Second Edition

A Builder's Guide to WELLS and SEPTIC SYSTEMS

R. DODGE WOODSON

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SECOND EDITION

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Dedication

I dedicate this book to Adam and Afton. Adam enters high school this year and Afton begins her journey for a master's degree. As their father, I am incredibly proud of both of them for being the people they are.

About the Author

R. Dodge Woodson is a best-selling author who has written more than 80 books relating to the construction trades. He is a licensed general contractor and a licensed master plumber who has built as many as 60 single-family homes a year. In addition to being a builder, he is a remodeling contractor and plumbing contractor who has owned his own businesses since 1979. Mr. Woodson is accredited as an expert witness and does consulting on construction and plumbing litigations.

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Introduction

R. Dodge Woodson has over 30 years of experience in the construction trades. He has built up to 60 single-family homes a year, has remodeled countless homes and buildings, and is licensed as a master plumber and gasfitter. A seasoned author, he is well known throughout the professional community. His writing style and ability to turn complicated tasks into easy-to-understand terms makes this book your guide to getting your questions answered with less stress.

Here is your ticket to simplifying the cryptic code that you work with on a daily basis. This commonsense approach to working with wells and septic systems lets you see the code as a real-world guide instead of some foreign language that only some people can begin to sift through.

How important is understanding the code when you are working with septic systems? It is essential for professionals in the trade. Installing or connecting to systems without code compliance is an expensive mistake. Many good plumbers and contractors mean well and still stray from the code. This is often due to the code being difficult to understand and follow. This book will walk you through the requirements for working with wells and septic systems.

Thumb through the pages here. Notice the tip boxes. You will find that some key components of your work are highlighted in these. Go ahead, take a peek. While you are at it, pick a few topics that you are either familiar with or confused about and look them up. See for yourself how easily this book puts your mind at ease.

You might find another book that attempts to do what this one does, but if you are looking for the best guide to wells and septic systems, this is it.

Acknowledgments

I want to thank the entire team at Lone Wolf Enterprises, Ltd. for their many years of dedicated assistance in growing the company and allowing it to reach the successful level it now enjoys. Lone Wolf has become well known in the publishing industry as a specialized book producer with much to offer.

The key players in the corporation are Ginny, Jacquie, Wendy, and Leona. I can do a lot on my own, but I would not have been able to grow Lone Wolf without the help of these fine professionals.

Gang, thank you!

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Water Wells Can Cost You Plenty

How can you keep your costs down on well systems? There are many ways to reduce or limit what you pay for a well. Some of these methods have to do with field conditions. Others depend on your ability as a negotiator. Is it really possible to keep well expenses in check? Sure it is. You will have to exert a little effort, but the savings can be considerable.

In this chapter, we are going to look at a number of ways to reduce or hold your costs on well systems. This includes not only wells but the pump systems that are used with them.

Cutting Too Many Corners

Cutting too many corners to save money is dangerous. You can damage your reputation, offend customers, and suffer other consequences. I don't recommend providing substandard materials or workmanship on any job at any price. Even if a customer asks you to provide low-quality work, I suggest that you do not do it. If you do intend to do it, get all of the facts concerning your agreement with the customer in writing. Let's look at some examples that illustrate the risks of working below normal standards.

Using a Spring

Using a spring as a primary water source can put you at risk in many ways. Springs are a cheap source of water, but the water may not remain available at all times of the year. It's possible that the water source will dry up in the summer or freeze in the winter. As a builder of a new house, you have a warranty period to honor. If the spring you use for a water supply fails to produce water, you might have to provide the customer with a well at no charge. Paying for a well and a pump system out of your own pocket will not be a pleasant experience.

When you bid on a house that requires a private water source, you should normally plan on a well system. You will have to determine what type of well system should be installed. We will talk more about this a little later. But for now, what should you do if a customer insists that you use a spring as a water source?

Let's say that you have a couple that wants you to build a custom home in the country. The house will need a private water supply. It so happens that the land where the house will be built has a good spring on it. In fact, the person who sold this couple the land said that people had used the spring for drinking water for years. Based on representations made by others, the couple feels the spring will be adequate for their household water needs. They have instructed you to bid the job based on the spring as the only domestic water source. What are you going to do?

If you have enough experience, you might counsel the couple about the risks associated with using a spring as the only water source. Should you not have an adequate grasp of the facts pertaining to the use of various water sources, it would be appropriate to suggest that the couple talk to experts before committing to using the spring.

You could at least explain the risk that the spring may run dry. Then you might mention, depending upon the geographic location, the risk of freezing during winter months. Contamination of the water is another issue that you might bring up. The cost of enclosing the spring and making it acceptable as a source of potable water should definitely be discussed. Many people have misconceptions about the use of a spring as a domestic water source.

I would guess that a number of people would tell you that all that is needed to use a spring is to put a pipe in it and pump the water to the house. You now know that this is not true. Some type of containment should be placed around a spring that will be used as a water source. It's very important to protect the spring from any entry of ground water. This process costs money. Granted, it doesn't cost nearly as much as digging or drilling a well, but it is an expense that some people will not be aware of.

In addition to the cost of a casing or lining for the spring, trenching and fencing may be needed. Springs located on the side of a hill should have trenched-in drainpipe installed on their uphill side. These slotted drainpipes collect surface water running down the hill and divert it away from the spring. Fencing may be needed to keep livestock from contaminating the spring. Since houses using springs for drinking water are usually in rural locations, the presence of livestock is a possibility that should be considered.

Once you, or some other expert, have explained all the facts involved in using a spring to your customers, they may need some time to think over their options. If the couple still wants to use the spring, you may have to agree if you want to build a house for the customers. But don't do this without some protection.

Assuming that your customers insist on using the spring, you should ask them to put their desires in writing. This written agreement is your protection. If the couple puts the order in writing and assumes all responsibility for the quantity and quality of water provided by the spring, you can limit your exposure to only the pump system. This type of action should be acceptable to any reasonable person. If the couple is unwilling to sign a statement of the specifications, there may be a good reason to avoid doing business in this case. I hate to say it, but sometimes people set other people up to be taken advantage of. My personal experience has proved this to be true far too often.

What might happen if you don't get a liability waiver from the couple in our example? Maybe nothing, but a lot could happen. If you don't have anything in writing, the circumstances surrounding your work might be presented very differently in legal litigation. For example, the couple might tell a judge that you recommended using the spring without ever advising them of the possibilities that might make it unsuitable.

If a judge were given a false impression of what actually went on between you and your customers, you might be found to be responsible

WELL TIP

Using only one stainless-steel clamp per pipe joint will save a few dollars on a typical well installation, but the savings is not worth the risk in my opinion. If you cut every material corner that you can, the savings might reach a couple hundred dollars. This amount of money is nothing to be sneezed at, but why would you risk your reputation, your customer satisfaction, and the cost of callbacks for such a small savings? I just wouldn't do it.

for the lack of adequate or suitable drinking water. As an experienced builder, you may be judged to be much more knowledgeable than your customers on the subject of private water supplies. All in all, you might be ordered by the court to provide a suitable conventional water source for the customer at your own expense. If this were the case, the cost you incur could easily run in excess of $4,000. That simple little liability waiver could save you this aggravation and expense.

Cheap Pumps

Cheap pumps are one way to reduce the cost of a well system. They may, however, be more trouble than they are worth. Some builders may feel that the pumps installed for new houses don't have a direct effect on their businesses. I disagree with this line of thinking.

Most builders don't install their own pump systems. They typically subcontract the work out to specialized contractors. In doing this, the builders put a buffer between themselves and the work being done by the subcontractors. Materials such as pumps might be provided by builders or by the installers hired to put the pumps in. My experience has shown that most installers prefer to provide the materials that they will be working with. When this is the case, a pump failure ultimately rests on the shoulders of the installer who supplied the pump.

A builder who hires a pump contractor to supply and install a pump doesn't have to assume any cost in having the pump repaired or replaced while it is under warranty. The pump installer will have to make good on the work done. This doesn't mean, however, that the customer won't blame the builder for trouble with a pump. When a pump fails, people tend to get upset. If you want to avoid disgruntled customers, you should use the best materials available that fit into your budget.

There is not a lot of cost difference between a good pump and a questionable pump. The difference in cost between a nylon insert fitting and a brass insert fitting is minimal compared to the added benefits provided by the brass fitting. Using only one stainless-steel clamp per pipe joint will save a few dollars on a typical well installation, but the saving is not worth the risk in my opinion. If you cut every material corner that you can, the savings might reach a couple hundred dollars. This amount of money is nothing to be sneezed at, but why would you risk your reputation, your customer satisfaction, and the cost of callbacks for such a small saving? I just wouldn't do it. I'm all for saving money and reducing job costs, but I won't do it at the expense of my customers or my reputation.

WELL TIP

Shallow wells are much less expensive than drilled wells. If you have a choice between these two types of wells and feel that a shallow well will be adequate, there is no reason to spend extra money for a drilled well. While drilled wells do offer advantages over shallow wells, the additional cost might not be justified by the differences in a particular case.

Smart Ways to Cut Costs

There are many smart ways to reduce the costs of wells and well systems. Many of the options don't have any effect on the quality of work or materials that you provide your customers with. These types of savings are well worth looking into. And this is what we are going to do right now.

Well Selection

Well selection can have a lot to do with the cost of a job. Driven wells are your least expensive option. Dug or bored wells are less expensive than drilled wells. Knowing this, you have some room to work with in your budget, subject to local conditions.

When you do a site inspection, you have an opportunity to choose a location where a well will be best placed. There is more to choosing a well location than just a spot where the well will be out of the way. For example, a well that is placed 50 feet further from a house than it needs to be will increase the cost of a job. The cost of extra trenching and pipe will be more. This is due directly to the additional length of piping needed to reach the home. A more costly aspect of this situation could be the upgrading of the needed pump.

If a well is at a distance and depth that is borderline between a half-horsepower pump and a three-quarter-horsepower pump, the extra 50 feet of distance would clearly call for the larger pump. This would increase the cost of the pump system. The combined cost of trenching, pipe, and increased pump size could amount to hundreds of dollars. Assuming that there is no real reason for extending the distance to the well, keeping it closer to the home will provide a cost savings without sacrifice to you or your customer.

Shallow Wells

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Depending on ground conditions, you may not have any choice in the type of well you choose for a job. Your customer might spec out a drilled well, regardless of geological conditions. If this happens, you will have little choice in the matter. It might be prudent to make your customer aware of the cost savings possible by using a shallow well, but I'd steer clear of recommending a shallow well.

If you have customers who specify a drilled well and you talk them into a shallow well, you could wind up in a world of trouble later. Since the people wanted a drilled well and you talked them into a shallow well to save them money, you would bear responsibility, in my opinion, if the shallow well did not perform to the customers' satisfaction. You are usually safe in recommending a superior product or service, but you can get into deep water fast by recommending something that is of a lesser quality.

Driven Wells

Driven wells are the least expensive form of well that can be created. There are times when these wells are adequate for a full-time residence. But there are also times when driven wells can't keep up with the water demands placed on them. Should you install driven wells for new houses? Not normally.

If you are going to install a driven well for a customer, I feel that you should treat it in much the same way that we discussed with springs. Driven wells, in my opinion, should only be used in special circumstances. Trying to save money with the use of a driven well can be very risky.

Pumps

Pumps are a necessary part of well systems. As a builder, you might select the type of pump to be used for a new home. Customers may often tell you what type of pumps they want. The decision as to what type of pump to use might be made by the pump installer. If you or your installer chooses a pump for a customer, you will be on the hook if something goes wrong with it. The only time when you will not have to bear the burden of responsibility for pump performance (outside of an improper installation) is when a customer gives you specific instructions on what type of pump to use. This means that you owe it to yourself to become aware of pump selection and applications.

There are three types of pumps available to you for routine residential installations. They are:

- Single-pipe jet pumps
- Two-pipe pumps
- Submersible pumps.

Submersible Pumps

Submersible pumps are my preference for deep wells. Can you save some money by installing a two-pipe pump for a deep well? It's very possible that you can. Should you take this approach? It really depends on your customers and your circumstances. Typically, I would recommend using a submersible pump, but there are some disadvantages.

The disadvantages of submersible pumps are few. One possible disadvantage is the need to pull the pump out of a well if it fails. When a two-pipe pump fails, it is normally very accessible for repairs. This is comforting to some people, and it can result in lower repair costs.

I've heard that lightning is more prone to strike a submersible pump than a pump that is installed within a home. Whether or not this is true I don't know. It has been my experience that more submersible pumps are affected by lightning than jet pumps. In fact, I don't know of a single instance when a jet pump has been hit by lightning. But I do have personal knowledge of several submersible pumps being struck. This may not seem like a big deal, but if a pump is not covered by lightning insurance, the

WELL TIP

Cost can be a disadvantage of submersible pumps. In my opinion, submersible pumps are a good value, but their costs do tend to be higher than above-ground pumps. Money is always some part of the decision-making process for builders. Even if a submersible is worth every penny of its cost, such a pump may not be needed.

cost of replacement can run several hundred dollars. Admittedly, lightning strikes might not be a good reason for choosing an above-ground pump, but it is a potential consideration.

Two-Pipe Pumps

Two-pipe pumps can be used for deep wells. These pumps require two pipes, and that is a disadvantage in two ways. The cost of a second pipe causes the overall price of a pump system to increase. Perhaps more importantly, the need for a second pipe creates twice the risk of pipe failure. There are tradeoffs both pro and con with two-pipe pumps.

Submersible pumps can move more water more efficiently than two-pipe pumps. This may not matter to a homeowner. Having a pump sitting in a closet produces some risk to a home. If something goes wrong with the pump system, the home could be flooded. Noise is another factor to consider when deciding between a submersible pump and an above-ground pump. Pumps installed in basements or the common living space of a home can be noisy. Submersible pumps cannot be heard when they run. Jet pumps can be heard. This can be a concern for some homeowners.

I've had homeowners complain about being able to hear water running down a drain located in some wall of their homes. If people will complain about the relatively quiet draining of water, they are certainly likely to complain about the running noise of an inside pump. If you consider installing a pump system close to living space to reduce the cost of a water-distribution system, thereby saving some money, consider the noise factor carefully.

Single-Pipe Pumps

Single-pipe pumps are very limited in their uses. If water has to be lifted more than about 25 feet, single-pipe jet pumps become questionable in their ability to perform. This is not to say that a jet pump can't pull water

WELL TIP

Single-pipe pumps are very limited in their uses. If water has to be lifted more than about 25 feet, single-pipe jet pumps become questionable in their ability to perform.

> **WELL TIP**
>
> Never try to save money by eliminating the use of a pressure tank. I'm quite sure you will regret any action along this line.

up to 30 feet. It is also possible that a jet pump won't be able to raise water more than 20 feet. The elevation above sea level is a factor in how well a jet pump, which works on a vacuum basis, will perform.

Installing a single-pipe pump and expecting it to lift water more than 25 feet is a risk. While you can save some money with a single-pipe pump, you must not install this type of pump under questionable circumstances. Common sense goes a long way in day-to-day decisions.

Circumstances will often dictate whether or not a single-pipe pump can be used. Just as you can't drive a well point through bedrock, you can't expect a simple jet pump to pull water up from a 100-foot-deep well. The main question you will normally have to consider will be a decision between jet pumps and submersible pumps.

Pressure Tanks

Pressure tanks should be used on all residential well systems. The size of a tank is relevant to the pump it is working with. You already know that larger pressure tanks reduce the running time of a pump over a period of years. However, a superlarge tank is not usually necessary. As long as the tank being used is sized in conjunction with the pump it's working with, it is not necessary to oversize the tank.

Pressure tanks that hold between 20 to 40 gallons generally work out very well. The additional cost of a larger tank may not be worthwhile. Before you can justify an extra large tank, you must have some special considerations to take into account.

Shopping Prices

Shopping prices can really pay off. Some suppliers charge more than others. This should come as no surprise. Competitors in most fields charge varying prices. If you go to buy gas, you can find a multitude of dealers who are offering essentially the same gasoline for prices that are nowhere near the same. Do all banks charge the same interest fees on loans? Of course not. It stands to reason that some prices will be higher than others for identical equipment.

Being a builder, you may not buy your well pumps and associated equipment directly. You may buy it indirectly through your pump installer. Either way, shopping pays off. You can shop individual material prices or you can shop subcontractor prices.

It doesn't hurt you or your customers to look for lower prices. Keeping a good perspective is, however, important. Going with the low bidder on a labor-and-material bid can be very risky. This is not the case when you are looking only at material prices. If you get three prices on an identical pump, you have nothing to lose by going with the lowest price. It is not until you factor in the quality of workmanship, dependability, and similar human traits that prices become difficult to rely on.

Experience goes a long way in knowing which subcontractors to work with. Until you have a lengthy track record with subcontractors, you don't know what to expect from them. Regardless of what is promised, you can't be sure of what you will get. Really, you can never be sure. However, after doing several jobs with the same subs, you begin to get comfortable with them. This in itself can be dangerous. If you get lulled into a sense of security, you can come up short at some point.

Most installers prefer to provide their own materials. There are two good reasons for this. One reason is that when an installer is supplying material for a job, you will not be depended upon to put the proper materials on the job site. This saves you time, but it can cost you money. Most subcontractors who supply their own materials mark up the costs. This isn't all bad if you look at all sides of the deal.

If you assume that the markup on a well system is $100, it may very well be worthwhile to you to let the pump installer supply all materials. A markup of $300 is a little harder to swallow. Since there are no set rules on how much markup may be added to the cost of products, you have to educate yourself. If you don't, there will be no way for you to know how much you are being charged for materials that you would be able to buy yourself.

Some material suppliers won't sell pumps and related materials to builders for the same prices that they charge plumbers and pump installers. This may not seem fair, but it does happen. If you check material prices, you might find that your pump installer can have a strong markup on the products being offered without having much effect on your costs. Let me give you an example of what I'm talking about.

Assume that you need a complete pump setup for a deep well. You will be installing a submersible pump and a stand-type pressure tank.

> **WELL TIP**
>
> When you price out materials, read the specs carefully. You should also pay close attention to the proposals installers supply you with. A few little gimmicks in a proposal can make a big difference in the bid price.

For the sake of this example, assume that the wholesale cost to your plumber is $750. Further assume that the plumber adds a hefty markup to the wholesale price and gives you a figure of $900. Is this too much for you to pay? It depends.

Let's say that you can't buy direct from plumbing wholesalers. This is basically the case in Maine. Plumbing wholesalers in my area will sell only to licensed plumbers. A builder can't buy from them at all, at least in theory. I know of a few nonlicensed people who deal with these suppliers, but most can't.

If you have to go to a building-supply center or hardware supplier to buy a pump, you might get a 10 percent discount off the retail price. Even with your discount the price might be more than what your plumber is charging you. I know this can be true, because I've seen it from both sides of the table. As both a licensed builder and a master plumber, I have better buying power than most builders. There are times when I can buy something through my plumbing company at wholesale prices, mark it up 30 percent for my building company, and still be paying less for it than what it would cost me with my builder's discount at many stores. In my personal circumstances, this doesn't mean much on a paper trade. But, it could mean a lot to you.

Think about what I've just told you. It might be just as cost-effective for you to pay your plumber an inflated price as it would for you to pay your supplier a discounted price. This makes everyone happy. Your plumber makes some extra money, and you don't lose any money; you might even save a few bucks. This is the type of consideration you have to weigh carefully.

Read the Specs

When you price out materials, read the specs carefully. You should also pay close attention to the proposals installers supply you with. A few little gimmicks in a proposal can make a big difference in the bid price.

Two well pumps that appear identical could be very different. Motor size is one factor to consider, but so is the production rate of the pump. There are many good brands of pumps available. The brand you choose is likely to depend on the dealers in your area. I don't have a particular favorite, but there are two name brands that I have a lot of confidence in. If I'm calling the shots, one of these brands is used on my jobs.

As a plumber, I've worked with many different brands of pumps. Some are easier to get parts for than others. It seems that some brands are more prone to failure than others, but this might not be true. Just because my plumbers repair a lot of pumps from one particular manufacturer doesn't necessarily mean that the manufacturer produces bad pumps. It could simply be that the brand being serviced is much more popular than other brands. If you have 25 Brand A pumps in an area and only 2 Brand X and 5 Brand B, it stands to reason that there should be more failures reported with Brand A pumps. It's purely a numbers game.

I do believe that some pumps are better than others. There is no question that some pumps are easier to work on than others. Each manufacturer usually has something special to offer as a feature or benefit. You can save some money by purchasing no-name pumps, and they might do a fine job. However, you will normally be better off sticking with major brands that are used regularly in your area. If nothing else, parts should be easier to come by.

Most architects specify materials very clearly. Homeowners rarely do. Depending upon who is providing you with job specifications, you may know exactly which materials to bid, or you might have no idea of what is wanted. If you have questions, ask them. The type and brand of pump you figure into your bid could be enough to sway the decision on who wins a job. Don't take chances. Get a clear understanding of what is wanted, and bid the job accordingly.

WELL TIP

A tricky contractor can use a common phrase to fool you. Being a contractor, I assume you are familiar with the old "or equal" expression. Who's to say what is equal? When I get a quote or proposal with the "or equal" phrase, I strike through it. If contractors won't commit to using the materials I specify, they don't work for me.

Watch the proposals given to you by subcontractors for little phrases that may come back to haunt you. Let's say, for example, that you spec out a Brand D submersible pump for the installer to bid. If two contractors follow your instructions and bid the work with a Brand D pump and one contractor bids the job with a Brand X pump, the bid with the different pump won't be comparable to the others. This kind of tactic is used from time to time by contractors striving to be the low bidder. Some of these contractors are very good at hiding their true intentions. You may never know that the type of pump used wasn't the type you specified.

How many builders hang around and watch an entire pump installation? Not many. Do you know how easy it would be for me to switch pump types on you? If you're like most builders, it would be very easy. I could even substitute a used pump without your knowing about it. These types of switches are very easy when submersible pumps are being installed.

Once a pump goes down into a well, it doesn't normally surface again until something is wrong with its performance. So if I stick a cheap pump in your well and charge you for an expensive one, I've made a few extra dollars. If I'm really tricky, I'll have one of the good pumps set out in the open when I arrive on the job and as I'm working. At the last moment, I'll switch to a used or cheap pump. If you happen to stop by to look over the materials or to chat, you see the good pump or maybe just a box for a good pump. What you don't see is the inexpensive pump I've installed in place of the pump you think you are getting.

I'm not saying that pumps are switched on the job very often, but it can happen. And really, who's going to know the difference until the pump fails? By then, the warranty has probably expired and the ripoff contractor may be long gone. I don't want to scare you, but it seems to me that you should be aware of what could happen on an unsupervised job.

Do Your Own Installations

If local authorities will allow it, it might be worth it to do your own installations. The installation of a pump system is not very complicated. If you have basic mechanical skills and can follow instructions, you can install a pump and pipe up the accessories. Doing this work yourself can save you hundreds of dollars.

Some areas will allow individuals who are not working under the supervision of a master plumber to install pump systems. The regulations generally require the installer to stop after the installation of the pressure tank. In other words, you might be allowed to install the pump and related accessories but not the water-distribution pipes of a house.

If you can get a limited license or if no license is required, there is an opportunity for you to pick up extra profit from each job you do. In my area, the labor to install a submersible pump system, not counting the cost of trenching, is usually around $950. Since the work can be done in about half a day by an experienced installer, this isn't a bad rate of pay. I don't know if you would be allowed to do your own installations, but it's worth considering.

Negotiations

Negotiations with your well and pump installers are one option for getting lower prices. When a bid price is submitted to a general contractor from a subcontractor, there is often some room in it for haggling. Simply asking for a lower price may be all that's required. If your subcontractors have figured the job tightly and won't budge on their numbers, there is another card you can play.

Flexible Installation Time

Wells don't generally have to be installed at any particular time or phase of construction. Since most contractors hit dead days, you may be able to use these broken days to your advantage. Subcontractors may be willing to give you a lower price if you don't pin them down to an exact installation date. If a sub knows that your job is ready and waiting when a dead day comes along, the sub can work on your job. This is much better than sitting in the shop waiting for the phone to ring. Since your job is being treated as fill-in work, you might see a lower price.

I've often used the fill-in procedure to lower my costs with subcontractors. Rarely have I encountered trouble from doing this. However, make sure that some time limit is set on when the work will be done. This limit should be explained in your written agreement. For example, you might note that the well will be drilled within 45 days from the date of your agreement. This protects you and still gives the well driller a wide latitude within which to work. Creative ideas like this can definitely work to your advantage.

Volume Deals

Volume deals can pay off for you by the end of a year. If you are in a position to offer your well and pump installers several jobs in close proximity of one another, discounts should be available to you.

When I was building at peak volume, I was producing about 60 houses a year. It was common for me to start 10 houses in 10 days. Knowing that I had these houses coming up, I was able to negotiate some very good volume discounts with all my subs. All the plumbing for the houses was done by my own piece workers, so discounts weren't a factor in the pump installations. The well work, however, was done by subcontractors, and I was able to get price breaks by giving them several contracts to take care of at the same time. Between offering multiple contracts and a flexible production schedule, my well installers gave me great prices. Not all builders are in a position to offer multiple contracts, but if you are, it should be worth a discount.

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Septic Systems Can Sink You!

The cost of a septic system can ruin your budget. Systems can cost between $4,500 to $15,000 or more. Making a habit of installing low-cost septic systems doesn't mean than you are cheating your customers. Actually, you may be doing them a very big favor. If you pass the savings from these systems on to consumers, you have used your knowledge to save them money. What customer wouldn't appreciate this type of surprise?

Builders can face some very tough times during their careers. I know I have. Surviving economic downturns and recessions is just one of the obstacles to overcome. Increased competition is always a threat, and there are many other factors that can put a builder out of business. One way to improve your odds of survival is to hone your skills at saving money.

Making money is very nice, but it requires you to pay taxes. Saving money can be even better than making money, because the tax bite is not so vicious. I've never met anyone yet who enjoys paying taxes. Most of us do it, but few of us feel we get our money's worth.

The cost of living goes up almost constantly. This means that our incomes should rise with the increases in the cost of living. Did your income rise the year before last? How much more money did you make last year? Are you on track to make more money this year? A lot of businesses, including building businesses, suffer from declining sales and income. Left alone, this type of pattern will eventually drive a business out of existence. If you are feeling a pinch in your pocketbook, you must look for new ways to make or save money.

One way for rural builders to reduce their cost of doing business comes in conjunction with septic systems. Some systems simply cost less than others to install. For you to assure reduced septic costs time and time again, you must get involved. Spec builders have to look for good land. Custom builders sometimes have to look for alternatives to high-priced septic systems. If you can get into the swing of doing this right, you can make and save more money.

Knowledge

Knowledge is one of the best tools that a builder can possess. If you know enough about what you're doing, you should be able to do it well. More knowledge in some work areas, such as septic systems, can give you a competitive edge. You've already taken a giant step in the right direction by reading this book. The fact that you are willing to invest your valuable time reading about one or two phases of your building business proves that you care about your business and hopefully about your customers.

Informed builders are better builders. This book is an excellent starting point for you, but it is not the only source of knowledge that you need to become more competitive. Seek other reading materials from local and government agencies. Agencies such as the United States Environmental Protection Agency can provide you with valuable reading material. Local and state agencies may also be able to offer some guidance on the issue of septic systems.

Your subcontractors are a natural source of information. If you have questions about your next septic job, who is better qualified to answer them than your septic engineer or installer? Ask questions. Become informed. Get on the right track, and you can see substantial savings over the coming years. These savings can help offset any economic drops in business production.

Try Installing a System Yourself

If local regulations will allow you to install a septic system, try installing one yourself. Even if you don't make much money from the work, the hands-on experience will do a lot for you. Once you have put your feet in the trenches and your hands on the pipes, you will have a better understanding of how septic systems are installed. Reading about procedures

SEPTIC TIP

Many jurisdictions will not allow unlicensed installers to install septic systems.

is good, but carrying out the procedures is the best way to understand them. You might even discover that installing your own septic systems is an excellent way to boost your income from every rural house sold.

Custom builders are at the mercy of the market. So are spec builders, for that matter. In economies where building is kept at a minimum, making the most from every job is important. You might accomplish this by being your own septic installer. If this line of action doesn't suit you, there is still room to make and save more money by using your head.

Choose Sites Selectively

Choose your building sites selectively whenever possible. Site selection is critical to the ability to install a low-cost septic system. If you can avoid chamber and pump systems, you're money ahead. Building lots and land can be in short supply. Sometimes builders have to take lots that are not as desirable as they would like them to be. Any builder who has been in the business for a few years knows this. But some sites simply aren't worth the prices being asked for them. This doesn't necessarily mean that you shouldn't buy the lots. What it does mean is that you should negotiate a lower price.

If you have a solid understanding of soil types, you can use perk tests to drive the cost of some building lots down. Sellers are reluctant to drop their prices for no apparent reason, but if you build a strong case, you may be able to influence them to lower their prices. I've done this many times and under varied circumstances. This approach is so effective that it is worth spending some time on the details.

A spec builder has a wealth of options in choosing building sites. Since houses being built on speculation can be built almost anywhere, a builder doesn't have to accept the first building lot to come along. Unlike custom builders, who must build on the land that their customers own or want to buy, spec builders have a free hand to wheel and deal. They can look for the best land bargains available. As long as the building site shows good promise for resale, a spec builder doesn't have to put emotions in front of financial logic.

Let's assume that you are a spec builder. You have found three building sites. All of them appeal to you. The three building lots are similar in size and price. Location is not a problem with any of the lots. A spec house built on any one of them should sell well. You only want one of the lots, so you must decide which one to buy. All three lots will require a septic system and well. When all factors are considered, the lots seem

SEPTIC TIP

Cost overruns are not uncommon among builders. When septic systems are involved, the chances of going over budget are increased. If you are building a house where the private sewer will be connected to a public sewer, there are fewer variables than there are with septic systems. Problems can come up with any type of work. Septic systems, however, seem to be especially prone to cost increases.

to be equal in potential for a quick sale once a house is built. Which one will you buy?

In this scenario, there may not be much haggling to be done. Since all of the lots are about the same, you don't have a lot of room to work on the price. In this case, you might just pick the lot you like best and go with it. Or, you could try a price-lowering strategy. How can you do this? You can start by requesting septic designs for the various lots.

Once you have septic designs to review, you might find some differences in the land. One lot might require only a pipe-and-gravel septic system, while the other two call for a chamber system. If this were the case, you should choose the lot that is cleared for an inexpensive pipe-and-gravel system. With all other factors being equal, it would be foolish to buy a lot that required a more expensive septic system.

Let's change some of the criteria in our example. Assume that one of the three lots has a much better location than the other two. This one lot is the site you really want. But there is a problem. The good lot requires a chamber system for its septic disposal. Pipe-and-gravel systems are all you need on the other two lots. After doing some estimates, you discover that the better lot will require about $5,000 in additional site work due to the chamber system. This in effect puts the price of the better lot $5,000 higher than the other two, even though all three are priced the same. As much as you like the one lot, your budget numbers show that the area will not support a higher-priced house. This means that you will have to take the $5,000 out of your building profit. You don't like this idea, so you try a negotiation tactic.

After compiling cost estimates from three septic installers, you make the landowner an offer to buy the building site at a reduced cost. Your justification is the expensive septic system required for the lot. The seller may not accept your offer, but there is a fair chance that you will get the land at a lower price. Since you are able to document and show the landowner a viable reason for making a low offer, you are in a better position to win the negotiation.

I have often been able to acquire land at reduced prices after showing sellers my reasons for making a low offer. If you can get a lower price for a building lot to compensate for an expensive septic system, you have balanced the scales. It's true that you must still install a costly septic system, but the lower price of the land compensates you for it.

Cost Overruns

Cost overruns are not uncommon among builders. When septic systems are involved, the chances of going over budget are increased. If you are building a house where the private sewer will be connected to a public sewer, there are fewer variables than there are with septic systems. Problems can come up with any type of work. Septic systems, however, seem to be especially prone to cost increases. There is really no good excuse for this. Bidding and installing a septic system is not a difficult task. It is far more difficult to anticipate the shift in lumber prices than it is to calculate the cost of installing a septic system.

Why do so many builders find themselves in financial straits when dealing with septic systems? The common denominator seems to be negligence. Too many builders make assumptions and then find out that their guesses were incorrect. I've seen this happen over and over again. And, yes, it has happened to me, too.

How many times have you given customers a ballpark price? When was the last time that you took an educated guess at the cost of an electrical rough-in? Builders frequently plug numbers into their estimates based on experience. They also use square-foot pricing formulas. These approaches can be surprisingly accurate in many cases, but they should not be applied to septic installations.

Septic installations are like snowflakes; no two are identical. Many septic systems are similar enough to allow the use of an average cost when figuring a job. But for every nine that come out on the average, one will come out costing much more. This nine-out-of-ten statement is only an example. I don't know what the true percentages would work out to be. But I do know that if you bid low and have to pay high for a septic system, it could cost you thousands of dollars.

Get septic installers to give you firm price quotes before you make any commitments to customers. Don't accept estimates; demand quotes.

A lot of contractors fall into trouble when they rely on price estimates. An estimate is not the same as a quote. If you have three solid quotes from reputable septic installers, there is no reason why you should suffer from cost overruns. The septic installer might lose money from a mistake in judgment, but you won't. Work only with firm, written quotes, and you should not have to worry about coming in over budget on your next septic system.

Shop Around

Before you accept the bid of a septic installer, shop around. You might be surprised at how much difference there can be in the prices offered by various contractors. I'm sure you already have a good idea of the potential price spreads. Any builder who has worked with subcontractors for a while has seen wide-ranging prices for identical work.

I've gotten bids for jobs where the prices were so far apart that I assumed a mistake had been made by someone. In running down these bids, I've rarely found the great difference in price to be the result of a mistake. Some contractors simply ask for more money that others do. This has proved to be true in all the trades that I've subcontracted over the years.

The septic installer I now use is a great guy. He does fantastic work for a fair price. However, when I was searching for the perfect septic installer, I got some wild bids. There have been times when one contractor has offered a bid price that was nearly double that of competitors. This is the exception rather than the rule, but vast differences do exist. It has not been unusual for me to see prices as much as 40 percent higher for identical work specifications.

As a bidding contractor, I know that it is unusual for contractors to arrive at identical prices for work. But I consider any price that varies more than 10 percent from a competitor's to be suspect. It might be too low or too high. Either way, I become concerned. I like to check my subcontractors out thoroughly before I give them any work. In doing this, I've often found a number of reasons for not using particular contractors. I've had the feeling that some were trying to take advantage of me. Sometimes I've sensed that a contractor didn't seem to want my work. And I've seen a lot of sloppy estimating. In my opinion, a contractor who cannot estimate a job properly is a risk as a subcontractor.

If you don't already have a septic installer whom you know well and trust, find one. Solicit bids from several installers. I recommend getting at least five bids. The more prices you get, the easier it will be to predict who is on target. I'm not going to take up your time telling you how to deal with subcontractors, but you should be shopping your septic prices if you want to consistently produce profitable work. Even if you have an installer who is near-perfect, like mine, you should solicit outside bids from time to time to make sure that you are not paying too much for your septic work. I'm willing to pay a little extra to get the kind of service I get from my installer, but there has to be a limit as to how much extra cost is justified.

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3

Evaluating Sites for Well Locations

On-site evaluations for water wells are often taken for granted by builders. I have known many builders who have submitted bids for work without ever seeing the building lot. There is a lot of risk in doing this. A builder cannot bid a job competitively without knowing what type of well will be used. If a bid calls for a bored well and it turns out that a drilled well is needed, the bidder will lose money. If you estimate for the most expensive type of well in lieu of examining the site, you can overbid and lose the job. Failure to do a site inspection can be a very big mistake.

What can you really tell by walking a piece of land? It depends on your past experience and skill level. Some conditions point to obvious solutions. For example, when I built my last home, I was able to see bedrock sticking up in places. These humps in the land indicated rock close to the surface. A little scratching and digging proved that bedrock was right at the ground surface in some spots and not more than a couple of feet down in most locations. This automatically told me that a drilled well would be needed. When bedrock is present, drilling is the only sensible option.

You can't always see what's likely to be under the ground by looking at the surface. Knowledgeable builders want to know what they will get into when drilling wells and digging footings. Many experienced builders require customers or landowners to provide them with soil studies before

> **WELL TIP**
>
> Since most builders are not experts on the subject of wells, I think it is wise to have well installers make site inspections and give solid bids.

> **CODE CONSIDERATION**
>
> If there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern.

giving a firm bid. When such studies have not been done, some builders do their own. I'm one of these builders.

It is not uncommon to see me or one of my people out digging holes on potential building sites. A post-hole digger can reveal a lot about what conditions exist below the topsoil. Augers and probe rods can also provide some insight into what is likely to be encountered. A probe rod will tell you if a lot of rock is present. But to see the soils, you need a hole. An auger or post-hole digger is the best way to get these samples. Augers are often easier to use. A power auger is ideal, if you happen to have one.

When you can create some test holes, you have a lot more information to base your bid decisions on. There are only a few ways to bid a job where a well will be installed. You can guess what will be needed, but this is very risky. Digging test holes will give you a very good idea of what types of wells might be suitable. Interviewing well owners on surrounding property can provide a lot of data that can help you with your decision. Hiring soil-testing companies is a great but expensive way to find out what you are getting into. Having a few well installers walk the land with you so that they can provide you with solid bids is another good way to protect yourself.

Since soils tests are required for land where a septic system will be used, the results from these tests can be reviewed to aid in the evaluation of the well type that will be needed. This, however, is not always a safe way to proceed. Since septic locations will typically be at least 100 feet from a well location, ground conditions might be very different. If you are going to rely on tests, the testing should be done at the proposed well site.

Since most builders are not experts on the subject of wells, I think it is wise to have well installers make site inspections and give solid bids.

> **CODE CONSIDERATION**
>
> The provisions of the governing building code do not nullify any provisions of local, state, or federal law.

If you have three to five bids from reputable well installers, you can feel secure in the fact that a bid that you present to a customer is safe. This is the easy way out, but it's a good way to go.

When you have firm quotes from well installers, you should be able to depend on them. Having only one bid is risky. The well installer might be too busy to do your job when the work is needed. It's possible that the installer who gave you a bid will be out of business before you can request service from the company. As long as you have multiple bids from reputable installers, you should have very little to fear in terms of your well price.

Location

The location of a well is important. Choosing a location is not always easy. Many factors can influence the location of a well. The most obvious might be the location of a house. It is not common to place a well beneath a home, so most people will choose a location outside of the foundation area of a home. Septic fields are another prime concern. Wells are required to be kept a certain distance from septic systems. The distance can vary from jurisdiction to jurisdiction and due to topography. Access to a location for a well-drilling rig is also a big factor. These large trucks aren't as maneuverable as a pickup truck. Picking a place for a well must be done with access in mind.

Appearance can be a factor in choosing a well location. Wells are not pretty, so they usually aren't welcome in locations where their presence is obvious. A drilled well is easier to hide than a bored well. The difference between a 6-inch well casing and a 3-foot well casing is considerable.

The location of a well also depends on where an expert believes water will be found. Few people know for sure where water will be found, but some people have a knack for being right more often than not. This brings us to the question of prospecting for water. Is it possible to predict where water will be found? A lot of people think so. Let's talk about this.

CODE CONSIDERATION

Additions, alterations, renovations, or repairs to any private sewage-disposal system must conform to the requirements for a new system, though the existing system does not have to comply with all the requirements of the code.

Finding Water

Have you ever heard of reading signs to find water? Well, you won't find billboard signs with arrows pointing down and the words "Water is Here" painted on them. However, there are some natural signs that an experienced eye can detect that can reveal data on potential underground water sources.

Maps

Maps can give you a lot of guidance on where water might be found. Some regional authorities maintain records on wells already in existence. Reviewing this historical data can definitely help you pinpoint your well type and location. Unfortunately, there is never any guarantee that water will be where you think it is. A neighboring landowner might have a well that is 75 feet deep while your well turns out to be 150 deep. It is, however, likely that wells drilled in close proximity will average about the same depth. I've seen houses in subdivisions where one house has great well water and the next-door neighbors' water suffers from unpleasant sulfur content. Fifty feet can make quite a difference in the depth, quantity, and quality of a well.

Topographical maps show land elevations. You can look at these maps and put many things into perspective. If there is a river or stream in the area, you can plot the position of your property in respect to the surface water. Does this help you? Not necessarily.

My property has a good deal of river frontage. My well location is probably 50 feet or so above the river. Yet my well is over 400 feet deep. Why? I'm not sure. I think it has to do with the bedrock that my well is drilled into. Water doesn't run through solid rock very well.

Some maps are helpful, especially the ones that indicate depths and types of wells already in existence. Water does run through rock, but it needs cracks or some other form of access to get into and out of it. This makes it difficult to predict what you will find when you attempt to install a well.

Plants

Plants can be very good indicators of whether and how much water is available beneath the ground's surface. Trees and plants require water. The fact that plants and trees need water might not seem to provide much insight into underground water. Take cattails as an example. If you

CODE CONSIDERATION

Changes in occupancies are not allowed without code approval.

see cattails growing nearby, you can count on water being close by. It's suggested that the depth of water in the earth can be predicted to some extent by the types of trees and plants in the area.

Cane and reeds are believed to indicate that water is within 10 feet of the ground's surface. Arrow weed means that water is within 20 feet of the surface. There are many other rules of thumb for various types of plants and trees in terms of finding water. From a well-drilling point of view, I'm not sure how accurate these predictions are. I know that cattails and ferns indicate that water is close by, but I can't say that it will be potable water or how deep it will be found in the ground. I suspect that there are some very good ways to predict water with plants and trees.

Since I am not an expert in plants, trees, or finding water, I won't attempt to tell you how to find water at a certain depth just because some particular plant grows in the area. It is my belief that with enough knowledge and research, a person can probably predict water depths with good accuracy in many cases. If water can be predicted with plants and trees, can it be found with a forked stick?

Dowsing

Dowsing is a subject that can bring a lot of controversy. There are people who swear they can find water with nothing more than a forked stick. Can they do it? Sometimes they can. People have been successful in locating water with what some people call witching sticks, but how hard is it to do this? There is a huge amount of underground water in the United States. Finding water might be just as possible with a fireplace poker as it is with a twig from a willow tree. I'm not in a position to make a judgment call on this. Dowsing is an activity that I have no first-hand experience with.

I have known builders who hired dowsers to come to job sites and pick locations for wells. They probably always hit water, but then, so have I, and I've never used the services of a dowser. Rumor has it that the type of wood used for a divining rod (forked stick) is important. Favorite wood species include peach, willow, hazel, and witch hazel. It's said that since these trees require a lot of water to grow, their wood is ideal for locating water.

I've studied the use of divining rods to a minor extent. People use metal rods instead of forked sticks to look for gold, water, and other underground treasures. As an amateur treasure hunter, I'm often captivated by new ways of locating hidden bounty. One treasure-hunting show I saw on television conducted a controlled test of self-proclaimed dowsing experts. If my memory is correct, their tests were much better in identifying water than they were in finding gold. The test was controlled over a man-made test bed. Did the testing prove anything? I don't know, but it was interesting to watch.

In my experience as a builder, I've never found a need to hire professional dowsers. You can try their services if you like, but I don't feel it's necessary. An experienced well installer who knows the area and has access to maps is probably just as good a bet and maybe a better one.

High-Tech Equipment

Some professional water hunters have high-tech equipment to work with. I assume that their sophisticated scientific gear works, but I don't know this to be true. If you were looking for an underground water source to serve a small community, it might be worthwhile to enlist the services of some of these professionals. For a single house, I can see no reason to go to the trouble or expense. Hire a well driller on a flat-rate basis who will guarantee water, and you are probably money ahead.

It Doesn't Take Very Long

It doesn't take very long to perform a site inspection. An hour or so is the most time that is normally needed. Can you afford to spend thousands of dollars to save an hour or so? Maybe you can, but I can't. Site inspections are important. Whether it is you or your well installer who makes a decision on what type of well will be needed, someone is assuming a lot of responsibility. Planning to use a bored well and then finding that a 400-foot drilled well is needed is going to cost somebody a lot of money. Customers will expect you to guarantee them a firm price. You should expect the same from your well installer. While you might win more often than you lose by playing the odds, the losses can be very expensive. Someone should definitely perform a site inspection before commitments are made on wells.

4

Evaluating Sites for Septic Locations

Site evaluation is a very important step in the installation of a septic system. Most people know that a perk test is needed before a suitable location can be established, but there is more to the process than just the test. When a site is under consideration for a septic system, the following items must be evaluated:

- Soil conditions
- Properties
- Permeability
- Depth to zones of soil saturation
- Depth to bedrock
- Slope
- Landscape position
- Setback requirements
- Flooding potential

Soil-test data must be taken from undisturbed elevations. A vertical-elevation reference point must be established. Reports on site evaluation must be prepared using approved forms and filed within 30 days of the site testing.

SEPTIC TIP

If a potential site for a soil-absorption system has a slope of more than 20 percent, the system cannot be installed in the location.

When a site is being evaluated for a replacement system, a percolation test is generally not required. Care must be taken when replacing a system, however. It is not acceptable to disturb the existing site in such a way as to compromise the performance of the location for its intended use. A replacement system cannot be used for the following purposes:

- Building construction
- Parking lots
- Parking areas
- Below-ground swimming pools
- Other uses that may adversely affect the replacement area

Slope

If a potential site for a soil-absorption system has a slope of more than 20 percent, the system cannot be installed in the location. Conventional soil-absorption systems must be located a minimum of 20 feet from the crown of a site with a slope greater than 20 percent, except where the top of the aggregate of a system is at or below the bottom of an adjacent roadside ditch.

Test Boring

Test boring is done to retrieve soil samples for evaluation and testing. This type of testing is required on any site where a septic system is to be installed. A boring must extend at least three feet below the bottom of the proposed septic system. It is common for the boring samples to be taken prior to the perk test. Power augers must not be used to collect boring samples; boring must be done with a backhoe or dug by hand.

A minimum of three borings per intended site is required. Accurate details of the bore-hole locations must be logged and maintained, and reports on the locations must be drawn to scale.

Soil-profile descriptions must be written for all borings. All differences in the thickness of different soil horizons observed must be indicated.

CODE CONSIDERATION

Used materials that meet the code requirements for new materials are permitted for use in building septic systems.

Horizons are differentiated on the basis of:

- Color
- Texture
- Soil mottles
- Bedrock
- Depth measured from the ground surface

Soil Mottles

The highest level of soil mottles must be used when estimating the seasonal or periodic soil-saturation zone. On occasion, a code officer may require a detailed description of soil mottling. This is normally required only on marginal sites. Abundance, size, contrast, and color of soil mottles must be described consistently.

When mottled color occupies less than 2 percent of an exposed surface, a sample is said to have an abundance of "few." When the percentage ranges from 2 to 20 percent, the rating is listed as "common." An abundance rating of "many" is given to a sample whose percentage is in excess of 20 percent.

The length of the mottle must be measured. This determines the "size" of the mottle. When the mottle is less than 5 millimeters in length, the sample is said to be "fine." A length of 5 to 15 millimeters is noted as "medium." Samples that are longer than 15 millimeters are rated as "coarse."

Contrast is another factor in soil evaluation. This refers to the difference in color between the soil mottle and the background color of the soil. When the mottle is evident only on close examination, the rating is "faint." Mottle that can be seen readily but is not striking is given a rating of "distinct." A rating of "prominent" is given when the mottle is obvious and one of the outstanding features of the horizon. Reports must include the color or colors of the mottle or mottles.

CODE CONSIDERATION

Code officers are allowed to inspect and evaluate systems, equipment, buildings, devices, premises, and spaces to be used before issuing a permit.

CODE CONSIDERATION

The time limitation to submit a soil report, except under special circumstances, is 180 days after the date of filing.

Ground Water

When ground water is present, it must be reported. The depth to the ground water must be measured and recorded. Measurements are made from ground level. Ground water is measured from its highest location in a bore hole or at the highest level of seepage through the side of a bore hole. Soil above the level of existing ground water must be tested for the presence of soil mottles.

Color Patterns

Color patterns may not be indicative of soil saturation. Soil profiles that have an abrupt textural change, with finer-textured soils overlying more than 4 feet of unmottled, loamy sand or coarser soils, can have a mottled zone for the finer-textured material. If the mottled zone is less than 12 inches thick and located immediately above the textural change, a soil-absorption system is permitted in the loamy sand or coarser material below the mottled layer. When soil mottle occurs in sandy material, a site is considered unsuitable for a conventional system. Certain coarse, sandy loam soils may be considered as coarse material.

Not all soil mottles occur due to seasonal or periodic soil-saturation zones. Many natural occurrences can result in soil mottles. Some conditions that result in soil mottles but are not related to seasonal or periodic soil-saturation zones include the following:

- Residual sandstone deposits
- Uneven weathering of glacially deposited material
- Glacially deposited material that is naturally gray in color
- Concretionary material in various stages of decomposition
- Deposits of lime derived from highly calcareous parent material
- Light-colored silt coats deposited on soil bed faces

SEPTIC TIP

Any loose material collected in a test hole must be removed. The bottom of a test hole must be covered with two inches of gravel or coarse sand.

- Soil mottles that are usually vertically oriented along old or decayed root channels with a dark organic stain usually present in the center of the mottled area

Any mottled soil conditions must be reported. A code official will evaluate the report and determine if a site is suitable for a proposed use.

Bedrock

With the exception of sandstone, the depth of bedrock must be established at the depth in a soil boring where more than 50 percent of the weathered-in-place material is consolidated. When the bedrock is sandstone, the depth is determined by the point where increased resistance to the penetration of a knife blade is established.

Alluvial and Colluvial Deposits

If you encounter alluvial or colluvial deposits, you may have a problem. Subsurface soil-absorption systems are not allowed in alluvial or colluvial deposits when any of the following conditions exist:

- Alluvial or colluvial deposits have shallow depths
- Extended periods of saturation exist or are expected
- Flooding is possible

Percolation Tests

Percolation tests are required when evaluating a potential site for a private sewage-disposal system. A minimum of three perk tests is required. Test holes must be labeled and recorded. The depth of the test holes must extend at least to the bottom of the proposed absorption system.

Test holes can be bored or dug. The holes must have a horizontal dimension of four to eight inches. A sharp instrument must be used to scrape the bottom and sides of a test hole. This is done to expose natural soil. Any loose material collected in a test hole must be removed. The bottom of a test hole must be covered with two inches of gravel or coarse sand.

Sandy Soils

When testing sandy soils, the test hole must be filled with clear water to a minimum of 12 inches above the bottom of the hole. Once the hole is filled with water, the seepage of the water into the soil must be timed and recorded. Clear water is added to the hole until it is not more than 6 inches above the gravel or coarse sand. A timetable of 10 minutes is used to record the absorption rate. This testing goes on for 60 minutes. If 6 inches of water seep away in less than 10 minutes, a shorter interval between measurements should be used. It is important that the water depth is never more than 6 inches. If 6 inches of water seep away in less than 2 minutes, the testing can be stopped and a rate of less than 3 minutes per inch can be reported.

Other Soils

Test holes for soils other than sandy soils should be filled with 12 inches of clear water. The water level must be maintained at this depth for 4 hours. Once the 4-hour period passes, any water remaining should be left in the hole. The soil should be allowed to swell not less than 16 hours and not more than 30 hours. Once the soil-swelling process is complete, the measurements for determining the perk rate can be made.

To conduct a test, all loose material filling a test hole must be removed. The water level in the hole has to be adjusted to a depth of six inches above the gravel or coarse sand. From a fixed reference point, the water level must be monitored in 30-minute intervals for a period of four hours. An exception to this is if two successive water-level drops do not vary by more than 0.62 inch.

A minimum of three water-level drops must be observed and recorded. A test hole must be filled with clear water to a point not more than six inches above the gravel or coarse sand whenever a hole becomes nearly empty. It is not acceptable to make adjustments to the water level during a test, except to the limits of the last measured water-level drop. Once the first six inches of water seep away in less than 30 minutes, the time interval between measurements becomes 10 minutes, and the test must last for an hour. Water depth is not to exceed five inches at any time during the measurement period. When the final drop occurs during the final measurement period, it should be used in calculating the percolation rate.

Mechanical test equipment must be of an approved type. Soil evaluations must establish the estimated percolation based on structure and texture in accordance with accepted soil-evaluation practices.

Verification

Code officials can require the verification of soil evaluations. They may ask that soil testing be done under the supervision of a code official.

When monitoring levels of ground water, a property owner or developer has an option to provide documentation that soil mottling or other color patterns at a particular site are not an indication of seasonally saturated soil conditions or high ground-water levels.

The monitoring of ground-water levels must be done at a time of the year when maximum ground-water elevation occurs. The area must be investigated for any artificial drainage, such as drainage tile or open ditches. If artificial drainage is present, full documentation on the drainage system is required.

When an owner or an owner's agent plans to monitor ground water, the individual must notify a code official of the monitoring. The code official may perform a field check. A minimum of three monitoring sites is required for an official monitoring test.

Design of Monitoring Wells

A minimum of two monitoring wells is required to extend to a depth of at least six feet below the ground surface and a minimum of three feet below the system design. When layered, mottled soil exists, at least one monitoring well must terminate within the mottled layer. Depending on site conditions, a deeper depth for monitoring holes may be required.

Monitoring wells are to be made with solid pipe that is installed in a bored hole. A minimum pipe size is one inch, and a maximum size is four inches. The bore hole should be a minimum of 4 inches and a maximum of 8 inches larger than the pipe to be inserted in the hole.

Observation Requirements

Observations must be done every seven days or until a site is found to be unacceptable. If water is observed above the critical depth, another observation is required one week later. If water is found at that time to be above the critical depth, the site is determined unacceptable. When rainfall of 0.5 inch or more occurs in a 24-hour period during monitoring, observations must be made at more frequent intervals.

If monitoring reveals saturated soil conditions, the following data must be submitted in writing:

- Test locations
- Ground elevations at wells
- Soil-profile descriptions
- Soil series
- Dates observations were made
- Depths of water observed
- Local precipitation data

If a site is monitored and found to be acceptable, the following data is required to be supplied in writing:

- Location of test holes
- Depth of test holes
- Ground elevations at wells
- Soil-profile descriptions
- Soil series
- Dates observations were made
- Results of observations
- Information on artificial drainage if any
- Local precipitation data

Site Requirements

The surface grade of all soil-absorption systems must be located at a point lower than the surface grade of any nearby water well or reservoir on the same or adjoining property. In cases where this is not possible, the system must be located in such a way to prevent surface water from draining towards a well or reservoir. There are minimum horizontal distances for the location of soil-absorption systems and other elements. The following list reveals many of the horizontal distance requirements:

- Cistern: minimum of 50 feet
- Habitable building with a below-grade foundation: minimum of 25 feet

- Habitable building, slab-on-grade: minimum of 15 feet
- Lake, high-water mark: minimum of 50 feet
- Lot line: minimum of 5 feet
- Reservoir: minimum of 50 feet
- Roadway ditch: minimum of 10 feet
- Spring: minimum of 100 feet
- Stream: minimum of 50 feet
- Swimming pool: minimum of 15 feet
- Uninhabited building: minimum of 10 feet
- Water main: minimum of 50 feet
- Water service: minimum of 10 feet
- Water well: minimum of 50 feet

It is not acceptable to install a private sewage-disposal system in a compacted area, such as a parking lot. At no time should surface water be allowed to be diverted to a private sewage system on the same or a neighboring property.

Bedrock

Bedrock, ground water, and slowly permeable soils require special consideration when creating a private sewage system. A minimum of three feet of soil is required between the bottom of the soil-absorption system and high ground water or bedrock. Any soil that has a perk rate of 60 minutes per inch or faster to the bottom of the proposed soil-absorption system and at least three feet below the proposed bottom of the system. There must be a minimum of 56 inches of suitable soil from original grade for a conventional soil-absorption system.

Perk Rate

Trench and bed-type septic systems cannot be installed if the perk rate for any one of the three perk tests is slower than 60 minutes for water to fall 1 inch. The slowest perk rate on any test hole is the rate that must be used when establishing the perk rate of the soil.

Seepage pits require perk tests in each horizon penetrated below the inlet pipe. Soil strata where perk rates are slower than 30 minutes per inch cannot be included in computing the absorption area.

Some parcels of land suffer from severe limitations for on-site liquid-waste disposal systems. These limitations might be determined through the use of soil maps. If permission to install a system is denied based on data from a soil map, a property owner has a right to present any evidence that will prove that a suitable site is available on the property.

Filled Areas

Filled areas are not acceptable sites for sewage systems. However, it is possible to obtain written approval to install a system in a filled area under certain conditions. If there is evidence that proves that a filled site can conform to code requirements, perk rates, and elevation, the site might be approved by the code officials.

There are times when filled sites are created for a septic system. This seems like a contradiction to the code, which typically indicates that filled sites are not suitable. When are you allowed to fill a site? When there is less than 56 inches but at least 30 inches of soil over bedrock. The existing soil must be sand or loamy sand to fit the protocol. Any fill that is used must be of the same soil texture as the existing soil. This same basic procedure can be used when a site with high ground water is encountered. When fill is installed, the installation must be inspected by a code official.

Design Requirements

Any filled area for a septic system must be large enough to accommodate a shallow trench system and a replacement system. The installation area must be approved based on the perk rate of the soil and the use of the building that will be served by the system. If any portion of the trench system or its replacement is placed in the filled area, the fill must extend 20 feet beyond all sides of both systems before the slope begins. Topsoil and vegetation must be removed from any area that will be filled. Maximum slope requirements are one vertical unit to three horizontal units, provided that the 20-foot spacing distance can be maintained. A variance to slope rates may be available under special circumstances.

