THE "*HOW TO*" MANUAL

CONSTRUCTION OF WATER WELL SYSTEMS ACCORDING TO ILLINOIS CODES

FORWARD

The scope of this manual is to: 1) explain the licensing and permitting process; 2) detail how forms are to be completed; 3) highlight the procedures to follow to be in compliance with the appropriate Codes; and 4) present examples of good industry practices for the design and construction of a water well system. This manual is to be used as a reference by the professional contractor and health department personnel.

The authors published this manual to assist in understanding how the Codes impact the Water Well Industry. It is important to note that although specific procedures were detailed to help explain the interaction of the Codes with the construction of a water well system, these procedures are not the only acceptable procedures.

The governing rule is:

The Codes dictate what will be done.

The Licensed Water Well and Pump Installation Contractors determine how it will be done.

LICENSED CONTRACTOR IS REQUIRED FOR WORK

In the State of Illinois, a person shall be licensed to contract for and perform water well system work and to supervise unlicensed personnel performing water well system work.

Note: it is an individual person that is licensed not a company.

No matter how large or small the company, it is the licensed contractor who is responsible for contracting for the work, supervising the individuals performing the work, and executing the required forms. For a company to contract for work or perform work in the water well industry, a licensed contractor shall be available to contract for work and supervise unlicensed personnel. There are two methods for a company to have a licensed contractor available: 1) the licensed contractor is employed by the company; or 2) the company has a contractual agreement with a licensed contractor to perform the duties of a licensed contractor for the company. If a company is operating with a contractual agreement with a licensed contractor, the company should advise the health department that this is the company's method of operation.

LICENSE CATEGORIES

There are three categories of contractor's licenses for the Water Well Industry:

1) 092—the Water Well Contractor's license
   A person holding a Water Well Contractor's License (092) is qualified to contract for water well work and supervise unlicensed personnel performing water well work.

2) 101—the Water Well Pump Installation Contractor's license
   A person holding a Water Well Pump Installation Contractor's License (101) is qualified to contract for water well pump work and supervise unlicensed personnel performing water well pump work.

3) 102—the Water Well and Pump Installation Contractor's license
   A person holding a Water Well and Pump Installation Contractor's License (102) is qualified to contract for both water well work and water well pump work and supervise unlicensed personnel performing both water well work and water well pump work.

WHO CAN BE LICENSED

The following qualifications are required of an individual in order to obtain a contractor's license:

1. be at least 18 years of age,
2. be a citizen of the United States or has declared his/her intention to become a citizen of the United States,
3. possess good moral character,
4. has the required experience as follows:

a. an applicant for a water well contractor's license shall have worked two years under the supervision of a licensed water well contractor;
b. an applicant for a water well pump installation contractor's license shall have worked two years under the supervision of a licensed water well pump installation contractor;
c. an applicant for a water well and pump installation contractor's license shall have worked two years under the supervision of a licensed water well and pump installation contractor and the applicant shall show evidence to the Department of Public Health that he has engaged in both water well contracting and pump installation during the two year period,
d. two years experience means a minimum of 420 working days in a minimum of two years.

WHAT A PERSON HAS TO DO TO BE LICENSED

The following actions are required of an individual in order to obtain a contractor's license:

1. submit an application and pay the appropriate fee
    a) An application to take the exam for registration as a licensed water well contractor and/or water well pump installation contractor must be received in the office of the Department of Public Health in Springfield, Illinois, at least 45 days prior to the date of examination. Applications shall be made on forms provided by the Department and shall include the following information:
        1) name and address of the applicant;
        2) age of the applicant;
        3) a statement that the applicant is a citizen of the United States or has declared his/her intention to become a citizen of the United States; and
        4) employment records, W-2's, copies of paychecks, or other evidence that the applicant has been employed in water well construction or water well pump installation for a minimum of 420 working days in a minimum of two years.

    b) A recent photograph shall be submitted as part of the application form and become a permanent record.

    c) Affidavits by three responsible persons as to the applicant's moral character; honesty and integrity shall be submitted as part of the application form and become a permanent record.

    d) Affidavits from previous and current licensed contractor employers must accompany the application indicating the dates that the applicant was employed and the locations of previous jobs the applicant performed, verifying that the applicant was engaged in water well or water pump installation work and that he performed this work under the supervision of a licensed contractor. An applicant for a water well contractor license shall submit copies of at least 10 water well construction reports that identify the applicant as the driller. To identify himself or herself as the driller, the applicant, along with the licensed driller performing the supervision, must sign and date each of the water well construction reports. An applicant for a water well pump installation contractor license shall submit copies of at least 10 water well pump installation reports that identify the applicant as the pump installer. In order to identify himself or herself as the pump installer, the applicant, along with the licensed pump installer performing supervision, shall sign and date the water well construction report or the water well pump installation report. The names and addresses of previous licensed contractor employers shall be included. These affidavits shall be submitted as part of the application form and become a permanent record.

2. make a satisfactory grade on the examination for the particular license for which he/she is applying. A satisfactory grade is as follows:
    a. The water well contractor's examination is a two part examination. The first part is an examination of the applicant's knowledge of the Water Well Code. The second part is an examination of the applicant's general knowledge of the well drilling industry. A satisfactory grade is a minimum average score of 75 on both parts of the examination with a grade no lower than 70 on either part of the examination;
    b. The water well pump installation contractor's examination is a two part examination. The first part is an examination of the applicant's knowledge of the Water Well Pump Installation Code. The second part is an examination of the applicant's general knowledge of the pump installation industry. A satisfactory grade is a minimum average score of 75 on both parts of the examination with a grade no lower than 70 on either part of the examination;
    c. For a water well and pump installation contractor's license, the applicant must receive a satisfactory grade for both the water well contractor's examination and the water well pump installation contractor's exam. An applicant can obtain a satisfactory grade for one exam and a satisfactory grade for the other exam at different times thereby satisfying the requirements for the water well and pump installation contractor's license examination.

LICENSED PLUMBER EXCEPTION

The one exception to complying with all of the aforementioned qualifications is a person who already holds a valid license under the Illinois Plumbing License Act. This person may apply for and receive, without examination or fee, a water well pump installation contractor license provided that all other requirements of the Water Well and Pump Installation Contractor's License Act are met.

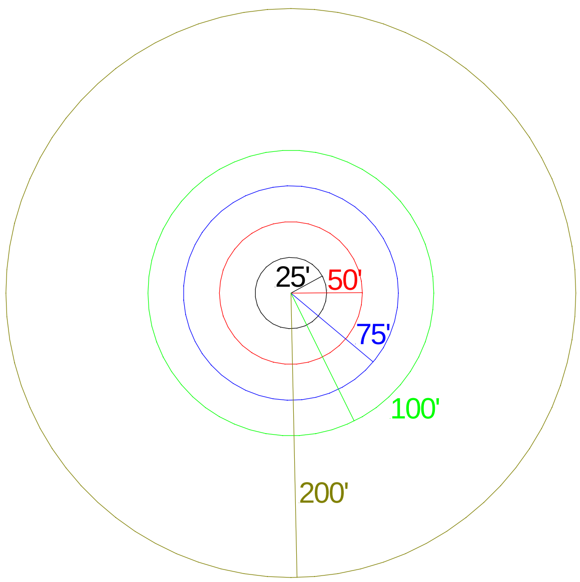
RENEWAL OF LICENSE

All contractors' licenses expire every year on January 31. A license may be renewed for the ensuing license year by making application and paying the prescribed fee at least 30 days prior to the expiration date of the current license. This means that if the contractor has not submitted the application and fee by January 1st, the contractor will have to pay a reinstatement fee in order to obtain the license. In addition, a contractor renewing a license shall have attended a minimum of one continuing education session in the preceding 2 years.

DESIGN AND CONSTRUCTION OF A WATER WELL

CONTRACTOR'S RESPONSIBILITY FOR SITING OF WATER WELL

It is the responsibility of the licensed water well contactor to site the water well in order to be in compliance with the requirements of the Water Well Construction Code. Normally on new construction, the septic plan will have the location of the water well. The licensed contractor shall verify that the water well is appropriately sited when visiting the work site. If the water well is sited according to an approved septic plan but the water well does not comply with the siting requirements of the Water Well Construction Code, the licensed water well contractor shall properly abandon the water well and construct a new water well at a site which complies with the Water Well Construction Code.



Minimum Lateral Distances From Water Well

25' or less:	2' pump house floor drains 5' pits, crawl spaces, basements 10' footing drains – no connections to sewer or sumps 10' sewers sealed joints and approved pipe 25' lakes, ponds, streams, cisterns
50'	sewers non-sealed joints, septic tanks, barnyards, confinement lots
75'	pit privy, seepage fields, manure piles, closed loop well for owner of private well & closed loop well
100'	leaching pit
200'	closed loop wells, primary potential source, potential secondary source, potential route, abandoned well

PRELIMINARY WATER WELL DESIGN

After the licensed contractor has assessed that the water well can be properly sited on the property, the licensed contractor should evaluate the available information about the aquifers to determine which aquifer(s) will be available to satisfy the demand of the proposed water well system. When there is a possibility that the shallow aquifers will not provide sufficient water yield, the licensed contractor should design the water well to be constructed to a deeper aquifer. If the water well is designed for a shallow aquifer and the shallow aquifer can not provide sufficient water yield, the licensed contractor might be unable to install and properly seal a liner in this water well as required by the Water Well Construction Code. In this case, the water well will have to be properly abandoned and the deep aquifer designed water well shall be constructed.

VARIANCE REQUESTS

If the water well can not be sited on the property in accordance with the requirements of the Water Well Construction Code and the licensed contractor has determined that construction techniques will allow for the construction of a continuously safe and sanitary water well supply, the licensed contractor should request a variance from the health department. It is critical that a variance be requested and granted prior to the start of the construction process when the contractor is aware of Code problems. If during the construction of the water well, an unforeseen condition arises that prevents the continuing construction process from being in compliance with the requirements of the Water Well Construction Code, the licensed contractor should suspend the construction process and apply for a variance when a variance would be appropriate. Continuing the water well construction in violation of the Water Well Construction Code and then requesting a variance is a violation of the Water Well Construction Code.

Important: A variance **does not** compromise a water well system.

A variance is appropriate when the only reasonable possibility of constructing or maintaining a water well system is to modify the requirements of the Codes **and** the water well system is not put at risk.

A variance request must be submitted in writing by the licensed contractor. The written request shall contain:

1. the requirement(s) of the Code which can not be complied with;
2. the proposed corrective action;
3. the reasons the proposed corrective action will not place the water well system at risk;
4. a plot plan of the property showing lot size, the locations of sewers, septic tanks, buildings, seepage fields, and other sources of contaminations on the property and adjacent property with distances to the proposed well;
5. a description of geological and soil conditions.

COMPLETING THE WATER WELL PERMIT APPLICATION

After the design of the water well has been determined, the licensed water well contractor shall complete and file the water well application. Most of the local county health departments administer the water well program for the State Department of Public Health. For these counties, the licensed contractor files the water well application with the local county health department. For the other (7) counties, the licensed contractor files the water well application with the State Department of Public Health.

This new application is a dual form in that it is to be used for both the construction of water wells and the sealing of abandoned water wells. Even if a local health department does not require a permit for the sealing of a water well, the licensed contractor should file this application with the local health department when sealing a water well. By filing the sealing application, the licensed contractor has identified the work for the local health department and has given the local health department the minimum 48 hours notification.

Following is a copy of the application form. After the application form, there is a description of the information required in each section. The descriptions are in italics.

State of Illinois
Illinois Department of Public Health

APPLICATION FOR PERMIT TO CONSTRUCT, MODIFY, OR ABANDON A WATER WELL

DO NOT SEND CASH **PERMIT FEE: $**______

Local Health Department ______
Address ______
City/State/Zip Code ______
Phone Number ______ Fax Number ______

FOR OFFICIAL USE ONLY
TYPE OR PLACE
LABEL WITH NEEDED
INFORMATION

☐ If this box is checked, the permitting authority plans to complete a comprehensive inspection and shall be notified of any scheduling changes.

Owner ______ Owner Phone Number ______
Mailing Address ______ Owner Fax Number ______
City ______ State ____ Zip Code ______

Well Site: Property Address ______ Township Name ______

City ______ Zip Code ______ County Property Identification # ______

County ______ Subdivision ______ Lot # ______

Township ______ Range ______ Section ______ ______ ¼ of the ______ ¼ of the ______ ¼

Directions to Site ______

WATER WELL INFORMATION

Permit To: [ ] Construct [ ] Deepen [ ] Repair [ ] Seal **well type:** [ ] Dug [ ] Driven [ ] Bored [ ] Drilled

for a: [ ] A. Private Well [ ] B. Semi-Private Well [ ] C. Non-Community

use: [ ] Residential [ ] Commercial [ ] Livestock [ ] Irrigation [ ] Other ______

Complete if B or C checked: Number of people served ______ Type of facility ______

(If C is checked, an application For Permit to Construct, Alter or Extend a Non-Community Public Water Supply must be submitted.)

[ ] Check if anticipated pumping capacity is greater than 100,000 gallons per day

WELL CONSTRUCTION OR ABANDONMENT INFORMATION
1. If well log is available, attach the log to this form
2. If well log is not available, well must be sealed from bottom to top.

Borehole: Size ____ in/ft depth ______ ft Size ______ in/ft depth ______ ft Size ______ in/ft depth ______ ft

Aquifer: [ ] Sand & Gravel [ ] Limestone [ ] Sandstone [ ] Other ______

Casing: Type ______ Size ______ in/ft Estimated Amount ______ ft

Liner: Type ______ Size ______ in/ft Estimated Amount ______ ft

Top of Liner ______ ft Type Seal ______ Bottom of Liner ______ ft Type Seal ______

Existing water well on property? [ ] Yes [ ] No Will it be used? [ ] Yes [ ] No Is it to Code? [ ] Yes [ ] No

Existing well to be sealed: [ ] Well in building [ ] Well in pit [ ] Pit retained Pit eliminated by: [ ] Contractor [ ] Owner

Is well free of obstruction? [ ] Yes [ ] No If No, at what depth is obstruction? ______ ft

FOR OFFICIAL USE ONLY

Construction Permit Number

______ / ______ / ______
FIPS Code Number Year

______ ______
Approved by Date

Sealing Permit Number

______ / ______ / ______
FIPS Code Number Year

Form Number IL 482-0620

State of Illinois
Illinois Department of Public Health

APPLICATION FOR PERMIT TO CONSTRUCT, MODIFY, OR ABANDON A WATER WELL

ATTACH A SHEET WITH DIAGRAM OF WELL SITE SHOWING DIMENSIONS

Furnish septic system plot or draw the proposed construction site with dimensions showing the water well, direction of slope, distances to buildings and property lines, sewer lines, all septic systems components including septic tanks and seepage fields, and other sources of contamination, e.g., abandoned wells, storm water dry wells and underground storage tanks, indicate distance to community water supply, if available. If there is an existing well on the property, indicate location and status.

WATER WELL PUMP INFORMATION

Pump Type ______________________ Capacity ______ gpm Storage/Pump Cycle ________ gallons

WORK SCHEDULE*

Estimated schedule date to start work on water well (MM/DD/YR): ______________________

***NOTE:**
Illinois Water Well Construction Code, Section 920.130 g) Notification. Any person who constructs or deepens a water well for which a permit has been issued under this Part, shall notify the Department, or approved local health department, or approved unit of local government by telephone or in writing at least two days prior to commencement of the work.

LICENSED CONTRACTOR CERTIFICATION
I certify that the attached information is complete and correct and that the work will conform to the current Illinois Water Well Construction Code and to the current Illinois Water Well Pump Installation Code.

Licensed Water Well Contractor

______________________ Print Name of Licensed Water Well Contractor ______________________ License Number

______________________ Address ______________________ City, State, Zip Code

______________ Office Phone Number ______________ Fax Number ______________ Cell Phone Number

______________________ Signature Licensed Water Well Contractor / Property Owner ______________________ Date

Licensed Water Well Pump Installation Contractor

______________________ Print Name of Licensed Water Well Pump Installation Contractor ______________________ License Number

______________________ Address ______________________ City, State, Zip Code

______________ Office Phone Number ______________ Fax Number ______________ Cell Phone Number

______________________ Signature Licensed Water Well Pump Installation Contractor / Property Owner ______________________ Date

COPIES
THREE COPIES ARE RETURNED TO THE LOCAL HEALTH DEPARTMENT WHERE THE PERMIT IS ISSUED
One copy is retained by the health department where the permit is issued
One copy of the approved application is sent to Illinois State Water Survey
One copy is sent to the water well contractor

IMPORTANT NOTICE
This state agency is requesting disclosure of information that is necessary to accomplish the statutory purpose as outlined under Public Act 85-0863. Disclosure of the information is mandatory. This form has been approved by the Forms Management Center

State of Illinois
Illinois Department of Public Health

APPLICATION FOR PERMIT TO CONSTRUCT, MODIFY, OR ABANDON A WATER WELL

DO NOT SEND CASH **PERMIT FEE: $________________**

Local Health Department ____	**FOR OFFICIAL USE ONLY**
Address ____	TYPE OR PLACE
City/State/Zip Code ____	LABEL WITH NEEDED
Phone Number ______________________ Fax Number _______________________	INFORMATION

**The above information is filled out for the specific local health department having the authority to issue the water well permit.*

☐ If this box is checked, the permitting authority plans to complete a comprehensive inspection and shall be notified of any scheduling changes.

