Chapter 5: Well Construction and Well Components

The quality and quantity of water obtained from a well is largely determined by the construction of the well. This chapter will stress the importance of proper well construction, discuss some of the more common construction problems that are encountered, and outline the resources available to find information related to a specific well and/or other ground water collector. A brief discussion of water rights is also provided to emphasize the importance of having a protected right to use the water in the well. A diagram of a water well is included as Figure 5.1.

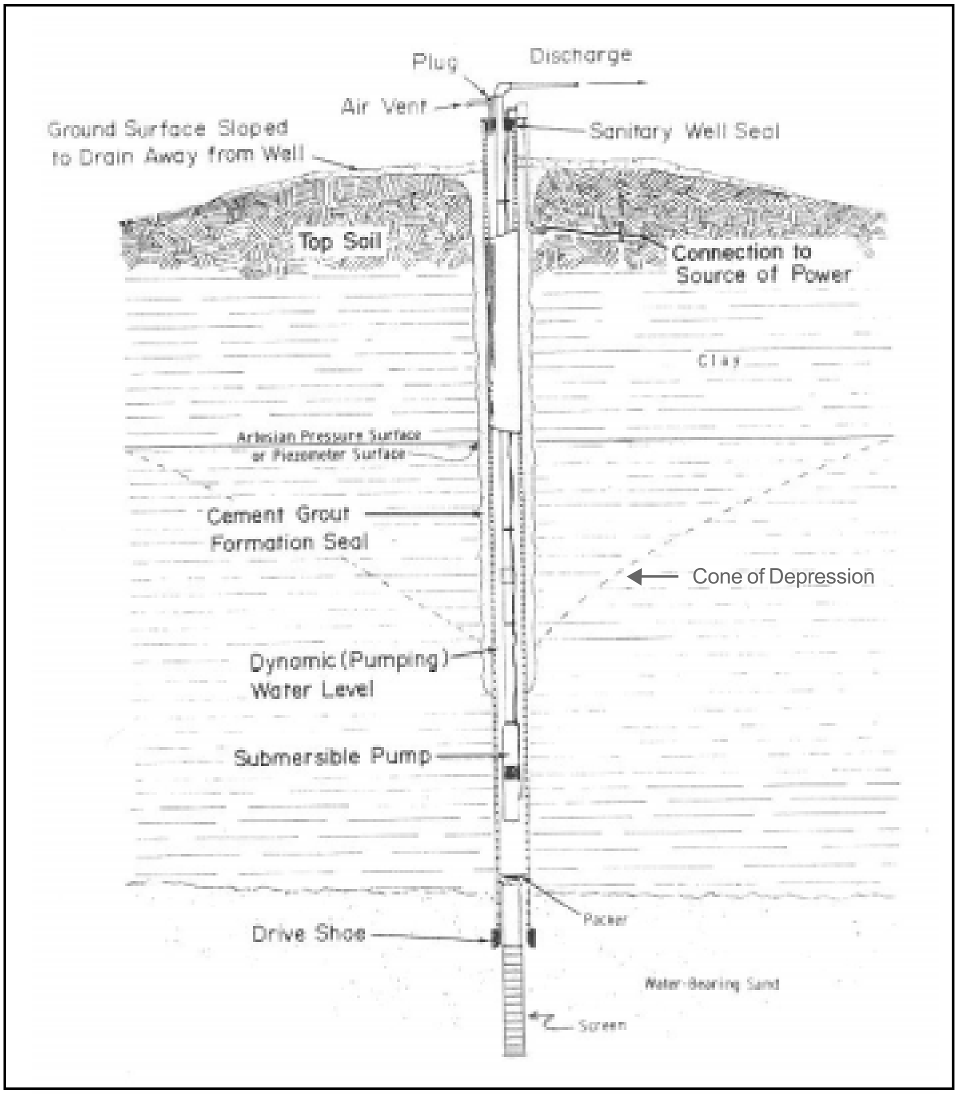

Figure 5.1.
Well cross section

5.1 Information and Records

Owners and operators new to a public water supply system may find few records of well construction, maintenance and monitoring have been retained. Information related to Water Rights and a copy of the Well Log Report for each well are important documents and should be kept in permanent system files.

5.1.1 Water Rights

State law requires the owner of a well with a maximum use of *less* than 35 gallons per minute (gpm) or 10 acre-feet to file Form 602, "Notice of Completion of Groundwater Development". This form, along with additional documentation, is to be filed by the owner within 60 days after the water has been put to use. Priority is determined by the date of filing. Filing is made through the appropriate Montana Department of Natural Resources & Conservation (DNRC) Regional Office. These Regional Offices are referred to as Montana Water Resources Regional Offices (WRRO), and can be located in your phone book under State Government - Natural Resources and Conservation - WRRO. Each WRRO has responsibility for several specified counties. Form 602 is available on the reverse side of the first copy of Form 603, "Well Log Report", which is to be given to the well owner by the well driller when the well is drilled. It is then the responsibility of the owner to complete the form and send the entire form to the appropriate WRRO. A "Certificate of Water Right" will be issued by the WRRO.

