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Heating & Cooling Products

WATER SYSTEMS

AND

WELL PUMP AND PIPE SIZING

FOR

WATER SOURCE HEAT PUMPS

BARD MANUFACTURING COMPANY
Bryan, Ohio 43506

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WATER SUPPLY

Water is an essential consideration in the design of a ground water system. There are three basic elements of water that must be evaluated.

These are:
1. Quantity
2. Temperature
3. Quality

These elements of water must be considered not only in the selection of a proper source of water supply, but also in determining a proper method of water disposal.

SUPPLY WATER

The most important element of supply water is quantity. Sufficient water flow is required to properly balance the system. First step is to determine water requirements. See manufacturer's water source heat pump (WSHP) specification sheets for the water requirements of the unit selected.

The next step is to consult with a local well driller to determine if the required quantity is available from ground water. A listing of certified well drillers for your area can be obtained from the National Well Water Association (NWWA), or your local equipment distributor. Once the certified well driller has determined that sufficient water quantity is available, proceed with the design of a well system. If the necessary water quantity is not available, then use an earth coupled system. (See manufacturer about equipment that will work on earth coupled closed loop systems.)

Temperature of the water is another element of supply water. Water temperature is a measure of the amount of heat energy contained in the water. It has a direct effect on the heat pump unit's ability to transfer heat energy. Once the specific cooling and heating loads are known, and the temperature of the water is determined, use the water source heat pump specification sheets to determine the specific equipment and flow rate required for the system.

The final element of supply water to be considered is the quality. All water contains a certain amount of impurities, which may or may not affect performance of the heat pump system. Since ground water heat pumps usually operate on untreated well water, a general rule to use is this: If untreated well water is suitable for drinking, then it is suitable for use in a heat pump system. Of course, the water must be free of sand and other particulates in order to prevent erosion of the heat exchanger and fouling of the valves. For this reason the use of a filter in the supply water line is recommended.

RETURN WATER

Supply water, having passed through the ground water heat pump unit, must be disposed of. Any disposal method must be designed to replenish the source from which the water was drawn. The common practice is to replenish the water source by reinjecting (returning) used water directly to the source. Hence, the term "return water." The three elements of supply water—quantity, temperature and quality—must also be applied to return water.

On the return side of the system, our major concern must be water quality. After all, essentially pure water is drawn from an aquifer, from which others may draw water for drinking or cooking purposes. With a typical water source heat pump system, ***the water that is returned to the aquifer is as safe and sanitary as the water that came from the aquifer.*** There are no health problems associated with the disposal of this water. This is because water flows through the heat pump system in pipes under pressure, without ever contacting air or refrigerant. The only change to the water is a change of temperature of about 5° - 15°F. Should a pipe, carrying water to or from the heat pump unit break, the result would be a water spill, but no health hazard. If the piping in the water-to-refrigerant heat exchanger should break, then it would be possible for refrigerant (R-22) and refrigerant oil to enter the return water. However, these impurities DO NOT create a health hazard. Refrigerant oil (less than one pint per unit) is a highly refined mineral oil of greater purity than the mineral oil sold as a laxative in drug stores. R-22 (Monochlorodifluromethane) is a man-made refrigerant that is stable, non-toxic, non-corrosive, non-irritating, and non-flammable. A typical ground water heat pump unit contains only 64 oz. of R-22. Therefore, water leaving a heat pump unit is as safe and sanitary as the water entering the unit.

The elements of return water temperature and quantity must also be considered in the proper design and installation of a ground water source heat pump system. Allowances must be made so that return water temperature does not affect the supply water temperature. Furthermore, the ability of the aquifer to reabsorb return water will affect the selection and design of a return water system. These considerations are covered more fully in this manual.

COPPER VS. CUPRO-NICKEL HEAT EXCHANGER

The water source heat pump unit contains a heat exchanger that allows heat energy to flow from refrigerant to water and vice-versa without allowing contact between the two. Water and refrigerant each flow through separate coils of pipe. The standard materials used for the water coil is copper or cupro-nickel. Cupro-nickel is a special alloy of copper that has a higher resistance to corrosion. The major advantage gained through the use of a cupro-nickel heat exchanger is this increased resistance to corrosion, which may substantially increase the service life of the heat exchanger depending on the quality of the water going through it. There is no appreciable difference in the rate of fouling between copper and cupro-nickel, but with its higher resistance to abrasion, the cupro-nickel coil will also tend to wear better through successive cleaning periods.

AVOID POTENTIAL PROBLEMS

As was mentioned earlier, all water contains some degree of impurities, which may affect the performance of a heat pump system. The use of a cupro-nickel water coil is the first step to be taken to avoid potential problems. Cupro-nickel, however, is no panacea for correcting these problems. The following guidelines should be used to minimize the harmful effects of scaling, corrosion, and incrustation.

SCALING is the process by which minerals contained in water precipitate out of solution and build up on the inside surfaces of pipes and valves. As scale builds up, heat transfer efficiency diminishes and resistance to water flow increases, thereby decreasing pump capacity and water volume through the system. Left unchecked, scale will eventually clog the system.

The minerals which combine to form scale are normally present in well water. These minerals are locked in solution by carbon dioxide. If the water temperature rises excessively and/or the pressure in the water line drops suddenly, the suspended minerals will be released from solution and will form carbonate scale. Therefore, the first step toward preventing scale is to keep all water lines under pressure. This is accomplished by placing solenoid valves and regulating valves only in the discharge (return water) line. Also use slow-closing solenoid valves to avoid sudden pressure drops. The second step to reduce scaling is to limit the temperature rise of the water to less than 20°F when the heat pump unit is in the cooling model. Scaling is unlikely to occur when the heat pump is in the heating mode.

CORROSION is the process by which pipes and valves are eroded or dissolved by compounds suspended in the water. Most groundwater is not highly corrosive. However, when present, corrosion, if not corrected, will cause the complete deterioration of the water piping system. The first step to protect against corrosion is a cupro-nickel heat exchanger in the heat pump unit. To protect the supply and return water lines, use PVC or polybutylene pipe. Use pipe fittings that will not corrode.

Another common form of corrosion is called galvanic corrosion. This occurs when dissimilar metals are mixed in a water system. To prevent galvanic corrosion, do not use iron or galvanized steel pipe and/or fittings. The best materials are: copper, PVC, polybutylene, polyethylene, and rubber.

INCRUSTATION is a buildup of a slimy, orange, brown deposit. It is caused by iron bacteria, and can clog a water system as effectively as scale. Keeping the water line pressurized and free of contact with air will inhibit the growth of iron bacteria. However, if iron bacteria are present in the water, they will form a deposit and will require periodic cleaning with phosphoric acid (food grade acid) solution. Therefore, specify the use of a cupro-nickel water coil. This will not reduce the growth of iron bacteria, but it will maximize the service life of the heat exchanger.

TABLE 1 —WATER COIL SELECTION GUIDE

Potential Problem	Use Copper Coil	Use Cupro-Nickel Coil
Scaling—		
Calcium and magnesium salts (hardness)	Less than 350 ppm (25 grain/gallon)	More than 350 ppm (up to sea water)
Iron oxide	Low	High
Corrosion*—		
pH	7 to 9	5-7 and 8-10
Hydrogen sulfide	Less than 10 ppm	10-50 ppm
Carbon dioxide	Less than 50 ppm	50 to 75 ppm
Dissolved oxygen	Only with pressurized water tank	All systems
Chloride	Less than 300 ppm	300 to 600 ppm
Total dissolved solids	Less than 1,000 ppm	1,000 to 1,500 ppm
Biological Growth—		
Iron bacteria	Low	High
Suspended Solids—	Low	High

* Important: If the concentration of these corrosives exceeds the maximum tabulated in the cupro-nickel column, then the potential for serious corrosion problems exists. Water treatment may be required.

WELL WATER SUPPLY

Well water, or ground water, is found in pore spaces within the sand, gravel, and rocks under the ground. To some extent there is ground water everywhere, but the depth, quantity, temperature, and relative purity vary widely. These parameters are extremely important in the selection, sizing, and installation of a ground water source heat pump system. A local well driller should be consulted for information on ground water in your area.

The most common, type of well today is the drilled well. Drilled wells are small diameter holes bored into the ground by a screw-type shaft attached to a drilling rig. Most of us are already familiar with the basic concept of a drilled well. The hole can be bored to any depth required to find ground water (to 500 feet deep if necessary). Once the hole is drilled, a pipe of suitable, non-corrosive material (PVC or steel) is inserted. This pipe is called a ***well casing***. It protects the well from collapsing, allowing a free and unobstructed path for water to flow from the underground aquifer to the surface. The basic components of a drilled well are detailed in FIGURE 1.

One very important difference between a drilled well and other well types is that a drilled well does not operate on the reservoir principle. Water is not stored in the well pipe for normal use. Rather a drilled well system depends on flowing ground water. The water contained within the pore spaces of the soil must flow to the opening of the well casing at a rate that is sufficient to supply enough volume to operate the heat pump system. Although the rate at which water will flow through soil is dependent on many complicated soil characteristics, any competent local well driller will be capable of determining the volume of water available from any particular location.

DRILLED WELL SYSTEMS

Before discussing the different aspects of a well system, it is important for the reader to become familiar with the following basic terminology:

Aquifer—A body, or quantity, of water. An underground aquifer is a water bearing formation contained below the surface of the earth.

Water Table—The surface of an aquifer. In an underground aquifer, the water table is the level of the water bearing formation that is closest to the surface of the earth.

Static Water Level—The level to which water will rise in a well. At any given time the static water level (SWL) is at the surface of the water column contained in a well.

Consolidated Formation—A solid layer of rock (granite, limestone, sandstone, shale, etc.)

Unconsolidated Formation—A mixture of materials (sand, gravel, soft clay, soil, etc.)

Supply Wells—It is important to remember that a supply well depends on flowing water and that it is a one-way system. Discharge water is never returned directly to a supply well. Furthermore, supply well systems are typically used in areas with unconsolidated underground geological formations.