**If the local health department intends to inspect this water well, the local health department shall notify the licensed contractor by checking above box. Then it is the responsibility of the licensed contractor to notify the local health department of any changes to the start time.*

Owner ____	Owner Phone Number __________________________
Mailing Address _______________________________________	Owner Fax Number ____________________________
City ______________________ State ____ Zip Code__________________	

**The owner is the entity/person the licensed contractor has contracted with. This address information is not necessarily the address where the water well will be constructed.*

Well Site: Property Address ____ Township Name _______________________

City ______________________________ Zip Code _______________ County Property Identification # ____________________

**The above address information is for where the water well will be constructed. Give as much of the street address as available. Some areas of the State use a fire # and road name. If an address does not exist at the time the water well is constructed, provide local method of identifying property. The city is the mailing address city. The County Property Identification # is the number the county uses to identify the property for real estate tax purposes.*

County _________________ Subdivision ____________________________________ Lot # _________________________

**If water well is not located in subdivision, write in N/A. If there no lot #, write in N/A.*

Township __________ Range __________ Section _________ ________¼ of the _______ ¼ of the _______ ¼

**The ¼, ¼, ¼ is read backwards. The largest ¼ of the section is the farthest right ¼; the middle ¼ is the ¼ of the first ¼; and the left ¼ is the smallest divided ¼.*

Directions to Site ____

____

**Write the direction for someone who is NOT familiar with the area. Use references found on a road map.*

WATER WELL INFORMATION

Permit To: [ ] Construct [ ] Deepen [ ] Repair [ ] Seal **well type:** [ ] Dug [ ] Driven [ ] Bored [ ] Drilled

**Indicate the work to be performed and on what type of water well.*

for a: [ ] A. Private Well [ ] B. Semi-Private Well [ ] C. Non-Community

**A Private Well is a water well which provides water for drinking, culinary, and sanitary purposes for an owner occupied home. A Semi-Private Well is a water well which is not a public water well, yet which serves a segment of the public other than an owner-occupied single family dwelling. A few examples of a Semi-Private Well are: a well for a rental home, a small factory, irrigation well, dewatering well, well to fill a pond. A Non-Community Well means a public water system which is not a community water system, and has at least 15 service connections used by nonresidents, or regularly serves 25 or more nonresident individuals daily for at least 60 days per year. A Non-Community Well could be for a large factory, gas station, school, campgrounds.*

use: [ ] Residential [ ] Commercial [ ] Livestock [ ] Irrigation [ ] Other ______________________________

**Indicate the intended use of the water well at the time the water well is constructed. More than one use can be checked.*

Complete if B or C checked: Number of people served ________ Type of facility ___________________________

(If C is checked, an application For Permit to Construct, Alter or Extend a Non-Community Public Water Supply must be submitted.)

[ ] Check if anticipated pumping capacity is greater than 100,000 gallons per day

WELL CONSTRUCTION OR ABANDONMENT INFORMATION

1. If well log is available, attach the log to this form
2. If well log is not available, well must be sealed from bottom to top.

Borehole: Size ____ in/ft depth ______ ft Size ____ in/ft depth _____ ft Size ______ in/ft depth _______ ft

**This section is to describe how the licensed contractor intends to construct the bore hole for the water well. For example, a water well that is to be over-drilled for the installation of 6" diameter water well casing could read: 10in depth 180ft; 6in depth 300ft. If a liner is to be installed, the reduction in bore hole size shall be indicated. This could read as: 10in depth 180ft; 6in depth 300ft; 4in depth 600ft. The actual construction will depend on the actual geology.*

Aquifer: [ ] Sand & Gravel [ ] Limestone [ ] Sandstone [ ] Other ________________________________

**The licensed contractor is estimating the formation in which the water well will be completed based upon the typical geology of the area and other water wells in the area. This is just a best estimate. It is OK for the water well to be completed in a different formation. But if all the water wells in the area are finished in one formation, i.e. sandstone, and the licensed contractor is indicating another formation, i.e. limestone, the local health department should question the licensed contractor why the formation is selected.*

Casing: Type ________________________ Size __________ in/ft Estimated Amount ___________ft

Liner: Type ________________________ Size __________ in/ft Estimated Amount ___________ft

Top of Liner _____ ft Type Seal ________________ Bottom of Liner _____ ft Type Seal ___________

**The estimated amount of casing and liner is the licensed contractor's best guess based upon the typical geology of the area and other water wells in the area. The information listed by the licensed contractor should be consistent with the area. If the aquifer indicated above is below other water bearing aquifers, the liner information must be completed. The liner must be installed to seal off all aquifers above the aquifer used for the water well. The top of the liner should be above the static water level of the aquifers being sealed off.*

Existing water well on property? [ ] Yes [ ] No Will it be used? [ ] Yes [ ] No Is it to Code? [ ] Yes [ ] No

Existing well to be sealed: [ ] Well in building [ ] Well in pit [ ] Pit retained Pit eliminated by: [ ] Contractor [ ] Owner

Is well free of obstruction? [ ] Yes [ ] No If No, at what depth is obstruction? ___________ ft

**If the water well is retained, indicate how water well will be used. If water well is retained, the water well must be in compliance with all Code requirements.*
If there is an obstruction in the water well, the depth of the obstruction is a critical factor. If the obstruction is within the casing, the obstruction must be removed. When the obstruction prevents the placement of sealing material at the juncture of the casing and rock, the obstruction must be removed. The significant factor of the water well casing is that the water well casing can deteriorate. The void left by the absence of water well casing can be a route for contamination. Whenever there is a possibility for a route of contamination developing below the obstruction, the obstruction must be removed. If the obstruction can not be driven deep enough into the water well to allow for proper sealing, the obstruction must be drilled out. If the obstruction can not be drilled out and the water well can not be properly sealed, the water well must be over-drilled and sealed.

FOR OFFICIAL USE ONLY

Construction Permit Number

_________ / _________ / _________
FIPS Code Number Year

_______________________________ ____________________
Approved by Date

Sealing Permit Number

_________ / _________ / _________
FIPS Code Number Year

State of Illinois
Illinois Department of Public Health

APPLICATION FOR PERMIT TO CONSTRUCT, MODIFY, OR ABANDON A WATER WELL

ATTACH A SHEET WITH DIAGRAM OF WELL SITE SHOWING DIMENSIONS

Furnish septic system plot or draw the proposed construction site with dimensions showing the water well, direction of slope, distances to buildings and property lines, sewer lines, all septic systems components including septic tanks and seepage fields, and other sources of contamination, e.g., abandoned wells, storm water dry wells and underground storage tanks, indicate distance to community water supply, if available. If there is an existing well on the property, indicate location and status.

**The intent of the diagram is to demonstrate that the water well can be sited in compliance with the requirements of the Water Well Construction Code.*

WATER WELL PUMP INFORMATION

Pump Type ______________________ Capacity _________ gpm Storage/Pump Cycle ______________ gallons

**The licensed pump installation contractor is responsible for this information. This information is required to comply with the notification requirement of the Pump Installation Code. A water well permit can be issued without this information.*

WORK SCHEDULE*

Estimated schedule date to start work on water well (MM/DD/YR): ____

**The time indicated is the licensed water well contractor's anticipated start time. By indicating a time and submitting the application, the licensed contractor is providing the minimum 48 hours notice as required by Code. If the local health department does not intend to inspect this water well, the licensed contractor can proceed if the start date is at least 2 days after the date the permit is issued. If there is a significant change in the start time, the licensed contractor should notify the local health department. If after the application has been submitted and the local health department decides to inspect this water well, the local health department shall notify the licensed contractor and then it is the licensed contractor's responsibility to notify the local health department with any changes to the start time. Even if the local health department does not notify the licensed contractor, the local health department can inspect any water well.*

***NOTE:**
Illinois Water Well Construction Code, Section 920.130 g) Notification. Any person who constructs or deepens a water well for which a permit has been issued under this Part, shall notify the Department, or approved local health department, or approved unit of local government by telephone or in writing at least two days prior to commencement of the work.

LICENSED CONTRACTOR CERTIFICATION
I certify that the attached information is complete and correct and that the work will conform to the current Illinois Water Well Construction Code and to the current Illinois Water Well Pump Installation Code.

Licensed Water Well Contractor

____ ______________________________
Print Name of Licensed Water Well Contractor License Number

____ ______________________________
Address City, State, Zip Code

__________________________ __________________________ __________________________
Office Phone Number Fax Number Cell Phone Number

____ ______________________________
Signature Licensed Water Well Contractor / Property Owner Date

**The only time the property owner signs the application is when the property owner is the home owner and is physically going to construct his own water well. If the home owner is contracting for the water well, the licensed contractor shall sign the application.*

Licensed Water Well Pump Installation Contractor

Print Name of Licensed Water Well Pump Installation Contractor ______ License Number ______

Address ______ City, State, Zip Code ______

Office Phone Number ______ Fax Number ______ Cell Phone Number ______

Signature Licensed Water Well Pump Installation Contractor / Property Owner ______ Date ______

** The only time the property owner signs the application is when the property owner is the home owner and is physically going to install his own water well pumping system. If the home owner is contracting for the installation of the water well pumping system, the licensed contractor shall sign the application.*
**A water well permit can be issued without this information.*

COPIES
THREE COPIES ARE RETURNED TO THE LOCAL HEALTH DEPARTMENT WHERE THE PERMIT IS ISSUED
One copy is retained by the health department where the permit is issued
One copy of the approved application is sent to Illinois State Water Survey
One copy is sent to the water well contractor

IMPORTANT NOTICE
This state agency is requesting disclosure of information that is necessary to accomplish the statutory purpose as outlined under Public Act 85-0863.
Disclosure of the information is mandatory. This form has been approved by the Forms Management Center

Form Number IL 482-0620 Page 2 of 2

Note: If printing the water well application form using a computer, print and submit 3 completed copies to the department.

After the licensed contractor has completed the application and submitted it, with the proper fee, to the local health department, the department will review the application. The department will process the application and will issue a Water Well Permit.

Important: Prior to starting construction of the water well, the licensed contractor must: 1) have possession of a valid Water Well Permit, and 2) notified the department at least 2 day prior to commencement of the work. The start date shall be at least 2 days after the date the permit is issued.

Important: When the Water Well Application is used for notification, the start date listed has to be at least 2 days after the Water Well Permit is issued. If the department normally requires 4 days to process and issue a permit, the start date should be a minimum of 7 days after the date the permit application was submitted. Emergencies will be handled on an individual basis.

And if the department has notified the licensed contractor that the department intends to inspect this water well, the licensed contractor must notify the department of the start time. If the department has identified a specific phase of construction for inspection, the licensed contractor must notify the department of the start of that phase of construction. The licensed contractor does not have to delay any phase of the construction process to accommodate the department. It is the licensed contractor's responsibility to notify the department of the time and it is the department's responsibility to be at the site at that time. It is in the best interest of all for both parties to work together in scheduling of inspections.

PREPARATION TO CONSTRUCT WATER WELL

Once the permit to construct a water well has been issued, the construction of the water well can begin. The appropriate Department shall be notified prior to beginning construction. The licensed water well contractor is responsible for supervising the start of the construction process. That means the contractor must confirm the following:

1. The drilling permit has been issued.
2. Proper notification has been given to all necessary parties.
3. The well location is accurate and meets all Code requirements.
4. The drilling crew is properly supervised as required by the Illinois Water Well Construction Code.

Safety is a very important issue in setting up and operating any drilling equipment. Before any equipment is moved onto a job site, the site must be deemed safe. To be deemed safe all underground utilities must be located prior to beginning any work, the area must be clear of any overhead utilities, and the ground surface must be sound and solid. Once the site has been deemed safe, the rig can be moved into position and the setting up of the drill rig can begin.

CONSTRUCTION OF WATER WELL WITH AIR/ MUD ROTARY

Photo courtesy of Boysen Well Drilling

The drill rig must be properly blocked and leveled before any drilling can start. The rotary machine will have outriggers or stabilizers. The purpose of the outriggers is to lift the tires off the ground and stabilize and level the rig for the drilling process. It is imperative that proper material be used under the outriggers to support the weight of the rig and balance the load of the machine. Rig tires touching the ground could cause the machine to jump or move during drilling.

Once the drilling equipment is properly set into position the actual drilling process can begin. It is important to have as much information about the geology of the area to serve as a guide for the driller. Drilling logs for a particular area are available from a number of sources and serve as a valuable tool in planning the estimated depth and materials required to complete the water well.

The Rotary style of drilling requires that mud slurry be circulated down the well during the drilling process in the drift. The manner in which this mud slurry is dealt with and contained can be one of two ways: a portable mud pit or an in-ground slurry pit. Either method of mud containment is acceptable.

If an in-ground mud pit is used, a trench must be cut from the bore hole to the front of the pit. This will allow the drilling mud coming out of the bore hole to flow, by gravity, to the mud pit and deposit the drill cuttings lifted out of the bore hole into the pit. Since the pit is baffled, the cutting will stay in the front chamber of the pit while fresh drilling fluid will be pumped back down the well from the rear of the pit through either a piston or centrifugal mud pump.

Typical in-ground mud pit:

Photo courtesy of Boysen Well Drilling

An above ground mud pit, also referred to as a drilling boat, requires a conductor pipe and trough to remove drill cuttings and circulate drilling mud down a hole. The boat needs to be located near the well site.

A typical above ground mud pit:

Photo courtesy of Boysen Well Drilling

The conductor pipe which is a minimum of 3” larger than the intended size of the well casing is placed into the ground.

A typical conductor pipe

Photo courtesy of K&K Well Drilling - Batavia

The trough links the conductor pipe to the front of the drilling boat. The drilling mud is pumped up the hole and over the top of the conductor pipe into the trough. Gravity deposits the drilling mud and drill cuttings into the pit where the cuttings are trapped in the first chamber of the mud pit. Clean drilling mud is pumped from the back of the drilling boat and back down the well through the drill rod.

Circulation of drilling mud:

Photo courtesy of K&K Well Drilling - Batavia

The drilling mud is mixed prior to drilling. The thickness or weight, sometimes called viscosity, of the drilling mud will vary depending upon geological conditions. The purpose of the mud is to assist the drill cuttings out of the hole and at the same time stabilize the side walls of the hole to prevent the hole from collapsing.

ROTARY DRILLING PROCESS

Pilot holes are optional. A pilot hole is a bore hole opened up to a depth that will accommodate a drilling stabilizer and drill bit. The pilot hole makes it easy to either place your conductor pipe in the ground or to start your mud flowing into your mud pit.

The drilling bit is attached to a stabilizer or drilling collar. The design and type of these drilling tools vary. The purpose of the stabilizer is to add weight and stability to the drill bit so it does not wander off center and drill a crooked hole. A properly designed drilling stabilizer is just as important as the drilling bit itself.

Stabilizer with drill bit:

Photo courtesy of K&K Well Drilling - Batavia

The stabilizer and bit have to be only a few feet in the ground before mud circulation can begin. The circulation of drilling mud is accomplished by use of a mud circulating pump.

There are two types of mud pumps: a centrifugal pump and a piston pump. The centrifugal pump is a single impeller type pump capable of high volume and low pressure pumping. The piston type mud pump is capable of both high pressure and high volume pumping. The purpose of the mud pump is to pump the clean drilling mud from the mud boat or pit and force it through the drill rod and out the end of the bit. This mud keeps the bit cool. The mud that is pumped into the bore hole cakes the side wall of the bore hole keeping it from caving or sloughing. The mud also lifts the ground-up drill cuttings up and out of the hole and deposits them in the mud box or pit. The driller takes samples of the drill cuttings and registers the results in the driller's log. Drill cuttings are the road map to water well construction. The drill cuttings tell the driller what geology the drill bit is penetrating and if the material is suitable enough to make water. The drill cuttings are important in that they will be recorded in the water well completion report for that particular well. This information is important because it will assist other drillers in the future, become part of the State of Illinois Water Well Registry, and be available to Hydrologists and Geologists for use or study.

MIXING DRILLING FLUIDS

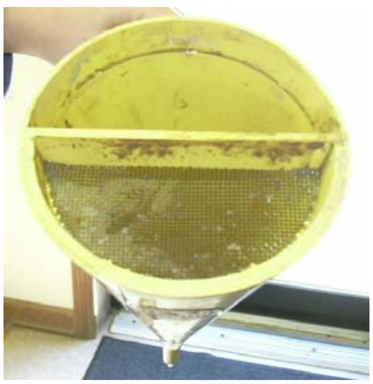
Drilling mud is a mixture of water and any bentonite clay material. The purpose of a drilling mud is to assist the drilling operation in a number of areas. The mud is the primary mover of the drill cuttings up and out of the bore hole, the mud stabilizes the hole to prevent caving or sloughing, and the mud helps to lubricate the bit during the entire drilling process.

There is no one set procedure for mixing drilling mud before beginning a hole. Knowledge of the geology to be encountered is critical in determining how best to mix the drilling mud. In drilling scenarios where the entire bore hole will encounter nothing but clay material, it may not be necessary to add any bentonite to the drilling water before beginning. In drilling scenarios of sand and gravel, the drilling mud will have to have a higher viscosity and/or weight to better stabilize the bore hole and to lift the cuttings up and out of the bore hole.

On the average, the ratio of drilling mud mix to water is 15 to 20 pounds of mud mix to 100 gallons of water. Where greater viscosity or mud weight is required you can increase this ratio to 30 to 40 pounds of mud mix per 100 gallons of water. The recommended ph of the drilling water is between 8 and 9. Normally city water has a ph of 6.5 to 7. The ph level can be raised from 6.5 to over 8 by adding 6 ounces of soda ash to every 300 gallons of mixing water.

