



Well Construction

It is important that the water operator have some understanding of well construction and how Minnesota regulates it. Poor construction methods can contaminate aquifers. See the chapter on “Rules Relating to Wells and Borings” for a summary of items of interest to the water-supply operator.

WELLHEAD PROTECTION

Under MN Rule 4720 (4720.5100 – 0.5590), any well added to a municipal water supply system will trigger the development of a Wellhead Protection Plan, not only for the new well, but for all wells in the public water supply system.

The purpose for wellhead protection “set-back” is to prevent harmful contaminants from entering public water wells. Since the early 1900s, isolation distances have been used to prevent disease organisms from entering public wells. *However, between wells and contamination sources, isolation distances have been set mainly to prevent bacteriological contaminants from entering wells. They are not as effective in preventing chemical contaminants from entering wells.* This is because chemicals either do not degrade or breakdown over time or because their breakdown products are as toxic as the parent compound. The Minnesota Department of Health (MDH) is leading efforts to establish a wellhead protection program that will help prevent chemical contaminants from entering public wells.

The focus of wellhead protection is the wellhead protection area (WHPA). The WHPA includes the surface and subsurface areas that supply water to a public well. Once the WHPA is determined for a public well, the vulnerability of the well and the local geological setting are assessed to determine potential sources of contamination that may affect the well. Next, a contaminant source inventory is conducted to identify potential contaminant sources in the WHPA, and a plan for managing these sources is developed. Implementing a WHPA plan to protect a public well will require the cooperation of public water suppliers, land owners, local governments, state agencies, and the general public.

Wellhead protection has proven to be an effective method to protect public wells from contamination that can result from land use activities. Minnesota is required, under provisions of the federal Safe Drinking Water Act, to develop and implement a Wellhead Protection Program. The Minnesota Department of Health has completed the State’s written groundwater rule changes necessary for implementing a mandatory wellhead protection program. All public water suppliers will eventually be required to develop and implement wellhead protection plans; however, voluntary participation is currently being encouraged.



Potential Contamination Sources

<u>Category</u>	<u>Sources</u>	
Agriculture	Animal burial areas Animal feedlots Fertilizer storage/use	Irrigation sites Manure spreading area/pits Pesticide storage/use
Commercial	Airports Auto repair shops Boatyards Construction areas Car washes Cemeteries Dry cleaners Gas stations Golf courses	Jewelry/metal plating Laundromats Medical institutions Paint shops Photography establishments Railroad tracks and yards Research laboratories Scrap and junkyards Storage tanks
Industrial	Asphalt plants Chemical manufacture/storage Electronics manufacture Electroplaters Foundries/metal fabricators Machine/metalworking shops Mining and mine drainage	Petroleum production/storage Pipelines Septage lagoons and sludge Storage tanks Toxic and hazardous spills Wells (operating/abandoned) Wood preserving facilities
Residential	Fuel Oil Furniture stripping/refinishing Household hazardous products Household lawns	Septic systems, cesspools Sewer lines Swimming pools (chemicals)
Other	Hazardous waste landfills Municipal incinerators Municipal landfills Municipal sewer lines Open-burning sites	Recycling/reduction facilities Road deicing operations Road maintenance depots Storm water drains/basins Transfer stations



WELL SITING

When in need of a first well or a new well, city officials should follow the guidelines below:

1. All municipal water-supply wells should be designed by a competent professional engineer who knows the geology of the area where the well is to be constructed and has experience and expertise in well design and drilling and is familiar with state requirements.
2. Considerations in site selection include the location of existing water towers, storage areas, and treatment plants as well as the availability of the property and whether or not the city owns this property. In addition, the well should be located so that it will not be contaminated by any identifiable source in the area. Variables influencing the movement of contaminants through the groundwater include contour of the land, slope of the water table (which could be different than that of the surface), and geology permeability or transmissivity of the soil.
3. A well construction plan, specifications, and a well construction notification must be submitted to the Minnesota Department of Health (MDH) for approval prior to construction. The well contractor must also notify MDH by phone, fax, or in person at least 24 hours prior to the start of construction. Government owned wells are exempt from the notification fee.