State law requires owners of wells (either a single well, or wells manifolded together) with a maximum use of *greater* than 35 gpm or 10 acre-feet to file for a permit. This differs from the notice of completion filed for small capacity wells. For wells producing greater than 35 gpm, the initial application used is Form 600, "Application for Beneficial Water Use Permit" which is to be filed *prior to water use*. The process for obtaining a permit is more complicated than for wells under 35 gpm because site-specific conditions must be considered. The local WRRO office will review other ground water withdrawals in the area, the potential impact on other users, the need for public notice, and the need for preparation of an Environmental Impact Statement. Filing these applications does not guarantee receiving the water rights. Contact the appropriate WRRO for the county while in the design-phase of planning a new well to determine requirements for your situation and to obtain additional information.

If a water right record for an existing well is not available, or it is not known if one has been obtained, check with the appropriate WRRO for the county. They can search for an existing water right or help file for a new one.

5.1.2 Well Log Reports

When a well driller drills a well, they are required to complete Form 603 - "Well Log Report", and file a copy with the appropriate WRRO within 60 days after completion of the well. A copy with Form 602 on the reverse side as described above is to be given to the owner for water right filing with the appropriate WRRO. If you are drilling a well, you should obtain copies of the well log report from the driller.

If no well log report is available for an existing well a copy should be acquired. Contact the well driller since they may keep a file of well log reports for all wells they have drilled. If the driller is unknown or doesn't have a copy, contact the appropriate WRRO for the county. As a last resort, try the Montana Bureau of Mines and Geology in Butte.

If a well log report cannot be found, have the well probed for static water level and depth of well the next time the pump is replaced, and keep this information with the permanent system records.

In addition to routine address and well location information, the well log report describes each geologic stratum encountered, the various depth(s) where water was encountered, and the overall depth of the well. It also lists construction details such as casing type and size, perforation type and depth, screens used, grout and sealing methods, etc. Careful study will also reveal static water level, and test pump rates and drawdown. Interpretation of the data will help to determine whether the well is in a confined or unconfined aquifer, what the maximum pumping rate of the well should be, and many other pertinent factors. The well log report is also a critical document when making the "Ground Water Under the Direct Influence of Surface Water" evaluation described in Section 4.1.2.

5.2 Well Construction

Well construction begins with preparation of specifications tailored to system needs, based on the geology of the area. Community public water supply systems must use a professional engineer for this step. Non-community systems can obtain a standard set of specifications from DEQ, and their personnel can provide additional specific advice. A contractor licensed by the Montana Board of Water Well Contractors must be present and in responsible charge whenever a drilling rig is in operation for a well to be used for a public water supply system.

Well construction is one of the most important aspects of system construction. Owners and operators need to have a basic understanding of well construction techniques, components, terminology and maintenance. This section provides a discussion of significant items.

> Additional details on well operation, maintenance and construction are found in *Small Water System Operations and Maintenance, 3rd Edition*— See bibliography.

5.2.1 Soil and Water Bearing Formations

As the well is being drilled, the driller logs each change of formation and each water bearing formation. Interpretation of this data indicates where the casing will be perforated and the quantity of water that might be expected. It also shows whether there could be water movement from shallow ground waters to deeper aquifers.

5.2.2 Well Construction Methods

The four most common types of wells are dug, drilled, bored and driven wells.

Hand-dug wells were once common in areas of Montana where ground water was shallow. However, because these shallow wells are prone to contamination and lower yield during times of drought, many have been abandoned and replaced. Of those still in use, most have required disinfection as treatment to protect consumers from pathogenic organisms which may reach the shallow aquifer or contaminate the well through deficiencies in its construction.

Drilled wells are typically constructed either by rotary drilling or the cable-tool method. Rotary drilling involves the use of a rotating cutting bit on the end of a rotating drill pipe. Drilling fluid, compressed air or suction is used to carry the cuttings to the ground surface. In the cable-tool method, a heavy drill bit and stem are raised and dropped to crush pieces of the formation. A bailer is used to periodically bring a slurry of water and cuttings to the surface.

Bored wells are constructed with earth augers which look similar to an oversized drill bit. They are typically less than 100 feet deep.

Driven wells are constructed of a well-point connected to pipe sections. The well-point is driven into the formation with some sort of maul. They are common in sandy alluvial formations.

5.2.3 Well Depth and Casing Depth

Except in unique circumstances, all wells are required to be cased to the bottom of the usable bore hole. A well must be at least 25 feet deep, and have unperforated casing to that depth, or it is considered to be a shallow ground water well and continuous disinfection must be provided.

5.2.4 Casing Type and Size

Most well casing used in Montana is either steel or PVC plastic. Minimum specifications for casing diameter, wall thickness, weight, depth, and joints apply.

Temporary or surface casing may be used in the construction of drilled wells, and is withdrawn as sealing material is placed around the permanent or production casing.

The exception to this is where plastic PVC permanent casing is used, it may telescope into the surface casing that has been left in place.

On some older wells the surface casing has never been withdrawn so it is not always apparent what the size and type of the production casing really is. Temporary casing is almost always steel, and at least 2 inches larger than the production casing.

Design standards require well casings extend not less than 18 inches above the finished ground surface, 12 inches above the pump house floor, or three feet above the 100 year flood level.

Casings terminating flush with the ground, below the flood level of depressions, or below ground should be extended. This is accomplished by welding another piece of casing pipe to the existing casing.

Casings terminating almost flush with a concrete floor in a well house should also be extended. Often these casings are badly corroded so concrete chipping may be needed to get down to sound casing necessary for an adequate weld.