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Taking Bids for the Work

To be a successful contractor, you must protect yourself during the bidding phase. This can be done in many ways. One of the most important steps is to put everything in writing. Verbal statements rarely hold water in court. In order to have solid footing in a legal battle, you need written documentation.

You've seen some of the many risks associated with wells and septic systems. When you assume responsibility for installing these systems, you are putting yourself at risk. This, however, is part of your job. But the risk factor can be kept in check with a little thought and preparation on your part.

What type of proposal do you use? Is it one of those generic, fill-in-the-blank forms that you can order from a catalog? I know that generic proposals and contracts are used by a lot of contractors. Just because the forms are used in large numbers doesn't mean that they are good forms. You should have your attorney draft documents for you to use.

Even if you have the best forms in the world, they are not much good unless you use them. How many times have you given customers a quote over the phone? Do you have any record of your conversation? I doubt it, and even if you did, it probably wouldn't be enough to save you in a court battle. Your bids should be given in writing. If you have to give a price over the phone, follow it up with a written proposal.

> **PRO POINTER**
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> Confusion is one of the biggest reasons why contractors get into arguments with their customers. If your intentions are spelled out in black and white, there is much less room for confusion to set in.

Confusion is one of the biggest reasons why contractors get into arguments with their customers. If your intentions are spelled out in black and white, there is much less room for confusion to set in. Until you and your customer understand each other's plans completely, there is the risk of a conflict.

As a builder, you have to take responsibility for a lot of trades. You are probably more familiar with some than you are with others. This is only natural. Regardless of how much you know or think you know about a trade other than your own, you can't afford to make representations without documentation. And you may not be able to create solid documentation without some help from experts in the fields of work with which you are dealing.

Look at the last contract you signed with your well driller. Pay particular attention to the disclaimers. Now do the same thing with the last contract you signed for a septic installer. Compare those contracts with the proposals you presented to your customers for those jobs. Does you bid package detail the same disclaimers that are found in the proposals from your subcontractors? If it doesn't, you are assuming too much risk.

Many contractors take a casual approach to bidding jobs. I've seen bids come into my office for major work in which only a couple of paragraphs described the work and terms being offered. This not only makes for a poor proposal in terms of sales appeal, but it leaves a lot of room for confusion and confrontation.

Your formal quote to a customer is a serious communication. If you leave details out of your quote that will later be put into a contract, you may run into resistance with your customers when you ask them to sign your contract. I believe it is best to provide complete details of every offer in the quote. If there will be exclusions, they should be spelled out in the quote. Any substitution of materials should also be put in clear language. Your quote is your sales presentation, so it should be accurate and enticing.

As a general contractor or builder, I'm sure that you've received numerous quotes and estimates from subcontractors. You must have seen some pretty skimpy ones from time to time. My experience has shown that a majority of bids are poorly prepared. Customers take accuracy, neatness, and thoroughness into consideration when trying to decide on a contractor. But getting the job is not your only concern.

Once you have won a bid, you want to make money and keep your customer happy. Detailed quotes and contracts are a good step toward

> **PRO POINTER**
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> Every well proposal I have ever seen has had some form of disclosure. A common statement is that the driller will not guarantee the quantity or quality of the water produced by a well. This one simple sentence in the quote or contract can have a huge impact.

reaching your goal. If pertinent details are omitted from either a quote or a contract, you might very well have a disgruntled customer on your hands. It's possible that you will even be dragged into court. I can give you an example of this eventuality to consider.

One of my carpentry subcontractors told me a story about a house he built recently for a customer. As part of the contract, he was supposed to have his site subcontractor provide a certain amount of loam for a job. During the construction process, the site contractor and the owner of the property had a discussion. They agreed jointly to use sand in place of loam for much of the fill work, as sand would be cheaper. A written change order was not issued to document this new agreement. The site contractor performed the services that he and the homeowner had agreed to.

After the house was built, the homeowner refused to pay the subcontractor for some of the work that had been done. One of the phases being contested was the site work. The owner wouldn't pay up, so the site contractor took him to court. As the general contractor, my friend was also required to make an appearance in court.

I'm told that the court hearing didn't last very long. After some verbal exchanges and accusations, the judge referred to the only written agreement between the parties. The contract called for a certain amount of loam. When the judge asked if the described amount of loam had been installed, the site contractor had to admit that it had not. He tried to qualify his answer by telling the court about the verbal agreement to substitute sand for a portion of the loam, but the judge wouldn't hear it. Based on the written agreement, the court ruled in favor of the homeowner.

If everything I was told was true, and I believe it was, the site contractor got a raw deal. I can't fault the judge for going by the only real evidence available, but the homeowner took advantage of the site contractor. If you want to avoid this type of problem, make sure that all of your agreements are in writing. This pertains to all aspects of your deal, including any exclusions.

> **PRO POINTER**
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> With the use of disclosures, disclaimers, exclusions, and liability waivers, you can put up a good shield around you and your business.

Disclosures

Every well proposal I have ever seen has had some form of disclosure. A common statement is that the driller will not guarantee the quantity or quality of the water produced by a well. This one simple sentence in the quote or contract can have a huge impact. Let's talk about this.

Assume that you are building a new house for a young couple. The house is in a rural location and will require both a well and a septic system. As the builder, you are responsible for all aspects of the job, including the well. Further assume that your agreement with the well driller does contain some version of the standard disclosure about quantity and quality. Now let's say that the well driller hits water and everything is fine until about six months later, when the dry season rolls around.

One day, as you are going about your business, the homeowner calls and complains that the house you built has no water. After troubleshooting the situation, you discover that the well has run dry. Being a builder, you have to warranty the house for one year. After only six months, the well has dried up. What's going to happen?

The homeowner is probably going to expect you to dig or drill a deeper well. If you go back to your well driller with this request as warranty work, you will probably be told to forget it. The driller can simply produce the contract you signed, the one with the innocent little sentence in it, and prove that the quantity of water was not guaranteed. Where does this leave you? Sort of between a rock and a hard spot. You've got to give the customer a better well, and your well driller doesn't have to do any of the work as warranty work. Under the circumstances, you are going to have to pay for the new well out of your own pocket.

You can avoid this type of situation by putting the same disclosure in your contract with the homeowner. If the homeowner is getting the same deal as you are, and the facts are set down in writing and signed, you're in a much better position to avoid paying for a new well.

The use of disclosures and liability waivers can go a long way toward protecting you and your business. If you have specific terms written clearly into any agreement you make with a customer, you are much less likely to get into arguments. This is not only good protection but good public relations as well.

Danger Spots

What are some of the danger spots that you should be extra cautious about as you are bidding jobs with wells and septic systems? There are many circumstances that can put you at risk. Some cannot be avoided, but others can be. With the use of disclosures, exclusions, and liability waivers, you can put up a good shield around you and your business. To expand on this, let's look at some of the specific areas of concern as a bidding contractor. We will start with septic systems.

Septic Systems

Septic systems are fairly simple to install. Yet there can be a great deal of risk when bidding jobs involving private sewage systems. To help protect yourself and your company, you need to address some of these key issues in your proposals and contracts.

Septic Permits

Septic permits are typically required before the septic system can be installed. This is normally not a problem, but it can be. If you are bidding a job where the customer wants or needs a private waste-disposal system, you should make your price and work subject to the issuance of a septic permit. Then, if for any reason a permit cannot be obtained, you have an out.

Having a request for a septic permit denied is not common, but it can occur. It could be due to poor soil conditions, but there is another major reason why the request might be turned down. There are some areas where a public sewer has been installed in recent years. Assuming the building lot is large enough to accommodate a septic system, a property owner might prefer to have a private system. This would eliminate the tap fee charged by the sewer authorities for connecting to the public sewer. It would also do away with monthly usage fees for the public sewer. However, even if other houses in the area are using private systems, the jurisdiction issuing permits might not allow the installation of another private system when a public sewer is available. This is a common practice. You could walk into a nightmare if your quotes and contracts don't cover this possibility.

A Specific Design

When you write up a quote or contract to install a septic system, you should name a specific type of design. If your quote is based on a pipe-and-gravel system, say so in your quote. Reference the septic design drawing that you used to calculate your pricing. If for some reason the specified design isn't approved, you're at much less risk. An open clause that states that you will install a septic system for a certain price is much more dangerous. The more specific you are in your language, the less likely you are to have a problem.

Clearing

The clearing of an area is often needed for the installation of a septic field. Who's responsible for this work? If your proposal says you will install a septic system and does not exclude clearing, it could (and probably should) be interpreted that you will take care of all aspects of the job, including clearing.

If you are going to clear land for a septic system, detail in your proposal what work will be done. How large an area will be cleared? The answer to this question should be a part of your proposal. Will you remove stumps, rocks, and other leftover debris? If not, exclude this work. Otherwise, stipulate what you will do with the debris. Make your work description very clear.

Access

Access to a septic site can be a problem. You might have to cut down trees to get trucks and equipment to the site. If your customer is not aware that trees outside the septic area will be removed, you might wind up with an

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Rock can make the normal installation of a septic system impossible. You should address this issue, as well as other underground obstacles, somewhere in your proposal and contract. I leave it up to you and your lawyer to work out the exact wording, but make sure that you have some type of protection in the event that unseen obstacles prevent you from doing the work you are proposing at the price you are quoting.

> **PRO POINTER**
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> Are you going to take care of landscaping the septic area? Will you be doing the finish grade work? Who will seed and straw the area? All of these questions should be answered in your proposal and contract. Even the type of dirt used to cover the excavated site should be detailed.

angry client on your hands. If the customer comes out to inspect your progress and is shocked to see favorite trees gone without notice, you could be in trouble. If an access path must be made, be specific about where it will be and what will be done.

I've had occasions when the only practical way to get equipment to a septic site was by crossing over the land of adjoining owners. This, obviously, is not something that should be done without written permission. If your customer tells you that the neighbors won't mind a bit if you use their driveway or land for access, don't believe it until you have it in writing.

Materials

The availability and price of materials are other issues that you might want to cover in your protective paperwork. I don't believe this is a big issue with septic systems, but it wouldn't hurt to have some type of clause in your agreements to deal with rising prices and materials that are not readily available.

The Sewer

Who is going to run the sewer from the house to the septic tank? Septic installers often run the sewer to within five feet of a home's foundations. From there a plumber takes over. This, however, is not always the case. Sometimes plumbers do it all. If you are bidding all phases of a job, this is not such a big deal. However, if you are bidding the septic work and not the plumbing work, the question of who is responsible for the sewer could become an issue. Digging the trench for a sewer can take some time. There is also the labor and material needed to install the pipe to be considered. Keep the sewer installation in mind when you are bidding your next job.

Perimeter Trees

Perimeter trees can interfere with septic systems. If trees are left standing too close to a drain field, their roots may invade it. If you feel that perimeter trees should be taken down, stress your point in your proposal. Owners who prohibit you from following your professional instincts on this issue should be asked to sign a liability waiver that releases you from any damage done by the perimeter trees.

Wells

Wells, like septic systems, can present bidding contractors with some problems. Certain clauses often found in the contracts offered by well drillers can set a builder up for trouble. If you don't provide some protection for yourself in the contracts signed between you and your customers, you could lose thousands of dollars. A lot of houses depend on wells for their potable water, so you had better be prepared for bidding on them. Let me give you a few pointers on what to look out for.

By the Job

Will you be paying your well driller by the job or by the foot? Both payment methods are usually available. Depending upon circumstances, there can be dramatic differences in the overall cost of producing a well, depending upon which pricing method is used. Since this is a serious subject, let me give you a little background on how I have worked with wells in the past.

All of the well drillers I have worked with have always given me two payment options. I can pay so much for each foot of depth in a well, or I can pay a flat rate that will not change no matter how deep the well is. The flat-rate price also guarantees me water, so if a driller hits a dry hole, I'm not paying to have the second well sunk. Under these conditions, which way would you go?

The flat-rate price for a well is usually pretty steep. Well drillers usually look at historical data for existing wells in the area. They calculate what they believe to be the worst-case scenario and base their prices on that. The per-foot price often works out to be cheaper, sometimes as much as $1,000 less, but there is additional risk involved for the person paying the bill.

In the past, I've always gambled on my wells. Even though the guaranteed deals are safe, I wanted to save the extra money if I could. Just like

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Dug wells are cheaper than drilled wells, but they sometimes run dry. Drilled wells rarely run out of water due to their extreme depth. If your customer is looking to cut corners and the local ground conditions will allow it, dug and jet-pump wells are the least expensive way to go while still maintaining a viable hope for a steady water supply.

the well drillers, I would do my own research on area well depths. Sometimes I would just talk to owners of adjoining properties to see how deep their wells were. This gave me a good idea, but no guarantee, of how deep my wells would have to be. Using this strategy, I've saved lots of money over the years. I could have been caught on some of them with extra-deep wells or even a dry hole, but I never have.

When I built my most recent personal home, I opted for a guaranteed price. This was the first time in all of my building activity that I ever went with a flat-rate fee. I'm not even sure myself why I did it, but I did. And, am I ever glad that I did.

Most wells in my area are between 250 and 300 feet deep. If I were estimating my costs on a per-foot basis, I would have used the 300-foot figure. I have river frontage on my land, and I thought the water vein might be even closer. My neighbors live some distance away (about half a mile), so their wells are not a great barometer to use, but they are better than nothing. I figured my well would not be deeper than 300 feet and maybe as shallow as 200 feet. Yet something gnawed at me about this. For whatever reason, I decided to go with a fixed price. My well wound up being 404 feet deep. Even the driller was shocked at the depth. In this case, the driller lost and I won. If I'd chosen a per-foot price, the cost would have been well above my budgeted amount.

Which pricing method should you use? If you want to be safe, go with the guaranteed price. It's up to you to decide which way you will go, but you should put something in your proposal to identify which conditions you are giving your customer. You might say that the cost of the well will be a specific amount and that the amount is guaranteed. The price might scare your customers, but they will rest easy knowing that there will be no surprises.

You could say that your price is based on so much per foot for the well. If the depth is less, you will credit the difference to the customer.

Should the depth be more than what your estimated cost is, the customer will pay the extra. This approach might frighten your customers more than the higher fixed price.

As a matter of practice, I give my customers the same option that the well drillers give me. I let them choose between the per-foot and the fixed-price method. Once they have made a decision, I memorialize it in our agreement. This method has always worked very well for me.

I've been lucky with my wells. Few have run deeper than expected, and I've never run up against a dry hole. Other contractors I know have not been so fortunate. Having to pay for two or three wells to get one is no bargain, so be careful on this issue.

Drilled or Dug?

Will the well you provide be drilled or dug? You could simply put in your agreement that you will provide a well. Most customers wouldn't question this approach, but some might. However, after the well is installed, you could get some grief if you installed a dug well and the customer thought a drilled well was being installed. You should identify clearly the type of well your price includes.

Dug wells are cheaper than drilled wells, but they sometimes run dry. Drilled wells rarely run out of water due to their extreme depth. If your customer is looking to cut corners and the local ground conditions will allow it, dug and jet-pump wells are the least expensive way to go while still maintaining a viable hope for a steady water supply.

Driven wells, in my opinion, should not be considered a worthwhile option for full-time homes. These little wells can produce good water, but the quantity is limited. While a driven well makes sense for a weekend cottage or fishing camp, I don't feel it is suitable for the demands of full-time use.

Drilled wells are the most expensive to install, but they are also the most dependable. A submersible pump and a drilled well are the way to

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Drilled wells are the most expensive to install, but they are also the most dependable.

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Location might be an issue that will come to haunt you with the installation of a well. If the only place to put a well is smack dab in someone's front lawn, you might have a problem. Dug wells have a large diameter and usually consist of a concrete casing and top. Having one of these for a lawn ornament will not get a person's home on the cover of a fashionable magazine. Drilled wells are not as conspicuous as dug wells, but they are still not things of beauty.

go in my opinion. I've owned houses that were served by dug wells and by drilled wells. In my opinion, the drilled well can't be beat.

Well preference should be left to the customer's discretion. However, you need to make it clear in your paperwork what is wanted, what your prices are based on, and how problems that may arise will be handled.

Water Quantity

Will your customer be guaranteed a certain quantity of water from a well? Your well driller will probably not make this commitment, so you shouldn't either. I've never seen a driller's proposal that didn't exclude the quantity of water. This is a touchy subject, but it is one you should deal with before a problem pops up. If your customer comes back to you because of a lack of water quantity, you are unlikely to have anywhere to turn. Think about this.

How can you get your customer to accept the fact that you will not guarantee a quantity of water? There is a method that I've used for years that has never let me down. Get several quotes from well drillers. If you're not afraid to show your customers the prices that you are paying, show them the actual quotes. In my experience, every quote has stipulated that the well company would not be responsible for quantity. Once you prove to the customer that it is an industry standard to exclude quantity, you should have made your point. If not, get more estimates. Once you have collected a handful of quotes, all of them excluding quantity, your customer should give in.

Flow Rate

I've had customers demand that I guarantee them a minimum flow rate of recovery for their wells. No driller I have ever dealt with was willing to do this. Therefore, I've never done it. This problem is similar to the issue of quantity. If you can't find a driller who will give you a guarantee, you shouldn't offer such a commitment to a customer. Even if I found a driller who would make such a claim, I don't think I would be comfortable doing so.

Water Quality

Water quality is another issue that most well drillers will not guarantee. The perspective of most drillers is that, once water is hit, their job is done. Most drillers will go deep enough to provide a reasonable rate of recovery, but they will not refund your money if the water smells like rotten eggs. Water with high sulfur content does stink, and some wells are full of this disgusting water.

Sulfur is not the only disagreeable element found in water. Iron can be a big problem. It stains plumbing fixtures and leaves a black buildup in toilet tanks, water heaters, storage tanks, and so forth. Hard water is very common in some areas, and it makes washing dishes, clothes, and hair difficult. Soap does not perform well when mixed with hard water. Acid can be so dominant in drinking water that it will eat holes in copper pipes and upset the stomachs of some people. There are other types of mineral inclusions that can disappoint homeowners. While sulfur is not too common, other types of mineral conditions are.

The types of water conditions we are discussing don't usually make water unsafe to drink. But smelling rotten eggs every time you put a glass of water to your mouth certainly isn't something most people want to live with. For this reason, you need to cover the bases on water quality in your quotes and contracts. Again, I would use the quotes of well drillers as evidence that a guarantee of quality just isn't standard procedure within the industry.

Location

Location might be an issue that will come to haunt you with the installation of a well. If the only place to put a well is smack dab in someone's front lawn, you might have a problem. Dug wells have a large diameter and usually consist of a concrete casing and top. Having one of these for a lawn ornament will not get a person's home on the cover of a fashionable magazine. Drilled wells are not as conspicuous as dug wells, but they are still not things of beauty. The six-inch steel casing of a drilled well is easier to camouflage than the three-foot diameter of a dug well,

> **PRO POINTER**
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> Well-drilling rigs are big. It takes a lot of room to move them around. Tree limbs or entire trees might have to be removed to allow access for these big rigs. Make sure you talk this situation over with your customers in advance. Have the customers agree to whatever your needs are for getting a well truck in and out.

but you'd better clear the location with your customer before you make a firm commitment.

I suggest that you locate the proposed well site during your site visit. Have the customer agree to the location and identify some landmarks and measurements to detail the location on paper. Include some option for yourself in case the proposed location proves unsuitable.

Permission

Getting permission from a governing body to install a well is normally not a big deal. However, you could run into a problem similar to the one we talked about with septic systems. If a public water supply is available, it may be mandatory to hook up to it. This is not an uncommon situation. You will seldom run into this type of a problem, but don't assume that it couldn't come up.

The Trench

Who is going to be responsible for the trench needed from the well to the house? Well drillers will sometimes take care of the trench if they are installing the pump system, but they don't normally provide a trench in their drilling price. If you have full responsibility for all aspects and costs of building a home, you will have to get a price on the trench from somewhere, and there will be no need to bother the customer with details of who will install it. However, if you are acting as the general contractor on only parts of the construction process, the trench could be an expensive issue to have to settle at some point.

The Pump System

The pump system falls into a category similar to the trench. If you're taking care of the whole job, the customer doesn't have to know whether the pump system will be installed by a plumber or by a well driller. But if your job is segmented, you might have to determine who is assuming responsibility for the pump system. This work involves a good deal of material and labor, so it is not a cheap item to make a mistake on.

A Spec Sheet

A detailed spec sheet should accompany all of your proposals and contracts. This is just good business for any contractor. Many of the risk elements that we have discussed can be covered in the spec sheet. For example, you should list in the specifications for a well system all of the types of materials that will be used. This would start with the type of well being priced. The type of casing and grouting should also be listed. You would then note the brand and size of the pump being supplied. Reference should be made to the brand, type, and capacity of the pressure tank. The more details you put on your specifications sheet, the better.

As a part of my company policy, I require customers to sign more than just my contracts. I ask them to sign the specifications sheets and any blueprints or drawings being used. This eliminates any possibility that the customer will claim that the documents were never shown to them. There have been occasions when this practice saved me a lot of trouble. If a customer starts complaining about something that is covered in the documents, a quick reminder of their signatures settles them down fast.

What You Don't Know

What you don't know can definitely hurt you when bidding jobs. If you are not familiar with septic systems and wells, spend some time studying them. You have to be able to talk intelligently about these subjects even though you are not expected to be an expert. If a customer asks you the difference between a one-pipe jet pump and a two-pipe jet pump, you had better have a good answer. What would you say if a customer wanted your advice on whether to use a jet pump or a submersible pump? You should be prepared to answer such questions with solid answers. Would you recommend using a garbage disposer with a septic tank?

A lot of builders don't know much about wells or septic systems. This is understandable but not acceptable. You owe it to your customers and yourself to become educated on the services you offer. Failure to do this can hurt your reputation and your bank account. Since you are reading this book, you are obviously interested in learning more about rural water and waste systems. I applaud you for this.

6

Soil Studies

As a builder, it is not your job to do your own soil studies. These will be done by soil engineers or county officials. Drawing septic designs will not be a part of your job description either. But you do have to know how to interpret them. Code-compliance issues will be incumbent on the contractor you hire to install your septic systems. However, if you don't have a cursory knowledge of code issues, you may find yourself feeling very foolish. So what are we going to do about this? I'm going to prepare you with enough background so that you can hold your own with any builder when it comes to talking turkey about septic systems.

Septic Designs

I think we should start our discussion with septic designs. Chronologically, soil studies would come first, but it may help you to understand soil studies if you first have knowledge of design criteria. As we run through the information required on a septic design, you will see that there are differences in what is required for a new system and a replacement system.

As a builder, you will most often be dealing with new systems. However, you may become involved in the utilization of a building lot that once supported a house and a septic system. If, for example, the home was destroyed by fire, the new house you are contracted to build might

> **SEPTIC TIP**
>
> Trench and bed systems are both types of drain fields that do not require the use of chambers. Bed systems are the more common of the two. The design criteria for either of these systems are different from what would be used to lay out a chamber system. Both require a replacement septic system. For this reason, I will go over both areas of the design form.

The top section of the design form calls for information pertaining to the job location and the property owner's name and address. This information is located at the top left corner of the form. At the right corner, you will find an area where a septic permit must be attached once the design has been approved.

As we move into the main part of the design, there are many individual boxes that request pertinent information. See the list below for samples of questions that you will need to answer:

- Will the system will be a new system?
- Will the system be a replacement system?
- Will the system be an expanded system or an experimental system?
- Will the system consist of a bed, trench, or chamber design?
- What is the size of the property where the system will be installed?
- Will a variance be required?
- What type of structure will the system serve?
- Is the system to be engineered?
- Will the system be nonengineered?
- Does the system include the use of an alternative toilet?
- What type of water supply will the structure depend upon?
- What type of treatment tank will be used?
- What is the capacity of the tank to be used?
- Will the tank be of a standard style or will it be a low-profile unit?
- Will there be any special procedures used to conserve water?

GOING GREEN

Some types of green sewage-disposal systems are not practical for single-family homes. One such example is a constructed reed-bed system. This requires a lot of land. The system is inexpensive to build and very energy-efficient. Maintenance requirements are low. Wildlife can thrive in the artificially crated wetland. If there is enough land to work with, a reed-bed system is well worth considering.

> **SEPTIC TIP**
>
> In terms of texture, a sandy or loamy soil is best suited to trench and bed systems. Gravelly and cobbled soils are not as desirable. Clay soil is the least desirable. The box provided for soil data is ruled to allow for depths ranging from zero to 50 inches.

- What is the size of the design: small, medium, medium-large, large, or extra large?
- Will the system require a pump?
- How large will the septic bed be?
- Is a chamber system required?
- If a trench system is to be used, how long will the trench be?
- For residential applications, how many bedrooms will the home contain?

The top half of page two of this form has grid boxes. This grid system is supplied so that the design professional can draw a site plan to scale. Part of the site plan will show the location of the building being served, its well (if one is to be installed), and the septic system. Other information may be included in the drawing, such as roads, rivers, ponds, property boundaries, and so forth.

Soil Considerations

The bottom section of the second page of the form deals with soil descriptions and classifications as they were determined at observation holes. The first question asks if the hole was a test pit or created by boring.

Subjects covered for the soil include:

- Texture
- Consistency
- Color
- Mottling

To explain more about soil conditions I will give you an example of the last home site that I developed. In the case of my tests, the soil texture was sandy loam to a depth of 36 inches, where bedrock was encountered.

The consistency was friable throughout. Color ran from brown in the first 6 inches to reddish in the 6 to 16 inch depths to light brown in the final depths.

Additional information in the bottom section states the soil profile, which in my case was a two. The soil classification was condition A. My slope was 10 to 15 percent, and my limiting factor was 36 inches, due to bedrock.

Page three of my septic design consisted mostly of a detailed drawing of the septic layout. It mandates a low-profile, 1,000-gallon septic tank and no pump. All of the details of the septic system, including the tank, the distribution box, and the bed, are drawn to scale.

Directly below the drawing of my septic system are some fill-in-the blank spaces. The first one indicates the depth of fill required on the upslope. In my case, this was 12 inches. Given the conditions of the septic system was being designed for the depth of fill on the downslope I was required to have between 30 and 60 inches.

Construction elevations are also given in this section of the report. My reference elevation was set at zero and was marked with a nail and red flag on a tree. The bottom of my disposal area was set at 72 inches below the benchmark (also indicated by a nail and red flag attached to a tree).

For the top of my distribution lines, a calculation was made for 60 inches below the benchmark.

Two cross-section drawings were attached to my design. These drawings showed all the details of the installation. For example, the drawing started at the bedrock and showed the original soil surface. It then showed a 12 inch layer of crushed stone. It indicated a layer of hay and 4-inch perforated pipe. This was to be covered by a 12 inch layer of sandy-type fill. Further details showed the rest of the fill needed to accommodate the slope of my system.

Anyone with a reasonable understanding of construction terms could look at my septic design and see exactly what was involved in a satisfactory installation. Even if you are a builder who is not familiar with septic systems, reviewing a septic design will bring you up to speed quickly.

Design Criteria

Design criteria for septic systems can vary from one jurisdiction to the next. You should always consult local authorities to determine the requirements in effect within your region. However, I can give you a broad-brush understanding of how criteria are often set.

SEPTIC TIP

When you are looking at the color of soil with the intention of installing a trench or bed system, look for bright, uniform colors. This indicates a well-drained, well-aerated soil. Ground that has a dull, gray, or mottled appearance is usually a sign of seasonal saturation. This makes soil unsuitable for a trench or bed system.

Soil Types

Which soil types are suitable for an absorption-based septic system? There are a great many types of soils that can accommodate a standard septic system. Naturally, some are better than others. Let's take a few moments to discuss briefly what you should look for in terms of soil types.

The Best

What is the best type of soil to have when you want to install a normal septic system? There is not necessarily one particular type of soil that is best. However, there are several types of soil that would fall into a category of very desirable. Gravels and gravel-sand mixtures are some of the best soils to work with. Sandy soil is also very good. Soil that is made up of silty gravel or a combination of gravel, sand, and silt can be considered good to work with. Even silty sand and sand-silt combinations rate a good report card. In all of these soil types, it is best to avoid what is known as fines.

Pretty Good

Just as there are a number of good soils, there are many soil types that are pretty good to install a septic system in. Gravel that has clay mixed with it is fairly good to deal with, and so is a gravel-sand-clay mixture. The same can be said for sand-clay mixtures. Moving down the list of acceptable soil types, you can find inorganic silts, fine sands, and silty or clayey fine sands.

Not So Good

Inorganic clay, fat clay, and inorganic silt are not so good in terms of drainage values. This is also true of micaceous or diatomaceous fine, sandy or silty soils. These types of soils can be used in conjunction with absorption-based septic systems, but the systems will have to be designed to make up for the poor drainage characteristics of the soils.

Just Won't Do

Some types of soils just won't do with a standard septic system. Of these types of soils, organic silts and clays are unacceptable. So are peat and other soils that have a high organic rating.

I've read some quite sophisticated books on the subject of soils. Believe me when I tell you that an entire book could be written on the subject of soils alone. Operating on the assumption that you are a builder and don't wish to become a soil scientist, I will spare you all the technical information that is available on various types of soils. As a builder, you will have to rely on a specialist to design your septic systems.

Other Considerations

Soils that are wet and holding water are not going to be suitable for a septic field. Beware of field locations that are in close proximity of wetland vegetation. Not only will the soil likely be unacceptable, disturbing wetlands can create serious problems in the way of laws and fines. The Department of Environmental Protection (DEP) has strict regulations on construction around wetland areas.

Avoid site locations that are close to trees. Even small trees that have creeping roots can ruin a septic field quickly. It is important to factor in the removal of any rooted growth from a proposed septic area.

Perk Tests

If you are evaluating potential septic sites on your own initially, you do simple perk tests to get a fair idea of how suitable the local soils are for an absorption field. I do not recommend relying only on your own perk tests. Eventually a professional will be needed to conduct the soil testing. However, if you are a builder considering a building lot and don't want to spend a lot of money on speculation, you can do your own perk tests.

In order to conduct your own perk test you will need to dig some holes, fill them with water, and keep track of the time it takes for the water to be absorbed into the soil. Dig several holes in an area. A post hole digging tool or an auger works best.

You want to establish holes that have a minimum diameter of 4 inches. The holes should be deep enough to reach what would be the drainfield level. Remove any clay or compacted soil from the holes. Scratch the sidewalls and bottom of the holes. Ideally, you should add two inches of fine gravel to each hole. Then you soak the hole with water. Let the soils absorb the water for at least 4 hours before you conduct your perk test.

When the holes are ready for testing, add six inches of water over the gravel and select a fixed point at ground level where repeated measurements can be made. Use the same time interval between measurements and record the settling distance over the time interval. Add water if the depth of the water over the gravel falls below two inches. Take measurements at approximately the same time intervals until a constant rate of percolation is found. The time in minutes required for the water to drop one inch is the percolation rate in minutes per inch.

Required percolation rates vary from jurisdictions. You can obtain the range of acceptable perk speeds from your local code enforcement office. Usually, a rate of 5–10 minutes per inch is ideal, but again, check your local regulations to establish the rate that is your goal.

Without going into far more scientific data we have done about as much here as a builder is likely to do. The information here will allow you to get a realistic idea of the type of soil conditions that are likely to be suitable for private waste disposal sites.

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Septic Designs

Have you ever heard of using recycled car tires to build a leach field? It is being done. The chipped tires replace crushed stone. Cost is conserved while recycling is achieved. This can be an excellent way to go green.

How much greener can you get than a waterless compost system that converts 95 percent of residential sewage into carbon dioxide and water vapor that is continuously vented, with the final result being about 5 percent of the waste being converted to humuslike material that can be used as fertilizer for landscaping? According to current listings, the cost for a complete residential system, which includes two special toilets, is about $6,000.

Some types of green sewage-disposal systems are not practical for single-family homes. One such example is a constructed reed-bed system. This requires a lot of land. The system is inexpensive to build and very energy-efficient. Maintenance requirements are low. Wildlife can thrive in the artificially created wetland. If there is enough land to work with, a reed-bed system is well worth considering.

Most private disposal sites are made with simple pipe-and-gravel absorbsion fields. These are the least expensive type of septic field to construct. But, they are not always suitable. Much depends on the soil quality that you will be working with. Sometimes a chamber system is needed. These designs are much more expensive.

As for soil structure, a strong, granular, blocky, or prismatic structure is best. Platy or unstructured massive soils are the least desirable. When you are looking at the color of soil with the intention of installing a trench or bed system, look for bright, uniform colors. This condition indicates a well-drained, well-aerated soil. Ground that has a dull, gray, or mottled appearance is usually a sign of seasonal saturation. This makes soil unsuitable for a trench or bed system.

If you find soil that is layered with distinct textural or structural differences, be careful. This may indicate that water movement will be hindered, which is not good. Ideally, there should be between 2 and 4 feet

GOING GREEN

Have you ever heard of using recycled car tires to build a leach field? It is being done. The chipped tires replace crushed stone. Cost is conserved while recycling is achieved. This can be an excellent way to go green.

of unsaturated soil between the bottom of a drain system and the top of a seasonal high-water table or bedrock.

When you are looking at the color of soil with the intention of installing a trench or bed system, look for bright, uniform colors. This indicates a well-drained, well-aerated soil. Ground that has a dull, gray, or mottled appearance is usually a sign of seasonal saturation. This makes soil unsuitable for a trench or bed system.

Trench and Bed Systems

Trench and bed systems are both types of drain fields that do not require the use of chambers. Bed systems are the more common of the two. The design criteria for either of these systems are different from what would be used to lay out a chamber system. The landscape position that is normally considered suitable for a trench system should not have a slope of more than 25 percent. A slope greater than this can impair the use of equipment needed to install a system.

Bed systems may be limited to a slope of no more than 5 percent. Keep in mind that the numbers I'm giving you are only suggestions. They do not necessarily represent the requirements in your area.

These systems can be installed on land that is level and well-drained and on the crests of slopes. Convex slopes are considered the best location. Areas where these systems should not be installed include depressions and the bases of slopes where suitable surface drainage is not available. In terms of texture, a sandy or loamy soil is best suited to trench and

bed systems. Gravelly and cobbled soils are not as desirable. Clay soil is the least desirable.

A septic tank is an underground, watertight vessel installed to receive wastewater from the home. It is designed to allow the solids to settle out and separate from the liquid, to allow for limited digestion of organic matter, and to store the solids while the clarified liquid is passed on for further treatment and disposal.

Since subsurface soil treatment and disposal relies upon gradual seepage of wastewater into the surrounding soils, these systems can only be considered where favorable soil characteristics and geology exist for treatment and subsequent disposal of the treated wastewater into the environment.

Conventional septic systems are designed to operate indefinitely if properly maintained. However, because most household systems are *not* well maintained, the functioning life of septic systems is typically 20 years or less.

A septic system usually includes three components: the septic tank, a drainfield and the soil beneath the drainfield. The tank must be a watertight container constructed of a sound, durable material resistant to corrosion or decay (concrete, fiber reinforced plastic, fiberglass, or polyethylene). The septic tank is connected to a piping system that distributes wastewater effluent into subsurface soil for absorption and subsequent treatment.

Wastewater generated from a household is collected and transported through the house drains to the buried septic tank, where most of the solids settle while grease and scum float to the surface. Inlet baffles or effluent screens help to force wastewater down into the tank, preventing short-circuiting across the top. Outlet baffles keep the scum layer from moving into the soil absorption system. Collected solids undergo some decay by anaerobic digestion in the tank bottom. The capacity of a septic tank typically ranges from 1,000 to 2,000 gallons.

Clarified septic tank effluent exits the septic tank and enters the soil absorption system (also called a “leachfield” or “drainfield”) where a biological “clogging mat” or “biomat” forms, contributing to even distribution of the waste into the drainfield

Regulations usually require between two and four feet of unsaturated soil beneath the drainfield to renovate wastewater before it reaches a “limiting layer”—the point at which conditions for waste renovation become unsuitable. The limiting layer may be bedrock, an impervious soil layer or the seasonal high water table.

Absorption beds and trenches are the most common design options for soil absorption systems.

Trenches are shallow, level excavations, usually from one to five feet deep and one to three feet wide. The bottom is filled with at least six inches of washed gravel or crushed rock over which a single line of four-inch perforated pipe is placed. Additional rock is placed over and around the pipe. A synthetic building fabric is laid on top of the gravel to prevent backfill from migrating into the gravel trench.

Beds are constructed analogously to trenches, but are more than three feet wide and may contain multiple lines of distribution piping. While beds are sometimes preferred for space savings in more permeable soils, trench designs provide more surface area for soil absorption.

Mound and chamber systems can have different design criteria from those discussed for bed and trench systems. A leaching chamber is a wastewater treatment system consisting of trenches or beds, together with one or more distribution pipes or open-bottomed plastic

chambers, installed in appropriate soils. These chambers receive wastewater flow from a septic tank or other treatment device and transmit it into soil for final treatment and disposal.

A typical septic tank system consists of a septic tank and a below-ground absorption field (also called a drainfield, leaching field, or nitrification field). Leaching chambers are drainfields used to dispose of previously treated effluent. The drainfield system typically consists of leaching chambers installed in trenches and connected to the septic tank via pipe.

Effluent flows out of the septic tank and is distributed into the soil through the leaching chamber system. The soil below the drainfield provides final treatment and disposal of the septic tank effluent. After the effluent has passed into the soil, most of it percolates downward and outward, eventually entering the shallow groundwater. A small portion of the effluent is used by plants through their roots or evaporates from the soil.

Leaching chambers have two key functions: to dispose of effluent from the septic tanks and to distribute this effluent in a manner allowing adequate natural wastewater treatment in the soil before the effluent reaches the underlying groundwater aquifer. Although the septic tank removes some pollutants from wastewater, further treatment is required after the effluent leaves the tank. Nitrogen compounds, suspended solids, organic and inorganic materials, and bacteria and viruses must be re-

SEPTIC TIP

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duced before the effluent is considered purified. These pollutants are reduced or completely removed from the wastewater by the soil into which the wastewater drains from the leaching chambers.

Depending on the drainfield size requirements, one or more chambers are typically connected to form an underground drainfield network. The leaching chambers are usually made of sturdy plastic and do not require gravel fill. The sides of each chamber have several openings to allow wastewater to seep into the surrounding soil.

A typical leaching chamber consists of several high-density polyethylene arch-shaped, injection-molded chamber segments. A typical chamber has an average inside width of 20 to 40 inches and an overall length of 6 to 8 feet. The chamber segments are usually one-foot high, with wide slotted sidewalls, which are usually 20 degrees toward the chamber center or away from the trench sidewall. Each chamber segment is designed to mechanically interlock with the downstream chamber segment, forming a complete drainfield trench that consists of an inlet plate with a splash plate below the inlet on the trench bottom, and a solid-end plate at the distal end of the chamber drainfield line.

Typical leaching chambers are gravelless systems, with drainfield chambers with no bottoms and plastic chamber sidewalls, available in a variety of shapes and sizes. Some gravelless drainfield systems use large diameter corrugated plastic tubing covered with permeable nylon filter fabric not surrounded by gravel or rock. The area of fabric in contact with the soil provides the surface for the septic tank effluent to infiltrate the soil. The pipe is a minimum of 10 to 12 inches in diameter covered with spun bonded nylon filter fabric to distribute water around the pipe. The pipe is placed in a 12 to 24 inches wide trench.

These systems can be installed in areas with steep slopes with small equipment and in hand dug trenches where conventional gravel systems would not be possible. Use of these systems decreases overall drainfield costs and may reduce the number of trees that must be removed from the drainfield lot. However, fabricwrapped pipe cannot overcome unsuitable site conditions and should not be installed where gravel systems will not function properly or in fine sandy organic rich, coastal plain soils with shallow groundwater.

Leaching chambers are widely used as drainfield systems for septic tank effluent discharge. Many leaching chambers have been installed in 50 states, Canada, and overseas over the last 15 years.

Currently, a high percentage of new construction uses lightweight plastic leaching chambers for new septic tank systems in states such as

Colorado. Leaching chambers are an alternative to the conventional septic tank drainfield, which consists of several trenches with gravel beds and perforated plastic pipes. Leaching chambers allow more of the soil profile to be used since the septic tank effluent is distributed to the ground below and the soil surrounding the chamber. Therefore, leaching chambers are more effective than traditional gravel drainfields, especially when the drainfield must be located on a steep slope.

Leaching chambers are suitable for lots with tight sizing constraints or where water tables or bedrock limit the depth of the drainfield. Some states offer up to 50 percent sizing reduction allowance when using leaching chambers instead of conventional septic tank gravel drainfields.

Because they can be installed without heavy equipment, leaching chamber systems are easy to install and repair.

These high-capacity open-bottom drainfield systems can provide greater storage and more time for proper infiltration than conventional gravel systems and, therefore, are also suitable for stormwater management.

Septic tank system drainfields are usually classified as two types: gravel or gravelless systems. In gravel drainfield systems, the pipelines distributing septic tank wastewater are placed over a layer of gravel. Four inches of additional rock are then typically placed around the pipe and two inches above the pipe.

Gravelless systems provide the same functions as gravel drainfields while overcoming the potentially damaging impacts of gravel such as compaction of moist soil during installation and reduction of infiltration by obstructing the soil. The leaching chambers create a larger contact area for effluent to infiltrate into the soil, providing efficient treatment.

Typically, leaching chambers consist of series of large, two to four foot wide modular plastic arch segments that snap together. These arch segments replace the perforated drainpipes used in gravel drainfields. The wide chambers are manifolded with conventional plastic pipe such as high-density polyethylene.

Leaching chamber application is limited under certain conditions. The main limitations for installation and normal operation are small lot sizes, inappropriate soils, and shallow water tables. Leaching chamber systems can be used only in areas with soils that have percolation rates of 5 to 60 minutes per inch. Neglect of septic tank and leaching chamber maintenance can lead to drainfield failure and soil and groundwater contamination.

Leaching chambers are reliable, do not have moving parts, and need little maintenance to function properly. They are usually made of plastic materials, with a useful life of 20 years or more in contrast to the average useful life of a drainfield of 15 years, with a maximum of 20 to 25 years.

Some systems can be combined with other drainfield systems such as mounds and pressure distribution systems. Some can also be used for stormwater applications. Leaching chambers do not require more maintenance than conventional drainfield systems.

Key advantages of leaching chamber systems compared to gravel drainfields include:

- Easier and faster to install.
- Soil in the trenches is not as likely to be compacted.
- Less expensive in areas where gravel must be transported over a long distance.
- Leaching chambers allow for lower intrusion of soil and silt into the drainfield and thereby extend the useful life of the drainfields.
- Some leaching chambers have greater storage volumes than gravel trenches or beds.
- Inspection of the chambers is easier.
- Eliminates the need for gravel.
- Leaching chambers require a smaller footprint.

The lightweight chamber segments available on the market stack together compactly for efficient transport. Some chambers interlock with ribs without fasteners, cutting installation time by more than 50 percent over conventional gravel/pipe systems. Such systems can be relocated if the site owner decides to build on the drainfield site. Leaching chamber systems can be installed below paved areas and areas of high traffic.

A key disadvantage of leaching chambers compared to gravel drainfields is that they can be expensive if a lowcost source of gravel is readily available. Also, tests to assess the effectiveness of these drainfield systems have yielded mixed results. Direct effluent infiltration is advantageous in some soils yet detrimental in others. While open chambers can break up tight, clay soils and open up more airspace for biological treatment, they are less effective than gravel drainfields in preventing groundwater pollution. Because the open bottom allows septic tank effluent to infiltrate the soil unfiltered, high percolation rates (sandy soils) and groundwater levels must be carefully considered before installing such systems.

The size of a leaching chamber system is based on the wastewater flow and soil properties. For a three bedroom home, the area needed for a leaching chamber system could range from 200 square feet for a coarse-textured soil up to 2,000 square feet for a fine textured soil.

When the total drainfield area is estimated, setbacks from the house and property lines must be provided. These are usually state-regulated and vary from state to state The key design parameter for leaching chambers is the maximum long-term acceptance rate (LTAR), which depends on the type of drainfield soils. The design LTAR should be based on the most hydraulically limiting naturally occurring soil horizon within three feet of the ground surface or to a depth of one foot below trench bottom, whichever is deeper.

To determine the total trench bottom area required, the design daily wastewater flow should be divided by the applicable LTAR. The minimum linear footage of the leaching chamber system should be determined by dividing the total trench bottom area by 4 feet, when used in a conventional drainfield trench. No reduction area is allowed for leaching chamber systems installed in bed or fill systems. In addition to the area needed for the leach field, space should be reserved for possible expansion.

Leaching chamber systems in septic tank drainfields are typically installed in three foot wide trenches, separated by at least nine feet, edge to edge. Soil backfill is placed along the chamber sidewall area to a minimum compacted height of eight inches above the trench bottom. Additional backfill is placed to a minimum compacted height of 12 inches above the chamber. The leaching chamber trench bottom is usually at least 24 inches below finished grade, and the inlet invert is approximately 8 inches above the trench bottom, and at least 17 inches below the finished grade.

Most health codes limit the length of individual trenches to 60 feet. A leaching chamber system should have at least two trenches. Individual chamber trenches should be leveled in all directions and follow the contour of the ground surface elevation without any dams or other water stops.

Leaching systems installed on sloping sites may use distribution devices or step-downs when necessary to channel the level of the leaching chamber segments from upper to lower elevations. The manufacturer's installation instructions should be followed and systems should be installed by an authorized contractor. When septic systems are designed and installed properly they can provide decades of service without any need of replacement.

8

Code-Related Issues

The administration of code requirements for septic systems has changed over the last few years. Under the guidance of the International Code Council®, there is now an International Private Sewage Disposal Code®. Unlike the plumbing code, the septic code is small, but don't let the size fool you into thinking that it is not important. Rules and regulations for septic systems are needed to safeguard public safety.

General Regulations

Understanding the general regulations of the septic code is not difficult. However, as with any code, there are exceptions to many of the rules and regulations. The septic code is not nearly as complex as the plumbing code, but it can still be a bit daunting for those who are not familiar with its provisions.

The scope of the septic code encompasses septic tanks and effluent absorption systems. Treatment tanks and effluent disposal systems are also mentioned, but these systems are generally not permitted unless a public sewer system is not available.

Private waste-disposal systems are required to be entirely separate from and independent of any other building. It is possible to gain an official variance to this rule, but there must be compelling reasons for it. When the job uses a common system or a system on a parcel other than the one where the structure is being served, the installation must be in full compliance with code requirements.

CODE CONSIDERATION

Public sewer connections must be used when they are available.

Public Sewer Connections

Public sewer connections must be used when they are available. If a property is operating on a private waste-disposal system and a public sewer is installed and accessible to the property, the private system must be abandoned. The time allowed for such a conversion is subject to local law but must not exceed one year.

Discontinued Disposal Systems

Discontinued disposal systems must be plugged or capped at the time of abandonment. Any abandoned treatment tank or seepage pit must be pumped free of its contents. All waste must be disposed of properly. Once all waste is removed, the tank must either be removed or filled with a permanent filler, such as concrete.

Faulty Systems

Faulty systems must be repaired or abandoned within the time allowed by local code requirements. In no case may a faulty system remain in operation for more than one year. It is essential to avoid environmental contamination.

What constitutes a failing system? If a system is unable to accept sewage discharge and backs up into the structure served by the system, you must consider the system to be faulty. When sewage is discharged to the surface of the ground or drain tile, a system is also deemed faulty. Any system that discharges sewage to any surface or ground water must be repaired or abandoned. Another form of failure is the introduction of sewage into saturation zones, adversely affecting the operation of a private disposal system. The septic code exists to protect public health, safety, and welfare to any extent that they may be at risk due to the installation or maintenance of a private sewage-disposal system.

CODE CONSIDERATION

Discontinued disposal systems must be plugged or capped at the time of abandonment. Any abandoned treatment tank or seepage pit must be pumped free of its contents.

CODE CONSIDERATION

Modifications to existing sewage systems must be made in compliance with code requirements. Additions, alterations, repairs, and renovations must be made in compliance with this code just as if the work were being performed on a new system.

Applicability

Existing systems may be grandfathered. Private sewage systems that were in lawful existence when the septic code was put into effect are allowed to be used in their existing condition. Maintenance and repair are allowed, so long as the systems are in accordance with the original design and do not pose a risk to public safety, life, health, or property.

Maintenance

Routine maintenance is required to assure the proper and legal functioning of private sewage systems. Property owners or their agents are responsible for the maintenance of systems that serve their property. It is the privilege of the local code-enforcement officer to require an inspection of any private waste-disposal system.

Modifications

Modifications to existing sewage systems must be made in compliance with code requirements. Additions, alterations, repairs, and renovations must be made in compliance with this code just as if the work were being performed on a new system. No modification will be allowed if the change may cause an existing system to become unsafe, unsanitary, or overloaded. An exception to this rule pertains to minor modifications.

When minor modifications are made, they may be done in a manner consistent with the existing system. Special permission may be required to deviate from the code requirements. Check with your local code-enforcement office to obtain approval of your plans. Generally speaking, minor alterations are allowed even if not code-compliant when the changes are minimal and do not present a hazard.

> **CODE CONSIDERATION**
>
> If code officials have reasonable cause to believe that a building or property contains unsafe, unsanitary, dangerous, or hazardous conditions, they may enter the building or property to inspect the installation.

Change in Occupancy

If a change in occupancy is planned that will subject a structure to any special provision of the septic code, approval for the change must be obtained from a code officer. A code officer will have to determine that the change of use will not result in any hazard to public health, safety, or welfare.

Historic Buildings

Historic buildings are generally exempt from the septic code. However, if there is a risk to health, safety, or public welfare, special requirements may be dictated by the local code official. To qualify for special treatment, the building must be identified and classified by the state or local jurisdiction as a historic building.

Relocated Buildings

Relocated buildings generally must be treated as new construction in terms of the septic systems used. There can be exceptions to this rule, so check with your local code office if you will be working with relocated buildings.

Code Officials

Code officials have significant power. These officials enforce the local code requirements. When questions arise about the installation, alteration, repair, maintenance, or operation of a private sewage-disposal system, a code official must respond. If circumstances pertaining to public health, safety and general welfare indicate a risk, the local code officer is empowered to interpret and implement the provisions of the code to eliminate the threat.

Code officials receive permit applications and decide their disposition. Additionally, the local code officer is responsible for site inspections of new installations and alterations.

It is not always mandatory for a code officer to perform site inspections. Approved agencies and professionals can perform required inspections and submit their reports to the code officers. The reports must be in writing and certified by a responsible officer, an approved agency, or the responsible individual.

If code officials have reasonable cause to believe that a building or property contains unsafe, unsanitary, dangerous, or hazardous conditions, they may enter the building or property to inspect the installation. Such access to the building or property is required to be exercised at reasonable times. If a building is occupied, the code officer must present proper credentials to gain entry to the building. When a building is vacant, a code officer must make a reasonable effort to locate the owner of the building or the person responsible for the building. In the event that access to a building or property is denied, the code officer may exercise every remedy provided by law to secure entry.

All code officials are required to maintain full records for permit applications, permits, certificates issued, fees collected, reports of inspections, notices, and orders. These documents must be maintained for as long as the building remains in existence, unless otherwise provided for by other regulations.

Approval

Variances are sometimes allowed to meet approval standards under the code. A code officer has the power to authorize a variance when strict compliance with the code creates an unusual hardship. Variances are considered on a case-by-case basis. As long as the intent of the code is maintained and no health, safety, or welfare problems are created, a variance may be approved for extenuating circumstances.

Permits

When a permit is required for the work to be done, work must not be started until it has been issued. Permit applications are filed with the local

CODE CONSIDERATION

Two sets of plans and specifications must be submitted with a permit application.

code-enforcement office. The application will require basic information, such as the following:

- A description of the type of system to be installed
- The system location
- The occupancy of all parts of the structure and all portions of the site or lot not covered by the structure
- The maximum number of bedrooms for residential occupancies
- Additional information that may be required by the local code-enforcement office

Plans and Specifications

Two sets of plans and specifications must be submitted with a permit application. The drawings must be drawn to scale and show adequate detail for the work proposed. Any equipment, such as pumps or controls, must be identified and described completely. When a job involves only minor work, a code officer may waive the requirement for plans and specs.

Once a permit is issued, the plans and specifications will be marked with an official approval. Once the plans and specs are approved, they must not be altered without further permission from a code official. Most code officials require one set of approved plans and specifications to remain on the job site.

Soil Reports

Soil reports must be provided with applications for septic permits. The reports must detail boring procedures and percolation rates. Surface elevations are required for all boring details. Reference points, final grade elevation, and other pertinent data may also be required prior to the approval and issuance of a permit.

Site Plans

Site plans are another requirement when applying for a septic permit. The plans must be drawn to scale and show the proposed locations of

CODE CONSIDERATION

A permit will expire if the work is not started within 180 days of the issuance of the permit.

septic tanks, holding tanks, treatment tanks, building sewers, wells, water mains, water services, streams, lakes, dosing or pumping chambers, distribution boxes, effluent systems, dual disposal systems, replacement-system areas, and the locations of all buildings and structures.

Site plans are required to show distances and dimensions between items on the plans. Vertical and horizontal reference points must be noted. Grade slopes with contours are required on site plans for systems serving structures other than single-family homes.

Permit Expiration

A permit will expire if the work is not started within 180 days of the issuance of the permit. Expiration will also occur if work begun is abandoned or suspended for a period of 180 days or more. If a permit expires, a new permit must be issued. When a time extension is needed, it can be requested. A code officer can approve the extension for a period of time up to 180 days, assuming that there is reasonable cause for the extension. There can only be one extension per permit.

Suspension

Code officers have the authority to suspend or revoke active permits. If false information was given in the application process, a code officer may revoke an approved permit.

Inspections

Inspections are usually conducted by code officers at various points during an installation. It is possible for an independent agency or inspector to conduct site inspections and provide written reports to the local code officer. Independent inspectors must meet requirements set forth by the local code-enforcement office. Once all required inspections are complete with satisfactory results, a certificate of approval will be given to the permit holder.

Violations

It is unlawful for any person, firm, or corporation to erect, construct, alter, repair, remove, demolish, or utilize any private sewage-disposal system, or cause the same to be done, in conflict with or in violation of any code requirements. Anyone creating a violation will receive notification of the violation from a code official. If a violation is ignored and not corrected, prosecution for the violation will be considered. Punishment for violations can include the levying of fines, revocation of permits, and even imprisonment.

Stop-Work Order

A stop-work order can be given when a code officer feels that such action is warranted. The notice will be in writing and given to the property owner or the owner's agent. Reasons for the issuance of a stop-work order will be explained in the notification. If an emergency situation exists, a code officer can post a stop-work order without giving written notice. Once a stop-work order is issued, all work must stop immediately, with the exception of work required to remove a violation or safety hazard. Failure to comply with a stop work-order can result in fines and other punitive action.

Unsafe Conditions

When unsafe conditions are found, they must be dealt with. Such conditions may result in the need to repair, rehabilitate, demolish, or remove an entire septic system or the defective elements of a system. Potentially unsafe conditions include the following:

- Inadequate maintenance
- Dilapidation
- Obsolescence
- Disaster
- Damage
- Abandonment

A code officer has the power to condemn a septic system that is deemed to be unsafe. If this type of action is required, the code officer will provide written notice to the owner or the owner's agent. The notification may require repair or removal of a defective system. A time period for required action will be identified in the official notification. If a notice of this type is issued, the septic system that is found to be unsafe must cease all use. In an emergency situation, a code officer may disconnect a system immediately and without prior written notice.

CODE CONSIDERATION

Soil-absorption systems must not be installed in a floodway. This type of system is also prohibited in a flood fringe unless specific approval is given by a code official.

Appeal

Anyone can file an appeal to a decision made by code officials. Such appeals are made to the board of appeals. An application for an appeal must be filed on a form obtained from a code officer. A person must file an appeal request within 20 days of receiving the notice that is being appealed.

Reason for appeal must be based on a claim that the true intent of the code has been interpreted incorrectly by the code official. Another reason for an appeal could be that the code does not apply fully to the situation being appealed. If equally good or better construction is used and denied, there is reason for an appeal.

Specific Limitations

Domestic waste, which includes all wastes and sewage, derived from ordinary living uses must terminate in an approved septic or treatment tank if a public sewer connection is not available. It is possible for a code officer to create a variance to this requirement. Privies are not allowed. Except where specifically approved by a code officer, cesspools are prohibited.

The disposal of industrial wastes must be approved by a code officer. Certain objects must be prevented from entering a private sewage system. Some of the prohibited materials include:

- Ashes
- Cinders
- Rags
- Flammable substances
- Poisonous substances
- Explosive liquids and gases
- Oil
- Grease
- Insoluble materials

Clear water, such as surface water, rain, or other types, is not allowed to enter a private sewage-disposal system. Water from a water softener or iron filter backwash must discharge into a septic system, unless it can be disposed of on the ground surface without creating a nuisance.

Flood Plain

A flood plain can create a serious problem for the installation of a septic system. Soil-absorption systems must not be installed in a floodway. This type of system is also prohibited in a flood fringe, unless specific approval is given by a code official. No new sewage-disposal system may be installed in a floodway.

Replacement systems utilized to abate health hazards in floodways are considered and evaluated on a case-by-case basis. When a holding tank is installed in a floodway, the tank must be made floodproof. A soil-absorption system can be replaced outside a flood-plain boundary connected to the development by a force main or an approved site location outside the floodway but in the flood-fringe area. Any septic tank in a floodway must be floodproofed. A malfunctioning soil-absorption system must be replaced in the flood fringe, so long as the soil conditions and other site factors are suitable.