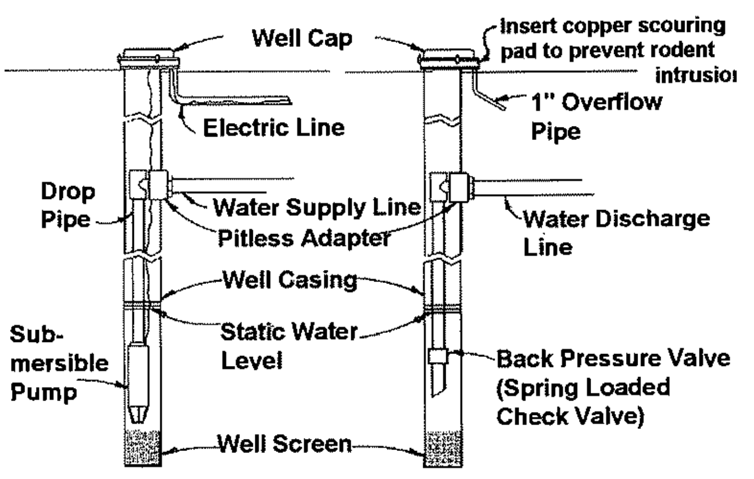


FIGURE 1
TYPICAL SUPPLY WELL

FIGURE 2
TYPICAL RETURN WELL

RETURN WATER DISPOSAL

Ground water that has passed through the water source heat pump must be disposed of properly. Although the dischargc (return) water is as safe and sanitary as thc source from which it is drawn, some local governments regulate water disposal. These regulations must be followed whcre applicable.

SURFACE WATER DISPOSAL

A pond, lake, or stream can be used to accept water discharged from a ground water heat pump system. The discharge pipe should be sized to minimize friction loss and tilted such that gravity will cause water to flow toward the pond, lake, or stream. The discharge end of the pipe should be placed above the water surface to avoid clogging by fish, frogs, or algae. Special care should be exercised to insure that the discharge pipe cannot freeze in winter. See FIGURE 4.

DRY WELL DISPOSAL

The dry well is basically a large hole in the ground that is filled with gravel. Discharge water flows into the hole and through the gravel. This method is practical only in a porous solid environment such as sand, and will not work in a non-porous ground environment, such as clay. This is because the discharged water must be able to pass through the gravel, then seep through the porous soil back to the water table below. See FIGURE 3. A percolation test for sizing is necessary.

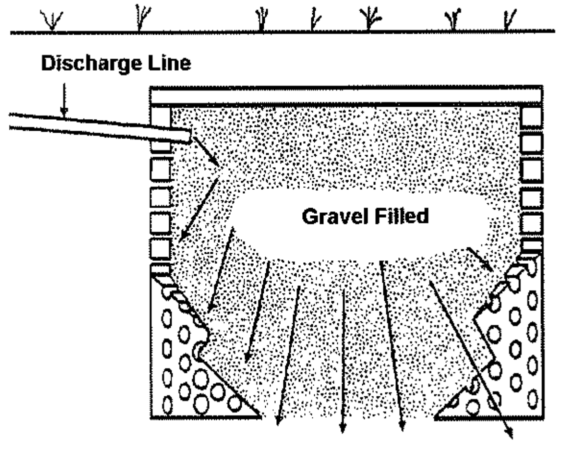


FIGURE 3 — DRY WELL

FIELD TILE DISPOSAL

Plastic field tile are commonly used in farmland areas with heavy clay coils. These tile are buried from three (3) to seven (7) feet below the surface in order to drain otherwise wet soil. With this disposal method, return water is discharged to tile, through which it eventually seeps to an area where it can be absorbed back into the underground aquifer.

RETURN WELL DISPOSAL

A return well is merely a supply well in reverse. In a geothermal well system, discharge water is returned to the supply well. This insures an adequate supply volume to the heat pump. In a supply well (one-way) system, a separate return well may be used. However, a typical well will accept only 75-80% of the water that it will yield. Therefore, when a separate well is used to reinject return water, a cone of impression is created in the soil. The cone of impression is the mounding of water pumped into the ground, and is directly the opposite of the cone of depression, or the drop in water level, that is created when water is pumped out of the ground. If the static water level is near the surface and the cone of impression rises far enough to reach the surface, the return well will overflow. Although this condition will rarely occur, it is possible. Therefore, all return wells should be designed to accommodate overflow in a controlled manner.

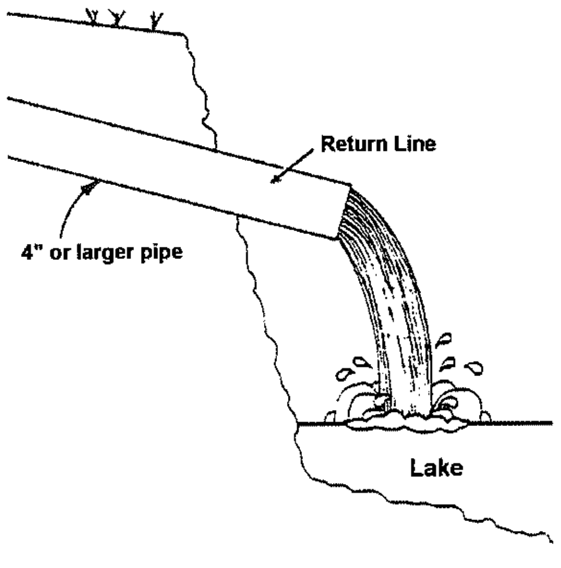


FIGURE 4 — DISCHARGE ABOVE A POND, LAKE OR STREAM SURFACE

The basic components of a discharge (return) well are detailed in FIGURE 2. There are several important points to consider when planning the installation of a separate return well. First of all, to avoid overlap between the supply and return, the wells must be positioned a certain distance apart. Although the precise separation distance will vary according to the underground geology, a good rule of thumb is to separate these wells by at least 100 feet. Secondly, the return well must be greater than or equal in diameter to the supply well with a screen length greater than that of the supply well. Typically, the return well has twice the screen of the supply well. Finally, to prevent air entrainment, which stimulates incrustation, the drop pipe in the return well must terminate below the static water level in the well and have a back pressure valve to maintain 10 psi in system at all times.

TABLE 1A — PRESSURE REQUIRED ON BACK PRESSURE VALVE (Spring-Loaded Check Valve) TO MAINTAIN 10 PSI ON DISCHARGE LINE

Depth to Static Water Level (Feet)	Spring Release Pressure (PSI)
0	10
10	14
20	18
30	23
40	27
50	31
60	36
70	40
80	45
90	49
100	53

The return well systems in FIGURE 2 employ a single water pump, with water always flowing in the same direction through the system. Another option is to install a ***Two-Well Reversible System***. Two pumps are used to reverse the flow allowing each well to alternate duty between supply and return. See FIGURE 5. During the heating season, Well A might be used for water supply, and Well B used for return. At the start of the cooling season, the flow is reversed, so that Well B is the supply well, and Well A the return. Three benefits are derived from this type of system. First of all, there is a residual temperature benefit that will increase seasonal operating efficiency. Secondly, replenishment of the aquifer is more effective, with the return redeveloped each year. Finally, the wells may be spaced closer together.

One important caution: The first ten (10) minutes of reversed flow should be pumped to waste (outside of the system) so that no sand or particulates are pumped through the valves or the heat pump unit. Also, when reconnecting the system, remember to connect the supply well line to the unit adapter marked "inlet" with the return well line connected to "outlet." This is extremely important.

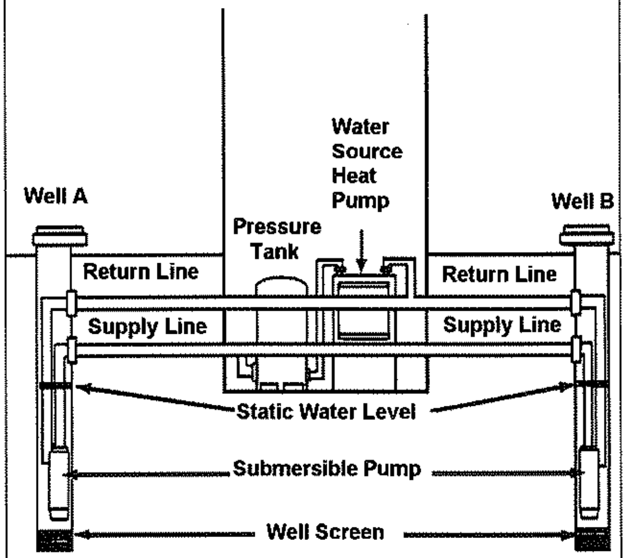


FIGURE 5 — TWO WELL REVERSIBLE SYSTEM

ALTERNATIVE WATER SYSTEMS

When there is insufficient ground water available for an open loop well system, then a closed ground coupled loop should be considered. In a ground coupled system, the earth itself is used as a heat source or sink. As water circulates through the piping system, heat energy transfers between water and soil. No boiler or fluid cooler is required. In a conventional closed loop (commercial) system, excess heat energy is added to or rejected from the loop by a make-up boiler or a fluid cooler respectively (see section titled, "An Alternate Water System: The Commercial Closed Loop System"). (See manual 2100-099, "Ground Coupled Loop System Design", available from your Bard distributor.)

WATER PUMP AND PRESSURE TANK

Most ground water source heat pump systems use a single water pump (see "two-way reversible system" for the exception to this rule) that is set in the supply well. The two common types of well pumps available are the jet and the submersible. The submersible pump is much more efficient than the jet pump, and is less likely to scale in the well.

PUMP SIZING

The first step to take in selecting the proper pump size is to determine the volume of water required from the well. Strictly speaking, sizing the well pump is the responsibility of the well drilling contractor. It is important, however, that the HVAC contractor be familiar with the factors that determine what size pump will be required. Rule of thumb estimates will invariably lead to under or oversized well pumps. Undersizing the pump will result in inadequate water to the whole plumbing system but with especially bad results to the heat pump—***no heat/no cool*** calls will result. Oversized pumps will short cycle and could cause premature pump motor or switch failure. Generally, a well pump must supply water both for heat pump operation and domestic (household) use. In this case, a decision must be made whether to select a well pump for the total combined volume (domestic and heat pump), or for the greater of the two. Generally, the domestic use is 75 gallons per day per person, or 5 gallons per minute. The figure of 5 GPM is based on peak demand rather than average need. See TABLE 2. The volume of water required by a water source heat pump unit can be found in the unit specification sheets. Contact your local equipment distributor for additional information.

DEDICATED SYSTEM—If the well water system is dedicated to the heat pump, with no additional requirements for household use, then the pump may be sized to supply the precise flow required by the heat pump only. Common well pump sizes in a dedicated system are 1/2 HP and 3/4HP.

COMBINED SYSTEM—In a combined system, the well pump supplies water for both the heat pump and for household use, a decision must be made whether to provide enough volume for both uses simultaneously, or for the greater of the two uses only. In either case a pressure tank must be used to temporarily store water for use in the system.

SHORT CYCLING—Another factor to consider in pump selection is short cycling. Although the average life of a well pump is seven (7) years, that figure may be significantly reduced if the pump is allowed to short cycle.

