Chapter 9: Water Storage

The core of a cistern system is a water-storage tank with a water delivery point, a properly sized overflow pipe, an accessible serviceway (remaining locked when not in use), a working vent, an operational water-pump line, pump and tank walls. Optional items include electric lines, a float switch, in-tank filters, a level reader line, an auxiliary water line, and a ladder, rope or cable (for accessing some of the components).
The **delivery point** (labeled point A in Figure 9-1) is the place where roof water enters the tank. It is located near the top of the tank.

The **serviceway** (B), also known as the "access way" or "manhole" is needed for cistern maintenance, including servicing the pump, float switch(es), level reader, vent pipe, water lines and electrical lines. The above-grade serviceway opening should remain locked when not in use for safety reasons.

The **vent pipe** (C) of the depicted cistern begins to the right of the serviceway. This vent is necessary both for effective pumping and for the effective intake of a high volume of water during extreme events. (Vent pipes should be covered with a fine-mesh screen to prevent mosquitoes and small animals from entering the system.)

The **pump line** (D) directs harvested water to the plant material via the distribution system using a **pump** (E). In the case of a separate inline pump and pump house, the pump line would still direct the flow of water to the pump to be distributed. The

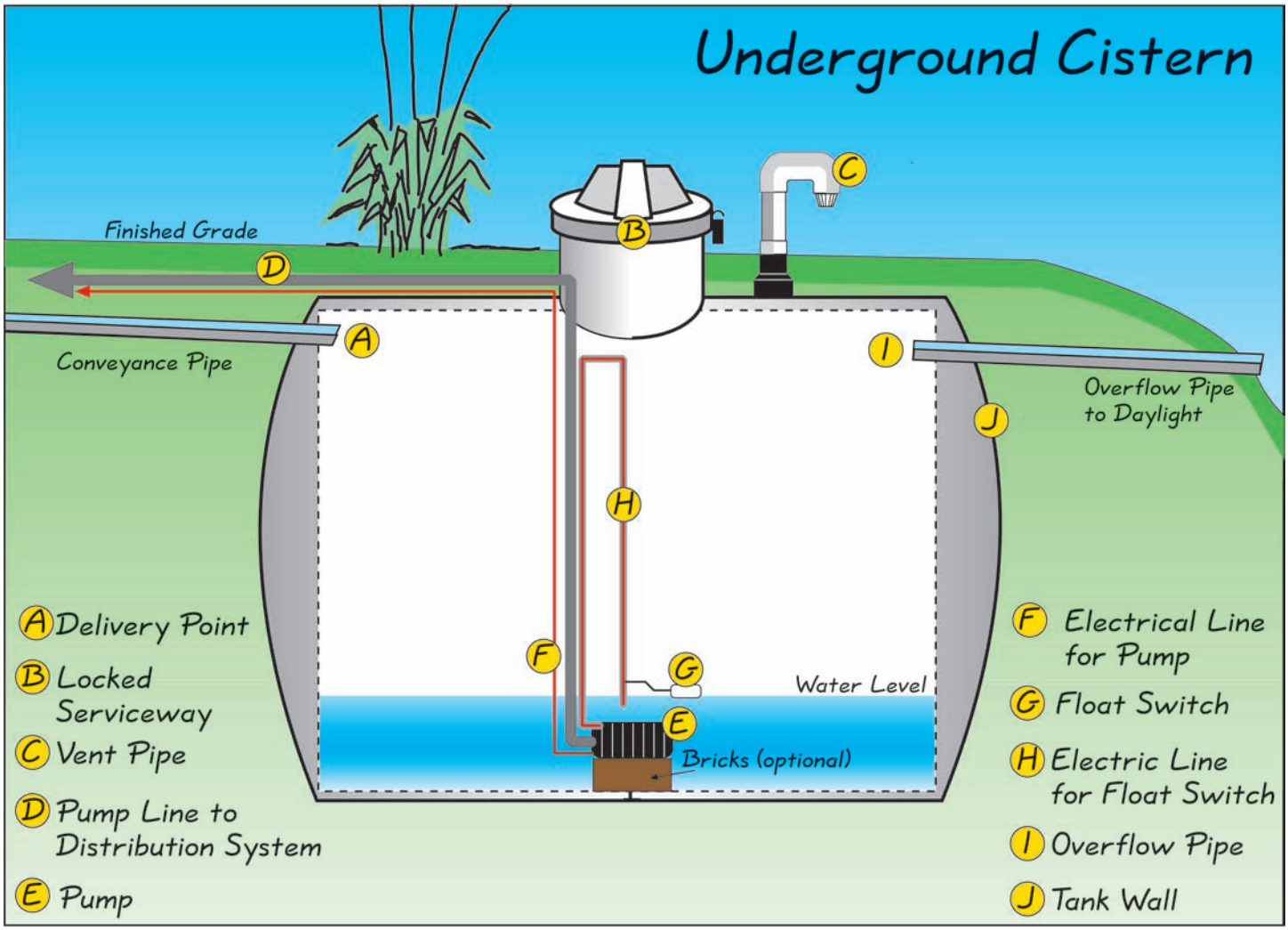

Figure 9-1: This cutaway illustration shows the components of an underground cistern system.

one difference is that the line would typically have a foot valve at the bottom of the line in the tank so that the pump outside the tank will remain primed (full of water) during the watering season. In many cases, this foot valve is removed during the colder months to prevent freeze damage.