Materials for private sewage systems must meet minimum standards as set forth by the code used by the local jurisdiction. A manufacturer's mark or name and the quality of the product or identification must be cast, embossed, stamped, or indelibly marked on each material used in an installation. Septic tanks must be marked to identify the tank's capacity.

Any materials used in an installation must be of an approved type. Professional and protective handling of materials is required during the installation of materials. Defective or damaged materials may not be installed.

Septic Tanks

All septic tanks installed must be in compliance with the local code requirements. Steel septic tanks that show any damage to the bituminous coating must be repaired by recoating the tank. The gauge of the steel must conform to local code requirements. Fiberglass tanks may be used, but they must also meet local code requirements.

Concrete tanks may be precast or built on site. When a concrete tank is built on site, the floor and sidewalls of the tank must be monolithic, except that a construction joint is permitted in the lower 12 inches of the sidewalls of the tank. The construction joint must have a keyway in the lower section of the joint. The width of the keyway must be approximately 30 percent of the thickness of the sidewall, with a depth equal to the width. A continuous water stop or baffle at least 56 inches wide must be set vertically in the joint, embedded one-half its width in the concrete below the joint, with the remaining width in the concrete above the joint. The water stop or baffle must be copper, neoprene, rubber, or polyvinyl chloride designed for the specific purpose.

Tongue-and-groove or shiplap joints are required for joints between the concrete tank and the tank cover and between the tank cover and the manhole riser. These joints must be sealed watertight with cement, mortar, or bituminous compound.

Tank capacity, vertical cylindrical, gauge thickness, and minimum diameter are determined by the local code.

Manhole collars and extensions must be made of the same material as the tank being served. Covers for manholes must be made of concrete, steel, cast iron, or another approved material.

Pipe

Pipe for a private sewage-disposal system must have a smooth wall and conform to the requirements of the local code. Distribution pipe, the perforated pipe used for distribution systems, must also conform to the local code requirements.

Joints and Connections

There are many types of joints and connections that may be used in a private sewage system. All joints must confirm to requirements set forth by the local code. Some types of joints are subject to more regulation

> **CODE CONSIDERATION**
>
> Some joints and connections are prohibited. Concrete and cement joints are not allowed, nor are mastic or hot-pour bituminous joints.

than others. Refer to the following list for a quick review of common code requirements:

- ABS joints: general regulations
- Mechanical joints: general regulations; must be made with elastomeric seals and installed in accordance with manufacturer's instructions
- Solvent cementing: general regulations; joint surfaces must be clean and dry and joints made while the cement is wet
- Asbestos-cement joints: general regulations; must be made with a sleeve coupling of the same composition as the pipe and sealed with an elastomeric ring
- Bituminized fiber joints: general regulations; must be made with tapered-type couplings of the same material
- Cast-iron joints: general regulations
- Caulked joints: general regulations; joints for hub and spigot pipe must be firmly packed with oakum or hemp (Molten lead must be poured in one operation to a depth of not less than 1 inch. The lead must not recede more than 0.125 inch below the rim of the hub and must be caulked tight. If the joints are to be painted, varnished, or covered with another coating, this process must wait until the joints have been inspected and approved.)
- Mechanical compression joints: general regulations; gaskets must be compressed when the pipe is fully inserted
- Mechanical joint coupling: general regulations; these joints, when installed above ground, must use an elastomeric sealing sleeve with a center stop; underground joints must be made in accordance with the manufacturer's instructions
- Concrete joints: general regulations; must be made with an elastomeric seal
- Copper joints: general regulations
- Soldered joints: general regulations; joint surfaces must be cleaned and coated with an approved flux before being soldered in compliance with local code requirements
- Polyethylene joints: general regulations
- Heat-fusion joints: general regulations; joints must be clean and dry; all joint surfaces must be heated to the melting temperature and joined; this type of joint may not be disturbed before it has cooled

- Mechanical joints: general regulations; they must be made in compliance with the manufacturer's installation recommendations
- PVC joints: general regulations; joint surfaces must be clean and dry; a purple primer must be applied prior to cementing a joint
- Vitrified clay joints: general regulations; these joints must be made with an elastomeric seal
- Copper-to-cast-iron joints: general regulations; these joints must be made with a brass ferrule or compression joint (A suitable solder joint must be made between the copper and the ferrule. The ferrule must be joined to the cast iron by a caulked or mechanical compression joint.)
- Plastic-to-cast-iron joints: general regulations; the plastic-pipe joint must be joined where it meets the cast-iron hub with either a caulked or a mechanical joint
- Dissimilar plastic joints: general regulations

Prohibited Joints and Connections

Some joints and connections are prohibited. Concrete and cement joints are not allowed, nor are mastic or hot-pour bituminous joints. Any joint made with a fitting that is not approved for the use is prohibited. Solvent-cement joints between dissimilar plastic pipes are prohibited. Any joint made with an elastomeric rolling O-ring on pipes that have different diameters is prohibited.

The code requirements for materials are easy to understand and comply with. Pay attention: It can save you a lot of time, money, frustration, and embarrassment.

Cesspools

Cesspools have to conform to local code requirements that are set forth for seepage pits. The seepage pit must have a minimum sidewall of 20 feet below the inlet opening. Where a stratum of gravel or equally pervious material of 4 feet or more in thickness is found, the sidewall need not be more than 10 feet below the inlet.

Pressure-Distribution Systems

Pressure-distribution systems are allowed on any site that is suitable for a conventional private sewage-disposal system. There must be at least

6 inches from the original grade to the top of the distribution piping. What is the required minimum depth from original grade? You will have to check your local code requirements. The data should be available to you, probably in tabular form. In general, the depth ranges from 49 to 53 inches.

The estimated daily wastewater flow and the design loading rate based on the perk rate for a site are used to determine the required size of the absorption area. Once again, data in your local code requirements will help you to define a proper size. Normally you will need an absorption area that equals the wastewater flow divided by the design loading rate that is provided in your local code. The design load factor depends on the perk rate. For example, my local code says that a perk rate of 10 to less than 30 minutes will give me a load factor of 0.8. Since local jurisdictions adopt a code and have the right to alter it, you must check your current codes to ensure that you remain in compliance.

A rule of thumb for computing wastewater flow is to consider that a residence will use 150 gallons per bedroom per day. You can find more data of this type in your local code book.

System Design

Any pressure-distribution system must discharge effluent into trenches or beds. Every pipe that is connected to an outlet of a manifold is counted as a separate distribution pipe. Spacing for horizontal distribution pipes must be between 30 to 72 inches.

Distribution pipe size, hole diameter, and hole spacing have to be selected. The hole diameter and spacing must be equal for each manifold segment. Distribution pipe size is not required to be the same for each segment.

To do a full sizing of piping, you will have to use data from your local code. This will involve the Hazen-Williams friction factor in most cases. The math is more than some plumbers want to do. However, most sizing is done by engineers, so few plumbers or septic installers have to learn the finer details of the math required to size a system.

The size of a force main between a pump and a manifold must be based on the friction loss and velocity of effluent through the pipe. Velocity of the effluent in a force main must not be more than 5 feet per second.

Pumps

The pumps used with a pressure system are sized based on the discharge rate and total dynamic head of the pump performance curve. Total dynamic head must be equal to the difference in feet of elevation between the pump and the distribution pipe invert plus the friction loss and a minimum of 2.5 feet where utilizing low-pressure distribution in the delivery and network pipes.

Control systems for a pumping chamber consist of a control for operating the pump and an alarm system to detect a pump. Start and stop depth controls must be adjustable. Pump and alarm controls must be of an approved type. All switches must be resistant to sewage corrosion.

An alarm system for a pumping station must consist of a bell or light mounted in a structure and must be located to be easily seen or heard. A high-water sensing device must be installed approximately 2 inches above the depth set for the "on" pump control but below the bottom of the inlet to the pumping chamber. Alarm systems have to be installed on a separate circuit from the electrical service. All electrical connections must be located outside the pumping chamber.

Dosing

Dosing frequency must be a maximum of four times a day. The volume per dose is established by dividing the daily wastewater flow by the dosing frequency. The dosing volume must be a minimum of 10 times the capacity of the distribution-pipe volume.

Most installation contractors don't design and size their own pressure-distribution systems. This work is usually done by engineers. However, if you want to size your own system, you should be able to find all the information in your local code.

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9

Drilled Wells

Drilled wells are the most dependable individual water source I know of. These wells extend deep into the earth. They reach water sources that other types of wells can't come close to tapping. Since drilled wells take advantage of water that is found deep in the ground, it is very unusual for them to run dry. This accounts for their dependability. However, dependability can be expensive.

Of all the common well types, drilled wells are the most expensive to install. The difference in price between a dug well and a drilled well can be thousands of dollars. But the money is usually well spent. Dug wells can dry up during hot summer months. Contamination of water is also more likely in a dug well. When all the factors are weighed, drilled wells are worth their price.

A house is a big investment. Like a house, a well can be looked upon as an investment. Nobody likes to spend more money than necessary. Builders don't want to run the prices of their projects up unnecessarily. Homebuyers prefer not to pay outrageous prices for the properties they purchase. In an effort to keep costs down, some builders look for the cheapest water source they can find. This can be a big mistake. How good is a house without water? Is it really a bargain to install a cheap well only to have it fail six months later?

I don't want to paint a picture that indicates that the only type of well worth using is a drilled well. Dug wells can perform very well. Even driven wells can provide a suitable supply of potable water. Some houses get their water from springs and other natural water sources. Your selection of a water supply for the houses you build will depend on many factors. Drilled wells will not always be practical. However, deep wells with submersible pumps are hard to beat when you want to guarantee a good supply of drinking water.

When I built houses in Virginia, most of the wells used were dug wells. In Maine, drilled wells are much more common than dug wells.

Geographic location makes a difference in the type of water source used for a house.

Depth

The depth of a drilled well can vary a great deal. In my experience, drilled wells are usually at least 100 feet deep. Some drilled wells extend 500 feet or more into the earth. My personal well is a little over 400 feet deep. Based on my experience as both builder and plumber, I've found most drilled wells to range between 125 to 250 feet deep.

It's hard for some people to envision drilling several hundred feet into the earth. I've had many homebuyers ask me how I was going to give them such a deep well. Many people have asked me what will happen if the well driller hits rock. Getting through bedrock is not a problem for the right well-drilling rig. While we are on the subject of drilling rigs, let's talk about the different ways to drill a well.

Well-Drilling Equipment

Well-drilling equipment is available in various forms. While one type of rig may be the most common, all types of well rigs have advantages and disadvantages. As a builder, it can be helpful to know what your options are for drilling wells on different types of sites. There are two basic types of drilling equipment.

Table 9.1 Cable selection. *© 2008 ITT Corporation.*

SINGLE PHASE MOTOR MAXIMUM CABLE LENGTH (Motor to Service Entrance) (2)

Motor Rating		Copper Wire Size (1)								
VOLTS	HP	14	12	10	8	6	4	2	0	00
110-115	1/3	134	212	333	522					
	1/2	100	159	249	390	608				
220 - 230	1/3	533	850							
	1/2	404	641	1003						
	3/4	293	473	740	1161					
	1	248	392	617	968	1507				
	1 1/2	205	326	510	801	1248				
	2	180	286	449	703	1096	1675			
	3		229	359	563	877	1339	2041		
	5			216		490	750	1142	1540	

THREE PHASE MOTOR MAXIMUM CABLE LENGTH (Motor to Service Entrance) (2)

VOLTS	HP	14	12	10	8	6	4	3	0	00	000	0000
200V 60 Hz or 50 Hz	1.5	320	510	800	1260							
	2	250	390	610	960	1500						
	3	180	290	450	710	1110	1690					
	5			300	470	730	1110	1690				
	7.5				340	530	810	1230	1660			
230V 60 Hz and 220V 50 Hz	1.5	430	680	1070	1680							
	2	320	510	790	1250	1940						
	3	240	380	600	940	1470	2240					
	5		250	390	620	960	1470	2230				
	7.5			290	450	700	1070	1630	2200			
460V 60 Hz and 380V thru 460V 50 Hz (Divide lengths by 1.4 for 380V 60 Hz)	1.5	1720										
	2	1280	2030									
	3	960	1530	2400								
	5	630	1000	1570	2470							
	7.5	460	730	1150	1800	2810						
	10		550	850	1340	2090	3190	3340				

CAUTION: Use of wire size smaller than listed will void warranty.

FOOTNOTES:

1. If aluminum conductor is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3Ø motor starter should not exceed 25% of the total maximum to assure reliable starter operation. Single phase control boxes may be connected at any point of the total cable length.

> **WELL TIP**
>
> As an experienced builder, I recommend that you consult with your customers on where they would like their well. Some people are adamant about where they do and do not want a well placed. I often allow my customers to choose preferential well sites. Many of the home-buyers leave the decision on well placement up to me.

Rotary drilling equipment is very common in my area. This type of rig uses a bit to auger its way into the earth. The bit is attached to a drill pipe. Extra lengths of pipe can be added as the bit cuts deeper into the ground. The well hole is constantly cleaning out air, water, or mud under pressure.

Percussion-cable-tool rigs make up the second type of drilling rig. These drilling machines use a bit that is attached to a wire cable. The cable is raised and dropped repeatedly to create a hole. A bailer is used to remove debris from the hole. Between rotary equipment and percussion-cable equipment, there are a number of variations in the specific types of drilling rigs.

We could go into a lengthy discussion of all the various types of well rigs available. But since you are a builder and probably have no desire to become a well driller, there seems to be little point in delving into all the details. What you should know, however, is that there are several types of drilling rigs in existence. Your regional location may affect the types of rigs being used. A few phone calls to professional drillers will make you aware of what your well options are. For my money, I've always contracted the services of rotary drillers. There are times when other types of rigs could be a better choice. My best advice to you is to check with a number of drilling companies in your area and see what they recommend.

The Basics

Let's go over the basics of what is involved, from a builder's point of view, in drilling a well. Your first step must be deciding on a well location. The site of a proposed house will, of course, have some bearing on where you want the well to be drilled. Local code requirements will address issues pertaining to water wells. For example, the well will have to be kept at some minimum distance from a septic field, assuming that one is to be used.

Who should decide where a well will be placed? Once local code requirements are observed, the decision about well location can be made by a builder, a homebuyer, a well driller, or just about anyone else. If you're building spec houses, the decision will be up to you and your driller. Buyers of custom homes may want to take an active role in choosing a suitable well site. As an experienced builder, I recommend that you consult with your customers on where they would like their well. Some people are adamant about where they do and do not want a well placed.

I often allow my customers to choose preferential well sites. Many of the homebuyers leave the decision on well placement up to me. Sometimes a customer will choose a site that is not practical. For example, a well-drilling rig might not be able to get access to the location easily. When a customer makes what I perceive to be a bad decision, I offer recommendations. Working out an agreeable location is rarely a problem.

I never leave well location to the discretion of well drillers. Some drillers will take the path of least resistance when installing a well. This can result in some very unpleasant well sites. Drilled wells are not as obtrusive as dug wells, but they still don't make good lawn ornaments. If you don't want to arrive on your job site to find a freshly drilled well in the middle of the front lawn, don't allow well drillers to pick their sites at random.

An experienced driller can provide you with a lot of advice when it comes to picking a spot for a well. Don't overlook this opportunity. It always pays to listen to experienced people. Once you or your customer have chosen a well site, talk the decision over with your driller. You may

WELL TIP

Access is one of the biggest concerns a builder has in the well-drilling process. It is a builder's responsibility to make access available to a well driller. Drilling rigs require a lot of room to maneuver. A narrow, private drive with overhanging trees may not be suitable for a well rig.

Having enough width and height to get a well truck into a location is not the only consideration. Well rigs are heavy—very heavy, in fact. The ground that these rigs drive over must be solid. New construction usually requires building roads or driveways. If you can arrange to have a well installed along the roadway, your problems with access are reduced.

find that there is a good reason to move from the intended site to a more suitable one. While I feel that you or a trusted supervisor should take an active part in picking a well location, I don't think that you should go against the recommendations of a seasoned well driller. If a reputable driller advises you to choose a new location, you should seriously consider doing so.

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It is not always desirable to install a well alongside a driveway. This may not cause any additional concern, but it could. If the ground where you are working is dry and solid, a well rig can drive right over it. But if the ground is wet and muddy or too sandy, a big truck won't be able to cross it. You must consider this possibility when planning a well installation.

Don't build obstacles for yourself. Just as the old joke goes about painting yourself into a corner, you can build yourself right out of room. Some builders put wells in before they build houses. Others wait until the last minute to install a well. Why do they wait? They do it to avoid spending the money for a well before it's needed. This reduces the interest they pay on construction loans and keeps their operating capital as high as possible. When the well is installed last, it can often be paid for out of the closing proceeds from the sale of a house.

I have frequently waited until the end of a job to install wells. There is some risk to this method. It's possible, I suppose, that a house could be built on land where no water could be found. This would truly be a mess. A more likely risk is that the house construction will block the path of a well rig.

When you are confirming the location for a well, make sure that you will be able to get drilling equipment to it when you need to. Going to the buyers of a custom home and informing them that their beautiful shade trees will have to be cut down to get a well rig into the site is not a job I would enjoy having. It is safer to install wells before foundations are put in.

Working on Your Site

Once you have a well driller working on your site, there's not much for you to do but wait. The drilling process can sometimes be completed in a single day. There are times, however, when the rig will be working for longer periods of time. Depending on the type of drilling rig being used, a pile of debris will be left behind. This doesn't usually amount to much, and your site contractor can take care of the pile when preparing for finish grading.

The well driller will usually drill a hole that is suitable for a six-inch steel casing. The casing will be installed to whatever depth is necessary. Once bedrock is penetrated, the rock becomes the well casing. How much casing is needed will affect the price of your well. Obviously, the less casing that is needed, the lower the price should be.

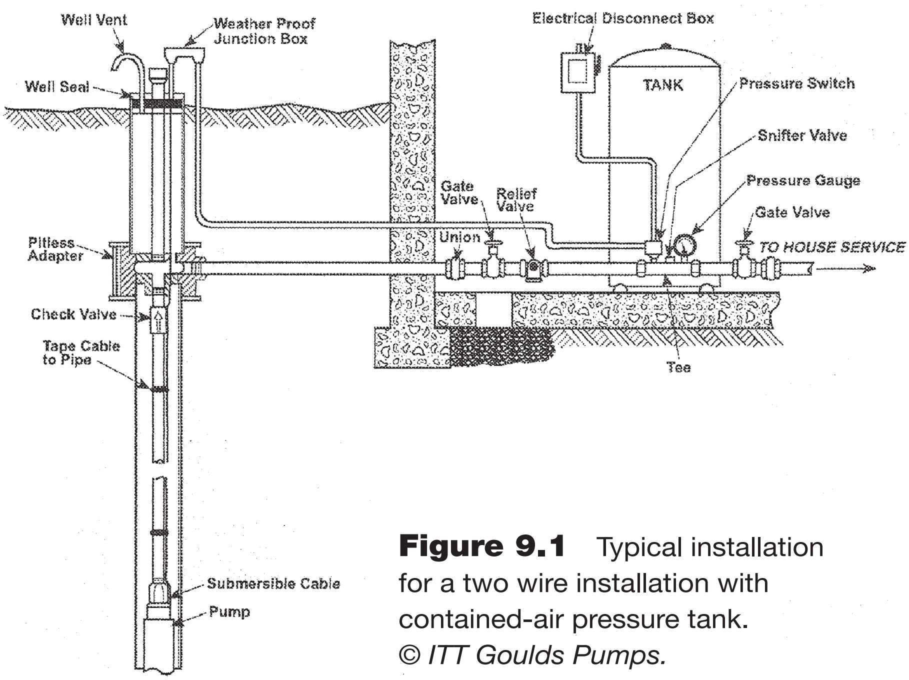

Figure 9.1 Typical installation for a two wire installation with contained-air pressure tank. © *ITT Goulds Pumps.*

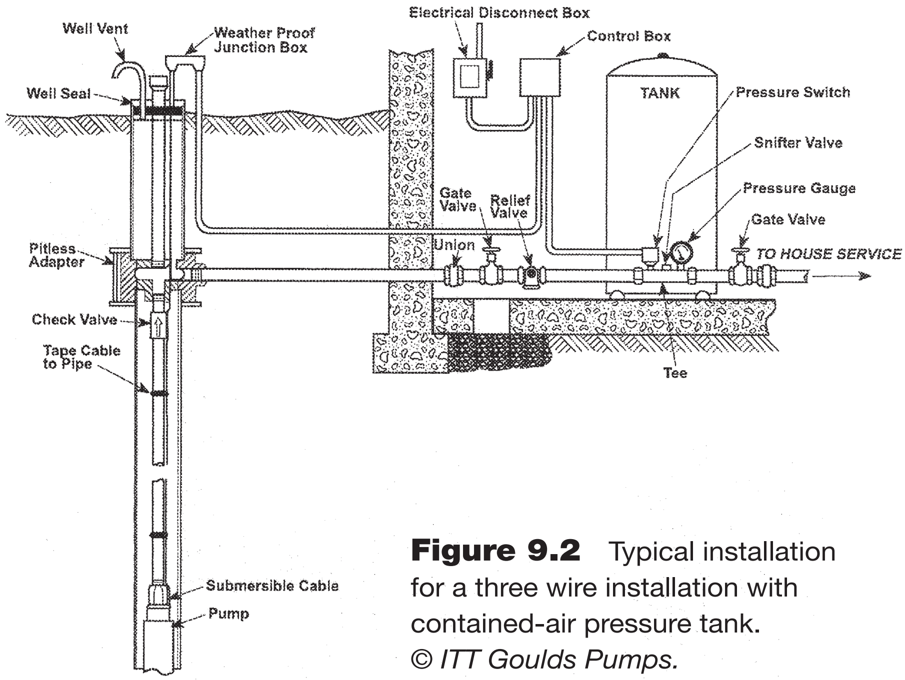

Figure 9.2 Typical installation for a three wire installation with contained-air pressure tank. *© ITT Goulds Pumps.*

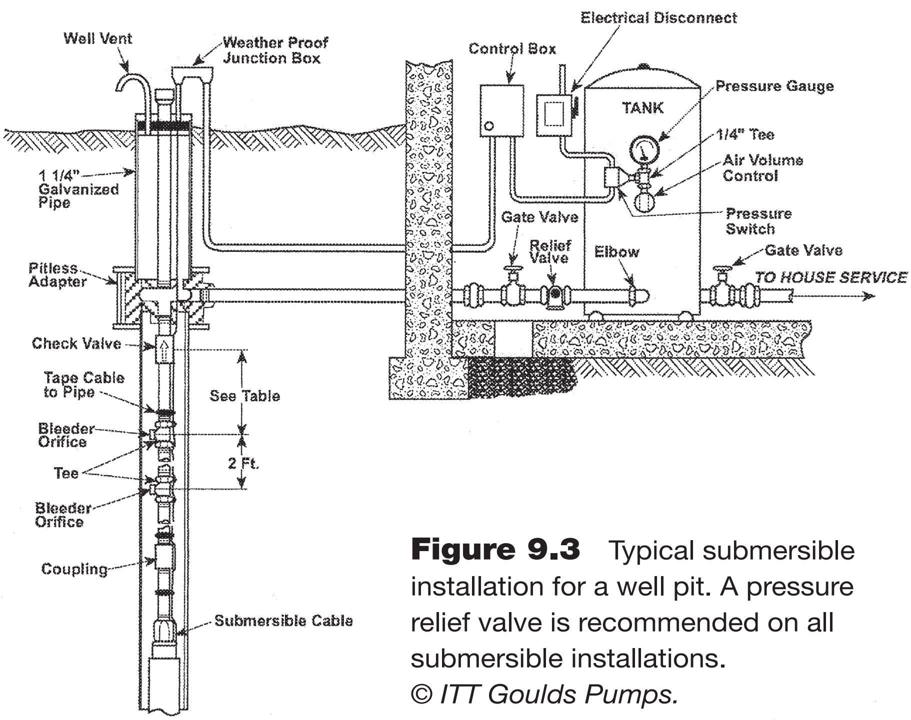

Figure 9.3 Typical submersible installation for a well pit. A pressure relief valve is recommended on all submersible installations. *© ITT Goulds Pumps.*

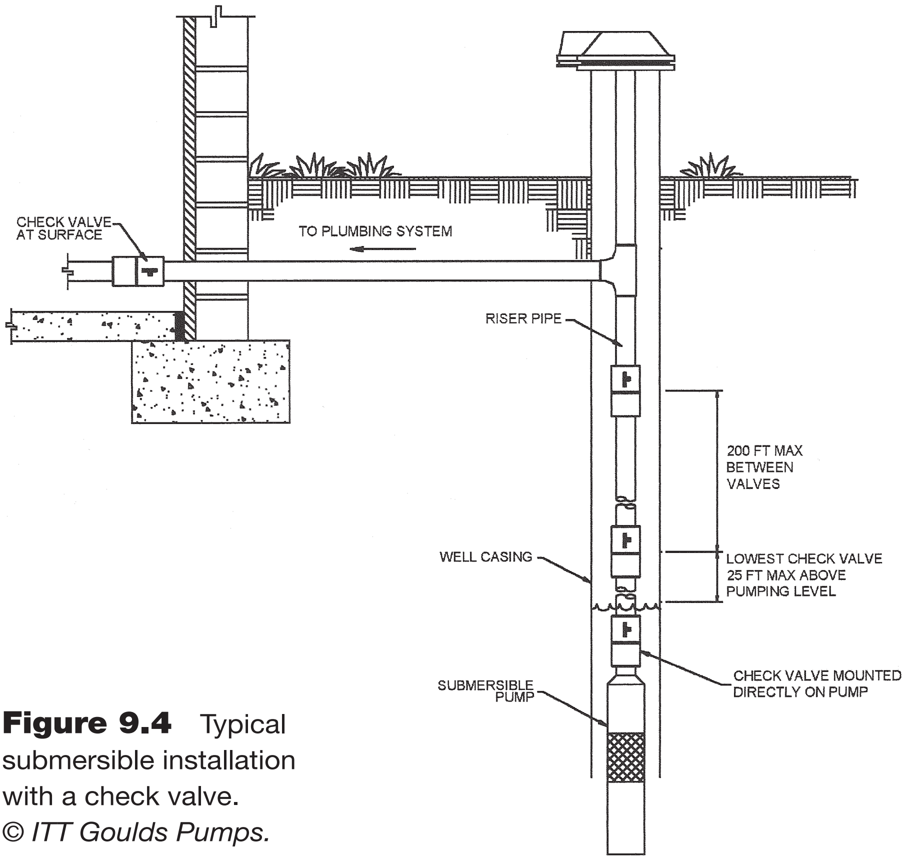

Figure 9.4 Typical submersible installation with a check valve. © *ITT Goulds Pumps.*

Your well driller will grout the well casing as needed to prevent ground water from running through the casing and dropping down the well. This is normally a code requirement. It limits the risk of contamination from surface water. A metal cap is then installed on the top edge of the casing, and then the well driller's work is done.

Pump Installers

Many well drillers offer their services as pump installers. You might prefer to have the driller install the pump, or maybe you would rather have your plumber do the job. A license may be needed in your area for pump installations. Any master plumber will be allowed to make a pump installation, but you should check to see if drillers are required to have special installation licenses. If they are, make sure that any driller you allow to install a pump is properly licensed.

If you want your driller to install a pump setup as soon as the drilling is done, you will need to make arrangements for a trench to run the water-service pipe in. The cost of this trench is usually not included in prices quoted by pump installers. Watch out for this one, because it is an easy way to lose a few hundred dollars if you don't plan on it.

After your well is installed, you should take some steps to protect it during construction. Heavy equipment could run into the well casing and damage it. I suggest that you surround the well area with some highly

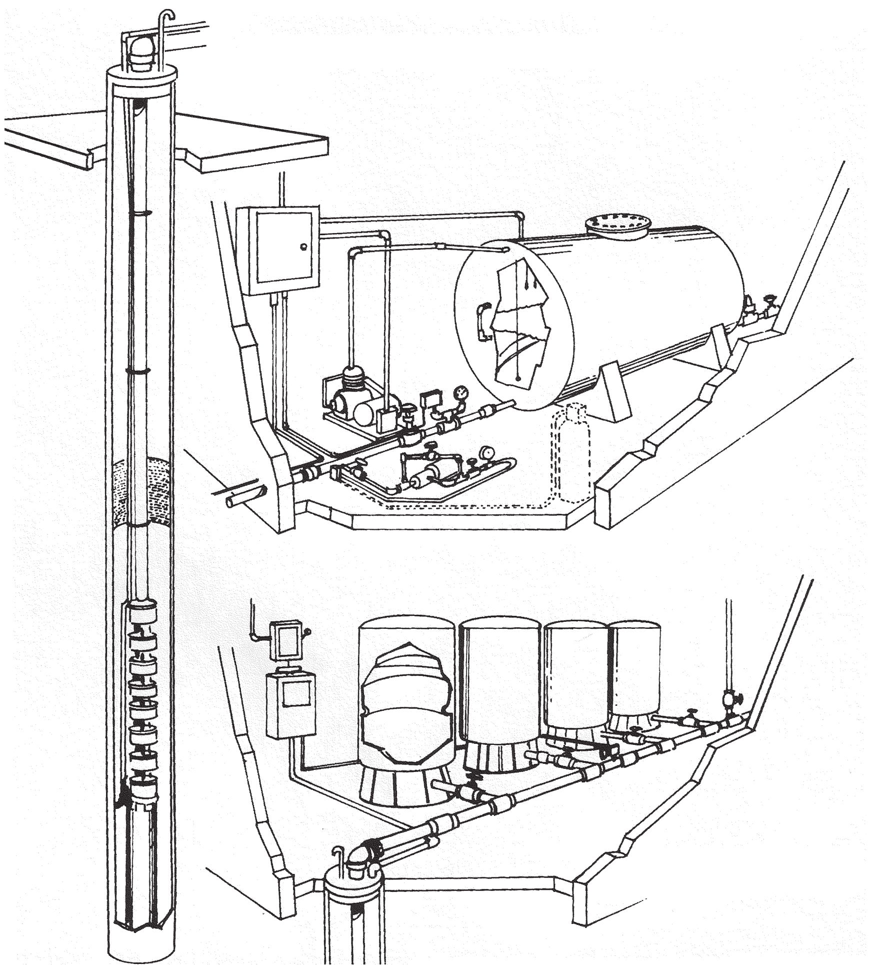

Figure 9.5 Typical high capacity submersible pump installation. Header pipe must be large enough to get enough water to all tanks equally. © *ITT Goulds Pumps.*

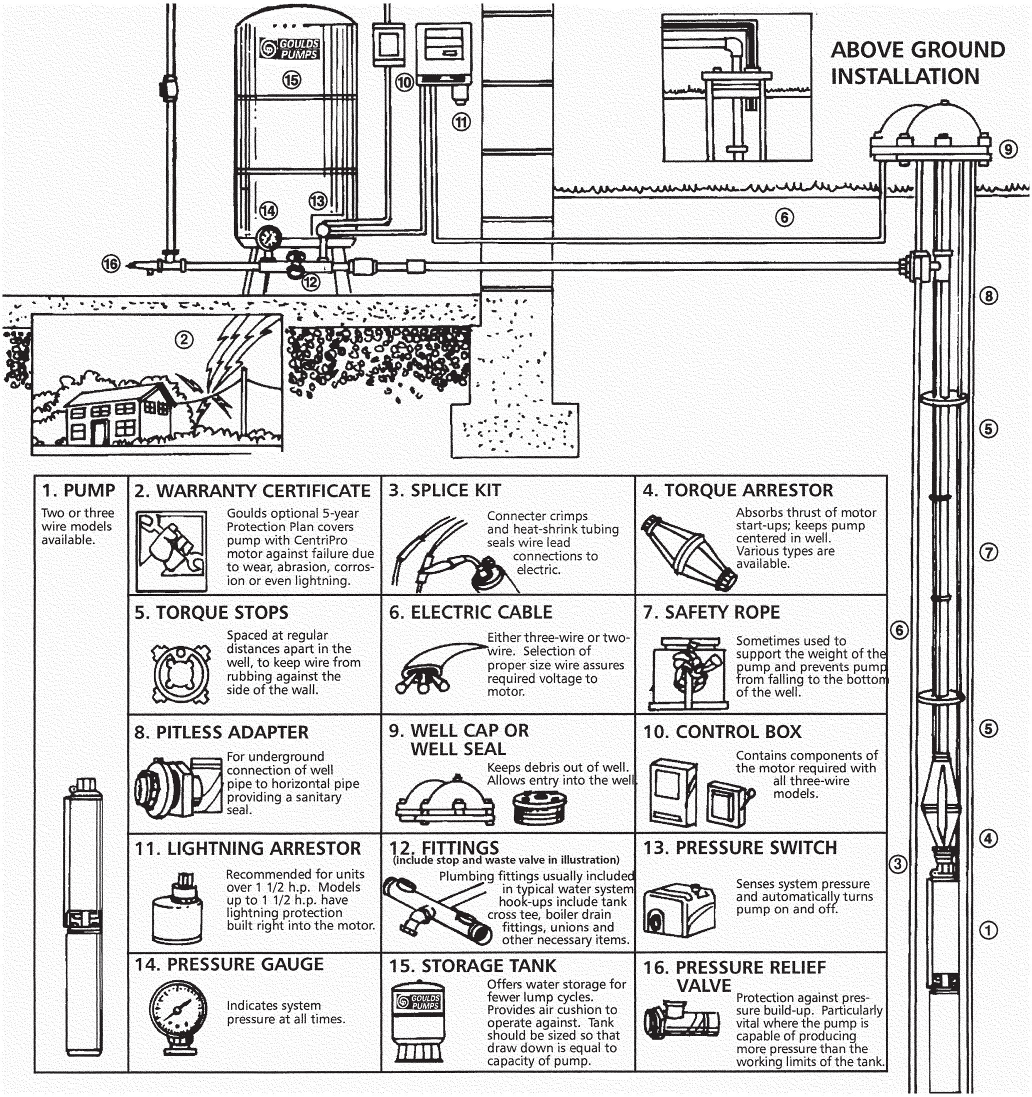

Figure 9.6 Typical installation for four-inch submersibles. *© ITT Goulds Pumps.*

visible barrier. Colored warning tape works well, and it can be supported with nothing more than some tree branches stuck in the ground. A lot of builders don't take this safety precaution, but they should. A bulldozer can really do a number on a well, and a well casing can be difficult for an operator to see at times.

WELL TIP

The cost of a trench is usually not included in prices quoted by pump installers. Watch out for this one, because it is an easy way to lose a few hundred dollars if you don't plan on it.

How far will the pump installer take the job? Will the water-service pipe be run just inside the home's foundation and left for future hookup? Who will run the electrical wires and make the electrical connections? Does the installation price include a pressure tank and all the accessories needed to trim it out? Who will install the pressure tank? You need answers to these questions before you award a job to a subcontractor. Pump systems involve a lot of steps and materials. It's easy for a contractor to come in with a low bid by shaving off some of the work responsibilities in fine print. Be careful, or you may wind up paying a lot more than you planned for a well system.

We have now covered the installation of a drilled well and a pump system in an abbreviated version. There are some particulars, however, that you should be aware of so that you can supervise the work more effectively. Let's concentrate on these issues now.

Quantity and Quality of Water

When it comes to the quantity and quality of water produced by a well, few (if any) well drillers will make commitments. Every well driller I've ever talked to has refused to guarantee the quantity or quality of water. The only guarantee that I've been able to solicit has been one of hitting water. This is an issue that builders have to be aware of.

Quantity

Customers may ask you, the builder, to specify what the flow rate of their new well will be. It is beyond the ability of a builder to do this. An average, acceptable well could have a three-gallon-per-minute recovery rate. Another well might replenish itself at a rate of five gallons per minute. There are wells with much faster recovery rates, and there are others with slower rates. Anything less than three gallons per minute is less than desirable, but it can be made to suffice.

Table 9.2 Electrical information.

			SINGLE PHASE										THREE PHASE					THREE PHASE					
MOTOR		H.P.	1/3	1/3	1/2	1/2	3/4	1	1 1/2	2	3	5	1 1/2	2	3	5	7 1/2	1 1/2	2	3	5	7 1/2	10
		VOLTAGE	115	230	115	230	230	230	230	230	230	230	230	230	230	230	230	460	460	460	460	460	480
Standard Fuse Size (Amps)			25	15	30	15	20	25	30	35	45	80	20	25	30	45	70	15	15	15	25	35	45
Dual Element Fuse Size			10	5	15	7	9	12	15	15	20	30	8	10	15	20	30	4	5	6.25	10	15	20
Minimum Voltage (volts)			105	210	105	210	210	210	210	210	210	210			210						414		
Maximum Voltage (volts)			125	250	125	250	250	250	250	250	250	250			250						506		
Maximum Current (amps)-Motor Running Under			8.9	4.4	11.9	5.9	8.0	9.6	11.5	13.2	16.5	26.2	6.4	8.2	11.4	17.4	26.8	3.2	4.1	5.7	8.7	13.4	17.6
Load Motor Resistance (ohms) 1	Main Winding (black & yellow)	Minimum	1.5	6.0	1.0	4.2	2.7	2.2	1.5	1.6	.9	.68	3.1	2.4	1.8	.93	.76	11.3	9.7	7.0	3.6	2.4	1.8
		Maximum	1.9	7.4	1.3	5.2	3.4	2.8	1.9	2.3	1.5	1.0	4.1	3.0	2.2	1.2	.93	15.0	12.0	8.7	4.4	3.4	2.3
	Start Winding (red & yellow)	Minimum	5.7	23.4	3.8	15.5	11.0	9.5	6.2	5.2	3.0	2.1	--	--	--	--	--	--	--	--	--	--	--
		Maximum	7.1	28.6	4.7	19.6	13.6	11.7	8.5	7.1	4.6	2.8	--	--	--	--	--	--	--	--	--	--	--

For All 4" Submersible Pumps
(1) For motor without drop cable attached.
NOTE: For operation of 230 volts motors on 208 volts, substitute special relay No. 155031-103 in control box, and use 2 sizes larger cable.
CAUTION: USE OF WIRE SIZES SMALLER THAN DETERMINED ABOVE WILL VOID WARRANTY, since low starting voltage and early failure of the units will result. Larger wire sizes (smaller numbers), may always be used to improve economy of operation. FOR 3Ø MOTORS, standard 3Ø magnetic starter with special extra-quick trip overload relays in all 3 legs is required for positive motor protection. Consult Franklin Electric Service Manual for proper overload relay to use. WARRANTY IS VOID where this protection is not used.

Install 1/8" or 1/4" tubing long enough to be 10' to 15' below low water level. Measure the tubing length as it is lowered into the well.

Once the tubing is fixed in a stationary position at the top, connect an air line and pressure gauge. Add air to the tubing until the pressure gauge reaches a point that it doesn't read any higher. Take a gauge reading at this point.

A. Depth to water (to be determined).

B. Total length of air line (in feet).

C. Water pressure on air tubing. Gauge reads in pounds. Convert to feet by multiplying by 2.31.

Example:
If the air tube is 100' long, and the gauge reads 20 lbs.
20 lbs. x 2.31 = 46.2 ft.
Length of tube = 100 ft.
minus 46.2 ft. = 53.8 ft.

Depth to water (A) would be 53.8 ft.

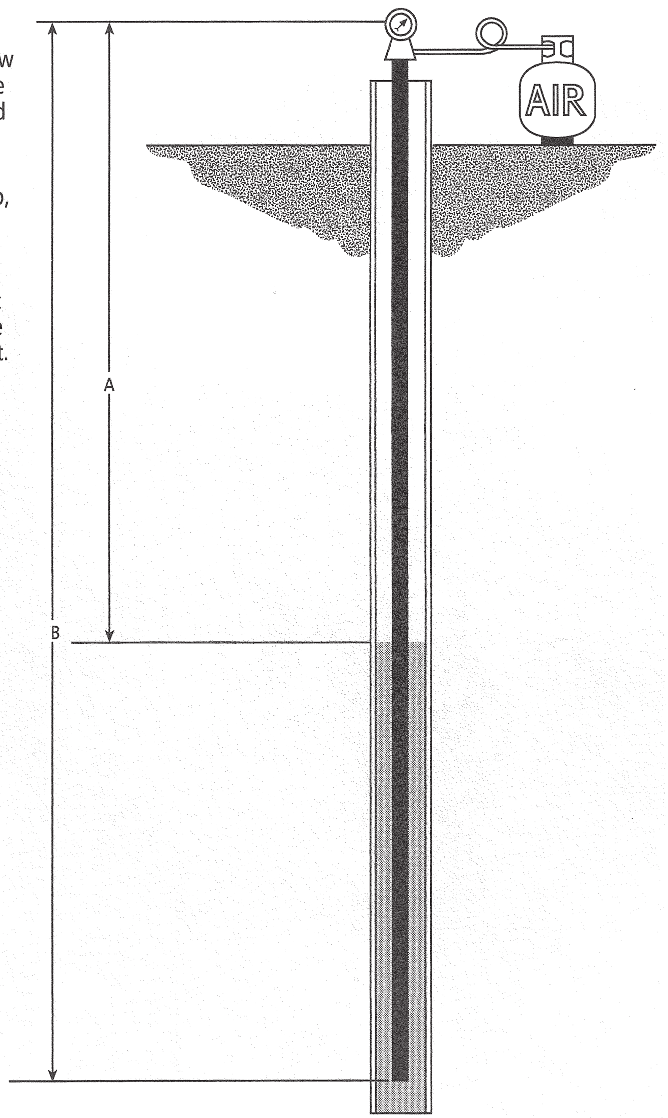

Figure 9.7 Determining water level. © *ITT Goulds Pumps.*

How can you deal with the recovery rate? You really can't. Sometimes by going deeper, a well driller can hit a better aquifer that will produce a higher rate of recovery, but there is no guarantee. So don't make a guarantee to your customers. Show your customers the disclaimers on the quotes from well drillers and use that evidence to back up your point that there is no guarantee of recovery rate in the well business. Now, I could

> **WELL TIP**
>
> If you're the type of person who likes to do a little engineering on your own, you can refer to information provided by pump manufacturers to calculate your pump needs.

be wrong. You might find some driller who will guarantee a rate, but I never have.

Even though you can't know what a recovery rate will be when you start to drill a well, you can determine what it is after water has been hit. Your well driller should be willing to test for and establish the recovery rate for you. Every driller I've ever used has performed this service. You need to know what the recovery rate is in order to size a pump properly. There is an old-fashioned way of determining a recovery rate, but I'd rather ask my driller to do it for me.

It is also important that you know the depth of the well, and this your driller can certainly tell you. As you gather information, record it for future reference. The depth of the well will also be a factor when selecting and installing a pump. Don't let your driller leave the job until you know what the depth and the recovery rate are.

Quality

The quality of water is difficult to determine when a new well is first drilled. It can take days or even weeks for the water in a new well to assume its posture. In other words, the water you test today may offer very different results when tested two weeks from now. Before a true test of water quality can be conducted, it is often necessary to disinfect a new well. Many local codes require disinfection before testing for quality.

> **WELL TIP**
>
> Once a water sample is collected, it is taken or mailed to a lab. Time is of the essence when testing for bacteria, so don't let a water bottle ride around in your truck for a few days before you get around to mailing it. Again, follow the instructions provided by the lab for delivering the water.

Wells are usually treated with chlorine bleach to disinfect them. Local requirements on disinfection vary, so I won't attempt to tell you exactly what to do. In general, a prescribed amount of bleach is poured into a well. It is allowed to sit for some specific amount of time, as regulated by local authorities. Then the well pump is run to deplete the water supply in the well. As a rule of thumb, the pump is run until there is no trace of chlorine odor in the tap water. When the well replenishes itself, the new water in the well should be ready for testing. But, again, check with your local authorities for the correct procedure to use in your area. By the way, builders usually are responsible for conducting the disinfection process.

Once the well is ready to test, a water sample is taken from a faucet in the house. Test bottles and collection instructions are available from independent laboratories. Follow the instructions provided by the testing facility. As a rule of thumb, you should remove any aerator that may be installed on the spout of a faucet before taking your water collection. It is often recommended that a flame be held to the spout to kill bacteria that may be clinging to the faucet and washed into the collection bottle. Don't attempt this step when testing from a plastic faucet! Many plumbers take water tests from outside hose bibbs, and this is fine. A torch can be used to sterilize the end of the hose bibb, and the bibb provides almost direct access to water.

When collecting water for a test, water should be run through the faucet for several minutes before catching any for a test. It is best to drain the contents of a pressure tank and have it refill with fresh well water for the test. You can run reserve water out quickly by opening the cold-water faucet for a bathtub.

Once a water sample is collected, it is taken or mailed to a lab. Time is of the essence when testing for bacteria, so don't let a water bottle ride around in your truck for a few days before you get around to mailing it. Again, follow the instructions provided by the lab for delivering the water.

There are different types of tests that you can request the lab to perform. A mandatory test will reveal if the water is safe to drink. If you want to know more, you have to ask for additional testing. For example, you might want to have a test done to see if radon is present. Many wells have mineral contents in sufficient quantity to affect the water quality. Acid levels in the well may be too high. The water could be considered hard, which can make washing with soaps difficult and can leave staining in plumbing fixtures. There are a number of potential tests to run.

Table 9.3 Hydraulic check chart.

CONDITION
1. Motor runs but delivers no water
2. Low delivery
3. Pump does not stop running
4. Pump starts and stops too often
5. Service line discharges milky water

1	2	3	4	5	WHAT TO CHECK
✓					Pump not in water supply
✓					Check valve backwards or stuck shut
✓		✓			Pump air or gas locked
✓	✓	✓			Inlet screen clogged
✓	✓				Pump plugged with deposits from well
✓	✓	✓			Water pumping level lowers
✓	✓				Pump setting in sand or mud
✓					Broken pump shaft or coupling
✓	✓				Drop pipe clogged or broken
✓	✓	✓			Incorrectly selected pump
✓	✓	✓			Worn pump parts
	✓	✓	✓	✓	Leak in drop pipe
		✓			Cut-out of pressure switch too high
		✓	✓		Leak on discharge side of tank
			✓		Tank water-logged
			✓		Tank too small in size
			✓		Switch out of adjustment
			✓		Check valve stuck open
			✓		Bleed-back valve plugged
				✓	Air volume control faulty
				✓	Bleed-back valve set too deep
				✓	Well water naturally gaseous

© ITT Goulds Pumps.

Drinking water, or potable water as it is often called, is your primary goal when drilling a well. It is rare that a drilled well will not test well enough to meet minimum requirements for safe drinking. In fact, I've never known of a drilled well that wasn't suitable for drinking. Nevertheless, an official statement of acceptability is generally required by code officials and lenders who loan money on houses.

If you get into a discussion on water quality, you may have to pinpoint exactly what it is that you are talking about. Is it only safety? Or does it extend to mineral contents and such? Most professionals look at water quality on an overall basis, which includes mineral contents.

Trenching

Trenching will be needed for the installation of a water service and for the electrical wires running out to a submersible pump. It is possible to

WELL TIP

Supervising the drilling of a new well is not something that you should have to worry about. Standing around all day, watching a well rig drill, is pretty boring and not very productive. Once you have chosen a well location and have made sure the driller is drilling in the proposed area, you can pretty much ignore the drilling process until it's done. Near the end of the job, you might want to make an appearance to see what height the well casing is being set and to obtain information on the well depth and flow rate.

Table 9.4 Electric check chart.

CONDITION
1. Motor does not start when fused switch is closed
2. Overload protector trips
3. Relay chatters but overload does not trip
4. Fuses blow but overload does not trip
5. Overload trips after pump has run for some time

1	2	3	4	5	WHAT TO CHECK
✓					Power is off
✓					Loose or broken wire
✓		✓			Line fuse is blown
✓	✓	✓			Overload not set
✓	✓				Pressure switch contacts burned or open
✓	✓	✓			Wiring wrong in control box
✓	✓				Crooked well
✓					Low voltage
✓	✓				Loose connection in control box
✓	✓	✓			Wires to control box too small
✓	✓	✓			Amperage too high
	✓	✓	✓	✓	Insufficient power at entrance box
		✓			Cable size to motor too small
		✓	✓		Motor winding faulty
			✓		Motor or cable grounded
			✓		Wrong relay in control box
			✓		Capacitor faulty
			✓		Relay faulty
			✓		Pump running tight
				✓	Locked with sand
				✓	Worn bearing
				✓	Control box in hot location
	✓			✓	Voltage too high
✓	✓				Wrong control box
			✓		Bare wire touching control box
			✓		Line fuses too small

© ITT Goulds Pumps.

pump water from a deep well with a two-pipe jet pump, but submersible pumps are, in my opinion, far superior. When a submersible pump is used, it hangs in the well water. Electrical wires must be run to the well casing and down into the well. The wires and the water-service pipe can share the same trench.

As with any digging, you must make sure that there are no underground utilities in the path of your excavation. Most communities offer some type of underground-utility identification service. In many places, one phone call will be all that is needed to get all underground-utility locations on your work site marked. It may, however, be necessary in some parts of the country to call individual utility companies. I expect that you are familiar with this process; most builders are.

Once you have a clear path to dig, a trench must be dug to a depth that is below the local frost line. The water-service pipe will have water in it at all times, so it must be buried deep enough to avoid freezing. How deep is deep enough? It varies from place to place. In Maine, I have to get down to a depth of four feet to be safe from freezing. In Virginia, the frost line was set at 18 inches. Your local code office can tell you what the prescribed depth is in your area.

After a trench is opened up, you can arrange for your pump installer. Most installers will want to do all of their work in one trip. This means that you must have enough of the house built to allow an installer to bring the water pipe through the foundation and to set the pressure tank. As a helpful hint, you should install a sleeve in your foundation as it is being poured so that the pump installer will not have to cut a hole through the foundation.

Check with your local plumbing inspector to determine what size sleeve will be needed. Most plumbing codes require a sleeve in a foundation wall to be at least two pipe sizes larger than the pipe being installed. For a typical one-inch well pipe, this would mean that the sleeve would have to be at least two inches in diameter. But again, check with your local code office, because plumbing codes do vary from place to place.

At this point, you are ready to have your pump system installed. The pump might be installed by your well driller or your plumber. Wiring for the pump should be done by a licensed electrician. All of your subcontractors should, of course, carry liability insurance to protect you and the property owner from their mistakes and accidents.

Installing a Pump System

Installing a pump system for a drilled well is not a difficult procedure. It is, however, a job that is usually required to be done by a licensed professional. Even if you know how to do all of the work, you probably can't do it legally without a license. Since almost everyone uses submersible pumps when dealing with deep wells, I'll base my examples on the assumption that you, too, will be using a submersible pump.

Since you are a builder rather than a pump installer, I will not go into every little detail of a pump installation. I will cover all the key points but without the step-by-step instructions that I would give someone wishing to learn the trade. In other words, I'm not going to waste your time with instructions to apply pipe dope or how tight to turn a fitting or how to carry out every other little plumbing process. What I will tell you is how to make sure that the installer you choose is doing a good job.

At the Well Casing

Let's start our work at the well casing. You should be looking at an empty trench and the side of a steel well casing when a pump installation begins. A hole has to be cut through the side of the well casing to allow what is called a pitless adapter to be installed. A cutting torch can be used to make this hole, but most installers use a metal-cutting hole saw and a drill. The size of the hole needed is determined by the pitless adapter. Keeping the hole at proper tolerances is important. If the pitless adapter doesn't fit well, ground water might leak into the well by getting past the gasket provided with the adapter.

The hole in the side of the well casing should be positioned so that a water pipe lying in the trench will line up with the pitless adapter once it is installed. Once the hole has been cut, the pitless adapter needs to be installed. This is really a two-person job. One person will work down in the trench, while another person will work from above the main opening in the well casing.

A long, threaded pipe is needed to position the piece of the pitless adapter that is installed inside the well. Most plumbers make up a T-shaped pipe tool to use for this part of the job. The pitless adapter is screwed onto the threads of the T-shaped tool. With this done, one person lowers the pitless adapter down the well and into position. A threaded protrusion on the adapter is intended to poke through the hole in the side of the well casing. When it does, the person in the trench installs a gasket and the other part of the pitless adapter, which is basically a retaining ring. The ring is tightened to create a watertight seal and to hold the pitless adapter in place. At this point, the T-shaped tool is unscrewed from the pitless adapter and laid aside. As a builder, you should check to see that the pitless adapter is tight and in position to prevent contaminated ground water from entering around the hole.

Most installers put their pump rigs together next. This involves either a truck that is equipped with a reel system for well pipe or enough room to lay all of the well pipe out in a fairly straight line. With deep wells, this can be a problem. It is important, however, that the well pipe be laid out and not allowed to kink unless it is being fed into the well from a reel system.

The pipe used for most wells comes in long coils. It is best to avoid joints in well pipe whenever possible. With the long lengths of pipe available, there should be no reason why a joint would be needed to splice two pieces of pipe together. When joints and connections are made with standard well pipe, it is best to use metallic fittings. Nylon fittings are available, but they may break under stress more quickly.

PE pipe is the type used most often for well installations. This black plastic pipe is sold in coils and can be used for both the vertical drop pipe in the well and the horizontal water service in the trench. In houses where hot water will be available, PE pipe must not extend more than five feet inside the foundation wall. The plumbing code requires the same pipe type to be used for water distribution of hot and cold water. PE pipe is not rated to handle hot water, so it cannot be used as an interior water-distribution pipe.

Other types of pipe can be used for well systems, but PE pipe remains the most popular. This pipe has some drawbacks for installers. The material will kink easily. If the pipe kinks, it should not be used. The bend in the pipe weakens it. If you see an installer kink a pipe, make sure that the

WELL TIP

All connections made with PE pipe should be made with two stainless-steel hose clamps. One clamp is all that is required by code, but a second clamp provides cheap insurance against leaks.

WELL TIP

Smart installers attach nylon rope to the submersible pump as a safety rope. I've seen a number of installers skip this step, but I won't allow it on my jobs. I insist on installing a safety rope.

section of pipe that was kinked is not used. Since couplings are undesirable both in the well and in the trench, a kinked pipe may mean getting a whole new roll of pipe, depending upon where the kink occurs.

Another fault of PE pipe is its tendency to become very hard to work with in cold weather. Fittings are difficult to insert into the pipe when it's cold. Warming the ends of the pipe with a torch or heat gun will make the material pliable and easy to work with. However, care must be used to avoid melting the pipe. All connections made with PE pipe should be made with two stainless-steel hose clamps. One clamp is all that is required by code, but a second clamp provides cheap insurance against leaks.

When a coil of PE pipe is unrolled, it will take some work to straighten it out. This is basically a two-person job, although I have done it alone. The pipe should be stretched out as straight as possible without kinking it, and then the pipe must be manipulated in a looping motion to make it lie flat. This step of the installation process should not be ignored.

Once the well pipe is lying flat, an installer can proceed with putting the pump and accessories together with the pipe. A torque arrestor should be installed on the pipe. This will limit vibration in the well as the pump runs. A male insert adapter (brass please) should be used to connect the pipe to the pump. Another insert adapter will connect the pipe to the pitless adapter fitting that has yet to be installed.

Electrical wires must run from the pump to the top of the well casing. Some plumbers use electrical tape to secure electrical wire to the well pipe. This is a common procedure. Other installers use plastic guides that slide over the well pipe to secure the wires. Either way, someone has to make sure that the wires are secure. It is also very important to make sure that the wires are not damaged as the pump assembly is lowered into the well. Waterproof splice kits can be used to join electrical wires that are extending into a well, and of course, waterproof wire is required.

All of the piping and wiring are connected to a submersible pump before the pump is installed. This work is normally done near the well on the ground. Once the entire assembly is put together, it is lowered into the well. Some companies have special trucks for this part of the job, but a lot of installers do it the old-fashioned way, by hand.

When the pump assembly is put down the well, the work goes much better if two people are involved. Lowering a pump assembly by hand is not difficult. The T-bar tool is once again connected to the part of a pitless adapter that is wedge-shaped and attached to the upper end of the drop pipe. Smart installers attach nylon rope to the submersible pump as a safety rope. I've seen a number of installers skip this step, but I won't allow it on my jobs. I insist on installing a safety rope.

Submersible pumps are held in the well by only the well pipe unless a safety rope is used. If a fitting pulls loose, an expensive pump can be lost in the well forever. The rope, which is ultimately tied to the top of the well casing, gives you something to retrieve the pump with if anything goes wrong with the piping arrangement. For the low cost of nylon rope, it's senseless not to use it.

The pump is lowered into the well. During this process, the person working the assembly down into the casing must take care not to scrape the electrical wires along the edge or sides of the casing. If the insulation on the wires is cut by the casing, the pump may fail to operate. Once the pump is in position, the part of the pitless adapter that is secured to the well casing is put into place. This is done simply by lining the wedge up with the groove in the stationary piece and tapping it into place. Then the safety rope is adjusted and tied off to the casing. The T-bar is unscrewed and removed. The only step remaining at the well head is the connection of electrical wires and the replacement of the well cap. An experienced crew can put together and install a pump assembly in about two hours or so.

The Water Service

The next step in the installation of a pump system is the water service. This pipe might be the same type as is used in the well, or it may be some other type. Copper tubing was used as a water-service material for years. It is still used at times. Most installers use PE pipe, and there is no reason not to. It's less expensive than copper, it's not affected by acidic water in the same way that copper is, and it has a long life span.