WELL NOTIFICATION

Send notification form with \$100 check or money order payable to the Minnesota Department of Health to:
Minnesota Department of Health, Well Management Unit, P.O. Box 64975, St. Paul, Minnesota 55164-0975,
ATTN: CASHIER

Minnesota Unique Well No. _____

Exempt from paying fee ☐ Yes ☐ No

MDH USE ONLY
Date Rec'd _____
Deposit Number _____
Amount and Payment Form _____ (TIN#)

Check well type: ☐ Single Family/Other (Specify) (01) ☐ Irrigation (71)
☐ Remedial (72) ☐ Community PWS (73) ☐ Noncommunity PWS (74)

☐ Dewatering Wells(s) Total number of dewatering wells _____ ☐ \$100/well-1 to 4 wells (22) ☐ \$500/site-5 or more wells (31)

WELL LOCATION	County	Township Name	Township No.	Range No.	Section No.	Fraction	1/4	1/2	3/4
	Well Location Address			City	State	Zip Code	Fire Number		
PROPERTY OWNER	Well/Property Owner Name (Print)						Daytime Telephone Number ()		
	Property Owner Street Address						City	State	Zip Code
	Property Owner Signature						Date		
WELL CONTRACTOR	Well Contractor (Print)				Well Contractor Signature				Date
									License No.

Failure to provide proper notification and fee prior to the beginning of well construction is a violation of Minnesota Statutes, Chapter 103L, and may result in the assessment of an administrative penalty.

4. The well must be constructed by a licensed well contractor in accordance with Minnesota's Rules Regarding Wells and Borings (Well Code - MN Rules Chapter 4725)



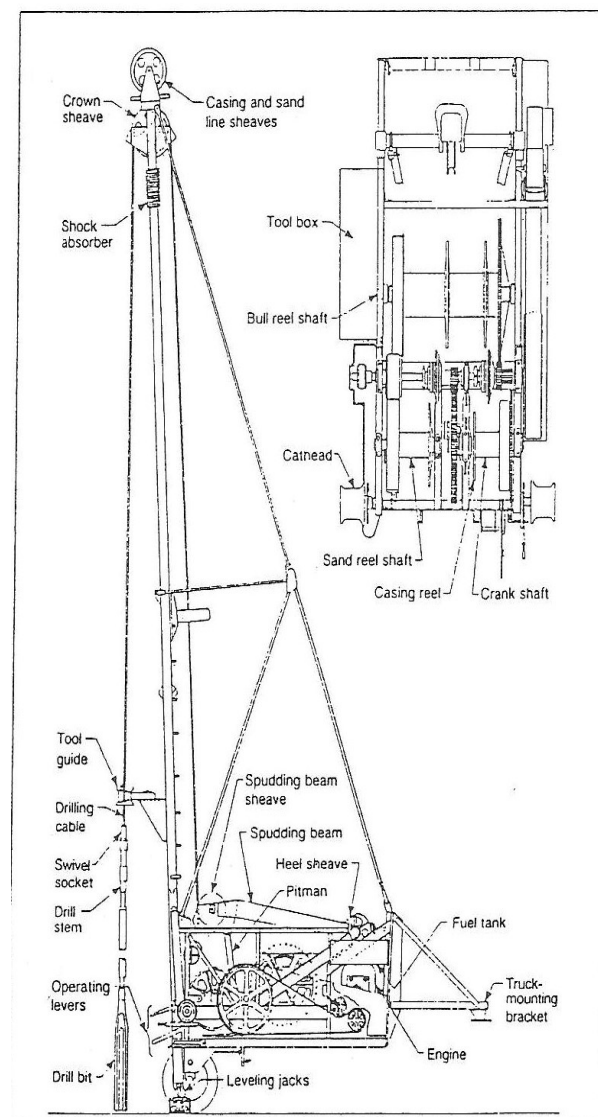
Before a well site will be approved by the Minnesota Department of Health, it must meet minimum distance requirements from various contamination sources. These distances, established by rule, are guided by a concern for the toxicity of the contaminants, the ability of the material to penetrate the soil, and the contaminant's potential concentration. The chapter summarizing the "Rules Related to Wells and Boring" includes a listing of the minimum isolation distances required in Minnesota's Water Well Code for a potable-water well.