An electric line (F) is required for a sump pump. The electric line is shown entering the tank near the top left side of the serviceway in Figure 9-1. Use professional electricians licensed with the state of New Mexico for this and all electrical work other than 24-volt (and lower) electrical lines.

Float switches (G) like the one under the serviceway in Figure 9-1, are balloon-like devices that float on the surface of the water in the tank in order to tell a pump to turn on or off. Typically, when the water level in a cistern reaches a certain (low) depth, the float switch drops into the "OFF" position, which turns off the pump. (These are also commonly called "pump down switches.") A float switch can prevent a pump from burning out when the cistern is empty. Also available are submersible pumps with thermal protection shutoffs, so a float switch is not always needed.

The **overflow pipe** (I) must be large enough to carry runoff in a "100-year storm," and it must not be the cause of any soil erosion. Erosion-control treatments such as French drains, swales, riprap and wire gabions are often necessary at such points. It is also important to prevent insects and small animals from getting into the overflow pipe. A swing-check valve (that opens only when water is flowing through it) provides this protection.

The **tank walls** (J) come in a variety of shapes and sizes. Tank walls may be constructed out of a variety of materials, many of which are described later in this chapter. Underground tank walls must resist both the inward pressure from the soil and the outward pressure from the stored water. Aboveground tank walls should be dark colored, opaque and UV resistant in order to prevent algae growth that is associated with sunlight exposure.

A level reader (not shown) can be as primitive as a stick with units of measurement etched on the side. The stick is lowered carefully to the tank bottom to determine the height of the water. If you are familiar with the dimensions of your tank, knowing the depth of the water should be enough to give you a ballpark figure of how much water is in storage. Inexpensive level readers, which provide a digital readout of the percentage of water in your cistern, are also available.

If a cistern is empty, manually adding auxiliary water with a hose or via a manual valve may be the only way to use the installed water-delivery system to irrigate the landscape. An auxiliary water source can be used when the cistern system is not associated with a strict water budget and when the goal is something less than total roof reliance. However, because the focus of this manual is roof-reliant landscaping, the use of an auxiliary water source is not emphasized in this manual nor is it endorsed by the New Mexico Office of the State Engineer. A better option is to provide a secondary water source that can hook directly into your distribution system. This leaves the cistern available for the next precipitation event.

Elevation Options

You will need to determine in the early stages of your water harvesting system's design whether your cistern will be aboveground, partially buried or underground. Here, are some of the advantages and disadvantages of each of these water-storage options.

Figur 9-2: An underground cistern being installed.

Aboveground Cisterns

Figure 9-3: Aboveground cisterns can be painted to help them blend into the nearby buildings and surroundings.

An aboveground cistern is a water-storage tank situated on grade or on a concrete or gravel pad on or just above grade with no significant berming or excavation associated with the installation of the tank.

Advantages. For the majority of people, the most important benefit of an aboveground cistern is cost. The design, materials and installation costs of aboveground tanks are significantly lower than those of partially buried and underground alternatives. The most significant cost savings is due to the fact that relatively little work is needed to put aboveground cisterns in place. The relative ease of installation associated with aboveground water-storage tanks is an important consideration, especially for the do-it-yourselfer. Aboveground cisterns range from very simple rain barrels to more complex gravity-fed systems. The simplest systems require only basic common sense, some "handyman" skills, a thorough reading of this and other similar texts[13] and a permit (when required).[14]

[13] See Appendix 8 for additional reference sources.
[14] Always check with the Construction Industry Division (505-476-4700, www.rld.state.nm.us) and local governing bodies for details concerning specific requirements.