PE pipe for a water service is prepared in the same way as for use as a drop pipe. It is laid out and straightened to get the loops out. When this is complete, it is placed in the trench. One end of the pipe connects to the protrusion from the pitless adapter. This connection is made with two hose clamps. The other end of the pipe is placed through a foundation sleeve and extended into a home. The entire length of the pipe should be lying flat on the bottom of the trench. There should not be any rocks or other sharp objects under or around the pipe. This is important, and it is something that not all installers are especially careful about, so you might want to check it yourself. Any sharp objects may puncture the pipe during the backfilling process. It is also possible for rough or sharp objects to the cut the pipe months after installation as the ground settles and the pipe moves. Make sure the trench and the backfill material are free of objects that may harm the pipe.

Water-service pipes often have to be inspected before they are covered up. This is not directly your responsibility, but you should make sure that an inspection has been done if one is required. Backfilling the trench should be done gradually. If someone takes a backhoe and pushes large piles of dirt into the ditch, the pipe might kink or collapse. Require the backfilling to be done in layers so that there will not be excessive weight dumped on the pipe all at once.

Inside the Foundation

The rest of the work will take place inside the foundation. A pressure tank should be used on all jobs. This tank gives a reserve supply of water that allows the house to have good water pressure. The tank also preserves the life of the pump. Without a pressure tank, a water pump would have to cut on every time a faucet was turned on. This short cycling of the pump would wear it out quickly. A pressure tank removes the need for a pump to cut on every time water is needed. Until the tank drops to a certain pressure, the pump is not required to run. When the pump refills the tank, it runs long enough to avoid short cycling.

The size of a pressure tank is normally determined by the number of people and plumbing fixtures expected in a house. Larger tanks require the pump to run less often. In addition to the pressure tank, there are many accessories that must be installed. For example, there will be a pressure gauge, a relief valve, a drain valve, a pressure switch, and a tank tee. Electrical regulations may call for a disconnect box at the tank location. Even if your local code doesn't require a disconnect box, it's a good idea to install one.

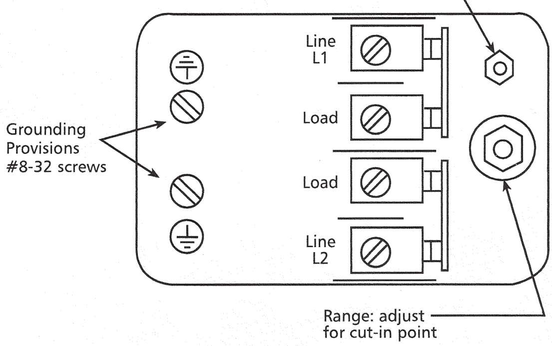

Figure 9.8 Pressure switch wiring and adjustments. Centripro and square "D" switches. © *ITT Goulds Pumps.*

Under normal circumstances, an experienced installation crew can complete an entire pump installation, including inside work, in less than a day. As a builder, you will have to hang around the job if you want to see that all of the work is being done correctly, because it will happen quickly. However, you can tell a lot about the workmanship by making periodic inspections.

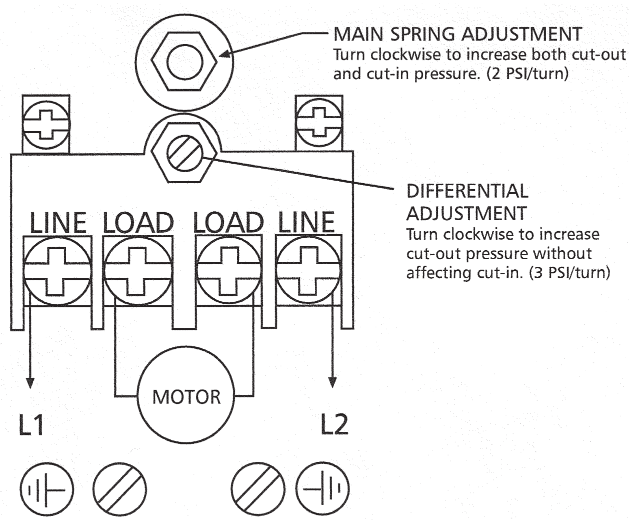

Figure 9.9 Hubbell (Furnas) Pro control switch. © *ITT Goulds Pumps.*

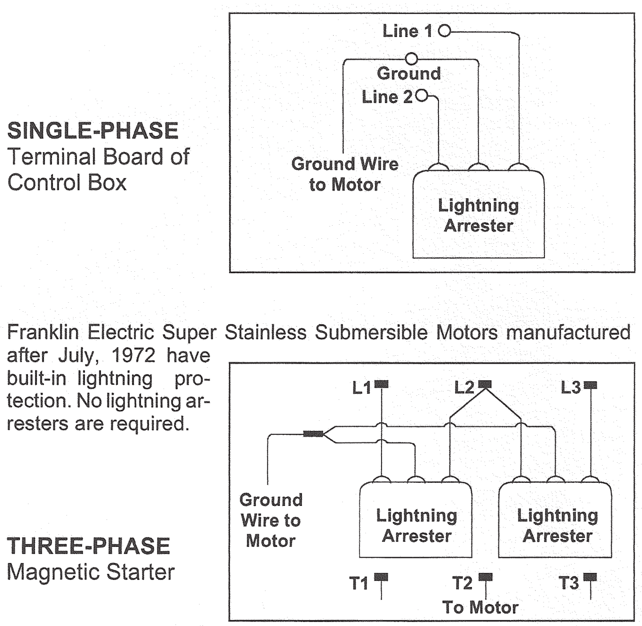

Figure 9.10 Lightning protector. © *ITT Goulds Pumps.*

The Finer Points

We didn't discuss the finer points of pump installations, but you now have a good idea of what goes on during the process. There are a few other issues that we should cover. One is pump selection. This decision is usually left up to the driller or plumber who will supply and install the pump. It's best not to undersize a pump. While it makes no sense to buy an extremely powerful pump that is not required, it is in your customer's

> **WELL TIP**
>
> Pumps should not be suspended too close to the bottom of a well. How far from the bottom should a pump be placed? It depends on the static water level in the well. If a pump is placed too close to the bottom of a well, it can pick up gravel, sand, and other debris. Some wells fill in a little over time, and having a pump too close to the bottom in this circumstance is bad news. A pump should be, in my opinion, at least 15 feet above the bottom and higher when practical.

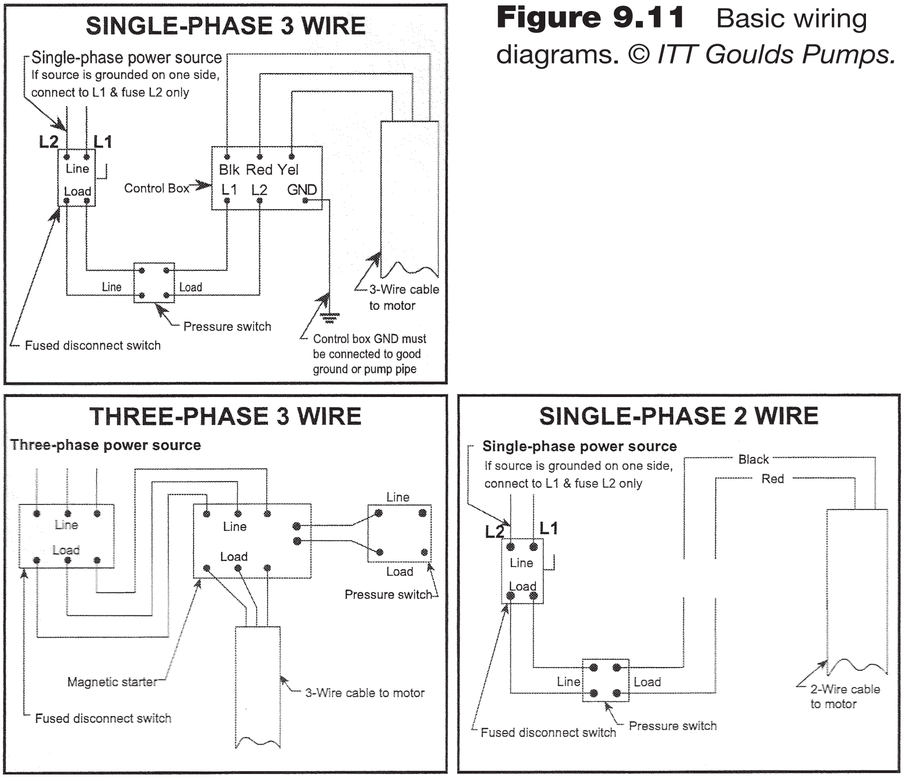

Figure 9.11 Basic wiring diagrams. © *ITT Goulds Pumps.*

best interest to get a pump that exceeds its requirements by some degree. Getting a pump that is too powerful can cause some problems. Let me explain.

Pumps are rated on their output in gallons per minute (GPM). Sizing charts are available to show you what pumps of various sizes are capable of producing. Let's say that you have a well with a recovery rate of three GPM. Can you imagine what might happen if you install a pump that is rated at five GPM? If you guessed that the well might be pumped dry, you're right. The pump should not produce more water than the well can replenish. Keep this in mind when you are looking over the specifications provided to you by bidding subcontractors. Compare the pump rate with the well rate, and make sure that the pump is not too powerful for the well.

Pumps should not be suspended too close to the bottom of a well. How far from the bottom should a pump be placed? It depends on the static water level in the well. If a pump is placed too close to the bottom of a well, it can pick up gravel, sand, and other debris. Some wells fill in a little over time, and having a pump too close to the bottom in this circumstance is bad news. A pump should be, in my opinion, at least 15 feet above the bottom and higher when practical.

My personal pump is about 30 feet above the bottom of the well. The depth of my well is a little over 400 feet. The static level of my well water is only about 15 feet from the top of my well casing. This means that I have a column of water that is about 385 feet deep. That's a substantial reserve. I would have to pump hundreds of gallons of water at one time to run the well dry. Since I have so much water, it's easy for me to keep my pump hanging high above the bottom. Not all wells have so much reserve water, and this can force an installer to hang a pump closer to the bottom. The key is to keep the pump far enough from the bottom to avoid problems with debris being sucked into the pump.

Problems

Problems sometimes arise with well installations. What would you do if the trench for your water service could not be dug deep enough to protect the pipe from freezing? This doesn't happen often, but it does happen. In fact, it happened at my house. Bedrock was between 18 and 24 inches down, so getting to a depth of four feet was not feasible. Winters are very cold in Maine, so there was no doubt that my water service would freeze if left unprotected at such a shallow depth. You might run into a similar situation.

With my home, I took three precautions. I insulated the water-service pipe with foam pipe insulation. Then I ran it through a continuous sleeve of three-inch plastic pipe. The air space between the sleeve and the water service adds to frost protection. My final and most effective step was to install an in-line heat tape. This type of heat tape is expensive, but it's a bargain when you are faced with a difficult situations such as mine.

The heat tape is waterproof. It runs the full length of the water pipe. The heating element is inside the water pipe in the water. A sensor and control are installed in some practical location. Mine is in a crawl space, with the temperature sensor positioned by an air vent. This allows the sensor to feel the outside temperature.

During the winter, I plug in the control unit, which is thermostatically controlled, and the heat tape runs automatically. It heats the water in the pipe to a point above freezing. I used it all of last winter and experienced no problems. If you can't dig as deep as you would like to, I strongly recommend an in-line heat tape.

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10

Dug Wells

Dug and bored wells, or shallow wells, as they are often called, are very different from drilled wells. While most drilled wells have diameters of six inches, a typical dug well will have a diameter of about 3 feet. Concrete usually surrounds a dug well, rather than the steel casing used for a drilled well. While drilled wells often reach depths of 300 feet, a dug well rarely runs deeper than 30 feet. There are, to be sure, many differences between the two types of wells.

In the old days, dug wells were created with picks, shovels, and buckets. It was dangerous work. Today, boring equipment is normally used to create a dug well. I suppose it would be more proper to call these wells bored wells, but most professionals I know refer to them as dug wells. To be specific about the type of well I'm talking about, let me explain the basic makeup.

If you see a concrete cylinder that has a diameter of approximately three feet sticking out of the ground, you are looking at what I call a dug well. The concrete casing will typically be covered with a large, heavy concrete disk.

Old dug wells were dug by hand. Many of them were lined with stones. I've crawled down a few of these as a plumber to work on pipes and such, but I don't think I'd do it today. My younger years as a plumber were more adventuresome than I would care to repeat.

WELL TIP

Shallow wells are common in many parts of the country. When the water table is high and reasonably constant, shallow wells work fairly well. They may dry up during some hot, dry times of the year, but this is not always the case. Some shallow wells maintain a good volume of water all through the year.

Dug wells are always shallow in comparison with drilled wells. Finding a dug well that is 50 feet deep would be similar to finding pirate treasure sitting on top of a sandy beach. Most dug wells that I've seen have been no more than 35 feet deep. Bored wells can run much deeper. It's possible for a bored well to reach a depth of 100 feet or more. The depth is regulated by the ground the well is dug in. Some types of earth allow for a deeper well than others. Still, in practical terms, most dug or bored wells won't exceed 50 feet in depth. Beyond this level, a drilled well is more practical.

A lot of people know dug or bored wells as shallow wells. This is why jet pumps, which are often used with these types of wells, are called shallow-well pumps. Without trying to get extremely technical, I will simply refer to these wells as dug wells.

Shallow wells are common in many parts of the country. When the water table is high and reasonably constant, shallow wells work fairly well. They may dry up during some hot, dry times of the year, but this is not always the case. Some shallow wells maintain a good volume of water all through the year.

Most of the homes that I've owned have had shallow wells. My present home has a drilled well, and I feel much more secure than I ever did with shallow wells. But I only ever had trouble with one of my shallow wells, and that trouble only occurred for one summer. At other times and with my other wells, I never experienced any problems.

Shallow wells are much less expensive to install than drilled wells. This is one good reason for using a shallow well. But there are drawbacks as well. Having a sufficient water quantity is one of these drawbacks. Due to the large diameter of a dug well, a lot of water can be stored in reserve. While the water in a shallow well may be only a few feet deep, it has a lot more surface area than water stored in a deep well. The increased surface area helps to make up for the lack of depth.

Even with a large diameter, dug wells do often run dry for short periods of time. If they don't run completely dry, they may contain such a small quantity of water that rationing is needed. For example, you may have to go to a local laundromat to wash clothes for a few weeks out of the year. This, of course, is more inconvenience than some homeowners are willing to put up with.

When Should You Use a Shallow Well?

When should you use a shallow well? The ground conditions where the well will be drilled have a lot of influence on this decision. If bedrock is

Table 10.1 Jet and submersible pump selections.

PRIVATE RESIDENCES

Outlets	Flow Rate GPM	Total Usage Gallons	Bathrooms in Home			
			1	1½	2-2½	3-4
Shower or Bathtub	5	35	35	35	53	70
Lavatory	4	2	2	4	6	8
Toilet	4	5	5	10	15	20
Kitchen Sink	5	3	3	3	3	3
Automatic Washer	5	35	–	18	18	18
Dishwasher	2	14	–	–	3	3
Normal seven minute* peak demand (gallons)			45	70	98	122
Minimum sized pump required to meet peak demand without supplemental supply		7 GPM (420 GPH)	10 GPM (600 GPH)	14 GPM (840 GPH)	17 GPM (1020 GPH)	

Notes:
Values given are average and do not include higher or lower extremes.
* Peak demand can occur several times during morning and evening hours.
** Count the number of fixtures in a home including outside hose bibs. Supply one gallon per minute each.

YARD FIXTURES

Garden Hose – ½"	3 GPM
Garden Hose – ¾"	6 GPM
Sprinkler– Lawn	3-7 GPM

FARM USE

Horse, Steer	12 Gallons per day
Dry Cow	15 Gallons per day
Milking Cow	35 Gallons per day
Hog	4 Gallons per day
Sheep	2 Gallons per day
Chickens/100	6 Gallons per day
Turkeys/100	20 Gallons per day
Fire	20-60 GPM

PUBLIC BUILDINGS

Pump Capacity Required in U.S. Gallons per Minute per fixture for Public Buildings							
Type of Building	Total Number of Fixtures						
	25 or Less	26-50	51-100	101-200	201-400	401-600	Over 600
Hospitals	1.00	1.00	.80	.60	.50	.45	.40
Mercantile Buildings	1.30	1.00	.80	.71	.60	.54	.48
Office Buildings	1.20	.90	.72	.65	.50	.40	.35
Schools	1.20	.85	.65	.60	.55	.45	
Hotels, Motels	.80	.60	.55	.45	.40	.35	.33
Apartment Buildings	.60	.50	.37	.30	.28	.25	.24

1. For less than 25 fixtures, pump capacity should not be less than 75% of capacity required for 25 fixtures.
2. Where additional water is required for some special process, this should be added to pump capacity.
3. Where laundries or swimming pools are to be supplied, add approximately 10% to pump capacity for either.
4. Where the majority of occupants are women, add approximately 20% to pump capacity.

BOILER FEED REQUIREMENTS

Boiler		Boiler		Boiler		Boiler		Boiler	
HP	GPM	HP	GPM	HP	GPM	HP	GPM	HP	GPM
20	1.38	55	3.80	90	6.21	160	11.1	275	19.0
25	1.73	60	4.14	100	6.90	170	11.7	300	20.7
30	2.07	65	4.49	110	7.59	180	12.4	325	22.5
35	2.42	70	4.83	120	8.29	190	13.1	350	24.2
40	2.76	75	5.18	130	8.97	200	13.8	400	27.6
45	3.11	80	5.52	140	9.66	225	15.5	450	31.1
50	3.45	85	5.87	150	10.4	250	17.3	500	34.5

1. Boiler Horsepower equals 34.5 lb. water evaporated at and from 212°F, and requires feed water at a rate of 0.069 gpm.

Select the boiler feed pump with a capacity of 2 to 3 times greater than the figures given above at a pressure 20 to 25% above that of boiler, because the table gives equivalents of boiler horsepower without reference to fluctuating demands.

WELL TIP

Shallow wells are much less expensive to install than drilled wells.

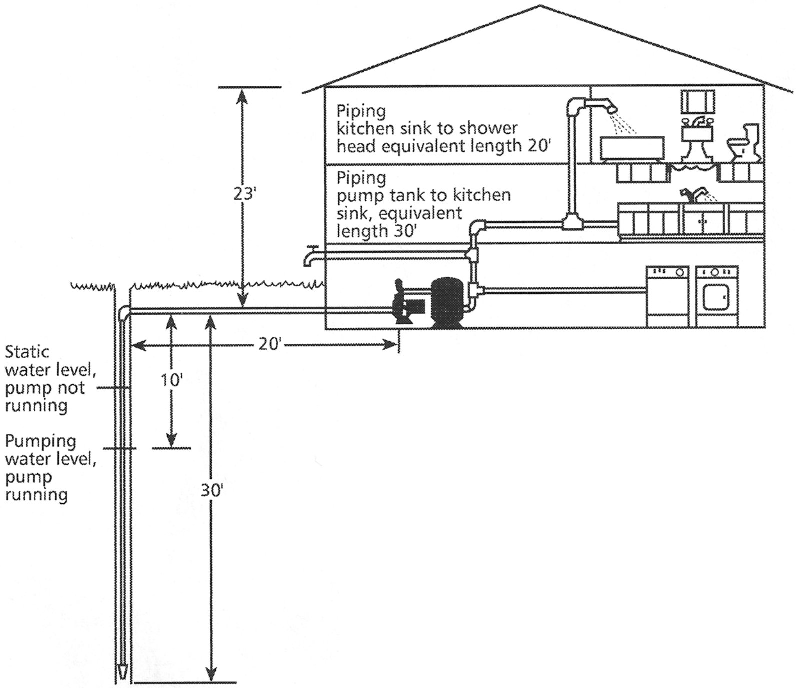


Figure 10.1 The capacity required of the pump is determined by the number of continuously flowing demands. © *ITT Goulds Pumps.*

near the ground surface, a dug well is not practical. Drilled wells are the answer when you have to penetrate hard rock. To give you a good idea of what depths are possible and in what types of soil conditions different types of wells can be used, let me break them into categories.

True Dug Wells

True dug wells can be created with depths of up to 50 feet. Their diameter may range from a common 3 feet to a massive 20 feet. In terms of geographic formations, clay, silt, sand, gravel, cemented gravel, and even

> **WELL TIP**
>
> Jetted wells can run up to 100 feet in depth. They cannot be installed in bedrock, limestone, or sandstone. Boulders, cemented gravel, and large, loose gravel all prohibit the use of jetted wells.

boulders can be dealt with. Sandstone and limestone may allow the use of a dug well, but the material must either be soft or fractured. Dense igneous rock cannot be penetrated with a dug well.

Bored Wells

Bored wells can reach depths of 100 feet. The diameter of this type of well can be a minuscule 2 inches. Larger diameters in the 30 inch range are also common. Clay, silt, sand, and gravel can all support a bored well. Cemented gravel will stop a bored well, and so will bedrock. Boulders can sometimes be worked around, and sandstone and limestone affect a bored well in the same way that they do a dug well.

Drilled Wells

Drilled wells can run to depths of 1000 feet. This is far from being a shallow well. All of the geologic formations mentioned for the well types above can be overcome with a drilled well. Percussion and hydraulic rotary drilling are very similar in their abilities.

Jetted Wells

Jetted wells can run up to 100 feet in depth. They cannot be installed in bedrock, limestone, or sandstone. Boulders, cemented gravel, and large, loose gravel all prohibit the use of jetted wells. Clay, sand, and silt are the best types of geologic formations to use a jetted well. The diameter of a jetted well may be anywhere from 2 to 12 inches.

Table 10.2 Seven minute peak demand period usage.

Outlets	Flow Rate GPM	Total Usage Gallons	Bathrooms In Home 1	1½	2-2½	3-4
Shower or Bath Tub	5	35	35	35	53	70
Lavatory	4	2	2	4	6	8
Toilet	4	5	5	10	15	20
Kitchen Sink	5	3	3	3	3	3
Automatic Washer	5	35	–	18	18	18
Dishwasher	2	14	–	–	3	3
Normal seven minute*peak demand (gallons)			45	70	98	122
Minimum sized pump required to meet peak Demand without supplemental supply			7 GPM (420)	10 GPM (600)	14 GPM (840)	17 GPM (1020)

Note: Values given are average and do not include higher or lower extremes. * Peak demand can occur several times during morning and evening hours.

Additional Requirements: Farm, irrigation and sprinkling requirements are not shown. These values must be added to the peak demand figures if usage will occur during normal demand periods.

© ITT Goulds Pumps.

Characteristics of Dug Wells

Let's talk about some of the characteristics of shallow wells. Dug wells can extend only a few feet below a water table. The geologic conditions affect the recovery rate of a well. For example, a dug well that is surrounded by gravel might produce an excellent recovery rate, while one surrounded by fine sand may produce a poor rate of recovery. Dug wells cannot be considered terrific water producers.

Bored wells are a little different. They can extend deeper into the water table. Going 10 feet below the edge of a water table is not uncommon. This added depth gives bored wells an advantage over dug wells. Having an 8-foot head of water with a 3-foot diameter provides a good supply of water, assuming that the recovery rate is good. It would not be considered strange or unusual for a bored well to have a recovery rate of 20 GPM. This is about double what would be expected of a good dug well.

Even though many professionals, myself included, call all shallow wells dug wells, there is clearly a difference between a bored well and a true dug well. Most shallow wells installed today are bored wells. If your well installer talks about a dug well, make sure that the installer is actually referring to a bored well.

Some bored wells hit artesian aquifers. When this happens, the static water level in the well rises. For example, a bored well that extends 10 feet past the water table would normally be thought of as holding 10 feet of water. If an artesian aquifer is hit, the actual water reserve could be 20 feet deep or more. I've seen bored wells with such powerful artesian effects that water actually ran out over the top of the well casing. It is certainly possible to obtain plenty of water for a residence with a bored well. But, there is no guarantee of it.

Look Around

If you are unsure of what type of well to use, look around at the wells being used for houses near your building site. If you see a lot of concrete casings sticking up out of the ground, it's a good indication that shallow wells work in the area. A host of steel casings indicates a need for a drilled well. Looking at neighboring homes is a good way to get a feel for what type of well is likely to be needed. It is not, however, a sure bet.

If you want more dependable information on which type of well is likely to be suitable for your project, talk to some experts. Well installers are an excellent place to start. Local installers should know a great deal

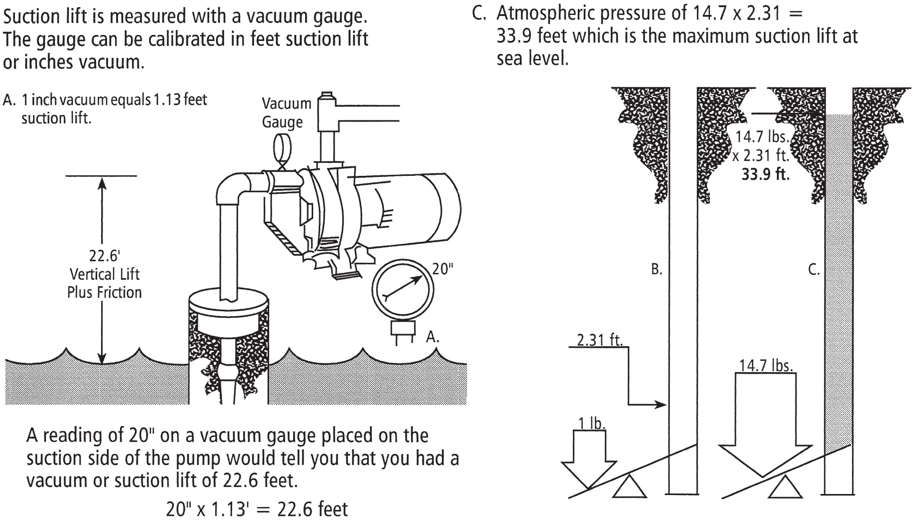


Figure 10.2 Terms and usable formulas. Calculating suction lift. © *ITT Goulds Pumps.*

about the pros and cons of various types of wells in the region where you plan to build. But be careful. You may run across an installer who is not equipped to install all types of wells. If this is the case, it's possible that the recommendations made may be in the best interest of the installer rather than you or your customer.

Combined research is the true key to success. Visit your county extension office and look over the maps. Take an inventory of wells on surrounding properties. Talk to several well installers. Combine all the knowledge and advice you collect to make a wise decision. Don't be afraid to install a bored well if evidence points to it being a good choice.

As a builder in Virginia, I was responsible for the installation of dozens upon dozens of shallow wells. To the best of my knowledge, only one of

WELL TIP

Most rural areas have county extension offices or some similar facility to help with all sorts of issues. Wells fall into this category. A visit to the right local agency may reveal detailed maps that show aquifers and soil types. If you can pinpoint your building location on a map of this type, you can make some sound decisions on the type of well to use.

the wells ever gave anyone any trouble, and that was one on my personal property. When the conditions are right and the job is done properly, a shallow well can give years of quality service at an affordable price.

The Preliminary Work

The preliminary work for a builder who is having a shallow well installed is very similar to that of a builder who is preparing for the installation of a drilled well. Since we covered the steps for this in the last chapter, I won't repeat them here. The only big difference is the size of a shallow well. A drilled well can be hidden easily with a few strategically placed shrubs. The casing and cap of a shallow well are much harder to hide. Aside from the size of the well, the rest of the steps are about the same.

After a Well Is In

After a well is in, you are faced with the disinfection process. Just as we discussed in the last chapter, chlorine is normally used to purify a well before testing is done on the water. There are a few extra things to consider, however, when testing a shallow well. For one thing, the well cover is heavy. One person can slide the cover aside, but it is easier with two people. The concrete cover is brittle. Rough handling can cause it to crack or break. Having a concrete cover drop and catch your finger between the lip of the well casing and the cover is extremely painful. Be careful when handling the cover.

The odds of a child or an animal falling into an uncovered drilled well are much lower than they are with a shallow well. Two adults could jump into the opening of a bored well without any problem. Never leave the cover off a shallow well when you are not right at the well site. Even if you are just going into the house to turn the water on or off, put the cover back on the well. Pets and people can fall into an open well quickly, and the results can be disastrous. Even drilled wells should be covered every

WELL TIP

Never leave the cover off a shallow well when you are not right at the well site. Even if you are just going into the house to turn the water on or off, put the cover back on the well. Pets and people can fall into an open well quickly, and the results can be disastrous.

time they are left unattended. Curious kids and pets can find themselves in some very dangerous circumstances in the blink of an eye.

When you are purging chlorine from a shallow well, you must monitor the water level closely. While it is uncommon for a drilled well to be pumped dry during a purging, it is not unusual for a dug or bored well to have its water level fall below the foot valve or end of the drop pipe. If this happens, the pump keeps pumping, but it's only getting air. This is bad for the pump and can burn it up. Monitor the water level closely as you empty a shallow well.

You can watch the water level in most shallow wells without any special equipment. Your eyes should be the only tools needed to tell when the water level drops down too far. However, a string with a weight attached to it can be used to gauge the water depth. If you know how long the drop pipe in the well is, and your pump installer should be able to tell you, make the string a foot shorter than the drop pipe. As long as the string hits water each time it is dropped into the well, you know the water level is safe.

Pump Selection

Pump selection for a shallow well is sometimes more complex than it is for a deep well. Almost everyone uses submersible pumps for drilled wells. It's possible to use a two-pipe jet pump for a deep well, but few installers recommend this course of action. Shallow wells, on the other hand, can use single-pipe jet pumps, two-pipe jet pumps, or even submersible pumps. The use of submersible pumps in shallow wells is not common. In wells where the water lift is not more than about 25 feet, single-pipe jet pumps are often used. Deeper bored wells and some dug wells use two-pipe jet pumps. If a well of any type has an adequate depth of water to work with, a submersible pump can always be used.

Single-Pipe Jet Pumps

Single-pipe jet pumps are the least expensive option available for a shallow well. But their lifting capacity is limited. Since single-pipe jet pumps work on a suction-only basis, they must be able to pull a vacuum on the water. Since physics plays a part in how high above sea level a vacuum can be made, jet pumps can only pull water so high. Without looking it up, I can't remember the exact maximum lift under ideal conditions. I know it's around 30 feet. But for practical purposes most profession-

Table 10.3 Tank selection. Capacities of tanks of various dimensions.

Dia. in inches	Length of Cylinder																		
	1"	1'	5'	6'	7'	8'	9'	10'	11'	12'	13'	14'	15'	16'	17'	18'	20'	22'	24'
1		0.04	0.20	0.24	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.80	0.88	0.96
2	0.01	0.16	0.80	0.96	1.12	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.56	2.72	2.88	3.20	3.52	3.84
3	0.03	0.37	1.84	2.20	2.56	2.92	3.30	3.68	4.04	4.40	4.76	5.12	5.48	5.84	6.22	6.60	7.36	8.08	8.80
4	0.05	0.65	3.26	3.92	4.58	5.24	5.88	6.52	7.18	7.84	8.50	9.16	9.82	10.5	11.1	11.8	13.0	14.4	15.7
5	0.08	1.02	5.10	6.12	7.14	8.16	9.18	10.2	11.2	12.2	13.3	14.3	15.3	16.3	17.3	18.4	20.4	22.4	24.4
6	0.12	1.47	7.34	8.80	10.3	11.8	13.2	14.7	16.1	17.6	19.1	20.6	22.0	23.6	25.0	26.4	29.4	32.2	35.2
7	0.17	2.00	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0	34.0	36.0	40.0	44.0	48.0
8	0.22	2.61	13.0	15.6	18.2	20.8	23.4	26.0	28.6	31.2	33.8	36.4	39.0	41.6	44.2	46.8	52.0	57.2	62.4
9	0.28	3.31	16.5	19.8	23.1	26.4	29.8	33.0	36.4	39.6	43.0	46.2	49.6	52.8	56.2	60.0	66.0	72.4	79.2
10	0.34	4.08	20.4	24.4	28.4	32.6	36.8	40.8	44.8	48.8	52.8	56.8	61.0	65.2	69.4	73.6	81.6	89.6	97.6
11	0.41	4.94	24.6	29.6	34.6	39.4	44.4	49.2	54.2	59.2	64.2	69.2	74.0	78.8	83.8	88.8	98.4	104.0	118.0
12	0.49	5.88	29.4	35.2	41.0	46.8	52.8	58.8	64.6	70.4	76.2	82.0	87.8	93.6	99.6	106.0	118.0	129.0	141.0
13	0.57	6.90	34.6	41.6	48.6	55.2	62.2	69.2	76.2	83.2	90.2	97.2	104.0	110.0	117.0	124.0	138.0	152.0	166.0
14	0.67	8.00	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0	128.0	136.0	144.0	160.0	176.0	192.0
15	0.77	9.18	46.0	55.2	64.4	73.6	82.8	92.0	101.0	110.0	120.0	129.0	138.0	147.0	156.0	166.0	184.0	202.0	220.0
16	0.87	10.4	52.0	62.4	72.8	83.2	93.6	104.0	114.0	125.0	135.0	146.0	156.0	166.0	177.0	187.0	208.0	229.0	250.0
17	0.98	11.8	59.0	70.8	81.6	94.4	106.0	118.0	130.0	142.0	153.0	163.0	177.0	189.0	201.0	212.0	236.0	260.0	283.0
18	1.10	13.2	66.0	79.2	92.4	106.0	119.0	132.0	145.0	158.0	172.0	185.0	198.0	211.0	224.0	240.0	264.0	290.0	317.0
19	1.23	14.7	73.6	88.4	103.0	118.0	132.0	147.0	162.0	177.0	192.0	206.0	221.0	235.0	250.0	265.0	294.0	324.0	354.0
20	1.36	16.3	81.6	98.0	114.0	130.0	147.0	163.0	180.0	196.0	212.0	229.0	245.0	261.0	277.0	294.0	326.0	359.0	392.0
21	1.50	18.0	90.0	108.0	126.0	144.0	162.0	180.0	198.0	216.0	238.0	252.0	270.0	288.0	306.0	324.0	360.0	396.0	432.0
22	1.65	19.8	99.0	119.0	139.0	158.0	178.0	198.0	218.0	238.0	257.0	277.0	297.0	317.0	337.0	356.0	396.0	436.0	476.0
23	1.80	21.6	108.0	130.0	151.0	173.0	194.0	216.0	238.0	259.0	281.0	302.0	324.0	346.0	367.0	389.0	432.0	476.0	518.0
24	1.96	23.5	118.0	141.0	165.0	188.0	212.0	235.0	259.0	282.0	306.0	330.0	353.0	376.0	400.0	424.0	470.0	518.0	564.0
25	2.12	25.5	128.0	153.0	179.0	204.0	230.0	255.0	281.0	306.0	332.0	358.0	383.0	408.0	434.0	460.0	510.0	562.0	612.0
26	2.30	27.6	138.0	166.0	193.0	221.0	248.0	276.0	304.0	331.0	359.0	386.0	414.0	442.0	470.0	496.0	552.0	608.0	662.0
27	2.48	29.7	148.0	178.0	208.0	238.0	267.0	297.0	326.0	356.0	386.0	416.0	426.0	476.0	504.0	534.0	594.0	652.0	712.0
28	2.67	32.0	160.0	192.0	224.0	256.0	288.0	320.0	352.0	384.0	416.0	448.0	480.0	512.0	544.0	576.0	640.0	704.0	768.0
29	2.86	34.3	171.0	206.0	240.0	274.0	309.0	343.0	377.0	412.0	446.0	480.0	514.0	548.0	584.0	618.0	686.0	754.0	824.0
30	3.06	36.7	183.0	220.0	257.0	294.0	330.0	367.0	404.0	440.0	476.0	514.0	550.0	588.0	624.0	660.0	734.0	808.0	880.0
32	3.48	41.8	209.0	251.0	293.0	334.0	376.0	418.0	460.0	502.0	544.0	586.0	628.0	668.0	710.0	752.0	836.0	920.0	1004.0
34	3.93	47.2	236.0	283.0	330.0	378.0	424.0	472.0	520.0	566.0	614.0	660.0	708.0	756.0	802.0	848.0	944.0	1040.0	1132.0
36	4.41	52.9	264.0	317.0	370.0	422.0	476.0	528.0	582.0	634.0	688.0	740.0	792.0	844.0	898.0	952.0	1056.0	1164.0	1268.0

Capacities, in U.S. Gallons, of cylinders of various diameters and lengths.

Volume $= \frac{\pi d^2}{4} \times$ H (Cylinder), L x W x H (Cube)

als agree that a suction-based pump should not be expected to lift water more than 25 feet.

Jet pumps are installed at some location outside of the well. Unlike submersible pumps, which hang in the well water, jet pumps are normally installed in basements, crawl spaces, or pump houses. The pumps and their pipes must be protected from freezing temperatures. A pressure tank should be used with jet pumps, just as with submersible pumps. Many jet pumps are made to sit right on top of a pressure tank with the use of a special bracket. The pressure tank must also be protected from freezing temperatures.

WELL TIP

Submersible pumps push water up out of a well. Since the pump is pushing rather than sucking, it can be installed at great depths. In many ways, submersible pumps are far less prone to failure than jet pumps. They are more expensive, but they tend to last longer and there are not as many parts and pieces to fail.

Two-Pipe Jet Pumps

Two-pipe jet pumps can be used to pump water from deeper wells. These pumps use two pipes. The pump forces water down one pipe to allow it to be sucked up in the other. Since a two-pipe pump is not dependent solely on suction, it can handle higher lifts. The physical appearance of a two-pipe pump is basically the same as that of a one-pipe pump except for the extra pipe.

Submersible Pumps

Submersible pumps push water up out of a well. Since the pump is pushing rather than sucking, it can be installed at great depths. In many ways, submersible pumps are far less prone to failure than jet pumps. They are more expensive, but they tend to last longer and there are not as many parts and pieces to fail. This makes submersible pumps a favorable choice when the water depth is sufficient to warrant their use.

Since jet pumps are most often used with shallow wells, we will concentrate our efforts on them. Submersible systems were described in the last chapter if you wish to review them. Since most shallow wells are equipped with a single-pipe jet pump, we will start our installation procedures here.

Installing a Single-Pipe Jet Pump

Installing a single-pipe jet pump is fairly easy. The well portion of the work is particularly simple. Almost anyone with modest mechanical skills and an ability to read instructions can manage the installation of a jet pump. However, a license to perform this type of work is probably required in your area. This may prohibit you from making your own installations.

The first step in installing a jet pump will be digging a trench between the well casing and the pump location. Since we covered trenching in the last chapter, we will skirt the issue here. Once the trench is dug, you are ready to make a hole in the side of the well casing. Since most shallow wells are cased with concrete, a cold chisel and a heavy hammer are all that are needed to make a hole. The hole will have to be patched to make it watertight after the well piping is installed. Otherwise, ground water will run into the well and may contaminate it.

After a hole is made, you are ready to install the well pipe. The pipe will probably be PE pipe. Insert fittings should be made of metal, in my opinion, and all connections should be double- clamped. A foot valve is usually installed on the end of the pipe that will hang in the well water. The foot valve serves two purposes. It acts as a strainer to block out gravel and similar debris that might otherwise be sucked into the pipe and pump. Foot valves also act as check valves to prevent water in the drop pipe from running out into the well. If the water in a drop pipe is not controlled with a check or foot valve, the jet pump would lose its prime and fail to pump water.

After the foot valve is installed, an elbow fitting is attached to the other end of the pipe. This fitting will allow the water-service pipe, which

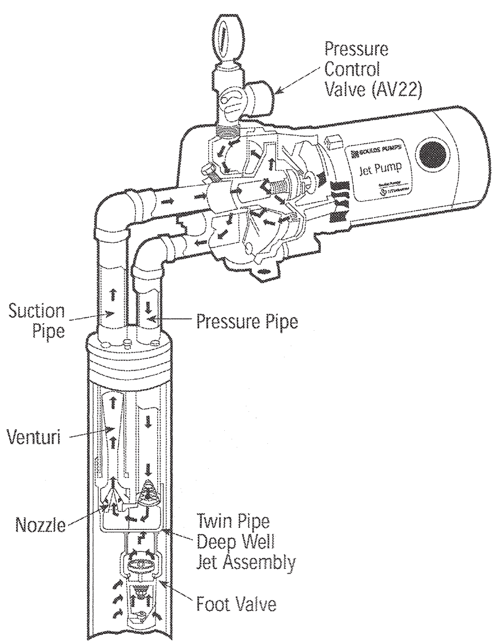


Figure 10.3
Deep well jet pump.
© ITT Goulds Pumps.

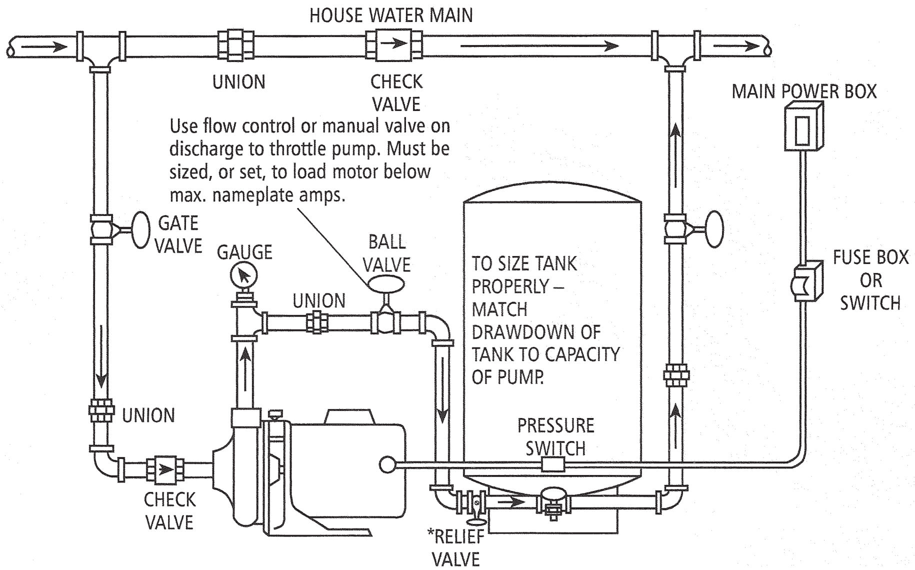


Figure 10.4 Centrifugal booster pump installations. Automatic operation. © *ITT Goulds Pumps.*

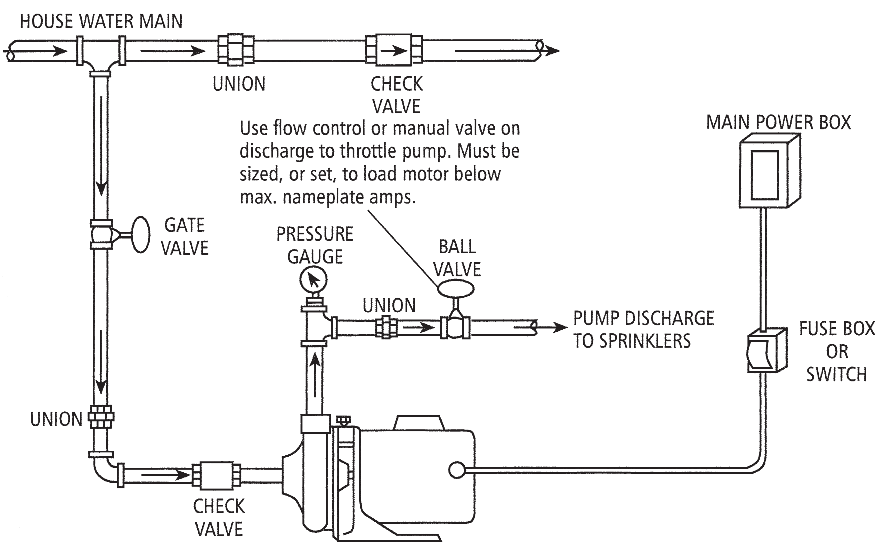


Figure 10.5 Centrifugal booster pump installations. Manual operation. Required if system pressure can exceed 100 psi. © *ITT Goulds Pumps.*

will be placed in the trench, to connect to the drop pipe. Some form of protection should be provided for the water-service pipe where it penetrates the concrete casing. Foam pipe insulation can sometimes be used, and rigid plastic pipe, like the type used for drains and vents in plumbing systems, can always be used. If PE pipe is allowed to rest on the rough edge of concrete, constant vibration of the pipe when the pump is pumping will eventually wear a hole through the pipe.

After the connection is made between the drop pipe in the well and the water-service pipe in the trench, the rest of the work will be done at the pump location. Backfilling the trench should be done with caution.

Jet pumps can be installed almost anywhere where they will not get wet or become frozen. Crawl spaces, basements, pump houses, and even closets are all potential installation locations. A pressure tank is usually installed in close proximity to a jet pump. In some cases, the pump will be bolted to a bracket on a pressure tank. Sometimes a small pressure tank is suspended above a pump. Many tanks stand independently on a solid surface, such as a floor. Part of the decision as to the type of tank used and its location will be based on the space available for the tank and pump. It is not mandatory that a pressure tank be used, but it is highly recommended to prolong the life of a pump. However, a pressure tank does not have to be installed adjacent to a pump. It can be in a remote location. Pressure tanks can even be installed underground as long as the tank is an underground model.

The piping arrangement for a jet pump is not complicated. There are, however, many accessories that are commonly used, such as an air-volume control. Shutoff valves are, of course, installed in the pipes leaving the pump. In the case of a one-pipe jet pump, one large pipe brings water to the pump. A smaller pipe distributes the water to a water-distribution system. A pressure switch is needed to control when the pump cuts on and off. Relief valves are needed to protect pressure tanks. Drain valves are typically installed for pressure tanks, and a check valve

WELL TIP

A pressure tank does not have to be installed adjacent to a pump. It can be in a remote location. Pressure tanks can even be installed underground as long as the tank is an underground model.

Pipe below the jet, or "tail pipe" as it is commonly known, is used when you have a weak deep well. Under normal conditions, the jet assembly with the foot valve attached is lowered into the well. You receive your rated capacity at the level you locate the jet assembly. On a weak well, as the water level lowers to the level of the foot valve (attached to the bottom of the jet assembly), air enters the system. By adding 34' of tail pipe below the jet assembly with the foot valve attached to the bottom of the 34' length of pipe, it will not be possible to pull the well down and allow air to enter the system. The drawing indicates the approximate percentage of rated capacity you will receive with tail pipe.

Using a tail pipe, the pump delivery remains at 100% at sea level of the rated capacity down to the jet assembly level. If water level falls below that, flow decreases in proportion to drawdown as shown in the illustration. When pump delivery equals well inflow, the water level remains constant until the pump shuts off.

This rule can also be used when determining suction pipe length on shallow well systems.

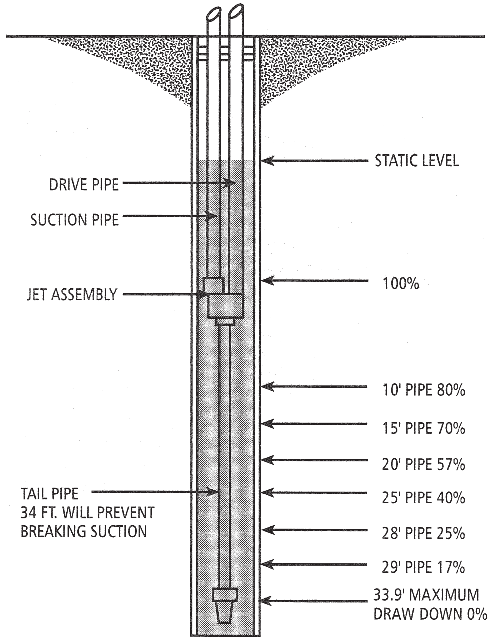


Figure 10.6 How to use tail pipe on deep well jet pumps. *© ITT Goulds Pumps.*

might be installed. In special situations, a pressure-control valve might be desirable.

Installing Two-Pipe Pumps

Two-pipe pumps look very similar to one-pipe pumps except for the extra pipe involved. While one-pipe jet pumps have only a suction pipe, two-pipe pumps have both a pressure and a suction pipe. There are some differences in the piping arrangement in the well to go along with this most noticeable difference. An ejector is installed to enable the pressure pipe to assist the suction pipe in lifting water from the well.

A pressure tank should still be used with a two-pipe system. In fact, a pressure tank should be installed with all types of well pumps for residential use.

Pressure Tanks

Pressure tanks should be considered standard equipment with every residential pump installation. The tanks are not very expensive, and they

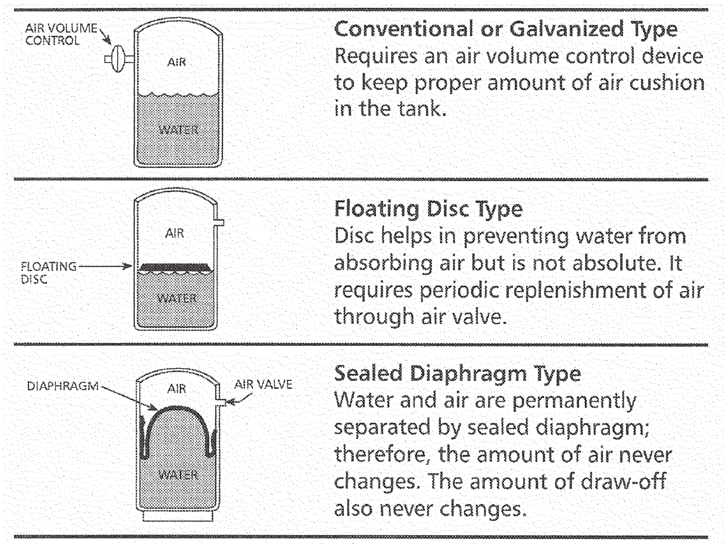


Figure 10.7 The three basic types of tanks in use today.
© ITT Goulds Pumps.

can add years to the life of a pump. They can also provide residents with better water pressure, which is an important aspect to consider. It's very rare today to see a plumbing system fed by a well where a pressure tank is not used. I can't imagine a pump installer bidding a job without including the cost of a pressure tank, but make sure that your next well system does provide a pressure tank. With that said, let's talk about the specifics of various sizes and types of pressure tanks.

Small Tanks

Small tanks are available in sizes that hold no more than two gallons of water. This is a very small tank. In my opinion, it is too small for almost any application. A tank that has such a minimum capacity will do almost no good in a routine residential plumbing system. When you consider that many toilets use more than two gallons of water each time they are flushed, you can see that the pump will be running a lot. Think about showers. At a flow rate of three gallons per minute, the first minute of a shower will deplete the supply of a supersmall pressure tank.

The whole purpose of installing a pressure tank is to take some strain off a pump. While a 2 gallon buffer provides some support to a pump, the help is minimal. A pressure tank should be sized to meet the needs of the house it serves. In other words, the number of people using the plumbing system and the types of fixtures available should be taken into consideration when choosing a pressure tank.

Large Tanks

Large tanks can take up a substantial amount of room. This is not normally a problem in houses where a basement, cellar, or crawl space is available. But if the pump system and tank must be installed within the primary living space of a home, tank size can become an issue. Residential pressure tanks can be purchased with a capacity of 100 gallons of water or more. In most circumstances, this is overkill. A tank that holds between 20 and 40 gallons should perform well under average residential conditions.

In-Line Tanks

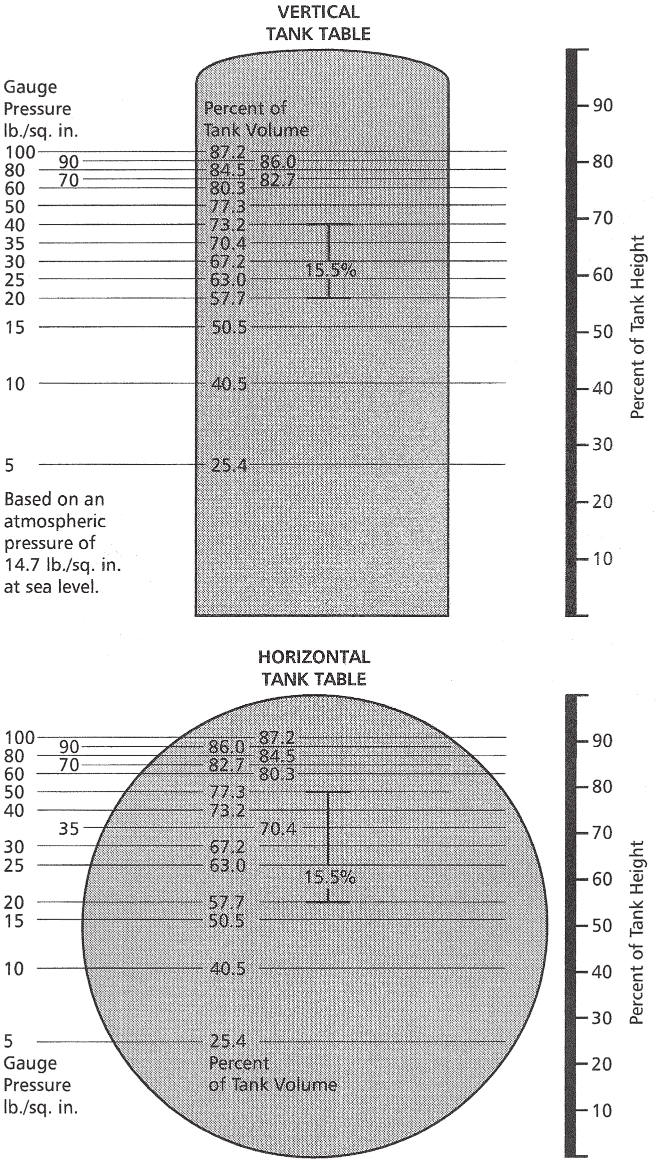
In-line tanks are designed to be installed right off a water pipe. They may be suspended below the pipe, or they may rise above the pipe. The sizes of in-line tanks vary. A brand that I use offers in-line tanks with capacities of 2 gallons, about 4.5 gallons, about 8.5 gallons, a little over 10 gallons, and 14 gallons. This range of sizes is adequate for small homes.

An in-line tank is not normally mounted on a bracket or set on a floor. It typically hangs from a pipe or sticks up above the pipe. When floor space is at a premium, an in-line tank is desirable. As a builder, I would try to keep the size in the 10-gallon range as a minimum. However, I recently installed a smaller tank for a summer cottage. It was one of the 4.5 gallon models. Since the cottage had only one bathroom and rarely accommodated more than two people, the small tank was deemed adequate. You must match your tank to your needs.

Stand Models

Stand models are the type of pressure tank most often installed in homes. These units sit on a floor in a freestanding mode. Piping is run from the pump to the tank and then from the tank to the water-distribution system. With capacities ranging from about 10 gallons up to 119 gallons, this type of tank can meet any residential need.

When a stand model is used, it is easiest to install with a tank tee, or a tank cross as it is often called. This is a fitting that is designed for use



When using large standard galvanized tanks, a constant air cushion is required for proper operation of the water system.

The illustrations show the percent of tank volume as related to the pressure gauge reading. To determine the amount of water you will receive as drawoff from the tank, you should subtract the smaller number from the larger number to get the percentage. Then multiply by the size of the tank to get the gallons drawoff.

Example:

50 lbs. = 77.3
minus 30 lbs. = 67.2
= 10.1%
x 120 gallon size (size of tank)
= 12.12 gallons drawoff

Figure 10.8 Tank selection. © *ITT Goulds Pumps.*

with a pressure tank. The tank tee screws into the pressure tank and provides both an inlet and outlet opening. In addition to these openings, the fitting is tapped for accessories, such as pressure gauges and relief valves. The use of this fitting not only makes a job easier to install; it also gives the appearance of a more professional installation.

Pump-Stand Models

Pressure tanks are available in pump-stand models. These tanks are frequently used in conjunction with jet pumps. They are not needed with submersible pumps, since submersibles are hung in a well. A pump-stand model is designed to sit horizontally. It has a bracket on top of it so that a pump can be bolted down to it.

Using a pump-stand model is one way to conserve floor space. Since a pump attaches to the top of the stand, there is only one object sitting on the floor. With a typical stand model, both the pressure tank and the pump would be installed on the floor. The manufacturer I deal with provides two sizes of pump-stand tanks. One is about 8.5 gallons, and the other is 14 gallons. I would opt for the latter.

Underground Tanks

Although I have never installed one, there are underground tanks available. Their size ranges from 14 gallons to 62 gallons when purchased from the manufacturer of my choice. Personally, I can't think of a time when an underground tank would have helped me, but I'm sure there must be occasions when they are desirable.

Diaphragm Tanks

Diaphragm pressure tanks are common in today's plumbing systems. This was not always the case. Older houses often have plain galvanized storage tanks. These standard tanks can be a real pain to live with. They frequently become waterlogged. By this I mean that they lose their air content and fill with water. When this happens, the tank must be drained, pumped up with air, and refilled with water. A waterlogged tank will make a pump run every time water is called for at a faucet, thus eliminating the advantage of having a pressure tank.

Modern pressure tanks come precharged with air, and they have a diaphragm system that eliminates waterlogging. Standard tanks are still available, but they are rarely used. I suggest that you specify a diaphragm tank in your well specs.

Another problem with a standard tank is rust. After some period of time, a metal holding tank will begin to rust. Air will leak out, and eventually water will leak. This means a patch or replacement will have to be made. With modern pressure tanks, liners are used so that water never comes into contact with the metal housing of the tank. This, of course, eliminates the possibility of interior rust. Bacteria growth and rust in drinking water are not nearly as likely with a lined tank as they are with a traditional metal tank.

Sizing

Sizing a pressure tank is an important step in designing and installing a good pump system. The pressure tank protects the pump. I mentioned earlier that you should take the number of people and plumbing fixtures into consideration when choosing a size for your pressure tank. My comment was meant to get you thinking about how little use it takes to drain down a small tank. If you want to seriously size a tank, you should work from the specifications for the pump that will be installed. In other words, the ideal sizing comes from carefully matching your tank to your pump. The relevance of the number of people or plumbing fixtures plays only a small role, if any, in determining tank size.

