# Groundwater Production

Groundwater sources may include spring-fed systems as well as aquifers. The vast majority of groundwater production comes from wells. Even though groundwater sources only represent about 25% of total drinking water production, 75-80% of the public water systems in the US are groundwater systems.

## Water Well Location

Several factors are involved in selecting a site for a new well. The most important of these is finding adequate quantities of water that will meet SDWA drinking standards with the minimum amount of treatment. Potential pollution of the water supply is another major concern. Economics related to purchasing easement and connecting to the system, and population or demand within the system will also be factored into the decision. Finally, politics can become an issue in some cases.

Consulting engineers will rely on well logs from other wells in the area, geological data, and test holes to determine where the best chance of finding the appropriate quantity and quality of water exists. But even then, drilling a well is still a hit or miss proposition.

## Sanitary Considerations

Sanitary hazards must be considered when locating a well. The State environmental agency should be consulted regarding requirements concerning well location, especially with regards to potential sources of pollution. The minimum distance from a well to a potential pollution source should be at least 200 feet. Potentially hazardous conditions such as petroleum storage areas, chemical or radioactive disposal sites, and industrial waste treatment facilities may require special consideration as far as well location is concerned. Wells should never be located in a 100-year flood plain.

## Water Well Construction

Water wells may be classified according to the method of construction. The type of construction will depend on the depth of the well, the geological formations to be encountered, and the amount of water needed for the system.

Small wells, particularly private wells, may be dug or driven**.** Public water systems usually require more water than either dug or driven well can produce. The most common method of construction used by public water systems is the drilled well. These wells are ideally suited to deep water bearing formations where larger yields are available. This type of well, when properly constructed offers good protection against contamination from the surface**.** Two different methods of constructing drilled wells are the cable tool or percussion method and the rotary drilling method**.**

## Cable Tool Method

The impact created by raising and dropping a heavy drill bit and stem crushes and dislodges pieces of the formation as the well is drilled**.** The up and down motion of the drill bit mixes the cuttings with water to form slurry and a bailer is used periodically to remove the slurry. A bailer is made of a 10 to 20 foot section of pipe with a foot or check valve at the bottom. The casing is usually put in place as the well is drilled, especially in loose formations such as sand and sandy loam. Wells drilled by the cable tool method are more likely to have problems with vertical alignment than those drilled by the rotary method.

## Rotary Drilling Method

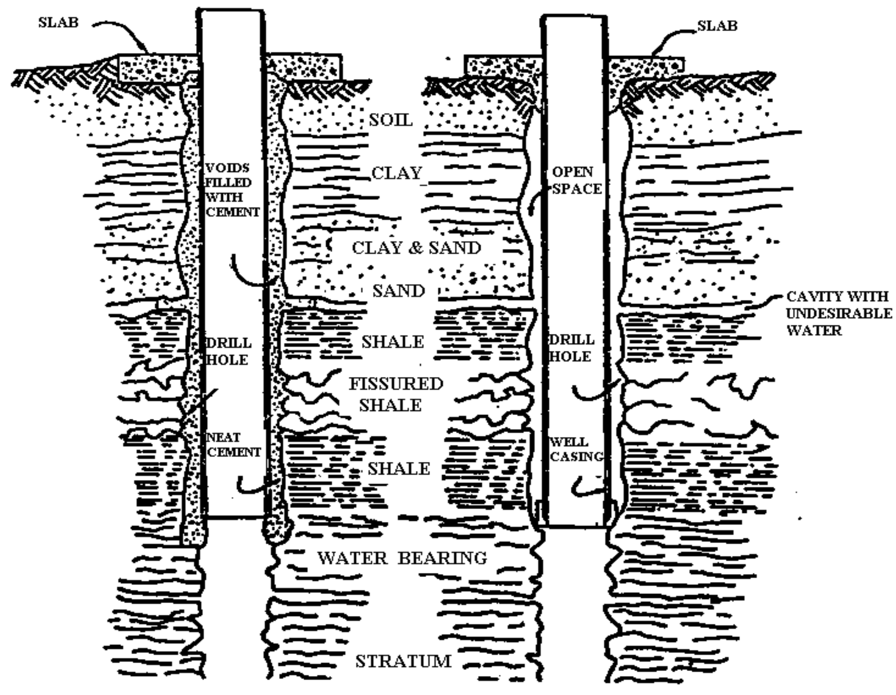
These types of wells use power driven drill stems, which in most cases are hollow. The drill bit is attached to the lower end of the drill stem and breaks up the material as it advances. Water or drilling mud is pumped down the drill stem to cool the bit. It also picks up the cuttings or drilling fines and carries them to the surface. The mixture of mud cuttings is discharged to a settling pit where the cuttings are removed and the drilling mud is recirculated. When the well hole is completed, the drill stem is withdrawn and the casing is put in place.

## Vertical Casing Alignment

It is important that the casing is in proper vertical alignment when it is installed. Even a slight misalignment may create stress on the pump shaft and bearings that can lead to mechanical failures. If a casing is misaligned, it may be necessary to install a submersible well pump instead of a line shaft pump. This may be the only solution to chronic line shaft failures in a misaligned casing. There are several ways to check casing alignment. Down hole TV inspection is popular because the condition of the casing and screen can be checked at the same time.

## Sanitary Protection of the Well

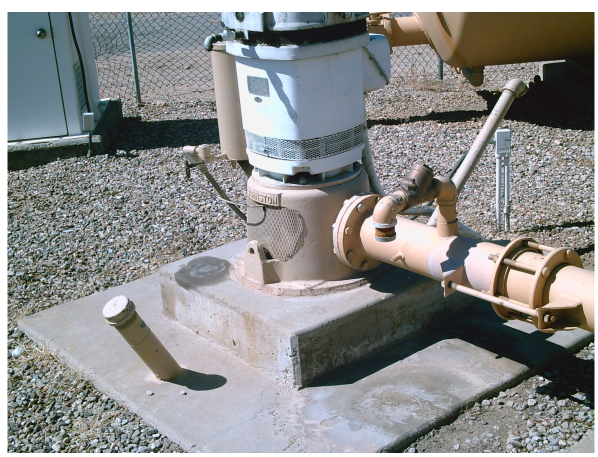
After a well has been drilled, care must be taken to prevent any surface contamination from entering the water supply. First, the casing is set to prevent the well from caving in or becoming contaminated from undesirable water sources located above the aquifer. The casing should be grouted with concrete on the outside to a depth of at least 50 feet or until an impervious layer of clay or rock is encountered. It may be necessary to grout deeper than this to seal any undesirable water formations off the well. The depth of grout is usually addressed by the state environmental agency on a case-by-case basis. In most instances, grouting will be required to extend to the water table. The grout must be pumped into the well from the bottom to the top. Otherwise, air will be trapped and prevent proper sealing of the cavity.