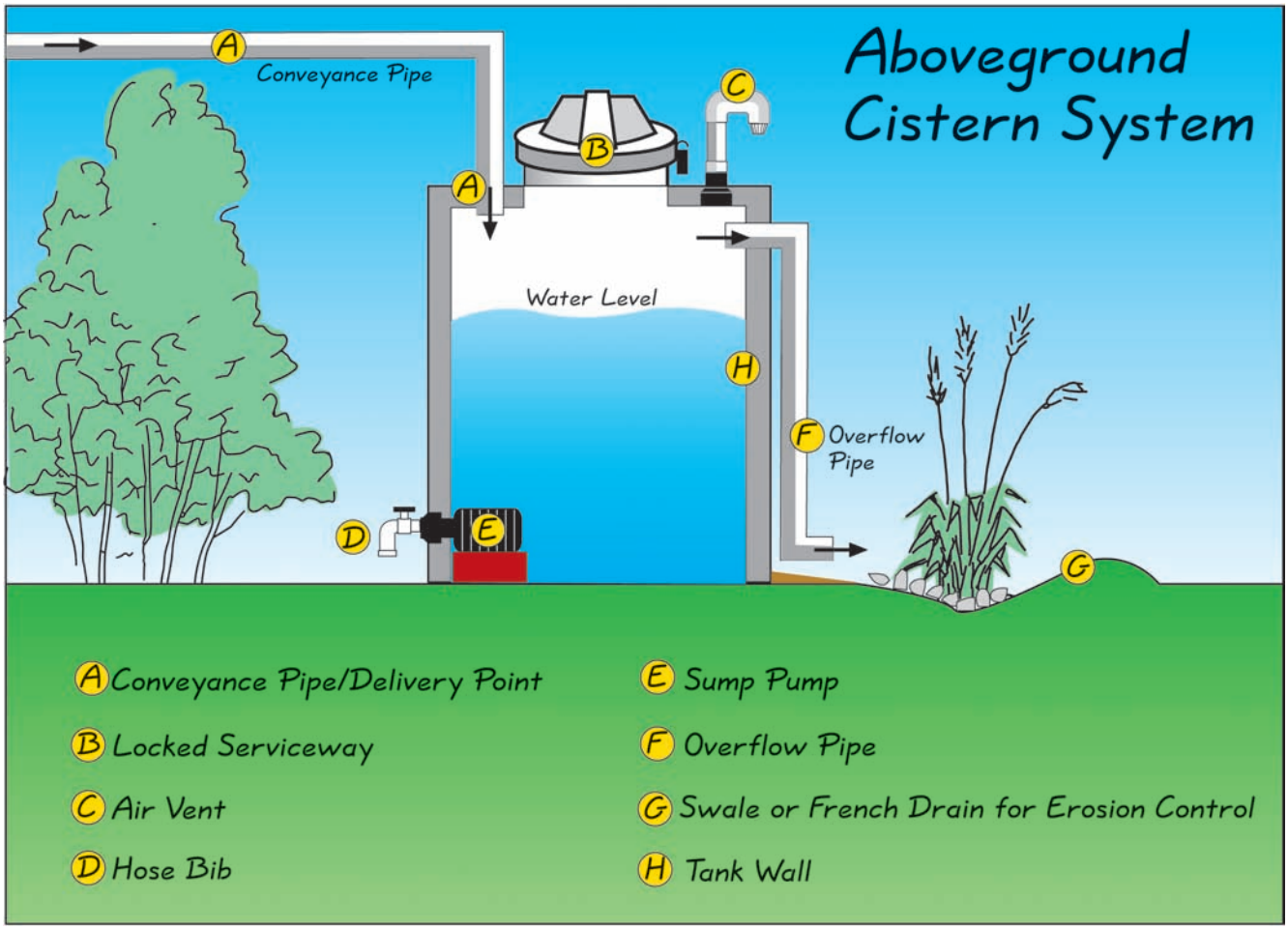

Figure 9-4: A "cutaway" drawing of an aboveground cistern system

Another reason to choose an aboveground cistern is if you plan to water your roof-reliant landscape using gravity. Given the right terrain and landscape design, a properly elevated cistern and a hands-on owner can eliminate the use of a pump for both hose watering and drip irrigation. (For more information on this subject, see Chapter 10, Distribution.)

An aboveground cistern can provide wind protection, privacy, shade and even serve as an inspirational conversation piece. In addition, aboveground cistern systems can be easier to maintain than underground systems. Leaks are more easily spotted when they occur aboveground, and they can be repaired without any of the excavation often necessary when leaks occur underground.

Disadvantages. Many people fail to see the inherent "beauty" of a big, opaque, industrial-looking aboveground cistern, so the potential costs of visual screening should not be overlooked. Screening a cistern can be accomplished least expensively by planting young trees, shrubs or trellised vines in front of your tank. Although they are more expensive, large trees, fencing, stucco walls and fine masonry make great screening options. Painting a mural on the tank is one way to increase the aesthetic appeal of an aboveground cistern. (See Figure 9-5.)

Figure 9-5: Aboveground cisterns can be painted to give them a distinctive look.

If you are successful at creating a roof-reliant landscape and your tank is well-hidden or attractively presented, it is quite possible that your property will increase in value. Certainly, homebuyers who appreciate beauty, comfort, convenience and water consciousness will consider a concealed above- ground cistern to be an important property asset.

Another important disadvantage of aboveground systems is that cisterns, pipes and pipe connections can freeze during the winter. This is a concern throughout the state of New Mexico. Be sure you know the frost depth for your area, and be sure to drain and/or insulate pipes so that no leaks occur.