5.2.5 Perforated Interval and Screens

As the well is being drilled, the driller logs the depth to each water bearing formation as it is encountered. After the casing is in place, various tools can be used to perforate the casing at these intervals to allow water into the casing. Some wells are drilled into a single water bearing formation, and the casing is left open at the bottom. Screens are often installed in high production wells, and in some wells where sand or other soil conditions might be a problem. A few low production wells have actually been extended an additional depth into non-water bearing formations for the sole purpose of providing additional water storage in the bottom of the casing.

5.2.6 Grouting and Sealing

Grout is a generic term used to describe the seal of the ***annular space*** between the outside of the bore hole and the permanent well casing. Typically some type of cement or clay grout is used. The purpose of grouting is to prevent possible downward movement of surface water or runoff along the outside of the permanent well casing, and also to prevent ground water movement between aquifers which might impair water quality or result in cascading water. In general, all wells must be grouted to a minimum depth of 18 feet.

When grout is applied, it should be tremmied into the annular space from the bottom-up to prevent bridging and voids. Grout should also be added after excavation for installation of a pitless adapter.

5.2.7 Well Production Terminology

The following are important terms used to understand production obtained from a well.

1. ***Static Water Level***: The distance from the ground surface to the water level in the well when no pumping is occurring.

2. ***Pumping Water Level*** (or dynamic level): The distance from the ground surface to the water level in the well when pumping.

3. ***Drawdown***: The difference between the static and pumping water levels. Drawdown is generally calculated based on a fixed pumping rate and a stabilized drawdown condition. The pump intake must be below this level.

4. ***Well Yield***: The quantity of water pumped per unit of time usually in gallons per minute (gpm).

5. ***Specific Capacity***: A measure of yield per foot of drawdown expressed as gpm/ft. (For example, if a pumping rate of 320 gallons per minute causes a drawdown of 16 feet, the specific capacity is 320 gpm/16 ft. = 20 gpm/ft.

5.2.8 Test Pumping

Test pumping is a procedure used to determine the yield of a well by installing and operating a pump for an extended period of time.

Test pumping must occur at 1 1/2 times the required design flow rate for the system, and should reach a stabilized drawdown condition for 6 to 8 hours. If stabilized drawdown is not reached, pumping must continue for a minimum of 24 hours.

It pays to be just a little skeptical of recorded test pump results on some well log reports. If the data is questionable and the yield is marginal for design flows, additional test pumping would be required.

5.2.9 Pitless Adapters, Well Caps, Well Seals, and Well Vents

A *pitless adapter* (Figure 5.2.9a) is a fitting designed to permit frost free underground discharge from a well, while still providing access to the well for installation and removal of a pump and/or appurtenances. Most pitless adapters are used with submersible pumps, although units are made to accommodate suction centrifugal and jet pumps. Submersible pumps may also be installed without using a pitless adapter by bringing the discharge pipe out through a sanitary well seal at the top of the casing. (Figure 5.2.9c) In this case a heated well house must be constructed over the well to prevent freezing. When metering and/or chlorination equipment is used, this construction is common.

Well caps (Figure 5.2.9b) are designed for outdoor use, and come in many configurations and sizes to fit most well casings. A good well cap is designed to be both watertight and insect resistant. These caps have a steel collar with a