Viscosity is a measure of a fluid's ability to flow. The higher the viscosity rating the harder it is to pump and the slower it will flow. The viscosity of a drilling mud is directly related to the mud's ability to lift drill cuttings up and out of the bore hole. Viscosity is measured by using a Marsh funnel viscometer. This device measures the time it takes one quart of fluid to pass through the funnel. Water has a Marsh funnel viscosity of around 25 seconds. Drilling mud has an average Marsh funnel viscosity of around 35 to 40 seconds.

Marsh Funnel Top



Marsh Funnel Side

Photos courtesy of Boysen Well Drilling

The mud must be monitored during the entire drilling operation. To maintain the proper mud viscosity, either mud mix or water is added to the mud. It is important to know and have a good understanding of not just the properties of the mud but also of all the additives available to assist a driller in maintaining a proper mud for any geological circumstance.

WATER WELL COMPLETION

Water wells will be completed in one of two possible formations: 1) Unconsolidated formations are sand or gravel deposits found above the limestone bedrock. These formations normally will collapse if the hole is left open. Therefore, these types of formations will require some type of screening material to keep them open for water withdrawal. 2) Consolidated formations are solid rock formations that are drilled into with the intent of penetrating enough rock to expose fissures and crevices that allow water to freely flow into the open hole. Material requirements and drilling techniques will vary depending upon what type of water well will be constructed.

DRILLING IN UNCONSOLIDATED FORMATIONS

Proper preparation and knowledge of equipment and drilling techniques is required when drilling a water well that will be completed in a sand or gravel aquifer. The first decision that must be made is to select the proper drilling tools. The bore hole must be a minimum of 3" larger in diameter than the outer diameter of the water well casing or outer diameter of the water well casing coupling, whichever is greater. For example; drilling a water well utilizing a 5" diameter threaded and coupled water well casing would require a 9 $^{1}/_{8}$" diameter bore hole. That is because the outside diameter of the 5" coupling is 6 $^{1}/_{8}$" O.D. In order to meet Illinois Water Well code requirements, a minimum of a 9 $^{1}/_{8}$" diameter hole must be drilled. A 9" diameter tri-cone drill bit should be selected along with the proper stabilizer for a 9 $^{1}/_{8}$" diameter hole.

The drill bit must be operated at the rotation speed appropriate for the formation. There is no standard rotating speed at which a drill rig should be operated. The type of equipment and the geology of the area will determine the best rotation speed to maintain.

Rotation speed and drilling mud velocity must be compatible in order to maximize hole penetration, clean the cuttings from the hole and stabilize the hole. The drilling mud should have a mud weight of around 9 pounds to the gallon at the start. As the mud circulates down through the bore hole it will increase some in weight and may need to be thinned with clean water throughout the entire drilling process. Clay will normally thicken the drilling mud which requires the drilling mud to be thinned as opposed to sand that may require the drilling mud to be thickened.

Once the bore hole has been started the driller must take drill cuttings samples and record this information. The drill cuttings tell the driller exactly what material the bit is penetrating and will eventually create an entire profile of the hole. It would be up to the driller to determine if a particular formation is suitable to construct a water well or to keep drilling. The driller is looking for suitable material, sand or gravel, which would potentially become a water well.

After it has been determined that a particular unconsolidated formation is suitable for a water well, materials are prepared for installation. The information that the driller must know is the depth of the hole, the material size, and the depth of the unconsolidated formation.

The sand material should always be sieved to determine the proper size of well screen to use. It is recommended that the slot size of the screen be selected that will retain 40% of the sand formation that has been encountered. The length of the screen should be long enough to expose as much of the unconsolidated formation as required to produce the volume of water that is desired.

There are two methods of installing screens: 1) One method is to attach the screen to the end of the water well casing and lower it to the bottom of the bore hole. Precautions must be taken to keep the weight of the casing from collapsing the screen once the string of material is at the bottom of the hole. 2) The second method is telescoping the screen inside the casing. With this method, the water well casing is installed to the bottom of the hole. The well screen is usually 1" in diameter smaller than the casing and is fitted with a rubber packer, called a K-packer. This K-packer attaches to the top of the well screen and is fitted with a rubber material that fits tightly in the inside of the well casing.

Well Screen with K Packer

Photo courtesy of Larson Becker Co - Batavia

The screen is then run to the bottom of the hole and held in place with drill rod while the casing is lifted high enough to expose the entire screen's open area to the unconsolidated formation. The casing is held in place with some type of blocking and the developing of the formation can begin.

AIR ROTARY DEVELOPMENT

When the screen is in position and the casing is set in place and being held by blocking or pipe elevators, the formation must now be developed. The purpose of this procedure is to break down the mud cake in the formation so the unconsolidated material will collapse around the screen and allow the water to start flowing into the well.

The methods used to develop well screens will vary in technique. Many of the developing tools are fabricated in house and will vary in design. The most basic of developing tools is the "jetting tool" which is a solid piece of steel pipe, 1" smaller in diameter than the screen it is developing. It has a solid bottom and a top that will thread into drill rod. The entire length of the pipe will have small holes, $^{1}/_{16}$" or $^{1}/_{8}$" in diameter, drilled through the pipe which will allow high pressure air to be channeled through the holes and into the screen. High pressure air is directed from the rig's air compressor through the jetting tool and back into the unconsolidated formation. The continuous action of the high pressure air hitting the surface of the formation will break down the mud caked walls and allow the water to start flowing into the well. The developing process can take hours or even days depending upon the size of the air compressor, thickness of the drilling mud used to stabilize the hole and the size of the material being developed. Besides breaking down the formation, this process rids the well of all fine material that is able to pass through the screen. The air being forced into the formation creates significant turbidity in the formation. The very fine material will be forced through the well screen and the larger matter will pack around the screen creating a barrier or shield that finer material can no longer pass through. Only when no more fine material is being pumped from the well and the anticipated volume of water is achieved is the water well considered developed.

DRILLING IN CONSOLIDATED FORMATIONS

Consolidated formations consist mainly of solid rock formations, i.e. limestone and sandstone. These can be very unpredictable sources of ground water. Unlike the unconsolidated formations where the entire formation is saturated with water, the rock formations rely on fissures or crevices to channel water into the bore hole. The productivity of a water well constructed in a consolidated formation is totally dependent upon the size and quantity of crevices or fissures encountered.

To construct a water well in a consolidated formation the drilling equipment is set up exactly the same as an unconsolidated formation well. The drilling pits are prepared, the hole sized properly to the diameter of casing to be used, and drilling and sampling of the glacial drift material is performed.

There are 2 options for the diameter size of the bore hole. 1) If the water casing is to be grouted with a tremie pipe inserted into the annular space, the bore hole must be a minimum of 3" larger in diameter than the outer diameter of the water well casing or outer diameter of the water well coupling, whichever is greater. For example; drilling a water well utilizing a 5" diameter threaded and coupled water well casing would require a 9 $^{1}/_{8}$" diameter bore hole. That is because the outside diameter of the 5" coupling is 6 $^{1}/_{8}$" O.D. In order to meet Illinois Water Well code requirements, a minimum of a 9 $^{1}/_{8}$" diameter hole must be drilled. A 9" diameter tri-cone drill bit is selected along with the proper stabilizer for a 9 $^{1}/_{8}$" diameter hole. 2) If the water casing is to be grouted through the inside of the water well casing, the bore hole must be a minimum of 2" larger in diameter than the outer diameter of the water well casing or outer diameter of the water well coupling, whichever is greater.

The real difference between the two types of water wells begins once the drill cuttings indicate that the top of the rock formation is encountered.

Once it has been determined that the top of the consolidated formation has been reached and the bore hole has penetrated into the firm consolidated material, the casing is readied for installation.

The bottom of the casing is fitted with a rotary style drive shoe. The purpose of the drive shoe is to firmly seat the casing into the consolidated formation. The drive shoe has a sharp bottom edge that will cut into the consolidated material and firmly seat the pipe into the rock.

Rotary drive shoe:

Photo courtesy of K&K Well Drilling - Batavia

The types of water well casing allowed are A-53 steel casing and SDR 17 and SDR21 PVC water well casing.

Steel casing can have threaded and coupled joints or welded joints.

Threaded and couple joint steel casing:

Photo courtesy of K&K Well Drilling - Batavia

PVC casing can have bell and socket glued joints or mechanical seal joints.

A PVC casing mechanical joint:

Photos courtesy of K&K Well Drilling - Batavia

A typical mechanical joint will have an o-ring in the bell end and a slot in both the bell end and in the plain end. When the two pieces are joined, a flexible connecting rod is inserted into the bell end and fits into the slot of the plain end. The rod is pushed into the bell end until it has traveled around the entire slot of the plain end. This flexible rod locks the 2 pieces of casing together. After the flexible rod is completely installed, the excess is cut off.

When steel pipe is used, the weight of the pipe itself is enough to hold the pipe in place as drilling continues. When setting PVC casing on top of a consolidated formation it is recommended that a length of A-53 grade steel pipe, fitted with a drive shoe be attached to the bottom of the string of PVC casing. This adds weight to the string of casing and serves to protect the bottom of the PVC casing from the drill bit and drill cuttings as they are being air lifted out of the well.

The drilling of a consolidated formation is done with either a tri-coned drill bit or an air operated drilling hammer. A tri-cone bit can be used with relatively low volumes of air while a hammer bit will require a greater amount of air pressure depending on the depth of the hole and the diameter of the hole.

Typical air operated drilling hammer:

Photo courtesy of K&K Well Drilling - Batavia

The bit used to drill a rock formation will dictate the amount of air pressure required as well as down pressures that should be maintained to maximize the penetration rate. Consolidated formations are drilled to whatever depth is required to intersect enough cracks and fissures in the formation to achieve the desired volume of water. The size of the water bearing fissures encountered in the rock formation is directly related to the yield of a water well. The more crevice openings encountered in the hole should result in higher yields of water flow.

<u>GROUTING A ROTARY DRILLED WATER WELL</u>

All rotary drilled water wells must be grouted after the construction of the water well is complete. The two acceptable materials required for grouting are bentonite grout or neat cement grout.

Bentonite grout is a mixture of sodium bentonite and water. The recommended mixing ratio is a 50 pound sack of bentonite to 24 gallons of water to make a 20% active solids slurry with a grout weight of 9.4 lb/gal and a yield of approximately 26.6 gallons of grout. The viscosity and consistency of bentonite grout may be altered to meet equipment or hole constraints by adjusting the amount of water used to obtain varying solids content. It is recommended that each driller carry and use a mud scale (mud balance). This device measures the specific volume of grout slurry and density and converts it into pounds per gallon. Each batch of grout mix should be measured with a mud scale to assure proper grout density.

grouting machine

mixed grout

Photos courtesy of K&K Well Drilling - Batavia

Neat cement grout is a mixture of one bag of cement (94 pounds) with no more than 6 gallons of clean water.

GROUTING METHODS

There are a number of approved methods available to properly grout an annular space of a rotary drilled water well. The licensed water well contractor decides what method is best suited for each well. The amount of grout needed will be dependent upon the depth and effective diameter of the annular space. There are charts and tables available to help the contractor determine the correct amount of grout to be mixed and placed in the annular space. It is recommended that the total amount of grout available be a minimum of 20% more than the required amount of product, according to the published table, to assure that the well has sufficient grout seal. It is the responsibility of the licensed water well contractor to make certain that sufficient grout has been placed in the annular space.

It is imperative that whichever method of grouting is used, the grout must be pumped from the bottom to the top of the annular space.

Normally for a properly grouted water well casing, the subsidence, if any, will be minimal.
(A chart is available in Appendix W-1)

TREMIE PIPE METHOD

This method of grouting requires a grout pipe, called a tremie pipe, which is usually flush joint plastic, to be lowered to the bottom of the annular space. A good practice is to circulate clean water through the tremie pipe to both clean the annular space to be grouted and assure that the tremie pipe is not plugged. Once the grout is properly mixed, it should be pumped through the tremie pipe into the annular space until the grout mix reaches the surface. Sufficient grout should be pumped to the surface to assure that the annular space is filled which results in minimal subsidence of the grout.

GROUT SHOE METHOD

This type of grouting is normally employed when grouting deep liner pipes. With this method of grouting, the bottom of the liner pipe is fitted with a grouting shoe, sometimes called a float shoe. This shoe is a fabricated, drillable check valve type fitting. It is the same diameter as the liner pipe and has a cement center with a female taper fitting. The grouting pipe can either be a tremie pipe or drill rod. The grouting pipe is equipped with a male fitting called a stinger that will taper tightly into the female fitting of the grout shoe. The grout material is pumped through the grout pipe and into the grout shoe. Grout can only move up the annular space. In one continuous operation all the grout mixture is pumped into the hole. When the grout pipe and the stinger are removed, the grout shoe will close and not allow any grout to move backward. After the grout has set, the grout shoe is drilled out.

BRAIDEN HEAD METHOD

This method of grouting requires the well casing to be lifted slightly off the bottom of the well. Grouting pipe is installed to the bottom of the well. A well seal or well packer is installed on the casing so that no material can exit the well up through the casing. The well is then filled with water and grout is pumped through the grout pipe located at the bottom of the well and can only exit through the annular space. Once all the grout has been pumped into the annular space and a sufficient grout return is measured at the surface, the casing can then be firmly seated to the bottom of the well.

securing tremie pipe top of casing
with a well seal

Photo courtesy of K&K Well Drilling - Batavia

HALLIBURTON METHOD

This method of grouting requires the well casing to be lifted slightly off the bottom of the drilled hole. The calculated amount of grout required to fill the entire annular space is mixed and pumped into the casing. A drillable plug that fits tightly into the casing is mechanically pushed to the bottom of the well forcing the grout up into the annular space. The casing is then firmly seated to the bottom of the hole. To assure that no grout will be lost back into the casing, the casing can be filled with water and a water tight cap be placed on top of the casing. This will assure that no grout will move backward into the casing.

LINER INSTALLATION

There are 3 situations for the installation of a liner: 1) The purpose of the liner is to seal off a formation with caving material and/or very little water; 2) The purpose is to seal off a formation that produces 1 – 2 gpm of good quality water that is being used by others; and 3) The purpose of the liner is to seal off a formation with a significant quantity of water and/or the water quality is undesirable. There are some instances where the water is very aggressive. If a steel liner were exposed to this water, the water would corrode and eat through the liner which renders the liner useless. In this case, it is imperative that the whole liner be grouted to protect the future integrity of the liner.

Situation 1): This could be a shale formation or a clay formation below a rock ledge in which the casing has already been set. The amount of water is minimal and of decent quality. In this case the liner can be sealed with a packer on the ends of the liner. The quality of the packer for the bottom of the liner has to be manufactured for setting in a rock formation, e.g. a K-packer is not appropriate for setting in a rock formation. A K-packer can be used on the upper part of the liner if the upper part of the liner terminates in the casing. A rock packer on the bottom of the liner will provide the necessary seal. In most cases the shale will cave around the rock packer.

K-Packer

Rock Packer

K-Packer Rock Packer

Photos courtesy of Larson Becker Co - Batavia

Rock-type packer affixed to liner pipe

Photo courtesy of K&K Well Drilling - Batavia

Situation 2): This could also be a shallow dolomite formation which produces in 1 - 2 gpm of good quality water and other water wells are pumping from this aquifer. In this case, even if there is a caving formation to be sealed off with the liner, more than just a rock packer is required on the bottom of the liner. An acceptable method of sealing the liner is to install a rock packer on the bottom of the liner and another rock packer 10' above the rock packer on the bottom of the liner. As the liner with the packers is being installed, the 10' annular space between the packers and casing is filled with bentonite chips. This creates a 10' bentonite plug on the outside of the liner. If any water would leak by the upper packer, the water would hydrate the bentonite. In addition, any water in the rock formation in which the bottom 10' of liner is set would hydrate the bentonite. This type of sealing will prevent the dewatering of the upper formation.

Situation 3): This could be where the amount of water is greater than 2 gpm and/or the water quality is bad. In these cases the liner must be grouted in place to be properly sealed. If the grout is to be pumped through a tremie pipe, the diameter of the bore hole constructed through the formation shall be a minimum of 3 inches greater in diameter than the outside diameter of the liner pipe or outside diameter of the liner pipe coupling, whichever is greater. If the grout is to be pumped through the inside of the liner and up the annular space, the diameter of the hole constructed through the formation shall be a minimum of 2 nominal inches greater in diameter than the outside diameter of the liner pipe or the outside diameter of the liner pipe coupling, whichever is greater. Another method is construct a hole 2 nominal inches greater in diameter than the outside diameter of the liner pipe or outside diameter of the liner pipe coupling, whichever is greater, fill the hole with grout, and then push the liner pipe through the grout so that the liner sets at the bottom of the hole. After the grout has set, the grout inside the liner is drilled out. When the bottom of the liner is set at a depth greater than 500 feet from the surface, the liner shall be grouted with only neat cement.

MOBILIZATION

After the water well has been properly grouted and developed, the drilling tools and grouting tools are removed and properly stored.

"Blowing off well" to develop and clean

Photo courtesy of Boysen Well Drilling

The water well must then be chlorinated and secured with a tamper proof well seal or cap. The drill rig is "folded up" and readied to move to the next site. The site is left ready for the water well pumping system to be installed.

CABLE DRILLING PROCESS

Photo courtesy of M. Ebert Company

The drill rig must be properly blocked and leveled before any drilling can start. The drill rig can have hydraulic or screw jacks for the leveling. It is imperative that the proper material be used under the leveling jacks to support the weight of the rig and balance the load of the machine. The drill string is a superb plumb bob for the leveling of the drill rig.