If you must situate an aboveground cistern on the north side of a building in the northern part of the state where freezing temperatures are most likely to occur, you may wish to drain your tank before the first hard frost of winter. If you can place your aboveground cistern on the south side of your structure or if you live in southern New Mexico at a relatively low elevation, you may be able to store winter moisture with minimal fear of discovering freeze-related leaks when temperatures warm up. One way to insulate an aboveground cistern is to berm it into the ground at a depth such that the outlet pipe from the side or bottom is below the frost line. (See next section, Partially Buried Cisterns.)

Because plants often need supplemental moisture in the spring and early summer, storing water throughout the winter is extremely important for the roof-reliant landscaper. The disadvantages associated with ineffectively insulated aboveground cisterns and their fittings should be seriously weighed against the cost advantages that such cisterns provide. An inexpensive system that has to either be quickly drained in the middle of a cold winter night or repaired every spring is usually not worth the potential cost savings in the long term when compared to the price of a frost-free underground or partially buried cistern.

Aboveground cisterns also have the greatest tendency to harbor algae due to the intense New Mexico sunlight to which they are exposed. Be sure that the cistern you are using is opaque and UV resistant. Typically, darker colors are preferable to light colors in this regard.

Another disadvantage is the water in an aboveground cistern, especially a dark-colored cistern, can often get too hot to use on plants during certain times of day in the summer. Of course, watering should not be done during the hottest parts of the day to prevent evaporative loss (and because it is not allowed in many communities in New Mexico). Keep in mind, however, that the water in your cistern may remain too warm for landscape use well into the evening and sometimes into the nighttime hours, which leaves the morning as the best time to water from an aboveground cistern in the hot summer months.

Partially Buried Cisterns

Figure 9-6: Two partially buried cisterns

A partially buried cistern is a water-storage tank situated such that the bottom portion of the cistern and its pressurized pipe are protected by the soil from freezing. The remainder of the tank is exposed to the elements (particularly sunlight).

Advantages. In certain situations, partially buried cisterns offer an excellent alternative for people on a limited budget. Compared to an underground cistern system, installation cost savings for partially buried cisterns are significant and the aesthetic issues associated with aboveground cistern systems are easier to solve. Partially burying a cistern also solves the potential problems of water freeze damage, and partially buried cisterns also have the potential for eliminating the need for a water pump.

If your storage tank is small enough, it may be possible to excavate the hole for a partially buried cistern with picks and shovels as opposed to using a backhoe. If you dig the hole by hand, the cost savings could be considerable, but be aware that this is very strenuous work. Renting a backhoe can be cost-effective, but manual excavation makes the most sense in situations where backhoe access is difficult. In the case of new construction, consider excavating your hole when a backhoe is already on site—another cost-benefit of landscape planning.

Manufacturers are not inclined to endorse partially burying a cistern that is intended for underground use. That is because underground tanks are typically not UV protected, which means they will not last long in the bright New Mexico sun. Also, the walls of underground tanks use the earth around them to support the massive weight of water in a full cistern, so the walls of underground tanks are often much thinner than their aboveground counterparts and often cannot be used without the support of properly compacted earth around them.

Typically, the most important reason to partially bury a cistern is to keep your pipes from freezing. Before renting a backhoe, determine your local frost depth. (Contact your local County Cooperative Extension Office, http://cahe.nmsu.edu/county/). Then, if you plan to partially bury an aboveground cistern, make sure your tank can withstand the inward pressure on the tank's walls at the selected depth when your cistern tank is empty.

Disadvantages. The main disadvantage of a partially buried cistern is that after all of your hard work digging, the tank looks like a smaller version of an aboveground cistern. Yes, money has been saved and the pipes are less likely to freeze, but many people will still want to invest in a fence or dense plants to hide the exposed portion of the tank.

In many situations, a partially buried cistern is a perfect mix of cost savings and frost prevention. However, just as partially buried systems come with many of the advantages of aboveground and underground cisterns, they also come with many of the same disadvantages. Therefore, if you are already thinking of excavating with a backhoe for a partially buried cistern, you may wish to choose an underground cistern instead.

Underground Cisterns

Figure 9-7: Once this underground cistern is installed and the hole is backfilled with dirt, only the serviceway will be visible.

An underground cistern is a water-storage tank that is situated below grade. Here is a description of the advantages and disadvantages associated with underground cistern systems:

Advantages. The advantages of storing water underground are frost protection, invisibility, landscape versatility, less chance of algae growth in the tank and cooler water temperatures.

A cistern buried at the proper depth is extremely unlikely to result in problems associated with frozen water. Underground leaks can still occur, but these would more likely be associated with the water-pumping system.

An underground cistern is literally out of sight. Not only will your views be unencumbered by the tank, your quality of life may be improved by the absence of a large, industrial-looking vessel in your yard. This could also translate into a greater return on your investment when it comes time to sell your property.

Buried cisterns do not get in the way of many other potential uses of your property such as planting (plants and shrubs, though not trees), entertaining, etc. Just remember to avoid putting a permanent structure (such as a storage shed or a concrete patio) on top of an underground cistern—blocking future access if it ever needs repair or replacement. Many underground cistern materials can withstand vehicular traffic, but others cannot, so make sure your cistern suits your landscape goals.