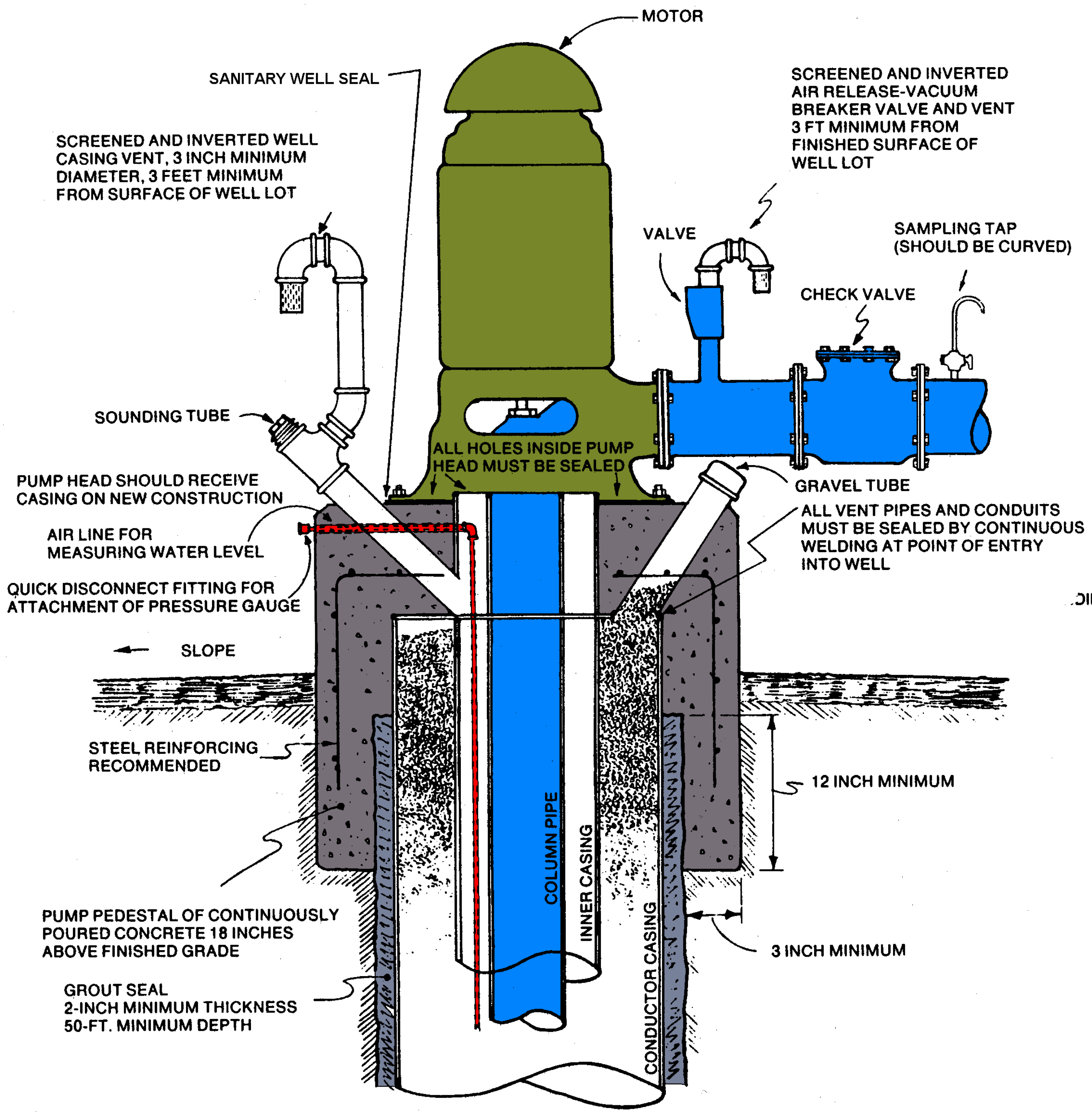



Grouting A Well Casing

The casing should extend at least 6 to 12 inches above the well pad, depending on whether the well is located in a well house or out in the open, to prevent standing water from entering the well. The well pad should be sloped away from the casing. A sanitary well seal must be used to connect the wellhead and motor to the casing. Well seals are usually made of rubber or neoprene. A welded seal is also approved and used in some cases.

Well casing and discharge column pipe vents should extend at least 18" above grade. The outlets should be turned down to prevent rainwater from entering and screened to keep bugs out. Well housings should never be located in a pit. Abandoned wells should be plugged to a depth of at least 10 feet. In some states they must be completely cemented.






GRAVEL PACK WELL CONSTRUCTION SHOWN

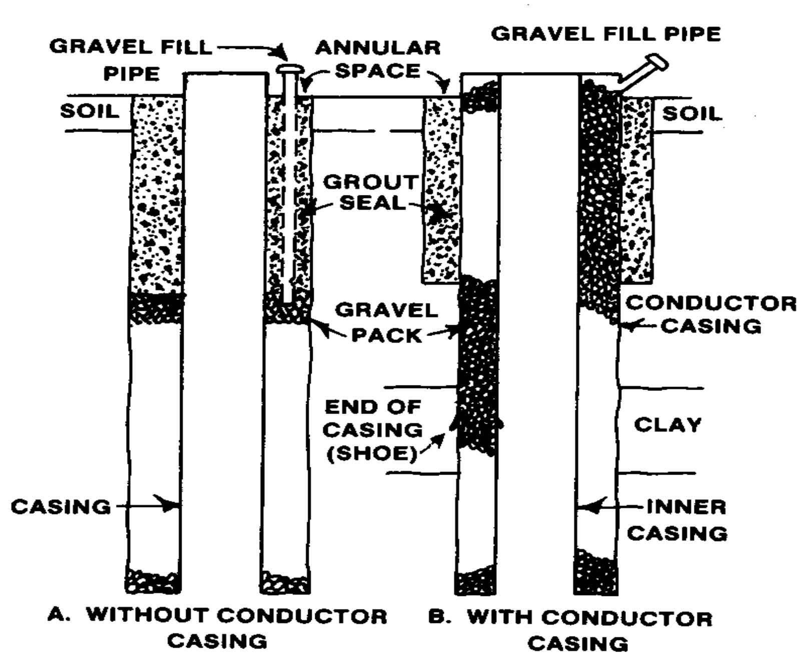
## Gravel Packed Wells

Wells that are located in fine sand formations, where sand pumping presents a problem, are usually gravel packed. If gravel packing is not used, the screen openings may have to be so small that the yield of the well is dramatically reduced. A layer of gravel is placed around the screen to hold the sand back and allow a larger well screen to be installed. The gravel packing is usually three times the diameter of the well screen or a minimum of 4" thick. The selection of the size of the gravel to be used depends upon the type of sand formation that is encountered and the type of screen that is being installed.

The gravel does not filter the sand. It is the increasing velocity, as the water gets closer and closer to the screen, which draws the sand into the well. The gravel pack holds the sand out away from the screen where the velocities are significantly lower than they are at the point where the water enters the screen. This minimizes the amount of sand that enters the well.

As sand is pumped out of the well, the gravel will fill in the cavity that is created and the gravel level will drop. This can result in exposing the well screen if gravel is not added periodically. The gravel is usually added to the well through a gravel packing pipe. This pipe is usually 4 inches in diameter. The level of the gravel pack should be checked at least yearly.

Gravel should be cleaned and disinfected with a strong chlorine solution before it is added to the well. The level should be rechecked as the new gravel is added. Gravel should never be allowed to stand in the packing pipe. The vibration that is created when the pump is running can cause the gravel to compact and block the pipe.




GRAVEL PACKED WELLS

## Developing A Well

Once construction is complete, the well is developed to remove the very small sand, shavings, and drilling mud from the surrounding aquifer. Two methods used to develop the well are surging and backwashing. Water is forced in and out through the screen as it flushes out the drilling mud and fine sand**.** Usually a pump much larger than the actual production pump is used. The well is pumped at the highest rate possible. This is done not only to remove the loosened mud but also to determine the well log data such as the yield, static and pumping levels, and specific capacity. The development of this data may require that this pumping rate be maintained for at least 8 hours.