DRILLING METHODS

Cable In Minnesota, two basic methods of well construction are used: the cable tool method and the mud rotary method. Other methods—such as air rotary drilling, air percussion drilling, bucket drilling (for very large diameter wells), jetting, and augering—are used occasionally, but the cable tool and rotary methods are the most common. There are a number of different rotary methods that are now used including dual rotary, rotaomic, mud rotary, and air rotary/hammer. Small diameter, shallow "sand-points" are commonly driven by hand and use the water table aquifer.

CABLE TOOLS

Cable tool drilling—also known as percussion drilling, churn drilling, solid tool or spudding—is a widely used method of drilling wells in Minnesota. The cable tool drill operates by raising and lowering a heavy set of tools, called a tool string, suspended from a cable. This tool string has a drilling bit, which is a heavy chisel-shaped tool four to five feet long and flared at the end to the size of the well being drilled, and a swivel socket at the top that enables the string to rotate. The drill stem is a round bar which provides the weight for drilling and guides the rest of the tools. The cable is threaded over a pulley or crown sheave at the top of the mast, down to a walking beam, and on to a cable drum where the excess cable is stored. The up and down drilling motion is transmitted to the tool string by the action of the walking beam. Additional cables or lines are used to raise the casing or lower the bailers or other tools during the process.





The constant raising and lowering of the tool string by the walking beam action results in the breaking up of the rock and sediment into smaller pieces called “cuttings.” The length of the cable (stroke) can be adjusted so that the bit will strike the bottom with the force needed. The socket at the end of the tool string allows the bit to turn on impact and create the drilling action. Typically, four-to-six feet are drilled with each run of the drill bit. Hard rock is drilled at a faster operating speed than clays and soft material. Cuttings, which are mixed with a small amount of water, are removed from the hole by “bailing.” A bailer consists of a hollow pipe, smaller in diameter than the drill hole or casing, usually six-to-twenty feet long with a valve on the bottom to retain the cuttings. The bailer is lowered to the bottom of the hole where it fills with a mixture of water and cuttings, and is then raised to the surface where the cuttings are discharged. It is through the examination of the cuttings that the driller determines the types of formations to record on the well record.

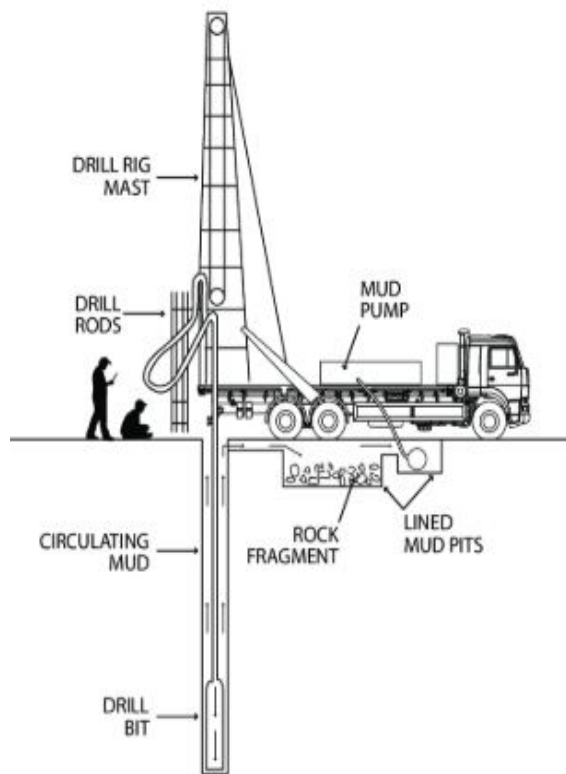
As the drilling proceeds, casing is continually forced into the ground. This is accomplished by attaching “drive clamps” to the tool string. The walking beam raises and lowers the string rapidly, and the weight of the tool string hitting against the top of the casing causes the casing to advance downward into the hole. The bottom of the casing is equipped with a hardened fitting called a “drive shoe” that protects the end of the pipe from damage. The top of the casing is also protected by a drive cap during the driving process.

The complete process involves the drilling of a few inches—or at most a few feet—past the end of the casing, bailing the hole to remove the cuttings, driving the casing, and then resuming the drilling. In a bedrock well, the casing would generally end at the top of the solid rock, with open hole drilled into the water-bearing strata. Some geological conditions require an inner casing and cement grout.