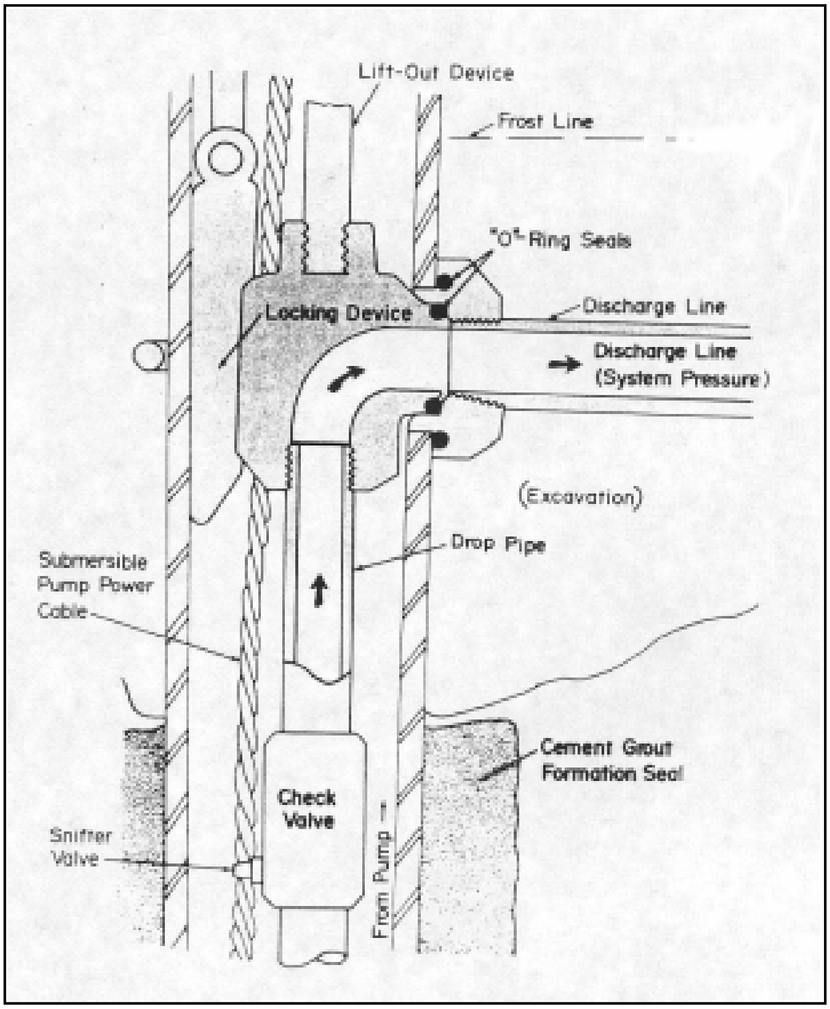

Figure 5.2.9a.
Pitless adapter

gasket that is bolted to the well casing. A second full-cover piece with gasket and built-in screened vent is then bolted to the collar. This provides easy access to the well if needed. These caps are much better than ordinary slip-on caps. They are also reasonably priced.

Well seals (Figure 5.2.9c) are designed primarily for indoor use where a well is located in a pump house away from precipitation. These seals have an expanding rubber gasket and fit inside the top of the well casing. Standard openings are provided for various pipe sizes and pump configurations. These seals are not intended for outdoor-wells since it is virtually impossible to seal

Figure 5.2.9b.
Well Cap
with Vent

them sufficiently tight to shed water. When used outdoors, they should be replaced with the gasketed caps just described. Even when used on wells inside, these seals may develop open holes where insects can enter the well and may not have a vent. These situations need to be corrected where they exist.

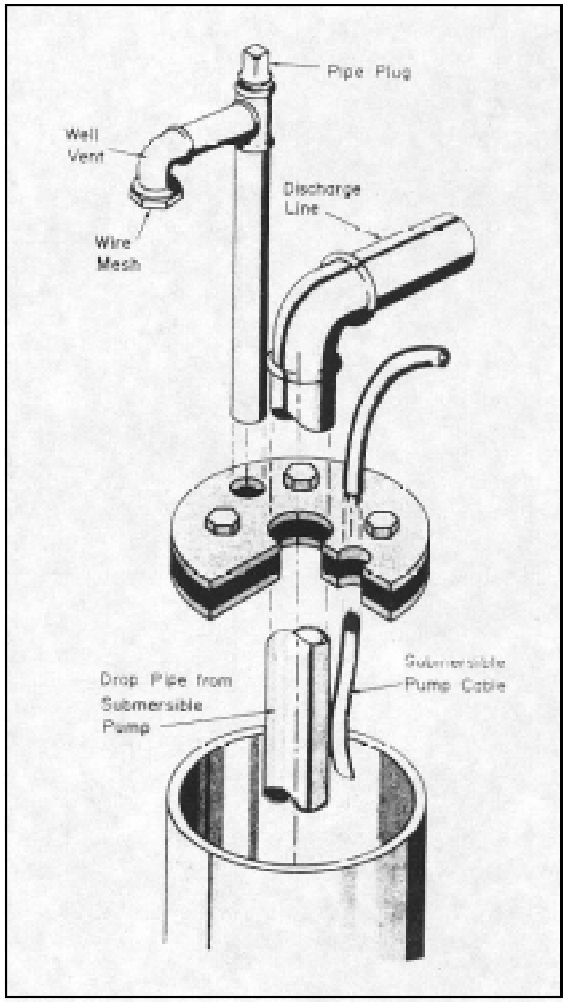

Figure 5.2.9c. Well seal, Vent with Screen

When a pump starts, drawdown of the well begins, and there is a need to rapidly supply air to the well to compensate for the drawdown void in the casing. Likewise, when the pump goes off and the water in the well returns to a static condition, air must be expelled. This is the purpose of the ***well vent.*** Venting is important so a vacuum won't develop in the well and draw contamination into the well from some unknown source. A high capacity pump in a well with a significant drawdown will require more air than a low capacity pump with little or no drawdown. Use of an appropriate well cap as described above will provide the proper venting in a single unit. However, most well seals need to have a vent installed, especially if the holes in the seal are plugged to keep insects out. Small capacity wells can be fitted with an inverted vent pipe covered with 24 mesh screen. A hose clamp would hold the screen in place. Larger capacity wells and pumps may require a larger casing vent be welded into the side of the casing. All vents must face downward and be screened.

5.3 Site Considerations and Location

Wells are very vulnerable to invasion by insects and rodents and a poorly sited or constructed well may be impacted by surface water or runoff. Following are some of the more common siting and location considerations impacting public water supply systems.

5.3.1 Well Location

Rules governing licensed well drillers and DEQ design standards are specific in terms of well location. Wells should not be located within 50 feet of septic tanks, 100 feet of drainfields and seepage pits, or 50 feet of sewer lines. In addition, wells are to be located within a 100 foot radius control zone that is protected by ownership, easements, leasing, or other acceptable methods.

Even if wells meet this setback criteria, it is not positive assurance they won't be impacted by contaminated ground water. These should be considered minimum set-back criteria. Soils, shallow groundwater conditions and the effect of pumping adjacent wells can influence the movement and transport of contaminants. Adjacent surface waters such as lakes, rivers, and streams also may impact wells as described in the ground water under the direct influence of surface water discussion in Chapter 4.

Wells must also be protected from livestock access. Horses, cattle and other livestock should be fenced away from wellheads to prevent damage to the cap, controls, seal and drainage area. DEQ recommends source water protection planning occur before well installation takes place.

