as an electric snake can rip it apart if a line needs augering to clear a blockage. Its weak walls make it suspect for deep trenches, and its fittings do not seem to seal well.

In deep systems where it is necessary to carry large volumes of water, corrugated galvanized-steel or thick-walled ABS or PVC pipe may be preferable. Under these conditions, you should consult a geotechnical engineer for specific recommendations regarding dimensions and types of pipe.

All of our drainage systems are designed with cleanouts, similar to conventional waste-line plumbing systems, so that the system can

***Two pipes.*** **To properly drain a structure, you need to pick up subsurface water moving through the soil as well as runoff carried from flat surfaces and roofs. The pipe in the bottom of the trench above is perforated, with its holes oriented downward. Gravel covers it to within a foot of grade, and filter fabric is folded over the gravel to keep fines from clogging the drain line. The top pipe carries surface runoff from downspouts and drains. The pipe stub projecting above the tamped earth will attach to an area drain.**




be cleaned with an electric snake. We put them at 30-ft. to 40-ft. intervals on straight runs and at strategic locations elsewhere: major bends, intersections with other lines and the point at which downspouts enter the surface-water drain system (a prime target for a leaf clog). We always cap the cleanout with a plug so that it does not collect debris.

We handle surface-drain flow either with an area drain, a catch basin, or a trench drain (drawing, p. 85). The first two are concrete, alloy or plastic boxes that have metal grills to keep debris out of the systems. The area drain is connected to a leader that ties into the surface drain line (drawing above). A catch basin collects water from several surface drains and feeds it into a single outlet. A catch basin is also deep enough to allow sand and soil to fall to the bottom, where they collect without interrupting the water flow. These "fines" settle into

Drawings: Frances B. Ashforth


**Retrofit drainage work begins with excavation of a 12-in. to 18-in. wide trench to the base of the footing (photo above). You know you've got a subsurface water problem when your basement is 9 ft. below grade, water is 5 ft. below grade and the remains of your drain line are 1 ft. below grade. It can be seen in the center of the photo (left), on the trench's right bank. At the high end of the system (photo below), cleanouts should be installed allowing access in both directions. Shown in this photo is the subsurface line—the surface line will also need cleanouts.**

a sludge that should be removed periodically. Trench drains are long, narrow steel, plastic or fiberglass boxes with grills on them. You see them at the base of driveways, where they catch the water before it inundates a garage that's downhill from the street. We usually install the ones made by Polydrain (ABT, Inc., P. O. Box 837, Murdock Rd., Troutman, N. C. 28166).

Tools of the drainage trade are neither mysterious nor high-tech. They include picks and shovels as well as pneumatic and electrical demolition and digging tools to break up the earth. Good wheelbarrows are essential. We recently acquired a Takeuchi tractor, which has a backhoe and an auger attachment. It speeds up excavation considerably, but in some cases, even a little tractor Tike this is tough to maneuver. Therefore, drainage work on steep hillsides tends to be labor-intensive, and impossible without a conscientious crew.

**Putting it in the ground**—Naturally it's best to think about controlling subsurface water in the planning phases of a new construction project. The pipes can be installed alongside the new footings before the trenches are backfilled. But I can assure you, plenty of houses have been built with inadequate systems for controlling ground water, if any at all. The methods for assembling a system during new construction are the same as that for a retrofit—it's just a lot easier to do it before the foundation trenches are backfilled and the landscaping has taken root. We find that it costs two to three times more to install a drainage system around an established house than it does to add drainage around a new house. The photos illustrating this article show a couple of typical retrofit installations.

When we can get the tractor into place, we begin a job by trenching alongside the foundation (top photo, facing page) until we've reached the base of the footing without undermining it. In the project shown in the photos on p. 82, facing page above and below left, the house was cut into the hillside to create space for a garage, and the cast-concrete foundation and the stairs to the side yard were gradually being shoved east by the swelling of the clay-laden soils. When this house was built in the '20s, the builders had included foundation drain lines. But they were cast-iron pipes installed a foot or so below grade. When we found them, they were rusted out, clogged with mud and totally useless. We also found lines as we trenched along the back of the house (bottom left photo, facing page) and hit water at about 5 ft.—4 ft. above the level of the garage slab.