It may take much longer to clear the well of drilling mud prior to disinfection. It is also important to determine the well recovery rate after the test is completed. The pump used to develop the well should never be the pump that is to be installed upon completion.

## Disinfecting Water Wells

The final step, prior to putting any new well, or old well that has had major cleaning or repair, in service, is disinfection and testing for bacteriological quality. The well should be flushed or redeveloped to remove drilling mud and debris prior to disinfection.

Disinfection is achieved by the addition of a strong solution of chlorine to the well. The chlorine dosage should be at least 50 mg/l. If dosages in the range of 200-400 mg/l are added, less contact time will be required. The well should then be agitated periodically by surging. The contact time at a dosage of 50 mg/l should be 18 to 24 hours but at 200 mg/l only about 2 hours is needed. However, with longer contact times, the chlorine will move farther out into the surrounding aquifer.

The well should be flushed to remove the remaining chlorine once disinfection is completed. The discharged water will need to be dechlorinated to reduce the residual to below 2.0 mg/L. The flush should continue until the residual from the well is also below 2.0 mg/L. Microbiological (Bac-T) samples should then be taken from the well and submitted for testing. These samples must be taken daily until they are negative on two consecutive days.

## Well Pumps

Most well pumps that are installed in public water systems are vertical turbine centrifugal pumps. The main difference between vertical turbines and other types of centrifugal pumps is that the vertical turbine impeller discharges water out of the top of the impeller. This water flows upward along the pump shaft, instead of at a right angle to the shaft. These pumps can generate the high discharge pressures needed to pump water several hundred feet out of the ground.

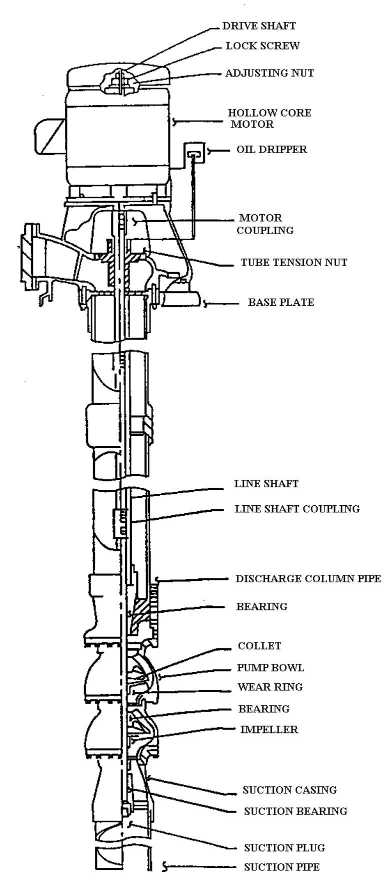
"Staging", or stacking several impellers on the shaft, is how the high pressures are generated. As the water passes from the discharge of one impeller to the suction of the impeller above it, the pressure that the pump develops is increased. If five impellers that each generates 100 feet of head are staged in a pump, the pump will generate 500 feet of head pressure. Anytime pumps are operated in series, where one pump or impeller discharges to the suction of another pump; the pressure will increase while the flow remains constant.

## Vertical Turbine Installations

There are two kinds of vertical turbine pumps installed in wells. One of these is known as a submersible pump. A submersible pump will have the motor located beneath the pump. In a small well, it is the least expensive centrifugal well pump to purchase and install. Because there is no pump shaft running to the surface, the submersible is also the ideal pump installation in wells where vertical casing alignment problems exist. The biggest disadvantage of submersible pump installations is that the pump must be pulled from the well when the motor needs repair. Since this is usually the most common type of repair for water wells, the cost of maintenance for submersible pumps is very high.

The other type of vertical turbine well pump is known as a line shaft pump. Line shaft pumps have the motor located on the wellhead. A line shaft runs down the discharge column pipe to the pump. The shaft is supported by line shaft bearings that center and stabilize the shaft in the column pipe. Line shaft pumps will cost more than submersible installations.

Vertical casing misalignment may make a line shaft pump installation impractical. The stress placed on the shaft and bearings can lead to chronic maintenance problems. The biggest advantage of a line shaft installation is that the motor can be repaired without pulling the pump and column pipe from the well.




VERTICAL TURBINE CENTRIFUGAL PUMP

## Line Shaft Pumps

The line shaft must be supported to minimize vibration and radial (side-to-side) movement when the shaft spins. A line shaft bearing, also known as spider support or spider bearing, will be located in every section of discharge column pipe. Since column pipe sections vary in length from 12 to 20 feet, there are 5-8 bearings for every 100 feet of shaft. These bearings must be lubricated. There are two methods of lubricating line shaft bearings. One method utilizes water to lubricate the bearings while the other uses an oil-lubricated system.

## Line Shaft Bearings

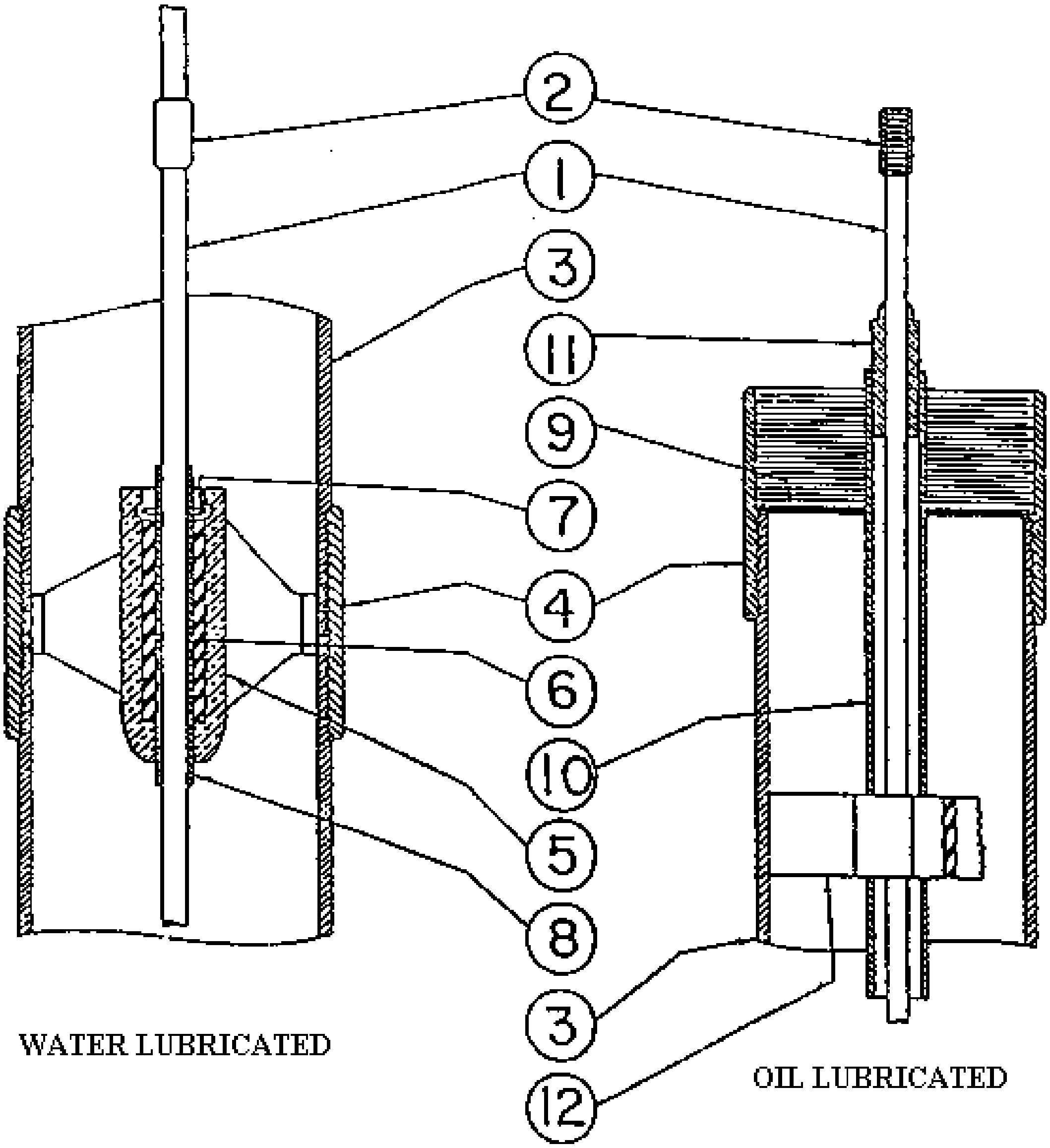
Water lubricated line shaft bearings rely on the water that is pumped through the column pipe for cooling and lubrication. When the water table is very shallow, water in the column pipe will reach the bearing almost immediately. If the water table is deeper it can take several seconds for water to reach the uppermost bearings. If these brass or rubber bearings are allowed to spin for even a few seconds without lubrication they will fail prematurely. This type of installation will normally have some type of pre-lubrication system that allows water to run down the shaft and lubricate the top bearings before the pump starts. It may be set on a timer or it may drip continuously. Even with this type of pre-lubrication system, it is difficult to guarantee that all of the bearings that are located above the water table are properly lubricated before the pump starts.