5.3.2 Drainage Around the Wellhead

Surface drainage should be directed away from the wellhead. After installation of a pitless adapter, settling almost always occurs around the well casing. If this depression is not filled and mounded around the casing, surface water can collect in the depression and eventually "pipe" down the side of the casing into the water bearing formation. Proper well grouting and a multitude of other factors can influence this situation, but keeping drainage away from the well is the an important barrier.

5.3.3 Well Pits

Well pits were commonly used in systems constructed prior to the innovation of pitless adapters. Pits were used to avoid constructing well houses and to prevent freezing.

A few of the problems associated with well pits include flooding from seasonal high groundwater and/or system leaks, poor and dangerous access for inspection and repair, and lack of maintenance and inspection due to poor access.

Existing well pits create a danger to operators and a contamination hazard to the water system. They should be eliminated by installing a pitless adapter and extending the casing above ground. Pressure tanks can often be moved to a nearby heated building.

5.3.4 Well Slabs

In general, concrete well slabs can be useful to direct water away from the well if properly constructed. "Proper construction" is the key phrase since many slabs eventually settle and crack. The slabs could then serve as a place for water to collect and be directed to the casing. Well slabs may also provide safe harbor for burrowing animals, so should always be built with a footing along the entire perimeter.

5.3.5 Pump Power Cable Installation

Pump power cables must be installed with appropriate cable conduit. Without sealing the conduit around the well cap, access holes are sufficiently large to permit entry of both the cable and insects. Even when conduit is used in conjunction with a good well cap on an outdoor installation, these conduits may break loose from the fitting on the well cap if the area around the casing has settled. In all cases, these need to be immediately repaired since this is a primary entry port to the well casing for insects.

5.3.6 Yard Hydrants and Sample Taps

A sample tap is required close to the well where untreated well water can be accessed. These taps are used for monitoring many chemical contaminants and to check on the quality of untreated water.

Some wells with pitless adapters have been fitted with a frost-free yard hydrant adjacent to the wellhead. Although this provides the required sample tap, the location is undesirable since those hydrants drain to a gravel bed which may serve as a conduit for contaminants to reach the well.

Current standards require yard hydrants to be located at least 20 feet away from any wellhead. For most public water supply systems, an appropriate sample tap in the pump house or first point of entry to a building is more acceptable. An appropriate sample tap is defined as a smooth nosed tap without interior or exterior threads.

Figure 5.3.6
Poor hydrant installation

Yard hydrants are also occasionally found installed directly into the well casing through a well seal (see Figure 5.3.6). This is a direct cross connection between the well, its hose, and standing water at the end of the hose. These hydrants must be removed from the well head to prevent contamination of the well.

5.4 Artesian Wells

Artesian wells have specific design and construction standards. Artesian wells are drilled into a confined aquifer where the water is under sufficient pressure to raise the level of water in the well above the point at which it was first encountered. A "flowing" artesian well is one where the water overflows the top of the well casing.

Sealing standards for an artesian well require unperforated well casing be extended into the confining layer overlying the artesian zone. Artesian wells are grouted into the confining layer to prevent subsurface leakage from the artesian zone.

In addition, flowing artesian wells must be equipped with a control valve so that flow can be completely stopped. They must also be sealed by the well driller to completely eliminate any leakage around the casing.

5.5 Well Abandonment

Wells requiring permanent abandonment include those where use has been permanently discontinued, those in such a state of repair that continued use is impractical, those allowing intermixing of water from different water bearing formations to the extent there is degradation of the water resource, and those rendered unusable due to problems encountered during the drilling process.

Wells to be abandoned must be completely filled so that vertical movement of water within the well bore and the annular space surrounding the well casing is permanently restricted. This is accomplished by following the criteria for well abandonment required by the Board of Water Well Contractors' construction standards. A copy of these standards may be obtained by contacting the Board of Water Well Contractors, Montana Department of Natural Resources and Conservation.

5.6 Well Pumps and Other Appurtenances

Wells not only need pumps, but also several other critical appurtenances to function properly. Appurtenances include pumps, valves, meters, and often pressure tanks, among others. This section is written to overview these critical items as they pertain to the small public water supply system.

> More information on pump types, maintenance and selection is found in *Small Water System Operations and Maintenance, 3rd Edition,* Chapter 3—see Bibliography.

5.6.1 Pump Types

Pumps used in public water supply systems may be categorized into two broad groups, ***positive displacement pumps*** and ***variable displacement pumps*.**

Many liquid chemical feed pumps used in the water industry are positive displacement pumps. This includes rotary pumps and piston or plunger pumps. They are also referred to as constant displacement pumps.

Constant displacement pumps deliver virtually the same quantity of water regardless of the ***head conditions*** (how much pressure—in feet of height—the pump must work against).

Variable displacement pumps include centrifugal pumps, jet pumps and air lift pumps. As the head increases on these pumps, the flow decreases. The type and size of pump selected for a particular situation will depend on the required capacity, location and operating conditions, and total head for the system. ***Pump curves*** are used to determine the expected performance of a pump at a given head and flow. Pumps need to be selected carefully, using the expertise of the pump manufacturer's representative or an engineer after the needed characteristics have been determined.