Once the drilling equipment is properly set into position, the actual drilling process can begin. It is important to have as much information about the geology of the area as possible. Drilling logs for a particular area are available from a number of sources and serve as a valuable tool in planning the estimated depth and materials required to complete the water well.

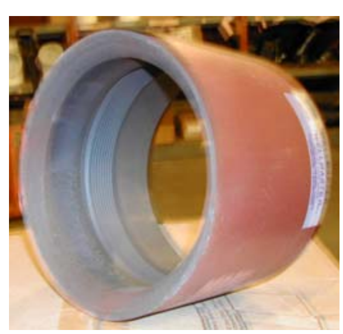
The starting hole is an oversized hole constructed to a minimum depth of ten (10) feet to a maximum of twenty (20) feet. The purpose of this hole is to provide for the removal of the drive nipple and the installation of a new length of water well casing.

A tool guide can be used to control the drill string during the construction of the starting hole. Another method for construction of the starting hole is to slide the drill string inside the first length of casing which has the drive shoe. Then, using the sand line to lift and drop the casing, the drive shoe can enlarge the drill hole to create the starting hole. A third method for construction of the starting hole is to hand auger an 8" diameter hole to a depth of 5 feet for a pilot hole. Then this hole is continued to a depth of 20 feet by drilling with an 8" diameter bit. A 6" diameter water well casing is set into this bore hole for temporary surface casing.

The drive shoe is a critical component in the drilling process. The drive shoe is a hardened steel cutting tool that is slightly greater in diameter than the couplings of the casing. The drive shoe keeps the bottom of the casing true and round as the casing is driven through the overburden. When the water well is finished in a consolidated formation, the drive shoe is driven into bedrock formation. The drive shoe is tapered to cut into bedrock formation and form a seal.

Cable drill shoe

Photo courtesy of Larson Becker Company Batavia



The drilling process is either: 1) drilling an open hole below the bottom of the casing when the formation is stable or 2) driving the casing into the unstable formation and then drilling out the casing. The drill cuttings are removed from the bore hole with a bailer. One type of bailer is the dart bailer. This type of bailer is a long tube with a dart valve on the bottom. The dart valve opens on the bottom of the hole and allows the cuttings to enter the tube. When the bailer is lifted off the bottom, the dart closes and holds the cuttings. When the bailer is set into the mud tub, the dart valve opens and the cuttings flow out.

bailer

dart valve

Photos courtesy of M. Ebert Company

When the casing is being driven, either granulated bentonite or a natural clay mixture is mounded around the casing at the bottom of the starting hole. The bentonite or natural clay mixture is dragged downward as the water well casing is driven and seals the annular space created by the drive shoe. The casing is driven by: 1) attaching drive clamps to the drill string; 2) screwing a drive nipple into the top collar of the water well casing to protect the top collar; and 3) using the drilling motion, pound the casing down.

drive nipple

Photo courtesy of M. Ebert Company

When the water well is completed in a sand and gravel formation, the sand material should always be sieved to determine the proper size of well screen to use. It is recommended that a slot size of a screen be selected that will retain 40% of the sand formation that has been encountered. The length of the screen should be long enough to expose enough of the formation to produce the volume of water that is desired.

The screen is installed by telescoping the screen inside the casing. With this procedure, the water well casing is driven to the bottom of the water producing a sand/gravel formation. The well screen is usually 1” in diameter smaller than the casing and is fitted with a rubber packer, called a K-packer or a swedge packer. The K-packer attaches to the top of the well screen and is fitted with a rubber material that fits tightly in the inside of the well casing. The screen is then placed at the bottom of the casing. The casing is fitted with a drive head and then driven back up the hole using the up-down motion of the drill string. Because the casing is being driven back with sharp blows, the screen will stay in place at the bottom of the hole. The casing is driven back a total distance that will expose enough of the screen area for the required yield and still allow for the K-packer sealing at the top of the screen.

A swedge packer is the approximate diameter of the screen. When the casing is pulled back to expose the screen, the swedge packer is free from the casing and will stay in place. Since the swedge packer is free of the casing, this allows the use of hydraulic jacks to pull back the casing. Once the casing has been pulled back the proper distance, a swedge is used to expand the top of the swedge packer against the casing forming a seal.

The water well can then be developed using the bailer, a surge tool, or by installing a temporary pumping system specifically designed for developing. The fine material will be forced though the well screen into the water well and removed and the larger matter will pack around the screen creating a barrier or shield so that the finer material can no longer pass through. Only after all fine material has been removed from the well and the anticipated volume of water is achieved is the water well considered developed. In a properly developed water well, the formation material, which is 60% of the size of the composite material contained in the formation, will have been removed from around the screen.

When the water well is completed in a rock formation, the casing is driven firmly into the bedrock and an open hole is drilled until sufficient water is encountered. The drive shoe allows for the casing to be driven firmly into the rock. When the rock is first encountered, the casing is driven to the rock. As the drill is continued into the rock, the casing is periodically driven to ensure that the casing is firmly seated into the rock. When the drill hole is far enough below the bottom of the casing so that the action of the drill string does not impact the casing, the casing should be driven once more to establish the firm seating into the rock.

The water well is completed when the water well has been properly developed. The water well is properly developed when sufficient water is being produced and the water well has been bailed clean.

MOBILIZATION

After the water well has been properly developed, the drilling tools are removed and properly stored. The water well must then be chlorinated and secured with a tamper proof well seal or cap. The drill rig is “folded up” and readied to move to the next site. The site is left ready for the water well pumping system to be installed.

<u>BORED WATER WELLS</u>

Bored water wells are constructed mainly in the southern half of the state of Illinois. Many parts of this area do not have acceptable supplies of water from deeper rock formation either from lack of water bearing rock formations or poor water quality. The shallow aquifers which consist of sand layers or sandy clay are often marginal producers of water. The normal yield of these aquifers is in the range of a half gallon per minute or less. In rare cases, a property could have two bored wells in order to supply the needs of the household. These formations are also prone to reductions in yields during dry times of the year. Generally, the more shallow and thin the formation, the greater the impact of dry weather on the reduction of yield of water from the water well.

When locating the water well on the property, two parameters that the experienced bored well contractor considers are: 1) the surrounding topography and 2) information about other bored wells in the immediate area. Many times the customer will have selected the site for constructing the water well. If a site is bored without success, the experienced bored well contractor will then use the information about the topography and water wells in the area to select another site on the property. Since the location of these formations is so unpredictable, it is not uncommon to try two or three holes on a single property. It is also possible for one neighbor's well to be 35' deep while his adjoining neighbor's is 75'.

It is also possible to have a formation just above bedrock which produces a useable yield of water but has little artesian pressure. This results in a water well with very limited storage capacity. For this situation, there are 2 possible solutions:

1) If the bedrock is a soft sandstone, it is possible to extend the bore hole into the sandstone. A smaller diameter drilling bucket is used to cut into the sandstone as much as 10'. The diameter of the bucket is increased and the bore hole reamed out. The procedure of increasing the diameter and reaming is repeated until the hole is a sufficient diameter size to be able to install the casing.

Different diameter buckets for reaming of bore hole in soft sandstone formation

Photo courtesy of
Kohnen Concrete Products, Inc., Germantown

2) If the bedrock is too hard to penetrate with smaller drilling buckets it would be possible to pump the water from the shallow well into a large storage vessel such as a cistern using a water level monitoring system in the cistern. This type of installation would then require water treatment for the cistern water since it would no longer be considered water from a sealed water well.

Although most bored wells will be constructed in formations with marginal water yields, there are shallow formations which do produce large flow rates of 100 GPM or more. Usually these are deeper formations which are under significant artesian pressure. In these instances, the driller will not be able to set casing fast enough to stay ahead of the rising water. In these situations, the contractor relies on his experience to properly seat the upper casing on the casing below.

EQUIPMENT

Photo courtesy of Kohnen Concrete Products, Inc., Germantown

The earliest forms of the large diameter wells were hand dug wells which could be in excess of 6’ in diameter. These wells were being constructed into the 1950’s. The earliest forms of boring rigs used a clutch to engage the ring gear which was located at the rear of the rig. The ring gear is a large diameter gear open in the center to allow the bucket and drill rod to pass through.

yoke out of ring gear

yoke in ring gear

ready to start boring

Photos courtesy of Kohnen Concrete Products, Inc., Germantown

The drill rod is a series of square steel stock usually 20’ to 25’ in length. In order to get to the depths needed there will be multiple square rods which fit inside of each other and telescope. The outer bar slides inside a yoke which in turn fits inside the ring gear and is turned by the ring gear. The inner most drill rod is attached to the drill cable with a swivel.

When the bucket is full it is pulled up and above the ring gear where a cable is attached and the bucket is pulled away from the rig.

Photos courtesy of Kohnen Concrete Products, Inc., Germantown

The bucket has a hinged bottom which is tripped and the cuttings are allowed to dump onto the ground near the rig. The cable which pulls the bucket away from the rig is rigged through a moveable steel arm which guides the direction of the bucket. This arm is attached to the rig so the arm can be moved in either direction to start a new cuttings pile when needed. This basic operation has remained unchanged for decades.

The major improvement in boring rig design has been the hydraulic system replacing the clutch driven operation of the ring gear. In addition to the continuous maintenance of the clutch driven equipment, the clutch driven mechanism is much more dangerous than hydraulic since it is possible to put excess stress on all components of the rig. As with all drilling rigs, it is advisable for the licensed water well contractor to work with an operator for a number of years so that the operator has the experience to be comfortable with the operation and to be able to safely construct wells in different conditions.

BORED WELL DESIGN

In Illinois there is no code restriction on the size of casing to be used. The type of casing must be either reinforced concrete or NSF approved fiberglass. Because the storage capacity is exponentially increased as the casing size increases it is recommended that a minimum of 30" ID be used as the initial casing size. 30" ID holds 36 gallons per foot while 36" ID holds 53 gallons per foot. This can be the difference between a well providing an adequate supply for the residence and running low on water during drought periods. Another consideration for larger size is the possibility of wanting to deepen the well later or the need to use a reduced size casing to extend the well deeper in the initial drilling. Casing less than 24" will not provide enough storage capacity for the majority of the bored wells water well systems.

Regardless of the size or type of casing used, the lid placed on top of the upper large diameter casing must be reinforced precast concrete.

In the Illinois Code there are two approved methods of finishing the upper part of the bored well: 1) buried slab and 2) above grade.

BURIED SLAB

The buried slab method involves placing the concrete lid a minimum of 10’ below finished grade. The concrete lid will have a minimum 4” ID approved casing or coupling cast into the lid. An Illinois Code approved casing is extended from the concrete lid to a minimum of 8” above finished grade.

lifting concrete casing

setting casing through the ring gear

setting casing into hole

concrete lid with coupling

lid in place

casing extended from lid to above surface

Photos courtesy of Kohnen Concrete Products, Inc., Germantown

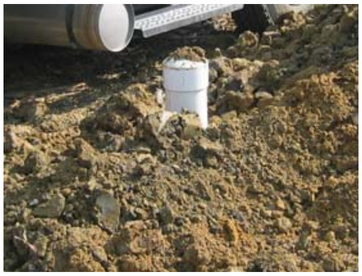
The advantage of this type of construction is the ability to install an Illinois Code approved pitless adaptor on the small diameter well casing and exiting the well below the frost level. This type of construction method is utilized most often. The lid can be placed more than 10’ below finished grade but two factors need to be taken into consideration: 1) weight and 2) storage capacity. The deeper the lid is placed the more weight is exerted downward on the concrete lid by the fill dirt. A safety margin must be maintained between the weight bearing limit of the lid and the pressure exerted on it. The generally accepted safety margin is 50% greater load capacity than the anticipated load. The other consideration is the lost storage capacity. Sometimes the static water level will be between 10’ and 20’ below grade. In those situations where storage capacity is critical, the larger casing should be brought to a level to assure maximum storage capacity.

After the concrete lid and upper casing has been installed, 3/8" washed pea gravel shall be installed between the annular space of the large casing and the bore hole. This annular space shall be at least 4" greater than the outer diameter of the casing. Granular 70% chlorine shall be added to the gravel as it is being installed. The purpose of the pea gravel is to stabilize the hole around the casing and prevent caving of the hole around the casing which could have a sealing effect on the entrance of groundwater through the joints of the casing. It also provides a base for the bentonite seal. This seal is constructed by placing bentonite clay product, powder, granular or hole plug in dry form a minimum thickness of 1' from the top of the concrete lid. The well is then finished by backfilling the annular space above the bentonite seal with the cuttings from the bore hole operation to grade. This backfill should be mounded to allow for settling. The bentonite seal is required because the backfill of the cuttings will allow for channeling of surface water through the backfill directly to the well until the backfill has settled and compacted sufficiently which could take more than a year.

adding pea gravel & chlorine

adding bentonite

backfilling



completed

Photos courtesy of Kohnen Concrete Products, Inc. Germantown

ABOVE GRADE CONSTRUCTION

The second approved method is to bring the large diameter casing to at least 8" above finished grade. The concrete lid is placed on top of the casing. The concrete lid will have a pipe cast in which allows for the installation of an Illinois approved well seal. This method is not used very often and normally would only be used in unusual circumstances. One such case would be where there are no buildings on site to house pump equipment. However, the water line **must** exit the well a minimum of 8" above grade. Galvanized couplings shall be cast into the casing above grade to allow the water lines to be installed on the inside and outside of the well casing. The annular space between the casing and the bore hole shall be filled with clean pea gravel with chlorine added as described for buried slab construction to within 10' of finished grade. The annular space in the top 10' shall be filled with concrete with a minimum 5 bag mix. The concrete that seals the upper 10' of the annular space shall be a minimum of 6" thick.

All bored wells require a permit to construct and a completion report completed and filed with the county within 30 days of completion.

MOBILIZATION

After the water well has been properly completed, the drilling tools are removed and properly stored. The water well must then be chlorinated and secured with a tamper proof well seal or cap. The drill rig is "folded up" and readied to move to the next site. The site is left ready for the water well pumping system to be installed.

WATER WELL CONSTRUCTION REPORT

WELL CONSTRUCTION REPORT

TYPE OR PRESS FIRMLY WITH BLACK INK PEN
COMPLETE FORM WITHIN 30 DAYS OF WELL COMPLETION
AND SEND TO THE APPROPRIATE HEALTH DEPARTMENT

1. Type of Well: a. Driven Well: Casing Diam. _____ in. depth _______ ft.

b. Bored Well: Buried Slab [ ]yes [ ]no
Hole Diam. _______in. to _______ft. ______in. to _______ft. ______in. to _______ft.

c. Drilled Well: PVC casing Formation packer set at a depth of ______________ ft.
Hole Diam. _______in to_______ft _______in to _______ft ______in to ________ft

Type of Grout	# of Bags	Grout Weight	From (ft)	To (ft)	Tremie Depth (ft)

d. Drilled Well: Steel Casing Mechanically Driven [ ] yes [ ] no
Hole Diam ______in to ______ft _______in to ________ft ______in to _______ft

Type of Grout	# of Bags	Grout Weight	From (ft)	To (ft)	Tremie Depth (ft)

e. Well finished within [ ] Unconsolidated Materials [ ] Bedrock

f.

Kind of Gravel/Sand Pack	Grain Size/Supplier #	From (ft)	To (ft)

2. Well Use: [ ] Domestic [ ] Irrigation [ ] Commercial [ ] Livestock
[ ] Monitoring [ ] Other ____________________
3. Date Well Completed: _______________ Well Disinfected [ ]Yes [ ]No
Driller's estimated well yield __________ gpm
4. Date Permanent Pump Installed ________________
5. Pump Capacity ______ gpm Set at (depth) _________ ft.
6. Pitless Adapter Model & Manufacturer: ____________________
Attachment to Casing: [ ] Threaded [ ] Welded [ ] Compression
7. Well Cap Type & Manufacturer: ____________________
8. Pressure Tank: Working Cycle _______ gals. Captive Air: [ ] Yes [ ] No
9. Pump System Disinfected: [ ] Yes [ ] No
10. Name of Pump Company ____________________
11. Pump Installer: ____________________ License # ______________

12. ____________________ License # ______________
Licensed Pump Contractor Signature

Illinois Department of Public Health
Division of Environmental Health – 525 W. Jefferson
Springfield, IL. 62761

DO NOT write on these lines

IMPORTANT NOTICE. This State Agency is requesting disclosure of information that is necessary to accomplish the statutory purpose as outlined under Public Act 85-0863. DISCLOSURE OF THIS INFORMATION IS MANDATORY. This form has been approved by the Forms Management Center.

Date ____________________

GEOLOGICAL & WATER SURVEY WELL RECORD

13. Property Owner__________________ Well # _________
14. Driller ____________________ License Number ______________
15. Name of Drilling Company____________________
16. Permit Number ____________________ Date Issued __________
17. Date Drilling Started ____________________
18. Well SITE Address ____________________
Township Name ____________________ Land ID # ______________
20. Subdivision Name________________ Lot #______________
21. Location: a. County ____________________
b. Township_______ Range_________ Section _______
c. GPS: ____° ____' _____._____"N _____° _____' _____._____"S
d. . _____Quarter of the _______Quarter of the _______Quarter
22. Casings, Liners *, & Screen Information

survey use only

Diam. (in)	Material, Joint Type, Slot Size	From (ft)	To (ft)

* ____________________

*(list reason for liner, type of upper and lower seals installed)
23. Water from ____________________ at a depth of ________ ft. to . ft.
a. static water level _______ ft. below casing which is_____ in. above ground
b. pumping level is__________ ft. pumping _______ gpm for ______ hours
24.