In a well completed in gravel or sand, the casing would be driven to the desired depth and normally a screen would be installed. A well screen is a sieve or strainer-like device that has holes or other openings small enough to allow water to pass into the well, but large enough to keep sediment out of the well. The screen, which is smaller than the casing, is telescoped or lowered to the bottom of the hole along with a packer to seal the screen to the casing. The casing is then pulled back to expose the screen to the producing formation.

Accurate samples can be obtained with a cable tool rig. It is possible to test for water quantity and quality of each formation as drilling progresses. While the reduced speed in overall drilling conditions is a disadvantage, a cable tool rig may be the best equipment for drilling a fractured rock well, or for large diameter wells. A cable tool rig may have to cease drilling if it encounters a large rock or boulder. In some cases explosives may be used to either shatter the boulder or move it out of the way of the drilling operation.

The cable tool method is often used for drilling large-diameter municipal wells in Minnesota.



ROTARY WELL DRILLING

Rotary well drilling is widely used in Minnesota. This is a method of drilling in which the bore hole is made with a constantly rotating bit. The bit is connected to a series of hollow-threaded drill pipes. A circulating fluid or “mud” is pumped down the drill pipe to the bit, where it then exits and flows upward. The fluid carries the drill cuttings to the surface and stabilizes the bore hole until a casing is installed. This process continues until the bit encounters a suitable water-bearing formation. Unlike the cable tool method, rotary wells are usually not cased until the final depth of the hole is reached.

The speed that can be achieved with rotary well drilling makes it a popular method. It was originally developed for the oil-drilling industry. The rotary rock bit with its roller cutters allow the drills to penetrate sands, gravel, clays, and, more importantly, boulders and bedrock formations more easily than other methods.

DRIVEN WELLS

In places where water is available near the surface, hand driven wells can be practical. The usual depth limit of hand-driven wells, “sand points” or “points,” is around 35 feet. Depths to 50 feet or more may be reached with weight or power assistance. However, since most drive points are pumped with shallow well jet pumps, the water level must be within 20 feet of the surface for the pump to work.

Sediment must be easy to drive through; rock, hard clays, silts, and very fine sands often present difficulties in completing a well. Many attempts at driving wells result in the point either being damaged or deviated off the vertical direction, by boulders or bedrock.

Many driven wells are started by auguring or digging a hole as deep as possible into the ground. The drive point, consisting of heavy-duty reinforced well screen with a steel drive cone on the bottom, is coupled with the first length of drive pipe, or casing. This assembly is lowered into the pre-dug starting hole. Then a drive cap is screwed on the top of the casing and a heavy weight is used to strike the drive cap, forcing the point into the ground. When the length of casing reaches ground level, the drive cap is removed, another length of pipe threaded on, the drive cap added, and the process continued.



A driven well is used in many remote locations for limited supplies of water. It can be installed by one or two people in a matter of hours or days, depending on driving conditions. Because driven wells are usually very shallow, they are susceptible to surface or near-surface contamination. Also, well points tend to encrust or plug up very quickly due to the galvanized casing used for most sandpoints on the market and due to fouling of the screen openings at a faster rate because of carbonates entering their small diameter. Yield is usually limited because of pumping systems available, the small diameter of the casing, and their usual application in aquifers with limited yield. Driven wells are commonly installed by homeowners at lake cabins. However, the well construction and siting still must comply with the well code.

WELL SCREENS AND GRAVEL PACKS

Wells completed in unconsolidated formations such as sand or gravel, and, under some circumstances, wells completed in loosely consolidated formations or consolidated formations with thin, loosely cemented beds are typically equipped with a well screen attached to the bottom of the casing. The purpose of the well screen is to prevent sediment from entering the well while allowing water to enter the well.

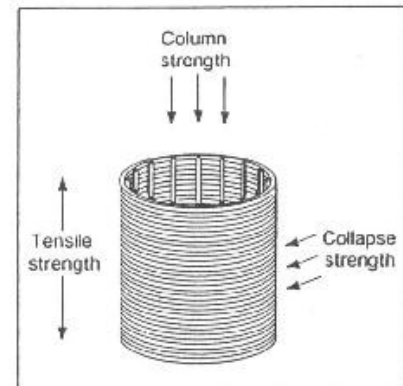
Metal, wire-wound, continuous-slot well screens are the most popular ones used. They provide the largest percentage of open area for a given slot size, consistent with adequate strength. Stainless steel is the most popular of the available metals because of its resistance to corrosion and its ability to withstand acid treatment (which may be used to remove encrustations when rehabilitating a well). Similarly constructed PVC plastic screens are manufactured, but have somewhat less open area, than metal screens of the same slot size. Where extra strength is required, a combination of continuous-slot screen over perforated pipe is available.