Since no appreciable light enters an underground cistern, it is unlikely that the harvested water will breed many forms of algae. This is an important advantage because one of the disadvantages of underground cisterns is that they can be difficult to clean.

Since the cistern is not exposed to sunlight and the water is well insulated by the earth, the water temperature in an underground tank will never be too hot for irrigation purposes. This means you could water from your underground cistern at any time of day (remembering, of course, that midday watering is not recommended and is often not allowed).[15]

Disadvantages. The disadvantages of storing water underground are higher costs, more difficult access, increased safety concerns and the necessity for a pump.

For most people, the biggest disadvantage is the cost of installation. As a general rule, an underground system costs about twice as much as a comparable aboveground system. This often prices people out of the underground-cistern market right from the start.

Excavation and backfill, required for the installation of both the cistern and its underground conduits, are the main reasons for the higher cost of an underground system. There are extra costs incurred by machinery and its skilled operator(s),

[15] Check with your local municipality or water service provider for any ordinances, administrative policies or water conservation restrictions.

designing and permitting a large excavation project and all of the properly executed backfilling and/or tamping that underground cisterns require. Another cost of burying a cistern that often surprises people is that of removing the large quantity of excavated earth that is left over at the end of the project.

Underground cistern systems often require longer runs of pipe, conduit and electrical wire, which adds to the expense side of the ledger. In order to get the necessary fall from conveyance piping (of 1/4 inch per linear foot) and in order to give the backhoe operator plenty of room in which to work, underground cisterns are usually situated farther from the house, and this means more pipe, conduit, electrical wire, etc.

If and when problems occur, having most of your system buried can also become an issue. Repairing the tank wall of an underground cistern is typically much more difficult than repairing that of an aboveground cistern. Although rarely necessary when prefiltration is adequately installed and maintained, cleaning an underground tank becomes a challenging job.

Underground cisterns, even when empty, can be dangerous, and the process of installation includes inherent risks. OSHA regulations (www.osha.gov) must be followed at all times during the installation process, and access to cisterns must always be locked (whenever the tank is not being accessed or maintained). Your highest priority should be the prevention of any accident and injury associated with your cistern system.

Underground cisterns are not conducive to water distribution via gravity; they almost always require a pumping system to get the water out of the lower depths of the tank. Also, since underground cisterns need access and venting, both of which will protrude from the ground, some screening is typically required.

Cistern Placement

To help determine the best location for your cistern, a set of seven guidelines for cistern placement are presented below. These guidelines are intended to help save time and money, as well as to make your whole system as efficient and productive as possible.

While many cistern tanks are added to residential properties after construction of the house has been completed, in new construction cistern design and placement issues should be considered at the beginning of the design process rather than as an afterthought. Designing the cistern system as an integral part of the site can add additional options for cistern locations including within buildings and on a structure's foundation.

1. Understand the Size and Shape of Your Tank

In Chapter 3, Sizing Your Cistern, we explained how to calculate the amount of water that can be harvested off your roof in a "normal" year. You were then instructed to multiply that number by one-third to get an approximate number of gallons you might consider storing in your cistern. Knowing the capacity of your cistern enables you to calculate the overall dimensions of your tank. Start by asking your tank supplier what size tanks are available in the number of gallons you require. Depending on the type of cistern material, this can often eliminate the need for you to calculate the dimensions of your tank on your own.

The dimensions of your tank are important for a number of reasons. First, you need to know how to get the tank to its desired location on your property. Some tanks need to be craned over trees and buildings, while others can slide right off of a truck and be rolled by one person to their proper place.

Second, there needs to be enough physical space available to excavate the hole and trenches. A backhoe, a big hole, piles of earth, the tank, tools and vehicles take up a tremendous amount of space. It is important to place your cistern so that it can be installed with ease instead of creating any extra cost and the potential for accidents and injury, which is another advantage to new construction and thoughtful landscape planning.

Third, being aware of the dimensions of your tank is useful if there is a chance you might hit bedrock or other materials that are difficult to excavate. Although there are tools for removing bedrock, this

type of work can get loud, expensive and dangerous.

You will also want to know approximately how much your tank will weigh. The empty weight is important because moving such a large, heavy vessel from the street to your backyard requires planning for an appropriate crew and/or the proper equipment. Aboveground cistern system designers should also be aware of the empty weight of any tank that is being placed in a wind corridor, so that effective measures can be taken to prevent the tank from being blown out of place by New Mexico's gusty winds.

2. Use Gravity

Let gravity fill your cistern whenever practical. Whether your conveyance system involves gutters and downspouts with little or no horizontal run piping or whether it uses funnel drains and long horizontal runs, your supply point should aim for the top of your cistern in such a manner that all conveyance piping will drain completely.