Earth Material Passed Through	From (ft)	To (ft)

(Continue on 2nd sheet, if necessary)
(If DRY HOLE, fill out log & indicate how hole was sealed)

25. ____________________ Licensed Water Well Contractor Signature ______________ License Number

COMPLETION OF THE WATER WELL CONSTRUCTION REPORT

The Water Well Construction Report is the last form the licensed contractor is required to file for the water well. This report must be completed and filed within 30 days after the completion of the water well. The water well is considered to be completed when the water well is ready to have the permanent pumping system installed. This means that if the water well is to be test pumped, the 30 day period would start after the water well had been test pumped and the test pumping equipment removed.

On the previous page is a copy of the Water Well Completion Report. The Water Well Construction Report is displayed on the following pages with a description, in italics, of the information required in each section.

WELL CONSTRUCTION REPORT

TYPE OR PRESS FIRMLY WITH BLACK INK PEN

COMPLETE FORM WITHIN 30 DAYS OF WELL COMPLETION
AND SEND TO THE APPROPRIATE HEALTH DEPARTMENT

1. Type of Well: a. Driven Well: Casing Diam. _____ in. depth ________ ft.

Even though a driven well is exempt from the requirement of being constructed by a licensed water well contractor, this construction report still is required.

b. Bored Well: Buried Slab [ ]yes [ ]no
Hole Diam. _______in. to _______ft. ______in. to _______ft. ______in. to _______ft.

c. Drilled Well: PVC casing Formation Packer set at a depth of _____________ft.

The purpose of the formation packer is for the grout weight to hold the PVC casing down. If a length of steel casing is attached to the bottom of the PVC, the formation packer is not required. The steel casing provides additional protection at the bottom.

Hole Diam. _______in. to _______ft. ______in. to _______ft. ______in. to _______ft.

Type of Grout	# of Bags	Grout Weight	From (ft)	To (ft)	Tremie Depth (ft)

The 2 types of grout are neat cement grout and bentonite grout. # of bags is the total number of bags used to fill the annular space. Sometimes an extra bag of bentonite grout is mixed to insure that the proper weight grout is surfacing. The grout weight is the weight of the grout being pumped. If a tremie pipe is used to place the grout, the depth of the tremie pipe is the bottom depth of the grout. The tremie pipe must be a minimum of sixty feet in depth and the bore hole a minimum of 3” greater in diameter than the outer diameter of the casing or coupling, whichever is greater.

d. Drilled Well: Steel Casing Mechanically Driven [ ]yes [ ]no
Hole Diam. _______in. to _______ft. ______in. to _______ft. ______in. to _______ft.

Type of Grout	# of Bags	Grout Weight	From (ft)	To (ft)	Tremie Depth (ft)

The steel casing is mechanically driven, the type of grout is granular bentonite. # of bags is the total number of bags mounded around the casing which were dragged down by the casing when the casing was driven. If the bore hole is over-drilled, then steel casing is grouted the same as PVC casing.

e. Well finished within [ ] Unconsolidated Materials [ ] Bedrock

Indicate the formation that the water to the well is coming from.

f.

Kind of Gravel/Sand Pack	Grain Size/Supplier #	From (ft)	To (ft)

When the screen is gravel packed, this section is completed.

2. Well Use: [ ] Domestic [ ] Irrigation [ ] Commercial [ ] Livestock

   [ ] Monitoring [ ] Other ___________________________

   Indicate the use of the water well. More than one use can be checked.

3. Date Well Completed: _________________ Well Disinfected [ ]Yes [ ]No

   Driller's estimated well yield ___________ gpm

   Date well completed is date water well was ready to have permanent pumping system installed. It is the responsibility of the licensed contractor to disinfect the water well so this should always be checked yes. The well could be tested for yield less than the maximum capacity of the well. The driller can sometimes calculate the yield without a formal test. That is the yield number inserted here.

   The following is the responsibility of the licensed pump installation contractor. If the licensed pump contractor is not associated with the water well contractor, this completion form can be submitted without the pump information. It is the responsibility of the licensed pump contractor to provide this information.

4. Date Permanent Pump Installed ____________________
5. Pump Capacity _____ gpm Set at (depth) _________ ft
6. Pitless Adapter Model & Manufacturer: __________________________________

   Attachment to Casing: [ ] Threaded [ ] Welded [ ] Compression
7. Well Cap Type & Manufacturer: ______________________________________
8. Pressure Tank: Working Cycle ______ gals. Captive Air: [ ] Yes [ ] No
9. Pump System Disinfected: [ ] Yes [ ] No

   It is the responsibility of the licensed pump installer to disinfect the pumping system. This should always be checked yes. The sampling tap, required by Code, near the tank will produce a sample that will verify if the pump installer has disinfected the pumping system. If the sampling tap produces a good water test and a bad sample comes from the household faucet, the plumbing system is defective. Neither the licensed water well contractor nor the licensed pump installer are responsible for the plumbing system.

10. Name of Pump Company ____
11. Pump Installer: ________________________ License # ___________________
12. ______________________________________ License # ___________________

    Licensed Pump Contractor Signature

**The pump installer can be a person working under the direct and personal supervision of the licensed pump installation contractor. If this is the case, the person's name should be entered to establish work experience for when the individual would want to be licensed. If the pump installer is licensed, enter the license number of the pump installer. The Licensed Pump Contractor Signature name must be the same as the name of the licensed pump installation contractor who signed the pump section on the water well application.*

Illinois Department of Public Health
Division of Environmental Health – 525 W. Jefferson
Springfield, IL. 62761

____
____
____
____
DO NOT write on these lines

IMPORTANT NOTICE. This State Agency is requesting disclosure of information that is necessary to accomplish the statutory purpose as outlined under Public Act 85-0863. DISCLOSURE OF THIS INFORMATION IS MANDATORY. This form has been approved by the Forms Management Center.

WELL CONSTRUCTION REPORT

Date ____________________

**This date is the date that this form was filled out by the licensed water well contractor.*

GEOLOGICAL & WATER SURVEY WELL RECORD

13. Property Owner____________________________________ Well # ____________

**The name of the property owner is the same name as the name of the owner who is on the water well application. The well # is the well # for this owner on this property.*

14. Driller ____ License Number __________________

**The driller can be a person who is working under the direct and personal supervision of the licensed water well contractor. If this is the case, the person's name should be entered to establish work experience for when the individual would want to be licensed. Enter the driller's license number if the driller is licensed.*

15. Name of Drilling Company____
16. Permit Number ___________________________ Date Issued _____________________
17. Date Drilling Started ______________________________________

**This date is the actual date that the drill rig began constructing the water well.*

18. Well SITE Address ____

**This is the same address as the address for the well site on the Water Well Application. If the address on the Water Well Application was incomplete and the true address is now known, enter the address from the Water Well Application and state changed to and list correct address.*

19. Township Name ________________________ Land ID # ________________________

20. Subdivision Name________________________________ Lot #_____________
21. Location: a. County ________________________

b. Township____________ Range__________ Section ________________

c. GPS: _____ ^{0} _____ ‘_____ . _____“N ______ ^{0} _____ ‘_____ . _____“S

d. ______Quarter of the ______Quarter of the ______Quarter

All of the above information on the location of the site should match the same information listed on the Water Well Application. If any the information has changed, note that the information on this report is the correct information. After 1/1/06, the GPS coordinates shall be used. On the Construction Report, the GPS coordinates are of the exact location of the water well. On the Water Well Application, the GPS coordinates are approximate coordinates since the water well has not been constructed.

22. Casings, Liners *, & Screen Information

Diam. (in)	Material, Joint Type, Slot Size	From (ft)	To (ft)

survey use only

*____

*(list reason for liner , type of upper and lower seals installed)

Reasons for the installation of a liner are: caving formation, prevent de-watering of upper aquifers, seal off undesirable water, or seal off a contaminated formation. Normally, proper sealing for caving formations and preventing de-watering of low capacity aquifers can be sealed with appropriate packers. Proper sealing for the other conditions requires pressure grout.

23. Water from ______________________________ at a depth of ________ ft. to ________ ft.

a. static water level __________ ft. below casing which is_________in. above ground

b. pumping level is________ ft. pumping ________ gpm for _____ hours

Water can be from one aquifer or multiple aquifers. The pumping level and pumping rate are the tested values. The pumping rate can be different from the quantity given in section 3. Normally, the testing of the water well is for a minimum of 1 hour.

24.

Earth Material Passed Through	From (ft)	To (ft)

(Continue on 2nd sheet, if necessary)

(If DRY HOLE, fill out log & indicate how hole was sealed)

**When filling out the formation log, use color and texture of the material to describe the formation. See Appendix W2 for a chart to assist in identification of material.*

____ ____________________

25. Licensed Water Well Contractor Signature License Number

**The licensed water well contractor is the person who contracted for the water well work. This name must be the same as the name of the licensed water well contractor who signed the water well application.*

With the submission of the completed Water Well Construction Report, the licensed contractor has completed the last phase of a normal water well system construction process.

If the licensed contractor was granted a variance for the construction of the water well, the licensed contractor is responsible for obtaining 2 water samples. The 1st sample must be submitted within 30 days after the permanent pumping system is installed and operated. The 2nd sample must be submitted after 30 days after the permanent pumping system is installed and operated but before 60 days after the permanent pumping system is installed and operated. These water samples are the responsibility of the licensed water well contractor who has submitted the variance request.

Note: If printing the water well completion report using a computer, print and submit 3 completed copies to the department.

DESIGN OF WATER WELL PUMPING SYSTEM

DETERMING THE WATER USAGE

The water usage demand should be determined for: 1) maximum water peak flow rate, 2) maximum water usage within one hour, and 3) total water usage within a twenty-four hour period.

The water usage demand can vary significantly for a domestic situation. For the basic domestic requirement, a pumping system with a nominal flow rate of ten gallons per minute (gpm) is normally sufficient. A higher flow rate can be required for an automatic underground sprinkler system, a whirl-pool type tub, and body showers which can have flow rates of 20 gpm or greater. The flow rate requirements for commercial and industrial applications are normally specified by the design engineer.

Whether a home has one, two, or three bathrooms or whether there are two, three, four or five residents, the water usage demand is fairly consistent for the home. The peak demands are normally an hour in the morning and an hour in the evening. There are several possible scenarios but the normal house water usage demands will be met with a water system that produces in the 10 – 12 gpm range. Even when another bathroom and another person are added to the home, people's schedules are such that 10 – 12 gpm remains a viable water flow rate. But when a high flow shower head is installed, the impact is significant. A high flow shower head can require 16 – 20 gpm flow rate. Normally, an underground sprinkler system is operated at night when there is minimal water usage. The sprinkler system is zoned and the zone sized to the available water supply rate. The flow rate for a zone can vary from 12 – 20 gpm. The entire sprinkling cycle can extend for 2 – 3 hours.

The morning and evening one hour periods are when the most water is used. Under normal conditions, the morning hour water usage could be between 170 – 300 gallons. The evening hour water usage could be up to 120 gallons. A sprinkler system could have a usage of 2,200 gallons. Thus, the daily water usage for a home could vary between 300 gallons to 2,800 gallons.

Since the maximum water gpm demand could vary between 10 to 30 gpm or greater and the maximum water usage could vary between 300 to 2,800 gallons or greater, it is advisable that the pump contractor discuss with the homeowner the possible water usage scenarios so that a properly sized pumping system can be designed and installed.

(See Appendix P1 for detailed calculations)

DETERMINING THE OPERATION SYSTEM PRESSURE

The two criteria for determining the operating system pressure are: 1) the pressure requirement of the water devices, and 2) the pressure requirement of the distribution system.

For a majority of domestic water devices, a minimum operating pressure of 30 psig (gauge pressure) is sufficient. Some pulsating shower heads require a higher operating pressure. The most influencing factor is the preference of the homeowner. Their desire to have a “full force” shower requires higher operating pressures. If the pressure regulating control is located a significant distance from the water device, the operating pressure has to be higher. The distance can be a lateral distance or a difference in elevation. If the plumbing distribution system has restrictions or is undersized, the operating pressure has to be higher.

Most modern domestic water usage devices will function with a minimum of 30 psig system pressure. When the minimum system pressure is raised to 40 psig, the performance is greatly enhanced. The pressure increase is most noticeable for the homeowner in the showers. Presently, two types of pressure systems are available for the home. One uses a pressure tank with sufficient storage so that the water pump will cycle within the limits of the motor manufacturer when operating with a pressure switch with a 20 psig pressure differential. The second uses a pressure sensor to vary the speed of the pump motor to maintain a preset pressure setting. In this latter system, a small captive air pressure tank that has a size between 2 to 4 gallons is used.

When the pressure tank is located in the basement of the house and a shower is on the second floor, there can be a 10 psig drop due to the elevation. If the shower has a ¾” copper pipe feed from the basement, for a low flow shower head, the pressure drop is less than ½ psig. But for a high flow shower head, the pressure drop could be over 15 psig. Since the overall pressure drop in the water distribution system of the house could be 25 psig or more, it is advisable for the pump contractor to review the plumbing distribution system to understand the potential pressure drops.

(See Appendix P2 for detailed calculations)

DETERMINING THE YIELD OF THE WATER WELL

The critical factor for the design of the water well pumping system is the water well. If the water well’s production capacity meets or exceeds the maximum peak usage rate, the pumping system is designed to meet the maximum peak usage rate. If the water well’s production capacity is less than the maximum peak usage rate, the pumping system is designed so that maximum water can be obtained from the water well without over pumping the water well and storage capacity is added to provide the additional water required in peak demand periods.

Factors required to determine the capacity of the water well are: 1) static water level, 2) working level, 3) depth of water well, 4) diameter of water well, 5) depth to the top of the producing aquifer, 6) depth to the bottom of the producing aquifer; and 7) specific capacity of the water well.

Static water level is the stabilized depth to the water from ground level after the water well has completely recovered from any previous withdrawal.

Working level is the stabilized depth to the water from ground level at a specified continuous withdrawal rate.

Specific capacity of the water well is the yield of the water well per foot of draw down. Normally specific capacity is expressed as the gallons per minute per foot of draw down.

Calculations using specific capacity are based upon the assumption that the water producing aquifer has uniform yield over the depth of the aquifer. This is usually true for sand & gravel aquifers. When an aquifer contains a crevice which produces a significant water yield, the specific capacity calculations are flawed. Limestone aquifers can contain crevices which produce significant water yields.

The parameters for determining the capacity of the water well can be obtained from: 1) the water well contractor who constructed the water well, 2) the water well construction report, or 3) from performing a pumping test on the water well.

(See Appendix P3 for detailed calculations)

WATER WELL PUMP APPLICATION

It is the Licensed Pump Installation Contractor’s responsibility to complete the Water Well Pump Information section on the Water Well Application and sign the application where indicated. This information is required to comply with Section 415 ILCS 35/6 Rules and regulations (b) of the Illinois Water Well Pump Installation Code.

WATER WELL PUMP INFORMATION

Pump Type ______________ Capacity ________ gpm Storage/pump cycle __________ gallons

(Pump type in most cases is submersible. Capacity is the nominal rating, i.e. 10 gpm, 18 gpm. Storage/pump cycle is 1 or 2 times nominal capacity or enter constant pressure.)

Licensed Water Well Pump Installation Contractor

____ ____________________

Name of Licensed Water Well Pump Installation Contractor License #

____ ____________________

Address City, State, Zip Code

__________________________/__________________________/__________________

Office Phone Fax Cell Phone

____ ________________

Signature Licensed Water Well Pump Installer/Property Owner Date

SELECTING THE SUBMERSIBLE PUMPING SYSTEM FOR A PRESSURE CYCLE SYSTEM

The pumping unit is determined from the Pump Manufacturers' published pump performance chart using the capacity and total dynamic head (TDH) required for the water well system. The minimum performance of the pumping unit selected will normally provide the maximum peak usage rate at the maximum TDH. The maximum TDH is the maximum operating pressure, converted to feet, plus the friction loss of the water well pumping system plus the depth from the pressure control device to the working level.

The maximum operating pressure is converted from psi to feet (head) by multiplying with the conversion factor of 2.31. The maximum operating pressure of 60 psig equals:

60 psi multiplied by 2.31 ft per psi = 138.6 ft (head)

The friction loss of the water well pumping system is calculated using the total effective length of the drop pipe, the diameter of the drop pipe, the maximum water gpm pumped, and the total effective length of the offset piping. The total effective length of the drop pipe or offset piping is the length of the piping plus the equivalent length of fittings. The length of drop pipe is the actual amount of piping installed, which will always be greater than the working level.

(See Appendix P4 for detailed calculations)

The size of the submersible cable is determined from the Pump Motor Manufacturers' published cable charts. The wire size depends upon: 1) the size of the submersible motor, 2) the operating voltage of the submersible motor, and 3) the distance from the main electrical disconnect to the submersible motor. To calculate the submersible cable size, the size and length of wire installed from the main disconnect to the pump control must be determined. This wire is installed by an electrical contractor.

(See Appendix P5 for detailed calculations)

The piping is sized for acceptable friction losses. The pipe is sized to limit the speed of the water in the pipe to less than 10 ft per sec. because the slower speed is equated to less friction loss and less water hammer. A significant reduction in friction loss can result in the use of a smaller horsepower pumping unit.

The parameters for determining the pitless adapter are: 1) the weight of the pumping system which will be supported by the pitless adapter, 2) the size of the drop pipe, and 3) the weight bearing capacity of the water well casing.

The most critical parameter is the weight bearing capacity of the water well casing. PVC water well casing has limited weight bearing capacity for the "through-the-casing" type pitless adapters. The manufacturer recommends a maximum weight of 500 # to be suspended on a "through-the-casing" adapter for SDR 21 water well casing. The weight bearing capacity of steel water well casing is normally significantly large enough not to be a factor.