Many other screen variations save on initial cost but offer considerably less open area, poorer performance, and, often, shorter useful life. Casing can be perforated or slots can be cut with a welding torch; such irregular openings are effective in gravel aquifers or gravel-packed wells but may result in sediment problems in the well because of the irregular and coarse opening. Metal mesh screen wrapped around or inside perforated pipe (the pipe provides necessary strength) or metal mesh inserts pressed into drilled holes in the pipe are typical of drive points available to homeowners at their local hardware store. These screens are easily plugged by sand grains, and their copper-based metal construction invites galvanic corrosion problems.

The size of the opening in a screen is designated by “slot” size or “gauze.” Slot size is the width of the opening in thousands of an inch. (10 to 40 slot is common) Gauze is the number of openings in a mesh per inch, and is more commonly used on smaller diameter screens for domestic wells. Gauze sizes of 80-90 are typical.



WellScreen length is influenced by the characteristics of the aquifer as well as by the anticipated yield. Screen length, in a homogeneous thick aquifer, has a greater effect on well yield than screen diameter. Doubling the screen diameter will typically result in only a 10 to 15 percent increase in well yield. Ideally, screens are placed at the base of an aquifer to maximize yield. Grain size of aquifer materials can be determined, such as through sieve analysis, to properly design a screen.



GRAVEL PACKS

In an artificially gravel-packed well, the formation material (sediment) around the well screen is removed and replaced by a coarser material of high uniformity, usually about five times the diameter of the native material. It is designed to (1) increase the permeability of the formation and screen, (2) exclude virtually all of the formation material beyond the gravel pack, and (3) stabilize the formation.

Gravel-pack construction is more expensive for numerous reasons: the borehole diameter must be larger to accommodate gravel, which may be up to 5 inches thick; accurately graded gravel must be purchased and hauled to the site. Increased labor is required to construct the well and install the gravel, and, in some cases, a temporary water casing may have to be installed and removed. The gravel must be smooth and rounded for maximum permeability; sharp, irregular shapes tend to pack more tightly during development and leave smaller spaces than rounded grains. It must be low in calcareous material, such as limestone, that could be dissolved by acid treatment used during rehabilitation of a well, leaving gaps in the pack and causing slumping. Since it could be possible that encrustation will eventually develop, the requirement for acid treatment must be anticipated.

The additional cost of using gravel pack may be justified in these situations:

1. A well in fine, uniform sand where development will not significantly improve permeability.
2. A thick artesian aquifer. This may permit use of a smaller diameter, longer screen. (Production increases only about ten percent if the diameter of the well is doubled, but it doubles if the screen length is doubled.)
3. Laminated formations (or formations with alternating finer and coarser layers). The finest sand layers in the aquifer determine the maximum screen slot size and the particle size in the gravel pack; however, gravel-packing permits use a larger slot screen.
4. Loosely cemented sandstones. Large consolidated formations may cause sand pumping.



The gravel is best placed by washing the gravel down a conductor or tremie pipe so that it is placed from the bottom of the hole upward. This prevents bridging (voids left in the pack) and sorting of the gravel (larger particles falling faster than smaller ones through the water or drilling mud), which would result from simply dumping the gravel into the annular space. Use of a temporary outer casing prevents sloughing of the borehole wall, which could eventually produce voids.

GROUTING

An open annular space between a drill hole and a casing, or between an inner and an outer casing, presents a direct pathway from the surface for contaminants to enter a well and the groundwater or to migrate from one aquifer to another. Besides preventing surface or near-surface contamination from entering a well, grouting provides support for the casing (particularly important for plastic casing), prevents inter-aquifer flow, seals a casing to prevent “washouts” due to flowing wells, and protects steel casing from corrosion.