Centrifugal pumps raise water by creating centrifugal force with a spinning wheel, referred to as the impeller, inside a tight casing. Vertical turbine pumps are a type of centrifugal pump used in many water wells. These pumps have the motor mounted at the casing top with a line shaft and column pipe which supports the pump section submersed in the well. The long pump shaft rotates inside of the pipe and drives the pump rotating impellers. A deep well turbine pump is a combination of several stages of centrifugal impellers connected in series to a common shaft. Correct alignment of the motor, shaft and the pump are important for long life and good performance. The pump column must be vertical and straight within the well casing and the motor mounting must be stable.

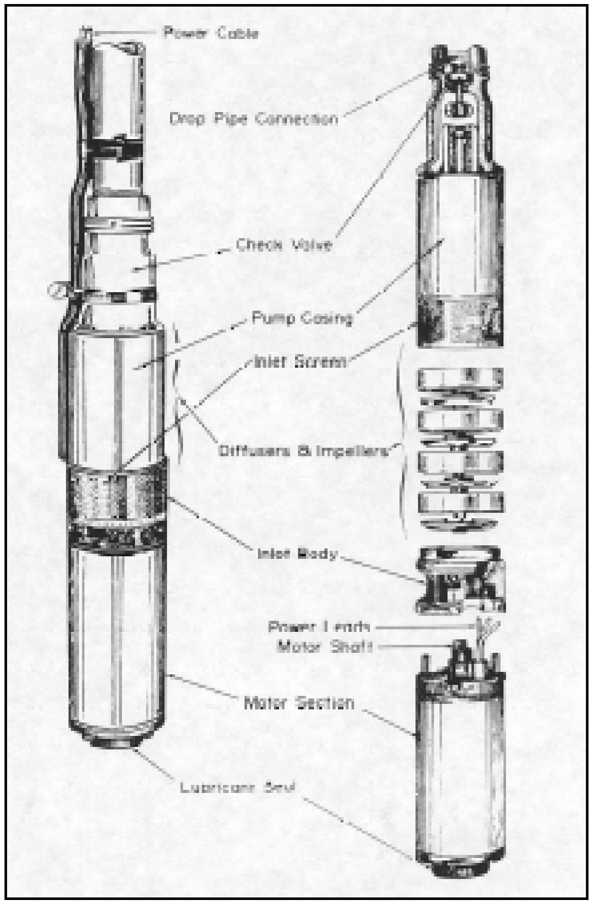

Figure 5.6.1a. Submersible Pump

Lubrication of the pump is essential for continued operation. Water is discharged at the surface and a heated well house is necessary.

Submersible pumps (Figure 5.6.1a) are also centrifugal pumps but have their motor mounted directly below the bowl assembly which houses the pump intake and impellers. Maintenance for these pumps is minimal because there is no line shaft or oil tube requiring operator attention. They are commonly used in moderately deep to very deep wells.

Jet pumps (Figure 5.6.1b) use a centrifugal pump and a nozzle and venturi tube to create a partial vacuum to pump water. A portion of the water is recycled to the nozzle and this makes jet pumps inherently inefficient. They are useful in small diameter domestic wells, but are also common to some water systems where the depth to water is relatively shallow.

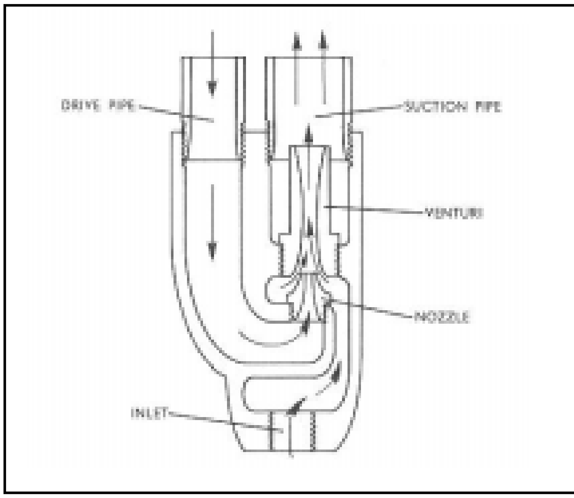

Figure 5.6.1b. How a Jet Pump Works

5.6.2 System Appurtenances

A *check valve* is necessary on the discharge-side of the pump. This valve acts as an automatic shutoff when the pump stops. It keeps water in the system from draining back down into the well.

A *pump control valve* eliminates pipeline surges when the pump starts or stops. It opens and closes slowly to prevent damaging surges in the water system.

A *foot valve* is often placed at the inlet to the pump suction line. It maintains the prime on the pump and prevents the reversal of water back into the well when the pump shuts off. This prevents sand from being stirred up in the bottom of the well.

Flow meters are essential to tracking the amount of water being delivered by the pump to the system. They are more accurate than the rated capacity of the pump. Flow meters allow monitoring the pump production in gallons per minute, total water system use (which can indicate leaks if demand suddenly increases), and can indicate changes in aquifer production or encrustation of the well screen.

Air and vacuum valves are also referred to as air release/vacuum breaker valves. They are used for deep well pumps to enable entry and release of air in the pump column when the pump stops and starts. This keeps air out of the water system distribution piping and prevents a vacuum from being created when the pump column drains of water.

5.6.3 Plumbing a Pump Station

Although a small water system operator may not be expected to perform detailed plumbing work, a few items regarding pump station plumbing are important.

The warm, humid and enclosed environment commonly found in pump stations and well houses may create a corrosive situation for exposed metal piping. Aside from controlling humidity in these facilities, maintaining a good coat of paint on exposed pipe surfaces will ensure greater longevity of the pipe.