The parameters for determining the size of the water storage tank are: 1) the horsepower of the submersible pumping unit, 2) the pressure cycle of the pumping system, 3) the pumping capacity of the pumping unit, 4) the anticipated water usage rate, and 5) the yield of the water well.

The horsepower of the submersible pumping unit is the factor that determines the allowable number of pump starts for a set period of time. A submersible motor should run a minimum time to dissipate the heat generated from the starting current. Under normal household water usage, pumps smaller than one horsepower should run a minimum of 1 minute and be off a minimum of 1 minute. That equates to 30 cycles in a one hour period. Pumps one horsepower and larger should run for 2 minutes and be off for 2 minutes. That equates to 15 cycles in a one hour period. The fewer the number of starts, the longer the submersible pumping unit lasts.

The pressure cycle of the pumping system determines the useable stored water per cycle. Normally, a pressure cycle operates with a 20 psi difference in the turn-on pressure and the turn-off pressure. The higher the turn-on pressure, the lower the amount of useable water storage for a water storage tank of a specific volume.

The pumping capacity determines the volume of the water storage tank.

The anticipated water usage rate determines the cycle time.

The yield of the water well determines whether additional water storage is required.

(See Appendix P6 for detailed calculations for tank sizing)

(See Appendix P7 for detailed calculations when water well yield is less than demand)

(See Appendix P8 for detailed calculations for 3-phase systems)

SELECTING THE PUMPING SYSTEM FOR A CONSTANT PRESSURE SYSTEM

The water well yield has to meet or exceed the maximum peak usage rate of the water well pumping system. If the water well can not produce the maximum peak usage rate, the constant pressure pumping system should not be used. However there can be situations when the maximum peak usage rate exceeds the yield of the water well, and a constant pressure pumping system can be used. If the maximum peak usage rate is for a short time period and the water well yield plus the water storage capacity of the water well exceeds the maximum peak usage volume, a constant pressure pumping system is a viable option.

The advantages of the constant pressure pumping system are:

1 The 20 psi pressure cycle is eliminated. The noticeable water pressure variation from the pressure cycle does not happen. For the three story home with the shower on the 3rd floor, the constant water pressure positively impacts the home owner.
2 Soft start eliminates the starting torque and in-rush current to the pump motor upon start up. With no starting torque, larger size pumps can use PVC drop pipe. With no in-rush current, there is no heat to dissipate upon start up.
3 Soft stop eliminates water hammer.

The sizing of the pumping system components uses the same procedures as used with the sizing of pumping system components for a pressure cycle system detailed above. Normally the wire size will be smaller since the power transmitted to the constant pressure pump is 3 phase. And the tank size will be considerably smaller, a nominal 2 or 4 gallon tank.

The installation of the pumping system components in the water well is the same as a normal pumping system installation except that torque stops are not required. Centering devices are still recommended on the drop pipe.

The pressure sensing device, the transducer or Franklin switch, is installed in the water system piping near the control. The desired system pressure is set, the tank pre-charged and the pumping system is energized. The water well pumping system is operational.

AFTER THE PUMPING SYSTEM IS INSTALLED

It is the responsibility of the licensed pump installation contractor to disinfect the water well system after the installation of the pumping system. When a pumping system is replaced, the disinfection procedure is normally completed before the crew leaves the job site.

For the pump installation for new construction, the pump installation contractor should establish his contractual obligation for disinfecting the water well system. The pump installation contractor is NOT responsible for the disinfection of the water well or the plumbing system. When the pump installation contractor has a relationship with the water well contractor, the disinfection of the water well system is a cooperative effort.

When the pump installation contractor is independent of the water well contractor, the pump installation contractor has to clearly state to the owner that he, the pump installation contractor, is not responsible for disinfecting the water well or for the integrity of the water well. Procedures should be established in the event a "good" water test can not be obtained from the water well system.

The pump installation contractor is not responsible for the disinfection of the plumbing system. It is good practice for the pump installation contractor to test a water sample from the sampling tap. When the situation occurs that the water sample from the plumbing system is "bad", the contractor will have a test result verifying that the water well system has produced a "good" sample. Normally, the owner looks to the pump installation contractor for providing a "good" sample. The contractor can demonstrate that the water well system is OK but that the plumber has not disinfected the plumbing system. Then the pump installation contractor can contract with the homeowner for the disinfection of the plumbing system.

The pump installation contractor should inform the owner that the water well system requires periodic maintenance and water sample testing. The pump installation contractor should inform the owner of a time table for action, or contract with the owner to provide timely service.

WATER WELL PUMP COMPLETION FORM

After a water well pumping system has been installed in a new water system, the licensed pump installation contractor can use one of 2 forms.

1st Form:
This form is contained in the Water Well Completion Report in sections 4 to 12. If the licensed water well pump installation contractor has access to the Water Well Completion Report, he can complete sections 4 through 12.

4. Date Permanent Pump Installed ____________________
5. Pump Capacity ______ gpm Set at (depth) ___________ ft
6. Pitless Adapter Model & Manufacturer: ______________________________
   Attachment to Casing: [ ] Threaded [ ] Welded [ ] Compression
7. Well Cap Type & Manufacturer: ______________________________
8. Pressure Tank: Working Cycle _______ gals. Captive Air: [ ] Yes [ ] No
9. Pump System Disinfected: [ ] Yes [ ] No

   **It is the responsibility of the licensed pump installer to disinfect the pumping system. This should always be checked yes. The sampling tap, required by Code, near the tank will produce a sample that will verify if the pump installer has disinfected the pumping system. If the sampling tap produces a good water test and a bad sample comes from the household faucet, the plumbing system is defective. Neither the licensed water well contractor nor the licensed pump installer is responsible for the plumbing system.*

10. Name of Pump Company ______________________________________
11. Pump Installer: ________________________ License # ___________________
12. ______________________________________ License # ___________________

   Licensed Pump Contractor Signature

   **The pump installer can be a person working under the direct and personal supervision of the licensed pump installation contractor. If this is the case, the person's name should be entered to establish work experience for when the individual would want to be licensed. If the pump installer is licensed, enter the license number of the pump installer. The Licensed Pump Contractor Signature name must be the same as the name of the licensed pump installation contractor who signed the pump section on the water well application.*

2nd Form:
If the licensed contractor can not access the Water Well Completion Report, the licensed contractor is required to complete the Installation Report for Water Well Pump. This report can be used for new construction or for replacement work.

The form is required for replacement work when:

1. the size of the pumping unit is changed because there is a significant change in the water being used; or
2. the size of the pumping unit is changed because the depth of setting is significantly changed as a result of the performance characteristics of the water well have changed.

9/98

ILLINOIS DEPARTMENT OF PUBLIC HEALTH
Division of Environmental Health
525 W. Jefferson St.
Springfield, IL 62761

INSTALLATION REPORT FOR WATER WELL PUMPS

Type of Installation [ ] Replacement
[ ] New Construction

Date of Installation:____________________________

County:_____________________________________

Permit Number:_______________________________
(new construction only)

Owner's Name: ____

Site Address:

_____________________________________ Street Address

______________________, IL City

_______________ ZIP Code

Township Name:_________________________________

Subdivision Name:_____________________

Twp:___________ [ ] N [ ] S Range:_________ [ ] E [ ] W Section:______________

Pump Manufacturer:_____________________________________ Model:______________________________

Well Depth:_____________ Depth pump Set:_______________ Pump Capacity:__________________

Static Water Level:_________________ Pumping Level:____________________

Pitless Adapter Manufacturer:_____________________________________ Model:_______________________

How Attached to Casing? [ ] Screw On [ ] Welded [ ] Compression

Type of Well Cap:____

Tank Working Cycle:__________________________ gallons Captive Air? [ ] Yes [ ] No

Pump Equipment Disinfected? [ ] Yes [ ] No

____ Pump installation Contractor

____ License Number

Comments:____

____

cc: White Copy – Local Health Department
Yellow Copy – Contractor
Golden Copy – Homeowner

IMPORTANT NOTICE

This state agency is requesting disclosure of information that is necessary to accomplish the statutory purpose as outlined under Public Act 85-0863
Disclosure of information is mandatory. This form has been approved by the Forms Management Center.

IL 482-0125

Printed by Authority of the State of Illinois
P. O. # 539266 10M 9/98

Note: If printing the Installation Report for Water Well Pumps using a computer, print and submit 3 completed copies to the department.

Usually, the owner relates to the pump installation contractor as the person responsible for providing water. When a water problem occurs, the owner contacts the pump installation contractor. The contractor should be knowledgeable of water wells and water treatment equipment so as to provide troubleshooting and direction to the owner.

GLOSSARY OF TERMS FOR APPENDIX

For all the math functions, the following are the meanings of the signs:

+	means add the number to the left of the sign to the number to the right of the sign
-	means to subtract the number to the right of the sign from the number to the left of the sign
*	means to multiply the number to the left of the sign by the number to the right of the sign
/	means to divide the number to the left of the sign by the number to the right of the sign

Abbreviations are used as follows:

psi	means pressure per square inch
psig	means pressure per square inch as measured by a gauge
psia	means pressure per square inch as measured by a gauge plus 14.7 for atmospheric pressure which results in absolute pressure
gpm	means gallon per minute
gals	means gallons
hr	means hour
mins	means minutes

APPENDIX W1

CALCULATING AMOUNT OF GROUT REQUIRED

One 50# bag of grout mixed with 24 gallons of water yields approximately 26.6 gallons of grout.

The following chart is based on 100' depth of annular space.

Borehole diameter (inches)	Nominal Casing Diameter (in inches)				
	4	5	6	8	10
6	2.4				
7	4.4	4.0			
8	6.7	7.3	3.1		
9		11.1	5.7		
10			8.6	3.9	
11				7.1	
12				10.7	4.4
13					8.2
14					12.3

To determine the number of 50# bags of grout required for a mix of 24 gallons of water per 50# bag: 1) divide the total depth of the annular space by 100; and 2) multiply that number by the number in the chart that corresponds to the borehole diameter and the casing diameter.

EXAMPLE:

6" threaded and coupled casing is to be installed. The casing is to be grouted with a tremie pipe on the outside of the casing. The 10" diameter borehole is drilled to a depth of 180' which becomes the depth of the annular space. Dividing the total depth of the annular space, 180', by the constant 100 yields a number of 1.8. The chart indicates that for a 6" casing with a 10" diameter borehole, the factor is 8.6. Multiplying 1.8 times 8.6 results in a number of 15.5. A minimum of 15.5 bags of grout are required to fill this annular space.

bags = 180'/100' * 8.6 = 15.5

20% extra grout should be available. Therefore, the total number of bags that should be on the job site is 18.6, rounded up to 19.

Total # of bags = 15.5 * (1+ 20%) = 15.5 * 1.2 = 18.6

APPENDIX W2

CONSTRUCTION LOG DESCRIPTIONS

Field Guide for Logging Water-Well Boreholes

Thomas M. Hanna, 2004

Descriptor	Log Entry	Field Test / Definition
Aquifer / Formation Name	Aquifer / Formation Name	Published name of aquifer / formation
Aquifer / Formation Category	Unconsolidated	Alluvial / unconsolidated materials (e.g., glacial, fluvial, soils, etc.)
	Bedrock	Bedrock / consolidated materials
Alluvial / Unconsolidated Type	Clay	Can be rolled into a rope 1/4 in diameter
	Silt	Can not be rolled into a rope
	Sand with Clay / Silt	20% of formation is clay/silt
	Sand, fine-med	Fine (<0.5mm-2mm)
	Sand, med-coarse	Medium - Coarse (2.2-5mm)
	Sand and Gravel	20% or more of formation is sand Fine (5-19mm), Coarse (19-75mm)
	Gravel	
Bedrock Type	Siltstone/Shale	Consolidated Formations/Bedrock
	Sandstone	
	Limestone	
	Conglomerate	
	Coal	
	Granite	
	Volcanic	
	Basalt	
	Other	
Hardness	Very hard	Difficult to break with hammer
	Hard	Easy to break with Hammer / >30 blows/ft
	Dense / Stiff	Can break in hand / 10-30 blows/ft
	Loose	Unconsolidated / < 10 blows/ft
Color	Moderate red	Color of washed samples
	Dark yellowish orange	
	Yellowish gray (tan)	
	Light grey	
	Pale blue	
	Greyish green	
	Dark grey	
Water Content	Dry	Moisture absent
	Moist	Damp no visible water
	Wet	Visible water
	High production	Fracture or zone of significant production
	Lost circulation	Significant loss of drilling fluids
Other	Other information	Any comments on drilling conditions or hydrogeology

Logging Procedure

1 Depth interval on log for the sample description.
2 Formation or aquifer name.
3 Alluvial/unconsolidated formation or bedrock formation.
4 Alluvial or bedrock type. If rock type is not present, select other type.
5 Rock hardness based on description. Typically unconsolidated alluvial formations are loose.
6 Color of washed samples.
7 Information for moisture content, fractures and water bearing zones.
8 Any other comments.

Example of Water-Well Borehole Log

Depth (from/ to in ft)	Formation /Aquifer	Bedrock / Unconsolidated	Type	Hardness	Color	Water Content	Other
0 - 20		Unconsolidated	Sand with Clay/Slit	Loose	Light grey	Dry	Poorly sorted
20 - 40	Denver	Bedrock	Sandstone	Dense/Stiff	Yellowish grey	Wet	Carbonate cement

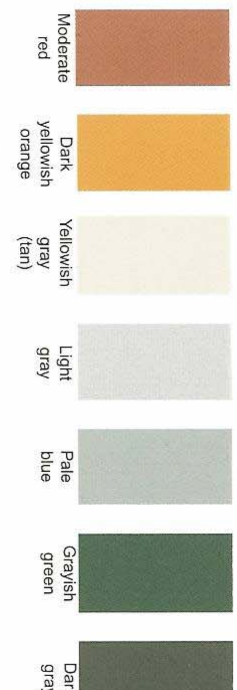
Classification of Granular Materials and Approximate Slot Size for Naturally Developed Wells

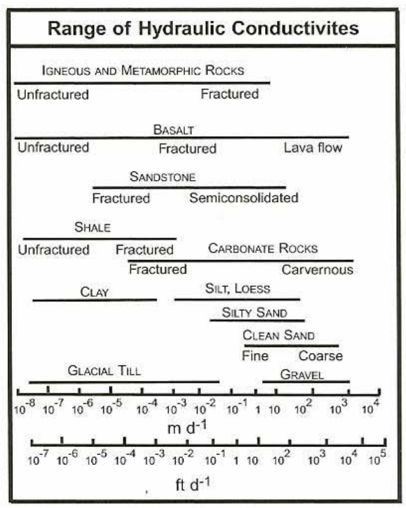
Name	Millimeters	Inches	Sieve Size	Slot Size (inches)	Slot Size (mm)
Boulders	>300	>11.8	>12"	>0.100	>2.5
Cobbles	300 - 75	11.8 - 2.9	12" - 3"	>0.100	>2.5
Gravel - coarse	75 -19	2.9 - 0.075	3" - 3/4"	>0.100	>2.5
Gravel - fine	19 - 4.8	0.075 - 0.19	3/4" - 4	>0.100	>2.5
Sand - coarse	4.8 - 2.0	0.19 - 0.08	4 - 10	0.100	2.5
Sand - coarse to med	3.3 - 1.8	0.13 - 0.07	6 - 12	0.090	2.3
Sand - medium	2.2 - 1.3	0.09 - 0.05	8 - 16	0.070	1.8
Sand - medium	1.8 - 1.0	0.07 - 0.04	12 - 20	0.050	1.3
Sand - medium	1.3 - 0.5	0.05 - 0.02	16 - 30	0.030	0.8
Sand - fine	0.5 - 0.2	0.02 - 0.008	30 - 70	0.015	0.4
Sand - fine	0.2 - 0.08	0.008 - 0.003	30 - 200	0.007	0.2
Slits and Clays	<0.08	<0.003	<200	NA	NA

Grain size classification is based on USCS and slot selection is based on well construction using natural development and average grain sizes.

Sand / Slot Size Gauge

Gauge	Name	Natural Development Slot		Filter Pack	Filter Pack Slot	
		Inches	mm	sieve	Inches	mm
	Gravel	0.125	3.2	3/8" - 3/4"	0.250	6.4
	Sand - Coarse	0.100	2.5	4 - 3/8"	0.160	4.0
	Sand - Coarse	0.080	2	3 - 6	0.0120	3.0
	Sand - Medium	0.060	1.5	4 - 8	0.090	2.3
	Sand - Medium	0.040	1	6 - 12	0.070	1.8
	Sand - Fine	0.020	0.5	10 - 20	0.040	1.0
	Sand - Fine	0.007	0.2	20 - 40	0.018	0.45





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The above charts are a reproduction, not to scale, of charts provided by Thomas M. Hanna, District Manager, Johnson Screens.

Laminated charts, that are to scale, can be purchased from Johnson Screens, 1-800-833-9473, or National Ground Water Association Bookstore, 1-800-551-7379.