Pressure tanks are designed to work with pressure switches. These switches can be set for various cut-in and cutout pressures. It has long been common for a pump to cut on when tank pressure drops to 20 pounds per square inch (PSI). At this cut-in rate, a typical cutout rate is 40 PSI. For years, this has been something of a standard in well systems. However, times change, and so do standards.

It is not at all uncommon for cut-in pressures to be set at 30 PSI today. A corresponding cutout pressure is 50 PSI. Some homes have their well systems set up with cut-in pressures of 40 PSI and cutout pressures of 60 PSI. The increase in pressure is due to many factors. People tend to enjoy increased water pressure at some of their plumbing fixtures, such as showers. Some plumbing fixtures and devices require higher working pressures than what was common in the past. These conditions all contribute to the trend toward higher pressures.

Before you can size a pressure tank, you must determine what the cut-in and cutout pressures will be. You must also know the gallons-per-minute (GPM) rating of the pump. How many start-ups can the pump be subjected to in a 24-hour period? A time period must be established as to the minimum run time for the pump. This is usually established by the manufacturer, so check your pump paperwork to see what the minimum run time should be.

Once you know all the variables mentioned above, you can select a tank of the proper size. However, you need some type of sizing chart to do this math. Most manufacturers of pressure tanks will be happy to provide you with sizing tables.

Installation Procedures

Installation procedures for pressure tanks can take many forms. You've already seen that there are numerous types of tanks available. The installation of these tanks varies as much as the tanks do. You might install an underground tank to work in conjunction with a submersible pump. A pump-stand tank is sometimes a good choice for a jet pump. In-line tanks can also come in handy. Stand models are the type that you will use most often. While it is highly unlikely in a residential system unless you are building a house on a farm, a multiple-tank setup shouldn't be called for. Your installer certainly should know how to make a good installation, and the diagrams I've provided you with can help you to understand the installation procedures.

Relief Valve

Make sure a relief valve is installed to protect the pressure tank from excessive pressure. Omitting this fitting could result in disaster. It is a code requirement, so someone should catch it if you and your installer miss it, but don't take this chance. Ratings on pressure tanks and relief valves can vary, but most tanks are rated at 100 PSI, and the relief valves used with them are rated at 75 PSI. If a relief valve isn't installed, a pressure tank can blow up, causing personal and property damage. The same thing can happen if the relief valve is rated higher than the tank's working pressure. This is a serious issue, so take an active part in making sure the right relief valve is installed properly.

Keep It Dry

A pressure tank will last longer when you keep the exterior dry. In some cases, this may require installing a tank on blocks or a platform. If the basement, cellar, or other area where a tank is being installed tends to get wet during some seasons, elevate the tank to protect it. This is very simple to do at the time of installation, but it becomes a bit complicated after the fact. Spending a few bucks for some blocks can save your customers money down the road. Happy customers are what successful businesses are all about, so don't forget them when you are putting out the specs on a job.

11

Alternative Water Sources

Alternative water sources, for our purposes, are any water sources that are not a dug, bored, or drilled well. Municipal water sources are excluded from the alternative category. Springs, lakes, cisterns, driven wells, and similar sources of water are the types that I will be calling alternatives. In some cases, the water will not have to be safe for drinking. There are times when rural builders have to provide water sources for homes and related structures, and some of the water is not required to be potable.

Let's say you are building an exclusive home for an owner who enjoys horses. The homeowner might want water available for the stables, and this water doesn't necessarily have to be safe for human consumption. It might be practical to put the horse and barn water on a separate system. You might even suggest a solar-powered system. If the barn chores will require a lot of water, it could put a strain on the residential well. Rather than deplete the home's drinking water, an alternative source might be desired for the stable's needs. This would be a case where two water sources are used. They might both produce potable water, but it would not necessarily be critical that they do.

GOING GREEN

The amount of water used for irrigation can be substantial, and it is usually needed most during dry seasons. Does it make sense to avoid using potable well water during a dry spell if you can? Of course it does, and an alternative water source can be the solution. There are, in fact, many reasons why a second water source might be wanted. In some cases, streams, ponds, cisterns, and similar water sources are ideal solutions to water shortages.

Even if you don't have a need for nonpotable water, an alternative water source may be worth considering. Some homes get their water from springs and driven wells. While these two sources of water are not normally considered to be dependable for a large quantity of water, a lot of houses do get by with them.

Irrigation systems for lawns and gardens can use nonpotable water. Like the stable example, irrigation is a prime candidate for a separate water source. The amount of water used for irrigation can be substantial, and it is usually needed most during dry seasons. Does it make sense to avoid using potable well water during a dry spell if you can? Of course it does, and an alternative water source can be the solution. There are, in fact, many reasons why a second water source might be wanted. In some cases, streams, ponds, cisterns, and similar water sources are ideal solutions to water shortages.

An alternative water system can produce potable water. Springs are an excellent example. Have you noticed all the bottled spring water being sold in your local grocery store? Many people feel that the only good drinking water is spring water. If it's good enough to serve in fancy restaurants, it's good enough to drink at home. However, some special precautions should be exercised to avoid contamination of a spring. We'll talk more about this later in the chapter.

Driven wells can produce enough water to serve a full-time residence. Due to their design, driven wells can't be considered a dependable source of water when a large quantity is needed, but they are very inexpensive to install. Limitations on their use exist, but you may find that a driven well is just what you need.

Have you ever worked on old homes where a large cistern was installed in the cellar? They are quite common in many of the older homes in Maine. I never saw one in Virginia, but I've seen several during my plumbing and remodeling work in Maine. Cisterns saw a lot of use in the old days. There is no reason why they can't still be useful today.

As we move through this chapter, you are going to learn a lot about various types of water sources. Without a doubt, conventional wells will

WELL TIP

An alternative water system can produce potable water. Springs are an excellent example.

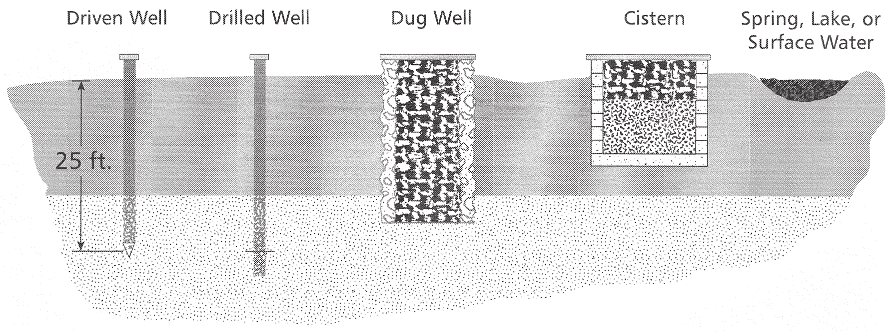


Figure 11.1 A shallow well is a source of water within 25 feet of ground level. © *ITT Goulds Pumps.*

be your most likely source of water when building a house in the country. But alternative water sources have their place, and this is the place to learn about them.

Driven Wells

Driven wells are very inexpensive to install. If ground conditions are suitable, a driven well is easy to make. No fancy truck or drilling rig is needed. A ladder, a sledgehammer, and a few specialized parts, along with a strong back and arms, are all that are needed.

What is a driven well? It is a pipe driven into the ground. Some people refer to these wells as driven points or just as points. Many of these wells exist in parts of Maine. They are especially popular along the coast, where summer cottages are built on sandy soil.

Personally, I wouldn't choose a driven well to supply a house with water when the property was going to be used as a full-time residence. I do, however, know of homes where a point provides the only source of potable water for entire families. Driven points have a very small reserve capability. If the water source for the well is strong, it can produce a lot of water. But if the water source is slow, it's easy to run this type of well dry. Let me give you some specifics on driven wells.

The components of a driven well are simple. The first piece is the drive point, which also serves as a filter. Pipe used to form the well makes up the second component, and the last piece of equipment needed is a pump. The size of the well pipe usually doesn't exceed 2 inches in diameter, and a 1.5-inch diameter is common. Under ideal conditions, this type of well can be driven to a depth of about 50 feet.

The Point

The point you select may be made of reinforced steel or it may have a bronze tip. The pointed end allows it to be driven into soft ground. At the opposite end of the point, there are pipe threads that allow additional sections of pipe to be added as the point is driven. These threads are protected by a drive cap during the driving phase of your work.

Well points are available with different types of screens. These screens act as a filter, and it's necessary for you to know the type of ground that the point will get its water from. For example, you would use a screen with a wide mesh if you were pulling water from coarse gravel. A fine-mesh screen would be used if water is being obtained from sand. The openings in the filter must be matched to the ground conditions to keep sand and similar particles from entering the well.

The Well Pipe

The well pipe you choose to use may be standard galvanized water pipe or special piping designed just for driven wells. Go with the specialized piping. Galvanized pipe tends to rust. This happens along the interior sides of the pipe as well as at the threads. Since threads have thin walls, it's not unusual for this to be the first point of deterioration. I don't recommend the use of galvanized pipe for several reasons, and rust is one of them.

Another problem with galvanized pipe is that it doesn't stand up well to heavy pounding. To get the pipe short enough to drive effectively,

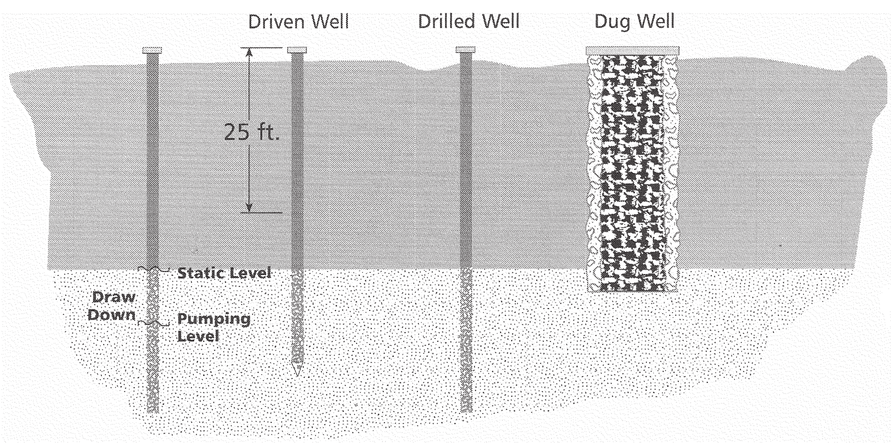


Figure 11.2 A deep well is a source of water more than 25 feet below ground level. © *ITT Goulds Pumps.*

WELL TIP

Drive caps are needed to protect pipe threads during the driving process. If you don't use a drive cap, the end of the pipe will roll out as it is hit. This, naturally, makes it impossible to thread couplings onto the pipe. Drive caps are available with either male or female threads. They are quite simple but very necessary.

you must cut and thread it. Making your own drive sections is certainly possible, but the work is time-consuming and hard on the arms unless you have a power threader. Since galvanized pipe does not drive well, the depth of a well made with it is often limited to about one-half the depth of a well constructed with specially designed drive pipe.

To drive a pipe with power, it must not be too tall. A five-foot section of pipe usually works well. A platform will be needed for the first few whacks with the hammer, but then a person can move down to the ground as the pipe is driven in deeper. The special drive pipe that I'm talking about is often called riser section. It runs about five feet in length, which makes it ideal for the purpose.

Power Driving

Power driving can accomplish a well depth of about 50 feet. Standard driving techniques, with a sledgehammer, will probably net only 30 feet of depth, which can be more than enough. A number of setups exist for using mechanical driving power. Impact drivers are also available, and they can make driving a well easier. If you were to set yourself up as a professional installer, mechanical means of driving would be the most sensible route to take. However, the majority of people whom I've known to drive wells have done it the old-fashioned way, with a sledgehammer and human sweat.

Getting It Out

Getting a drive pipe into the ground can be difficult, but getting it out can be even more troublesome. When you drive a well point, you never know when some buried obstruction will stop your best efforts. When this happens, you must remove the riser sections and point to start somewhere else. You won't have much success doing this by hand if the point has reached a significant depth.

Pipe clamps are one solution to the problem of pipe removal. Putting the clamps around the pipe can allow you to drive the pipe out of the hole with your hammer. Lifting jacks, such as the type used to jack up automobiles, can also be used in conjunction with pipe clamps to raise sections of pipe. Blocks of wood should be placed on the ground to keep the jacks from sinking in. The jacks will exert upward pressure on the pipe clamp, thereby lifting the pipe. You will have to reset the jacks and clamps frequently, but this method will certainly pull the pipe out of the ground. Other methods of removal, such as the use of winches, can also be employed to remove pipe.

Driving the Well Point

The actual driving of a well point should be started slowly. Many people use post-hole diggers or an auger to get a hole started up to a depth of about two feet. Once this hole is in place, the well point is set in the hole. I should add that some type of pipe sealant compound must be applied to the male threads of all joints to make them watertight. It's essential that the well point and first section of well pipe be driven into the ground at as close to a perfect vertical position as possible. A level can be used to line the drive point and pipe up in a vertical position. During this stage of the operation, don't bang the drive cap--tap it. Use light strokes so that you can control the position of the pipe. You must make sure that this first section goes into the ground straight.

As the first section goes into the ground, you must remove the drive cap, dope up the male threads on the riser, and add a new riser to the rig. Replace the drive cap and resume driving. As the first section disappears from sight, you can increase the power of your pounding. However, don't hit the pipe if it's vibrating. This could cause damage to underground sections.

The sequence of events in driving a well point is routine. You drive a section to a point near the top of the ground. Then you remove the drive cap, dope the threads, and add a new section. Replace the drive cap and keep driving. This goes on until you can go no further or until you have an abundant water supply.

Toward the End

Toward the end, you must decide how the well will terminate. Will you install a pitless adapter? This is a good idea for a well that will have its water service running below the frost line. Will you install a simple pitcher pump on top of the pipe? This can be a suitable solution for seasonal use. Your well can be terminated above or below grade. Elbow fittings can allow you to turn the well pipe horizontally if you desire. Plan your termination in advance.

Suitable Soils

Suitable soils must exist for driving a well. It is not possible, for example, to drive a point through bedrock. Soft, moist clay is a good soil for driving a well. So is coarse sand and gravel. Fine sand and hard clay can be driven through, but the work will be difficult. Not all ground conditions will allow a well point to be driven, even with mechanical assistance. If you can do some test boring before sinking a point, it will certainly prove helpful.

Water Quantity

There is no way to predict the quantity of water that will be produced by a well point. It may be 50 gallons of water, and it may be 250 gallons. The recovery rate is equally impossible to predict. Until you sink the point and test the well, there is no way to know what you will get. However, the combination of a driven well and a large pressure tank can produce adequate water for a full-time residence that is occupied by a family.

Water Quality

The quality of water produced from a driven well can be compared to that of water coming from a dug or bored well. Since these types of wells normally connect with water at similar depths, the type of water being produced should be similar. All potable water should be tested periodically to make sure it's safe to drink.

Cisterns

Cisterns can be considered holding vessels for water. They might be constructed above ground or below grade. Brick, stone, or concrete can be

> **WELL TIP**
>
> Cisterns typically rely on surface water to fill. For this reason, the water is not normally considered acceptable as drinking water.

GOING GREEN

Many cisterns collected rainwater from the roofs of the houses they were built under. A lot of water runs off the roof area of a house during a rainstorm. If this water is diverted to a cistern, it doesn't take long to build up several hundred gallons of reserve water. It can be used to water lawns, wash cars, and so forth.

used to build a cistern. Such a water-holding area can be small enough to water a family vegetable garden or large enough to provide water for a family during several months of dry times.

Cisterns typically rely on surface water to fill. For this reason, the water is not normally considered acceptable as drinking water. However, if filtering and treatment systems are used in conjunction with a cistern, the quality of the water can be raised to a potable level. Additionally, a cistern can be filled from a potable water source such as a well to create a large reserve of potable water. How long this water can be kept potable varies with conditions, but this is one way to make the most of a well during times of plentiful water.

In older homes, it was not uncommon for large cisterns to be built beneath the first floor. Some of these collection tanks resemble modern-day aboveground swimming pools in size. In fact, a modern aboveground pool can serve as a very effective cistern. Let me give you a quick example.

I purchased an aboveground pool for my young daughter to learn to swim. The pool is about 42 inches deep, and it has a diameter of 15 feet. According to the paperwork provided with the pool, its water capacity is 4400 gallons. This pool cost less than $300. Setting the pool up took only a few hours. If this holding tank were being used as a cistern, it would be quite effective, very efficient, and low in cost. Depending upon your cistern needs, don't overlook the possibility of aboveground pools as a material choice.

Many of the cisterns I've seen have been built in the cellars of homes. Some of these collection vessels were made to have water pumped into them. Many of them collected rainwater from the roof of the house they were built under. A lot of water runs off the roof area of a house during a rainstorm. If this water is diverted to a cistern, it doesn't take long to build up several hundred gallons of reserve water. It's entirely possible for a cistern to collect and contain enough water to provide a family with water for up to six months. In areas where rainfall comes in spurts, a cistern can be a lifesaver, so to speak.

Water from a cistern can be pumped in a manner similar to that used with shallow wells. This water can serve domestic needs when it's potable. Irrigation and farm animals are another two reasons for using a cistern. Roof water can be collected easily with the use of gutters and piping. A cistern might be filled from a stream during wet times so that water is available in dry times when the stream has dried up.

Cisterns are rarely considered a potable water source for a new house. This type of water collection is not comparable to a drilled well. However, there are many circumstances that might warrant the use of a cistern.

Ponds and Lakes

The use of existing ponds and lakes can do a lot for a property when high volumes of water are needed. One such situation might be a commercial greenhouse. A lot of water is used to grow plants commercially. If a lake or pond is handy, the expanse of reserve water works well for keeping plants healthy. The same can be said for irrigation purposes or livestock.

Ponds and lakes are not normally suitable as sources of potable water unless the water is purified. This is certainly possible, but the expense and trouble often outweigh the cost of drilling a well. For the most part, ponds, lakes, streams, and rivers should be ignored as potable water sources.

Springs

Springs have long been a source of drinking water. However, the water is not always of a quality considered to be safe for drinking. If a spring is to be used as a primary source of potable water, some special provisions should be made. For instance, the spring should be protected from surface water.

GOING GREEN

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If a spring is to be used for potable water, a watertight container of some type should be placed around the spring. Well casing works fine. Springs located on the sides of hills should have diversion ditches installed above them. This helps to keep surface water from running into the spring. Slotted pipe and gravel can be installed in trenches to intercept and divert surface water.

Fencing should be installed around a spring to protect it from animal entry. The uphill side of the spring should be fenced for a distance that is sufficient to prevent animal activity from contaminating the spring. Even with these protections, a spring should be tested regularly to assure its potability.

Springs, when available, are an inexpensive water source. They can provide large quantities of water, and the quality can be quite good. Since springs are not abundant, they cannot be counted on as a water source. But if one is available, it can provide numerous benefits to the property owner.

I remember visiting a spring on nearly a daily basis during the summers of my childhood. Going down to the spring was not a necessity for me. My parents and grandparents had municipal water supplies in their homes. I used to go to the spring as a pleasure. The spring was used as a water source by some people in the neighborhood. Looking back on this spring, I remember it having a metal lining. It seems to have been a 55-gallon drum. This probably wouldn't be considered a good lining, but as I recall, that's what was used. To the best of my knowledge, none of the people drinking from this spring ever became sick from the water. This doesn't mean that I would recommend using or installing such a water source.

GOING GREEN

Alternative water sources can fill many needs. They can provide water for all domestic uses. Livestock can be watered with alternatives sources. Gardens and lawns can be watered with nonpotable water. Fire protection can be boosted with the availability of a pond or cistern. Water-source heat pumps can collect from alternative water sources and wells. There are so many potential uses for water that alternative sources should always be considered.

There is a spring near where I live now that is visited daily by dozens of people. At times, people are lined up one after another for a nearly unbelievable distance to get access to the spring water. Some of these people have a great number of half-gallon plastic jugs with them to collect the water. Unlike the spring I used to play around, this one has a pipe that extends out of the side of a hill. Water runs from it constantly. I've never drunk the water, but it appears that a great number of people do. As often as I drive by this spring, I can recall only one or two occasions when the water wasn't running.

A gentleman I know gets all of his domestic water from a spring. He has done this for a long time. Last winter, his water-supply pipe froze. The spring didn't, but his water service did. When you consider that a spring in Maine can handle winter temperatures without freezing, it's certainly possible for it to provide year-round water to a home. Still, you can't count on a spring having enough constant flow to be a primary water source.

Many Needs

Alternative water sources can fill many needs. They can provide water for all domestic uses. Livestock can be watered with alternatives sources. Gardens and lawns can be watered with nonpotable water. Fire protection can be boosted with the availability of a pond or cistern. Water-source heat pumps can collect from alternative water sources and wells. There are so many potential uses for water that alternative sources should always be considered.

As a builder, you should stay abreast of the many options available to you when providing water to the homes you build. Conventional wells will continue to provide most of the water used in rural locations, but other natural resources and man-made provisions can enhance the living conditions of people in the country. With a little research and some creative thinking, you can offer your customers options for water that other builders may not be aware of. This can help you win more bids and make more money.

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Gravel-and-Pipe Septic Systems

Gravel-and-pipe septic systems are about the least expensive option available. Just because these systems are less expensive than other types doesn't mean that they are of a lower quality or don't perform as well. The reason pipe-and-gravel systems cost less is simple: They don't require as much material or time to build. Why is this? It's because the soil in which the systems are installed is of a better drainage quality than soils where more complex systems, such as chamber systems, would be required.

If you build houses on spec, you should be particularly alert to the type of septic system your houses will require. When people buy a new house, they don't normally care whether the septic system is of a pipe-and-gravel type or a chamber type, so long as the system meets code requirements and is designed and installed to give years of worry-free service. If you have two houses sitting side by side, one with a chamber system and one with a pipe-and-gravel system, no one will know the difference until you tell them. There will be, however, one big difference that potential buyers will notice, and that's the price. A chamber system can easily cost twice what a pipe-and-gravel system costs. To make the

GOING GREEN

Peat biofilter systems are designed for use in sensitive locations. Maintenance is minimal and effluent is treated within the system to make it easier to dispose of. The filters are modular in design. A three-bedroom home will require three modules. The cost of the filters and related supplies should be less than $5500. These systems are passive in nature and allow otherwise unsuitable land to be used for septic treatment.

same profit on both spec houses, you will have to price one thousands of dollars higher than the other. This is where you and your customers will notice the biggest difference.

When I was a builder in Virginia, I never had to install a chamber system. All of the septic systems installed through my building company were pipe-and-gravel systems. After moving to Maine, I saw a big swing. As a builder in Maine, I see a lot more chamber systems than I do pipe-and-gravel systems.

How much difference is there in the cost between a pipe-and-gravel system and a chamber system? Prices can vary. I'm sure that costs in Maine are not comparable to costs in Nebraska or California. From my personal experience, an average pipe-and-gravel system in Maine costs me, at builder's rates, a little over $4500. A chamber system for the same type of house will come in somewhere around $9500, although I've seen them sell for more than $12,000. This is a huge difference in cost. And the only reason for this increase is the suitability of the soil in which the system is being installed.

Maine has a lot of wetlands and a lot of bedrock. Both of these are factors forcing the use of chamber systems. I was lucky when I built my house, since I was able to use a pipe-and-gravel system. Was this only luck? Not exactly. Knowing that a chamber system would cost at least twice as much as a simple septic system, I considered this factor in my search for land. You can use the same approach when you are looking for lots and land to develop spec houses.

Consider what I'm about to tell you. I was involved in a fairly large land-development project some years back. The building lots were in a rural area and consisted of 20-acre building sites. Each lot was required to have its own septic system. The land chosen for this project perked well, and we were able to get approval for pipe-and-gravel systems. With this particular project, we were dealing with ten lots. If those lots had required more expensive septic systems, we might have lost $40,000 or more in sales potential. So you can see that the difference between a pipe-and-gravel system and a complex system can have a lot of impact on your profit picture.

The Components

Let's talk about the basic components of a pipe-and-gravel septic system. Starting near the foundation of a building, there is a sewer. The sewer pipe should be solid, not perforated. I know this seems obvious, but I

GOING GREEN

There are numerous filter systems available to aid in going green with septic systems. However, not all systems are approved for use in all states. Check your local regulations prior to suggesting or installing a system that incorporates new technology.

did find a house about three years ago where perforated drain-field pipe had been installed. It was quite a mess. Most jobs today involve the use of schedule-40 plastic pipe for the sewer. Cast-iron pipe can be used, but plastic is the most common and is certainly acceptable.

The sewer pipe runs to the septic tank. There are many types of materials that septic tanks can be made of, but most of them are constructed of concrete. It is possible to build a septic tank on site, but every contractor I've ever known has bought precast tanks. An average-size tank holds about 1000 gallons. The connection between the sewer and the septic tank should be watertight.

The discharge pipe from the septic tank should be solid, just like the sewer pipe. This pipe runs from the septic tank to a distribution box, which is also normally made of concrete. Once the discharge pipe reaches the distribution box, the types of materials used change.

The drain field is constructed according to an approved septic design. In basic terms, the excavated area for the septic bed is lined with crushed stone. Perforated plastic pipe is installed in rows. The distance between and the number of drainpipes are controlled by the septic design. All of the drain-field pipes connect to the distribution box. The septic field is then covered with material specified in the septic design.

As you can see, the list of materials is not a long one. Some schedule-40 plastic pipe, a septic tank, a distribution box, some crushed stone, and some perforated plastic pipe are the main ingredients. This is the primary reason why the cost of a pipe-and-gravel system is so low when compared to other types of systems.

CODE CONSIDERATION

If a food-waste disposal is installed in a septic system, the system must be designed to accommodate solids loading from the disposal unit.

Types of Septic Tanks

There are many types of septic tanks in use today. Precast-concrete tanks are by far the most common. However, they are not the only type of septic tank available. For this reason, let's discuss some of the material options that are available.

Precast Concrete

Precast concrete, as I've already said, is the most popular type of septic tank. When this type of tank is installed properly and is not abused, it can last almost indefinitely. However, heavy vehicular traffic running over the tank can damage it, so this should be avoided.

Metal

Metal septic tanks were once common. There are still a great number of them in use, but new installations rarely involve metal tanks. The reason is simple: Metal tends to rust, and that's not good for a septic tank. Some metal tanks are said to have 20 years of good service. This may be true, but there are no guarantees that a metal tank will last even 10 years. In all my years of being a contractor, I've never seen a metal septic tank installed. I've dug up old ones, but I've never seen a new one go in the ground.

Fiberglass

I don't have any personal experience with fiberglass septic tanks, but I can see some advantages to them. Their light weight is one nice benefit for anyone installing the tank. Durability is another strong point in their favor. However, I'm not sure how the tanks perform under the stress of being buried. I assume that their performance is good, but again, I have no first-hand experience with them.

CODE CONSIDERATION

Soil-absorption systems must be installed outside of flood-hazard areas.

> **SEPTIC TIP**
>
> Your local jurisdiction might require a special license to install septic systems, so check if you are planning to do your own installations without the aid of an outside contractor.

Wood

Wood seems like a strange material to use for the construction of a septic tank, but it does happen. The wood of choice, as I understand it, is redwood. I suppose that if you can make hot tubs and spas, you can make a septic tank. However, I don't think I would be eager to warranty a septic tank made of wood.

Brick and Block

Brick and block have also been used to form septic tanks. When these materials are employed, some type of parging and waterproofing must be done on the interior of the vessel. Personally, I would not feel very comfortable with this type of setup. This is, again, material that I have never worked with, so I can't give you much in the way of case histories.

Installing a Simple Septic System

Installing a simple septic system is pretty easy if you have the right tools, equipment, and knowledge. As a homebuilder or general contractor, you may have access to all the tools and equipment needed to make an installation. To illustrate what's involved, let's run through a typical installation. However, many code jurisdictions require septic installers to be licensed for the work that they perform, and this may mean that you can't install your own systems.

The first step in the installation of a septic system is the septic design. This will give you all the details needed to make an acceptable installation. The next step is a permit to do the installation. Your local jurisdiction might require a special license to install septic systems, so check if you are planning to do your own installations without the aid of an outside contractor.

SEPTIC TIP

The main thing to remember when installing a septic system is to follow the septic design to the letter.

Excavation is where your installation will begin. A backhoe is usually all that is needed for the digging. There will be a benchmark set somewhere, probably in association with a tree, which you will use for elevation measurements. These measurements should be precise, so a transit is needed. Once the septic system is laid out on the ground, you are ready to dig. A lot of contractors use ordinary flour to mark dig locations.

Unless there are extenuating circumstances, a standard backhoe will be capable of digging the sewer trench, the leach bed, and the hole for the septic tank. It is helpful to have your own dump truck, but you can get by with a contract hauler to do the hauling for you. Dirt and stone can be moved around with the front bucket on the backhoe. The main thing to remember when installing a septic system is to follow the septic design to the letter. It is also wise to check your work periodically to make sure that everything is in keeping with the requirements of the design.

After all excavation is done, you have to install the septic components. The leach field is often done first. With today's modern materials, this work doesn't involve complicated plumbing practices or equipment. A carpenter's saw can be used to cut plastic pipe. Joints are made with a solvent weld (glue). As you install the drainpipes, you must refer to the septic design and follow all requirements. Make sure that the septic system is far enough away from the house and the well to meet local requirements.

After the lines of the leach field are installed, they are connected to the distribution box. Again, this work is detailed on the septic design. Once the distribution box and field are set up, you are ready to set the septic tank. Keep in mind that this sequence is only a suggestion. Some contractors might prefer to set their septic tanks first. It doesn't matter where you start, so long as the job ends up properly installed.

CODE CONSIDERATION

Clear water is not allowed to enter a septic system.

SEPTIC TIP

Dropping a concrete tank can damage it, not to mention what it could do to a worker's foot trapped under it. Don't take any chances where safety is concerned. Don't put yourself or others in a position to get hurt if the chains should slip or snap.

When setting the septic tank, you must make sure that it is positioned on solid ground. This is rarely a problem. If the ground is weak, there will probably be some guidance provided in the septic design. It might be necessary to install a layer of stone under the tank, but this is not typical. You may have to use a tamper to compact the soil, but again, this is not a normal procedure. Usually a hole is dug and the tank is set into place.

Concrete septic tanks are heavy. A couple of workers can't just horse them into a hole. You will probably use the front bucket of your backhoe to manipulate the tank. In doing this, make sure that the chain used to lift the tank is strong enough to hold the load.

After the tank is set in its hole, you will probably have to position it with the help of the backhoe bucket and some backfilling. Get the tank to sit in place where you want it, and then connect it to the distribution box. As a reminder, the pipe used for the run from the tank to the distribution box should be solid, not perforated.

When you connect a pipe to the septic tank, you will not be using a glue joint. Instead, the pipe will push through a precast opening and extend into the tank for several inches. The annular space between the pipe and the opening in the tank will be filled with a cement mixture. You need to make this connection watertight. Otherwise, groundwater could run into the tank, and sewage could seep out into the ground. Neither of these possibilities is desirable.

An elbow fitting is normally attached to the end of the drainpipe that protrudes into the tank. A short piece of pipe is extended from the elbow

CODE CONSIDERATION

Privies are prohibited.

> **CODE CONSIDERATION**
>
> Code officials must approve all methods of treatment and disposal of all waste products.

into the liquid level of the tank. As the liquid level rises in the tank, it also rises up the short length of pipe and is drained out of the tank into the distribution box.

The run of drainpipe from the septic tank to the distribution pipe should be installed with a consistent grade or fall. In other words, the pipe should slope downward toward the distribution box. A standard fall is .25 inch of fall for every foot the pipe travels. For example, a pipe that is 8 feet long would be 2 inches higher at the septic tank than it would be at the distribution box. This same type of grading is used when a sewer is extending from a building to a septic tank.

Licensed plumbers typically connect building sewers to main sewers. However, most plumbers limit their rough-in work to a point not to exceed five feet past the foundation. If this is the case, you would have to run the sewer from a septic tank to within five feet of a foundation in order to have a plumber make the connection within the budget of rough-in work. When a plumber is asked to run sewer piping for more than the five feet we have discussed, you can expect some extra charge.

Most septic installers do run a sewer from the tank to a point near the foundation of the building being served. The pipe used for this can be thin-wall sewer pipe. Many installers prefer to use schedule-40 plastic pipe. This is the same type of pipe used for drains and vents inside a building. You should consult your local code requirements to determine what options are available to you. Personally, I prefer schedule-40 plastic, even if thin-wall pipe is an approved material. Long-turn fittings should be used instead of their short-turn cousins. I recommend installing a clean-out just outside the building's foundation.

There are some rules to follow with every installation, and they are as follows:

- The sewer that extends between a building and a septic tank must be installed with a consistent grade.
- The pipe must be supported by solid ground.

CODE CONSIDERATION

Zoning setback requirements must be considered when planning the installation of a septic system.

- It is not acceptable to stick blocks of wood or rocks under a pipe to support it.
- Loose fill dirt is not acceptable.
- The bed of the trench must be solid and graded, so keep this in mind as you dig.
- If your digging produces a trench in which there are gaps under a sewer pipe, the trench must be filled in to avoid these gaps. This can be done with crushed stone or dirt that is tamped into place.

The connection of the sewer pipe is parged with cement, just as the pipe to the distribution box is. Once the sewer pipe is extended into the septic tank, a tee fitting is installed on it. Sewage coming into the tank will hit the back of the tee fitting and be directed downward.

Don't cover up any of your work until it has been inspected and approved. Every jurisdiction that I've ever worked in required an on-site inspection of septic installations before they could be buried. Failure to get such an inspection prior to backfilling your work could be very expensive, so make sure the inspection has been made and is approved.

Do It Yourself

When your next septic job comes along, should you do it yourself? There are several things to consider before you can answer this question. The first one is easy. Can you install your own septic systems legally? Check with your local code-enforcement office to see if any special qualifications are needed to install septic systems. You may find that a license of some type is required to obtain septic permits. It may be the case that anyone can install a septic system so long as the installation complies with an approved design. Before you spend any time debating over whether or not to install your own systems, get the answer to this question. If you are not allowed to make your own installations, there is nothing else to think about.

Let's assume that you can install your own septic systems. Do you want to? If you don't want to get involved with the hands-on work, you can simply sub the work out to another contractor. This is what I've always done. However, there are some advantages to doing your own installations, and you may wish to consider them.

A builder who installs septic systems can eliminate one subcontractor. Anytime you can reduce the number of people whom you must count on in the production of a new home, you are one step closer to success. Depending upon other people will often get you in trouble. At least it has always been a sore spot in my business endeavors. I've found that work that I have complete control over goes much better than jobs where I must rely on others.

Money

Money is almost always a good motivator for expanding your services. If you could make a few extra thousand dollars on a job by installing a septic system yourself, this might be all the reason you need to do it. There is money to be made by installing your own septic systems. The amount of money varies from job to job, but is always enough to make the effort worth considering.

Builders who work primarily with subcontractors may not see the monetary gains of installing septic systems as advantageous. If you don't have your own employees and equipment, it will definitely be easier to just sub the work out to a septic installer. You could rent equipment and use your own payroll labor if you have any, and this should result in some positive cash flow. However, you might find that your time is better spent selling new jobs than it is overseeing the installation of a septic system. This is the position that I've often found myself in.

I've never owned heavy equipment. Piece workers and subcontractors have always made up most of my workforce. While I believe in having some employees available, my building business centers around subcontractors much more than it does employees. For these reasons, it has never seemed cost-effective for me to do my own septic installations.

My situation is a little unusual in that I'm a licensed builder and a licensed master plumber. The fact that I maintain both a building and a plumbing company makes me an ideal candidate to create a septic crew. Most of my work is presently done in areas where public sewers are not available. Even with all of this going for me, I've still never jumped into the septic business. Why? Well, I'm really not sure. It does seem that I should, but I've stayed busy doing what I do.

One reason why I've probably not made a transition into septic work is the need for equipment and operators. My volume of septic work would not support the purchase and upkeep of a backhoe, trailer, and dump truck. Neither would it keep an operator and driver busy. Come to think of it, this is probably why I haven't pursued the opportunity. If I had the equipment and personnel, I'm quite sure I would do my own septic installations.

If I were looking for an expansion option for my existing businesses, septic work might be a consideration. However, site contractors often have a lock on septic work. Since these contractors bid clearing, driveway installations, grading, excavation, and so forth, they are a natural source for septic installations. This, too, is probably another reason why I haven't made financial commitments to get into the septic business.

Work Is Work

When times are tough, work is work. Installing your own septic systems can put some extra money in your pockets. It can also help to keep your crews busy. This is a plausible reason to consider doing your own installations, even if you have to rent the equipment. If you have a choice of sending your crews home for lack of work, having them push inventory around for something to do, or installing a septic system, you should come out ahead if you take on septic systems.

Control and Quality

Control and quality are both good reasons for doing your own septic installations. If your crews are doing the job, you have more control over the quality and execution of the work than you would if a subcontractor was doing it. Outside of money, this may be the best reason to do your own septic work.

The Technical Side

The technical side of installing septic systems is not difficult to understand. If you can read blueprints, you should be able to interpret a septic design. Once this goal is accomplished, there is very little to stop you from installing septic systems properly. Field experience helps, just as it does in any type of work, but installing a septic system is not a job that requires a lot of hands-on experience to accomplish. I don't wish to minimize the skill required for septic work, but compared to other types of trade-related work, it is pretty easy to understand.

Bad Ground

Bad ground can force you away from a simple pipe-and-gravel septic system. If the percolation rate is not sufficient, you will have to look to some other type of system, such as a chamber system. We will talk about these expensive systems in the next chapter.

Some soils are not absorbent enough to accommodate a typical pipe-and-gravel septic system. You must be sure of what your septic options are before you bid a job. If you typically plug in a generic figure to represent the price of a septic system for a job without reviewing the septic requirements for a particular job, you are setting yourself up for big trouble. A day will come when you are forced to use a chamber or pump system, and your typical price will be way too low.

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Chamber-Type Septic Systems and Other Special-Use Systems

If you are dealing with a job where a typical pipe-and-gravel septic system can't be used, you are faced with chamber-type systems and other special-use systems. Any of these systems will typically cost more to install than a simple pipe-and-gravel system. The specific type of system used will depend greatly on existing soil conditions. Choosing a special-use system is rarely left to the discretion of a builder. Engineers and county officials are normally the ones to dictate what type of special system will be used.

There are four common types of special-use septic systems:

- Chamber systems are the most common.
- Trench systems are usually the most inexpensive type of special-use system available.
- A mound system might be prescribed.
- There are times when a pump system is required.

Your installation cost with any of these systems is likely to be higher than what you might expect.

Before moving north, I'd never encountered a chamber system. The soil in Virginia tended to be well suited to septic systems, so gravel-and-pipe systems were normally installed. Pump systems were required

> **SEPTIC TIP**
>
> Chamber septic systems are used most often when the perk rate on ground is low.

CODE CONSIDERATION

Mound systems are not approved for use in flood-hazard areas.

occasionally, but chamber systems were never required on any of my jobs in Virginia. While they were very unusual in Virginia, they account for a large number of systems in Maine.

My personal experience with septic systems is limited to the East Coast. I don't have first-hand experience with other parts of the country. However, a little research on your part will reveal the types of systems that are the most common in your area. Since septic systems require septic designs and permits to be installed, it is fairly easy to research which types of systems are being used in your region.

Chamber Systems

Chamber septic systems are used most often when the perk rate on ground is low. Soil with a rapid absorption rate can support a standard pipe-and-gravel septic system. Clay and other types of soil may not. When bedrock is close to the ground surface, as is the case in much of Maine, chambers are often used.

What is a chamber system? A chamber system is installed very much like a pipe-and-gravel system except for the use of chambers. The chambers might be made of concrete or plastic. Concrete chambers are naturally more expensive to install. Plastic chambers are shipped in halves and put together in the field. Since plastic is a very durable and relatively cheap material, plastic chambers are more popular than concrete chambers.

When a chamber system is called for, there are typically many chambers involved. These chambers are installed in the leach field between sections of pipe. As effluent is released from a septic tank, it is sent into the chambers. The chambers collect and hold the effluent for a period of time. The liquid is gradually released into the leach field and absorbed by

SEPTIC TIP

Trench systems are the least expensive special system.

the earth. The primary role of the chambers is to retard the distribution rate of the effluent.

Building a chamber system allows you to take advantage of land that would not be buildable with a standard pipe-and-gravel system. In these cases chamber systems are good. However, when you look at the price tag of a chamber system, you may need a few moments to catch your breath. I've seen a number of quotes that pushed the $10,000 mark. Ten grand is a lot of money for a septic system. But if you don't have any choice, what are you going to do?

A chamber system is simple enough in its design. Liquid leaves a septic tank and enters the first chamber. As more liquid is released from the septic tank, it is transferred into additional chambers that are further away. This process continues, with the chambers releasing a pre-determined amount of liquid into the soil as time goes on. The process allows more time for bacterial action to attack raw sewage, and it controls the flow of liquid into the ground.

If a perforated pipe-system was used in ground where a chamber system is recommended, the result could be a flooded leach field. This might create health risks. It would most likely produce unpleasant odors, and it might even shorten the life of the septic field.

Chambers are installed between sections of pipe within the drain field. The chambers are then covered with soil. The finished system is not visible above ground. All of the action takes place below grade. The only real downside to a chamber system is the cost.

Trench Systems

Trench systems are the least expensive special system. They are comparable in many ways to a standard pipe-and-gravel bed system. The main difference between a trench system and a bed system is that the drain lines in a trench system are separated by a physical barrier. Bed systems consist of drainpipes situated in a rock bed. All of the pipes are in one large bed. Trench fields depend on separation to work properly. To expand on this, let me give you some technical information.

> **CODE CONSIDERATION**
>
> Mound systems are not to be installed on slopes greater than six percent.

SEPTIC TIP

When a trench system is used, both the sides of the trench and the bottom of the excavation are outlets for liquid. Only one pipe is placed in each trench. These two factors differentiate a trench system from a standard bed system.

A typical installation is set into trenches that are between 1 and 5 feet deep. The width of the trench tends to run from 1 to 3 feet. Perforated pipe is placed in these trenches on a six inch bed of crushed stone. A second layer of stone is placed on top of the drainpipe. This rock is covered with a barrier of some type to protect it from the backfilling process. The type of barrier used will be specified in the septic design.

When a trench system is used, both the sides of the trench and the bottom of the excavation are outlets for liquid. Only one pipe is placed in each trench. These two factors differentiate a trench system from a standard bed system. Bed systems have all of the drainpipes in one large excavation. In a bed system, the bottom of the bed is the only significant infiltrative surface. Since trench systems use both the bottoms and sides of trenches as infiltrative surfaces, more absorption is potentially possible.

Neither bed nor trench systems should be used in soils where the percolation rate is either very fast or very slow. For example, if the soil will accept one inch of liquid per minute, it is too fast for a standard absorption system. This can be overcome by lining the infiltrative surface with a thick layer (about two feet or more) of sandy loam soil. Conversely, land that drains at a rate of one inch an hour is too slow for a bed or trench system. This is a situation where a chamber system might be recommended as an alternative.

Because of their design, trench systems require more land area than bed systems do. This can be a problem on small building lots. It can also add to the expense of clearing land for a septic field. However, trench

SEPTIC TIP

Neither bed nor trench systems should be used in soils where the percolation rate is either very fast or very slow.

CODE CONSIDERATION

The mound height consists of the fill, bed, or trench depth, the cap, and the topsoil depth.

systems are normally considered to be better than bed systems. There are many reasons for this.

Trench systems are said to offer up to five times more side area for infiltration to take place. This is based on a trench system with a bottom area identical to a bed system. The difference is in the depth and separation of the trenches. Experts like trench systems because digging equipment can straddle the trench locations during excavation. This reduces damage to the bottom soil and improves performance. In a bed system, equipment must operate within the bed, compacting soil and reducing efficiency.

If you are faced with hilly land to work with, a trench system is ideal. The trenches can be dug to follow the contour of the land. This gives you maximum utilization of the sloping ground. Infiltrative surfaces are maintained while excessive excavation is eliminated.

The advantages of a trench system are numerous. For example, trenches can be run between trees. This reduces clearing costs and allows trees to remain for shade and aesthetic purposes. However, roots may still be a consideration. Most people agree that a trench system performs better than a bed system. When you combine performance with the many other advantages of a trench system, you may want to consider trenching

GOING GREEN

Nondischarge, evaporative toilets do not conduct waste into the earth. These units work best in a location when sunlight is available for a minimum of half a day, but this is not a requirement. Gray water is produced by the toilet, but black water is contained without entering the soil. This type of toilet is expensive. The cost is approximately $4000 per toilet.

There are also shower units available that reduce the amount of water used for showering. The goal of going green is to have a septic system that enables all household wastewater to be reused for irrigation.

CODE CONSIDERATION

Trench depth should be a minimum of nine inches.

for your next septic system. It costs more to dig individual trenches than it does to create a group bed, but the benefits may outweigh the costs.

Mound Systems

Mound systems, as you might suspect, are septic systems that are constructed in mounds that rise above the natural topography. This is done to compensate for high water tables and soils with slow absorption rates. Due to the amount of fill material to create a mound, the cost is naturally higher than it would be for a bed system.

Coarse gravel is normally used to build a septic mound. The stone is piled on top of the existing ground. However, topsoil is removed before the stone is installed. When a mound is built, it contains suitable fill material, an absorption area, a distribution network, a cap, and topsoil. Due to the raised height, a mound system depends on either pumping or siphon action to work properly. Essentially, effluent is either pumped or siphoned into the distribution network.

As the effluent is passing through the coarse gravel and infiltrating the fill material, treatment of the wastewater occurs. This continues as the liquid passes through the unsaturated zone of the natural soil.

The purpose of the cap is to retard frost action, deflect precipitation, and retain moisture, which will stimulate the growth of groundcover. Without adequate groundcover, erosion can be a problem. There are a multitude of choices available as acceptable groundcovers. Grass is the most common choice.

SEPTIC TIP

Pump systems are expensive. They are needed when a septic system is installed at an elevation higher than the sewer being served. This situation is not as uncommon as you might think, especially when dealing with houses that have plumbing in their basements. However, houses with basements are not the only structures where pump systems might be needed.

CODE CONSIDERATION

A long, narrow bed design shall be used for permeable soils with high water tables.

Mounds should be used only in areas that drain well. The topography can be level or slightly sloping. The amount of slope allowable depends on the perk rate. For example, soil that perks at a rate of 1 inch every 60 minutes or less should not have a slope of more than 6 percent if a mound system is to be installed. If the soil absorbs water from a perk test faster than 1 inch per hour, the slope could be increased to 12 percent. These numbers are only examples. A professional who designs a mound system will set the correct criteria for slope values.

Ideally, about two feet of unsaturated soil should exist between the original soil surface and the seasonally saturated topsoil. There should be 3 to 5 feet of depth to the impermeable barrier. An overall range of perk rates could go as high as 1 inch in two hours, but this, of course, is subject to local approval. Perk tests for this type of system are best when done at a depth of about 20 inches. However, they can be performed at shallow depths of only 12 inches. Again, you must consult and follow local requirements.

The design and construction of mound systems can get quite complicated. This is not a problem to you as a builder, because experts will provide the design criteria. It will then be up to you or your septic installer to follow instructions and see to it that the mound is built as specified.

Pump Systems

Pump systems are expensive. They are needed when a septic system is installed at an elevation higher than the sewer being served. This situation is not as uncommon as you might think, especially when dealing with houses that have plumbing in their basements. However, houses

CODE CONSIDERATION

Construction must not begin if soil on the site is so wet that a soil wire forms when the soil is rolled between someone’s hands.

CODE CONSIDERATION

Excess vegetation must be cut and removed from a mound area.

with basements are not the only structures where pump systems might be needed.

If you are bidding a job where a pump system will be needed, you must be careful not to overlook the pump and related elements that are to be installed. Additional labor and material costs for pump systems can be very substantial

Holding Tanks

Holding tanks are sometimes used as a last resort for building sites that have very poor perk rates. The use of holding tanks may or may not be acceptable in your area. Don't buy land on the assumption that you will be able to install holding tanks as an alternative to an absorption septic system. Even if holding tanks are allowed in your area, the use of such a waste-disposal system is likely to have a negative impact on the value of any building you build.

Some land simply isn't suitable for any reasonable type of absorption septic system. This typically labels the land as unbuildable. Under these conditions, holding tanks might be a solution. Basically, a holding tank is just a large vessel that collects wastewater and sewage. The container holds the waste until a certain level is reached in the tank. At this point, the tank must be emptied. This is done with a truck setup to pump out septic tanks. Depending on the size of the holding tank and the volume of use, periodic pumping intervals vary.

Having holding tanks pumped out can be expensive. The process is also something of an inconvenience. Some people are willing to put up with the hassle and expense, and others aren't. If you are building on spec, you should avoid sites where holding tanks will be required unless you have some very good plan of attack for selling what you build. Average homebuyers will not normally like the idea of living with a holding tank in place of a septic system.

I can think of very few occasions when holding tanks have been used for full-time residences. This is a septic alternative that is better suited to seasonal cottages and camps. However, you might find some occasion when a holding tank can help you out of a tight spot. Remember, check

CODE CONSIDERATION

The bottoms of trench beds are to be level.

with your local code office to see if holding tanks may be used before you count on them as a solution to your septic-system problems.

Other Types of Systems

Engineers may be able to offer other types of systems to meet your special needs. It may be that a combination of systems will be pieced together to accomplish a difficult goal. If you run across a piece of land that doesn't perk well, avoid it if you can. Unless you are able to buy the land very inexpensively as an offset to the poor perk rate, the cost of a special septic system could ruin the profitability of building on the land. You will have to weigh each individual set of circumstances to determine whether it is worth pursuing. When you are asked to custom-build something for a customer on land that exhibits difficult septic characteristics, have the customer consult engineers or other professionals for a detailed septic design. As long as you are working from an approved septic design, you should be able to keep yourself out of trouble.

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Pump Stations

Pump stations are sometimes the only answer for difficult septic situations. There are three types of drainage pumping that we will discuss in this chapter. The first is a single-fixture pump. Our second type is a basin pump located within a house. The third type of pumping situation to be discussed is a whole-house pump station. Any of these methods of pumping might solve your problems. Some are cheaper and easier to install than others. All of them add some cost to a job, so you must be aware of this during the bidding phase.

Single-Fixture Pumps

Single-fixture pumps are inexpensive and easy to install. They don't have any real effect on the plumbing other than the fixtures they are installed on. This type of pump is often used on laundry tubs. In fact, a lot of plumbers call them laundry-tray pumps. The pumps can, however, be installed on any type of residential sink or lavatory. They are not suitable for bathtubs, showers, toilets, or washing machines. (There is one occasion when these pumps are suitable for use with washers. If the indirect waste of the washing machine dumps into a laundry tub, the pump can be used to empty the contents of the laundry sink. Even though the pump is limited in its flow rate, the holding capacity of a deep laundry sink is enough to allow the pump to keep up with the volume of water discharged by an automatic clothes washer.)

> **PRO POINTER**
>
> Single-fixture pumps are inexpensive and easy to install. They don't have any real effect on the plumbing other than the fixtures they are installed on.

A single-fixture pump is small. It installs directly under the bottom of the fixture it is serving. Electricity is needed to make the pump run. An experienced plumber can add a single-fixture pump to a new installation in just a matter of minutes. You must take into consideration, however, the expense of the pump and the electrical circuit that will be needed. All of these factors tend to push the price of your job up.

If you have only one sink that must be installed below the gravity level of other plumbing, a single-fixture pump is a cheap, easy way out. These pumps are often used on basement bar sinks. The discharge pipe from a single-fixture pump normally has only a 0.75 inch-diameter drain. This makes piping the drain in concealed locations easier.

There are some disadvantages to small, single-fixture pumps. Depending upon the type of fixture being served, the pumps may become clogged with sediment and debris. This is often the case when they are used with laundry tubs. When a clothes washer empties into a laundry tub, it often deposits lint in the sink. This lint, if it gets into the drainage system, can plug up the strainer in a small pump. One way to avoid this is by using a strainer to protect the drain opening of the laundry tub. But the strainer could clog and cause the sink to overflow. You could be fighting a losing battle either way.

Single-fixture pumps can be adjusted to cut on as soon as water is detected in a drain, or they can be set to wait until a specific amount of water pressure builds up. The pumps last longer if they don't have to cut on and off frequently and for short durations. Therefore, a setting that allows water to collect in a plumbing fixture before being pumped out is advantageous. It is also possible to use the pumps in a manual fashion, where someone turns the pump on and off as needed. This, of course, would not be suitable in the case of draining an automatic clothes washer, but it can work well for other applications.

The strainers in single-fixture pumps are sensitive. Dirt, sand, lint, and other items are all capable of blocking the pump filter, causing a

PRO POINTER

There are some disadvantages to small, single-fixture pumps. Depending upon the type of fixture being served, the pumps may become clogged with sediment and debris. This is often the case when they are used with laundry tubs.

backup of water in a fixture. Most pump failures that I've witnessed have occurred when the pumps were used on laundry trays with nothing more than cross-bar protection over the drain. Pumps installed on lavatories and bar sinks are less likely to fail.

While single-fixture pumps are inexpensive and effective, they are not always the best choice. I've just explained to you how the small pumps can become clogged and cause backups in fixtures. This type of failure could result in flooding. For example, if you were to have an automatic clothes washer dumping into a laundry tray where a single-fixture pump was installed, there could be more than enough water discharged to overflow the flood rim of the laundry tray if the pump were to fail.

How often do single-fixture pumps fail? Provided that they are protected from contaminants and are not abused, they perform very well. My plumbing company has responded to a lot of calls for failed pumps on single fixtures, but in most cases the failure was related to operator error. By this I mean that people allowed objects to go down a drain that were never intended to pass through a pump of such diminutive size.

I would not hesitate to install a single-fixture pump in my own home, but I'm always a little nervous when I install them for other people. Since I don't know how my customers will treat their pumps, I have no way of knowing if I will be getting frantic calls for help from people who are faced with a house that is flooding.

When I install a single-fixture pump professionally, I have a little instruction sheet that I give my customers. It warns them of the risks associated with careless use of the pump. Before I leave a job, I ask the customers to read and sign the form. A copy is given to them, and I keep a copy for my records. This provides written documentation that I instructed the individuals in the proper use of their pumps. If a problem arises from abuse or negligence on the part of a homeowner, I have my little piece of paper to help protect me.

Most plumbers don't go to the extremes that I do in getting paperwork signed for a pump installation. In all my years of plumbing and building, I've only had to produce my form as a defense on one occasion. This was after two free service calls to clear blockages in a strainer of a pump. On both occasions, the pump strainer was full of lint and sand. After the second trip I produced the paperwork and instructed the homeowner that if I were required to respond again and found lint or sand in the strainer, a charge for the service call would be made. The customer has never called me back with a pump problem since.

PRO POINTER

Is there an alternative to single-fixture pumps when only one fixture needs to be pumped? Yes, there is. A more costly but better pumping arrangement is available for all types of plumbing fixtures. Depending on the type and number of fixtures being pumped, requirements vary.

Gray-Water Sumps

Gray-water sumps and pumps can be used to collect and pump water from all plumbing fixtures that don't receive or discharge human waste. In a typical residence this would include all fixtures except toilets. Many commercial buildings use gray-water sumps to handle wastewater from sinks, and a lot of gray-water sumps are installed in houses for one reason or another.

What is a gray-water sump? The sump itself is not much more than a covered bucket. It is simply a watertight container that is used to collect wastewater from a plumbing fixture. The sump can be installed by sitting it on the floor under a fixture, or it can be buried in a concrete floor. Burying the sump or suspending it beneath a floor would be necessary if it were to serve a bathtub or shower.

A drain is run from a plumbing fixture to the sump, where a watertight connection is made. Another pipe is connected to the discharge outlet at the sump and run to a drainpipe that empties by the force of gravity. The pipe used for this type of pump often has a diameter of 1.5 inches, although, a larger pipe could be used.

The cover of the sump is often fitted with a gasket that comes into contact with the rim of the sump. A sump cover is normally held in place with machine screws. An air vent should extend from the top of the sump to either open airspace or to a connection with another plumbing vent that does terminate into open air. The diameter of the vent pipe will normally be two inches.

PRO POINTER

When equipped with a gas-tight cover and vent, a gray-water sump does not emit odors.

Gray-water sumps normally have a holding capacity of about five gallons. The sumps that I use are made of polyethylene and are therefore corrosion-resistant. When equipped with a gas-tight cover and vent, a gray-water sump does not emit odors. A key part of a sump system is the pump used. There are many options available for pump purchases.

When I'm required to install a gray-water sump system, I buy a kit. The kit includes the sump and a pump. The pump is a 1/3 horsepower unit that requires 115-volt electrical service. The amp draw is 2.3, and the pump is shipped with a 10-foot plug-in cord. When an existing outlet is within reach, additional electric work may not be needed.

Let me give you an idea of how much water a small pump like I use is capable of moving. Pumping water 10 feet high, one of these pumps can produce up to 2250 gallons per hour. That's a lot of water. The pump cuts on and off automatically with the use of a float switch. A check valve should be installed in the discharge line to prevent water that has been pumped into the vertical discharge line from returning to the sump.

A gray-water sump doesn't take up a lot of room. The sumps I use stand 15 inches tall and have a width of 15 inches. They weigh about 16 pounds. The supplier of my systems calls them sink-tray systems. Call them what you want—they are an economical alternative to a whole-house pump station. Due to the size and design of gray-water sumps, they are not affected by small particles of debris in the same way that a single-fixture pump is. While more expensive than a single-fixture pump, a gray-water sump system is more dependable and can handle a lot more water.