Oil lubricated line shaft pumps are normally installed when water table depths exceed 100 feet. In an oil-lubricated system, the shaft spins inside a tube that is kept full of oil. The oil used in these systems must be EPA approved. These oils can be either vegetable or mineral based. Line shaft bearings are located inside the tube. Spider supports stabilize the tube inside the discharge column pipe.

## Oil Dripper Systems

Oil lubricated line shafts will usually be supplied with a dripper system to keep the shaft tube full of oil. The dripper system will consist of two dripper assemblies. One dripper will be setup to drip constantly and the other will be activated by a solenoid and will drip only when the pump is running. The solenoid-activated dripper will normally be supplied with a cooling water jacket that helps to maintain a constant oil temperature in the dripper.

The cooling water is needed because temperature fluctuations will cause the viscosity or thickness of the oil to change. As the viscosity changes the drip rate will also change. The effect that these changes will have on the drip rate must be taken into consideration when the drip rate is adjusted. The drippers should be checked and adjusted at least twice a year, in the early summer and early winter.




1 - Line Shaft
2 - Shaft Coupling
3 - Column Pipe
4 - Column Pipe Coupling
5 - Stabilizer Support (Spider)
6 - Rubber Shaft Bearing
7 - Snap Ring
8 - Shaft Sleeve
9 - Column Pipe Spacer Ring
10 - Oil Tube
11 - Line Shaft Bearing
12 - Tube Stabilizer (Spider)

**SHAFT LUBRICATION SYSTEMS**

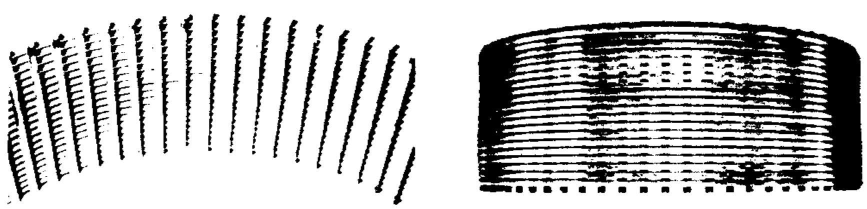
## Adjusting Dripper Systems

The constant dripper should be adjusted when the well has not been running for several hours. The oil temperature will be about the same as the ambient air temperature. This is the situation most of the time that the constant dripper is needed. If it is set in the summer and not checked again when it turns cold in the winter, the drip rate will be much lower as the oil temperature drops and the oil becomes thicker. The constant drip rate should be set at 1 drip/ minute.

The automatic dripper should be set after the well, and dripper-cooling water, has been running for an hour or so. If the drip rate is set when the well is not running and the oil temperature is higher, the drip rate may be too low when the cooling water lowers the oil temperature. In most wells, the automatic drip rate should be set at 6-10 drips/minute. Wells over 500 feet deep may require drip rates of up to 18 drips/minute.

## Well Screens

There are several types of well screens that can be installed in most wells. They range from well casing that is perforated on-site with a cutting torch to continuous-slot well screens made of steel, or sometimes plastic, strips that are wrapped around a wire cage. Louvered or perforated casing is also used in many installations. Continuous-slot screens are the most expensive and generally considered to be the best choice because of the low friction loss encountered as the water enters the well. These screens typically have openings that are equal to 40-50% of the total surface of the screen.