APPENDIX P1

WATER FLOW RATE AND USAGE AMOUNT

The following are nominal flow rates:

Reduced Flow Shower Head	3	gpm
High Flow Shower Head	16	gpm
Bathroom sink with aerator	1.5	gpm
Toilet	3	gpm
Kitchen sink with aerator	4	gpm
Clothes washer	5	gpm
Dishwasher	2	gpm

For a two and one-half bath home with 4 residents, the following are different scenarios for water usage rates:

Uses in morning:

Morning Hour Water Usage Rate #1

2	low flow showers	6	gpm
1	toilet flush	3	gpm
1	bathroom sink	1.5	gpm
	Peak water usage rate	10.5	gpm

Morning Hour Water Usage Rate #2

1	low flow shower	3	gpm
1	toilet flush	3	gpm
1	bathroom sink	1.5	gpm
1	kitchen sink	4	gpm
	Peak water usage rate	11.5	gpm

Morning Hour Water Usage Rate #3

1	high flow shower	16	gpm
1	toilet flush	3	gpm
1	bathroom sink	1.5	gpm
1	kitchen sink	4	gpm
	Peak water usage rate	24.5	gpm

Use in the evening:

	Evening Hour Water Usage Rate		
1	kitchen sink	4	gpm
1	toilet flush	3	gpm
1	clothes washer	5	gpm
	Peak water usage rate	12	gpm

For normal usage in a home, 10 to12 gpm is a sufficient supply rate. A high flow shower can increase the demand usage rate to 25 gpm or more.

The morning and evening hour are when the most water is used. Under normal conditions, the amount of the water used:

shower low flow	15	gals
shower teenager low flow	45	gals
shower high flow	80	gals
toilet	5	gals
bathroom sink	2	gals
kitchen sink	20	gals
clothes washer	35	gals
dishwasher	15	gals

For a family of 4 during the morning hour the amount of water used:

	Morning hour water usage with low flow showers		
2	showers	30	gals
2	showers teenagers	90	gals
4	toilet flushes	20	gals
4	bathroom sinks	8	gals
1	kitchen sinks	20	gals
	Water usage	168	gals

If 2 showers are taken with a 16 gpm high flow head:

	Morning hour water usage with high flow showers		
2	showers high flow	160	gals
2	showers teenagers	90	gals
4	toilet flushes	20	gals
4	bathroom sinks	8	gals
1	kitchen sinks	20	gals
	Water usage	298	gals

The morning hour water usage could be between 170 to 300 gallons.

For a family of 4 during the evening hour the amount of water used:

	Evening hour water usage		
4	toilet flushes	20	gals
4	bathroom sinks	8	gals
1	kitchen sink	20	gals
1	dishwasher	15	gals
2	clothes washer	70	gals
	Water usage	133	gals

The evening hour water usage could be 133 gallons.

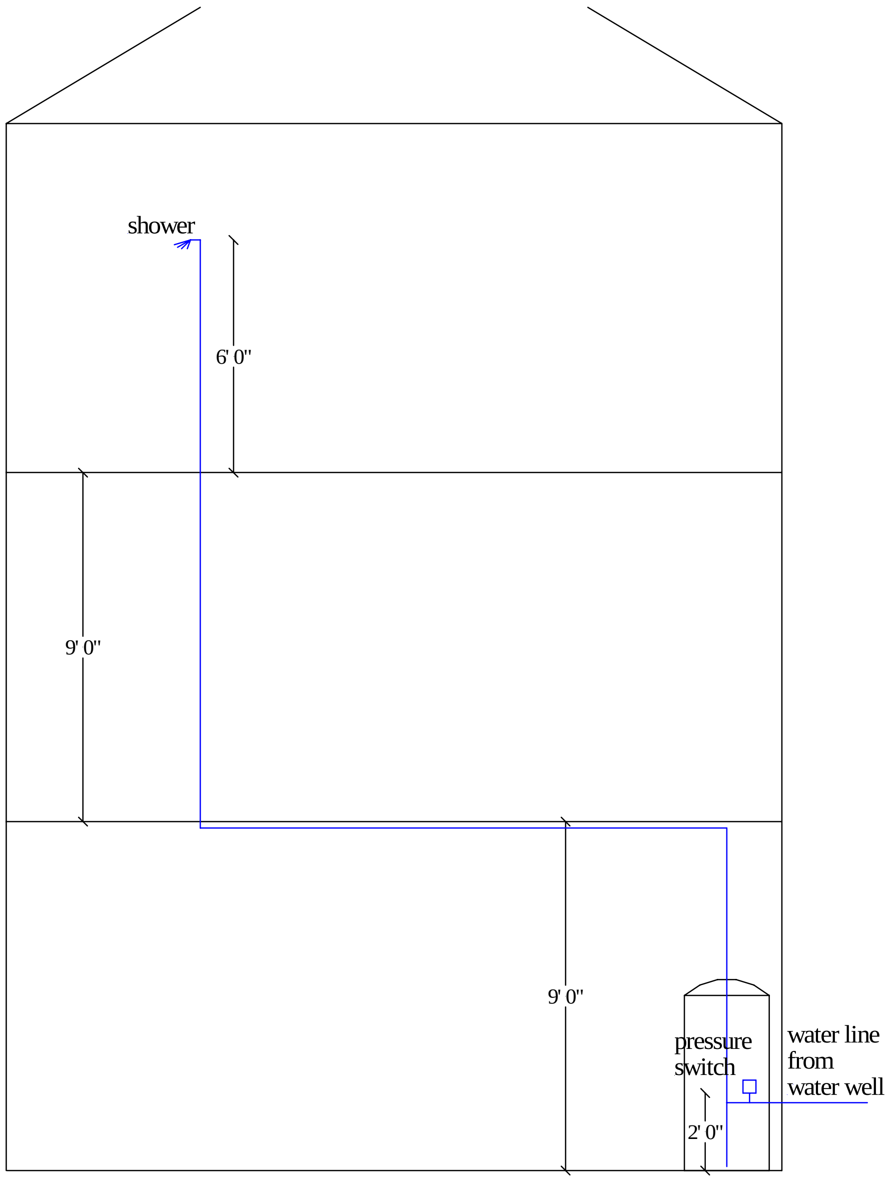
A lawn sprinkler system is zoned. If each zone is 12 gpm and set to run for an elapsed time of 15 minutes, the water usage per zone would be 180 gallons. If there are 12 zones, the water used is 2,160 gallons over 3 hours.

Allowing for periodic water usage during the day, the daily usage for a home could vary between 300 gallons to 2,800 gallons.

APPENDIX P2

OPERATING SYSTEM PRESSURE

When the pressure tank with the pressure switch is located in the basement of the house and a shower is on the second floor, there can be a 10 psi drop due to the elevation.



The vertical distances are:

Basement floor to 1st floor	9	ft
1st floor to 2nd floor	9	ft
2nd floor to shower head	6	ft
Overall height	24	ft

The height of the pressure switch above the Basement Floor is 2 ft.

The actual vertical height is 22 ft which equates to a pressure drop of:

Pressure drop (psi)	=	22	ft	*	0.433	psi/ft
Pressure drop (psi)	=	9.5	psi			

If the shower has a ¾" copper pipe feed from the basement, for a low flow shower head with a flow rate of 3 gpm, the pressure drop is a result of friction loss.

@ the flow rate of 3 gpm the friction loss factor is 2.6 ft per 100' of pipe

The overall length of ¾" pipe from tank shut off valve to shower head is:

	Vertical lengths		
	tank shut off valve to 1st floor	5	ft
	1st floor to 2nd floor	9	ft
	2nd floor to shower head	6	ft
	Horizontal length	23	ft
	Equivalent length per fitting		
6	elbows	18	ft
1	ball valve	3	ft
	total effective length	64	ft

The friction loss = total effective length multiplied by the friction loss factor.

friction loss	=	64	ft	*	2.6	ft/100' of pipe
friction loss	=	1.7	ft			
friction loss	=	1.7	ft	*	0.433	psi/ft (changing ft to psi)
friction loss	=	0.7	psi			

For the low flow shower head, the pressure loss is a little less than 1 psi.

The total pressure drop is the sum of the vertical pressure drop plus the friction loss.

total pressure drop	=	vertical pressure drop		+	friction loss	
total pressure drop	=	9.5	psi	+	0.7	psi
total pressure drop	=	10.2	psi			

The total pressure drop equals a little over 10 psi drop.

For a water well system operating on a 40 to 60 psi cycle, the shower will operate with a high pressure of 50 psi and low of 30 psi.

But for a high flow shower head with the ¾" copper piping, the pressure drop just due to friction loss could be over 15 psi.

@ flow rate of 16 gpm , the friction loss factor is 56.6 ft per 100' pipe.

friction loss	=	64	ft	*	56.6	ft per 100' of pipe
friction loss	=	36.2	ft	*	0.433	psi per ft
friction loss	=	15.7	psi			

For this high flow shower head, the pressure loss is almost 16 psi.

The total pressure drop equals almost 26 psi drop. This is the sum of the vertical pressure drop, 10.2 psi, plus the actual friction loss, 15.7 psi.

For a water well system operating on a 40 to 60 psi cycle, the shower will operate with a high pressure of 34 psi and low of 14 psi.

If the pipe feed to the shower is 1" copper piping, the friction loss factor = 16.2 ft per 100' of pipe.

friction loss	=	64	ft	x	16.2	ft per 100' of pipe
friction loss	=	10.4	ft	x	0.433	psi per ft
friction loss	=	4.5	psi			

With the increase in piping from ¾" to 1", the friction loss is reduced from a 15.7 psi drop to a 4.5 psi drop. This is over a 70% reduction in friction loss.

APPENDIX P3

DETERMINING THE YIELD OF THE WATER WELL

Factors required to determine the capacity are: 1) static water level, 2) pumping level, 3) depth of the water well, 4) diameter of the water well, 5) depth to the top of the producing aquifer, 6) depth to the bottom of the producing aquifer and 7) specific capacity of the water well.

Static water level is the stabilized depth to the water from ground level after the water well has completely recovered from any previous withdrawal.

Pumping level is the stabilized depth to the water from ground level at a specified continuous withdrawal rate.

Specific capacity of the water well is the yield of the water well per foot of draw down. Specific capacity is usually expressed as gallons per minute per foot of draw down.

Water Well # 1 is constructed.
The following information is obtained from the Water Well Construction Report:

Water Well depth	300	ft			
Depth 6" casing	180	ft			
Top Aquifer	180	ft			
Bottom Aquifer	290	ft			
Static water level	100	ft			
Test Pump Level	150	ft	@	25	gpm

Determining Specific Capacity for a water producing aquifer that has uniform yield over the depth of the aquifer:

Drawdown	=	pumping level	-	static water level
		150 ft	-	100 ft
Drawdown	=	50 ft		

Specific capacity	=	test pump rate	/	drawdown
		25 gpm	/	50 ft
Specific capacity	=	0.5 gpm/ft		

The Specific Capacity for this water well is 0.5 gpm per ft. Therefore, for every foot of drawdown, this water well will produce 0.5 gpm.

Calculations using specific capacity are based upon the assumption that the water producing aquifer has uniform yield over the depth of the aquifer. This is usually true for sand & gravel aquifers. For a water well completed in a limestone formation with just a few crevices producing the water, the specific capacity is valid above the crevices. When an aquifer contains a crevice which produces a significant water yield, the specific capacity calculations are flawed. Whenever the water well is to be pumped at a rate significantly higher than the test pumped rate, it is recommended to conduct an actual pumping test at the proposed pumping rate.

For the water well described in Case # 1, additional information about the aquifer would be required to determine capacity of the water well below the casing. In this case, the additional information is that the aquifer uniformly produces water over the entire depth of the aquifer.

The maximum yield of the water well can be calculated using the specific capacity.

The maximum drawdown level is the depth of the bottom of the producing aquifer.

maximum drawdown	=	bottom depth aquifer		-	static water level	
		290	ft	-	100	ft
maximum drawdown	=	190	ft			

maximum yield	=	specific capacity		*	maximum drawdown	
		0.5	gpm per ft	*	190	ft
maximum yield	=	95	gpm			

If this water well were to be pumped at a rate of 60 gpm,

the pumping level at 60 gpm is:

proposed pump rate		60	gpm			
drawdown	=	pump rate		/	specific capacity	
		60	gpm	/	0.5	gpm per ft
drawdown	=	120	ft			

pump level	=	static water level		+	drawdown	
		100	ft	+	120	ft
pump level	=	220	ft			

APPENDIX P4

SELECTING THE SUBMERSIBLE PUMPING SYSTEM

The required performance of the submersible pumping unit is based on 2 criteria:

1. The maximum water usage rate
2. The Total Dynamic Head (TDH)

The water well constructed is water well # 1 as described in Appendix P3. The home has one shower with a high flow shower head of 16 gpm.

The maximum water usage rate is 24.5 gpm.

The TDH is the sum of 3 factors:

1. The maximum system pressure expressed in feet
2. The pumping level at maximum water usage rate (measured from pressure switch elevation)
3. The friction loss in the water well system's piping (expressed in feet)

The water well pumping system will operate at 50 to 70 psi pressure system.

maximum system pressure	=	70	psi	*	2.31	ft per psi
maximum system pressure	=	162	ft			

The ground level at the well head is at the same elevation as the pressure switch. The pumping level at maximum water usage rate is calculated using specific capacity:

maximum drawdown =	maximum pumping rate		/	specific capacity	
	24.5	gpm	/	0.5	gpm per ft
maximum drawdown =	49	ft			

pumping level	=	static water level		+	maximum drawdown		+	well head to pressure switch elevation
		100	ft	+	49	ft	+	0
pumping level	=	149	ft					

The water system piping is the piping from the pressure switch to the well head, the pitless adaptor, and the drop pipe.

The water well is located 24’ from the pressure switch. The piping from the pressure switch to the well head is called the offset piping. The piping from the pressure switch to the well head and the pitless adapter will be the same diameter as the drop pipe.

The pump setting depth is calculated using the pumping level plus the submergence depth.

The submergence depth is the depth the inlet of the pumping unit is set below the pumping level. This accounts for seasonal water level variations and provides sufficient head to prevent cavitation. For this situation, the submergence depth should be a minimum of 30’ below the pumping level.

pump setting depth =	pumping level	+	submergence depth
	149 ft	+	30 ft
pump setting depth =	179 ft		

A length of PVC drop pipe is 20’ long. The pitless depth is 5’ below ground level. 9 joints of drop pipe plus the pitless depth equals a pump setting depth that is slightly more than the pumping level plus submergence depth.

pump setting depth =	drop pipe length	+	pitless adapter depth		
	9 lengths	*	20 ft	+	5 ft
pump setting depth =	185 ft				

The water system piping is:

water system piping = 180 ft drop pipe + 24 ft offset pipe + pitless adapter

Pipe Friction Loss = Effective Length of Pipe * Friction Loss Factor

Effective Length of Pipe = length of drop pipe + length offset pipe + equivalent length of pitless

Friction Loss Factor and Equivalent Length of Fittings are obtained from published charts.

The equivalent length for a fitting means the length, in feet, of same size pipe that the fitting will have on friction loss. For a 1” pitless, the equivalent length of 1” pipe is 3’ and for a 1 ¼” pitless, the equivalent length of 1 ¼” pipe is 4’.

effective length of 1" piping	=	180 ft	+	24 ft	+	3 ft	=	207 ft
effective length of $1^1/_4$" piping	=	180 ft	+	24 ft	+	4 ft	=	208 ft

An example of a Friction Loss Factor Chart is shown below. The factor is calculated on the length of pipe being 100'.

Friction Loss Factor

GPM	1" PVC	GPM	$1^1/_4$" PVC
24	31.9	20	6.0
26	36.9	25	9.1

When a flow rate is between the flow rates identified on the Friction Loss Chart, the acceptable method to determine the Friction Loss Factor (FLF) is to calculate the average for the value.

At a flow rate of 24.5 gpm, the Friction Factor for 1" pipe is:

FLF(24.5)=	32	ft	+ (	37	ft	-	32	ft	) /	2	gpm	*	0.5	gpm
	32	ft	+	2.5	ft/gpm	*	0.5	gpm						
	32	ft	+	1.25	ft									
FLF(24.5)=	33.25	ft												

The Friction Loss Factor for a flow rate of 24.5 gpm in 1" PVC pipe is 33.2' per 100' of pipe.

Pipe Friction Loss =	Effective Length of Pipe		*	Friction Loss Factor				
	207	ft	*	33.2	ft	/	100	ft
	207	ft	*	0.33				
Pipe Friction Loss =	69	ft						

When the water system has 1" piping :

TDH =	Pumping Level		+	Maximum System Pressure		+	Pipe Friction Loss	
	149	ft	+	162	ft	+	69	ft
TDH =	380	ft						

At a flow rate of 24.5 gpm, the Velocity of the water in the 1" pipe is:

Velocity =	Flow Rate		/	Cross Sectional Area of Pipe	
	24.5	gpm	/	0.7854	in^2
	31.2	gpm/in^2			
Velocity =	10.0	ft/sec			

At a flow rate of 24.5 gpm, the Friction Factor for 1 ¼” pipe is:

FLF(24.5)=	6.0	ft	+ (	9.1	ft	-	6	ft	) /	5	gpm	*	4.5	gpm
	6	ft	+	0.62	ft/gpm	*	4.5	gpm						
	6	ft	+	2.8	ft									
FLF(24.5)=	8.8	ft												

The Friction Loss Factor for a flow rate of 24.5 gpm in 1 ¼” PVC pipe is 8.8’ per 100’ of pipe.