Black-Water Sumps

Black-water sumps work on a principle similar to that of gray-water sumps. However, they may receive the discharge of toilets and other fixtures of a similar nature. The pumps used in a black-water sump are of a different type than those used in a gray-water setup. Black-water sumps are normally installed below a finished floor level. They are quite often buried in concrete floors. It is possible to install such a sump in a crawl-space by simply creating a stable base for it on the ground.

Black-water basins or sumps are available in different sizes. A typical residential sump may be 30 inches deep with an 18 inch diameter at the lid. Basin packages can be purchased that include all parts necessary to set up the basin.

A 2 inch vent pipe should extend from the basin cover to open air outside a building. A check valve is used in the vertical discharge line.

PRO POINTER

If you have a house where most of the plumbing can be drained by gravity and only a few fixtures need to be pumped, such as a basement bathroom, an in-house black-water sump is the way to go.

A 4 inch inlet opening is molded into the basin to accept the waste of all types of residential plumbing fixtures. Some type of float system is used to activate the pump that is housed in the basin. The exact type of float system used depends on the type of pump being used.

Pumps used for a typical in-house black-water sump are known as effluent pumps and sewage ejectors. The discharge pipe from the pump normally has a diameter of 2 inches, although a 3 inch discharge flange is available. Even if the waste of a toilet is being pumped, a 2 inch discharge pipe is sufficient.

The cost of a complete black-water sump system will run into several hundred dollars, but this is much less than what a whole-house pump station would cost. If you have a basement bathroom that requires pumping, this type of system is ideal. I’ve installed dozens if not hundreds of them, and I’ve never been called back for a failure. During my plumbing career I have responded to failures in similar systems. The most common problem is a float that has become wedged against the side of the sump. This won’t happen if the system is installed properly.

Whole-House Pump Stations

Whole-house pump stations are about as bad as it gets for a builder. These systems involve a lot of material, labor, and costs. They also pose the potential threat of disabling all the plumbing if the pump fails. As bad as they are, pump stations are sometimes a blessing. If you have land that cannot be built on under any other circumstances, pump stations look pretty darn good.

Since all the plumbing in a house with a pump station is dependent on a pump’s operation, you must take some special precautions when installing such a system. Code requirements are often very stringent on this issue, although they vary from place to place. We will talk more about code issues a little later.

It is standard procedure to install a whole-house pump station in a location outside of the home being served. A sewer pipe runs from the house or building to the storage sump. The size and capacity of this sump are determined by local code requirements and anticipated use. A sump can be made of many types of material, such as concrete or fiberglass.

Fiberglass sumps are not uncommon. One fiberglass sump that I know of is three feet deep and has a 30 inch diameter. This particular sump is designed for interior use with a grinder pump. It has a 4 inch inlet and an outlet for a 2 inch vent. The basin kit comes complete with a control panel, a hand-off automatic switch, a terminal strip, and an audible alarm. There are also three encapsulated mercury switches that provide positions for on, off, and alarm. This is only one example of a whole-house pumping system; there are many others available to choose from.

The potential designs for a whole-house pump system are too numerous to detail. I can, however, explain to you how one such system in a house I built for a customer was installed.

The house that required a full-scale pump station sat low on its building lot. Even with a full basement, half of which was exposed above the ground due to bedrock, a pump station was needed. A septic field was located behind and above the house at a considerable distance from the foundation. Chambers had to be installed in the leach field. The basic septic system was a gravity-fed system, but the sewage from the house had to be pumped up to the septic tank. Once waste was delivered to the tank, the septic disposal process could take its normal course.

To accomplish our goal, a black-water sump was installed underground outside of the house. I think it was about 15 or 20 feet from the foundation in the rear of the house. Plumbing fixtures in the home drained by gravity to the holding tank. A grinder pump, which was float-operated and equipped with an alarm system, pumped sewage up the hill to the septic tank. Since a fairly large holding tank was used, the pump didn't have to cycle each time a toilet was flushed. The holding tank was large enough to allow occupants of the house to use minimal plumbing fixtures for a short time even if electrical power or a pump failed.

If for some reason the grinder pump failed, lights and an audible alarm would come on in the house. This would alert the homeowners of a problem in an attempt to prevent flooding the holding tank, also known as the pump station. This system worked well when it was installed, and it is still functioning just fine, to the best of my knowledge, after several years of use.

Requirements for pump stations vary from place to place. Even plumbing codes disagree on some points of installation procedures. For example, one major plumbing code requires the use of two pumps in certain pump stations. This provides a backup pump in the case of a failure with the main pump. Another major plumbing code doesn't require a second pump. For reasons like this one, you must investigate the code requirements in your area to avoid costly mistakes.

Regardless of how they are installed, pump stations add to the cost of a project. This is something all builders should be aware of. If an alarm system is required, and it is in many cases, the cost will be higher than if one is not mandated. Before you bid a job with a pump station, get all of your facts straight.

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Gravity Systems

Gravity septic systems are the most common type of private sewage-disposal systems. Sizing this type of system requires the use of language and tables that exist in local code requirements. When a system has a daily effluent application of 5000 gallons or less, the sizing is fairly simple. It is possible to use two systems of equal size when the daily effluent application exceeds 5000 gallons. When this is done, each system must have a minimum capacity of 75 percent of the area required for a single system. Dual systems can be considered as one system, but an approved means of alternating waste application must be provided when such a system is used to accommodate a usage of more than 5000 gallons a day.

Pressure-distribution systems are permitted in place of a conventional or dosing soil-absorption system as long as a site is suitable for the conventional system. When a site is unsuitable for conventional treatment, a pressure- distribution system can be used as an alternative system. The result is that a pressure-distribution system can be used in either case but must be used when a conventional system is not feasible.

Flow from a septic or treatment tank to a soil-absorption system must be by gravity or dosing for systems receiving 1500 gallons or less of effluent a day. A tank that discharges effluent at a rate of more than 1500 gallons a day must be equipped to pump the effluent or to create an automatic siphon for the system. The goal is to keep the system working only with gravity. This keeps the cost of the system to a minimum.

The sizing of a private sewage soil-absorption system for residential properties is done with the use of data provided in the local code. This is

SEPTIC TIP

The goal is to keep the system working only with gravity. This keeps the cost of the system to a minimum.

> **SEPTIC TIP**
>
> Seepage trenches must be 1 to 5 feet wide. The trenches must be spaced at least 6 feet apart. Individual trenches must not exceed a length of 100 feet unless otherwise approved.

most commonly done with the use of a sizing table. You must know the perk-test data and the type of construction for the system in order to size the system. This applies to one- and two-family dwellings.

If you are sizing a system for another type of building, you will need to know the perk rate, the building usage, and the design details. This sizing is done with data from the local code.

Excavating Seepage Trenches

Seepage trenches must be 1 to 5 feet wide. The trenches must be spaced at least 6 feet apart. Individual trenches must not exceed a length of 100 feet unless otherwise approved. The absorption area of a seepage trench must be computed using only the bottom of the trench area. You cannot use the bottom excavation area of the distribution header as an absorption area.

Seepage Beds

The excavations for seepage beds must be a minimum of 5 feet wide and have more than one distribution pipe. The bottom of the trench is used to compute the absorption area. Distribution pipes must be spaced evenly with a minimum distance of 3 feet and a maximum distance of 5 feet between the pipes. Spacing between distribution pipes and the sidewall or headwall of a seepage bed must be set at a maximum of 3 feet and a minimum of 1 foot.

> **CODE CONSIDERATION**
>
> Each holding tank is required to be vented. The vent must not have a diameter of less than 2 inches and it must extend a minimum of 12 inches above finished grade. The terminating point of a vent must be fitted with a return bend fitting or approved vent cap.

> **CODE CONSIDERATION**
>
> The minimum capacity for a septic tank that serves a three-bedroom home is 1000 gallons.

Seepage Pits

Seepage pits require a minimum inside diameter of 5 feet. They must consist of a chamber walled up with perforated precast-concrete rigs, concrete block, brick, or other approved material that allows effluent to percolate in the surround soil. The bed of a seepage bed is to be left open to the soil.

Aggregate of 0.5 to 2.5 inches in size must be placed into a 6 inch minimum annular space separating the outside wall of the chamber and the sidewall excavation. The depth of the annular space is measured from the inlet pipe to the bottom of the chamber. Every seepage pit must be provided with a 24 inch manhole that extends to within 56 inches of the round surface and a 4 inch-diameter fresh air inlet.

Seepage pits must be located a minimum of 5 feet apart. The effective area of a seepage pit is the vertical wall area of the walled-up chamber for the depth below the inlet for all strata in which the perk rates are less than 30 minutes per inch. The 6 inch annular opening outside the vertical wall area can be included in determining the effective area. Sizing data should be available in your local code book.

Rules of Excavation and Construction

There are rules that must be obeyed when excavation and construction of soil-absorption systems are required. The basic rules are as follows:

- The bottom of a trench or bed must be level.
- Excavation is not allowed if the soil is so wet that it creates a soil wire when rolled between a person's hands.

> **CODE CONSIDERATION**
>
> Rectangular tanks are to be constructed with the longest dimensions parallel to the direction of the flow.

- Sidewalls or bottoms that suffer from smearing or compaction must be scarified.
- The bottom area must be scarified, and loose material must be removed.

Aggregate and Backfill

A minimum of 6 inches of aggregate ranging in size from 0.5 to 2.5 inches must be laid into a trench or bed below the distribution-pipe elevation. The aggregate must be evenly distributed a minimum of 2 inches over the top of the distribution pipe. The aggregate must be covered with approved synthetic materials or 9 inches of uncompacted marsh hay or straw. Building paper is not an approved means of covering. A minimum of 18 inches of soil backfill must be installed on top of the covering. No covering that will prevent the evaporation of effluent should be installed.

Piping Requirements

Requirements for distribution pipes are not overly complicated. Here are the basics:

- Distribution pipes for gravity systems must have a minimum diameter of 4 inches.
- Distribution heads must be made with solid-wall pipe.
- The top of a distribution pipe must not be less than 8 inches below the original surface in continuous straight or curved lines.
- Grade on a distribution pipe must be 2 to 4 inches per 100-foot run.
- Effluent must be distributed to all distribution pipes.
- The distribution of effluent to a seepage trench on a sloping site must be accomplished by using a drop-box design or some other approved method.
- If dosing is required, the siphon or pump must discharge a dose of minimum capacity equal to 75 percent of the combined volume of the distribution piping in the absorption system.

Observation Pipes

Observation pipes are required, and they must have a minimum diameter of 4 inches. The observation pipe must extend at least 12 inches

SEPTIC TIP

Under special circumstances and where approved, an observation pipe's location can be permanently recoded and the pipe can be installed not more than two inches below the finished grade.

above the final grade. Termination points for observation pipes must be equipped with an approved vent cap.

The bottom 12 inches of an observation pipe should be perforated and extend to the bottom of the aggregate. Observation pipes must be located at least 25 feet from any window, door, or air intake of any building used for human occupancy. No more than four distribution trenches can be served by one common 4 inch observation pipe when interconnected by a common header pipe.

Weather

Weather can play a part in the installation of a soil-absorption system. Unless otherwise approved, a system cannot be installed during adverse weather conditions. If the installation area is frozen, a system cannot be installed. Any existing snow must be removed prior to installing a system. The snow must be moved to avoid any water from ponding as the snow melts.

Backfill material must be protected from freezing. Frozen soil cannot be used as backfill material. Special inspection of the beds or trenches may be required during winter weather conditions. If you are working in cold weather, it is a good idea to contact the local code officer to see if any special inspections will be required before you place your gravel and backfill materials.

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Controlling Construction Costs

Controlling construction costs can require you to have more than a passing knowledge of the work involved in installing septic systems. You can make more money by avoiding cost overruns. I'm sure you know this, but you may not know how to avoid going over budget. A lot of contractors have trouble keeping their spending within the confines of a budget. When was the last time that you had a job run over what you were expecting? Do you perform job costs for all your work? If you're not doing job costing, you can't know how well your estimate worked out compared to the real cost of a job. It may be surprising to you, but a lot of contractors don't maintain regular job-costing procedures.

Before you can stay on budget, you have to create a budget to follow. This is something else that far too many contractors are lax in doing. Many contractors work up a lump-sum figure and work only from it. They may know if they make or lose money, but they don't have enough information to know where the wins and losses come from. This is bad business.

Setting Up a Job Budget

Setting up a job budget is not difficult to do. You don't need a degree in accounting to manage the task. It does take a little time to establish a framework of prices, but it is time well spent. Most successful contractors never start a job without a budget. You shouldn't either.

When I'm getting ready to bid on a job, I break my bid work down into phases. My breakdowns are done in tight categories. Some contractors lump all of their excavation and grading work into one category. I don't. My procedure calls for a category to cover every major aspect of a job. For example, I have a category for site clearing. Another category is reserved for crushed stone. A different category covers digging trenches.

SEPTIC TIP

You could lump all material costs into one category, but I'd go further than that. I would list all of the major components of the system separately. For example, I'd have space for crushed stone, concrete products, chambers (if needed), pipe, dirt, and so forth.

The cost of a septic tank and distribution box would be a category. So would pipe. Basically, every phase of a job would be broken down. Since we are talking about wells and septic systems, let's use these two aspects of a job as our working example.

Septic Systems

The manner in which you break down the costs for a septic system can vary. If you are hiring a subcontractor to provide all labor and materials to install a septic system, you might plug in only one price. This, of course, would be the price quoted to you by your septic installer.

If you are supplying materials for your septic contractor, the cost breakdown would be more detailed. You could lump all material costs into one category, but I'd go further than that. I would list all of the major components of the system separately. For example, I'd have space for crushed stone, concrete products, chambers (if needed), pipe, dirt, and so forth.

My reasons for going into detailed breakdowns are numerous. For one thing, I'm not as likely to overlook an expense if my worksheet for a budget details all major expenses. Using a septic system as an example, I might forget to figure in the cost of a permit if a slot didn't exist for it. It's conceivable that I would fail to figure a price for stone if a blank line or box doesn't exist for the cost. By having a detailed worksheet, I can go through it systematically and not worry about what I might be leaving out. This is good protection against cost overruns.

Once I start a job, I can use my budget to track the profit picture of my work. When an invoice is delivered for crushed stone, I can compare it with the figure I have in my budget. If the stone cost less than what I had figured, I'm in great shape. When the cost is on target, I'm okay. A price that is higher than my bid figure raises a red flag. There may not be much I can do about it on the particular job, but it tells me to find out what I did wrong so it won't happen again.

> **PRO POINTER**
>
> To complete an accurate take-off, you must do extensive breakdowns of what materials and labor will be needed for a particular phase of work.

When the dust settles, I can review my estimated figures and compare them with the true costs of materials. It's easy for me to job-cost any phase of a job, because I have each phase broken down independently. After a few jobs, I can compare notes and see if I'm experiencing any recurring problems. For example, if I'm habitually missing my estimated figures for fill dirt, I know this is an area I need to work on. When I'm constantly coming in under budget on concrete materials, I might decide to lower my prices a little if competition is tough. The budgets that I create serve many purposes.

Wells

When I have a house that will need a well, I break my budget down into several categories. One of the categories is for the direct well work, either the drilling or the boring. A second category covers the pump. Pressure tanks have a category of their own. Gauges, fittings, pipe, and miscellaneous items are lumped together. Trenching gets its own category. And, of course, labor has a section in the budget. I have used my extensive breakdowns for over 15 years, and I have always found them helpful.

Take-Offs

If you are figuring the cost of a job accurately, you must include take-offs.To complete an accurate take-off, you must do extensive breakdowns of what materials and labor will be needed for a particular phase of work. You are probably accustomed to doing this with your building materials. Since wells and septic systems might be beyond your scope of detailed knowledge, preparing a full take-off for such a system might be more than you can handle. If you're using subcontractors for the work, you're not the one who has to worry about take-offs. All you have to do is write or type in the prices given to you by your subs. This makes it that much easier to come up with budget numbers.

If you are figuring your own materials with a take-off, you can use the take-off as a part of your budget. For example, if you decide that 200 feet of PE pipe will be needed when doing your take-off, you can use that information in breaking down your budget. Putting together a budget from take-offs is simple and effective. You need to create some type of working budget. Take-offs don't have to be a part of this administrative task, but you do need some way of coming up with firm numbers. If you cheat and cut corners in arriving at your budget figures, you will only be hurting yourself. Trying to save time can wind up costing you money and maybe a lot of it.

Accuracy

The accuracy of any budget you build must be dependable. If the numbers aren't solid, they will do you very little good. Everyone makes mistakes from time to time. The odds of making an error in a complex take-off are high, especially if you are not doing the take-off in an undisturbed atmosphere. Even transferring numbers from a subcontractor's bid package to your budget sheet can result in mistakes. Sometimes a seven looks like a one. Forgetting to add a zero in a price can make a huge difference. If you depend on a computerized spreadsheet to add up your figures, you might never notice a simple mistake until it is far too late. After you have created your budget, go back over it and double-check its accuracy.

Sorting Through Bids

Sorting through bids can be a tedious job. In order to get a clear picture of what each bid includes, it is necessary to spend adequate time pouring over proposals and bid packages. During my many years as a builder, I've seen a number of strange proposals and bid packages. Some of the prices I've reviewed turned out to be way out of line. If I had been too busy to study prices given to me, my negligence could have cost me a bundle. This can be true of prices provided by both subcontractors and suppliers.

If you have much experience as a builder, you have undoubtedly had occasions when suppliers have botched up your price quotes. I've had suppliers omit all interior doors from my requests for prices. Hey, if you leave out all the interior doors for a house, your bid price is going to look pretty good. But, a cheap bid price that's wrong doesn't do anyone much good. It's essential that you take an active role in checking and double-checking all quotes given to you. Let's put this into perspective for wells and septic systems.

Well Prices

Well prices are generally fairly consistent. Some trades seem to vary in their prices much more than others. Well contractors with whom I've dealt have normally been close competitors. This makes it easier in some ways and more difficult in others.

Contractors who install wells typically offer two types of pricing. The options are normally either a per-foot price or a flat-rate fee. There are pros and cons to both of these types of pricing structures. When well installers quote a flat-rate fee, it is usually the highest price an installer expects a well to cost. It is often possible to beat flat-rate fees by choosing a per-foot price. But picking a per-foot price structure is risky. Flat-rate fees are guaranteed; per-foot prices can run away with your cash.

When you are reviewing bid prices from well installers, you have to look closely. Most of the prices will be fairly clear and concise. But, there can be hidden charges or wording that might leave you out on a limb. To expand on this, let's start with a per-foot price structure.

When you get a quote for a per-foot well, there will be no total price provided. The well installer will charge so much for every foot of depth that is required for a suitable well. Casing for the well will also be priced on a per-foot basis, with no reference to how many feet will be needed. This leaves you in an open-ended situation. You know how much the well will cost per foot, but you have no idea of how many feet you will be billed for. Under this circumstance, you are at risk in giving a customer a flat-rate quote. Are you going to make your price to the customer based on a per-foot basis, or are you going to make your best guess and give a firm price? Banks and other lenders will require a firm price if they are supplying construction financing.

I've only used flat-rate well pricing once in my long building career. With all the wells I've had installed, I always came out better by gambling on the per-foot price. Then when I built my most recent personal home, I opted for a guaranteed price. It's a good thing I did. My well turned out to be much deeper than I or my well driller thought it would be. To be safe, you should work with guaranteed prices. If you are willing to gamble, you can quote flat rates to your customers and play the odds of per-foot pricing with your well installer. This can net you more money out of a job, but it can also cause you to pay for cost overruns out of your own pocket.

Our main interest right now is in comparing price bids. In the case of well installers, this is pretty easy to do.

WELL TIP

If all your bidders are bidding the same type of well and quoting per-foot prices, you can look at their prices and compare apples to apples. But, there are some opportunities for unethical installers to take advantage of you. They may dig or drill deeper than necessary. The amount of casing installed may not be reflected accurately on your bill. A per-foot pricing basis is similar to a labor-and-material pricing structure. Both are risky. If you like to work with known figures, stick with guaranteed prices.

Guaranteed prices are often available from well installers. These prices tend to be on the high side, but they are dependable. If you have three well contractors all bidding identical specifications with guaranteed pricing, there is not much effort required in evaluating their prices. All you have to do is look for the low number. In theory, you can't lose money on a guaranteed deal. There will not be any cost overrun for you to suffer from. If anyone loses, it's the well installer. This approach is a conservative, safe one.

Reading between the Lines

Reading between the lines of a quote from a well company is sometimes necessary. Not all quotes are quite what they appear to be. A busy builder can make assumptions that result in big trouble due to a lack of details. Let me expound upon this.

Assume that you have received quotes for installing a well. If you're new to wells, you might think that the price you are given includes all the

WELL TIP

A lot of well installers do install pump systems, but I've never seen one include the pump work in the well price. A well price normally includes nothing more than drilling a well, installing a casing, and capping the casing. I suppose a really slick con artist could try to sell you a well without the casing and cap included. This has never happened to my knowledge, but it won't hurt for you to confirm exactly what is included in all prices you receive.

necessary work and materials for a pump system. This will not normally be the case. A lot of well installers do install pump systems, but I've never seen one include the pump work in the well price. A well price normally includes nothing more than drilling a well, installing a casing, and capping the casing. I suppose a really slick con artist could try to sell you a well without the casing and cap included. This has never happened to my knowledge, but it won't hurt for you to confirm exactly what is included in all prices you receive.

Pump systems are generally treated as a different job from well installations. Even when the same contractor is doing both jobs, the work is normally priced separately. It should be. This way you can compare the well installers' pump prices with those of your plumbers. If the pump work and well work are both mixed in together, you have no way of comparing the pump prices given to you by plumbers to those given to you by well installers.

In my experience, grouting has always been included in the prices given to me for well installations. This is an aspect of the job that I suppose could be left out of a proposal offered by a well installer. The installer might insist that you were planning to grout the well with your own crews. Again, I haven't seen this happen, but it is a potential risk if you want to consider all the pessimistic possibilities.

Your first job as a general contractor is to understand all the bid packages that you are working with. If you have questions, call the subcontractors and get answers to your concerns. Don't make assumptions; they generally only serve to hurt you. Get all the facts before you award a contract.

All the well installers I have dealt with in the past have been good ones. I've never had a bad experience with a well installer. I can't say this about many of the trades I've worked with, but well installers have been good to me. Still, you can't allow your defenses to become too lax. Read each quote carefully. Has anything been disclaimed? It's common for water quantity and quality to be disclaimed, but there shouldn't be any other caveats.

If you are having a well installer bid on your pump package, make sure the materials planned for use are specified. Here are some key thoughts and questions to consider when reviewing bid packages:

- Don't accept just the brand of the pump to be used. Get a model number and a description sheet.

- Compare flow rates, horsepower, voltage, and other specifics of the pumps competitive bidders are listing.
- Find out which type of pressure tank is being supplied and what its capacity is.
- Which type of pipe will be installed?
- Are nylon fittings going to be used, or will they be brass?
- Will the installer double-clamp all connections?
- Create a checklist of questions to ask installers. Don't attempt to choose the best bidder until you have all the facts to work with.

Trenching and backfilling are both parts of a pump installation. This is work that most installers don't include in their prices. Some companies do factor in this expense, but many don't. If you receive a bunch of bids and assume that the trenching is included, you can be in for a rude awakening. The cost of a backhoe or excavator and operator can become quite expensive, especially when it's not in your budget. Confirm who is responsible for digging and filling in the well trench before you make a decision on whom to award a job to.

Septic Prices

Septic systems can involve a lot of material and money. Unlike wells, where per-foot prices are common, most septic systems are priced with flat-rate fees. A septic design is handed out to a number of septic installers, who give you quotes. They are generally comprehensive, but there can be some hooks hidden in them.

If you have a septic system that requires a pump system, who is paying for the pump, the controls, and related pumping materials? Who is going to install this equipment? Are you going to have to pay a plumber to install the pump and an electrician to wire the system? Not all septic contractors include the price for labor and material required to make a

SEPTIC TIP

Most septic installers will provide prices that include all work and material associated with a designed system. But you can't count on this. You have to clarify the situation before you commit to accepting a bid.

SEPTIC TIP

Final grading over a septic system is normally done by the site contractor. This person might also be your septic installer. Many site contractors do install septic systems. Again, however, you can't afford to make assumptions. Determine exactly who is going to handle the final grading.

pump system operational. Making the mistake of thinking these prices are included in a septic price can cost you thousands of dollars.

It has been my experience that most septic installers provide their own permits and materials. There have been times when I've bought septic permits and septic materials for installers. Looking at a septic price and thinking that it includes everything when it actually only includes the cost of labor can be disastrous to your profit from a job. Make sure you understand what each bid includes.

Excavation can be a major expense in installing a septic system. This work is normally included in the bids of septic contractors. So is the cost of stone, pipe, and fill dirt. Septic tanks and distribution boxes are commonly provided by septic installers. The prices you get should be turnkey numbers, but check them out.

One aspect of septic systems that does seem to vary is the installation of a sewer between a septic tank and the sanitary plumbing from a house. Sometimes plumbers do this work; at other times septic installers do it. This work involves trenching, pipe, fittings, and labor. The amount of money is rarely a fortune, but it's enough that you won't want to pay it out of your own pocket. Find out which one of your subcontractors is bidding the sewer work.

Suppliers

When you will be supplying your own materials for either pump systems or septic systems, you will have to get prices from material suppliers. This work can be frustrating. Some suppliers just don't seem concerned enough about getting a person's business to meet the requirements set forth in a bid request.

When I built my most recent home, I sent bid packages out to seven major suppliers. Of those seven, only five responded with prices. Two of the suppliers must have decided that my job wasn't worth bidding. Now I'm not talking about a bid of a few hundred dollars. Tens of thousands of dollars in materials were on my list. Even so, two out of seven suppliers chose not to bid the job. Why? I don't know. It must be nice to be so independently wealthy that you don't need to bid work.

Most suppliers will bid jobs, but they may not do it in the way you request them to. I like my bids broken down into itemized lists. A lot of suppliers prefer to throw out a lump-sum figure. If you don't have itemized pricing to work with, you are at a disadvantage. It's possible to look at the bottom-line figures of lump-sum bids and choose a low bidder, but you could be wasting money. Let me tell you what I mean.

Take a pump installation as an example. If you get three lump-sum bids, you can easily see which supplier is offering the overall lowest price. But is one supplying a more expensive well pump than another? Could you buy a pressure tank for less from one place than you could from another? You won't know without an itemized list of prices.

It's rare when one supplier offers the best prices on all types of materials. This is true of building materials, plumbing materials, and probably most other materials. A supplier who can give you a great price on dimensional lumber might have lousy prices on siding or roof shingles. You probably already know this, but in case you don't, it's true.

Shopping individual prices can save you a lot of money. I'm not one to nickel and dime a supplier, but I do believe in shopping various phases of a job. I might buy a pump from one place, pipe from another, and a pressure tank from yet another. If my only extra effort is two additional phone calls and I can save a significant amount of money, I'm all for it. Now I wouldn't buy some of my fittings here and some of them there. That gets too confusing. But, within reason, selective shopping for itemized materials is good business.

PRO POINTER

Suppliers don't always have the time or the proper personnel to produce quality take-offs. Miscounting a few copper fittings is no big deal, but forgetting to include the cost of a pressure tank is another issue entirely. If you use take-offs prepared by suppliers, I suggest that you check them over very closely. Many times these lists will have omissions.

Some contractors rely on suppliers to do take-offs for them. I don't have a problem with letting suppliers provide a take-off for a job, but I certainly don't trust a take-off that is prepared by a supplier to be accurate. This type of take-off can be quite good, but it can be way off-base. I've seen it in both my building and my plumbing business.

I generally provide my suppliers with a bid list. After making a take-off, I spec out the brand names I want and ask all suppliers to bid the work as specified. This is the only way I know of to get a true comparison of prices. If suppliers are allowed to make their own decisions in the types of materials used for a bid, you might get five quotes with none of them being comparable.

When I recommend specifying material, I'm not talking only about big-ticket items. Many contractors will spec out a particular pump and pressure tank but fail to give specifications for valves, fittings, pipe, and other elements of a job. The difference in cost between a cheap gate valve and a name-brand valve can be $15 or more. With enough fittings and accessories, a supplier can lower the cost of a job considerably by pricing materials of a lesser quality. If you don't spec out a job in detail, you won't know what your prices are based on.

Once you get bids in from suppliers, read them over thoroughly. I can't count the number of times that suppliers have left whole categories of materials off their bids. Go down the bid lists item by item and make sure that everything that you wanted a price on is listed. Simply looking at the total on the bottom of a bid sheet can be very deceiving.

Once a Job Starts

Once a job starts, you have to stay on your toes to remain within your budget. How often do you compare your monthly invoices from suppliers with the prices that you have been quoted for materials being billed? Ideally, you should check each invoice against quoted prices. There are many times when the prices you are charged will not agree with the terms of a quote. How often is this likely to happen? It happens just about every month in my businesses.

When you get a quote from a supplier, it is natural to assume that you will be billed at the quoted price when the invoice arrives. I have found, however, that the prices billed are often higher than the quoted prices. Is this a computer error? Did someone forget to lock in the quoted prices? Do suppliers try to take advantage of contractors? I don't know why it happens, but it does. Sometimes the difference is only a few pennies, but sometimes the discrepancy amounts to hundreds of dollars.

I try to check each invoice that is tied to a quoted job with the quoted prices. Sometimes an invoice slips through, but this is rare. During my checks, I often find problems with my billing. The trouble doesn't come from just one or two suppliers; it seems to happen with a lot of them. There are some suppliers whom I've never caught in a mistake, but they are the exception rather than the rule.

Keeping tabs on your billing invoices from suppliers is a simple way to avoid cost overruns. If a supplier bills you at a price higher than the written, quoted price, you can ask for and usually receive the lower price. Even small price increases can add up over the course of a year. Paying $5 too much for this and $10 too much for that on job after job can cause you to lose thousands of dollars.

It takes time to go over invoices. Sometimes the price discrepancies you find will not be worth the time it takes to find and correct them. But, there can be some big differences in prices. On the last house I built, there was a $700 problem with one of my invoices. For this amount of money, I'm willing to scan invoices for errors.

Extras

How do you handle customers who want extras on a job? If someone asks you to add an in-line filter to the job while you are putting in the pump system, what do you do? A change order should be written and signed by all parties to reflect the change. This is the best way to avoid confusion and possible payment problems. Yet far too few contractors take the time to use change orders.

It is not uncommon for customers to request additional work and get it without ever being billed for it. This is a sure way to bust your budget. When proper records are not kept of changes on a job, the billing for additional work can easily slip through the cracks. Many times mechanics do little extras on jobs and forget to turn in work orders. Anytime additional work is done, it needs to be recorded and billed.

Written Records

Written records kept during a job can pay off later. There are different ways of keeping track of what goes into a job. You might just keep delivery tickets and time cards as reference points. Some contractors, like me, use day sheets to list the materials used on any given day. This procedure is more accurate than piling up delivery tickets.

When my crews go into the field for small jobs, they make written records of all materials used on their job. This is done each day that they work on a job. If they work two jobs in the same day, they turn in two different logs. Employee time is also kept in a journal. The time is broken down by phases. If two hours are spent putting a pump in and one hour in backfilling a trench, the day log will reflect it. This type of paperwork makes it easy for me to track production, inventory, estimates, and job costs.

As a Job Is Winding Down

As a job is winding down, you should start to gather your job-costing data. This might mean a trip into the field to count materials used, or you might be able to rely on paperwork created during the course of a job. One way or another, you need to know how much labor and material went into a job. This might be as simple as jotting down numbers from bills you have received from subcontractors. If you are not supplying any of the labor from payroll people and your subcontractors are providing all materials, your paperwork will be kept at a minimum.

By the time a job is finished, you should be geared up to perform a full job-cost report. It may be necessary to wait for final billing to come in from your suppliers before putting a final report together. This doesn't stop you from starting your work. The longer you wait to produce a job-cost report, the more likely you are to neglect doing the report at all.

Pulling It All Together

Once you have all the data needed for a job-cost report, you can get a clear view of how well you budgeted the job. Only an accurate job-cost

PRO POINTER

Job costs give you power, profit power. A good job cost will show you what you did right and where you went wrong. You can determine if your estimating skills are good when you review a job-cost report. There is a wealth of knowledge available to contractors who use job-costing techniques properly.

report can prove whether you made or lost money on a job. Finding out that you've lost money on a job is never pleasant. But discovering financial losses on one job can help you to avoid them on future jobs.

To stay on budget, you have to track all your financial activities. This should be done during the course of a job and after a job is finished. Until you can account for all your costs of doing a job, you can't be sure how profitable your business is. Since profit is a prime reason for being in business, it's very important to keep track of the money you are making or losing.

A Money Diet

You may have to put your company on a money diet. Sometimes businesses become fat with overhead expenses. This puts strain on a company. Reducing overhead can increase profits. If your business is too fat with overhead, put it on a diet. How does this apply to cost overruns? Well, I'll tell you.

Overhead reduction might not seem to have anything to do with cost overruns on jobs. In fact, it doesn't, assuming that a contractor calculates all overhead into job quotes. This is often done incorrectly if at all. But overhead expenses that are not accounted for can ruin the projected profit of a job.

Do you have field supervisors on your payroll? If you do, how do you bill out their time? How many employees do you have? Are some of them administrative employees? Do you account for their cost in your job quotes? How you factor in the cost of employees, insurance, rent, utilities, and other expenses can clearly affect the profit percentages on your jobs.

Employees cost employers a lot more than their hourly rate of pay when all associated expenses are factored into a total hourly cost. Someone who is being paid $10 per hour might be costing an employer $14 an hour. Many factors influence the total cost of employees. Paid vacation, company-provided insurance coverage, and a host of other expenses contribute to the total cost of an employee.

Not all builders have employees. Many contractors work exclusively with subcontractors. When this is the case, figuring overhead expenses is a little easier. I don't plan to get into a long discussion on company overhead. But, I do want you to be aware that any overhead that is not factored into a job quote can cause you to make less money than you were hoping to.

17

Common Problems with Well Installations

Common problems with well installations can make life difficult for builders. When a person has purchased a new house from a builder and the well fails, the person is likely to call the builder. Some builders have no idea of how to troubleshoot well and pump problems, but they are the first people to be contacted. Homeowners who have wells that are not functioning properly are usually distressed. If ignored, they can quickly become grumpy.

Problems with wells and well-pump systems are not unusual. These problems don't typically plague homeowners, but they do exist, sometimes with far more regularity than builders would like. Is there anything you can do to eliminate these problems? I doubt it. But you can reduce the occurrence of such problems with quality workmanship and supervision. However, I believe you must be prepared to deal with a variety of problems associated with wells and their pumping systems.

Assuming that you use subcontractors to create your wells and to install your pump systems, you can call those people to help solve your problems. Having this option doesn't release you from responsibility, but it does make your job easier. Still, homeowners with well-related problems will be looking to you for support and help. The more you know about troubleshooting wells and septic systems, the more valuable you become to your customers. This is important.

As I'm sure you have gathered, this chapter is dedicated to dealing with problems. I wouldn't expect you to throw a toolbox in the back of your truck and rush out to fix well problems. If you have enough background, you might be able to give customers helpful advice by telephone. Doing this might get their systems back in action right away. Your subcontractors will appreciate not having to make callbacks, and your customers will be pleased to have their water problems solved so quickly.

The information we will cover in this chapter is somewhat technical at times. I intend to break the chapter down into three primary categories. We will talk about water-source problems, problems with pumps and related equipment, and water quality. For example, if someone calls you and complains about a nasty smell in the water, you will be able to refer to this chapter for advice on what might be causing the odor. Just for the record, sulfur would be the most likely cause of this problem. Let's start with basic well problems.

Basic Well Problems

Basic well problems are not common. In this category, we are talking about trouble with wells themselves rather than with pumps. Water quality is not a part of our present discussion. Since well problems are often dependent on the type of well being used, we will investigate the problems arising with specific well types.

Driven Wells

Driven wells don't usually have a large holding capacity. It is not uncommon for flow rates or recovery rates to be low. Both of these factors can contribute to a home running out of water. If a customer calls with a complaint of having no water when a driven well is in use, you may be faced with a pump problem or a well problem. This is true of all types of wells. Driven wells are the most likely type of well to run dry. This is a simple problem to troubleshoot.

If you suspect that a driven well is out of water, you can gain access to the well and drop a weighted line into it to determine if any water is standing in the well. If there is little or no water present, your problem might be with the point filter or the water source. If the well point has become clogged, water will not be able to enter the well pipe. Assuming that there is insufficient water, you can take one of two actions.

You could pull the well point and inspect it. This will not be an easy task. If your area is experiencing an extremely dry spell, you may have to pull the well point to identify the problem. However, if area conditions don't point to a drop in local water tables, you might ask the customer to avoid using any water for a few hours and then try the pump again. Given several hours for recovery, the well may produce a new supply of water. This doesn't rule out a partially clogged point, but it tends to indicate a low flow rate. To be sure of what is going on, the point will have to be pulled and inspected.

Due to the nature of a driven point, your options for finding out if water is present in the water table are limited. If water can't pass through the filter of a point, water won't enter the well. This is not the case with other types of wells. Unfortunately, some of the money saved by installing a well point can be lost through later problems, such as having to pull the point for inspection and possible replacement.

Sand

Sand in a water-distribution system that is served by a well point is an indication that the openings in the screen filter on the well point are too large. This type of problem can be addressed by adding an in-line sediment filter, but the true solution lies in replacing the well point with one with a finer screen filter.

Other Contaminants

Other contaminants can enter a water-distribution system through a well point. These entries into the water system can be filtered out with water-treatment conditioning. Replacing a well point may help to solve this type of problem. Essentially, some type of conditioning equipment will probably be needed to eliminate very small contaminants.

Shallow Wells

Shallow wells are less likely to pose problems than driven wells. However, these wells can provide builders with head-scratching trouble. Some shallow wells cave in over time. It doesn't always take a long time for this to happen. A new well can experience problems with cave-ins long before warranty periods are over. This is not a common problem, but it is one that can occur.

Shallow wells do sometimes run out of water. Given some time, these wells normally recover a water supply. If a shallow well runs dry, there is

WELL TIP

Checking a shallow well to see if water is in reserve is easy. A weighted line can be dropped into a well to establish water depth. Assuming that water is present in sufficient quantity, you can rule out a dry well.

very little that can be done. You must either wait for water to return or create a new well.

Problems are sometimes caused by sand or other sediment pumping out of a shallow well. This is usually a result of the foot valve or drop pipe hanging too low in the well. If a well has worked well for a few months and then begins producing sand or other particles, it can be an indication that the well is caving in. Sometimes a foot valve will become clogged under these conditions. The simple act of shaking the drop pipe can clear a foot valve of debris and allow a pump to return to normal operation.

Checking a shallow well to see if water is in reserve is easy. A weighted line can be dropped into a well to establish water depth. Assuming that water is present in sufficient quantity, you can rule out a dry well. But you cannot rule out the fact that the drop pipe or foot valve in the pump may be installed above the water level. This can be checked by pulling the drop pipe out of the well and measuring it. The length of a drop pipe can then be compared to the depth at which water is located. If you have water in the well and your drop pipe is submerged in it, you can rule the well out as your problem.

Drilled Wells

Drilled wells very rarely run out of water. It is, however, possible that a drilled well could run dry. A weighted line will allow you to test for existing water. Pulling the drop pipe and comparing its length to the depth at which water is contacted will determine whether a lack of water in a house is due to the well or the pumping system.

In all of my years as a plumber, I've never known a drilled well to run out of water without some type of outside interference. By outside interference I mean some form of man-made trouble, such as blasting with explosives somewhere in the general area. Let me give you an example of this from my recent past.

A friend of mine has enjoyed a drilled well for decades. In all of these years the well had never given its owner any problem until this past summer. Roadwork was being done within a mile or so of my friend's house in the early summer. Part of the work involved the blasting of bedrock. Shortly after this blasting took place, my friend's well quit producing water. Why? My guess, and it's only a guess, is that the blasting caused a change in the underground water path. It may be that the blasting shifted the rock formations and diverted the water that was at one time serving the well of my friend. I've seen similar situations occur at other times. It's impossible for me to say with certainty that blasting ruined the well, but it's my opinion that it did.

Troubleshooting Jet Pumps

You are already aware that there are differences between jet pumps and submersible pumps. Knowing this, it only makes sense that there will be differences in the types of problems encountered with the different types of pumps. Let' start our troubleshooting session with jet pumps.

Will Not Run

A pump that will not run can be suffering from one of many failures. The first task is to check the fuse or circuit breaker. If the fuse is blown, replace it. When the circuit breaker has tripped, reset it. This is something you could ask your customer to check.

When the fuse or circuit breaker is not at fault, check for broken or loose wiring connections. Bad connections account for a lot of pump failures. It is possible the pump won't run due to a motor overload-protection device. If the protection contacts are open, the pump will not function. This is usually a temporary condition that corrects itself.

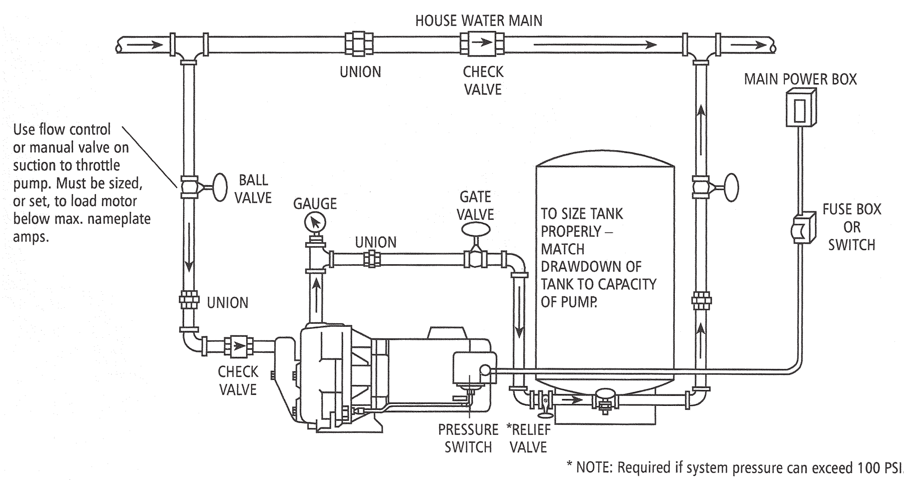

Figure 17.1 Jet booster pump installation. Automatic operation jet pump, shallow well or convertible with injector. © *ITT Goulds Pumps.*

Table 17.1 Sizing the booster pump.

Booster system pumps are sized the same as shallow well jet pumps with the exception being, we add the incoming city pressure to what the pump provides. The required flow is determined by the number of bathrooms or number of fixtures being used at any given time. City water is supplied under pressure, low incoming pressure is caused by undersized, crushed or severely corroded pipes or large elevation differences, such as a hill, between the city water line and the house.

Verify the incoming pressure with the water flowing to find the "dynamic suction pressure", static pressure is what you see with no water flowing. Use the dynamic suction pressure to calculate pump performance and selection. The J5S and the high pressure version, J5SH are very popular as booster pumps. The J5SH is a good choice for booster applications because of its narrow flow range and higher pressure capability. In the absence of performance data for 0' we use the 5' Total Suction Lift performance data. Add the incoming dynamic pressure to the pump's discharge pressure to find the total discharge pressure. Make a chart showing the flow, incoming dynamic pressure, pump discharge pressure and total discharge pressure for each job. It would look like this if using a J5SH pump with 15 PSI of incoming dynamic pressure:

Flow Rate GPM	Pump Discharge Pressure (PSI)	Incoming Dynamic Pressure (PSI)	Total Discharge Pressure (PSI)
11.5	20	15	35
11.3	30	15	45
11	40	15	55
7.7	50	15	65
4.8	60	15	75
0	83	15	98

If the pump is attempting to operate at the wrong voltage, it may not run. Test the voltage with a voltammeter. The power must be on when this test is conducted. With the leads attached to the meter and the meter set in the proper voltage range, touch the black lead to the white wire and the red lead to the black wire in the disconnect box near the pump. Test both the incoming and outgoing wiring.

Your next step in the testing process should be at the pressure switch. The black lead should be placed on the black wire and the red lead should be put on the white wire for this test. There should be a plate on the pump that identifies the proper working voltage. Your test should reveal voltage that is within 10 percent of the recommended rating.

An additional problem that you may encounter is a pump that is mechanically bound. You can check this by removing the end cap and turning the motor shaft by hand. It should rotate freely.

A bad pressure switch can cause a pump to stop running. With the cover removed from the pressure switch, you will see two springs, one tall and one short. These springs are depressed and held in place by individual nuts. The short spring is preset at the factory and should not need adjustment. This adjustment controls the cutout sequence for the pump. If you turn the nut down, the cutout pressure will be increased. Loosening the nut will lower the cutout pressure.

The long spring can be adjusted to change the cut-in and cutout pressure for the pump. If you want to set a higher cut-in pressure, turn the nut tighter to depress the spring further. To reduce the cut-in pressure, you should loosen the nut to allow more height in the spring. If the pressure switch fails to respond to the adjustments, it should be replaced.

It is also possible that the tubing or fittings on the pressure switch are plugged. Take the tubing and fittings apart and inspect them. Remove any obstructions and reinstall them.

The last possibility for the pump failure is a bad motor. You will use an ohmmeter to check the motor, and the power to the pump should be turned off. Start checking the motor by disconnecting the motor leads. We will call these leads L1 and L2. The instructions you are about to receive are for Goulds pumps with motors rated at 230 volts. When you are conducting the test on different types of pumps, you should refer to the manufacturer's recommendations.

Set the ohmmeter to RX100 and adjust the meter to zero. Put one of the meter's leads on a ground screw. The other lead should systematically be touched to all terminals on the terminal board, switch, capacitor, and protector. If the needle on your ohmmeter doesn't move as these tests are made, the ground check of the motor is okay.

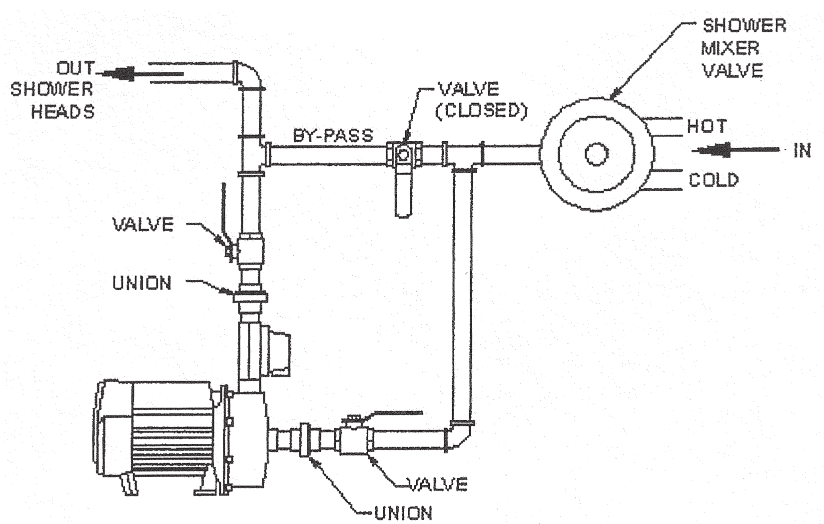

Figure 17.2 Shower pressure booster. © *ITT Goulds Pumps.*

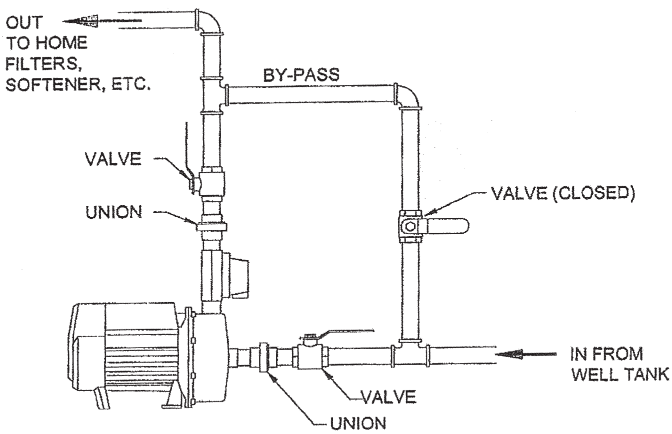

Figure 17.3 Typical home pressure booster. © *ITT Goulds Pumps.*

The next check to be conducted is for winding continuity. Set the ohmmeter to RX1 and adjust it to zero. You will need a thick piece of paper for this test; it should be placed between the motor switch points and the discharge capacitor.

You should read the resistance between L1 and A to see that it is the same as the resistance between A and yellow. The reading between yellow to red should be the same as L1 to the same red terminal.

The next test is for the contact points of the switch. Set the ohmmeter to RX1 and adjust it to zero. Remove the leads from the switch and

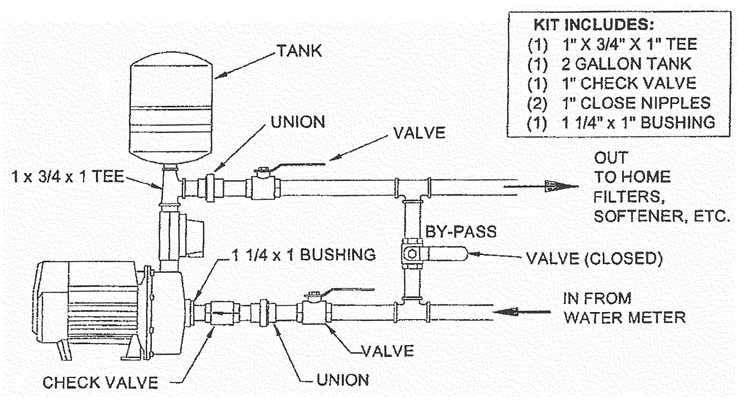

Figure 17.4 A check valve and expansion tank installation kit. © *ITT Goulds Pumps.*

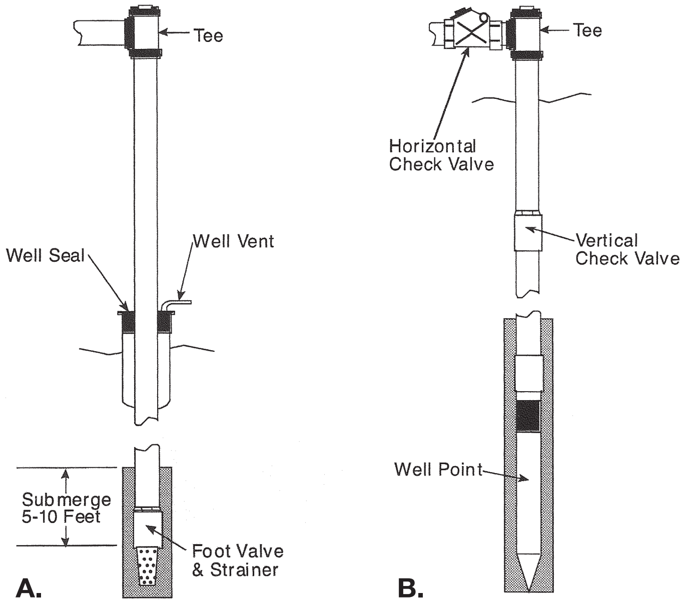

Figure 17.5 Shallow well installation. Drilled, bored or dug wells shown in **A**. Driven wells and sandpoints employ the configuration in **B**. © *ITT Goulds Pumps.*

attach the meter leads to each side of the switch; you should see a reading of zero. If you flip the governor weight to the run position, the reading on your meter should be infinity.

Now let's check the overload protector. Set your meter to RX1 and adjust it to zero. With the overload leads disconnected, check the resistance between terminals one and two and then between two and three. If a reading of more than one occurs, replace the overload protector.

The capacitor can also be tested with an ohmmeter. Set the meter to RX1000 and adjust it to zero. With the leads disconnected from the capacitor, attach the meter leads to each terminal. When you do this, you should see the meter's needle go to the right and drift slowly to the left. To confirm your reading, switch positions with the meter leads and see if you get the same results. A reading that moves toward zero or a needle that doesn't move at all indicates a bad capacitor.

I realize the instructions I've just given you may seem quite complicated. In a way, they are. Pump work can be very complex. I recommend that you leave major troubleshooting to the person who installed your problem pump. If you are not familiar with controls, electrical meters, and working around electrical wires, you should not attempt many of the procedures I am describing. The depth of knowledge I'm providing may be deeper than you ever expect to use, but it will be here for you if you need it.

Runs But Gives No Water

When a pump runs but gives no water, you have seven possible problems to check out. Let's take a look at each troubleshooting phase in its logical order.

The first consideration should be that of the pump's prime. If the pump or the pump's piping is not completely primed, water will not be delivered. For a shallow-well pump you should remove the priming plug and fill the pump completely with water. You may want to disconnect the well pipe at the pump and make sure that it is holding water. You could spend considerable time pouring water into a priming hole only to find out the pipe was not holding the water.

For deep-well jet pumps, you must check the pressure-control valves. The setting must match the horsepower and jet assembly used, so refer to the manufacturer's recommendations.

Turning the adjustment screw to the left will reduce pressure, and turning it to the right will increase pressure. When the pressure-control valve is set too high, the air-volume control cannot work. If the pressure setting is too low, the pump may shut itself off.

If the foot valve or the end of the suction pipe has become obstructed or is suspended above the water level, the pump cannot produce water. Sometimes shaking the suction pipe will clear the foot valve and get the pump back into normal operation. If you are working with a two-pipe system, you will have to pull the pipes and do a visual inspection. However, if the pump you are working on is a one-pipe pump, you can use a vacuum gauge to determine if the suction pipe is blocked.

WELL TIP

If the pump is running without delivering water, the most likely cause is a leak on the suction side of the pump. You can pressurize the system and inspect it for these leaks.

> **WELL TIP**
>
> Any leaks in the piping or pressure tank would cause frequent cycling of the pump.

If you install a vacuum gauge in the shallow-well adapter on the pump, you can take a suction reading. When the pump is running, the gauge will not register any vacuum if the end of the pipe is not below the water level or if there is a leak in the suction pipe.

An extremely high vacuum reading, such as 22 inches or more, indicates that the end of the pipe or the foot valve is blocked or buried in mud. It can also indicate that the suction lift exceeds the capabilities of the pump.

If the pump is running without delivering water, the most likely cause is a leak on the suction side of the pump. You can pressurize the system and inspect it for these leaks.

The air-volume control can be at fault with a pump that runs dry. If you disconnect the tubing and plug the hole in the pump, you can tell if the air-volume control has a punctured diaphragm. If plugging the pump corrects the problem, you must replace the air-volume control.

Sometimes the jet assembly will become plugged up. When this happens with a shallow-well pump, you can insert a wire through the 0.5-inch plug in the shallow-well adapter to clear the obstruction. With a deep-well jet pump, you must pull the piping out of the well and clean the jet assembly.

An incorrect nozzle or diffuser combination can result in a pump that runs but that produces no water. Check the ratings in the manufacturer's literature to be sure the existing equipment is the proper equipment.

The foot valve or an in-line check valve could be stuck in the closed position. This type of situation requires a physical inspection and the probable replacement of the faulty part.

Cycles Too Often

When a pump cycles on and off too often, it can wear itself out prematurely. This type of problem can have several causes. For example, any leaks in the piping or pressure tank would cause frequent cycling of the pump.

The pressure switch may be responsible for a pump that cuts on and off too often. If the cut-in setting on the pressure gauge is set too high, the pump will work harder than it should.

If the pressure tank becomes waterlogged (filled with too much water and not enough air), the pump will cycle frequently. If the tank is waterlogged, it will have to be recharged with air. This would also lead you to suspect that the air-volume control is defective.

An insufficient vacuum could cause the pump to run too often. If the vacuum does not hold at three inches for 15 seconds, it might be the problem.

The last thing to consider is the suction lift. It's possible that the pump is getting too much water and creating a flooded suction. This can be remedied by installing and partially closing a valve in the suction pipe.

Won't Develop Pressure

Sometimes a pump will produce water but will not build the desired pressure in the holding tank. Leaks in the piping or pressure tank can cause this condition to occur.

If the jet or the screen on the foot valve is partially obstructed, the same problem may result.

A defective air-volume control may prevent the pump from building suitable pressure. You can test for this by removing the air-volume control and plugging the hole where it was removed. If this solves the problem, you know the air-volume control is bad.

A worn impeller hub or guide-vane bore could result in a pump that will not build enough pressure. The proper clearance should be 0.012 on a side or 0.025 diametrically.

With a shallow-well system, the problem could be caused by the suction lift being too high. You can test for this with a vacuum gauge. The vacuum should not exceed 22 inches at sea level. Deep-well jet pumps require you to check the rating tables to establish their maximum jet depth. You should also check the pressure-control valve to see that it is set properly.

Switch Fails

If the pressure switch fails to cut out when the pump has developed sufficient pressure, you should check the settings. Adjust the nut on the short spring and see if the switch responds; if it doesn't, replace the switch.

Another cause for this type of problem could be debris in the tubing or fittings between the switch and the pump. Disconnect the tubing and fittings and inspect them for obstructions.

We have now covered the troubleshooting steps for jet pumps, but before we move on to submersible pumps, I'd like you to look over the illustrations I've given you on engineering data, multistage jet pumps, and typical installation procedures.

Troubleshooting Submersible Pumps

There are some major differences between troubleshooting submersible pumps and troubleshooting jet pumps. One of the most obvious differences is that jet pumps are installed outside of wells and submersible pumps are installed below the water level of wells.