Short cycling occurs when the pump is started less than one (1) minute after it has stopped. A pump will last much longer if it runs continuously than if it is repeatedly started and stopped. Therefore, the pump, in conjunction with the pressure tank, should be sized so that the pump will be off for more than two minutes during a shut-off cycle. Reducing the size of the pump in relation to the pressure tank will reduce the potential for short cycling. The ideal situation is to have the well pump run continuously while the heat pump is operating. This not only reduces the initial purchase cost of the pump (lower HP is required), but operating electric costs for the homeowner are also reduced. This is because the smaller pump requires less electricity to run, and, because it tends to run continuously, power surges associated with pump startup are reduced. The net result is a properly sized and balanced system, at the lowest cost to the installer, and with the greatest savings available to the customer.

HEAD PRESSURE—The final step taken in pump sizing is to determine the head pressure for the pump. Head pressure is the total pressure that the pump must work against in delivering water through the system. The three physical properties of the system that affect head pressure are lift, friction, and pressure resistance of the pressure tank. Lift is simply the work the pump must do against gravity in pushing water "uphill" from the pump level in the well to the pressure tank. It is the total weight of the water contained in the pipes on the uphill side of the system. Friction, of course, is the resistance to water flow through the system components. Finally, the pressure tank itself exerts a back pressure against the work done by the pump. Pressure tanks are commonly set for a 30-50 PSI cycle. These three components are added together to determine total head pressure, which is usually expressed in feet of water column (Ft. H_2O or Ft. WC).

1 PSI = 2.307 feet of water

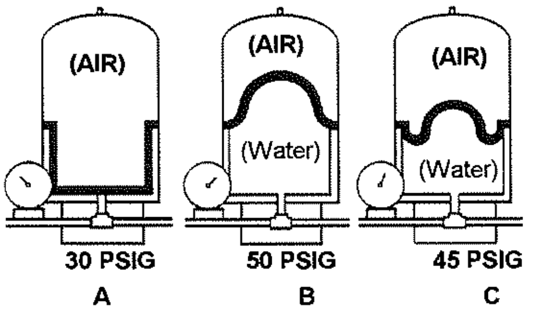
30 PSI = 69.21 feet of water

50 PSI = 115.35 feet of water

Once the required water volume and associated head pressure are determined, a properly sized well pump can be selected from pump performance curves published by the pump manufactured.

PRESSURE TANK SELECTION

The purpose of a pressure tank is to provide water to the system on demand, without short cycling the well pump. With the well pump off, the pressure tank will supply water when needed. This is because, as the name implies, water is held in the tank under pressure. In fact, at the beginning of a cycle an empty pressure tank contains compressed air which is separated from the water chamber by a rubber bladder. The pressure in an empty tank is the minimum operating pressure. The well pump works to fill the tank with water, thereby displacing the bladder and further compressing air in the tank. The pressure in the tank rises as it fills with water, until a maximum operating pressure is reached. Once the maximum pressure is reached, the well pump automatically shuts off. The pump remains off until the pressure in the tank returns to its minimum operating level (tank is empty). Then, the pump is cycled on again and the process is repeated. In this manner, cycling of the pump is reduced because the pressure tank does the work of supply water to the system. See FIGURE 6.



A. Factory installed precharged air cushion. Pump off.
B. When pump starts, water enters the reservoir. At 50 psig, system is filled. Pump shuts off.
C. When water is demanded, pressure in the air chamber forces water into the system. Pump stays off.

FIGURE 6 — OPERATION OF A PRESSURE TANK

In the applications discussed in earlier sections of this manual, the well system is often required to supply both domestic and heat pump water. Because the pressure tank actually replaces the well pump for brief periods of time, it must be capable of supplying a wide range of water flow, from minimum system requirements to peak demand volume. Therefore, to reduce short cycling of the well pump, the pressure tank should be large enough so that it takes more than one (1) minute to be filled by the well pump. Also, it should be large enough to supply water required by the heat pump for two (2) minutes or longer. In this manner, the well pump will run for longer periods of time, and will remain off for longer periods of time. This will increase the operating life of the well pump, and will decrease the amount of energy required to operate the system.

As a general rule, when sizing a pressure tank, bigger is better. However, selection of a proper tank must also consider the cost of purchase. A larger tank obviously costs more than a smaller tank. Regardless of the size selected, though, the pressure tank must be a prepressurized bladder type tank. Galvanized hydropneumatic tanks are unacceptable because of electrolysis and water logging. The table below describes various sizes of typical pressure tanks, and the draw-down capacities associated with each at various ranges of operating pressure. Typically, a pressure tank in a ground water heat pump system is set to operate between 30-50 PSI.

NOTE: Draw-down of a pressure tank is the usable volume of water between cut-in and cut-out pressures.

TABLE 2

Domestic Water Uses	Peak Demand Allowance for Pump	Individual Fixture Flow Rate
	gpm	gpm
Household Uses	Column 1	Column 2
Bathtub or tub-and-shower combination	2.00	8.0
Shower only	1.00	4.0
Lavatory	.50	2.0
Toilet—flush tank	.75	3.0
Sink, kitchen—including garbage disposal	1.00	4.0
Dishwasher	.50	2.0
Laundry sink	1.50	6.0
Clothes washer	2.00	8.0
Irrigation, Cleaning and Miscellaneous		
Lawn irrigation (per sprinkler)	2.50	5.0
Garden irrigation (per sprinkler)	2.50	5.0
Automobile washing	2.50	5.0
Tractor and equipment washing	2.50	5.0
Flushing driveways and walkways	5.00	10.0
Cleaning milking equipment & milk storage tank	4.00	8.0
Hose cleaning barn floors, ramps, etc.	5.00	10.0
Swimming pool (initial filling)	2.50	5.0

TABLE 3— PRESSURE TANK CHART

Nominal Capacity (Gallon)	Drawdown (Gal.)		
	20-40 PSI	30-50 PSI	40-60 PSI
20	7	6	5
30	10	9	8
40	14	12	10
80	28	25	21
120	41	35	31
200	69	60	52
270	93	80	70

WATER PIPING

PIPING MATERIALS

The final component to consider on the water side of a ground water system is the interconnecting piping, including valves and fittings, required to complete the loop from the supply well to the heat pump, then back to the return well (or other method of discharge). Typically, piping outside the building is either polyethylene or PVC, and is buried in a trench below the frost line, or at a minimum depth of four (4) feet, whichever is deeper. This piping is extended to the pressure tank in the building.

The use of one of the following pipe materials for connecting the pressure tank to the heat pump is suggested:

PVC	Rubber
Polybutylene	Copper

Never use iron or galvanized steel pipe in a ground water heat pump system. The use of a dielectric pipe material such as PVC to reduce sound transmission and electrolytic corrosion, whenever local codes permit, is recommended.

PIPE SIZING

The diameter of pipe chosen to carry water through the loop is an important consideration. Specific pipe size between the pressure tank and the heat pump unit depends on required flow and friction losses. As a general rule, the size of the pipe should not be smaller than the water connection adapters on the heat pump. Friction loss tables for various sizes of plastic pipe are included below for reference.

PIPE SIZING EXAMPLE—To properly size the piping in a ground water heat pump system, first draw a schematic diagram of the system, FIGURE 7, including all pipe lengths, valves, elbows and other fittings. The important parts of the system in this example, numbered 1 thru 11 below are:

1. Well pump selected for GPM system water flow and in this example set in the well 80 feet below horizontal pipe level.
2. Pump level (PL) - water level in well when pump is operating = 60 feet (supply) / 50 feet (return) — below level
3. Heat pump unit (HP) - 4 ton WSHP requiring 6 GPM.
4. Pressure tank (PT), selected for 30-50 PSI cycle.
5. Pipe elbows (plastic) - 3 (well pump to pressure tank) + 6 (pressure tank to discharge opening).
6. Drain cocks (or hose bibs) mounted tees = 3 total.
7. Ball valves = 2 total.
8. Constant flow valve = 1 total.
9. Slow closing solenoid valve = 1 total.
10. Discharge pipe opening = 70 feet below horizontal pipe level.
11. Back pressure valve. (Spring-loaded check valve)

Pipe sizing for the system is divided into three sections:

A. Piping from the well pump to the pressure tank.

B. Piping to domestic water.

C. Piping from the pressure tank to the discharge opening in the return well.

For the purpose of consistency most of the calculations are done in "feet of head" (Ft. Hd.) or "feet of water" (Ft. H_2O) which is a unit of pressure. This pressure is called pump head. Pump head (PH) is the sum of the pressure exerted by gravity (feet of lift), pressure exerted by the pressure tank, and pressure losses due to friction through the piping system (pipe, fittings, etc.).

The following is an example of sizing the piping, pump and pressure tank for the system in FIGURE 7 using the "Water System Worksheet," Form F1001.

STEP 1. Divide the water system schematic into branches, labeling each. See following:

Branch "A" Well Pump—Piping from pump in supply well to pressure tank.

Branch "B"—Piping from pressure tank to domestic water supply throughout house. Note: Most household systems require a minimum pressure of 69 Ft. Hd. (30 PSI). If you have a large house, it will require actually calculating the total branch pressure drop.

Branch "C"—Heat Pump Water Supply—Piping from pressure tank through heat pump to discharge point.

If you have more branches in a system, each one will have to be labeled and calculated separately.