Piping and fittings used should be of compatible materials. Connecting pipes of different metallic materials may result in ***galvanic corrosion*** - corrosion caused by the electrical current created when dissimilar metals are in contact with each other.

5.6.4 Electrical Safety

The combination of water and the electrical power needed to transport water can lead to an inherent danger of electrical shock to an unprepared water system operator. Although operators are not expected to be expert electricians, about 75 percent of well pump and control problems are reported to be electrical-related. Since this indicates some response to an electrical problem will be faced by many operators, electrical safety for small system operators is largely an emphasis of how to recognize and avoid potentially dangerous situations.

These safety precautions must be used when working around electrical equipment. The list is from *Small Water System Operations and Maintenance, 3rd Edition*. This reference has an additional list of troubleshooting tips for operators knowledgeable enough to work on electrical equipment.

1. Only qualified persons can work on electrical equipment,
2. Electrical installations must be maintained in a safe condition,
3. Electrical equipment and wiring must be protected from mechanical damage and environmental deterioration,
4. Covers or barriers must be installed on boxes, fittings and enclosures to prevent accidental contact with live parts,
5. An acceptable service pole must be used,
6. Equipment must be suitably grounded,
7. Provisions must be made for suitable undercurrent protection,
8. Machinery must be locked out during cleaning, servicing or adjusting,
9. Machinery must be de-energized, locked or blocked to prevent movement if exposed parts are dangerous to personnel,
10. If a switch or circuit breaker is tagged and locked out, only the person placing the tag should remove it, and
11. All outlets should have ground fault protection.

Small water systems who do not have a knowledgeable operator or electrician on staff should arrange with a local electrical firm or pump service company to perform this service. No one should attempt servicing or troubleshooting electrical components of well pump operations unless they have a good working knowledge of electrical circuits and circuit testing.

Motor starters are basically controls for starting and stopping motors. When 'on', electrical current is fed into the motor so it will run. Even if switches are in the 'off' position, electrical current is available to that switch for operations. Most wells or large pumps will be energized by 240 or 480 volts. Extremely large pumps may be energized even higher.

When any work is being done on wells or pumps, lock-out the electrical current to the equipment. This is done by opening the breakers so the electrical current is turned off. Non-conducting rubber mats should be placed on the floor in front of all power panels and motor control centers.

5.7 Pressure Tanks

Pressure tanks (Figure 5.7), or ***hydropneumatic pressure tanks***, can be used successfully to maintain pressure throughout small distribution systems. Tank size can range from 40-gallons to 21,000-gallons or more. The tank stores water under pressure.

In a conventional pressure tank, pressure is developed by pumping water into the tank until the air in the tank is compressed to a pre-set pressure. An air compressor is used to ensure adequate air pressure is maintained. When the pre-set pressure is obtained, the pump shuts-off and water demand in the system can draw on the stored water. When sufficient water has been withdrawn to reduce the pressure to a minimum level, the pump starts.

In larger installations, pressure tanks provide storage for the entire system. When smaller tanks are used their primary purpose is to provide only minimal storage so the pump does not activate every time water is used, allowing the well pump to cool sufficiently between starts. The DEQ recommends 6-8 pump cycles/hour with a minimum pump run time of one minute. Most water systems should have a pressure tank with a usable storage capacity of about twice the pump capacity in gallons per minute.

Figure 5.7
Captive air tanks

All pressure tanks should be installed with a pressure relief valve and some means to replace air in the tank. Maintenance of these tanks includes inspection of the exterior surface for signs of corrosion or other damage, checking the adequacy and operability of the air-charge system, verifying the pump cut-in and cut-out pressures are adequate to meet system needs within the safety limits of the tank, and checking the operability of the pressure gauge.

Many smaller tanks are now bladder-type tanks (sometimes called "captive air" tanks) which use a bladder to separate the air/water interface. This prevents loss of air to the water so an air compressor is not needed. More information on pressure tanks is included in Chapter 7: *Distribution Systems*.

5.8 Well and Pump Maintenance

A water well consists of three main parts:

1) the pumping equipment,
2) the well hole, including the casing and screen, and
3) the aquifer, especially the aquifer immediately around the well.

If any one of these parts begins to fail, the whole system suffers.

A public water supply system operator can do something about extending the useful life of a water well. Wells are expensive to drill and the cost of replacement is increasing. Therefore, it is important the old well be carefully examined to determine the reason for problems. Well problems which may affect production are typically caused by either normal wearing of pump parts or changing aquifer conditions. Keeping good records and well yield and other well characteristics assist in detecting problems which may affect production.

5.8.1 Routine Pump Maintenance

Because of the diversity of ground water systems and the pumps supplying them with water, it would be impossible to describe a pump maintenance program applicable to all possibilities. In general, however, there are key components of pump maintenance programs which all systems should follow.

Generally, maintenance requirements for submersible pumps are limited to tracking production of the well and periodic inspection of the pump. Well production is indicated by:

1) metering production and pressure from the well, and
2) tracking the flow in gallons per minute pumped and total volume of water pumped on a daily or weekly basis.

Since the pump itself is not easily accessible for routine inspection, some of the items indicated below do not apply. Submersible pumps *are* prone to problems caused by sand. Increases in the amount of sand pumped may result in lost production and be indicative of well screen corrosion.