Pipe Friction Loss =	Effective Length of Pipe		*	Friction Loss Factor				
	208	ft	*	8.8	ft	/	100	ft
	208	ft	*	0.088				
Pipe Friction Loss =	19	ft						

When the water system has 1 ¼” piping:

TDH =	Pumping Level		+	Maximum System Pressure		+	Pipe Friction Loss	
	149	ft	+	162	ft	+	19	ft
TDH =	330	ft						

At a flow rate of 24.5 gpm, the Velocity of the water in the 1 ¼” pipe is:

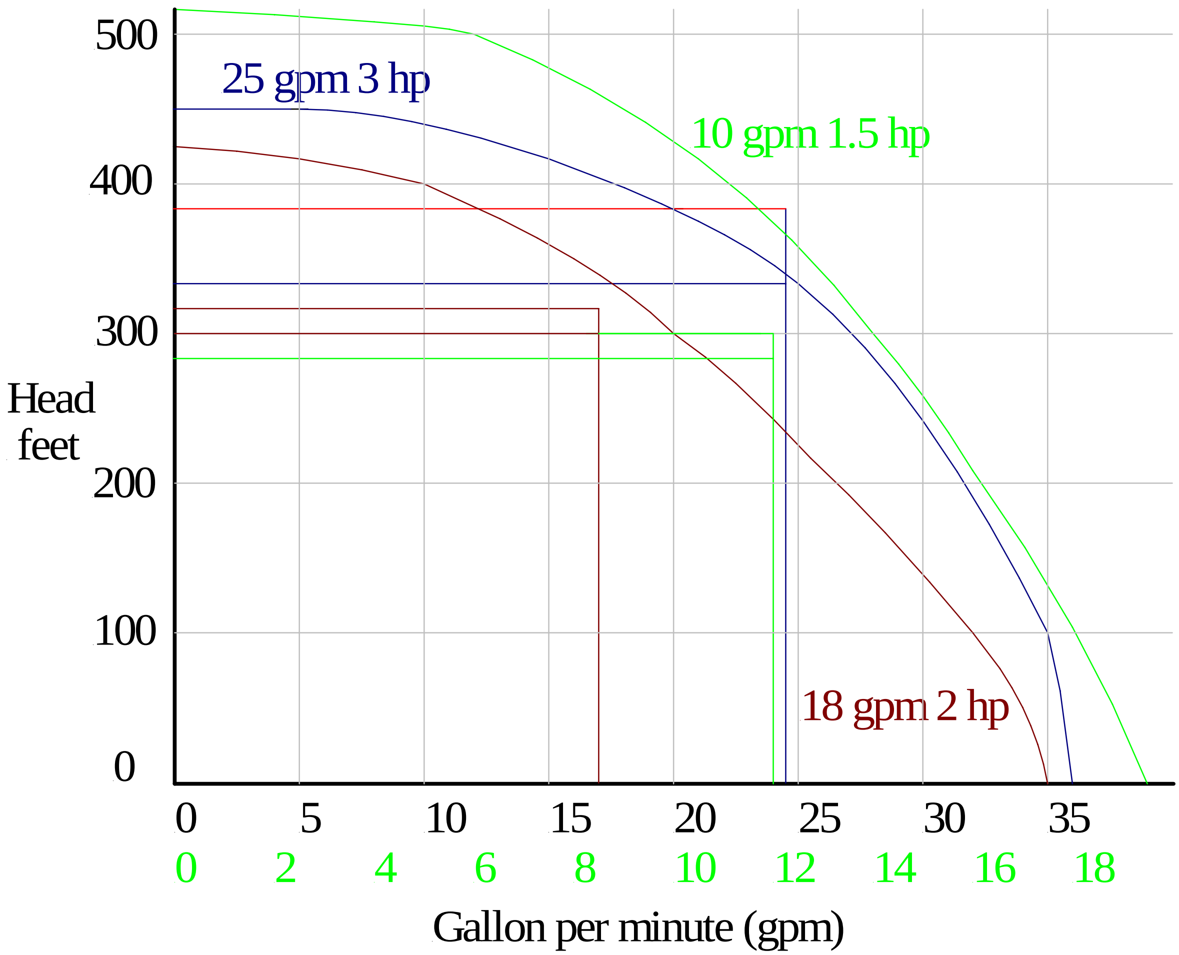
Velocity =	Flow Rate		/	Cross Sectional Area of Pipe	
	24.5	gpm	/	1.22718	in^2
	20.0	gpm/in^2			
Velocity =	6.4	ft/sec			

The pump performance required for the water system is:

For 1” drop pipe: 24.5 gpm @ 380’ TDH

For 1 ¼” drop pipe: 24.5 gpm @ 330’ TDH

The following is a typical pump chart for a 3 hp 25 gpm (blue), 2 hp 18 gpm (dark red), and 1.5 hp 10 gpm (green) submersible pumps:



From the above pump chart, the intersection of the 24.5 gpm line (blue) and 330' of head (blue) is below the 3hp pumping unit curve. The 3hp 25 gpm pumping unit with 1 ¼" drop pipe is a sufficient pumping unit for the water well system.

With the 1" drop pipe water well system, the TDH required is 380'. The intersection of the 380' head line (red) with the 24.5 gpm line (blue) is above the 3hp 25 gpm pumping unit curve. The performance requirement is greater than a 3 hp can provide. A 5 hp pumping unit would be required.

If the high head shower was used when there was no other water demand, the maximum water usage rate would be 16 gpm and the TDH would be 322' for 1" drop pipe and 302' for 1 ¼" drop pipe. The intersection of both the 332' head line (dark red) and the 302' head line (dark red) with the 16 gpm line (dark red) is below the 2hp 18 gpm pumping unit curve. A 2 hp 18 gpm type pumping unit would be sufficient for either case.

If the low flow shower heads were used, the maximum water usage rate would be 12 gpm and the TDH would be 301’ for 1” drop pipe and 286’ for 1 ¼” drop pipe. The intersection of both the 301’ head line (green) and the 286’ head line (green) with the 12 gpm line (green) is below the 1.5hp 10 gpm pumping unit curve. A 1.5 hp 10 gpm type pumping unit would be sufficient for either case.

The different scenarios demonstrate the importance of determining the expected water usage to be able to design the proper water well system.

The above analysis is appropriate for either a constant pressure pumping system or a pressure cycle pumping system.

APPENDIX P5

DETERMING THE SIZE OF THE SUBMERSIBLE PUMP CABLE

The size of the submersible cable is determined from published cable charts. The wire size depends upon: 1) the size of the submersible motor, 2) the operating voltage of the submersible motor, and 3) the distance from the main electrical disconnect to the submersible motor. To calculate the submersible cable size, the size and length of wire installed from the main disconnect to the pump control must be determined. This wiring is installed by an electrical contractor.

For this installation # 10 wire has been installed from the main disconnect to the pump control. The length of this wire is 28'.

Below is a typical cable chart for a submersible motor:

max cable length from service entrance to motor with a					5.0%	voltage drop	
	voltage	230	single phase				
	ohms/1000ft	1.59	1	0.628	0.395	0.248	0.156
	allowable amps	20	30	40	55	70	95
max amps	pump/wire size	12	10	8	6	4	2
8	3/4	476	719	1,145	1,820	2,898	4,607
9.8	1	388	587	934	1,485	2,366	3,761
11.5	1.5	331	500	796	1,266	2,016	3,205
13.2	2	288	436	694	1,103	1,756	2,792
17	3	224	338	539	856	1,364	2,168
27.5	5		209	333	529	843	1,340

The electrical power to the house is 230 volts single phase. The 3 hp pumping unit is installed. The offset distance is the distance from the well head to the pump control. That distance is 23'.

Length of Offset Cable =	offset distance	+	depth of pitless
	23 ft	+	5 ft
Length of Offset Cable =	28 ft		

Length Pump System Cable =	Pump Setting	+	Length of Offset Cable
	185 ft	+	28 ft
Length Pump System Cable =	213 ft		

The pump cable chart indicates that useable length of #12 wire for a 3 hp submersible pump motor is 224'.

The length of wire from the main disconnect to the pump control must be factored into the overall length of the pump cable.

% useable length used = length of wire / useable length

28 ft / 338 ft

% useable length used = 8%

Since 8% of the useable length of # 10 wire was used on the main disconnect to pump control installation, 92% is the useable length available for the Length of Pump System Cable.

For #12 wire, the Allowable Length is:

Allowable Length = Useable Length * % of useable length available

224 ft * 92%

Allowable Length = 206 ft

The allowable length of 206’ is less than the required length of 211’.

12 CAN NOT BE USED!

10 wire will have to be used as the pump system cable for this installation.

APPENDIX P6

SIZING OF PRESSURE TANK

The parameters for determining the size of the water storage tank are: 1) the horsepower of the submersible pumping unit, 2) the pressure cycle of the pumping system, 3) the pumping capacity of the pumping unit, 4) the anticipated water usage rate, and 5) the yield of the water well.

For this installation, the water well has sufficient yield to supply the 3 hp pumping system. The operating criteria for the water well system are:

pressure on	50	psig
pressure off	70	psig
maximum pump rate	25	gpm
maximum usage rate	24.5	gpm

The motor manufacturer recommends that the maximum starts for a 3 hp submersible motor are:

100 starts in 24 hour period = average of 4 starts per hour

Normally, there are several hours a day a pump does not operate. A more reasonable time frames is:

100 starts in a 12 hour period = average of 8 starts per hour

cycle time =	1	hr	/	starts per hr
	1	hr	/	8
cycle time =	7.5	mins		

Maximum cycling occurs when the usage rate is ½ the pumping rate. The maximum pumping rate is 25 gpm and the usage rate when the sprinkler system is activated is 12 gpm which is almost half the maximum pumping rate.

Cycle Time is defined as the total of the time to drain the tank plus the time to fill the tank. e.g. The tank is full at the shut off pressure of 70 psig. The Cycle starts when water is drawn out of the tank at the rate of 12 gpm until the tank pressure lowers to the turn on pressure, 50 psig. That amount of water removed from the tank is called the volume out. When the pump turns on, 12 gpm from the pump goes to the sprinkler and 13 gpm from the pump goes to fill the tank. When the tank pressure gets to 70 psig, the pump turns off and the Cycle is complete. The volume out is also equal to the volume in. That volume is the drawdown.

cycle time =	time to empty tank		+	time to fill tank												
time to empty tank =	drawdown		/	usage rate												
time to fill tank =	drawdown		/	fill rate												
drawdown =	cycle time		*	usage rate		*	fill rate		/ (	fill rate		+	usage rate		)
	7.5	mins	*	12	gpm	*	13	gpm	/ (	13	gpm	+	12	gpm	)
drawdown =	47	gals													

The water storage needs to be sized to have a drawdown of 47 gallons for a pressure cycle of 50 to 70 psig.

To calculate the size of the water storage tank, the system pressures (psig) have to be converted to absolute pressures (psia). To convert to absolute pressure, the factor 14.7 is added to each pressure.

Also, the tank will be pre-charged to 2 psi less than the cut-in pressure of the pressure cycle.

pre-charged pressure	48	psig	+	14.7	=	62.7	psia
cut-in pressure	50	psig	+	14.7	=	64.7	psia
cut-out pressure	70	psig	+	14.7	=	84.7	psia
maximum cycles	7.5	per hr					
pumping rate	25	gpm					
usage rate	12	gpm					
fill rate	13	gpm					
required draw off capacity	47	gallons					
required tank size	205	gallons					

This water well system requires 2 captive air water storage tanks with each having a size in the 114 to 119 gallon range.

If a constant pressure pumping system was installed, the same 3 hp pumping unit would be installed except that the motor would be a 230 volt 3 phase motor so that the submersible pump cable could be # 12. The tank size would be a 4 gallon tank instead of the two 114 to 119 gallon tanks.

APPENDIX P7

WATER WELL YIELD LESS THAN DEMAND

The yield of the water well determines whether additional water storage is required.

Water Well # 2 is constructed.
The following information is obtained from the Water Well Construction Report:

Water Well depth	300	ft			
Depth 6" casing	180	ft			
Top Aquifer	180	ft			
Bottom Aquifer	290	ft			
Static water level	100	ft			
Test Pump Level	260	ft	@	7	gpm

The water demands in the house are the same as in Appendix P1with the high flow shower head.

The peak demands are 120 gallons in 5 minutes; 300 gallons in 1 hour; and the sprinkler system operating @ 12 gpm for 3 hours.

It is important to size the pumping unit so as not to over pump the water well, but to maximize the use of the water storage capacity of the water well. Normally, an electronic control will be required to protect the pumping unit from running "dry". The use of a flow restricting control device in the piping is an extremely inefficient method of reducing the water output from the pumping unit.

The capacity of the water well is the yield at the pumping depth times the time period for the demand plus the gallons stored in the water storage tank plus the gallons stored in the water well.

A water storage tank with a drawdown of 22 gallons is installed.

The submersible pumping unit is set at a pumping depth of 285'. At this pumping depth, the water well's yield is 8 gpm.

specific capacity = well yield / (pumping depth - static water level)

s.c.	=	7	gpm	/	(260	ft	-	100	ft)
	=	7	gpm	/	160	ft			
	=	0.04	gpm/ft						

Well yield @ pumping depth = s.c * (pumping depth - static water level)

yield	=	0.04	gpm/ft	*	(285	ft	-	100	ft)
	=	0.04	gpm/ft	*	185	ft			
yield	=	8	gpm						

The gallons stored in the water well are calculated by subtracting the static water level from the working pumping depth and multiplying by the capacity of the water well in gallons per foot.

storage in the water well = (pumping depth - static water) * gallons/ft

storage	=	(285	ft	-	100	ft)	*	1.5	gals/ft
	=	185	ft	x	1.5	gals/ft			
storage	=	278	gals						

The capacity of the water well can meet the demand of 120 gallons in 5 minutes:

Demand = 120 gallons in 5 minutes

capacity	=	(yield		*	time period)		+	drawdown		+	gallons stored	
capacity	=	(8	gpm	*	5	min)	+	22	gals	+	278	gals
	=	40	gals				+	22	gals	+	278	gals
capacity	=	340	gals									

and 300 gallons in 1 hour:

Demand = 300 gallons in 1 hour

capacity	=	(yield		*	time period)		+	drawdown		+	gallons stored	
capacity	=	(8	gpm	*	60	min)	+	22	gals	+	278	gals
	=	480	gals				+	22	gals	+	278	gals
capacity	=	780	gals									

The sprinkler demand of 12 gpm for 3 hours exceeds the capacity of the water well:

Demand = 12 gpm for 3 hours = 2,160 gallons in 3 hours

capacity	=	(yield		*	time period)		+	drawdown		+	gallons stored	
capacity	=	(8	gpm	*	180	min)	+	22	gals	+	278	gals
	=	1,440	gals				+	22	gals	+	278	gals
capacity	=	1,740	gals									

The sprinkler demand for this water system can be met by:

adding additional storage of 420 gallons;

Or

adjusting the time interval of the sprinkler cycle so that there is a minimum of a 5 minute delay between stopping one sprinkler zone and activating the next zone.

APPENDIX P8

3-PHASE SUBMERSIBLE PUMPING SYSTEM

Some differences between a single phase and a 3-phase submersible pumping unit are:

1. all 3 wires of a 3-phase submersible pumping unit draw load current;
2. a 3-phase submersible pumping unit does not require starting capacitors, starting relays, or running capacitors;
3. current is balanced by rotating the wires;
4. the direction of rotation can be reversed on a 3-phase motor.

For 3-phase system, the voltage between the L1 terminal and the L2 terminal, between the L1 terminal and the L3 terminal, and between the L2 terminal and the L3 should be the same voltage.

A 3-phase submersible pumping unit has a rated input load of 40 amps. Current unbalance should not exceed 10% of rated input which would be 4 amps,

To calculate current unbalance:

The incoming electric terminals are labeled L1, L2, and L3. The wires to these terminals do not move. Whenever wires are to be moved, it is the pump wires that are moved between terminals M1, M2, and M3. For 3-phase systems, 3 different setups can be established by moving the pump wires between the M1, M2, and M3 terminals.

Set up #1								
R to M1	43	amps						
Y to M2	40	amps						
B to M3	38	amps						
	121	amps						
average amps	40.3	amps						
largest difference =	line amps - average amps							
	43	amps	-	40.3	amps	=	2.7	amps
	40	amps	-	40.3	amps	=	-0.3	amps
	38	amps	-	40.3	amps	=	-2.3	amps
largest difference =	2.7	amps						
% unbalance =	largest difference / average amps							
	2.7	amps	/	40.3	amps			
% unbalance =	6.7%							

Set up #2

B to M1	45	amps					
R to M2	38	amps					
Y to M3	41	amps					
	124	amps					
average amps	41.3	amps					
largest difference =	line amps - average amps						
	45	amps	-	41.3	amps =	3.7	amps
	38	amps	-	41.3	amps =	-3.3	amps
	41	amps	-	41.3	amps =	-0.3	amps
largest difference =	3.7	amps					
% unbalance =	largest difference / average amps						
	3.7	amps	/	41.3	amps		
% unbalance =	9.0%						

Set up #3

Y to M1	42	amps					
B to M2	41	amps					
R to M3	40	amps					
	123	amps					
average amps	41.0	amps					
largest difference =	line amps - average amps						
	42	amps	-	41.0	amps =	1.0	amps
	41	amps	-	41.0	amps =	0.0	amps
	40	amps	-	41.0	amps =	-1.0	amps
largest difference =	1.0	amps					
% unbalance =	largest difference / average amps						
	1.0	amps	/	41	amps		
% unbalance =	2.4%						

For the 3 setups, the % of current unbalance ranged from 9.0% to 6.7% to 2.4%. Always select the setup that produces the lowest % of current unbalance.

The rotation of a 3-phase submersible motor can be changed by moving any two of the pump motor wires to change the sequence, e.g. the pump control is wired R – M1, Y – M2, B –M3. To change rotation, change the sequence by moving two of the pump wires on the pump control to Y – M1, R – M2, B – M3. The correct rotation is always the rotation that produces the greater amount of water.

THE AUTHORS

David Dingledine

George Gaffke

Mike Gross

John Pitz

Greg Wilburn