STEP 2. Determine household water needs in GPM (gallons per minute) from TABLE 2. To use this table, list the number and type of fixtures

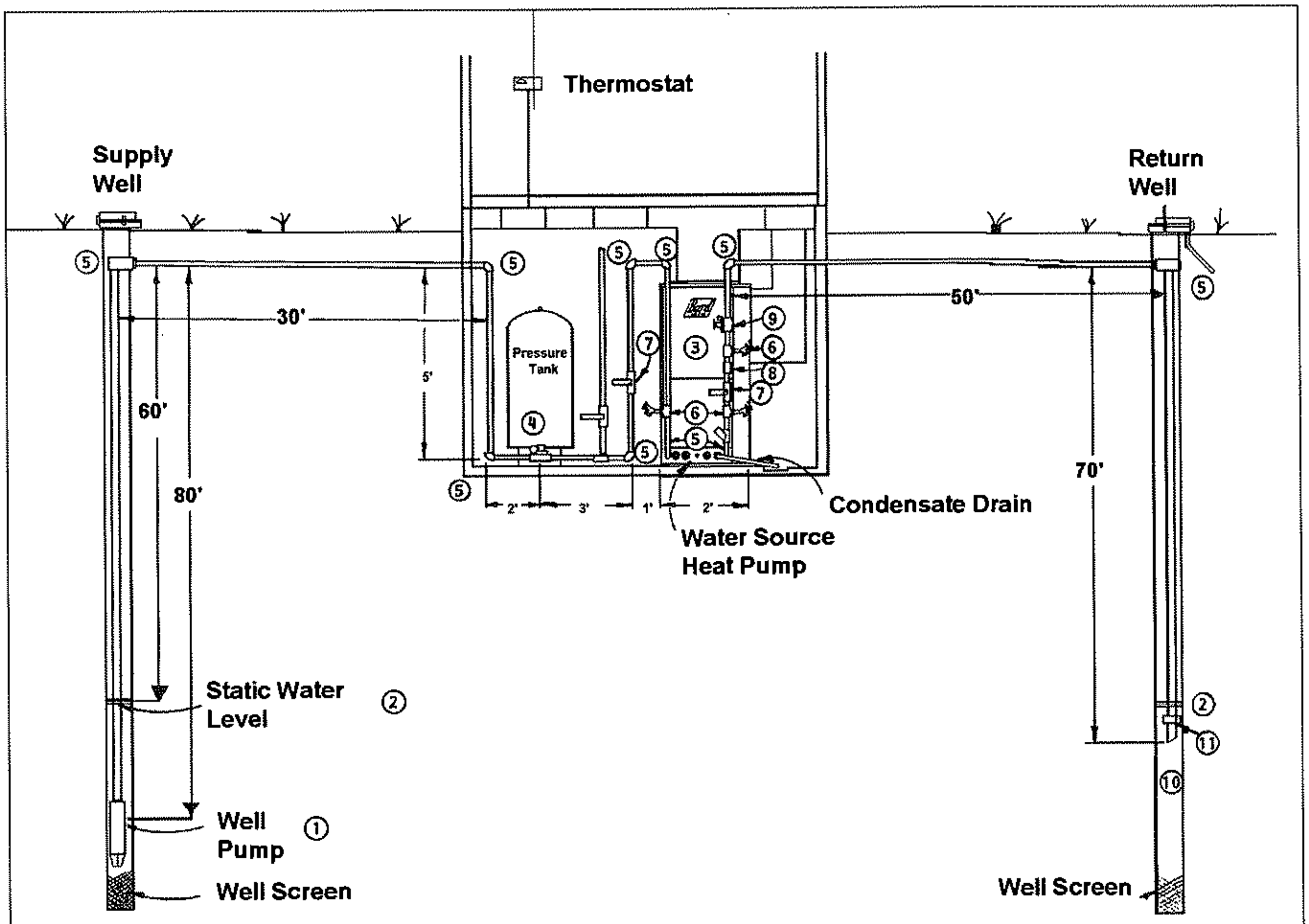


FIGURE 7 — TYPICAL RETURN WELL SYSTEM

in the home, such as tubs, sinks, toilets, etc. Then add up the peak demand allowance for each fixture (column 1 of table). The actual usage of each fixture will be larger than the peak demand GPM, however, not all fixtures in a household will require water at one time. Therefore, the pump will not be required to supply that total volume of water at one time.

EXAMPLE: Fixtures

Number		Peak GPM
(1) Tub and combination		2.0
(2) Laboratory		1.0
(2) Toilet		1.5
(1) Kitchen Sink		1.0
(1) Laundry Sink		1.5
(1) Clothes Washer		2.0
	Total	9.0 GPM

Enter this number on line 1 of worksheet.

STEP 3. From the manufacturer's specifications or installation instructions, determine the GPM water flow required for heat pump being installed and enter on line 2 of worksheet.

Example: A 4 ton heat pump requires 6 GPM.

STEP 4. Add up the total water requirement for each branch and enter on line 3 of worksheet. This is the total water flow the pump will be required to deliver to the house. In this example: 9 GPM domestic requirements + 6 GPM for water source heat pump = 15 GPM total requirement. This is also the amount of water (GPM) that is pumped in through branch "A", "piping from pump in supply well to pressure tank."

STEP 5. Tentatively select a pipe size for each branch, based on the GPM requirement for that branch. Select a pipe size which has a friction loss of less than 10 Ft. H_2O, from TABLES 4 or 5.

EXAMPLE: 1" plastic pipe will handle 14 GPM at 11.8 Ft. H_2O and 1-1/4" plastic pipe will handle 14 GPM at 3.1 FT. H_2O.

For this system a 1-1/4" plastic pipe was selected for Branch "A" and 1" plastic pipe was selected for Branch "C". Note 3/4" plastic pipe would handle the requirements for Branch "C", however, this particular heat pump has 1" pipe connection to the water coil, therefore, it is practical to use 1" pipe and keep pressure drop to a minimum.

STEP 6. Consult TABLE 7 and enter on line 5 of worksheet the equivalent feet of pipe for one elbow of the size pipe selected for each branch.

Example: 1-1/4" plastic pipe has 7 equivalent feet for each 90° elbow and 1" plastic pipe has 6 equivalent feet for each 90° elbow.

STEP 7. From the piping layout, determine the number of fittings (elbows, tees, ball valves, couplings, adapters, etc.) needed for each branch and enter on line 6 of worksheet.

EXAMPLE: Branch "A" has 3 elbows and 1 tee = 4 fittings total.
Branch "C" has 7 elbows, 3 tees and 2 ball valves = 12 fittings total.

STEP 8. Multiply line 5 by line 6 of worksheet and enter total on line 7.

STEP 9. From the piping schematic, determine total lineal feet of pipe in each branch and enter on line 8 of worksheet.

EXAMPLE: The 1-1/4" pipe is 118 feet long and 1" pipe is 140 feet long.

STEP 10. Add line 7 to line 8 of worksheet for total lineal feet of each branch and enter on line 9.

STEP 11. Consult TABLE 4 or 5 for pipe size and total GPM needed for each branch determined from Section A of worksheet and enter the friction loss per Ft. HD/100 Ft. on line 10 of worksheet.

EXAMPLE: 1-1/4" plastic pipe at 15 GPM would have approximately 3.5 FT. H2O per 100 FT. of pipe.

STEP 12. Multiply line 10 by line 9 of worksheet, then divide by 100 and enter the total on line 11 for each branch.

EXAMPLE: $\frac{212 \text{ FT. of 1" pipe} \times 2.5}{100}$ = 5.3 FT. HD total loss

STEP 13. Enter the pressure drop for the heat pump water coil on line 12 for Branch "C". This information is in the unit specification sheet. For this example, it is 5.8 Ft. Hd.

STEP 14. Enter the pressure drop for the constant flow valve and solenoid valve on line 13 for Branch "C". See TABLES 8 and 9.

EXAMPLE: Constant flow valve 34.7 FT. HD. + solenoid valve 3.5 FT. HD. = 38.2 FT. HD. total.

STEP 15. Calculate total pressure drop for Branch "A" and Branch "C" and enter on line 14 of worksheet.

EXAMPLE: Branch "A" has 5.1 FT. HD. and Branch "C" has 21.3 FT. HD.

STEP 16. Convert FT. HD. pressure to PSIG by multiplying line 14 by 0.433 and enter on line 15.

EXAMPLE: Branch "A"—5.1 x 0.433 = 2.2 PSIG
Branch "C"—49.3 x 0.433 = 21.3 PSIG

STEP 17. From the piping layout, determine parallel flow among branches. Beginning at the well pump, add the friction loss in PSIG for the well pump branch "A" to the branch having the higher pressure drop and enter on line 16.

NOTE: Branch "B", the domestic water line, has an assumed pressure drop of 30 PSIG (see section B of worksheet).

In the example, Branch "A" has 2.2 PSIG, Branch "B" 30 PSIG and Branch "C" has a 21.3 PSIG. Therefore, Branches "A" and "B" would be added together for a total of 32.2 PSIG. This is the lowest pressure that could be used in the system and still have adequate water flow through the fixtures with the heat pump operating at the same time.

STEP 18. Add 20 PSIG to the total system pressure drop on line 16 and enter on line 17 of worksheet. This is the cutout pressure for the pressure switch used to turn off the well pump.

NOTE: Most pre-set pressure switches for well systems are factory set at 20 PSI cut-in—40 PSI cut-out; 30 PSI cut-in—50 PSI cut-out or 40 PSI cut-in — 60 PSI cut-out. Therefore, if an adjustable pressure switch is not used, a preset pressure switch closest to the cut-out pressure from line 17 would have to be used.

EXAMPLE: 52.2 PSIG cut-out pressure would use the 30 PSI—50 PSI pressure switch

STEP 19. Multiply line 17 by 2.31 to convert the total system pressure from PSIG to FT. HD.

EXAMPLE: 52.2 PSIG x 2.31 = 120.6 Ft Hd

STEP 20. Enter on the worksheet the system water flow rate (GPM) from line 3, pressure drop in system (Ft. Hd.) from line 18 and the vertical distance in feet from the pressure tank to the pump in well, and enter in the respective spaces on line 19 of worksheet.

NOTE: It is very important to get correct vertical length from the water level in the well to pressure tank. For accuracy you will have to consult with a qualified well driller.

The information is now complete to select a well pump for this system. Refer to pump manufacturer's table to actually select the pump model based on requirements entered on line 19.

EXAMPLE: 15 GPM water flow rate at 120.6 Ft. Hd. pressure loss at 60 feet lift, for a total pressure of 180.6 Ft. Hd.

STEP 21. Selection of the water tank. Use only a tank with a bladder or diaphragm with a water source heat pump system. Enter desired minimum off time of the well pump in minutes and fractions of minutes (never less than two minutes) on line 20 of worksheet.

STEP 22. Enter the pressure switch cut-in point PSIG from line 16 on line 21 of worksheet.

STEP 23. Enter the pressure switch cut-out point PSIG from line 17 on line 22 of worksheet.

STEP 24. Multiply line 3 by line 20 to determine minimum drawdown volume required to keep the well pump off for at least two minutes, yet have enough water available to supply the household fixtures and the heat pump. Enter on line 23 of worksheet.

EXAMPLE: 2 min. x 15 GPM = 30 GPM requirement

STEP 25. Refer to TABLE 3 or pressure tank manufacturer's specifications to select the tank size required for the system. Now select a tank that has a drawdown volume in GPM equal to or greater than line 23 and within the pressure range of line 21 to line 22. Two small tanks with a combined drawdown equal to or greater than line 23 may also be used in place of one large tank.

EXAMPLE: A pressure tank with a nominal capacity of 120 gallons has a drawdown of 35 gallons at the 30-50 PSIG cut-in/cut-out pressure switch settings or combination of two pressure tanks with nominal capacities of 80 and 20 respectively have a combined drawdown of 31 gallons in the 30-50 PSIG range.