The following information was taken from Chapter 5 of California State University's *Water Distribution System Operations and Maintenance—see Bibliography.* Please refer to this reference and Table 2.2 (page 44) of the same reference for additional details.

Pump Inspection and Preventive Maintenance Procedures:

1. Observe and record pump pressures and flow and the pump's electricity demands.

2. Check for abnormal noise or vibration from all pumps and heat or odor from non-submersible pumps.

3. Provide proper lubrication of pump bearings using water or food-grade lubricants specified by the pump manufacturer. Over-greasing and under-greasing are both problematic for pump operation.

4. Look for soapy or foamy appearance of the lubricant which could indicate water infiltrating the bearing shaft seals.

5. Listen for any bearing noise.

6. Tighten packing glands to permit only a small amount of leakage. Do not over-tighten to prevent all leakage. Check the leakage rate daily.

7. Inspect the pump priming system for performance and leakage.

8. Check automatic pump controls and exercise standby generators each week.

9. Check pump alignment on cold pumps and after they have run long enough to reach the proper operating temperature.

Routine pump maintenance would be described in the owner's manual for an individual well pump. It is important to have a copy of the manual and to review maintenance items described therein.

5.8.2 Well Maintenance and Troubleshooting Declining Yield

One problem which may occur is a steadily declining yield of water from a well. This can be caused by poor performance of the pump, by encrustation or plugging of the well screen or slots in the casing, or by conditions in the aquifer. Before any action is taken, it is important to determine what is causing the reduction in yield. If it turns out to be a declining aquifer, drilling a new well in the same area may not be the answer.

The pumping equipment is the most easily controllable and correctable part of the system. Pump problems are mechanical or electrical and can be corrected by a knowledgeable operator or a good pump mechanic or electrician. Submersible pumps will tolerate little if any sand wear. For this reason submersible pumps should not be lowered too near the bottom of the well. However, proper positioning of the pump is important because submersibles can be damaged by running dry.

Before assuming the pump is the cause of reduced yield, a flow test of the pump should be made. Static and pumping water levels in the well should be checked against records of the well's previous performance.

Just as thorough medical records are an important tool in understanding and protecting human health, thorough well records are an important tool for understanding and protecting well water supplies.

The static water level measures the level of water in the well when the well is at rest with no pumping. The pumping water level is measured when the pump has operated long enough for the water level in the well to have stabilized. The difference between the static water level and the pumping water level is termed the drawdown (see Figure 5.1). If the pumping rate in gallons per minute is divided by the drawdown in feet, the ***specific capacity*** of the well is calculated. This is the number of gallons of water obtained for each foot of drawdown and is a good indicator of the health of the well. To measure static and pumping water levels, the operator needs to have some means of measuring the water level and the output of the pump.

Three methods can be used to measure water well levels:

1) A tape measure with a plumb bob can be used on shallow wells, but becomes nearly impossible on deeper wells,
2) A special tape which uses an electrode to indicate the point of water contact, and
3) The air line method.

In the air line method, tubing of known length is installed (preferably when the well is constructed) to a depth below the pumping water level reached during full drawdown. At the wellhead, air is pumped into the tube until a small constant pressure is shown on an attached gauge. This pressure represents the head necessary to displace the water in the tube to the depth of the tube and under water. The pressure head on the gauge, if in pounds per square inch (psi), times 2.31 is equal to the distance from the well water surface to the end of the tube. Subtract this distance from the total tube length and the distance from the top of the well to the water surface is known.

The air-line method is not quite as accurate as the electrode taping method, but has the advantage that the well head need not be opened to make measurements and is not affected by dripping water or by interference from a submersible pump.

Records of static level and pumping level taken seasonally over a period of years can give a good indication of potential problems and their source. If the static level is receding over time, then the water table may be dropping due to drought or over-pumping. If the static level remains about the same but the pumping level is decreasing over time, then there could be problems developing around the screen such as sand plugging, incrustation, pump wear, or some loss of permeability in the aquifer around the well.

Occasionally a well casing may collapse, leading to total failure of the well. This is usually caused by corrosion of the metal well casing causing structural weakness. Corrosion can also cause the screen openings to enlarge, and incrustation to form. Corrosion can be caused by the chemical makeup of water or bacterial growth on the screen or casing. Corrosive water may require the installation of corrosion resistant screen and/or plastic casing.

Wells are expensive and should have a carefully planned, systematic program of preventive maintenance to ensure they are kept in good health. A systematic program of preventive maintenance consists of:

1. *Records:* A complete record should be maintained during the construction of the well, including the test drilling and test pumping data that preceded selection of pumps for the well. The pump equipment and well house specifications, amount of water pumped, power usage, and the maintenance costs should be kept on file.

   Other characteristics, including the static water level, pumping water level and the total water pumped should be recorded weekly.

2. *Sanitation:* A well should be examined to ensure the top of the well is properly sealed and sources of contamination are prevented from entering the well. The well water should be tested, both for coliform bacteria and other contaminants as required by Montana's public water supply system regulations. The pump house should be kept clean, dry, and in order. The well house should not be a storage place for miscellaneous supplies, equipment or chemicals not part of the drinking water treatment process.

3. *Inspection:* A periodic program is needed to check the pump, the drop pipe, and the motor. Typically, pumping machinery is pulled from the well at intervals of three to six years and must always be disinfected before replacement.

4. *Efficiency:* A periodic check of the pump efficiency and well efficiency should be scheduled to check the well condition and to determine pumping costs.