Before we laid pipe in our trenches, we lined the trenches with geotextile fabric. Also known as filter fabric, this material is made of either woven or spun-bonded polyester or polypropylene fibers. The purpose of the fabric is to keep the fines in the soil from migrating into the gravel backfill, which eventually would clog the drain line. We use a 4-oz.-per-yard, spun-bonded fabric designed for soils that don't have a lot of silt in them. Under some conditions, soils that have high sand and silt contents can clog filter fabrics, so if you're in doubt about the makeup of the soil, have a soils lab test its constituents so you can choose a fabric accordingly. Filter fabric is remarkably tough stuff. To cut it we use sharp sheet-metal shears, but a sharp razor knife will work. We pay about 15 cents per sq. ft. for the fabric and buy it from a local vendor that supplies products related to concrete work. If you can't find filter fabric locally, two companies that make it are Mirafi (P. O. Box 240967, Charlotte, N. C. 28224) and Hoechst Celanese Corp. (Spundbond Division, P. O. Box 5887, Spartanburg, S. C. 29304).

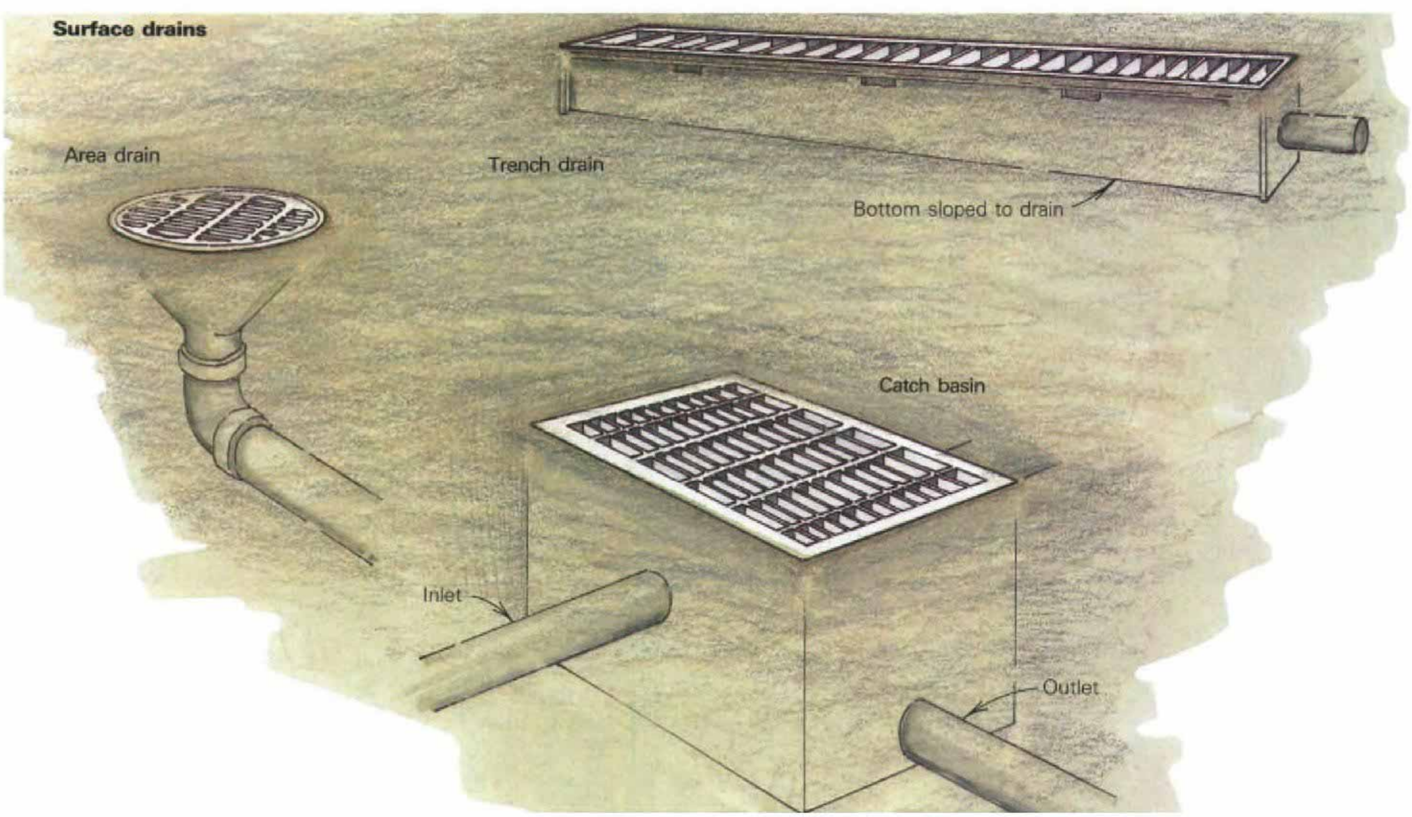
Before the fabric is down, we sometimes add a thin layer of sand to smooth out the bottom of the trench. This keeps the pipes from getting flattened at the high spots when the gravel backfill is placed. But if the bottom of the trench is pretty uniform, we skip the sand.