SUMMARY

This well system will require the following:

1. 1-1/4" piping between well pump and pressure tank.
2. 1" piping from pressure tank through heat pump to return well.
3. 30-50 PSI pressure switch setting.
4. Water pump capable of lifting 15 GPM of water 60 feet at delivery pressure of 120.6 FT HD or greater or a total of 15 GPM at a system total of 180.6 FT HD.
5. Pressure tank with a drawdown of 30 gallons or more at 30-50 PSI pressure range.

WATER SYSTEM WORKSHEET

(Method applicable to submersible pumps. Consult well driller for sizing of other types of pumps)

A. WELL PUMP SIZING

Branch "A" — Well Pump .... Piping from pump in well to pressure tank.

Branch "B" — Domestic Water Supply .... Piping from tank to the fixtures throughout house.

Branch "C" — Heat Pump Water Supply .... Piping from tank through heat pump coil to drain.

1. Determine household water needs for Table 2, Column 1 Enter here — 9 gpm Branch "B"
2. Enter gpm flow rate for heat pump to be installed from specifications (water coil rated flow). — 6 gpm Branch "C"
3. Add lines 1 and 2 for total water flow rate required. — 15 gpm Branch "A"

NOTE: If piping layout has more branches, determine the flow rate for these from Table 2, Column 1, and include in total.

B. DETERMINING WATER PRESSURE REQUIREMENTS PIPE SIZING FOR EACH PIPE BRANCH — Household plumbing, Branch "B", may be assumed to have a total pressure requirement of 30 psig (69 ft. hd.)

	BRANCH "A"	BRANCH "C"	
4. Tentatively select a pipe size and enter here. Table 4 or 5	1-1/4	1	inch pipe
5. Consult Table 7 and enter equivalent feet of pipe for one elbow of the size selected in step 4 above using gpm of the branch. Enter here.	7	6	equiv. feet
6. From the piping layout, determine the number of fittings needed for the branch. Enter here.	4	12	fittings
7. Multiply line 5 by line 6. Enter total here.	28	72	equiv. feet
8. From piping layout, determine total lineal feet of pipe in the branch. Enter here.	118	140	lineal feet
9. Add lines 7 and 8. Enter here.	146	212	total feet
10. Consult Table 4 and 5 for pipe size and total gpm needed for each branch determined from Section A above and enter friction loss here.	3.5	2.5	ft. hd./100 ft.
11. Multiply line 10 by line 9, divide by 100 and enter here as total piping friction loss.	5.1	5.3	ft. hd.
12. Consult heat pump specifications for the unit to be installed and enter unit pressure drop here. Branch C only. (Water coil pressure drop).		5.8	ft. hd.
13. Pressure drop for constant flow valve and solenoid valve. Tables 8 and 9.		38.2	ft. hd.
14. Calculate total pressure drop, Branch "C", by adding lines 11 and 12. Enter here. Branch "A" pressure drop is the same as line 11. Branch "A" should be entered here.	5.1	49.3	ft. hd.
15. Multiply line 14 by .433 to convert to psig. Enter here.	2.2	21.3	psig

16. From the piping layout, determine parallel flow among the branches. Beginning at the well pump, add the friction loss in psig for the well pump branch (Branch "A") to the branch having the higher pressure drop (Branch "B" or Branch "C"). Note: if more than three branches are required by the piping layout, select that branch which has the highest pressure drop and add this pressure drop to Branch "A". Enter on line 16 the number obtained as total piping pressure loss due to pipe friction — 32.2 psig
17. Add 20 psig to line 16 to obtain the pressure switch cut out point. Enter this value here. — 52.2 psig — tank cutout setting
18. Multiply line 17 by 2.31 to convert to ft. hd. Enter here. — 120.6 ft. hd.
19. Pump requirements will be: 15 gpm at 120.6 ft. hd. (line 18)

    plus 60 feet lift (Vertical distance to water in well)

    Total Pressure 180.6 ft. hd.

C. PRESSURE TANK SIZING (Applicable to bladder or diaphragm type tanks only — recommended type.)

20. Enter desired minimum off time of the well pump in minutes and fractions of minutes. Never less than two minutes. — 2 minutes
21. Enter pressure switch cut-in point psig. At least as great a pressure as required for cut-in pressure on line 16. — 32.2 psig
22. Enter pressure cut-out psig from line 17. Usually 20 psig higher than value in line 21. — 52.2 psig
23. Multiply line 3 by line 20 to determine minimum drawdown (acceptable volume). — 30 gallons
24. Refer to Table 3 or pressure tank specifications for a specific model of tank(s) to select nominal capacity of tank needed, using information from lines 21, 22 and 23 above. — 120 gallons

Friction loss tables and for common pipe diameters and materials. Figures given are friction loss in feet of head per one hundred feet of pipe. Doubling the diameter of a pipe increases its capacity four times, not two times.

TABLE 4

	1/2" ID = .622"				3/4" ID = .824"				1" ID = 1.049"			
	Steel		Plastic		Steel		Plastic		Steel		Plastic	
GPM	Ft.	Lbs.	Ft.	Lbs.	Ft.	Lbs.	Ft.	Lbs.	Ft.	Lbs.	Ft.	Lbs.
2	4.8	2.1	4.1	1.8								
3	10.0	4.3	8.7	3.8	2.5	1.1	2.2	1.0				
4	17.1	7.4	14.8	6.4	4.2	1.8	3.7	1.6				
5	25.8	11.2	22.2	9.6	6.3	2.7	5.7	2.5	1.9	.8	1.8	.8
6	36.5	15.8	31.2	13.5	8.9	3.9	8.0	3.5	2.7	1.2	2.5	1.1
7	48.7	21.1	41.5	18.0	11.8	5.1	10.6	4.6	3.6	1.6	3.3	1.4
8	62.7	27.2	53.0	23.0	15.0	6.5	13.5	5.9	4.5	2.0	4.2	1.8
9	78.3	34.0	66.0	28.6	18.8	8.2	16.8	7.3	5.7	2.5	5.2	2.3
10	95.9	41.6	80.5	34.9	23.0	10.0	20.4	8.9	6.9	3.0	6.3	2.7
12					32.6	14.1	28.6	12.4	9.6	4.2	8.9	3.9
14					43.5	18.9	38.0	16.5	12.8	5.6	11.8	5.1
16					56.3	24.4	48.6	21.1	16.5	7.2	15.1	6.6
18					70.3	30.5	60.5	26.3	20.6	8.9	18.7	8.1
20					86.1	37.4	73.5	31.9	25.1	10.9	22.8	9.9
22					104.0	45.1			30.2	13.1	27.1	11.8
24									35.6	15.5	31.1	13.5
25									38.7	16.8	34.6	15.0
30									54.6	23.7	48.1	20.9
35									73.3	31.8	64.3	27.9
40									95.0	41.2	82.0	35.6

Areas above the heavy lines are recommended for normal operation.

TABLE 5

	1 1/4" ID = 1.380"				1 1/2" ID = 1.610"				2" ID = 2.067			
	Steel		Plastic		Steel		Plastic		Steel		Plastic	
GPM	Ft.	Lbs.	Ft.	Lbs.	Ft.	Lbs.	Ft.	Lbs.	Ft.	Lbs.	Ft.	Lbs.
10	1.8	.8	1.7	.7								
12	2.5	1.1	2.3	1.0	1.2	.5	1.1	.5				
14	3.3	1.4	3.1	1.3	1.5	.7	1.4	.6				
16	4.2	1.8	4.0	1.7	2.0	.9	1.9	.8				
18	5.2	2.3	4.9	2.1	2.4	1.1	2.3	1.0				
20	6.3	2.7	6.0	2.6	2.9	1.3	2.8	1.2				
25	9.6	4.2	9.1	3.9	4.5	2.0	4.3	1.9	1.3	.6	1.3	.6
30	13.6	5.9	12.7	5.5	6.3	2.7	6.0	2.6	1.8	.8	1.8	.8
35	18.2	7.9	16.9	7.3	8.4	3.6	8.0	3.5	2.4	1.0	2.4	1.0
40	23.5	10.2	21.6	9.4	10.8	4.7	10.2	4.4	3.1	1.3	3.0	1.3
45	29.4	12.8	28.0	12.2	13.5	5.9	12.5	5.4	3.9	1.7	3.8	1.6
50	36.0	15.6	32.6	14.1	16.4	7.1	15.4	6.7	4.7	2.0	4.6	2.0
60	51.0	22.1	45.6	19.8	23.2	10.1	21.6	9.4	6.6	2.9	6.4	2.8
70	68.8	29.9	61.5	26.7	31.3	13.6	28.7	12.5	8.9	3.9	8.5	3.7
80	89.2	38.7	77.9	33.8	40.5	17.6	36.8	16.0	11.4	5.0	10.9	4.7
90	112.0	48.6	96.6	41.9	51.0	22.1	45.7	19.8	14.2	6.2	13.6	5.9
100	138.0	59.9			62.2	27.0	56.6	24.6	17.4	7.6	16.5	7.2
120					88.3	38.3			24.7	10.7	23.1	10.0
140					119.0	51.6			33.2	14.4	30.6	13.2
160					156.0	67.7			43.0	18.7	39.3	17.1
180									54.1	23.5	48.9	21.2
200									66.3	28.8	59.4	25.8
220									80.0	34.7		
240									95.0	41.2		
260									111.0	48.2		

Areas above the heavy lines are recommended for normal operation.

TABLE 7 — FRICTION LOSSES THROUGH FITTINGS IN TERMS OF EQUIVALENT LENGTHS OF PIPE

Type Fitting and Application	Pipe and Fitting Material ①	Equivalent Length of Pipe Nominal Size Fitting and Pipe						
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
Insert Coupling	Plastic	3	3	3	3	3	3	3
Threaded Adapter Plastic or Copper to Thread	Copper	1	1	1	1	1	1	1
	Plastic	3	3	3	3	3	3	3
90° Standard Elbow	Steel	2	3	3	4	4	5	6
	Copper	2	3	3	4	4	5	6
	Plastic	4	5	6	7	8	9	10
Standard Tee Flow Thru Run	Steel	1	2	2	3	3	4	5
	Copper	1	2	2	3	3	4	5
	Plastic	4	4	4	5	6	7	8
Stadard Tee Flow Thru Side	Steel	4	5	6	8	9	11	14
	Copper	4	5	6	8	9	11	14
	Plastic	7	8	9	12	13	17	20
Gate Valve (or Ball)	②	2	3	4	5	8	7	8
Swing Check Valve	②	4	5	7	9	11	13	16

Friction loss tables for fittings (Table 7). Figures given are friction losses in terms of equivalent length (in feet) of straight pipe.
① Loss figures are based on equivalent lengths of indicated pipe material and
② Loss figures are for screwed valves and are based on equivalent lengths of steel pipe.