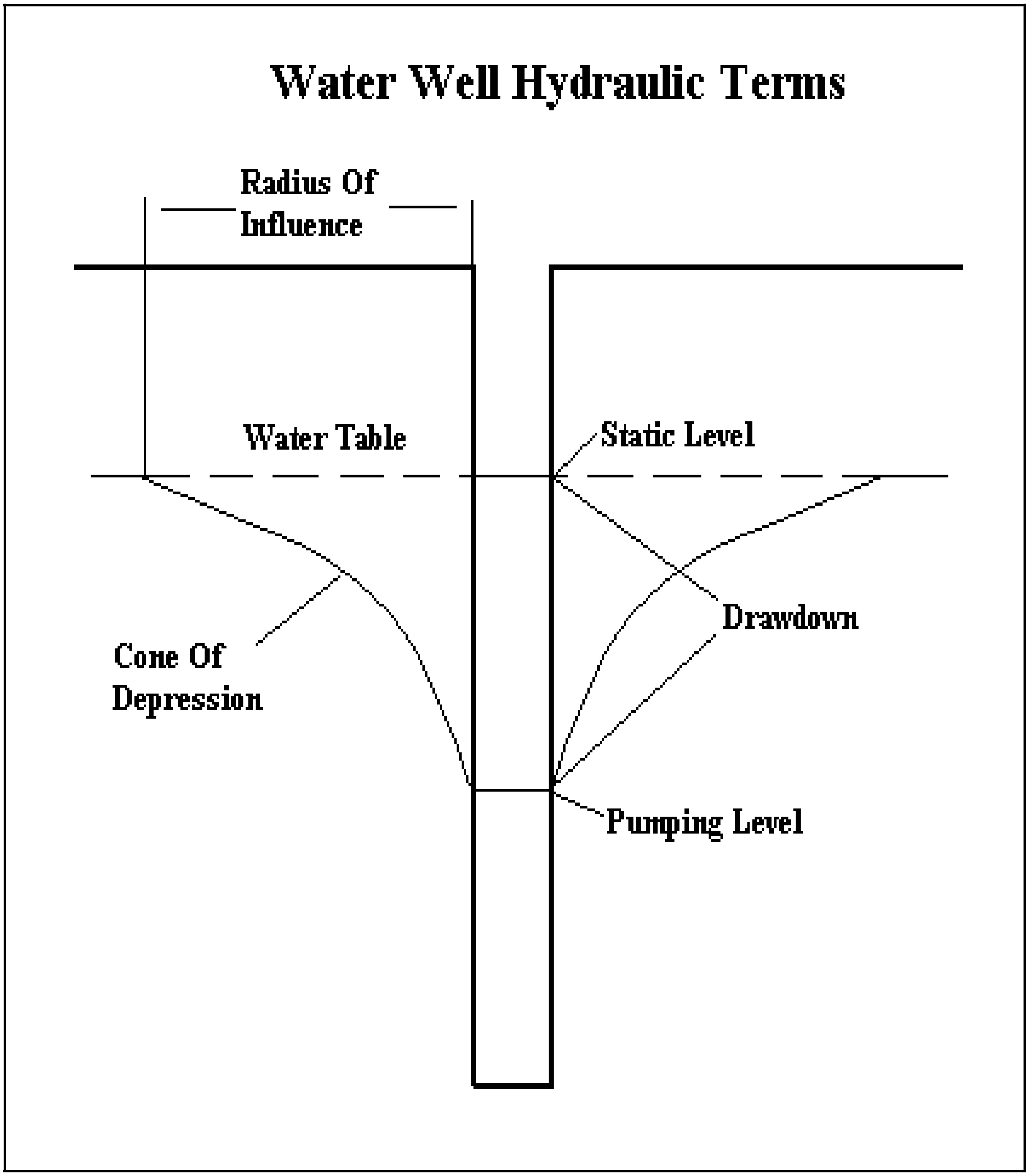
**Continuous Slot Well Screen**

**Perforated casing**

**Well Screens**

## Well Hydraulics

The amount of water a well will produce depends mainly on the type of aquifer, well construction, and the depth of the zone of saturation. The annual recharge rate from percolation, along with the ability of the water bearing formation to transmit water to any given point, will also influence well production. The performance of a well can be determined by taking readings of the hydraulic conditions. An operator must be familiar with these terms and definitions, in order to accurately troubleshoot problems that may be discovered.



**Static level** is the water level in a well when the pump is not operating**.**

**Pumping level** is the water level in the well when it is producing.

**Drawdown** is the difference in elevations between the static level and the pumping level. The amount of water produced is approximately proportional to the drawdown. For example, increasing the yield by 10% will increase the drawdown by 10%. The drawdown that occurs when a well is running is roughly equal to the head loss encountered in moving the water into the well. Water bearing formations of gravel, limestone and course sand will usually provide more water with less drawdown than formations containing fine sand or clay.

**Specific capacity** is the relationship between the yield of a well and the amount of drawdown in the well. It can be expressed as a ratio of the yield, in terms of gallons per minute, to the drawdown in feet. A well producing 100 gpm with a drawdown of 20 feet would have a specific capacity of 5 gpm per foot of drawdown.

$$\frac{100 \text{ gpm}}{20 \text{ feet}} = 5 \text{ gpm/foot}$$

In this particular case every time the yield is increased by 5 gpm the drawdown will increase by one foot. This relationship will exist until the yield exceeds the aquifer's ability to deliver water to any single point. When this limit is reached, the drawdown increases dramatically with little or no increase in the yield.

**Cone of depression** is directly related to the drawdown in the well. As the pump draws down the water level, a portion of the aquifer surrounding the well is drained of water. A cone shaped depression is formed in the water table around the well. The shape of the cone will vary depending on the type of formation in which the well is located. A fine sand formation will usually create a steep cone of depression, while a shallow cone is usually found in coarse sand and gravel formations.

**Radius of influence** is the farthest distance from the well that the cone of depression affects the water table. This distance can be determined by sinking test holes around the well and monitoring the water levels in them while the well is pumping.

**Recovery time** is the amount of time required for the aquifer to stabilize at its static water level once pumping has stopped. This can also be determined by monitoring the water levels in the test holes used to determine the radius of influence.

## Measuring Static and Pumping Levels

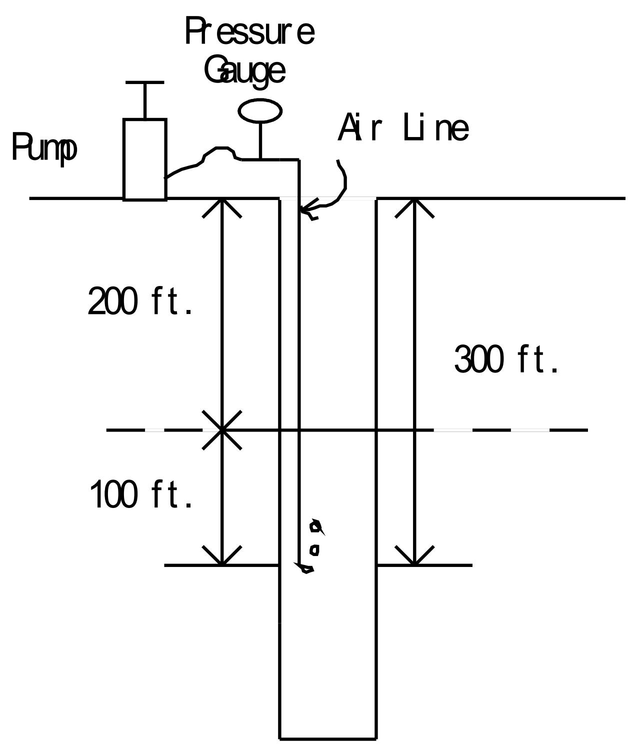
Several methods can be used to determine the elevation of water in the well. This can be accomplished by lowering some type of measuring device, that can locate the water level, into the well casing through a sounding tube (sometimes called a drawdown tube). A chalk line can be used if the approximate level is known. The bottom five to ten feet of the line is chalked and then lowered into the well to the estimated water level. The amount of line that is wet (easily identified by the wet chalk) is subtracted from the total amount lowered into the well to accurately locate the water level.

Another device that is used to determine water levels consists of an electrode attached to a cable and connected to a DC power supply. This type of device is sometimes referred to as an "M-scope." The electrode is lowered into the well casing until it contacts the water surface. Contact with water closes the electrical circuit and lights an indicator lamp on the power supply. The length of the cable that is in the casing is measured to determine the water level. The biggest disadvantage to using this type of "sounding" device is that the cable may wrap itself around the column pipe, making removal a real problem.

Another effective method of determining these levels involves using an air line. The air line is installed inside the casing and extends down to a point just above the bowls of the pump. A pressure gauge, installed at ground level, and an air pump (bicycle or hand pump) are all the equipment that is needed. The length of the air line must also be known in order to use this method.

As air is pumped into the line, the pressure gauge reading will begin to increase. When the pressure reading no longer rises, all of the water has been forced out of the pipe by the air. This gauge reading will represent a column of water the same height as the distance the line extends below the surface of the water. Subtracting this distance from the total length of the line will locate the elevation of the water in the well.

The gauge reading may be used directly if the gauge is calibrated in feet of head. If the gauge reading is in pounds per square inch (psi), it must be multiplied by a factor of 2.31 ft/psi before being subtracted from the length of the air



line. As an example, the air line is 300 feet long and the gauge reading is 100 feet of head when the pump is not running:

The static level is determined after the pump has not been running for several hours or overnight. The pumping level should not be determined until the well has been pumping long enough to insure that the pumping level has stabilized. It could take from 30 minutes to several hours to stabilize the pumping level.