Avoid pump tanks whenever possible. These are separate, smaller cisterns used temporarily to quickly and consistently pump roof water to the system's main cistern. The additional pump, tank and float switch associated with this kind of system complicates the project significantly and can increase the long- and short-term costs of a project unnecessarily (additional pump = additional electricity and more maintenance).

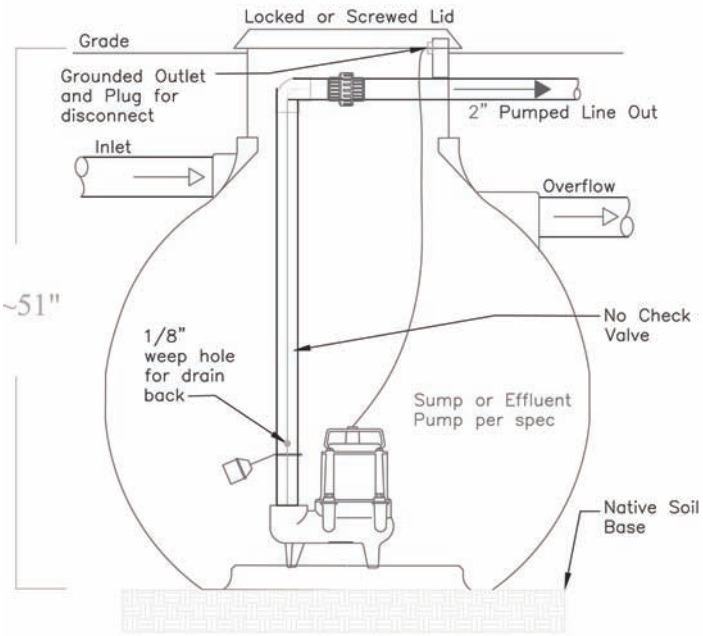

Figure 9-8: A pump tank can be used to pump water into a system's main water storage tank.

Be careful not to install underground cisterns any deeper than necessary. This mistake can appreciably increase the excavation and dirt-removal costs of the project. In addition, the labor and material costs associated with conveyance piping, sediment traps, overflow piping, vent piping and distribution piping will rise. Also, some tank materials may not be able to withstand the extra weight of the earth that will be backfilled onto a tank that has been installed too deeply.

Ideally, the proper placement of your cistern with respect to gravity could provide enough water pressure for your drip irrigation system. Most people, however, have neither the necessary terrain nor the requisite patience to use gravity in this way.

3. Keep Conduit Lengths to a Minimum

Another very important factor in cistern placement is its proximity to your roof, the distribution system and the electrical utility. Unnecessarily long runs of these and any other type of conduit will add to the price of your project. Long runs require wire sizing and voltage drop calculations. Not only does this make the project more expensive to install, it can also create work later if the runs of pipe and wire are accidentally cut during future work in your garden.

Your cistern and its associated parts should be located in a place where they are easy to observe, maintain and fix. If possible, place your level reader, pump, irrigation clock and any other feature requiring conduit in one convenient place.

4. Situate Overflow Pipe in an Appropriate Place

The location of your cistern's overflow pipe is critical when considering the placement of your cistern. In a properly designed system, excess water flows through an overflow pipe to a point called "daylight," which is where any underground drainage pipe emerges to the open air.

Of course, the best use of "overflow" water is to irrigate plants, such as trees that can benefit from occasional deep waterings. To handle a large volume of overflow water, simple but essential erosion-control measures should be installed at your daylight point. Often a hole filled with gravel and a swale that pours gently into a mulched bed planted with a few shrubs or a tree works well. When flows are high and/or your slope is steep, riprap and/or wire-wrapped gabions might be required to prevent soil erosion at the daylight point.

Note that on flat properties your run to daylight will be longer than the overflow run on the typical steep site. However, the erosion-control work needed at the daylight point of a flat site is usually less extensive than the work that is often required on steep sites. Civil engineers, drainage contractors and/or appropriate government regulators will need to be consulted in high-volume, steep-slope situations.

5. Locate Your Vent and Serviceway Appropriately

Part of determining the location of an underground cistern is making sure that the vent and serviceway access can be inexpensively hidden from view. Sometimes this is reason enough to move a cistern from one side of a house to another. If everything else is equal except that the vent and serviceway to your cistern would be seen through a living room window, why not (during the design phase of your project) move the cistern to a less-prominent place?

For cases in which moving your serviceway and vents to a less visible place is impossible, here are a few tips for hiding these necessary parts of your cistern system. Since vent pipes have a theoretically unlimited horizontal run, they can usually be hidden at a relatively low cost around the corner of a building or behind some plant material. This work shouldn't be too expensive, but your cost estimate should include all five steps in the process: digging a shallow trench, laying vent pipe, fitting the pipe, backfilling over the trench and tamping the backfill until properly compacted.

For ease of access and to prevent debris and other forms of runoff from falling into cisterns, serviceways should protrude out of the ground. Some of the best ways to camouflage a serviceway are to install earthen berms, plants, decorative boulders, mulch and fencing. Remember to keep your serviceway locked when not in use to prevent injuries.