TABLE 8 — FRICTION LOSS THROUGH CONSTANT FLOW VALVES

All GPM Ratings	PSI	FT. H_2O
	15	34.7

Minimum Water Regulating Valve Pressure Drop

	1/2"		3/4"		1"	
GPM	PSI	FT. HD	PSI	FT. HD.	PSI	FT. HD.
4.0	4.0	9.2	1.0	2.3	—	—
5.0	6.0	13.9	1.3	3.0	—	—
10.6	9.5	22.0	3.0	6.9	1.5	3.5
12.7	15.0	34.6	4.2	9.7	2.0	4.6

TABLE 9 — FRICTION LOSS THROUGH SOLENOID VALVE (FT. H_2O)

GPM	3/4"	1"
5	5.8	3.5
10	6.3	3.6
15	8.3	4.6
20	12.0	7.5
25	16.7	12.1
30	23.1	18.5

PIPING ACCESSORIES

Typical piping accessories included in the pipe lines from the pressure tank to the heat pump and from the heat pump to the discharge line are detailed in FIGURES 8, 9 and 10.

STRAINERS—The installation of a strainer in the water line as indicated to capture any sand or particulates in the water is recommended. The strainer should be placed between the water coil and the constant flow valve to insure that no sand or dirt collects in the openings of the constant flow valve.

CONSTANT FLOW VALVE—There is an automatic valve installed on the discharge side of the heat pump unit. It maintains the quantity of water through the unit to within 10% of required water flow rate even with the varying water pressures through the well system.

SHUTOFF VALVES—Use ball type shutoff valves to isolate sections of piping for periodic maintenance or changeout of parts.

SLOW CLOSING SOLENOID VALVE—A slow closing solenoid valve should be used to automatically shut off the heat pump low voltage circuit so that a signal to run the valve is wired to the heat pump low voltage circuit so that a signal to run the compressor opens the valve, and a shutoff signal closes the valve. These valves close (and open) slowly to avoid sudden pressure fluctuations which cause water hammer. See PROBLEMS TO AVOID below. They should be mounted only in the discharge line to maintain pressure in the heat pump water coil. This will reduce scaling in the coil.

NOTE: A slow closing solenoid valve is not required if pressure actuated water regulating valves are used.

DRAIN COCKS or HOSE BIBS should be installed as indicated to provide for periodic acid flushing of the water coil. Periodic acid flush is required to remove scale that builds up on the inside of the water coil.

PROBLEMS TO AVOID—Water pipes inside the house, even if they are plastic, may tend to *sweat*. For this reason, we suggest these pipes be insulated. Some recommended insulating materials:

Foam tubes	Insulating tape
Spiral wound fiberglass	

Another serious problem that deserves consideration is called ***water hammer***. Water hammer is the excessive vibration that can occur when flow in a pipe is started or stopped abruptly. Water hammer can be very noisy. To dampen the effects of water hammer, pipes may be anchored so that vibration cannot occur. Use a rubber bushing on the pipe where it is anchored to walls or joists (insulation will also serve as a bushing). Other piping techniques may be used to avoid water hammer completely:

1. A stand pipe such as is often used with automatic clothes washers.
2. Induce slight back pressure by partial closing of a ball type shutoff valve.
3. Use a slow closing solenoid valve.