## Overpumping The Well

In some wells, the pumping level may not stabilize. If the well pump capacity exceeds the aquifers ability to move water to the well (pumping it out faster than it comes in), the pumping level will continue to drop. This is known as exceeding the transmissivity of the aquifer. When this occurs the well pump will begin to cavitate, as the NPSH on the pump continues to drop, and will burn up if it is allowed to break suction. When this condition exists, a well runs for a certain period of time, trips a breaker, and then must sit for hours before it can be started. This situation results in damage to the pump because it is oversized. The pump should be downsized to the proper flow to correct the problem.

### The Well Log

When the contractor is developing the well, information about the well is being recorded for the well log. A well log will contain information that includes:

**WELL LOG DATA**

- Depth of the Well
- Length of Screen
- Pump Setting
- Yield
- Static Water Level
- Pumping Water Level
- Drawdown
- Specific Capacity
- Other Geological Data Regarding the Aquifer

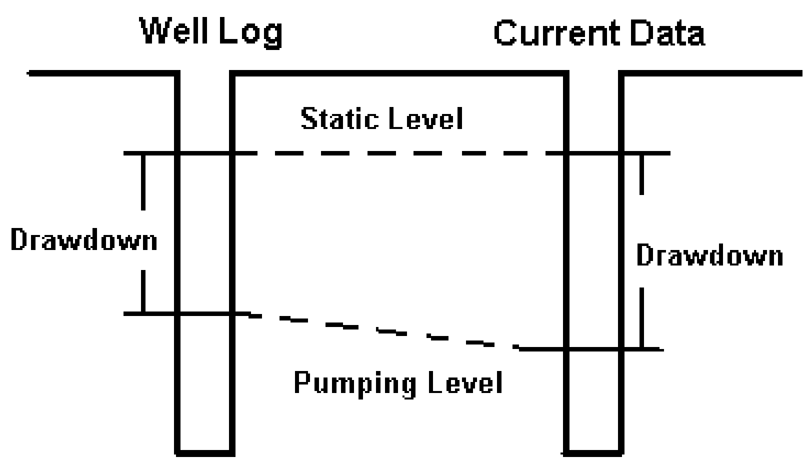
The well log is essential for troubleshooting well operational problems. It represents how the well should perform when everything is working right. Without this data it is very difficult to determine what, if anything, is wrong with current the well performance. Contractors are responsible for filing a copy of every public water supply well log with the State Engineer's Office.

## TROUBLESHOOTING WELL PROBLEMS

There is little information that can be gathered that will indicate how a well is performing. Changes in the **s**tatic level, the pumping level or the yield of a particular well will generally indicate a problem has developed. In addition to this information, the amps on the motor is the only other indicator poor of well performance. It is important to check static and pumping levels periodically to prevent any problems that may develop from becoming serious. The well log is used as a reference for each set of readings. Anytime there is a well problem, both the yield, and the specific capacity will be reduced.

## WELL PROBLEMS

Let's take a look at the example illustrated below. From the well log and current measurements it has been determined that the static level has remained the same but the pumping level has dropped several feet. If the static level had dropped it would indicate that the water table is dropping. This means that the well is exceeding the recharge capacity of the aquifer. This is often referred to as “mining water” since it results in the depletion of the aquifer.




Under these conditions it should be noted that the drawdown has increased. The drawdown is equal to the head loss encountered in moving water into the well. Since the drawdown has increased, there is more head loss now than when the well was new. It is unlikely that the conditions in the aquifer have changed. Therefore, the well screen must be getting clogged.

## Clogged Well Screens

There are several ways that a well screen can become clogged. The most common cause is chemical scaling or lime encrustation on the screen. Newer wells may develop a condition called "sand bridging." Another possibility is clogging due to iron bacteria colonies that are growing on the screen.

### Sand Bridging

Sand bridging is a condition that is normally only found in new wells. It occurs when sand, drawn toward the well, blocks the screen by forming an arch across the openings. Sand bridging is usually a result of improper development of the well or inadequate gravel packing. Surging water through the screen may break up the bridging. If surging doesn't work, it may be necessary to pull the pump and mechanically clean the screen with high-pressure jets to correct the condition. The well should be re-developed before replacing the well pump.

### Iron Bacteria

Clogging caused by iron bacteria is a problem for many wells in the Southwest. If the well has been in service for several years, and the water supply is low in alkalinity and corrosive, there is a good possibility that the clogging is a result of the build up of iron bacteria colonies on the screen. Iron bacteria feed on the iron that is naturally present in some supplies. They will attach themselves to iron and steel screens and a colony of the bacteria will begin to grow.

Clogging caused by iron bacteria is very difficult to remove. Chemical treatment with massive doses of chlorine (200-300 mg/l) followed by surging or even mechanical cleaning may be the only means of clearing clogged screen openings. Even then, it is unlikely that the entire colony has been removed. The remaining bacteria will begin to grow, causing a recurrence of the problem. Wells with iron bacteria should be treated with chlorine periodically to inhibit the regrowth for as long as possible. The discharged water must be dechlorinated to a residual level of less than 2.0 mg/L

### Lime Scaling

Lime scaling is most likely to occur when the water contains high amounts of alkalinity and hardness. Like iron bacteria, lime scaling will tend to be a chronic problem where the conditions that promote its formation exist. Lime scale cannot form if the source water is corrosive. There are several ways to clean a screen of lime scale.

## Cleaning Lime Scale From Well Screens

Well screens that are clogged with scale can be cleaned using one of several techniques. The four most commonly used methods are listed below:

1. Surging water through the screen may break up loose scale that is just beginning to form. This is accomplished by starting and stopping the pump. Water in the column pipe is allowed to fall back into the well and create a surge out through the screen. This is sometimes taken a step further by holding the check valve open when the pump is stopped so that more water will rush down the well and out into the surrounding aquifer. In order for this method to be effective, the condition must be identified before the scaling becomes very severe. This can't be done with small submersible pumps because the check valve is located just above the pump in the column pipe.

2. The percussion method may be the most dangerous method of cleaning a well screen. It involves the detonation of some type of explosive within the well casing. The theory behind this process is that the explosion will create shock waves that will vibrate the screen enough to shake the scale loose. This is sometimes accomplished by firing a blank down the well. This is only effective in very small, shallow wells where there is not much water standing above the clogged screen.

   In most public supply wells a larger charge is needed, and it is usually placed down the well in the vicinity of the screen. Blasting caps and primer cord are the most common explosives used in these situations. In addition to the obvious dangers involved in handling these types of explosives, the possibility for damaging the well screen also exists.

3. The acidizing method will clean all but the most severely scaled screens. Acid is poured down the well casing and allowed to stand for 8 to 12 hours. The acid will react with the lime and dissolve the deposits on the screen. The well is then surged to help loosen the remaining scale and flushed.