6. Synergize Your Cistern with Your Landscape

Consider the placement of your cistern in relationship to your landscape plan. The consequences of a poorly placed cistern can be serious, so make sure your cistern works not only with its collection, conveyance and distribution components but also with every component and feature of your roof-reliant landscape project.

Will your cistern and its associated components (such as its horizontal runs and its main distribution pipe) work with your landscape design? If at all possible, avoid placing your cistern in a place that prevents you from having some other important landscape feature. Try to place your tank in such a way that it improves your quality of life and increases your property's value.

Where might the placement of your cistern help reduce the total cost of your landscape? Do particular placement options put constraints on the size of your tank and therefore shrink your water budget? Will the placement of your tank affect your installation schedule? The answers to these questions will help you finalize the decision about your cistern's place in the landscape.

7. Get a Second Opinion

Once you have determined the best site for your cistern, it makes sense to get a second opinion. Ideally this opinion would come from a professional in the field, but second and third opinions can also come from acquaintances, friends and family. Given that inappropriate placement of your cistern could be the most costly mistake that you might make in this process, determining the most appropriate place for the heart of your roof-reliant landscape is critical.

Cistern Materials

Water-storage vessels come in a wide variety of materials, ranging from high-density polyethylene, epoxy-coated steel and fiberglass on the high-tech side to wood, rock and concrete on the low-tech side. Each type of material has its advantages as well as disadvantages. The following alphabetical list does not endorse any one material or system over any other.[16]

Concrete

Even taking into account the rising price of concrete in recent years, reinforced concrete tanks can be an economical choice. Such tanks can be custom-built on-site, or they can be prefabricated off-site. One important advantage of concrete tanks is that they are usually strong enough to support vehicular traffic.

To prevent water from leaching slowly out of the tank, the inside of a concrete tank is often coated with tar. However, tar can leach into your water supply and then subsequently end up in your soil. Your plants will survive, but over time, your soil might suffer from the increased quantity of low level toxins associated with tar.

Concrete can be used in aboveground, partially buried and underground systems. Plastic liners may also be used inside concrete tanks, which solves the problem of tar leaching and helps to prevent potential leaks.

Ferrocement

Ferrocement, often called ferroconcrete, is a form of concrete tank that uses significant amounts of rebar and chicken wire in the form of a skeleton, upon which a specific mixture of sand, cement and water is spread. Since ferrocement is thinner than concrete, it has the potential to be the least expensive of all cisterns. It also has a greater tendency to leak compared to other materials. Such tanks can easily increase the cost of your project if improperly installed or if leaks are not quickly and effectively addressed.

These tanks can be made into almost any shape. They can be used in any of the three relationships to grade (aboveground, partially buried or underground). They are used throughout the developing world with great success, but an on-site ferrocement-tank building project requires serious construction and management skills as well as some significant research.[17]

Fiberglass

Figure 9-9: A fiberglass tank being installed.

Underground fiberglass cisterns are commercially available and start becoming cost-effective in the 5,000- to 10,000-gallon range. You may have to crane an underground fiberglass tank into your hole due to its size (even though it is relatively lightweight), but this is also often true of other cistern materials including concrete and metal. Fiberglass is an extremely durable and long-lasting material that can be patched with relative ease.

Some underground fiberglass tanks can withstand vehicular traffic, which means that placement of the tank underneath a driveway becomes an option. Aboveground fiberglass tanks are available in smaller sizes, but they must be shaded and/or be UV resistant. Fiberglass fittings are integral parts of the tanks themselves, so they are less prone to leaks at pipe connections than are other materials.

[16] Please note that nothing herein should be construed as an endorsement of any product, person or corporation. Any and all references to products, persons, and corporations herein are intended merely to provide a brief and general sketch of the ever-expanding field of cistern technology. Since new advances in cistern technology are being made constantly, the Office of the State Engineer strongly encourages you to do your own due diligence when it comes to choosing the cistern material that is best suited for your particular situation.

[17] See *Water Storage* by Art Ludwig, p. 41.

Even though cisterns in roof-reliant landscaping are intended to provide water for landscape irrigation only, to be on the safe side you should consider having your tank coated with a USDA-approved food-grade coating. The extra cost is relatively low and the safety benefit is considerable since uncoated fiberglass can be dangerous if ingested. Your plants probably will not mind the leaching from your tank, but in case anyone accidentally puts his/her mouth to your hose to drink, you will not have the ingestion of fiberglass particles to worry about.

Metal

Figure 9-10: Steel tanks are a cost effective option at 5,000 gallons and larger.

Most metals are not used for storing water due to their cost, but there are two types of metal tanks that can be cost-effective. Galvanized steel, which is often corrugated, is one option. Another option is a non-galvanized underground steel tank, which can be a good choice for large-tank and heavy-vehicular-traffic installations.

As aboveground options go, galvanized steel is a good choice from an aesthetic perspective, as Figure 9-10 shows. These tanks come in a variety of sizes, but they are not the most durable of cistern materials.