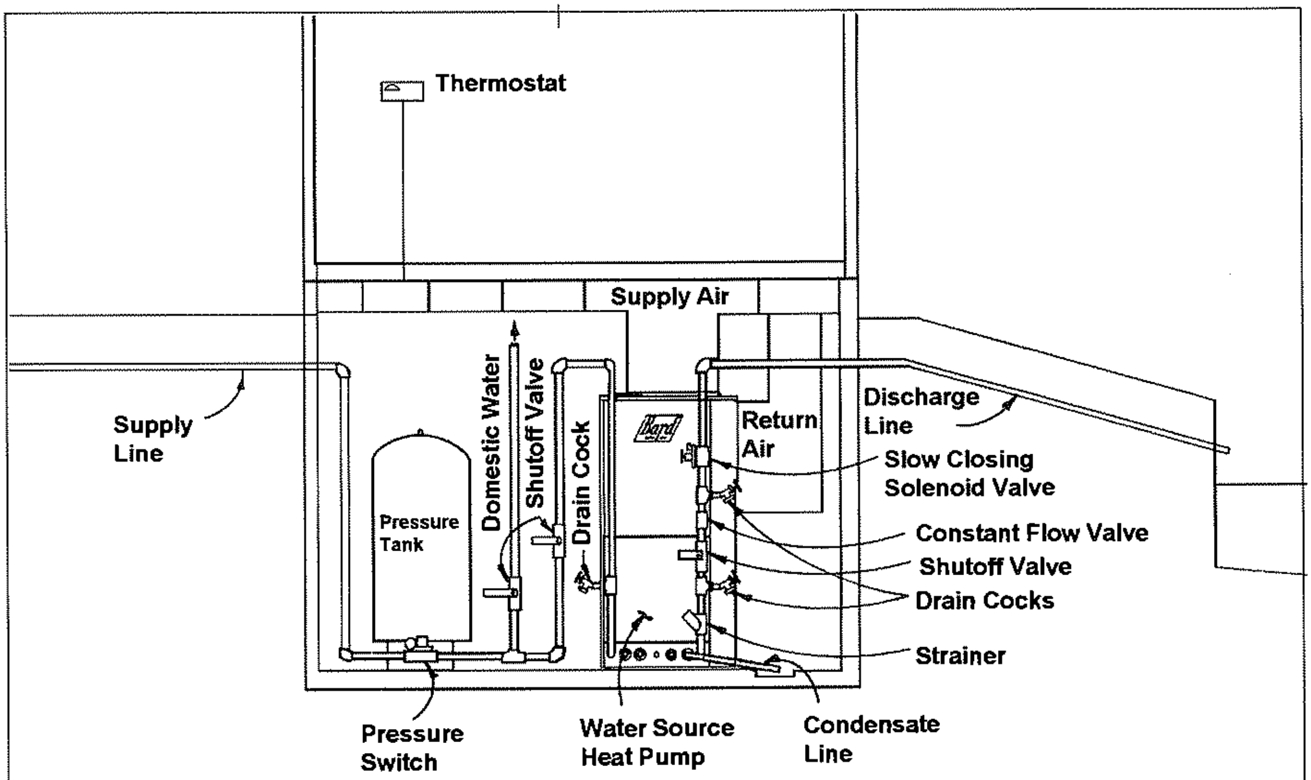


FIGURE 8 — TYPICAL PIPING TO WATER SOURCE HEAT PUMP

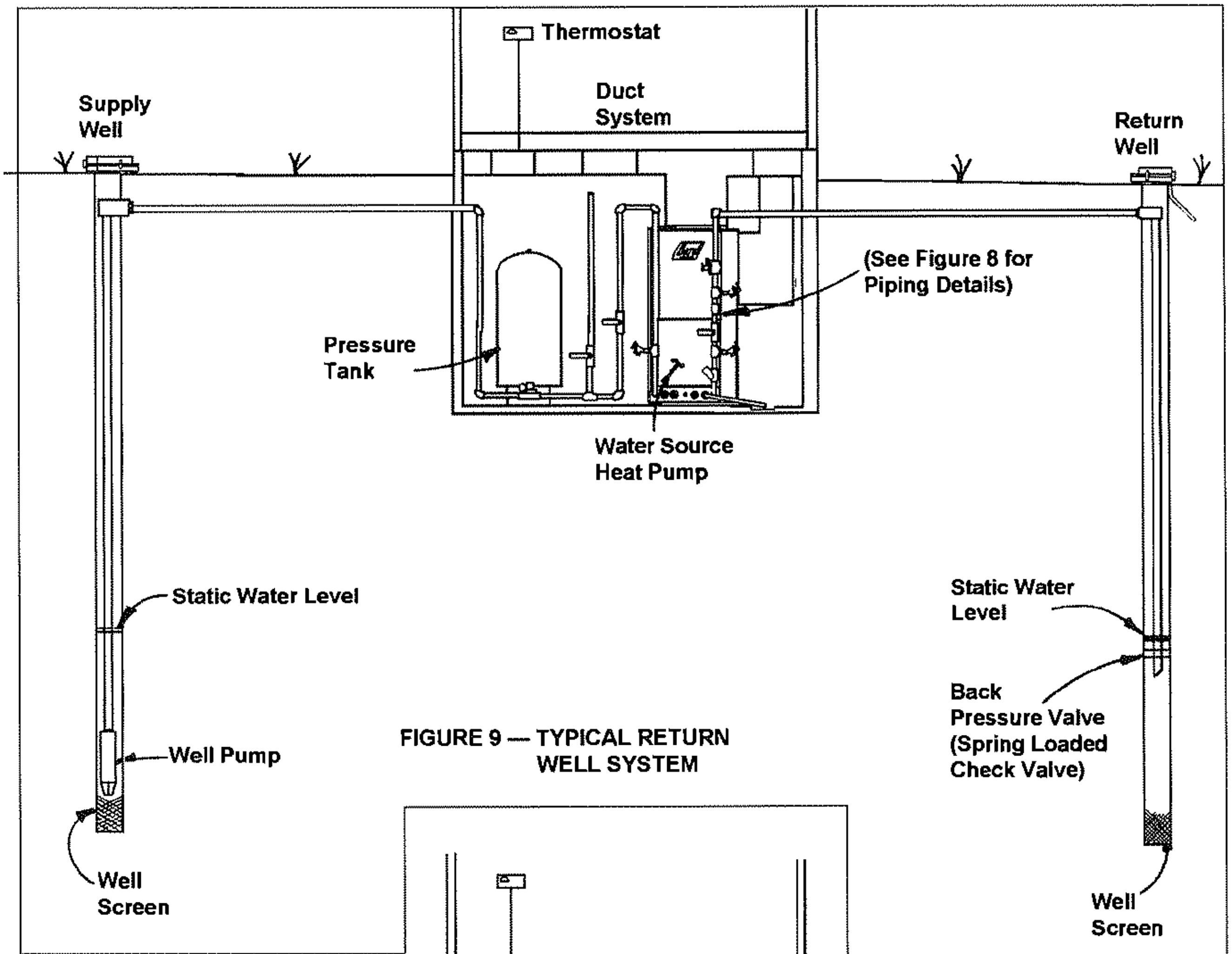


FIGURE 9 — TYPICAL RETURN WELL SYSTEM

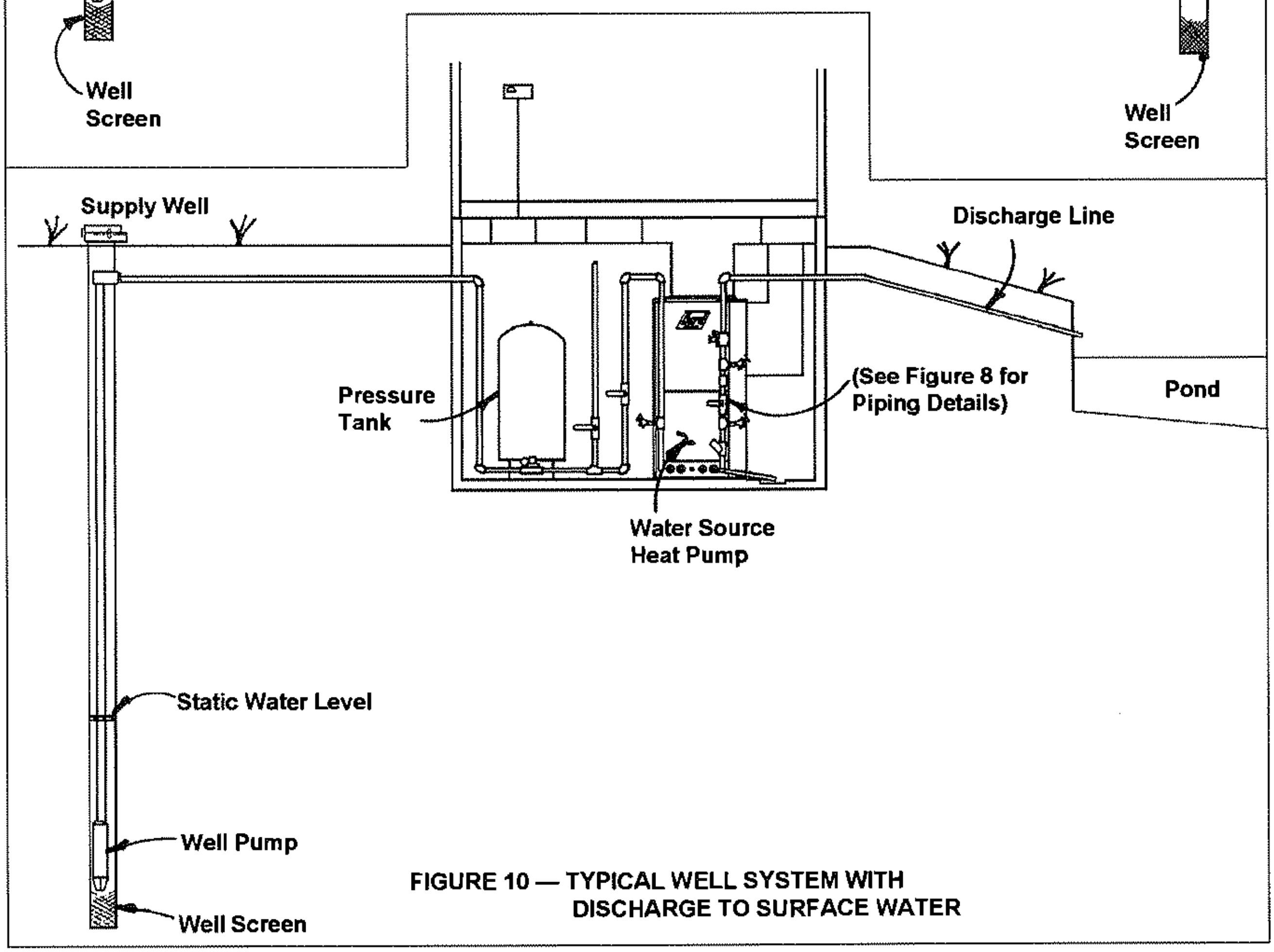


FIGURE 10 — TYPICAL WELL SYSTEM WITH DISCHARGE TO SURFACE WATER

LAKE OR POND APPLICATIONS

Lakes or ponds can provide a low cost source of water for heating and cooling with a ground water heat pump. Direct usage of the water without some filtration is not recommended as algae and turbid water can foul the water to the freon heat exchanger. Instead, we have had very good results using a dry well dug next to the water line or edge. Normal procedure in installing a dry well is to backhoe a 15 to 20 foot hole adjacent to the body of water (set backhoe as close to the water edge as possible). Once excavated, a perforated plastic casing should be installed with gravel backfill placed around the casing. The gravel bed should provide adequate filtration of the water to allow good performance of the ground water heat pump.

The following is a list of recommendations to follow when installing this type of system:

1. A lake or pond should be at least 1 acre (40,000 square feet) in surface area for each 50,000 BTUs of ground water heat pump capacity or have 2 times the cubic feet size of the dwelling that you're trying to heat (includes basement if heated).
2. The average water depth should be at least 5 feet and there should be an area where the water depth is at least 12 to 15 feet deep.
3. If possible, use a submersible pump suspended in the dry well casing. Jet pumps and other types of suction pumps normally consume more electrical energy than similarly sized submersible pumps.
4. Size the pump to provide necessary GPM for the ground water heat pump (normally 12 GPM for 3 ton unit).
5. A pressure tank should be installed in the dwelling to be heated adjacent to the ground water heat pump. A pressure switch should be installed at the tank for pump control.
6. All plumbing should be carefully sized to compensate for friction losses etc., particularly if the pond or lake is over 200 feet from the dwelling to be heated or cooled.
7. Keep all water lines below low water level and below the frost line.
8. Most installers use 4 inch field tile (rigid plastic or corrugated) for water return to the lake or pond.
9. The drainline discharge should be located at least 100 feet from the dry well location.
10. The drainline should be installed with a slope of 2 inches per 10 feet of run to provide complete drainage of the line when the ground water heat pump is not operating. This gradient should also help prevent freezing of the discharge where the pipe terminates above the frost line.
11. Locate the discharge high enough above high water level so the water will not back up and freeze inside the drain pipe.
12. Where the local conditions prevent the use of a gravity drainage system to a lake or pond, you can instead run standard plastic piping out into the pond below the frost and low water level.

WARNING

Thin ice may result in the vicinity of the discharge line.

WARNING

Many ground water heat pumps are designed to operate only at water temperatures of 45°F or higher. Water temperatures at the bottom of an ice covered pond can drop down close to freezing (38°F), which is too cold for some units to operate. Those ground water heat pumps designed for low water temperature operation normally are sent out from the manufacturer with a low pressure control set at between 28 to 35 PSIG. ***Be sure that you can get a unit that has low temperature performance down to 35°, that can operate safely without antifreeze.***

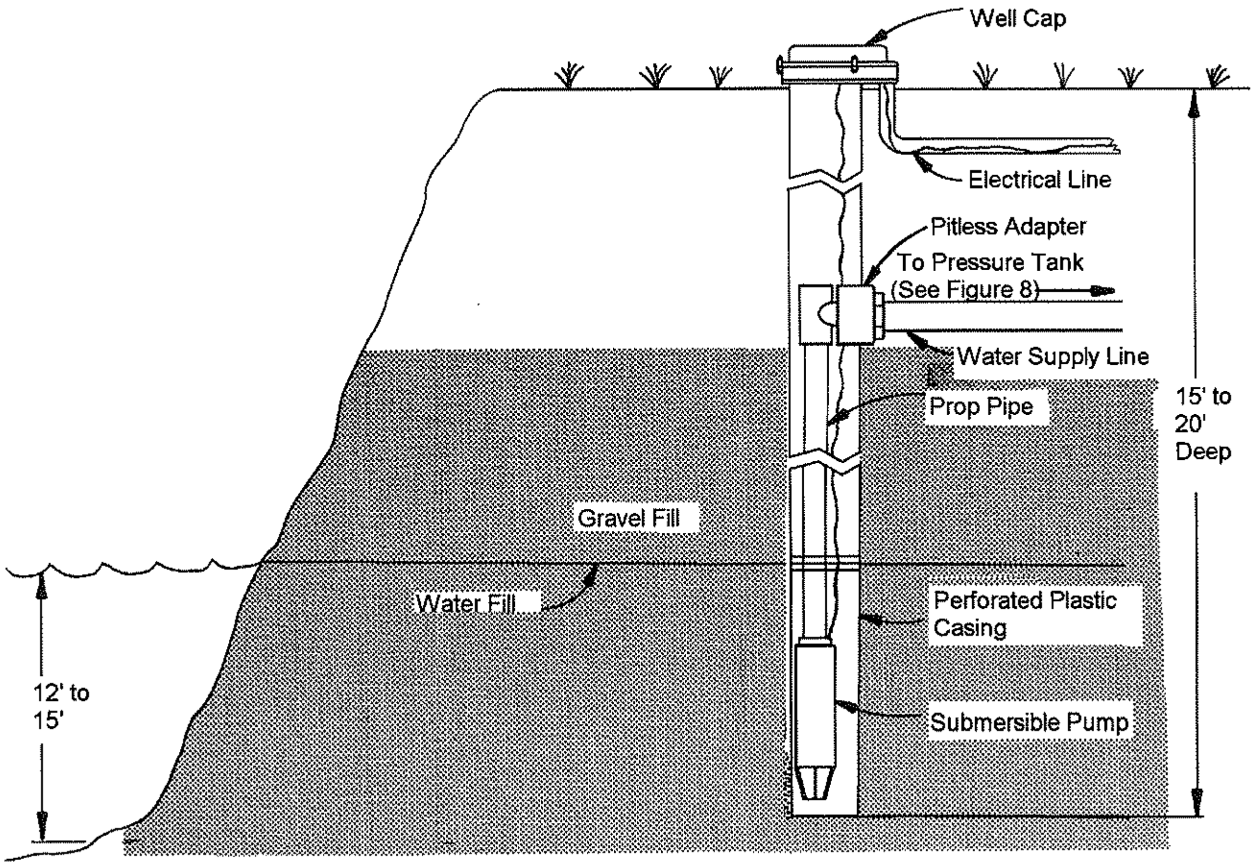


FIGURE 10B — LAKE AND POND APPLICATIONS

AN ALTERNATE WATER SYSTEM: THE COMMERCIAL CLOSED LOOP SYSTEM

The closed loop heat pump system consists of multiples of water source heat pumps connected in parallel in a two-pipe closed loop system through which water is circulated continuously. This type of system is used in buildings with heating and cooling zones. Example: Office and apartment buildings.

The temperature of the water in the supply loop is maintained within the approximate range of 60°F to 95°F by means of a central water heater which adds heat to the water at the low end of the range and a heat rejector which removes excess heat to cool the water at the high end of the range. This type of system can save over one-third of the building heating and cooling costs over a straight boiler and chiller operation.