There are times when a submersible pump must be pulled out of a well, and this can be quite a chore. Even with today's lightweight well pipe, the strength and endurance needed to pull a submersible pump up from a deep well are considerable. Plumbers who work with submersible pumps regularly often have a pump puller to make removing the pumps easier.

When a submersible pump is pulled, you must allow for the length of the well pipe when planning the direction to pull from and where the pipe and pump will lie once removed from the well. It is not unusual to have between 100 and 200 feet of well pipe to deal with, and some wells are even deeper.

It is important, when pulling a pump or lowering one back into a well, that the electrical wiring does not rub against the well casing. If the insulation on the wiring is cut, the pump will not work properly. Let's look now at some specific troubleshooting situations.

Won't Start

Pumps that won't start may be the victims of a blown fuse or tripped circuit breaker. If these conditions check out okay, turn your attention to the voltage.

In the following scenarios we will be dealing with Goulds pumps and Q-D-type control boxes.

To check the voltage, remove the cover of the control box to break all motor connections. Be advised: wires L1 and L2 are still connected to electrical power. These are the wires running to the control box from the power source.

Press the red lead from your voltmeter to the white wire and the black lead to the black wire. Keep in mind that any major electrical appliance that might be running at the same time, like a clothes dryer, should be turned on while you are conducting your voltage test.

Once you have a voltage reading, compare it to the manufacturer's recommended ratings. For example, with a Goulds pump that is rated for 115 volts, the measured volts should range from 105 to 125. A pump with a rating of 208 volts should range from 188 to 228 volts. A pump rated at 230 volts should measure between 210 and 250 volts.

If the voltage checks out okay, check the points on the pressure switch. If the switch is defective, replace it.

The third likely cause of this condition is a loose electrical connection in the control box, the cable or the motor. Troubleshooting for this condition requires extensive work with your meters.

To begin the electrical troubleshooting, we will look for electrical shorts by measuring the insulation resistance. You will use an ohmmeter for this test, and the power to the wires you are testing should be turned off.

Set the ohmmeter scale to RX100K and adjust it to zero. You will be testing the wires coming out of the well from the pump at the well head. Put one of the ohmmeter's leads to any one of the pump wires and place the other ohmmeter lead on the well casing or a metal pipe. As you test the wires for resistance, you will need to know what the various readings mean, so let's examine this issue.

You will be dealing with normal ohm values and megohm values. Insulation resistance will not vary with ratings. Regardless of the motor, horsepower, voltage, or phase rating, the insulation resistance will remain the same.

A new motor that has not been installed should have an ohm value of 20,000,000 or more and a megohm value of 20. A motor that has been used but is capable of being reinstalled should produce an ohm reading of 10,000,000 or more and a megohm reading of 10.

Once a motor is installed in the well, which will be the case in most troubleshooting, the readings will be different. A new motor installed with its drop cable should give an ohm reading of 2,000,000 or more and a megohm value of 2.

An installed motor in a well that is in good condition will present an ohm reading of between 500,000 and 2,000,000. Its megohm value will be between 0.5 and 2.

A motor that gives a reading in ohms of between 20,000 and 500,000 and a megohm reading of between 0.02 and 0.5 may have damaged leads or may have been hit by lightning; however, don't pull the pump yet.

You should pull the pump when the ohm reading ranges from 10,000 to 20,000 and the megohm value drops to between 0.01 and 0.02. These readings indicate a damaged motor or cables. While a motor in this condition may run, it probably won't run for long.

When a motor has failed completely or the insulation on the cables has been destroyed, the ohm reading will be less than 10,000 and the megohm value will be between 0 and 0.01.

With this phase of the electrical troubleshooting done, we are ready to check the winding resistance. You will have to refer to charts as references for correct resistance values, and you will have to make adjustments if you are reading the resistance through the drop cables. I'll explain more about this in a moment.

If the ohm value is normal during your test, the motor windings are not grounded and the cable insulation is intact. When the ohm readings are below normal, you will have discovered that either the insulation on the cables is damaged or the motor windings are grounded.

To measure winding resistance with the pump still installed in the well, you will have to allow for the size and length of the drop cable. Assuming you are working with copper wire, you can use the following figures to obtain the resistance of cable for each 100 feet in length and ohms per pair of leads:

- Cable size 14: resistance 0.5150
- Cable size 12: resistance 0.3238
- Cable size 10: resistance 0.2036
- Cable size 8: resistance 0.1281
- Cable size 6: resistance 0.08056
- Cable size 4: resistance 0.0506
- Cable size 2: resistance 0.0318

If aluminum wire is being tested, the readings will be higher. Divide the ohm readings above by 0.61 to determine the actual resistance of aluminum wiring.

If you pull the pump and check the resistance for the motor only (without testing the drop cables), you will use different ratings. You should refer to a chart supplied by the manufacturer of the motor for the proper ratings.

When all the ohm readings are normal, the motor windings are fine. If any of the ohm values are below normal, the motor is shorted. An ohm value that is higher than normal indicates that the winding or cable is open or that there is a poor cable joint or connection. Should you encounter some ohm values higher than normal while others are lower than normal, you have found a situation in which the motor leads are mixed up and need to be attached in their proper order.

If you want to check an electrical cable or a cable splice, you will need to disconnect the cable and submerge it in a container of water; a bathtub will work.

Start by submerging the entire cable, except for the two ends, in water. Set your ohmmeter to RX100K and adjust it to zero. Put one of the meter leads on a cable wire and the other to a ground. Test each wire in the cable with this same procedure.

If at any time the meter's needle goes to zero, remove the splice connection from the water and watch the needle. A needle that falls back to give no reading indicates that the leak is in the splice.

Once the splice is ruled out, you have to test sections of the cable in a similar manner. In other words, once you have activity on the meter, you should slowly remove sections of the cable until the meter settles back into a no-reading position. When this happens, you have found the section that is defective. At this point, the leak can be covered with waterproof electrical tape and reinstalled, or you can replace the cable.

Will Not Run

A pump that will not run can require extensive troubleshooting. Start with the obvious and make sure the fuse is not blown and the circuit breaker is not tripped. Also check to see that the fuse is of the proper size.

Incorrect voltage can cause a pump to fail. You can check the voltage as described in the electrical troubleshooting section above.

Loose connections, damaged cable insulation, and bad splices, as discussed above, can prevent a pump from running.

The control box can have a lot to do with whether or not a pump will run. If the wrong control box has been installed or if the box is located in an area where temperatures rise to over 122 degrees F, the pump may not run.

When a pump will not run, you should check the control box carefully. We will be working with a quick-disconnect type of box. Start by checking the capacitor with an ohmmeter. First, discharge the capacitor before testing. You can do this by putting the metal end of a screwdriver between the capacitor's clips. Set the meter to RX1000 and connect the leads to the black and orange wires leading out of the capacitor case. You should see the needle start toward zero and then swing back to infinity. Should you have to recheck the capacitor, reverse the ohmmeter leads.

The next check involves the relay coil. If the box has a potential relay (three terminals), set your meter on RX1000 and connect the leads to the red and yellow wires. The reading should be between 700 and 1800 ohms for 115-volt boxes. A 230-volt box should read between 4500 and 7000 ohms.

If the box has a current relay coil (four terminals), set the meter on RX1 and connect the leads to black wires at terminals one and three. The reading should be less than one ohm.

In order to check the contact points, you will set your meter on RX1 and connect to the orange and red wires in a three-terminal box. The reading should be zero. For a four-terminal box, you will set the meter at RX1000 and connect to the orange and red wires. The reading should be near infinity.

Now you are ready to check the overload protector with your ohmmeter. Set the meter at RX1 and connect the leads to the black wire and the blue wire. The reading should be a maximum of 0.5.

If you are checking the overload protector for a control box designed for 1.5 horsepower or more, you will set your meter at RX1 and connect the leads to terminal number one and to terminal number three on each overload protector. The maximum reading should not exceed 0.5 ohm.

A defective pressure switch or an obstruction in the tubing and fittings for the pressure switch could cause the pump not to run.

As a final option, the pump may have to be pulled and checked to see if it is bound. There should be a high amperage reading if this is the case.

Doesn't Produce Water

When a submersible pump runs but doesn't produce water, there are several things that could be wrong. The first thing to determine is if the pump is submerged in water. If you find that the pump is submerged, you must begin your regular troubleshooting.

Loose connections or wires connected incorrectly in the control box could be at fault. The problem could be related to the voltage. A leak in the piping system could easily cause the pump to run without producing adequate water.

A check valve could be stuck in the closed position. If the pump was just installed, the check valve may be installed backwards. Other options include a worn pump or motor, a clogged suction screen or impeller, and a broken pump shaft or coupling. You will have to pull the pump if any of these options are suspected.

Tank Pressure

If you don't have enough tank pressure, check the setting on the pressure switch. If that's okay, check the voltage. Next, check for leaks in the piping system, and as a last resort check the pump for excessive wear.

Frequent Cycling

Frequent cycling is often caused by a waterlogged tank, as was described in the section on jet pumps. Of course, an improper setting on the pressure switch can cause a pump to cut on too often, and leaks in the piping can be responsible for the trouble. You may find that the problem is caused by a check valve that has stuck in an open position.

Occasionally the pressure tank will be sized improperly and cause problems. The tank should allow a minimum of one minute of running time for each cycle.

Water Quality

Quality in private water supplies can vary greatly from one building lot to another. It can even fluctuate within a single water source. A well that tests fine one month may test differently six months later. Frequent testing is the only way to assure a good quality of water. Many times some type of treatment is either desirable or needed before water can be used for domestic purposes.

Many people have heard of hard water and soft water. While these terms may be familiar, a lot of people don't know the differences between the two types of water. Some water supplies have hazardous concentrations of contaminants, but most wells are affected more often by mineral contents that, while not necessarily harmful to a person's health, can create other problems.

Is it a builder's responsibility to provide customers with water that is free of mineral content? It shouldn't be. Water-conditioning equipment can get very expensive. Spending $1,500 or more for such equipment would not raise any eyebrows in the plumbing community. If you want to make sure that you don't become entangled in a lot of litigation over water quality, have your lawyer create a disclaimer clause for your contracts.

There are four prime substances that can affect the quality of water. Physical characteristics are the first. By physical characteristics we are talking about such factors as color, turbidity, taste, odor, and so forth. Chemical differences create a second category. This can involve such aspects as hard and soft water. Biological contents can modify both the physical and chemical characteristics of water. This third factor in determining water quality can often render water unsafe for drinking. The fourth consideration is radiological factors, such as radon. To understand these four groups better, let's look at them individually.

Physical Characteristics

Water quality can be assessed by its physical characteristics. Taste and odor rank high as concerns. Water that doesn't taste good or that smells bad is undesirable. It may perfectly safe to drink, but its physical qualities make it unpleasant to live with.

What causes problems with taste and odors? Foreign matter is at fault. It may come in the form of organic compounds, inorganic salts, or dissolved gases. Sulfur content is one of the best-known causes of odor in water.

Water that doesn't look good can be difficult to drink enjoyably. Color is a physical characteristic that can taint someone's opinion of water quality. Colored water rarely indicates a health concern, but it is a sure way of drawing some customer complaints. Dissolved organic matter from decaying vegetation and certain inorganic matter typically give water a distinct color.

Do you know what turbid water is? It's simply water that is cloudy in appearance. Turbidity is caused by suspended materials in the water. Such materials might be clay, silt, very small organic material, plankton, and inorganic materials. Turbidity doesn't usually pose a health risk, but it makes water distasteful to look at in a drinking glass.

Technically, temperature falls into the category of physical characteristics. This, however, is not a problem that many people complain about. Deep wells produce water at consistent temperatures. Shallow wells are more likely to have water temperatures that fluctuate. In either case, temperature is rarely a concern with wells.

Foam is something that you will not normally encounter in well water. However, foamability is a physical characteristic of water, and it can be an indication that serious water problems exist. Water that foams is usually being affected by some concentration of detergents. While the foam itself may not be dangerous, the fact that detergents are reaching a water source should raise some alarm. If detergents can invade the water, more dangerous elements may also be present.

Chemical Characteristics

Chemical characteristics are often monitored in well water. A multitude of chemical solutions may be present in a well. As long as quantities are within acceptable, safe guidelines, the presence of chemicals does not automatically require action. However, concentrations of some chemicals can prove harmful. Following is a list of some chemicals that might be present in the next well you install:

- Arsenic
- Barium
- Cadmium
- Chromium
- Cyanides
- Fluoride
- Lead
- Selenium
- Silver

Chlorides

Chlorides in solution are often present in well water. If an excessive quantity of chlorides is present, it may indicate pollution of the water source.

Copper

Copper can be found in some wells as a natural element. Aside from giving water a poor taste, small amounts of copper are not usually considered harmful.

Fluorides

Why pay a dentist to give your children fluoride treatments when fluorides may be present in your drinking water? Natural fluorides can be found in some well water. Too much fluoride in drinking water is not good for teeth, so quantities should be measured and assessed by experts.

Iron

Iron is a common substance found in well water. If water has a high iron content, it will be difficult to avoid brown stains on freshly washed laundry. Plumbing fixtures can be stained by water containing too much iron. The taste of water containing iron can be objectionable.

Lead

Lead is one contaminant you don't want to show up on a well test. It's possible for dangerous levels of lead to exist in a water source, but most water containing lead derives the detrimental element from plumbing pipes. Modern plumbing codes have provisions to guard against lead being introduced to potable water from piping, but older homes don't share this safeguard.

Manganese

Manganese, like iron, is very common in well water. Staining of laundry and plumbing fixtures is one reason to limit the amount of manganese in domestic water. It is not unusual for manganese to affect the taste of water adversely. Additionally, excessive consumption of manganese can cause health problems.

Nitrates

Nitrates show up most often in shallow wells. They can cause what is known as blue-baby disease in infants who ingest water containing it. Shallow wells that are located near livestock are susceptible to nitrate invasion.

Pesticides

As we all know, pesticides and well water don't mix--at least they shouldn't. Shallow wells located in areas where pesticides are used should be checked often to confirm the suitability of the well's water for domestic use.

Wells can also be contaminated during ground treatments for termite control around houses.

Sodium

Sodium can show up in well water. For average, healthy people this is not a problem. However, individuals who are forced to maintain low-sodium diets can be affected by the sodium content in water.

Sulfates

Sulfates in well water can act as a natural laxative. You can imagine why this condition would not be desirable in most homes.

Zinc

Zinc doesn't normally draw attention to itself as a health risk, and it is not a common substance in well water. But it can sometimes be present. Taste is normally the only objection to a quantityof zinc in well water.

Hard Water

Hard water is a common problem among well users. This type of water doesn't work well with soap and detergents. If you heat a pot of water on a stove and find a coating of a white dustlike substance left in the pan, it is a strong indication that hard water is present. This same basic coating can attack plumbing pipes and storage tanks, creating a number of plumbing problems. Hard water can even cause flush holes in the rims of toilets to clog up and make the toilets flush slowly or poorly.

Acidic Water

Acidic water is not uncommon in wells. When water has a high acid content, it can eat holes through the copper tubing used in plumbing systems. Plumbing fixtures can be damaged from acidic water. People with sensitive stomachs can suffer from a high acid content. The acidity of water is measured on a pH scale. This scale runs from 0 to 14. A reading of 7 indicates neutral water. Any reading below 7 is in an acidic range. Numbers above 7 are alkalinic.

Biological Factors

Biological factors can be a big concern for well water. To call water potable or suitable for domestic use, it must be free of disease-producing organisms. What are some of the organisms? Bacteria, especially of the coliform group, are one of them. Protozoa, virus, and helminths (worms) are others.

Biological problems can be avoided in many ways. One way is to use a water source that doesn't support much plant or animal life, such as a well. Springs, ponds, lakes, and streams are more likely to produce biological problems.

It is also necessary to protect a potable water source from contamination. The casing around a well does this. Light should not be able to shine on a water source, and a well cap or cover meets this requirement. Temperature can also play a part in bacterial growth, but the temperature of most wells is not something to be concerned about. If biological activity is a problem, various treatments to the water can solve it.

Radiological Factors

Radiological factors are not a big threat to most well users, but some risk does exist. Special testing can be done to determine if radioactive materials are a significant health risk in any given well. This test should in my opinion but conducted by experienced professionals. The same goes for biological testing.

Solving Water-Quality Problems

There are enough ways of solving water-quality problems that a small book could be written on the subject. Rather than give you a full tour of all aspects of water treatment, I will concentrate on the methods most often used in average homes. There is some form of treatment available for nearly any problem you encounter.

Bacteria

Bacteria in well water is serious. The most common method of dealing with this problem doesn't require any fancy treatment equipment. A quantity of chlorine bleach is usually all that is needed. Bleach is added to the contaminated well water and allowed to settle for awhile. After a prescribed time, the well is drained or run until no trace of the bleach is evident. This normally clears up biological activity. Sophisticated treatment systems do exist for nasty water, but the odds of needing it are remote.

Acid Neutralizers

Acid neutralizers are available at a reasonable cost to control high acid contents in domestic water. These units are fairly small, easy to install, not difficult to maintain, and don't cost a small fortune to purchase.

Iron

Iron and manganese can be controlled with iron-removal filters. Like acid neutralizers, these units are not extremely expensive, and they can be installed in a relatively small area. If both a water softener and an iron-removal system are needed, the iron-removal system should treat water before it reaches a water softener. Otherwise, the iron or manganese may foul the mineral bed in the water softener.

Water Softeners

Water softeners can treat hard water and bring it back to a satisfactory condition. The use of such a treatment system can prolong the life of plumbing equipment, while providing users with more desirable water quality.

Activated-Carbon Filters

Activated-carbon filters provide a solution for water that has a foul taste or odor. Many of these filters are simple, in-line units that are inexpensive and easy to install. When conditions are severe, a more extensive type of activated-carbon filter may be required. This type of filter can remove the ill effects of sulfur water (hydrogen sulfide).

Turbidity

Turbidity can be controlled with simple in-line filters. If the water being treated contains high amounts of particles, the cartridges in these filters will have to be changed frequently. Left unchanged, they can collect so many particles that water pressure is reduced greatly.

Understanding troubleshooting steps and knowing which symptoms point to specific problems are essential for anyone in a service-related business. Take the time to refine your troubleshooting skills, and you will find that your work is both more enjoyable and more profitable.

18

Septic Troubles

This chapter is filled with routine remedies for sorrowful septic troubles. If you install new septic systems for a living, you are bound to run into some problems after the job is done. Like any other type of new installation, there is a risk that something will go wrong while the installation is still under warranty. This makes a homeowner's problem a builder's problem.

If a builder such as yourself subs septic work out to an independent contractor, it does not make the independent contractor solely responsible for problems with a septic system. Since the builder is the general contractor, a customer for whom work is done has a right to look for help from the builder. In other words, even if you don't put a septic system in yourself, you are still responsible for it.

As a general contractor who has subcontracted a septic system, you are fortunate enough to have someone to call to solve your septic problems. If you install septic systems with an in-house crew, you or your employees will have to assume full responsibility. Either way, you need to be able to talk intelligently to your customers when problems arise.

There are several types of potential failures to consider. Many of the possibilities are avoidable if a builder informs customers of the dos and don'ts when a house is sold. Do you know what recommendations to make to your customers for the use of their septic systems? Many contractors don't. Even the ones who know what to say often never take the time to inform their customers. To me, this is stupid. If I can avoid warranty work by informing my customers, you can bet I'll spend a few minutes giving them the facts.

We are about to discuss many potential septic problems. But before we do, let me ask you a question. Pretend that I'm a homebuyer whom you are building a house for. Will I have any problems with my septic tank if you install a garbage disposer under my kitchen sink? Do you know what to tell me? If you don't, you should.

Garbage disposers are subject to conflicting reports from experts. Some plumbing codes prohibit the use of garbage disposers in houses where septic systems are used for waste disposal. Other plumbing codes do permit such installations. This would be the first thing you would need to know in order to answer my installation question. If it's against code to install a disposer, you have a quick answer to give me.

Assuming that the code will allow the use of a disposer, your answer should be more complex. For example, I might need a large septic tank to accommodate the use of a disposer. There is some risk that chunks of food from the disposer might clog up my drain field. If the field becomes clogged, it has to be dug up and repaired or replaced. It is not an inexpensive undertaking.

How you answer my installation question could have some serious effects on your company. For example, if you have me—the homeowner—sign a notice of what precautions to take and the potential risk I'm assuming by requiring you to install a garbage disposer, you're pretty well off the hook. If you don't advise me of the potential risks and simply tell me that it's no problem to install a disposer, I might be able to build a lawsuit against you when my septic system fails. Keep this type of scenario in mind as we discuss the various potential problems with septic systems. The more you can disclose to a customer in writing, the better off you are. It is, of course, always best to have customers sign a copy of the disclosure for you to keep in your files.

An Overflowing Toilet

Some homeowners associate an overflowing toilet with a problem in their septic system. It is possible that the septic system is responsible for the toilet backup, but in a house that is still under warranty this is not very likely. More likely, it is a stoppage either in the toilet trap or in the drainpipe. Knowing this can help you decide whom to send out on the call.

If you get a call from a customer who has a toilet flooding the bathroom, there is a quick, simple test you can have the homeowner perform to tell you more about the problem. Will the kitchen sink drain? Will other toilets in the house drain? If other fixtures drain just fine, the problem is not with the septic tank.

There are some special instructions that you should give your customers prior to asking them to test other fixtures. First, it is best if they use fixtures that are not in the same bathroom with the plugged-up toilet. Lavatories and bathing units often share the same main drain that a toilet

> **SEPTIC TIP**
>
> Whole-house backups (where none of the plumbing fixtures drains) indicate a problem in the building drain, the sewer, or the septic system. There is no way to know where the problem is until some investigative work is done.

uses. Testing a lavatory that is near a stopped-up toilet can tell you if the toilet is the only fixture affected. It can, in fact, narrow the likelihood of the problem down to the toilet's trap. But if the stoppage is some way down the drainpipe, it's conceivable that the entire bathroom group will be affected. It is also likely that if the septic tank is the problem, water will back up in a bathtub.

When an entire plumbing system is unable to drain, water will rise to the lowest fixture, which is usually a bathtub or shower. If there is no backup in a bathing unit, there probably isn't a problem with a septic tank. But backups in bathing units can happen even when the major part of a plumbing system is working fine. A stoppage in a main drain could cause the liquids to back up, into a bathing unit.

To determine if there is a total backup, have homeowners fill their kitchen sinks and then release all the water at once. Get them to do this several times. A volume of water may be needed to expose a problem. Simply running the faucet for a short while might not reveal a problem with the kitchen drain. If the kitchen sink drains successfully after several attempts, it's highly unlikely that there is a problem with the septic tank. This would mean that you should call your plumber, not your septic installer.

Whole-House Backups

Whole-house backups (where none of the plumbing fixtures drains) indicate a problem in the building drain, the sewer, or the septic system. There is no way to know where the problem is until some investigative work is done. This is not a good job to assign to homeowners. Your plumber is the most logical subcontractor to call when this type of problem exists. It's possible that the problem is associated with the septic tank, but your plumber will be able to pinpoint the location where trouble is occurring.

For all the plumbing in a house to back up, there must be some obstruction at a point in the drainage or septic system beyond where the last plumbing drain enters the system. Plumbing codes require clean-out plugs along drainage pipes. There should be a clean-out either just inside the foundation wall of a home or just outside the wall. This clean-out location and the access panel of a septic tank are the two places to begin a search for the problem.

If the access cover of the septic system is not buried too deeply, I would start there. But if extensive digging would be required to expose the cover, I would start with the clean-out at the foundation, hopefully on the outside of the house. Your plumber should be able to remove the clean-out plug and snake the drain. This will normally clear the stoppage, but you may not know what caused the problem. Habitual stoppages point to a problem in the drainage piping or septic tank.

Removing the inspection cover from the inlet area of a septic tank can show you a lot. For example, you may see that the inlet pipe doesn't have a tee fitting on it and has been jammed into a tank baffle. This could obviously account for some stoppages. Cutting the pipe off and installing the diversion fitting will solve this problem.

Sometimes pipes sink in the ground after they are buried. Pipes sometimes become damaged when a trench is backfilled. If a pipe is broken or depressed during backfilling, there can be drainage problems. When a pipe sinks in uncompacted earth, the grade of the pipe is altered and stoppages become more likely. You might be able to see some of these problems from the access hole over the inlet opening of a septic tank.

Once you remove the inspection cover of a septic tank, look at the inlet pipe. It should come into the tank with a slight downward pitch. If the pipe is pointing upward, it indicates improper grading and a probable cause for stoppages. If the inlet pipe is either not present or partially pulled out of the tank, there's a very good chance that you have found the cause of your backup. If a pipe is hit with a heavy load of dirt during

SEPTIC TIP

In the case of a new septic system, a total backup is most likely to be the result of some failure in the piping system between the house and the septic tank.

backfilling, it can be broken off or pulled out of position. This won't happen if the pipe is supported properly before backfilling, but someone may have cheated a little during the installation.

In the case of a new septic system, a total backup is most likely to be the result of some failure in the piping system between the house and the septic tank. If your problem is occurring during very cold weather, it is possible that the drainpipe has retained water in a low spot and that the water has since frozen. I've seen this happen several times in Maine with older homes (not ones that I've built).

Running a plumber's snake from the house to the septic tank will tell you if the problem is in the piping, assuming that the snake used is a pretty big one. Little snakes might slip past a blockage that is capable of causing a backup. An electric drain cleaner with a full-size head is the best tool to use.

The Problem Is in the Tank

There are times, even with new systems, when the problem causing a whole-house backup is in the septic tank. These occasions are rare, but they do exist. When this is the case, the top of the septic tank must be uncovered. Some tanks, like the one at my house, are only a few inches beneath the surface. Other tanks can be buried several feet below the finished grade. If you built the house recently, you should know where the tank is located and how deeply it is buried.

Once a septic tank is in full operation, it works on a balance basis. The inlet opening of a septic tank is slightly higher than the outlet opening. When water enters a working septic tank, an equal amount of effluent leaves the tank. This maintains the needed balance. But if the outlet opening is blocked by an obstruction, water can't get out. This will cause a backup.

Strange things sometimes happen on construction sites, so don't rule out any possibilities. It may not seem logical that a relatively new septic tank could be full or clogged, but don't bet on it. I can give you all kinds of things to think about. Suppose your septic installer was using up old scraps of pipe for drops and short pieces, and one of the pieces had a plastic test cap glued into the end of it? This could certainly render the septic system inoperative once the liquid rose to a point where it would attempt to enter the outlet drain. Could this really happen? I've seen the same type of situation happen with interior plumbing, so it could happen with the piping at a septic tank.

SEPTIC TIP

Can you have too much pitch on a drainpipe? Yes, you can. A pipe that is graded with too much pitch can cause several problems. In interior plumbing, a pipe with a fast pitch may allow water to race by without removing all the solids. A properly graded pipe floats the solids in the liquid as drainage occurs. If the water is allowed to rush out, leaving the solids behind, a stoppage will eventually occur.

What else could block the outlet of a new septic tank? Maybe a piece of scrap wood found its way into the tank during construction and is now blocking the outlet. If the wood floated in the tank and became aligned with the outlet drop, pressure could hold it in place and create a blockage. The point is that almost anything could block the outlet opening, so take a snake and see if it is clear.

If the outlet opening is free of obstructions and all drainage to the septic tank has been ruled out as a potential problem, you must look further down the line. Expose the distribution box and check it. Run a snake from the tank to the box. If it comes through without a hitch, the problem is somewhere in the leach field. In many cases, a leach-field problem will cause the distribution box to flood. If liquid rushes out of the distribution box, you should be alerted to a probable field problem.

Problems with a Leach Field

Problems with a leach field are uncommon among new installations. Unless the field was poorly designed or installed improperly, there is very little reason why it should fail. However, extremely wet ground conditions due to heavy or constant rains could force a field to become saturated. If the field saturates with ground water, it cannot accept the effluent from a septic tank. This in turn causes backups in houses. When this is the case, the person who created the septic design should be looked to in terms of fault.

I've never built a house where the leach field failed. But, as a plumbing contractor, I've responded to such calls, even for fairly new houses. The problem is usually a matter of poor workmanship. If you keep a watchful eye on your septic crew during an installation, you should not have to be awakened in the middle of a night by an irate customer with a failed leach field.

SEPTIC TIP

Older septic fields often clog up and fail. This type of problem is not likely to happen while a field is under warranty. But you may be interested to know which types of situations can cause a field failure.

Assuming that you are unfortunate enough to experience a saturated drain field, your options are limited. You might wait a few days in hopes that the field will dry out, and it might. Beyond that option, you've got some digging to do. Extending the size of the drain field is the only true solution when ground-water saturation is a seasonal problem.

Clogged with Solids

Some drain fields become clogged with solids. Financially, this is a devastating discovery. A clogged field has to be dug up and replaced. Much of the crushed stone might be salvageable, but the pipe, the excavation, and whatever new stone is needed can cost thousands of dollars. The reasons for a problem of this nature are either poor design, bad workmanship, or abuse.

If the septic tank is too small, solids are likely to enter the drain field. An undersized tank could be the result of a poor septic design, or it could come about as a family grows and adds onto their home. A tank that is adequate for two people may not be able to keep up with usage when four people are involved. Unfortunately, finding out that a tank is too small often doesn't happen until the damage has already been done.

As a builder, you might take on jobs that involve the building of room additions. If you do, and if a septic system is involved, you should check to see that you are not putting too much burden on the septic system. Local officials may require upgrades to an existing system when bedrooms are added to a house.

Why would a small septic tank create problems with a drain field? Septic tanks accept solids and liquids. Ideally, only liquids should leave the septic tank and enter the leach field. Bacterial action occurs in a tank to break down solids. If a tank is too small, there is not adequate time for the breakdown of solids to occur. Increased loads on a small tank can force solids down into the drain field. After this happens over time, the solids plug up the drainage areas in the field. This is when digging and replacement are needed.

Too Much Pitch

Can you have too much pitch on a drainpipe? Yes, you can. A pipe that is graded with too much pitch can cause several problems. In interior plumbing, a pipe with a fast pitch may allow water to race by without removing all the solids. A properly graded pipe floats the solids in the liquid as drainage occurs. If the water is allowed to rush out, leaving the solids behind, a stoppage will eventually occur.

In terms of a septic tank, a pipe with a fast grade can cause solids to be stirred up and sent down the outlet pipe. When a four-inch wall of water dumps into a septic tank at a rapid rate, it can create quite a ripple effect. The force of the water might generate enough stir to float solids that should be sinking. If these solids find their way into a leach field, clogging is likely.

Garbage Disposers

We talked a little bit about garbage disposers earlier. When a disposer is used in conjunction with a septic system, there are more solids than would be present without a disposer. This, where code allows, calls for a larger septic tank. Due to the increase in solids, a larger tank is needed for satisfactory operation and a reduction in the risk of a clogged field. I remind you again, some plumbing codes prohibit the use of garbage disposers where a septic system is present.

Other Causes

Other causes for field failures can be related to collapsed piping. This is not common with today's modern materials, but it is a fact of life with some old drain fields. Heavy vehicular traffic over a field can compress it and cause the field to fail. This is true even of modern fields. Saturation of a drain field will cause it to fail. This could be the result of seasonal water tables or prolonged use of a field that is giving up the ghost.

Septic tanks should have the solids pumped out of them on a regular basis. For a normal residential system, pumping once every two years should be adequate. Septic professionals can measure sludge levels and determine if pumping is needed. Failure to pump a system routinely can result in a buildup of solids that may invade and clog a leach field.

House Stinks

Have you ever had a customer call and say, "My house stinks"? This has never happened to me as a builder, but it has been a complaint that my plumbing company has dealt with. Houses sometimes develop unpleasant odors associated with a drainage or septic system. This can occur even in new houses. In fact, it happened in my mother-in-law's new house a couple of years ago.

Sewer gas is a natural element in drains and septic systems. The odor associated with this gas, which by the way is extremely flammable, is normally controlled with the use of vent pipes and water-filled fixture traps. If a fixture trap loses its water seal, gas can escape into a home. This is dangerous and unpleasant. A faulty wax ring under a toilet can lead to the same problem. So can blocked vents and leaking pipe joints.

If you have a customer who is complaining of sewer odors inside the house, call your plumber. The first thing an experienced plumber will check are the trap seals. In a fixture that is not used often, the water in its trap will evaporate. When this happens, sewer gas has a direct path into a home. This is common with floor drains and seldom used fixtures.

In my mother-in-law's case, the problem was a dry trap at her downstairs shower. The shower was almost never used, and the trap seal evaporated. I ran the shower for a few minutes to fill the trap and solved her problem. She now runs water in the shower periodically to prevent a reoccurrence of the odor.

When the source of the odor seems to be a toilet, the wax seal between the toilet bowl and its flange should be replaced. More complex problems can also occur in a plumbing system. For example, I once had a new house where the plumbing crew forgot to remove their test caps from the roof vents. Capped off, the vents couldn't work. This affected the drainage more than the odors. A poorly vented drain will drain very

SEPTIC TIP

Floor drains are frequently a cause of interior odors. Since these drains see so little use, their seals evaporate. Unless the trap is fitted with a trap primer, water must be poured down the drain now and then. A primer is a little water line that maintains a trap seal automatically, but it is not common in residential applications.

slowly. But a plugged vent, such as one that is filled with ice or that has a bird's nest in it, can start an odor problem. If leaking joints are suspected in a vent or drainage system, there are special tests that your plumber can perform. Colored smoke can be used to reveal leak locations. Another test uses a peppermint smell to pinpoint odor leaks. Your plumber should be aware of both of these tests.

Outside Odors

Outside odors normally have to do with a leach field. But the problem could be with the plumbing vents on top of a house. Sewer gas escapes from plumbing vents. Under most conditions it goes unnoticed. But under the right weather conditions, such as heavy air with no breeze, the odor from a vent might be forced down to where you can smell it. If a vent is too close to an open window, the gas can come into a house. The plumbing code sets standards for vent placement and height. If these regulations are observed, a problem should not exist. However, a short vent pipe or a vent that is close to a window or other ventilating opening could cause some problems.

Puddles and Odors

Puddles and odors are sometimes found in and near leach fields. If you have septic puddles, you're going to have septic odors. Pumping out the septic tank won't help here. Your problem is with the field itself. It is not too unusual for this type of problem to attack fairly new systems that were not installed properly.

One main reason for puddles in a new system is the grade on the distribution pipes in the leach field. These pipes should be installed relatively level. If they have a lot of pitch, effluent will run to the low end and build up. This causes the puddle and the odor. A sloppy installer who doesn't maintain an even, nearly nonexistent grade while installing pipes in a septic field can be the root cause of your problem. And, it's an expensive problem to solve.

Since effluent is running quickly to a low spot, most of the absorption field is not being utilized. It doesn't mean that the field is too small, although this could cause liquid to surface. In the case of overgraded pipes, the problem is that most of the leach field is not being used, and the volume being dumped in the low spot cannot be absorbed quickly enough. This will require excavating the field and correcting the pipe grade. Not a cheap situation. If, as a builder, you find the field pipes to be installed with too much grade, you should have some opportunity to force the septic installer to pay for corrections.

Saturation in part of a septic field will cause outside odors. The ground may drain naturally and solve the problem in time. This could be the case if odors occur only after heavy or prolonged rains. Outside odors shouldn't exist with septic systems. When they are present, especially for several days, you are probably looking at an expensive problem.

Supervision

Supervision of the work being done as septic systems are installed is one of your best protections as a builder. Homeowners might not expect you to be an expert in the installation of septic systems, but you can bet that they will expect you to provide them with a good job. If this means crawling down into a septic bed and putting a level on the distribution pipes to check for excessive grading, do it. As the builder and general contractor of a house with a septic system, you cannot avoid responsibility for the system.

You can take the attitude that you shouldn't have to get personally involved with the installation of a septic system. Your position might be that you hire competent professionals to make your septic installations and a code office inspects the work, so why should you inspect? I don't think that this position will hold up in court. Even if you never go to court, you have your reputation as a builder to think of. If your customers are getting bad septic systems, you're going to get a bad reputation. Some supervision on your part can avoid this problem.

When a Problem Occurs

When a problem occurs with a septic system that you are involved with, take fast action. Don't put your customers off. Most people are forgiving of mistakes as long as corrective action is taken quickly. Since you are not likely to know where the problem is coming from, a call to your plumber is usually a good first step. If you can't get your plumber quickly, go to the customer's house personally. An inspection done by you might not reveal the cause of a septic problem, but it will have a favorable impact on the customer. A visit of this type also buys you time to get your plumber or septic installer on the job.

A quick response is necessary when a customer's plumbing is failing. However, haste in making decisions as to what's causing the problem should never be considered. Take your time. Make your plumber investigate the situation thoroughly. Solve the problem right the first time. If you make some token gesture at fixing the problem and it doesn't work, you are going to look incompetent. It's better to spend enough time to fix a problem right the first time than it is to run back and forth trying one fix after another until you hit upon the right one.

Don't Be Afraid to Ask for Help

Don't be afraid to ask for help when you are faced with a septic problem. Unless you installed the system yourself, you should have some professionals available to help you. Your plumber and your septic installer can both be of help, and they both have a stake in your problems. Call them. Ask them to come out and investigate the problem. If they like working for you, they'll come.

Even if you installed a system yourself, consider calling in some experts when you are up against tough troubleshooting problems. Septic installers should be willing to help you for a price. County officials are another potential source of help. The person who drew your septic design might be able to shed some light on the cause of your problem. Make some phone calls. Get advice, even if you have to pay for it. You owe it to your customers to solve their warranty problems. If you don't offer your help freely, you may find yourself being served with legal papers.

Fortunately, problems with new septic systems are rare. Unless someone made a mistake in the design or installation, a septic system should function without failure for many, many years. A good system could easily go 20 years or more without anything more than routine pumping. With some exceptions a leach field should last indefinitely when installed with modern materials and proper workmanship.

Don't be afraid of septic systems. It's okay to respect them, but there is no reason to fear them. I've worked with septic systems for decades, and I've never had any significant problems. If you make it a rule not to build houses where septic systems are needed, you will be throwing away a lot of good work potential.

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Know Your Limitations

If you are going to participate in the installation of wells and septic systems for houses that you are building, you must know your limitations. Rules for the installation of wells and septic systems vary from state to state and jurisdiction to jurisdiction. Before you decide to become an installer, you must confirm that you are within the rules and regulations of your jurisdiction to perform the proposed work.

The first step in doing your own installations is to contact your local code-enforcement office. Confirm that special licenses are not required for the installation of well pumps or septic systems. I am assuming that you don't have and are not planning to purchase the equipment needed to create a well. Therefore, you are dealing with the well pump and the septic system if you are allowed to.

For the sake of this chapter, assume that you work in a region where builders are allowed to participate in the installation of well and septic systems. You may be limited as to what you can do, but there are still ways to stretch your hard-earned dollars if your subcontractor is willing to work with you. Since subcontractors may be needed for some elements of the work you have to do, let's talk about how you might convince them to allow you to take an active interest in your projects.

> **PRO POINTER**
>
> Special licensure may be required to install well and septic systems in your region.

PRO POINTER

Economic conditions can have a major impact on how flexible subcontractors will be in giving up some parts of jobs that they would normally perform.

Subcontractors

Subcontractors generally want as much work as they can handle. They can resist giving up any part of a job. For example, a pump installer may not want a builder to provide trenching work. A septic installer might hesitate to do an installation where a builder is providing the site work for a septic system.

Well Systems

Well systems typically have three major elements to be considered. A trench between the well and a home is needed. Installation of a pump is a second requirement in the installation of well systems. Then there is the work required to install the piping between the pump and the plumbing system of a home. Any one of these steps could save you money if you do the work yourself.

It is not uncommon for the installation of well pumps and piping to be installed by well drillers and plumbers. This is often due to licensing requirements. Many jurisdictions require installers to be licensed. Even when this is the case, the trenching can still be done by a builder.

The installation of a well pump and the related piping is not difficult. There are places where the installations are allowed to be done by builders. The work may still need to be inspected by a code officer, so check all local code regulations.

PRO POINTER

Make sure that all required code inspections are made before concealing any work.

Septic Systems

The installation designs for septic systems are usually done by engineers. This is not a job for an average builder. Once an approved design is in hand, the work required to install a septic system is normally well documented. Reading a septic design is similar to reading blueprints. Anyone with mechanical skills and the ability to follow instructions could logically install a septic system once they have an approved design.

When a septic system is built, there is often site work required to clear an area for the system. Builders can do this work. Then there is trenching and excavation for the tank. Again, builders can do this work. The actual placement of components for septic systems may have to be done by a licensed installer. A code inspection of the work is generally required prior to covering any of the components or installation work. Once a system is installed and inspected, it has to be covered. This is work that a builder can do. As you can see, there is a lot of work that a builder can do even when installers are required to be licensed. But you may still have a problem with your subcontractors.

Negotiations

Negotiations between builders and subcontracts can become spirited. The builders have the work, and the subcontractors want the work. With the proper negotiations a deal can often be struck. In good times, subcontractors may have enough opportunity to work without your job. This weakens your position. However, when times are tight and home building is down, you are holding the high cards. You must weigh the market conditions prior to approaching your subcontractors.

If the volume of construction is down, you should be able to persuade your subcontractors to allow you to do elements of a job that you want to do to save money. The subcontractors will be seeking work aggressively. If you have work to offer, most of them will talk to you and compromise on what they will and will not accept. Some subs will walk away if they don't get the entire job, but others will cooperate with you.

When construction is booming, it may not be worth your time to take on portions of the work for installing well and septic systems. Where should you invest your time? Shouldn't you be selling more houses? This would be my line of thinking.

Subcontractors who have plenty of work to choose from are unlikely to accept jobs where they are getting only portions of a job. This puts builders in a difficult spot. You might not be able to convince subcontractors to compromise during busy times.

What Will You Need?

If you decide to do part or all of your own well and septic-system installations you will need access to specialized tools and equipment. What will you need? It depends on what portions of the work you are doing.

The installation of a well system requires plumbing tools and trenching equipment. It is common to rent trenching equipment on a daily basis. Unless you plan to use the equipment very frequently, it is not feasible to purchase it. The plumbing tools, on the other hand, are minimal and can be purchased. These are largely hand tools that can be acquired for a few hundred dollars or less.

Septic systems are easiest to install when the installer has access to dump trucks, trenching equipment, and excavation equipment. You can hire contract drivers to satisfy the need for dump trucks. Trenching equipment can be rented, as can excavation equipment. Renting is the most reasonable option for these needs.

The basic tools needed for installing a septic system are minimal, with one exception. Hand tools for the job don't amount to much. You can probably buy all of the required hand tools for less than $200. I said there was an exception. It is a transit setup to confirm elevations. The person installing a leech field and septic tank will need to compute elevations and grades. Many builders already own this type of equipment. If you don't have the equipment, consider renting it.

The Drawbacks

What are the drawbacks of doing well and septic work yourself when you are a builder? The first consideration is liability. Work that you do will make you the liable party. This is worth weighing. When you subcontract the complete job and make certain that you have suitable certificates of insurance on file for your subcontractors, the risk of being

PRO POINTER

Septic designs are normally prepared by engineers.

hurt for system failure is reduced. It is not eliminated, but you do lower the risk considerably.

Taking time away from your normal duties as a builder is another drawback to taking on more work that is outside your normal area of expertise. If work is limited and difficult to find, this may be reason to reach out to save what you can where you can. Participation in the installation of well and septic systems can enhance your bottom line.

Who will warranty the work done as a team? At what point are you responsible, and at what point is your subcontractor responsible? This can be a difficult question to answer. It is, however, worth considering.

There are pros and cons to most everything we do. It will be up to you to decide if you should take a role in the hands-on installation of well and septic systems. Do your homework. Know what you are getting into. Don't jump in on a whim. Run the numbers. Once you are satisfied with your decision, stick with it and make it work.

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Landscaping Septic Systems

Landscaping septic-system areas is often needed to prevent erosion, but these areas have limitations on the types of landscaping that can be done. Obviously, it would not be wise to plant willow trees over a distribution area. The roots of this type of tree would get into the system and wreak havoc.

There are two prime considerations when landscaping a septic area. The first is appearance, and the second is plant choice. Picking the right plants is very important. Other considerations include creating a landscaping plan that will not require a lot of hands-on attention. Traffic, even foot traffic, should be avoided on septic mounds. If the landscaping plan requires frequent maintenance, the foot traffic in the area can be detrimental to the system.

Appearance

The appearance of a septic area can be enhanced greatly with good landscaping. Some distribution fields are flat and require no more effort than a lawn to fit into the landscape. But mound systems, for example, can be quite noticeable if they are merely planted with grass. A staggering of plants that grow to various heights is a good way to draw attention away from the shape of distribution mounds. Since appearance is a personal matter, we are not going to spend a lot of time on the subject. You and your customers will know the look you are after. However, you might not

> **SEPTIC TIP**
>
> Avoid traffic, even foot traffic, on septic mounds.

> **PRO POINTER**
>
> The types of plants used on a mound or distribution field should be of a type that does not require or seek out a lot of water. You don't want the roots getting into the distribution system.

know what your limitations are, so let's talk about the types of plants that should and should not be used.

General Information

There is some general information to keep in mind when planting over a septic system. Don't do excessive tilling of soil over the distribution area when planting. Too much tilling can result in erosion of a septic mound. It's a good idea to wear rugged gloves when working with soil over a septic system. Coming into direct contact with septic soil could create a potential health risk. Avoid skin contact with the soil if the system has been in operation.

The types of plants used on a mound or distribution field should be of a type that does not require or seek out a lot of water. You don't want the roots getting into the distribution system. Trees and shrubs should not be planted directly over mounds or distribution pipes. In fact, no woody plant should be planted on a mound or over a distribution field. Herbaceous (nonwoody) plants are best for installations on mounds and over septic fields.

Trees and shrubs can be used as a part of the landscaping plan but should not be too close to the distribution area. A rule of thumb is to keep trees and shrubs at least 20 feet away from the edge of the mound or field. If the trees being planted are known for seeking water, they should be planted at least 50 feet away. Some examples of these types of trees are poplar, maple, and elm.

The use of irrigation and fertilization on mounds is not recommended. Erosion is always a concern with mounds, so irrigation should not

> **PRO POINTER**
>
> The use of irrigation and fertilization on mounds is not recommended.

PRO POINTER

Flowers are an excellent choice for landscaping septic areas. Annual flowers can be used to make a seasonal splash of color. Perennial flowers, such as daylilies, can be grown in the septic area. Erosion can be a concern with flowers. The flowers should either be planted close together or mulched well to prevent erosion.

be a part of your landscaping plan. Root barriers can be installed to reduce the risk of roots reaching down into a septic system. A common form of root barrier is a geotextile membrane that is impregnated with a long-lasting herbicide that will kill plant roots. If animal burrowing or tunneling is discovered on a mound, you must take steps quickly to eliminate the activity. This type of destruction can lead to serious erosion and a costly repair to the septic system. A final piece of general advice is to avoid planting edible plants, such as vegetables and herbs, on a mound or drain field.

Plant Selection

Plant selection is a critical part of successful landscaping over septic mounds and fields. Geographical location has a lot to do with the types of plants that are suitable for landscaping. A job in Virginia is likely to have very different plants than a job in Maine would have. The climate drives much of the decision as to which plants will thrive. In the simplest of terms, grasses and flowers are the two best choices for landscaping septic mounds and fields. Deciding on which specific types of flowers and grasses to use will be dependent on climatic conditions. For this reason, I am not in a position to tell you precisely which types of plants are best in your region. To do so would require far more room than we have here to discuss the topic. But, I can give you some pointers.

Grass

Grass is usually the first thing planted on a septic mound or distribution field. A fine fescue grass can create dense cover that doesn't need a lot of mowing. This is good, since foot traffic over the septic system should be minimal. Fescue grass is a traditional lawn grass. It can tolerate dry soil and shady sites. This makes it ideal for a septic application. Remember to obtain grass that does not require frequent cutting or watering.

Flowers

Flowers are an excellent choice for landscaping septic areas. Annual flowers can be used to make a seasonal splash of color. Perennial flowers, such as daylilies, can be grown in the septic area. Erosion can be a concern with flowers. The flowers should either be planted close together or mulched well to prevent erosion. Wildflower assortments do well in septic situations. Violets, butterfly weed, prairie clover, wild geranium, and similar flowers all work well if they are hardy enough to grow in your region.

Other Options

In addition to grasses and flowers, there are other options. Trees and shrubs need to be kept away from the primary septic drainage area, but they can be used at a distance to add to the appearance of a mound or distribution field. What else can you use to dress up a mound? How about some colorful gravel? Have you considered attractive lawn ornaments? Would a birdbath in an area where foot traffic is acceptable look good? Pine-bark mulch can be used to accent landscaping. Short fencing, the type that is used around small flowerbeds, can be used to add both color and shape to a mound.

Creativity is the key when it comes to landscaping. Septic systems do demand that certain limitations be placed on the materials used for landscaping, but there are a lot of options available. Talk to your local nurseries to determine what plants will grow well in your area and not invade the septic distribution system. With a creative eye and some help from local plant professionals, you can create a fantastic look on what might otherwise be an eyesore.

Appendix A

Definitions

Aggregate: Hard rock that is graded with a value of three or more and washed with pressurized water over a screen to remove the fine material. A hardness value of three or more on the Mohs' scale of hardness means that it will scratch a copper penny without leaving a residue.

Alluvium: Soil deposits due to floodwaters.

Bedrock: Rock underneath or at the earth's surface. It is composed of weathered, in-place consolidated material, larger than 0.08 inch in size and greater than 50 percent by volume.

Cesspool: A covered excavation designed to retain organic matter and solids while receiving sewage or other organic wastes from a drainage system. The liquids then seep into soil cavities.

Clear-water wastes: Liquid having no impurities or impurities reduced below a harmful level. This liquid can come from cooling water and condensate drainage, water used for equipment-chilling purposes, or cooled condensate from steam heating systems.

Code official: The designated authority charged with administration and enforcement of a code or a duly authorized representative.

Colluvium: Soil moved by gravity.

Color: Based on the Munsell soil-color charts, the color of soil when moist.

Construction documents: All the documents necessary for obtaining a building permit.

Conventional soil-absorption system: A system in which effluent is elevated or distributed to a seepage trench or bed.

Effluent: Liquid discharged from a septic or treatment tank.

Flood fringe: The part of the flood plain located outside of the floodway and usually covered with standing water during regional floods.

Floodway: The channel that carries and discharges flood water in a river or stream; it can also include portions of the flood plain.

High ground water: Soil-saturation zones, aquifers, or periodically saturated zones.

High-water level: The highest known floodwater elevation of a water body as established by a state or federal agency.

Holding tank: An approved, watertight container for holding sewage.

Horizontal reference point: A stationary point to which horizontal dimensions are related.

Legal description: A lot and block number, a recorded assessor's plat, a public land-survey description, or an accurate metes-and-bounds description.

Manhole: An opening that allows a person to gain access to a sewer or sewage-disposal system.

Mobile unit: A portable structure with or without a permanent foundation, designed to be moved from one site to another.

Mobile-unit park: A plot of ground upon which two or more mobile units are located and owned by a person or a state or local government.

Nuisance: In common law or equity jurisprudence, whatever is dangerous to human life or health; a structure that is not well ventilated, sewered, cleaned or lighted; or whatever renders air, food, drink, or the water supply unwholesome.

Pan: A soil horizon cemented with an agent such as iron, organic matter, silica, or a combination of chemicals. It resists penetration with a knife blade and is impermeable or slowly permeable.

Percolation test: A way of testing soil-absorption qualities.

Permeability: The ease with which liquids move through soil; it is listed in soil-survey reports.

Pressure-distribution system: The introduction of effluent into the soil by a pump or automatic siphon, using piping with small-diameter perforations.

Private sewage-disposal system: A sewage-treatment system consisting of a septic tank and soil-absorption field, usually serving a single structure; it can also be an alternative sewage-disposal system, a system serving more than one structure, or a system located on a different parcel of land than the structure. Such a system can be owned by the property owner or a special-purpose district.

Privy: A structure used by persons for deposition of body waste but not connected to a plumbing system.

Registered design professional: A person licensed to practice a design profession as defined in statutory requirements of the jurisdiction in which the project is to be constructed.

Seepage bed: An excavated area of larger than five feet with a bedding of aggregate and more than one distribution line.

Seepage pit: A pit that allows disposal of effluent by means of an underground receptacle that absorbs soil through its floor and walls.

Seepage trench: A trench containing a bedding of aggregate and a single distribution line over an excavated area of one to five feet in width.

Septage: Material removed from a private sewage treatment and disposal system.

Septic tank: A tank that separates sewage into solids and liquids by the processes of sedimentation, floatation, and bacterial action. The liquid is then discharged into a soil-absorption system.

Soil: Porous material 0.08 inch and smaller over bedrock.

Soil boring: An observation pit, an augured hole, or a soil core taken intact and undisturbed with a probe.

Soil mottles: Contrasting soil colors caused by saturation over a normal year with a color value (lightness) of four or more and chroma (purity) of two or less.

Soil saturation: A condition in which all pores in a soil are filled with water and the water flows into a bore hole.

Vent cap: An approved cover for the vent terminal of an effluent-disposal system to prevent accidental closure and still permit circulation of air.

Vertical-elevation reference point: A visible stationary point for establishing the relative elevation of percolation tests and soil borings.

Watercourse: A stream flowing in a definite channel and discharging into another body of water. A watercourse is more than mere surface drainage in legal terms; it has a bed and banks and may sometimes dry up.

Workmanship: Work that secures health, safety, and welfare protection as intended in all sections of a code.

Appendix B

Additional Resources

The term "head" by itself is rather misleading. It is commonly taken to mean the difference in elevation between the suction level and the discharge level of the liquid being pumped. Although this is partially correct, it does not include all of the conditions that should be included to give an accurate description.

■ **Friction Head:** The pressure expressed in lbs./sq. in. or feet of liquid needed to overcome the resistance to the flow in the pipe and fittings.

■ **Suction Lift:** Exists when the source of supply is below the center line of the pump.

■ **Suction Head:** Exists when the source of supply is above the center line of the pump.

■ **Static Suction Lift:** The vertical distance from the center line of the pump down to the free level of the liquid source.

■ **Static Suction Head:** The vertical distance from the center line of the pump up to the free level of the liquid source.

■ **Static Discharge Head:** The vertical elevation from the center line of the pump to the point of free discharge.

■ **Dynamic Suction Lift:** Includes static suction lift, friction head loss and velocity head.

■ **Dynamic Suction Head:** Includes static suction head minus friction head minus velocity head.

■ **Dynamic Discharge Head:** Includes static discharge head plus friction head plus velocity head.

■ **Total Dynamic Head:** Includes the dynamic discharge head plus dynamic suction lift or minus dynamic suction head.

■ **Velocity Head:** The head needed to accelerate the liquid. Knowing the velocity of the liquid, the velocity head loss can be calculated by a simple formula Head = $V^2/2g$ in which g is acceleration due to gravity or 32.16 ft./sec. Although the velocity head loss is a factor in figuring the dynamic heads, the value is usually small and in most cases negligible. See table.

BASIC FORMULAS AND SYMBOLS

Formulas

$$GPM = \frac{Lb./Hr.}{500 \times Sp.\ Gr.}$$

$$H = \frac{2.31 \times psi}{Sp.\ Gr.}$$

$$H = \frac{1.134 \times In.\ Hg.}{Sp.\ Gr.}$$

$$H_V = \frac{V^2}{2g} = 0.155\ V^2$$

$$V = \frac{GPM \times 0.321}{A} = \frac{GPM \times 0.409}{(I.D.)^2}$$

$$BHP = \frac{GPM \times H \times Sp.\ Gr.}{3960 \times Eff.}$$

$$Eff. = \frac{GPM \times H \times Sp.\ Gr.}{3960 \times BHP}$$

$$N_s = \frac{N\sqrt{GPM}}{H^{3/4}}$$

$$H = \frac{V^2}{2g}$$

Symbols

GPM = gallons per minute
Lb. = pounds
Hr. = hour
Sp. Gr. = specific gravity
H = head in feet
psi = pounds per square inch
In. Hg. = inches of mercury
h_v = velocity head in feet
V = velocity in feet per second
g = 32.16 ft./sec.^{2} (acceleration of gravity)
A = area in square inches (πr^2) (for a circle or pipe)
ID = inside diameter in inches
BHP = brake horsepower
Eff. = pump efficiency expressed as a decimal
N_s = specific speed
N = speed in revolutions per minute
D = impeller in inches

Approximate Cost of Operating Electric Motors

Motor HP	*Average kilowatts input or cost based on 1 cent per kilowatt hour		Motor HP	*Av. kw input or cost per hr. based on 1 cent per kw hour
	1 Phase	3 Phase		3 Phase
⅓	.408		20	16.9
½	.535	.520	25	20.8
¾	.760	.768	30	26.0
1	1.00	.960	40	33.2
1½	1.50	1.41	50	41.3
2	2.00	1.82	60	49.5
3	2.95	2.70	75	61.5
5	4.65	4.50	100	81.5
7½	6.90	6.75	125	102
10	9.30	9.00	150	122
			200	162

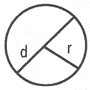
Figure B.1 Terms and usable formulas. © *ITT Goulds Pumps.*

BASIC FORMULAS AND SYMBOLS

Temperature conversion

DEG. C = (DEG. F – 32) x .555

DEG. F = (DEG. C x 1.8) + 32



CIRCLE

Area of a Circle

A = area; C = circumference. D = diameter

$A = \pi r^2$; $\pi = 3.14$ r = radius

$C = 2\pi r$

Water Horsepower = $\frac{\text{GPM x 8.33 x Head}}{33000} = \frac{\text{GPM x Head}}{3960}$

Where:
GPM = Gallons per Minute
8.33 = Pounds of water per gallon
33000 = Ft. Lbs. per minute in one horsepower
Head = Difference in energy head in feet (field head).