The pipes have to be sloped at a minimum of ⅛ in. per ft. For shallow trenches that have relatively short runs—say 40 ft—we'll use a 4-ft. level with gradations on the bubble that read slopes of ⅛ in., ¼ in. and ⅜ in. For longer runs, or deeper trenches, we use a transit and a rod to check the slope.

We cut pipes with a hacksaw, and for the most part, we rely on press-fitting the parts because they usually go together with a satisfying snugness. If so, we don't bother gluing them. But if they seem loose, we swab them with the glue supplied by our vendor for the particular kind of pipe and wrap them with duct tape as a further hedge against separation during backfilling.

When all the subsurface lines are in place and their cleanouts have been extended above grade, we fill the trench with gravel to within a foot of grade. This gravel should be clean ¾-in. material. If you are applying polyethylene sheeting to the foundation as a moisture barrier, use rounded rock. Crushed rock has sharp edges that will damage the poly. Otherwise, crushed rock is usable and probably cheaper. Don't use road-bed mix, though, because it has too many fines in it. Gravel in place, we wrap the fabric over the top like a big burrito.

Atop all this goes the unperforated surface runoff lines (photo, p. 83). While we usually position them about a foot below grade, they can be placed lower, if necessary, for positive drainage or to protect them from the gardener's shovel. The surface runoff lines, too, are sloped at least ⅛ in. to a foot. Leaders



from the rain gutters are connected to the surface lines by way of plastic fittings that are square on one end to accept the leader, and round on the other. At each leader entry we place a wye fitting for a cleanout, and at the highest elevation of the surface drain line we position a pair of cleanouts (photo, p. 84).

Usually the surface line and the subsurface line will drain to daylight at different places, but we sometimes combine the two if we need to go under a sidewalk with a line. In this case we make sure the intersection is at least 20 ft. downhill from the structure to minimize the chance of a blockage that would cause water to back up into the subsurface line. And we include a cleanout.

To finish the job, we will either compact a layer of soil on top of the buried lines, or cover them with more gravel if the surface is likely to get heavy runoff. Road base is usable here. It's probably overkill, but I think it's best to top the system with some type of paving—either a poured-concrete cap or individual pavers that direct the water away from the building.

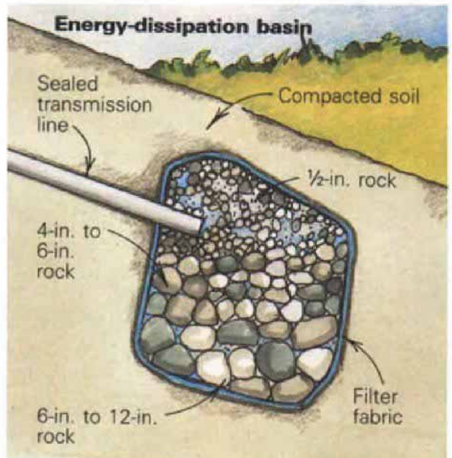
**What to do with the water**—The final phase in drainage work is doing something with all that water once you've got a system for collecting and rerouting it. Two guidelines are important to follow. First, if bad drainage is causing your property to deteriorate, then it's important to make sure that your depository doesn't cause the same problems, albeit in a different location. Second, don't put your storm drainage on your neighbor's property. In the latter case when you're on a hill, sometimes the only appropriate solution is to secure an easement for a drain line that will discharge below both properties.