The water in the pipes becomes a medium for transporting energy from warm spaces to cold spaces whenever they coexist within the building. This water circuit serves as a "heat sink" and a "heat source" that collects and stores energy from sources such as the sun, people, lights and heat generating equipment. The energy storage capacity can be increased through the use of a storage tank and a solar collector.

When heating is required, the heat pump will absorb heat from the water loop and reject it into the space to be heated. When cooling is required, the heat pump will absorb heat from the space to be cooled and reject it into the water loop.

If one-third of the units are in the cooling mode, they will reject enough heat into the water loop to supply heating for the remaining units, thereby using energy that would otherwise be wasted.

COOLING

During hot weather most or all of the units are cooing, the heat removed from the air is transferred to the water loop. A heat rejector, such as an evaporative water cooler, removes the excess heat from the water to maintain a maximum supply water temperature of approximately 95°F.

HEATING

In very cold weather when most or all of the units are heating, they absorb heat from the water. If a storage tank is in the loop, the amount of heat they can absorb from the water is increased. Once the supply water loop temperature falls to 60°F, the central water heater adds heat to the system. The heater is never larger than two-thirds the size required in other systems and is usually less because of diversity.

INTERMEDIATE

In moderate weather, units serving the shady side of the building are often heating while those on the sunny side require cooling. Office buildings with heat gain from lights, people or equipment in the interior areas may require cooling the year round. Heat absorbed from those areas is rejected to the water loop and transferred to the perimeter to provide heating.

During mild weather, buildings usually require cooling most of the day, except early in the morning when it is chilly. The heat collected from the units during the day is stored and provide enough heat for morning warm-up.

GENERAL NOTES TO KEEP IN MIND WHEN DESIGNING AND INSTALLING A COMMERCIAL CLOSED LOOP SYSTEM

1. Vibration isolation should be provided to equipment and piping systems in accordance with installation requirements.
2. Pressure gauges and thermometers should be provided as required to properly monitor system performance.
3. Some water heaters may require the addition of a runaround pump to insure minimum flow through the heat exchanger.
4. Insulate hot water line from boiler outlet to where it joins the main with insulation of required thickness.
5. In areas where the winter design temperature is below 40°F, the following items should be considered:
   - A. Insulate piping system where exposed to ambient to minimize heat loss.
   - B. Provide antifreeze to the water circulating system to prevent freezing. (15% ethylene glycol max)
   - C. Winterize cooling tower by draining the open water circuit, providing basin heaters, or providing a remote sump. Consult cooling tower manufacturer.
6. Consideration should be given to providing flow switch circuit interlocks to prevent operation of the heat pump compressors should there be no flow in the circulated water system.

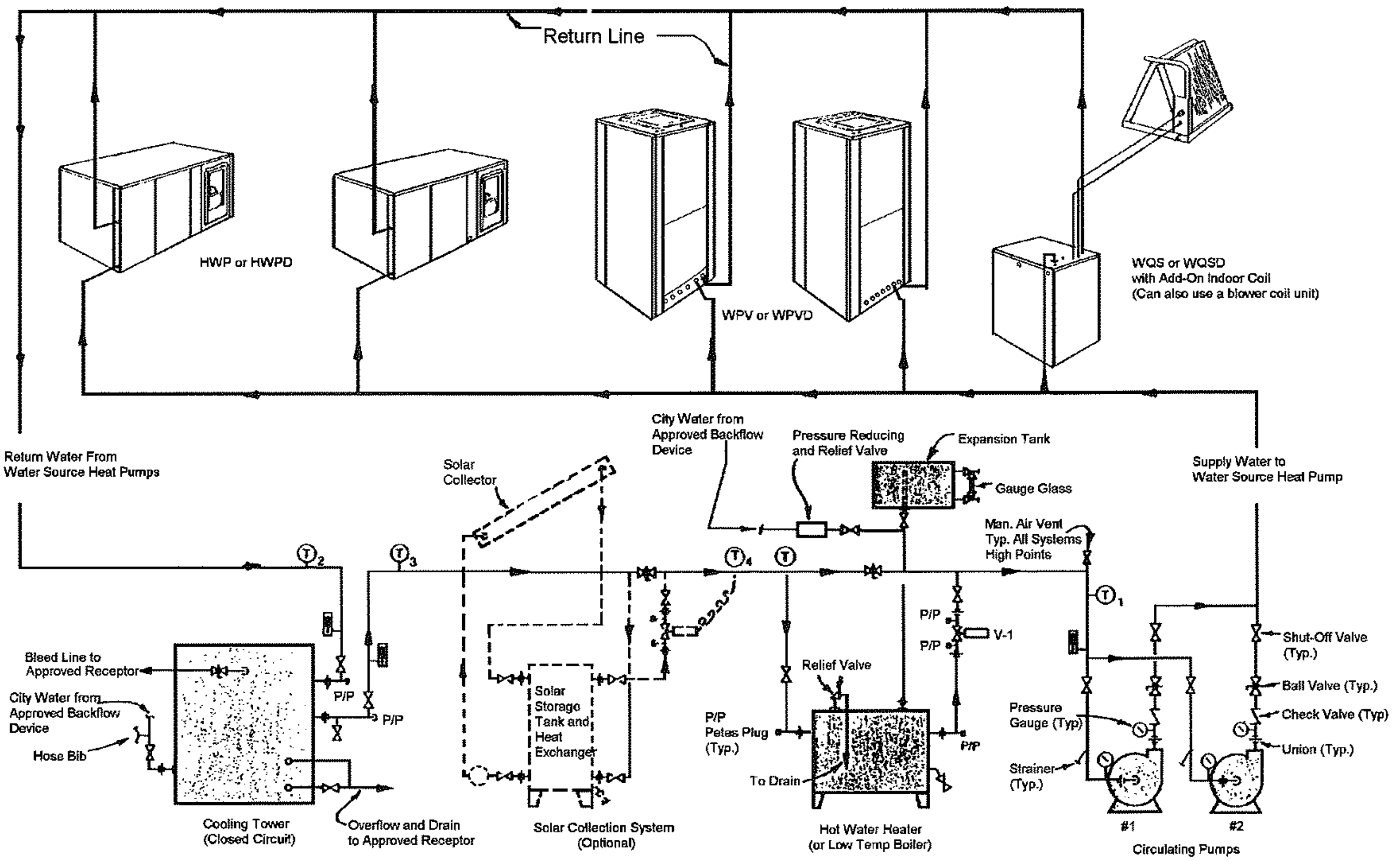


FIGURE 11 — TYPICAL CLOSED LOOP PIPING SYSTEM

WATER SYSTEM WORKSHEET

(Method applicable to submersible pumps. Consult well driller for sizing of other types of pumps)

A. WELL PUMP SIZING

Branch "A" — Well Pump .... Piping from pump in well to pressure tank.

Branch "B" — Domestic Water Supply .... Piping from tank to the fixtures throughout house.

Branch "C" — Heat Pump Water Supply .... Piping from tank through heat pump coil to drain.

1. Determine household water needs for Table 2, Column 1 Enter here ______________ gpm Branch "B"
2. Enter gpm flow rate for heat pump to be installed from specifications (water coil rated flow). ______________ gpm Branch "C"
3. Add lines 1 and 2 for total water flow rate required. ______________ gpm Branch "A"

NOTE: If piping layout has more branches, determine the flow rate for these from Table 2, Column 1, and include in total.

B. DETERMINING WATER PRESSURE REQUIREMENTS PIPE SIZING FOR EACH PIPE BRANCH — Household plumbing, Branch "B", may be assumed to have a total pressure requirement of 30 psig (69 ft. hd.)

	BRANCH "A"	BRANCH "C"
4. Tentatively select a pipe size and enter here. Table 4 or 5	______	______ inch pipe
5. Consult Table 7 and enter equivalent feet of pipe for one elbow of the size selected in step 4 above using gpm of the branch. Enter here.	______	______ equiv. feet
6. From the piping layout, determine the number of fittings needed for the branch. Enter here.	______	______ fittings
7. Multiply line 5 by line 6. Enter total here.	______	______ equiv. feet
8. From piping layout, determine total lineal feet of pipe in the branch. Enter here.	______	______ lineal feet
9. Add lines 7 and 8. Enter here.	______	______ total feet
10. Consult Table 4 and 5 for pipe size and total gpm needed for each branch determined from Section A above and enter friction loss here.	______	______ ft. hd./100 ft.
11. Multiply line 10 by line 9, divide by 100 and enter here as total piping friction loss.	______	______ ft. hd.
12. Consult heat pump specifications for the unit to be installed and enter unit pressure drop here. Branch C only. (Water coil pressure drop).		______ ft. hd.
13. Pressure drop for constant flow valve and solenoid valve. Tables 8 and 9. (or water regulating valves)		______ ft. hd.
14. Calculate total pressure drop, Branch "C", by adding lines 11 and 12. Enter here. Branch "A" pressure drop is the same as line 11. Branch "A" should be entered here.	______	______ ft. hd.
15. Multiply line 14 by .433 to convert to psig. Enter here.	______	______ psig

16. From the piping layout, determine parallel flow among the branches. Beginning at the well pump, add the friction loss in psig for the well pump branch (Branch "A") to the branch having the higher pressure drop (Branch "B" or Branch "C"). Note: if more than three branches are required by the piping layout, select that branch which has the highest pressure drop and add this pressure drop to Branch "A". Enter on line 16 the number obtained as total piping pressure loss due to pipe friction ______________ psig
17. Add 20 psig to line 16 to obtain the pressure switch cut out point. Enter this value here. ______________ psig — tank cutout setting
18. Multiply line 17 by 2.31 to convert to ft. hd. Enter here. ______________ ft. hd.
19. Pump requirements will be: ________ gpm at ______________ ft. hd. (line 18)

    plus ______________ feet lift (Vertical distance to water in well)

    Total Pressure ______________ ft. hd.

C. PRESSURE TANK SIZING (Applicable to bladder or diaphragm type tanks only — recommended type.)

20. Enter desired minimum off time of the well pump in minutes and fractions of minutes. ______________ minutes

    Never less than two minutes.
21. Enter pressure switch cut-in point psig. At least as great a pressure as required for cut-in pressure on line 16. ______________ psig
22. Enter pressure cut-out psig from line 17. Usually 20 psig higher valve in line 21. ______________ psig
23. Multiply line 3 by line 20 to determine minimum drawdown (acceptable volume). ______________ gallons
24. Refer to Table 3 or pressure tank specifications for a specific model of tank(s) to select nominal capacity of tank needed, using information from lines 21, 22 and 23 above. ______________ gallons