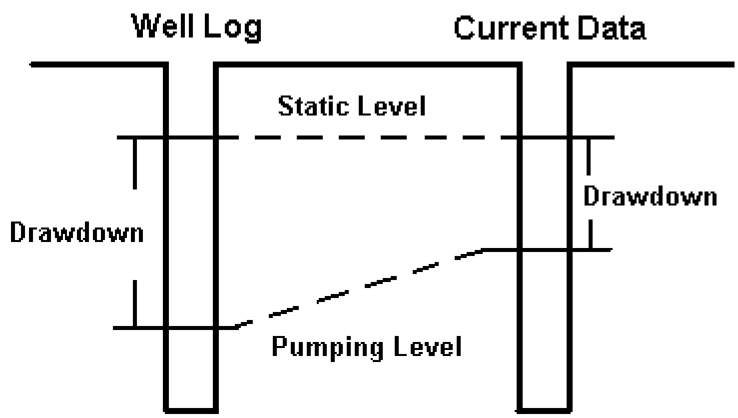
   <u>Always</u> <u>use</u> <u>inhibited</u> <u>acid</u>! Inhibited acid is chemically weakened. In this weakened state it will dissolve the lime without attacking the screen or pump parts. There are inhibited acids available in solid forms, sulphamic acid for example, that can make the acidizing process much easier and more effective. The pelletized acid can be poured into in casing where it will sink to the bottom of the well and dissolve in the area of the screen.

4. Mechanical cleaning may be the only method that is effective in situations where severe clogging exists. Mechanical cleaning will require the removal of the pump from the well. The screen will be cleaned using a larger wire brush or high-pressure water jets and then bailed to remove the debris that is knocked loose. In extreme cases, the screen may have to be pulled and cleaned or replaced. Not only is this very expensive, but it can also result in the collapse of the gravel pack around the screen. Anytime the pump is pulled

from the well and maintenance is performed, the well must be disinfected prior to being put back into service.

## WELL PUMP PROBLEMS

From the well log and current measurements, it is determined that the static level is the same, but the pumping level has risen several feet. Water production from the pump has also decreased. This reduced drawdown and yield from the well indicates a problem with the pump.




When the drawdown and pump production have both decreased, it usually means the pump efficiency is reduced. The most common cause of this problem in line shaft pumps is improper clearance between the impeller and the pump bowls. If the gap is too wide, recirculation inside the pump will reduce the discharge flow. If the gap is too small the impellers will drag on the pump bowls creating drag and reducing the flow.

If the impeller clearance is properly set, the only other cause of this type of condition is some type of mechanical problem with the pump or line shaft. Worn impellers or worn wear rings result in loss of production. Drag created by pump bearing or line shaft bearing failure will also reduce the flow. Checking the motor amps can eliminate two of the possibilities. If the amps are low, the drop in flow is due to damaged impellers, worn wear rings or too much impeller clearance.

If the amps are high, the problem is drag from bad bearings or too little impeller clearance. Mechanical problems will require pulling the pump, so the first step in troubleshooting a line shaft installation is to adjust the impeller clearance. Adjusting the impeller clearance is also referred to as adjusting the "lateral setting" or "setting the stretch" on the pump. The troubleshooting for small submersible pumps it easy and expensive. If the drawdown decreases it is a pump problem. Since there is no line shaft, the only solution is to pull the pump and rebuild or replace it.

## ADJUSTING IMPELLER CLEARANCE (LATERAL SETTING)

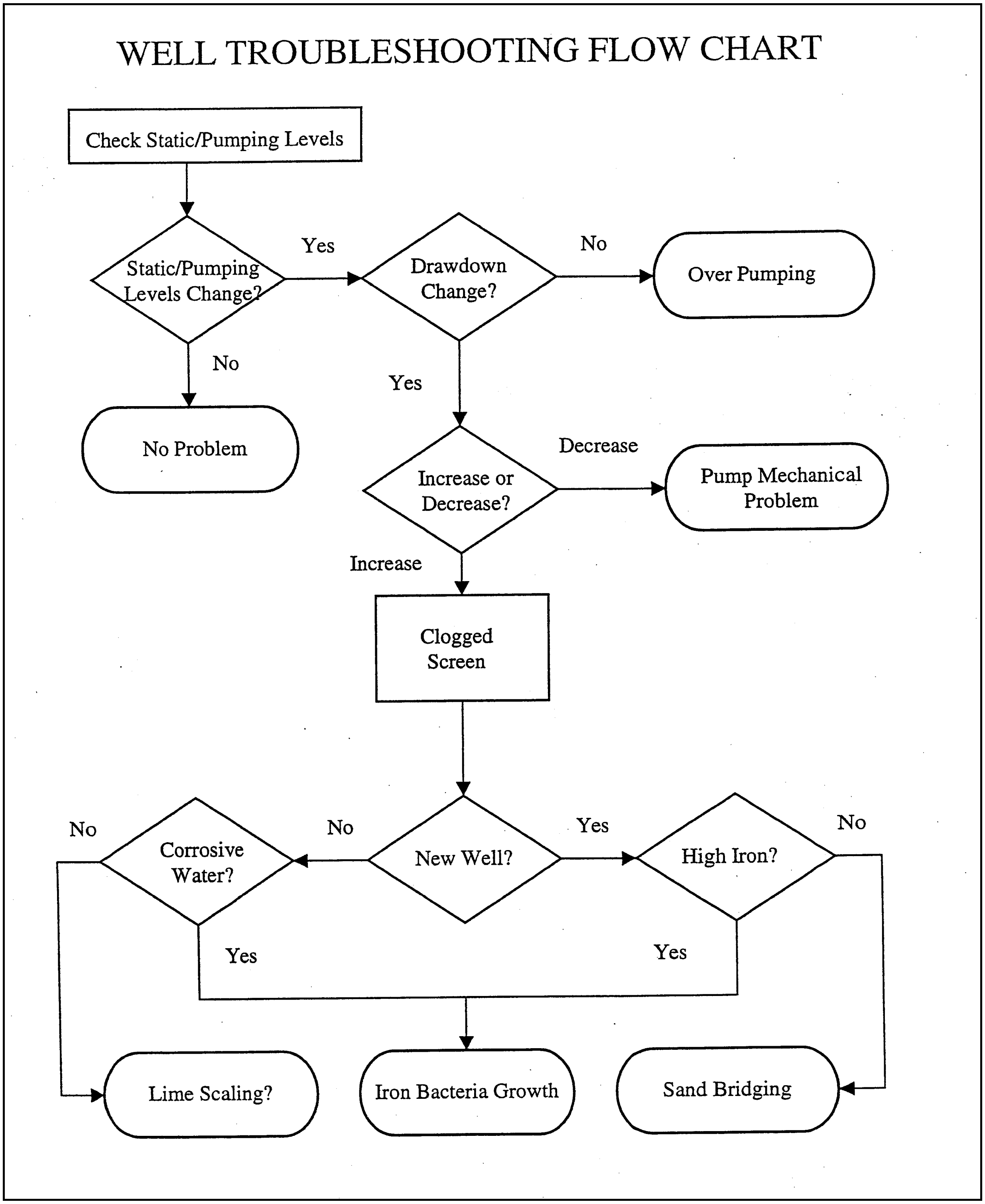
When the pump is operating, the proper clearance between the wear rings and the impeller should be between 1/32-1/4" (depending on the impeller design). Wear rings, as the name implies, are designed to eventually wear out. The clearance between the impeller will increase as wear occurs. Specific adjustments can be made to raise or lower the impellers and bring the clearance back within acceptable tolerances.