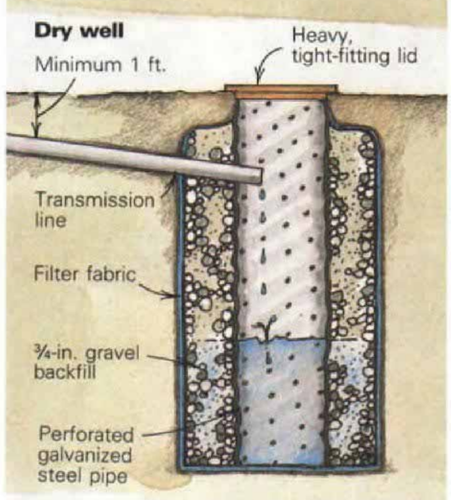
In many places storm drainage must be put into established sewer systems dedicated to carrying runoff. Local jurisdictions vary on the hookups required. In some cities you simply daylight the drain lines at the curb, sending the water to the storm sewers via the gutters, while other jurisdictions require a sealed hookup. Some will let you dump runoff into effluent sewer lines, but I've found this to be the exception. Given the differing approaches, make sure you check with your local building department to verify local practices.

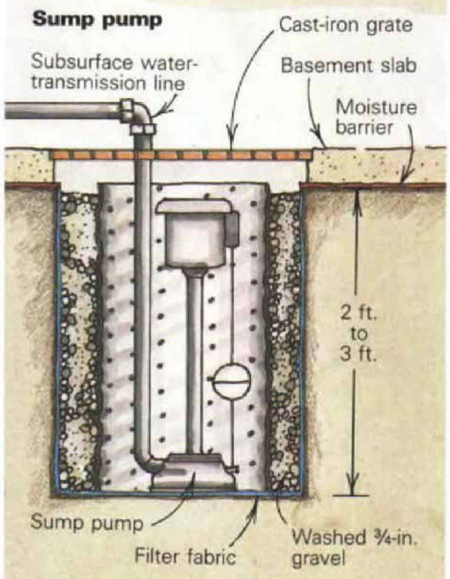
If there isn't a municipal storm sewer to carry away the water that is collected, things get more complicated. Leach fields, energy-dissipation basins and dry wells are three approaches to allowing the runoff to continue draining slowly, in a manner less likely to cause erosion and other related problems. But these strategies can concentrate an abnormal amount of water in one place. So if you're unsure about the stability of the soils at a likely water-dump site, you should consult a soils engineer.

If you have an open area with suitable soil, a leach field can be used to distribute the water back into the ground. Like a septic leach field, this requires a manifold of perforated pipes buried below grade. You run a sealed transmission line into one end, and the water will dribble back into the soil over a large area.

An energy-dissipation basin takes less space than a leach field. It usually consists of an excavation lined with filter fabric and filled with rock graded by size (drawing below). The ones that we've done have been about 5 ft. square and 4 ft. deep. The graded rock is arranged so that the big ones are on the bottom where they can get a good bite into the hillside. A sealed line enters the basin, and its end should be buried in about 2 cu. ft. of ½-in. rock. Recently we had to convey a load of 4-in. to 12-in. dia. rocks 200 ft. down a hillside. We made staging areas at 60-ft. intervals and rolled rocks to them through taped-together Sonotubes. The crew loved it.




Covered with a layer of native soil, an energy-dissipation basin can be made that will virtually blend into the landscape. But make sure you compact the soil before landscaping to avoid the inevitable settling that will occur.

If there is insufficient grade for positive drainage away from the building, a dry well (called a *stand pipe* in the midwest) could be your solution (see drawing). It is usually placed 15 ft. to 20 ft. from the house. When constructing one of these, we use an 18-in. to 24-in. dia. corrugated and perforated galvanized-steel pipe set vertically into an excavation roughly 4 ft. in dia. and 8 ft. to 10 ft. deep. The hole is lined with filter fabric, the pipe goes in the middle and a collar of ¾-in. drain rock fills the space between them. A sealed transmission line from the drainage system, sloped at ¼ in. per ft., enters the dry well. It should be at least 1 ft. deep to protect it from shovels and roto-tillers.

A dry well should be capped with a heavy, tight-fitting lid that is impervious to youngsters. I hasten to add, however, that dry wells are not appropriate alternatives in all situations. Installed on slopes, they may concentrate water where you don't want it, and could even create an unstable slope condition that might result in a landslide.

As a last resort, you can use a sump pump (see drawing) to lift water out of an undrainable situation. The sump pump goes in the deepest part of the basement and needs a reliable source of power. Two essential characteristics make sump-pump systems less than ideal solutions. For one, if they are installed within the home's footprint, water is still getting in or under the building. And two, they rely on manufactured energy vulnerable to outages that typically occur precisely when you need the pump the most. But in some cases, a sump pump is the only way to get the water to an acceptable distribution system. Regardless of the system you elect to install, it's a recommended practice to keep good records showing the details (size, depth, location, cleanouts) of the system. □

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