Due to the high expense, underground steel is not an option for small scale projects. Steel tanks begin to become cost effective in the 5,000- to 10,000-gallon range. Steel tanks need to be coated on the outside with coal tar epoxy or another coating or they will rapidly corrode in New Mexico's alkaline soils.

Plastic

Figure 9-11: A plastic tank can be very cost effective.

Plastic has become an increasingly common cistern material, in part because it can be very cost effective. It can be used in aboveground, partially buried and underground applications. Plastic tanks do not require any type of internal coating. However, plastic tanks that are aboveground (either fully or partially) and will be exposed to strong sunlight will need an exterior UV-resistant coating. Plastic tanks should be as opaque as possible in order to prevent algae growth. For aboveground applications, plastic tanks are typically molded into one-piece cylinders that stand on flat bottoms.

A lightweight and relatively inexpensive material, plastic can be prefabricated in a variety of shapes and sizes. Individual plastic tanks, however, are not available in large sizes, but they can be connected together to attain a large storage capacity for the entire system. (See Figure 9-12.)

Underground plastic tanks are available in a variety of sizes up to about 2,000 gallons. For structural reasons, many of these plastic tanks require that a percentage of the cistern remains full at all times. Some plastic tanks can be completely emptied, such as the tank shown in Figure 9-13, which has thick tank walls, a round bottom and deeply corrugated sides.

Modular tank systems represent a new development in cistern technology. Modular systems consist of strong but essentially empty plastic blocks that are stacked on top of each other. These blocks effectively create a skeleton, completely enclosed in a plastic liner, which can withstand vehicular traffic.

Figure 9-12: Tanks can be connected together to create larger storage capacity. These tanks will be connected in parallel, so that an individual tank can be shut off for maintenance or repair without disabling the entire system.

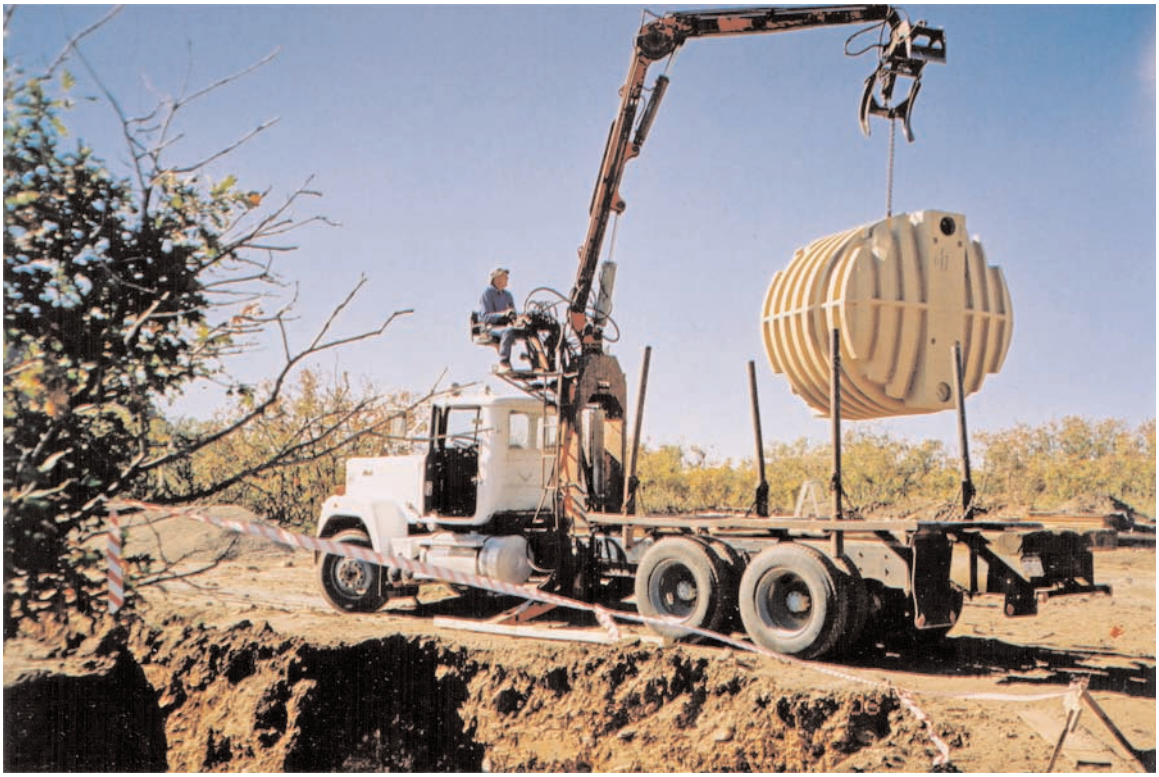

Figure 9-13: Large tanks must be delivered onsite via truck and lowered into place with a crane. The thick walls of this tank enable it to sit completely empty in the ground.