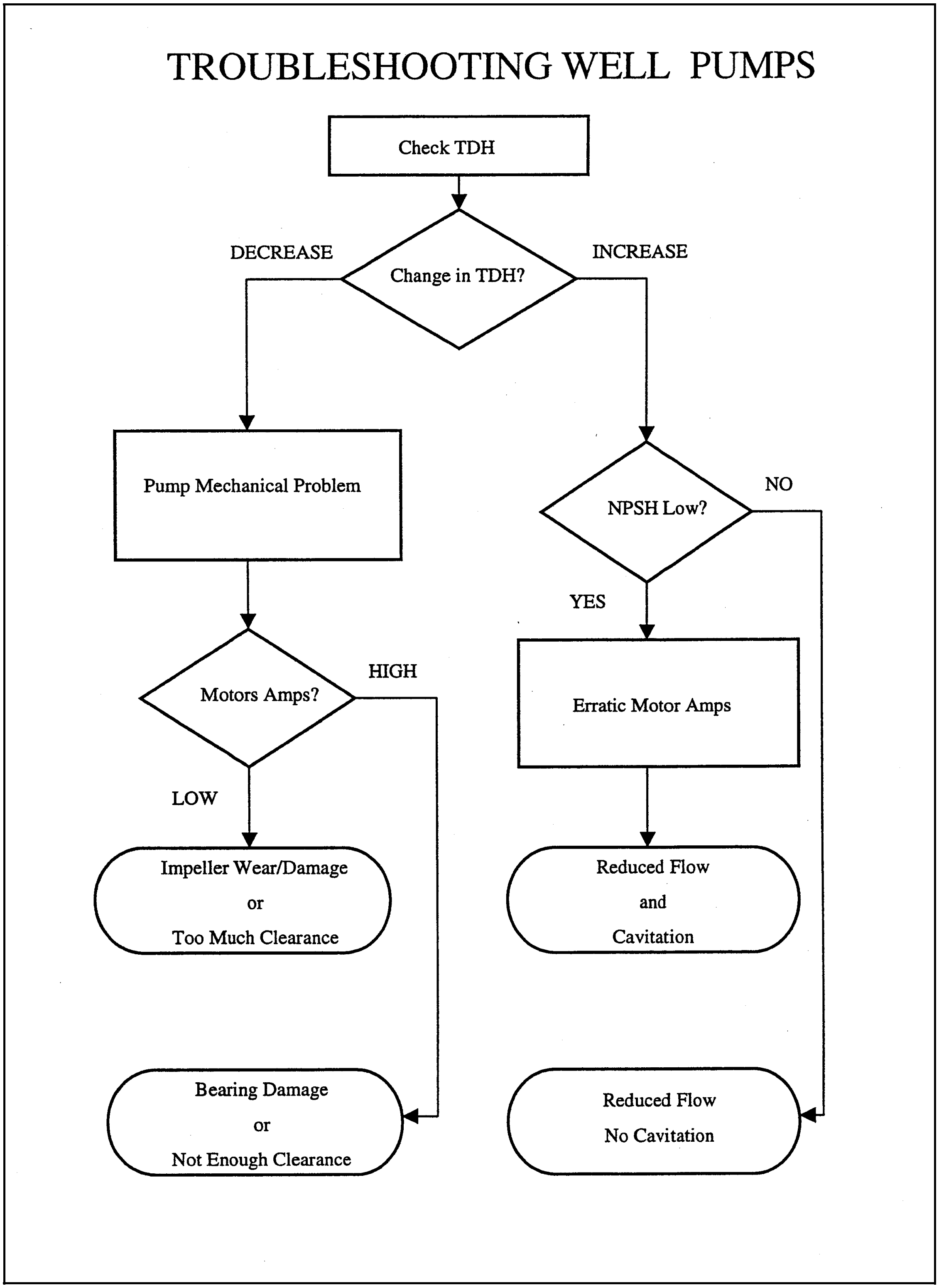
Line shaft stretch must also be taken into account. Even though the shaft is made of hardened steel, it will stretch under load. There are several factors that will impact the shaft stretch.

**FORCES THAT CAUSE SHAFT STRETCH**

1. **The weight of the shaft**
2. **The weight of the impellers**
3. **The downthrust exerted against the impellers**

The most common means of raising and lowering the shaft is by adjusting the top shaft nut or adjusting nut, located on the top of a hollow core motor. The rotor in a hollow core motor is hollow and the pump shaft can slide up and down through the rotor. The adjusting nut prevents the shaft from slipping down through the motor. Tightening and loosening the top shaft nut will then raise and lower the pump impellers. After a lateral adjustment is complete, motor amps can be used as a tool to check the adjustment.


WELL TROUBLESHOOTING FLOW CHART
Check Static/Pumping Levels
Static/Pumping Levels Change?
Yes
No
Drawdown Change?
No
Over Pumping
Yes
No Problem
Increase or Decrease?
Decrease
Pump Mechanical Problem
Increase
Clogged Screen
New Well?
No
Yes
Corrosive Water?
No
Yes
High Iron?
No
Yes
Lime Scaling?
Iron Bacteria Growth
Sand Bridging


TROUBLESHOOTING WELL PUMPS
Check TDH
Change in TDH?
DECREASE
INCREASE
Pump Mechanical Problem
NPSH Low?
NO
YES
Motors Amps?
HIGH
LOW
Erratic Motor Amps
Impeller Wear/Damage
or
Too Much Clearance
Reduced Flow
and
Cavitation
Bearing Damage
or
Not Enough Clearance
Reduced Flow
No Cavitation

## Basic Study Questions

1. What are some of the considerations for the location of a well?
2. What is the primary reason for grouting a well casing?
3. What is the drawdown in a well?
4. What are the requirements for disinfecting a well?
5. Which type of well pump will help minimize the problems caused by well casing misalignment?
6. What is the distance from the well to the edge of the cone of depression called?
7. When will sand production in a well be at it's highest?

## Advanced Study Questions

1. What are the limitations for water lubricated line shafts?
2. Why is a gravel pack used in wells?
3. What is specific capacity?
4. Public wells should be located how many feet from potential pollution sources?
5. What should be done when treating a well for iron bacteria?
6. Why might be wrong if a well pump runs for 45 minutes and then trips the circuit breaker?

## Basic Sample Test Questions

1. The distance from the well to the edge of the cone of depression is:

   A. Drawdown
   B. Radius of influence
   C. Infiltration
   D. Zone of saturation

2. If the drawdown increases, the screen is becoming clogged.

   A. True
   B. False

3. Sand production is usually at highest

   A. During startup
   B. After it has run for several hours
   C. When there is a pump-related problem.
   D. All of the above

4. Which of the following does not provide contamination protection for a well?

   A. Grout
   B. Well pad
   C. Motor coupling
   D. Sanitary seal

## ADVANCED SAMPLE TEST QUESTIONS

1. If the pressure gauge on an air line reads 25 psi and the air line is 400 feet long, how far is it to the water level?

   A. 25 feet
   B. 58 feet
   C. 342 feet
   D. 375 feet

2. The friction loss on the suction side of the well pump is equal to:

   A. The drawdown
   B. The specific capacity
   C. The pumping level
   D. The lateral setting

3. When the drawdown in a well increases:

   A. The screen is clogged
   B. The pump impellers may be worn
   C. The specific capacity increases

4. The drawdown in a well has decreased and the motor amps are high. The most likely problem is:

   A. The screen is clogged
   B. The pump impellers are worn
   C. The line shaft bearings are failing
   D. The TDH has increased

5. When the pumping level drops:

   A. The screen is clogged
   B. The pump impellers are worn
   C. The line shaft bearings are failing
   D. The TDH has increased