Laboratory BHP = $\frac{\text{Head x GPM x Sp. Gr.}}{\text{3960 x Eff.}}$

Field BHP = Laboratory BHP + Shaft Loss

Total BHP = Field BHP + Thrust Bearing Loss

Where:
GPM = Gallons per Minute
Head = Lab. Head (including column loss)
Eff. = Lab. Eff. of Pump Bowls
Shaft Loss = HP loss due to mechanical friction of lineshaft bearings
Thrust Bearing Loss = HP Loss in driver thrust bearings
(See (1) below under Misc.)

Input Horsepower = $\frac{\text{Total BPH}}{\text{Motor Eff.}}$

Motor Eff. from Motor mfg. (as a decimal)

Field Efficiency = $\frac{\text{Water Horsepower}}{\text{Total BHP}}$

Water HP as determined above
Total BHP as determined above

Overall Plant Efficiency = $\frac{\text{Water Horsepower}}{\text{Input Horsepower}}$

(See (2) below under Misc.)
Water HP as determined above
Input HP as determined above

Electrical

Input Horsepower = $\frac{\text{BHP}}{\text{Mot. Eff.}} = \frac{\text{4.826 x K x M x R}}{\text{T}} = \frac{\text{1.732 x E x I x PF}}{746}$

BHP = Brake Horsepower as determined above
Mot. Eff. = Rated Motor Efficiency
K = Power Company Meter Constant
M = Power Company Meter Multiplier, or Ratio of Current and Potential Transformers connected with meter
R = Revolutions of meter disk
T = Time in Sec. for R
E = Voltage per Leg applied to motor
I = Amperes per Leg applied to motor
PF = Power factor of motor
1.732 = Factor for 3-phase motors. This reduces to 1 for single phase motors

Kilowatt input to Motor = .746 x I.H.P. = $\frac{\text{1.732 x E x I x PF}}{1000}$

KW-Hrs. Per 1000 Gallons of Cold Water Pumped Per Hour = $\frac{\text{HD in ft. x 0.00315}}{\text{Pump Eff. x Mot. Eff.}}$

Miscellaneous

(1) **Thrust Bearing Loss** = .0075 HP per 100 RPM per 1000 lbs. thrust.*
(2) **Overall Plant Efficiency sometimes referred to as "Wire to Water" Efficiency**
***Thrust (in lbs.)** = (thrust constant (k) laboratory head) + (setting in feet x shaft wt. per ft.)
Note: Obtain thrust constant from curve sheets

Discharge Head (in feet of fluid pumped) = $\frac{\text{Discharge Pressure (psi) x 2.31}}{\text{Sp. Gr. of Fluid Pumped}}$

Figure B.2 Terms and usable formulas. © *ITT Goulds Pumps.*

Decimal and Millimeter Equivalents of Fraction

Inches		Millimeters	Inches		Millimeters
Fractions	Decimals		Fractions	Decimals	
1/64	.015625	.397	33/64	.515625	13.097
1/32	.03125	.794	17/32	.53125	13.494
3/64	.046875	1.191	35/64	.546875	13.891
1/16	.0625	1.588	9/16	.5625	14.288
5/64	.078125	1.984	37/64	.578125	14.684
3/32	.09375	2.381	19/32	.59375	15.081
7/64	.109375	2.778	39/64	.609375	15.487
1/8	.125	3.175	5/8	.625	15.875
9/64	.140625	3.572	41/64	.640625	16.272
5/32	.15625	3.969	21/32	.65625	16.669
11/64	.171875	4.366	43/64	.671875	17.066
3/16	.1875	4.763	11/16	.6875	17.463
13/64	.203125	5.159	45/64	.703125	17.859
7/32	.21875	5.556	23/32	.71875	18.256
15/64	.234375	5.953	47/64	.734375	18.653
1/4	.250	6.350	3/4	.750	19.050
17/64	.265625	6.747	49/64	.765625	19.447
9/32	.28125	7.144	25/32	.78125	19.844
19/64	.296875	7.541	51/64	.796875	20.241
5/16	.3125	7.938	13/16	.8125	20.638
21/64	.328125	8.334	53/64	.828125	21.034
11/32	.34375	8.731	27/32	.84375	21.431
23/64	.359375	9.128	55/64	.859375	21.828
3/8	.375	9.525	7/8	.875	22.225
25/64	.390625	9.922	57/64	.890625	22.622
13/32	.40625	10.319	29/32	.90625	23.019
27/64	.421875	10.716	59/64	.921875	23.416
7/16	.4375	11.113	15/16	.9375	23.813
29/64	.453125	11.509	61/64	.953125	24.209
15/32	.46875	11.906	31/32	.96875	24.606
31/64	.484375	12.303	63/64	.984375	25.003
1/2	.500	12.700	1	1.000	25.400

Atmospheric Pressure, Barometer Reading and Boiling Point of Water at Various Altitudes

Altitude		Barometer Reading		Atmos. Press.		Boiling Pt. of Water °F
Feet	Meters	In. Hg.	Mm. Hg.	Psia	Ft. Water	
- 1000	- 304.8	31.0	788	15.2	35.2	213.8
- 500	- 152.4	30.5	775	15.0	34.6	212.9
0	0.0	29.9	760	14.7	33.9	212.0
+ 500	+ 152.4	29.4	747	14.4	33.3	211.1
+ 1000	304.8	28.9	734	14.2	32.8	210.2
1500	457.2	28.3	719	13.9	32.1	209.3
2000	609.6	27.8	706	13.7	31.5	208.4
2500	762.0	27.3	694	13.4	31.0	207.4
3000	914.4	26.8	681	13.2	30.4	206.5
3500	1066.8	26.3	668	12.9	29.8	205.6
4000	1219.2	25.8	655	12.7	29.2	204.7
4500	1371.6	25.4	645	12.4	28.8	203.8
5000	1524.0	24.9	633	12.2	28.2	202.9
5500	1676.4	24.4	620	12.0	27.6	201.9
6000	1828.8	24.0	610	11.8	27.2	201.0
6500	1981.2	23.5	597	11.5	26.7	200.1
7000	2133.6	23.1	587	11.3	26.2	199.2
7500	2286.0	22.7	577	11.1	25.7	198.3
8000	2438.4	22.2	564	10.9	25.2	197.4
8500	2590.8	21.8	554	10.7	24.7	196.5
9000	2743.2	21.4	544	10.5	24.3	195.5
9500	2895.6	21.0	533	10.3	23.8	194.6
10000	3048.0	20.6	523	10.1	23.4	193.7
15000	4572.0	16.9	429	8.3	19.2	184.0

Figure B.3 Conversion charts. © *ITT Goulds Pumps.*

Head and Pressure Equivalents

1. Feet Head of Water and Equivalent Pressures
To change head in feet to pressure in pounds, multiply by .434

Feet Head	PSI	Feet Head	PSI	Feet Head	PSI	Feet Head	PSI
1	.43	30	12.99	140	60.63	300	129.93
2	.87	40	17.32	150	64.96	325	140.75
3	1.30	50	21.65	160	69.29	350	151.58
4	1.73	60	25.99	170	73.63	400	173.24
5	2.17	70	30.32	180	77.96	500	216.55
6	2.60	80	34.65	190	82.29	600	259.85
7	3.03	90	38.98	200	86.62	700	303.16
8	3.46	100	43.31	225	97.45	800	346.47
9	3.90	110	47.64	250	108.27	900	389.78
10	4.33	120	51.97	275	119.10	1000	433.09
20	8.66	130	56.30	-	-	-	-

2. Pressure and Equivalent Feet Head of Water
To change pounds pressure to feet head, multiply by 2.3

PSI	Feet Head	PSI	Feet Head	PSI	Feet Head	PSI	Feet Head
1	2.31	20	46.18	120	277.07	225	519.51
2	4.62	25	57.72	125	288.62	250	577.24
3	6.93	30	69.27	130	300.16	275	643.03
4	9.24	40	92.36	140	323.25	300	692.69
5	11.54	50	115.45	150	346.34	325	750.41
6	13.85	60	138.54	160	369.43	350	808.13
7	16.16	70	161.63	170	392.52	375	865.89
8	18.47	80	184.72	180	415.61	400	922.58
9	20.78	90	207.81	190	438.90	500	1154.48
10	23.09	100	230.90	200	461.78	1000	2309.00
15	34.63	110	253.98	-	-	-	-

Figure B.4 Conversion charts. © *ITT Goulds Pumps.*

English measures – unless otherwise designated, are those used in the United States.

Gallon – designates the U.S. gallon. To convert into the Imperial gallon, multiply the U.S. gallon by 0.83267. Likewise, the word ton designates a short ton, 2,000 pounds.

Multiply	By	To Obtain
Acres	43,560	Square feet
Acres	4047	Square meters
Acres	1.562×10^{3}	Square miles
Acres	4840	Square yards
Atmospheres	76.0	Cms. of mercury
Atmospheres	29.92	Inches of mercury
Atmospheres	33.90	Feet of water
Atmospheres	10,332	Kgs./sq. meter
Atmospheres	14.70	Lbs./sq. inch
Atmospheres	1.058	Tons/sq. ft.
Barrels-Oil	42	Gallons-Oil
Barrels-Beer	31	Gallons-Beer
Barrels-Whiskey	45	Gallons-Whiskey
Barrels/Day-Oil	0.02917	Gallons/Min-Oil
Bags or sacks-cement	94	Pounds-cement
Board feet	144 sq. in. x 1 in.	Cubic inches
B.T.U./min.	12.96	Foot-lbs./sec.
B.T.U./min.	0.02356	Horsepower
B.T.U./min.	0.01757	Kilowatts
B.T.U./min.	17.57	Watts
Centimeters	0.3937	Inches
Centimeters	0.01	Meters
Centimeters	10	Millimeters
Cubic feet	2.832×10^{4}	Cubic cms.
Cubic feet	1728	Cubic inches
Cubic feet	0.02832	Cubic meters
Cubic feet	0.03704	Cubic yards
Cubic feet	7.48052	Gallons
Cubic feet	28.32	Liters
Cubic feet	59.84	Pints (liq.)
Cubic feet	29.92	Quarts (liq.)
Cubic feet/min.	472.0	Cubic cms./sec.
Cubic feet/min.	0.1247	Gallons/sec.
Cubic feet/min.	0.4719	Liters/sec.
Cubic feet/min.	62.43	Lbs. of water/min.
Cubic feet/sec.	0.646317	Millions gals./day
Cubic feet/sec.	448.831	Gallons/min.
Cubic inches	16.39	Cubic centimeters
Cubic inches	5.787×10^{-4}	Cubic feet
Cubic inches	1.639×10^{-5}	Cubic meters
Cubic inches	2.143×10^{-5}	Cubic yards

Figure B.5 Conversion charts.
© ITT Goulds Pumps.

Properties of water – it freezes at 32°F., and is at its maximum density at 39.2°F. In the multipliers using the properties of water, calculations are based on water at 39.2°F. in a vacuum, weighing 62.427 pounds per cubic foot, or 8.345 pounds per U.S. gallon.

Multiply	By	To Obtain
Cubic inches	4.329×10^{-3}	Gallons
Cubic inches	1.639×10^{-2}	Liters
Cubic inches	0.03463	Pints (liq.)
Cubic inches	0.01732	Quarts (liq.)
Cubic yards	764,544.86	Cubic centimeters
Cubic yards	27	Cubic feet
Cubic yards	46,656	Cubic inches
Cubic yards	0.7646	Cubic meters
Cubic yards	202.0	Gallons
Cubic yards	764.5	Liters
Cubic yards	1616	Pints (liq.)
Cubic yards	807.9	Quarts (liq.)
Cubic yards/min.	0.45	Cubic feet/sec.
Cubic yards/min.	3.366	Gallons/sec.
Cubic yards/min.	12.74	Liters/sec.
Fathoms	6	Feet
Feet	30.48	Centimeters
Feet	12	Inches
Feet	0.3048	Meters
Feet	1/3	Yards
Feet of water	0.0295	Atmospheres
Feet of water	0.8826	Inches of mercury
Feet of water	304.8	Kgs./sq. meter
Feet of water	62.43	Lbs./Sq. ft.
Feet of water	0.4335	Lbs./sq. inch
Feet/min.	0.5080	Centimeters/sec.
Feet/min.	0.01667	Feet/sec.
Feet/min.	0.01829	Kilometers/hr.
Feet/min.	0.3048	Meters/min.
Feet/min.	0.01136	Miles/hr.
Feet/sec.	30.48	Centimeters/sec.
Feet/sec.	1.097	Kilometers/hr.
Feet/sec.	0.5924	Knots
Feet/sec.	18.29	Meters/min.
Feet/sec.	0.6818	Miles/hr.
Feet/sec.	0.01136	Miles/min.
Feet/sec./sec.	30.48	Cms./sec./sec.
Feet/sec./sec.	0.3048	Meters/sec./sec.
Foot-pounds	1.286×10^{3}	British Thermal Units
Foot-pounds	5.050×10^{7}	Horsepower-hrs.
Foot-pounds	3.240×10^{4}	Kilogram-calories

Figure B.5 Conversion charts *(continued)*. *© ITT Goulds Pumps.*

Multiply	By	To Obtain
Foot-pounds	0.1383	Kilogram-meters
Foot-pounds	3.766×10^{7}	Kilowatt-hours
Gallons	3785	Cubic centimeters
Gallons	0.1337	Cubic feet
Gallons	231	Cubic inches
Gallons	3.785×10^{-3}	Cubic meters
Gallons	4.951×10^{-3}	Cubic yards
Gallons	3.785	Liters
Gallons	8	Pints (liq.)
Gallons	4	Quarts (liq.)
Gallons-Imperial	1.20095	U.S. gallons
Gallons-U.S.	0.83267	Imperial gallons
Gallons water	8.345	Pounds of water
Gallons/min.	2.228×10^{-3}	Cubic feet/sec.
Gallons/min.	0.06308	Liters/sec.
Gallons/min.	8.0208	Cu. ft./hr.
Gallons/min.	.2271	Meters^3/hr.
Grains/U.S. gal.	17.118	Parts/million
Grains/U.S. gal.	142.86	Lbs./million gal.
Grains/Imp. gal.	14.254	Parts/million
Grams	15.43	Grains
Grams	.001	Kilograms
Grams	1000	Milligrams
Grams	0.03527	Ounces
Grams	2.205×10^{-3}	Pounds
Horsepower	42.44	B.T.U./min.
Horsepower	33,000	Foot-lbs./min.
Horsepower	550	Foot-lbs./sec.
Horsepower	1.014	Horsepower (metric)
Horsepower	0.7457	Kilowatts
Horsepower	745.7	Watts
Horsepower (boiler)	33,493	B.T.U./hr.
Horsepower (boiler)	9.809	Kilowatts
Horsepower-hours	2546	B.T.U.
Horsepower-hours	1.98×10^{6}	Foot-lbs.
Horsepower-hours	2.737×10^{5}	Kilogram-meters
Horsepower-hours	0.7457	Kilowatt-hours
Inches	2.540	Centimeters
Inches of mercury	0.03342	Atmospheres
Inches of mercury	1.133	Feet of water
Inches of mercury	345.3	Kgs./sq. meter
Inches of mercury	70.73	Lbs./sq. ft.
Inches of mercury (32°F)	0.491	Lbs./sq. inch
Inches of water	0.002458	Atmospheres
Inches of water	0.07355	Inches of mercury
Inches of water	25.40	Kgs./sq. meter
Inches of water	0.578	Ounces/sq. inch
Inches of water	5.202	Lbs. sq. foot
Inches of water	0.03613	Lbs./sq. inch
Kilograms	2.205	Lbs.

Figure B.5 Conversion charts *(continued)*. *© ITT Goulds Pumps.*

Multiply	By	To Obtain
Kilograms	1.102×10^{-3}	Tons (short)
Kilograms	10^3	Grams
Kiloliters	10^3	Liters
Kilometers	10^5	Centimeters
Kilometers	3281	Feet
Kilometers	10^3	Meters
Kilometers	0.6214	Miles
Kilometers	1094	Yards
Kilometers/hr.	27.78	Centimeters/sec.
Kilometers/hr.	54.68	Feet/min.
Kilometers/hr.	0.9113	Feet/sec.
Kilometers/hr.	.5399	Knots
Kilometers/hr.	16.67	Meters/min.
Kilowatts	56.907	B.T.U./min.
Kilowatts	4.425×10^4	Foot-lbs./min.
Kilowatts	737.6	Foot-lbs./sec.
Kilowatts	1.341	Horsepower
Kilowatts	10^3	Watts
Kilowatt-hours	3414.4	B.T.U.
Kilowatt-hours	2.655×10^6	Foot-lbs.
Kilowatt-hours	1.341	Horsepower-hrs.
Kilowatt-hours	3.671×10^5	Kilogram-meters
Liters	10^3	Cubic centimeters
Liters	0.03531	Cubic feet
Liters	61.02	Cubic inches
Liters	10^{-3}	Cubic meters
Liters	1.308×10^{-3}	Cubic yards
Liters	0.2642	Gallons
Liters	2.113	Pints (liq.)
Liters	1.057	Quarts (liq.)
Liters/min.	5.886×10^{-4}	Cubic ft./sec.
Liters/min.	4.403×10^{-3}	Gals./sec.
$\frac{\text{Lumber Width (in.) x Thickness (in.)}}{12}$	Length (ft.)	Board feet
Meters	100	Centimeters
Meters	3.281	Feet
Meters	39.37	inches
Meters	10^{-3}	Kilometers
Meters	10^3	Millimeters
Meters	1.094	Yards
Miles	1.609×10^5	Centimeters
Miles	5280	Feet
Miles	1.609	Kilometers
Miles	1760	Yards
Miles/hr.	44.70	Centimeters/sec.
Miles/hr.	88	Feet/min.
Miles/hr.	1.467	Feet/sec.
Miles/hr.	1.609	Kilometers/hr.
Miles/hr.	0.8689	Knots

Figure B.5 Conversion charts *(continued)*. *© ITT Goulds Pumps.*

Multiply	By	To Obtain
Miles/hr.	26.82	Meters/min.
Miles/min.	2682	Centimeters/sec.
Miles/min.	88	Feet/sec.
Miles/min.	1.609	Kilometers/min.
Miles/min.	60	Miles/hr.
Ounces	16	Drams
Ounces	437.5	Grains
Ounces	0.0625	Pounds
Ounces	28.3495	Grams
Ounces	2.835×10^{-5}	Tons (metric)
Parts/million	0.0584	Grains/U.S. gal.
Parts/million	0.07015	Grains/Imp. gal.
Parts/million	8.345	Lbs./million gal.
Pounds	16	Ounces
Pounds	256	Drams
Pounds	7000	Grains
Pounds	0.0005	Tons (short)
Pounds	453.5924	Grams
Pounds of water	0.01602	Cubic feet
Pounds of water	27.68	Cubic inches
Pounds of water	0.1198	Gallons
Pounds of water/min.	2.670×10^{-4}	Cubic ft./sec.
Pounds/cubic foot	0.01602	Grams/cubic cm.
Pounds/cubic foot	16.02	Kgs./cubic meters
Pounds/cubic foot	5.787×10^{-4}	Lbs./cubic inch
Pounds/cubic inch	27.68	Grams/cubic cm.
Pounds/cubic inch	2.768×10^{4}	Kgs./cubic meter
Pounds/cubic inch	1728	Lbs./cubic foot
Pounds/foot	1.488	Kgs./meter
Pounds/inch	1152	Grams/cm.
Pounds/sq. foot	0.01602	Feet of water
Pounds/sq. foot	4.882	Kgs./sq. meter
Pounds/sq. foot	6.944×10^{-3}	Pounds/sq. inch
Pounds/sq. inch	0.06804	Atmospheres
PSI	2.307	Feet of water
PSI	2.036	Inches of mercury
PSI	703.1	Kgs./sq. meter
Quarts (dry)	67.20	Cubic inches
Quarts (liq.)	57.75	Cubic inches
Square feet	2.296×10^{-5}	Acres
Square feet	929.0	Square centimeters
Square feet	144	Square inches
Square feet	0.09290	Square meters
Square feet	3.587×10^{-4}	Square miles
Square feet	1/9	Square yards
$\frac{1}{\text{sq. ft./gal./min.}}$	8.0208	Overflow rate (ft./hr.)
Square inches	6.452	Square centimeters
Square inches	6.944×10^{-3}	Square feet
Square inches	645.2	Square millimeters

Figure B.5 Conversion charts *(continued)*. *© ITT Goulds Pumps.*

Multiply	By	To Obtain
Square kilometers	247.1	Acres
Square kilometers	10.76×10^6	Square feet
Square kilometers	10^6	Square meters
Square kilometers	0.3861	Square miles
Square kilometers	1.196×10^6	Square yards
Square meters	2.471×10^{-4}	Acres
Square meters	10.76	Square feet
Square meters	3.861×10^{-7}	Square miles
Square meters	1.196	Square yards
Square miles	640	Acres
Square miles	27.88×10^6	Square feet
Square miles	2.590	Square kilometers
Square miles	3.098×10^6	Square yards
Square yards	2.066×10^{-4}	Acres
Square yards	9	Square feet
Square yards	0.8361	Square meters
Square yards	3.228×10^{-7}	Square miles
Temp (°C)+273	1	Abs. temp. (°C)
Temp. (°C)+17.78	1.8	Temp. (°F)
Temp. (°F)+460	1	Abs. temp. (°F)
Temp. (°F)-32	5/9	Temp (°C)
Tons (metric)	10^3	Kilograms
Tons (metric)	2205	Pounds
Tons (short)	2000	Pounds
Tons (short)	32,000	Ounces
Tons (short)	907.1843	Kilograms
Tons (short)	0.89287	Tons (long)
Tons (short)	0.90718	Tons (metric)
Tons of water/24 hrs.	83.333	Pounds water/hr.
Tons of water/24 hrs.	0.16643	Gallons/min.
Tons of water/24 hrs.	1.3349	Cu. ft./hr.
Watts	0.05686	B.T.U./min.
Watts	44.25	Foot-lbs./min.
Watts	0.7376	Foot-lbs./sec.
Watts	1.341×10^{-3}	Horsepower
Watts	0.01434	Kg.-calories/min.
Watts	10^{-3}	Kilowatts
Watt-hours	3.414	B.T.U.
Watt-hours	2655	Foot-lbs.
Watt-hours	1.341×10^{-3}	Horsepower-hrs.
Watt-hours	0.8604	Kilogram-calories
Watt-hours	367.1	Kilogram-meters
Watt-hours	10^{-3}	Kilowatt-hours
Yards	91.44	Centimeters
Yards	3	Feet
Yards	36	Inches
Yards	0.9144	Meters

Figure B.5 Conversion charts *(continued)*. *© ITT Goulds Pumps.*

EQUIVALENT NUMBER OF FEET STRAIGHT PIPE FOR DIFFERENT FITTINGS

Size of fittings, Inches	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"
90° Ell	1.5	2.0	2.7	3.5	4.3	5.5	6.5	8.0	10.0	14.0	15	20	25
45° Ell	0.8	1.0	1.3	1.7	2.0	2.5	3.0	3.8	5.0	6.3	7.1	9.4	12
Long Sweep Ell	1.0	1.4	1.7	2.3	2.7	3.5	4.2	5.2	7.0	9.0	11.0	14.0	
Close Return Bend	3.6	5.0	6.0	8.3	10.0	13.0	15.0	18.0	24.0	31.0	37.0	39.0	
Tee-Straight Run	1	2	2	3	3	4	5						
Tee-Side Inlet or Outlet or Pitless Adapter	3.3	4.5	5.7	7.6	9.0	12.0	14.0	17.0	22.0	27.0	31.0	40.0	
① Ball or Globe Valve Open	17.0	22.0	27.0	36.0	43.0	55.0	67.0	82.0	110.0	140.0	160.0	220.0	
① Angle Valve Open	8.4	12.0	15.0	18.0	22.0	28.0	33.0	42.0	58.0	70.0	83.0	110.0	
Gate Valve-Fully Open	0.4	0.5	0.6	0.8	1.0	1.2	1.4	1.7	2.3	2.9	3.5	4.5	
Check Valve (Swing)	4	5	7	9	11	13	16	20	26	33	39	52	65
In Line Check Valve (Spring) or Foot Valve	4	6	8	12	14	19	23	32	43	58			

① There are many new, full port valve designs available today which are more efficient and create much less friction loss, consult with valve suppliers for new data.

Example:

(A) 100 ft. of 2" plastic pipe with one (1) 90° elbow and one (1) swing check valve.

90° elbow – equivalent to	5.5 ft. of straight pipe
Swing check – equivalent to	13.0 ft. of straight pipe
100 ft. of pipe – equivalent to	100 ft. of straight pipe
	118.5 ft. = Total equivalent pipe

Figure friction loss for 118.5 ft. of pipe.

(B) Assume flow to be 80 GPM through 2" plastic pipe.

1. Friction loss table shows 11.43 ft. loss per 100 ft. of pipe.
2. In step (A) above we have determined total ft. of pipe to be 118.5 ft.
3. Convert 118.5 ft. to percentage 118.5 ÷ 100 = 1.185
4. Multiply 11.43 x 1.185

13.54455 or 13.5 ft. = Total friction loss in this system.

Figure B.6 Friction loss. © *ITT Goulds Pumps.*

OFFSET JET PUMP PIPE FRICTION

Where the jet pump is offset horizontally from the well site, add the following distances to the vertical lift to approximate capacity to be received.

PIPE FRICTION FOR OFFSET JET PUMPS

Friction Loss in Feet Per 100 Feet Offset

JET SIZE	SUCTION AND PRESSURE PIPE SIZES (in inches)									
HP	1¼ x 1	1¼ x 1¼	1½ x 1¼	1½ x 1½	2 x 1½	2 x 2	2½ x 2	2½ x 2½	3 x 2½	3 x 3
⅓	12	8	6	4						
½	18	12	8	6	3	2				
¾		22	16	11	6	4				
1			25	16	9	6				
1½	Operations Below Line Not Recommended				13	8	5	3		
2					20	13	7	5		
3							13	9	6	4

NOTE: Friction loss is to be added to vertical lift.

Figure B.6 Friction loss *(continued)*. © *ITT Goulds Pumps.*

COPPER PIPE: FRICTION LOSS (IN FEET OF HEAD) PER 100 FT.

GPM	GPH	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"
		ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
1	60	6.2	1.8	.39							
2	120	19.6	6.0	1.2							
5	300		30.0	5.8	1.6						
7	420		53.0	11.0	3.2	2.2					
10	600			19.6	5.3	3.9					
15	900			37.0	9.9	6.2	2.1				
18	1,080			55.4	16.1	6.9	3.2				
20	1,200				18.5	10.4	3.9				
25	1,500				27.7	14.3	5.3	1.5			
30	1,800				39.3	18.7	7.6	2.1			
35	2,100				48.5	25.4	10.2	2.8			
40	2,400					30.0	13.2	3.5	1.2		
45	2,700					39.3	16.2	4.2	1.6		
50	3,000						19.4	5.1	1.8		
60	3,600						27.7	6.9	2.5	1.1	
70	4,200						40.0	9.2	3.5	1.4	
75	4,500						41.6	9.9	3.7	1.6	
80	4,800						45.0	11.6	4.2	1.8	
90	5,400						50.8	13.9	4.8	2.2	
100	6,000							16.9	6.2	2.8	
125	7,500							25.4	8.6	3.7	
150	9,000							32.3	11.6	4.8	1.2
175	10,500							41.6	16.2	6.9	1.7
200	12,000							57.8	20.8	9.0	2.2
250	15,000								32.3	13.9	3.5
300	18,000								41.6	18.5	4.6
350	21,000									32.3	5.8
400	24,000									39.3	7.2
450	27,000									44.0	9.2
500	30,000										11.1
750	45,000										23.1
1000	60,000										37.0

Figure B.6 Friction loss *(continued)*. © *ITT Goulds Pumps.*

RUBBER HOSE: FRICTION LOSS (IN FEET OF HEAD) PER 100 FT.

GPM	Actual Inside Diameter in Inches							
	¾"	1"	1¼"	1½"	2"	2½"	3"	4"
15	70	23	5.8	2.5	.9	.2		
20	122	32	10	4.2	1.6	.5		
25	182	51	15	6.7	2.3	.7		
30	259	72	21.2	9.3	3.2	.9	.2	
40		122	35	15.5	5.5	1.4	.7	
50		185	55	23	8.3	2.3	1.2	
60		233	81	32	11.8	3.2	1.4	
70			104	44	15.2	4.2	1.8	
80			134	55	19.8	5.3	2.5	
90			164	70	25	7	3.5	.7
100			203	85	29	8.1	4	.9
125			305	127	46	12.2	5.8	1.4
150			422	180	62	17.3	8.1	1.6
175				230	85	23.1	10.6	2.5
200				308	106	30	13.6	3.2

GPM	Actual Inside Diameter in Inches							
	¾"	1"	1¼"	1½"	2"	2½"	3"	4"
250					162	44	21	4.9
300					219	62	28	6.7
350					292	83	39	9.3
400						106	49	11.8
500						163	74	17.1
600						242	106	23
700						344	143	30
800						440	182	40
900							224	51
1000							270	63
1250							394	100
1500							525	141
1750								185
2000								230

Figure B.6 Friction loss *(continued)*. © *ITT Goulds Pumps.*

STEEL PIPE: FRICTION LOSS (IN FEET OF HEAD) PER 100 FT.

GPM	GPH	3/8"	1/2"	3/4"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"
		ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
1	60	4.30	1.86	.26											
2	120	15.00	4.78	1.21	.38										
3	180	31.80	10.00	2.50	.77										
4	240	54.90	17.10	4.21	1.30	.34									
5	300	83.50	25.80	6.32	1.93	.51	.24								
6	360		36.50	8.87	2.68	.70	.33	.10							
7	420		48.70	11.80	3.56	.93	.44	.13							
8	480		62.70	15.00	4.54	1.18	.56	.17							
9	540			18.80	5.65	1.46	.69	.21							
10	600			23.00	6.86	1.77	.83	.25	.11	.04					
12	720			32.60	9.62	2.48	1.16	.34	.15	.05					
15	900			49.70	14.70	3.74	1.75	.52	.22	.08					
20	1,200			86.10	25.10	6.34	2.94	.87	.36	.13					
25	1,500				38.60	9.65	4.48	1.30	.54	.19					
30	1,800				54.60	13.60	6.26	1.82	.75	.26					
35	2,100				73.40	18.20	8.37	2.42	1.00	.35					
40	2,400				95.00	23.50	10.79	3.10	1.28	.44					
45	2,700					30.70	13.45	3.85	1.60	.55					
70	4,200					68.80	31.30	8.86	3.63	1.22	.35				
100	6,000						62.20	17.40	7.11	2.39	.63				
150	9,000							38.00	15.40	5.14	1.32				
200	12,000							66.30	26.70	8.90	2.27	.736	.30	.08	
250	15,000							90.70	42.80	14.10	3.60	1.20	.49	.13	
300	18,000								58.50	19.20	4.89	1.58	.64	.16	.0542
350	21,000								79.20	26.90	6.72	2.18	.88	.23	.0719
400	24,000								103.00	33.90	8.47	2.72	1.09	.279	.0917
450	27,000								130.00	42.75	10.65	3.47	1.36	.348	.114
500	30,000								160.00	52.50	13.00	4.16	1.66	.424	.138
550	33,000								193.00	63.20	15.70	4.98	1.99	.507	.164
600	36,000								230.00	74.80	18.60	5.88	2.34	.597	.192
650	39,000									87.50	21.70	6.87	2.73	.694	.224
700	42,000									101.00	25.00	7.93	3.13	.797	.256
750	45,000									116.00	28.60	9.05	3.57	.907	.291
800	48,000									131.00	32.40	10.22	4.03	1.02	.328
850	51,000									148.00	36.50	11.50	4.53	1.147	.368
900	54,000									165.00	40.80	12.90	5.05	1.27	.410
950	57,000									184.00	45.30	14.30	5.60	1.41	.455
1000	60,000									204.00	50.20	15.80	6.17	1.56	.500

Figure B.6 Friction loss *(continued)*. © *ITT Goulds Pumps.*

SCH 40 – PLASTIC PIPE: FRICTION LOSS (IN FEET OF HEAD) PER 100 FT.

GPM	GPH	3/8"	1/2"	3/4"	1"	1¼"	1½"	2"	2½"	3"	4"	6"	8"	10"
		ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
1	60	4.25	1.38	.356	.11									
2	120	15.13	4.83	1.21	.38	.10								
3	180	31.97	9.96	2.51	.77	.21	.10							
4	240	54.97	17.07	4.21	1.30	.35	.16							
5	300	84.41	25.76	6.33	1.92	.51	.24							
6	360		36.34	8.83	2.69	.71	.33	.10						
8	480		63.71	15.18	4.58	1.19	.55	.17						
10	600		97.52	25.98	6.88	1.78	.83	.25	.11					
15	900			49.68	14.63	3.75	1.74	.52	.22					
20	1,200			86.94	25.07	6.39	2.94	.86	.36	.13				
25	1,500				38.41	9.71	4.44	1.29	.54	.19				
30	1,800					13.62	6.26	1.81	.75	.26				
35	2,100					18.17	8.37	2.42	1.00	.35	.09			
40	2,400					23.55	10.70	3.11	1.28	.44	.12			
45	2,700					29.44	13.46	3.84	1.54	.55	.15			
50	3,000						16.45	4.67	1.93	.66	.17			
60	3,600						23.48	6.60	2.71	.93	.25			
70	4,200							8.83	3.66	1.24	.33			
80	4,800							11.43	4.67	1.58	.41			
90	5,400							14.26	5.82	1.98	.52			
100	6,000								7.11	2.42	.63	.08		
125	7,500								10.83	3.80	.95	.13		
150	9,000									5.15	1.33	.18		
175	10,500									6.90	1.78	.23		
200	12,000									8.90	2.27	.30		
250	15,000										3.36	.45	.12	
300	18,000										4.85	.63	.17	
350	21,000										6.53	.84	.22	
400	24,000											1.08	.28	
500	30,000											1.66	.42	.14
550	33,000											1.98	.50	.16
600	36,000											2.35	.59	.19
700	42,000												.79	.26
800	48,000												1.02	.33
900	54,000												1.27	.41
950	57,000													.46
1000	60,000													.50

NOTE: See page 5 for website addresses for pipe manufacturers – there are many types of new plastic pipe available now.

Figure B.6 Friction loss *(continued)*. © *ITT Goulds Pumps.*

DISCHARGE RATE IN GALLONS PER MINUTE/NOMINAL PIPE SIZE (ID)

Horizontal Dist. (A) Inches	Pipe Diameter											
	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"	12"
4	5.7	9.8	13.3	22.0	31.3	48.5	83.5					
5	7.1	12.2	16.6	27.5	39.0	61.0	104	163				
6	8.5	14.7	20.0	33.0	47.0	73.0	125	195	285			
7	10.0	17.1	23.2	38.5	55.0	85.0	146	228	334	380		
8	11.3	19.6	26.5	44.0	62.5	97.5	166	260	380	665	1060	
9	12.8	22.0	29.8	49.5	70.0	110	187	293	430	750	1190	1660
10	14.2	24.5	33.2	55.5	78.2	122	208	326	476	830	1330	1850
11	15.6	27.0	36.5	60.5	86.0	134	229	360	525	915	1460	2100
12	17.0	29.0	40.0	66.0	94.0	146	250	390	570	1000	1600	2220
13	18.5	31.5	43.0	71.5	102	158	270	425	620	1080	1730	2400
14	20.0	34.0	46.5	77.0	109	170	292	456	670	1160	1860	2590
15	21.3	36.3	50.0	82.5	117	183	312	490	710	1250	2000	2780
16	22.7	39.0	53.0	88.0	125	196	334	520	760	1330	2120	2960
17		41.5	56.5	93.0	133	207	355	550	810	1410	2260	3140
18			60.0	99.0	144	220	375	590	860	1500	2390	3330
19				110	148	232	395	620	910	1580	2520	3500
20					156	244	415	650	950	1660	2660	3700
21						256	435	685	1000	1750	2800	
22							460	720	1050	1830	2920	
23								750	1100	1910	3060	
24									1140	2000	3200	

THEORETICAL DISCHARGE OF NOZZLES IN U.S. GALLONS PER MINUTE

Head		Velocity of Discharge Feet Per Second	Diameter of Nozzle in Inches								
Pounds	Feet		1/16	1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8
10	23.1	38.6	0.37	1.48	3.32	5.91	13.3	23.6	36.9	53.1	72.4
15	34.6	47.25	0.45	1.81	4.06	7.24	16.3	28.9	45.2	65.0	88.5
20	46.2	54.55	0.52	2.09	4.69	8.35	18.8	33.4	52.2	75.1	102
25	57.7	61.0	0.58	2.34	5.25	9.34	21.0	37.3	58.3	84.0	114
30	69.3	66.85	0.64	2.56	5.75	10.2	23.0	40.9	63.9	92.0	125
35	80.8	72.2	0.69	2.77	6.21	11.1	24.8	44.2	69.0	99.5	135
40	92.4	77.2	0.74	2.96	6.64	11.8	26.6	47.3	73.8	106	145
45	103.9	81.8	0.78	3.13	7.03	12.5	28.2	50.1	78.2	113	153
50	115.5	86.25	0.83	3.30	7.41	13.2	29.7	52.8	82.5	119	162
55	127.0	90.4	0.87	3.46	7.77	13.8	31.1	55.3	86.4	125	169
60	138.6	94.5	0.90	3.62	8.12	14.5	32.5	57.8	90.4	130	177
65	150.1	98.3	0.94	3.77	8.45	15.1	33.8	60.2	94.0	136	184
70	161.7	102.1	0.98	3.91	8.78	15.7	35.2	62.5	97.7	141	191
75	173.2	105.7	1.01	4.05	9.08	16.2	36.4	64.7	101	146	198
80	184.8	109.1	1.05	4.18	9.39	16.7	37.6	66.8	104	150	205
85	196.3	112.5	1.08	4.31	9.67	17.3	38.8	68.9	108	155	211
90	207.9	115.8	1.11	4.43	9.95	17.7	39.9	70.8	111	160	217
95	219.4	119.0	1.14	4.56	10.2	18.2	41.0	72.8	114	164	223
100	230.9	122.0	1.17	4.67	10.5	18.7	42.1	74.7	117	168	229
105	242.4	125.0	1.20	4.79	10.8	19.2	43.1	76.5	120	172	234
110	254.0	128.0	1.23	4.90	11.0	19.6	44.1	78.4	122	176	240
115	265.5	130.9	1.25	5.01	11.2	20.0	45.1	80.1	125	180	245
120	277.1	133.7	1.28	5.12	11.5	20.5	46.0	81.8	128	184	251
125	288.6	136.4	1.31	5.22	11.7	20.9	47.0	83.5	130	188	256
130	300.2	139.1	1.33	5.33	12.0	21.3	48.0	85.2	133	192	261
135	311.7	141.8	1.36	5.43	12.2	21.7	48.9	86.7	136	195	266
140	323.3	144.3	1.38	5.53	12.4	22.1	49.8	88.4	138	199	271
145	334.8	146.9	1.41	5.62	12.6	22.5	50.6	89.9	140	202	275
150	346.4	149.5	1.43	5.72	12.9	22.9	51.5	91.5	143	206	280
175	404.1	161.4	1.55	6.18	13.9	24.7	55.6	98.8	154	222	302
200	461.9	172.6	1.65	6.61	14.8	26.4	59.5	106	165	238	323

Note:
The actual quantities will vary from these figures, the amount of variation depending upon the shape of nozzle and size of pipe at the point where the pressure is determined. With smooth taper nozzles the actual discharge is about 94 percent of the figures given in the tables.

Figure B.7 Determining flow rates. © *ITT Goulds Pumps.*

THEORETICAL DISCHARGE OF NOZZLES IN U.S. GALLONS PER MINUTE (continued)

Head		Velocity of Discharge Feet	Diameter of Nozzle in Inches								
Pounds	Feet	Per Second	1	1⅛	1¼	1⅜	1½	1¾	2	2¼	2½
10	23.1	38.6	94.5	120	148	179	213	289	378	479	591
15	34.6	47.25	116	147	181	219	260	354	463	585	723
20	46.2	54.55	134	169	209	253	301	409	535	676	835
25	57.7	61.0	149	189	234	283	336	458	598	756	934
30	69.3	66.85	164	207	256	309	368	501	655	828	1023
35	80.8	72.2	177	224	277	334	398	541	708	895	1106
40	92.4	77.2	188	239	296	357	425	578	756	957	1182
45	103.9	81.8	200	253	313	379	451	613	801	1015	1252
50	115.5	86.25	211	267	330	399	475	647	845	1070	1320
55	127.0	90.4	221	280	346	418	498	678	886	1121	1385
60	138.6	94.5	231	293	362	438	521	708	926	1172	1447
65	150.1	98.3	241	305	376	455	542	737	964	1220	1506
70	161.7	102.1	250	317	391	473	563	765	1001	1267	1565
75	173.2	105.7	259	327	404	489	582	792	1037	1310	1619
80	184.8	109.1	267	338	418	505	602	818	1070	1354	1672
85	196.3	112.5	276	349	431	521	620	844	1103	1395	1723
90	207.9	115.8	284	359	443	536	638	868	1136	1436	1773
95	219.4	119.0	292	369	456	551	656	892	1168	1476	1824
100	230.9	122.0	299	378	467	565	672	915	1196	1512	1870
105	242.4	125.0	306	388	479	579	689	937	1226	1550	1916
110	254.0	128.0	314	397	490	593	705	960	1255	1588	1961
115	265.5	130.9	320	406	501	606	720	980	1282	1621	2005
120	277.1	133.7	327	414	512	619	736	1002	1310	1659	2050
125	288.6	136.4	334	423	522	632	751	1022	1338	1690	2090
130	300.2	139.1	341	432	533	645	767	1043	1365	1726	2132
135	311.7	141.8	347	439	543	656	780	1063	1390	1759	2173
140	323.3	144.3	354	448	553	668	795	1082	1415	1790	2212
145	334.8	146.9	360	455	562	680	809	1100	1440	1820	2250
150	346.4	149.5	366	463	572	692	824	1120	1466	1853	2290
175	404.1	161.4	395	500	618	747	890	1210	1582	2000	2473
200	461.9	172.6	423	535	660	790	950	1294	1691	2140	2645

Note:
The actual quantities will vary from these figures, the amount of variation depending upon the shape of nozzle and size of pipe at the point where the pressure is determined. With smooth taper nozzles the actual discharge is about 94 percent of the figures given in the tables.

Figure B.7 Determining flow rates *(continued)*. *© ITT Goulds Pumps.*

STORAGE OF WATER IN VARIOUS SIZE PIPES

Pipe Size	Volume in Gallons per Foot	Pipe Size	Volume in Gallons per Foot
1¼	.06	6	1.4
1½	.09	8	2.6
2	.16	10	4.07
3	.36	12	5.87
4	.652		

STORAGE OF WATER IN VARIOUS SIZES OF WELLS

$$\frac{D^2}{24.5} = \text{Gals. of Storage per Foot}$$

Where: D = Inside diameter of well casing in inches

Examples:

2" Casing = .16 Gals. per ft. Storage	8" Casing = 2.6 Gals. per ft. Storage
3" Casing = .36 Gals. per ft. Storage	10" Casing = 4.07 Gals. per ft. Storage
4" Casing = .652 Gals. per ft. Storage	12" Casing = 5.87 Gals. per ft. Storage
5" Casing = 1.02 Gals. per ft. Storage	14" Casing = 7.99 Gals. per ft. Storage
6" Casing = 1.4 Gals. per ft. Storage	16" Casing = 10.44 Gals. per ft. Storage

MINIMUM FLOW TO MAINTAIN 2FT./SEC. *SCOURING VELOCITY IN VARIOUS PIPES

Pipe Size	Minimum GPM	Pipe Size	Minimum GPM
1¼	9	6	180
1½	13	8	325
2	21	10	500
3	46	12	700
4	80		

* Failure to maintain or exceed this velocity will result in clogged pipes.
Based on schedule 40 nominal pipe.

Figure B.8 Pipe volume and velocity. © *ITT Goulds Pumps.*

Appendix C

Facts, Figures, and Measurements

Size (inches)	Service Weight Per Linear Foot (pounds)	Extra Heavy Size (inches)	Per Linear Foot (pounds)
2	4	2	5
3	6	3	9
4	9	4	12
5	12	5	15
6	15	6	19
7	20	8	30
8	25	10	43
		12	54
		15	75

Figure C.1 Weight of cast-iron soil pipe.

	Diameter (inches)	Service Weight (lb)	Extra Heavy Weight (lb)
Double Hub, 5-ft Lengths	2	21	26
	3	31	47
	4	42	63
	5	54	78
	6	68	100
	8	105	157
	10	150	225
Double Hub, 30-ft Length	2	11	14
	3	17	26
	4	23	33
Single Hub, 5-ft Lengths	2	20	25
	3	30	45
	4	40	60
	5	52	75
	6	65	95
	8	100	150
	10	145	215
Single Hub, 10-ft Lengths	2	38	43
	3	56	83
	4	75	108
	5	98	133
	6	124	160
	8	185	265
	10	270	400
No-Hub Pipe, 10-ft Lengths	1½	27	
	2	38	
	3	54	
	4	74	
	5	95	
	6	118	
	8	180	

Figure C.2 Weight of cast-iron pipe.

Single-Family Dwellings; Number of Bedrooms	*Multiple Dwelling Units or Apartments; One Bedroom Each*	*Other Uses; Maximum Fixture-Units Served*	*Minimum Septic Tank Capacity in Gallons*
1–3		20	1000
4	2	25	1200
5–6	3	33	1500
7–8	4	45	2000
	5	55	2250
	6	60	2500
	7	70	2750
	8	80	3000
	9	90	3250
	10	100	3500

Figure C.3 Common septic tank capacities.

1 ft^3 of water contains 7½ gal, 1728 $in.^3$, and weighs 62½ lb.

1 gal of water weighs 8⅓ lb and contains 231 $in.^3$

Water expands 1/23 of its volume when heated from 40° to 212°.

The height of a column of water, equal to a pressure of 1 $lb/in.^2$, is 2.31 ft.

To find the pressure in $lb/in.^2$ of a column of water, multiply the height of the column in feet by 0.434.

The average pressure of the atmosphere is estimated at 14.7 $lb/in.^2$ so that with a perfect vacuum it will sustain a column of water 34 ft high.

The friction of water in pipes varies as the square of the velocity.

To evaporate 1 ft^3 of water requires the consumption of 7½ lb of ordinary coal or about 1 lb of coal to 1 gal of water.

1 $in.^3$ of water evaporated at atmospheric pressure is converted into approximately 1 ft^3 of steam.

Figure C.4 Facts about water.

Fixture	*Flow Rate (gpm)*[a]
Ordinary basin faucet	2.0
Self-closing basin faucet	2.5
Sink faucet, 3/8 in.	4.5
Sink faucet, 1/2 in.	4.5
Bathtub faucet	6.0
Laundry tub cock, 1/2 in.	5.0
Shower	5.0
Ballcock for water closet	3.0
Flushometer valve for water closet	15-35
Flushometer valve for urinal	15.0
Drinking fountain	.75
Sillcock (wall hydrant)	5.0

[a]Figures do not represent the use of water-conservation devices.

Figure C.5 Rates of water flow.

Type of Establishment	*Gallons (per day per person)*[a]
Schools (toilets and lavatories only)	15
Schools (with above plus cafeteria)	25
Schools (with above plus cafeteria and showers)	35
Day workers at schools and offices	15
Day camps	25
Trailer parks or tourist camps (with built-in bath)	50
Trailer parks or tourist camps (with central bathhouse)	35
Work or construction camps	50
Public picnic parks (toilet wastes only)	5
Public picnic parks (bathhouse, showers, and flush toilets)	10
Swimming pools and beaches	10
Country clubs	25 per locker
Luxury residences and estates	150
Rooming houses	40
Boarding houses	50
Hotels (with connecting baths)	50
Hotels (with private baths, 2 persons per room)	100
Boarding schools	100
Factories (gallons per person per shift, exclusive of industrial wastes)	25
Nursing homes	75
General hospitals	150
Public institutions (other than hospitals)	100
Restaurants (toilet and kitchen wastes per unit of serving capacity)	25
Kitchen wastes from hotels, camps, boarding houses, etc. that serve 3 meals per day	10
Motels	50 per bed

[a]Except for country clubs and motels.

Figure C.6 Potential sewage flows.

Pipe size (in inches)	PSI	Length of pipe is 50 feet
¾	20	16
¾	40	24
¾	60	29
¾	80	34
1	20	31
1	40	44
1	60	55
1	80	65
1¼	20	84
1¼	40	121
1¼	60	151
1¼	80	177
1½	20	94
1½	40	137
1½	60	170
1½	80	200

Figure C.7 Discharge of 50 foot pipe in gallons per minute.

Pipe size (in inches)	PSI	Length of pipe is 100 feet
¾	20	11
¾	40	16
¾	60	20
¾	80	24
1	20	21
1	40	31
1	60	38
1	80	44
1¼	20	58
1¼	40	84
1¼	60	104
1¼	80	121
1½	20	65
1½	40	94
1½	60	117
1½	80	137

Figure C.8 Discharge of 100 foot pipe in gallons per minute.

	No water pressure	No water pressure at fixture	Low water pressure to fixture
Street water main	X		X
Curb stop	X		X
Water service	X		X
Branches		X	X
Valves	X	X	X
Stems, washers (hot and cold)		X	X
Aerator		X	X
Water meter	X	X	X

Figure C.9 Where to look for causes of water-pressure problems.

Quantity	Equals
1 square meter	10.764 square feet 1.196 square yards
1 square centimeter	.155 square inch
1 square millimeter	.00155 square inch
.836 square meter	1 square yard
.0929 square meter	1 square foot
6.452 square centimeter	1 square inch
645.2 square millimeter	1 square inch

Figure C.10 Surface measures.

Quantity	Equals
144 sq. inches	1 sq. foot
9 sq. feet	1 sq. yard
1 sq. yard	1296 sq. inches
4840 sq. yards	1 acre
640 acres	1 sq. mile

Figure C.11 Square measure.

Quantity	Equals	Equals
7.92 inches	1 link	
100 links	1 chain	66 feet
10 chains	1 furling	660 feet
80 chains	1 mile	5280 feet

Figure C.12 Surveyor's measure.

Inches	Millimeters
1	25.4
2	50.8
3	76.2
4	101.6
5	127.0
6	152.4
7	177.8
8	203.2
9	228.6
10	254.0
11	279.4
12	304.8
13	330.2
14	355.6
15	381.0
16	406.4
17	431.8
18	457.2
19	482.6
20	508.0

Figure C.13 Inches to millimeters.

Inches	Millimeters
0.3927	10
0.7854	20
1.1781	30
1.5708	40
2.3562	60
3.1416	80
3.9270	100
4.7124	120
6.2832	160
7.8540	200
9.4248	240
12.566	320
15.708	400
18.850	480
21.991	560
25.133	640
28.274	720
31.416	800

Figure C.14 Area in inches and millimeters.

Inches	Millimeters
0.3927	10
0.7854	20
1.1781	30
1.5708	40
2.3562	60
3.1416	80
3.9270	100
4.7124	120
6.2832	160
7.8540	200
9.4248	240
12.566	320
15.708	400
18.850	480
21.991	560
25.133	640
28.274	720
31.416	800

Figure C.15 Circumference in inches and millimeters.

Quantity	Unit	Symbol
Time	Second	s
Plane angle	Radius	rad
Force	Newton	N
Energy, work, quantity of heat	Joule	J
	Kilojoule	kJ
	Megajoule	MJ
Power, heat flow rate	Watt	W
	Kilowatt	kW
Pressure	Pascal	Pa
	Kilopascal	kPa
	Megapascal	MPa
Velocity, speed	Meter per second	m/s
	Kilometer per hour	km/h

Figure C.16 Metric symbols.

Units	Equals
1 decimeter	4 inches
1 meter	1.1 yards
1 kilometer	⅝ mile
1 hektar	2½ acres
1 stere or cu. meter	¼ cord
1 liter	1.06 qt. liquid; 0.9 qt. dry
1 hektoliter	2⅝ bushel
1 kilogram	2⅕ lbs.
1 metric ton	2200 lbs.

Figure C.17 Approximate metric equivalents.

Feet	Meters (m)	Millimeters (mm)
1	0.305	304.8
2	0.610	609.6
3 (1 yd.)	0.914	914.4
4	1.219	1 219.2
5	1.524	1 524.0
6 (2 yd.)	1.829	1 828.8
7	2.134	2 133.6
8	2.438	2 438.2
9 (3yd.)	2.743	2 743.2
10	3.048	3 048.0
20	6.096	6 096.0
30 (10 yd.)	9.144	9 144.0
40	12.19	12 192.0
50	15.24	15 240.0
60 (20 yd.)	18.29	18 288.0
70	21.34	21 336.0
80	24.38	24 384.0
90 (30 yd.)	27.43	27 432.0
100	30.48	30 480.0

Figure C.18 Length conversions.

Unit	Equals
1 cu. ft.	62.4 lbs.
1 cu. ft.	7.48 gal.
1 gal.	8.33 lbs.
1 gal.	0.1337 cu. ft.

Figure C.19 Water volume to weight conversion.

Quantity	Equals
4 gills	1 pint
2 pints	1 quart
4 quarts	1 gallon
31½ gallons	1 barrel
1 gallon	231 cubic inches
7.48 gallons	1 cubic foot
1 gallon water	8.33 pounds
1 gallon gasoline	5.84 pounds

Figure C.20 Liquid measure.

Category	Estimated water usage per day
Barber shop	100 gal per chair
Beauty shop	125 gal per chair
Boarding school, elementary	75 gal per student
Boarding school, secondary	100 gal per student
Clubs, civic	3 gal per person
Clubs, country	25 gal per person
College, day students	25 gal per student
College, junior	100 gal per student
College, senior	100 gal per student
Dentist's office	750 gal per chair
Department store	40 gal per employee
Drugstore	500 gal per store
Drugstore with fountain	2000 gal per store
Elementary school	16 gal per student
Hospital	400 gal per patient
Industrial plant	30 gal per employee + process water
Junior and senior high school	25 gal per student
Laundry	2000–20,000 gal
Launderette	1000 gal per unit
Meat market	5 gal per 100 ft^2 of floor area
Motel or hotel	125 gal per room
Nursing home	150 gal per patient
Office building	25 gal per employee
Physician's office	200 gal per examining room
Prison	60 gal per inmate
Restaurant	20–120 gal per seat
Rooming house	100 gal per tenant
Service station	600–1500 gal per stall
Summer camp	60 gal per person
Theater	3 gal per seat

Figure C.21 Estimating guidelines for daily water usage.

Unit	Pounds per square inch	Feet of water	Meters of water	Inches of mercury	Atmospheres
1 pound per square inch	1.0	2.31	0.704	2.04	0.0681
1 foot of water	0.433	1.0	0.305	0.882	0.02947
1 meter of water	1.421	3.28	1.00	2.89	0.0967
1 inch of mercury	0.491	1.134	0.3456	1.00	0.0334
1 atmosphere (sea level)	14.70	33.93	10.34	29.92	1.0000

Figure C.22 Conversion of water values.

Contaminant	Suggested maximum level, mg/L
Calcium	2 (0.1 meq/L)
Magnesium	4 (0.3 meq/L)
Sodium	70 (3 meq/L)
Potassium	8 (0.2 meq/L)
Fluoride	0.2
Chlorine	0.5
Chloramines	0.1
Nitrate (N)	2
Sulfate	100
Copper, barium, zinc	0.1 each
Arsenic, lead, silver	0.005 each
Chromium	0.014
Cadmium	0.001
Selenium	0.09
Aluminum	0.01
Mercury	0.0002
Bacteria	200 (cfu/mL)

Source: Association for the Advancement of Medical Instrumentation (AAMI) "Hemodialysis Systems Standard," March 1990. Adopted by American National Standards Institute (ANSI), 1992.

Figure C.23 AAMI/ANSI water quality standards.

Type of soil	Required sq. ft. of leaching area/100 gal. (m^2/L)	Maximum absorption capacity gals./sq. ft. of leaching area for a 24 hr. period (L/m^2)
1. Coarse sand or gravel	20 (.005)	5 (203.7)
2. Fine sand	25 (.006)	4 (162.9)
3. Sandy loam or sandy clay	40 (.010)	2.5 (101.9)
4. Clay with considerable sand or gravel	90 (.022)	1.10 (44.8)
5. Clay with small amount of sand or gravel	120 (.029)	0.83 (33.8)

Figure C.24 Design criteria of five typical soils.

Anticipated well yield, gpm	Nominal pump bowl size, in	Optimum well casing size, in	Smallest well casing size, in
Less than 100	4	6 I.D.	5 I.D.
75 to 175	5	8 I.D.	6 I.D.
150 to 400	6	10 I.D.	8 I.D.
350 to 650	8	12 I.D.	10 I.D.
600 to 900	10	14 I.D.	12 I.D.
850 to 1300	12	16 I.D.	14 I.D.
1200 to 1800	14	20 I.D.	16 I.D.
1600 to 3000	16	24 I.D.	20 I.D.

Figure C.25 Recommended well diameters.

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