Grouting is a good idea for all wells, but is specifically required in some situations. Grouting refers to the filling or sealing of a space with a low permeability material or grout such as cement or a bentonite clay slurry. A variety of grouts are acceptable (cement, cement sand, bentonite) depending on geology. All public wells must be grouted full-depth.

GROUT MATERIALS

Water wells have been grouted with a variety of materials, mixtures, and additives but most contain either Portland cement or sodium bentonite. The Minnesota Water Well Construction Code requires that any open annular space be grouted and prescribes specific grout types for specific geologic or construction circumstances.

Cement Grout

Neat cement grout is a mixture of 94 pounds of Portland cement and not more than six gallons of water.

Bentonite

Sodium bentonite is a clay principally composed of the mineral montmorillonite. Bentonites have the ability to swell upon contact with water, theoretically up to 15 times the dry volume, but typically eight to ten times. Bentonite may be used as a grout in unconsolidated materials such as glacial drift or alluvium (deposits from rivers and wells). Minnesota Rules allow two types of bentonite grout—bentonite grout, which contains a minimum of 10 percent bentonite and 10 percent sand, cuttings or granular bentonite, and high solids bentonite grout which contains a minimum of 15 percent bentonite. The product must be designed as a grout or sealant and must be mixed according to manufacturer’s specifications.



GROUTING METHODS

To ensure a complete and effective seal, free of voids, and to comply with state regulations, grouts must be pumped into the annular space from the bottom upward, through a grout tremie pipe or by grouting through the bottom of the casing.

WELL RECORDS

There are many ways to obtain a well record of the depth and type of each formation encountered during the drilling. Most commonly, samples are taken as the hole is drilled from the surface to the bottom of the hole. This method is generally used to determine what types of soils or rock are being drilled into and to find the water-bearing formations. The Minnesota Geological Survey (MGS) at the University of Minnesota maintains records of most of the wells in the state, including historical well records of wells drilled before 1974. It is an excellent source of information about the geology of Minnesota.

Since 1974, the Minnesota Water Well Code has required licensed well contractors to submit a well and boring record within 30 days of construction of a new well. The record should include information about the geology, depth, diameter, drawdown, distance from sources of contamination, construction details of the well, and remarks about the drilling of the well. A copy is given to the Minnesota Geological Survey, Minnesota Department of Natural Resources, the property owner, and the local government (if required).



WATER SAMPLE INFORMATION

The well construction rules requires that a water sample be taken and tested for total coliform bacteria and nitrate nitrogen prior to placing the well in service. The results and the water sample information form must be sent to the well management unit at the Minnesota Department of Health.

WATER SAMPLE INFORMATION

Minnesota Unique Well Number

PLEASE PROVIDE ALL INFORMATION ON THIS CARD AND ON THE WATER ANALYSIS REPORT. PLEASE PRINT. THANK YOU.

Date of Water Sample Collection _____ Hour (a.m./p.m.) _____

Well Contractor Business Name _____ License Number _____

Well/Property Owner Name _____

Well/Property Owner Mailing Address _____

City _____ State _____ Zip Code _____

Well Location Address or Legal Description (if different than mailing address) _____

Tear off and send with the water sample to a certified laboratory. The water analysis report from the certified lab should be sent to: Minnesota Department of Health, Well Management Unit, P.O. Box 54975, St. Paul, Minnesota 55184-0975.

WELL LABEL

The Minnesota Department of Health provides well contractors with a metal identification label. The label is stamped with the Minnesota Unique Well Number and must be attached to the well casing or pump pedestal.

WELL IDENTIFICATION LABEL	
STATE OF MINNESOTA	
UNIQUE WELL NO. 595701	



MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD Minnesota Statutes Chapter 103J					MINNESOTA UNIQUE WELL NO. 	
WELL LOCATION County Name _____ WELL DEPTH (completed) _____ ft. Date Work Completed _____						
Township Name _____		Township No. _____	Range No. _____	Section No. _____	Fraction _____	
House Number, Street Name, City, and Zip Code of Well Location _____				or Fire Number _____		
Show exact location of well in section grid with "X". 				Sketch map of well location. Showing property lines, roads and buildings.		
DRILLING METHOD ☐ Cable Tool ☐ Driven ☐ Dig ☐ Auger ☐ Rotary ☐ Jetted ☐ _____				DRILLING FLUID USE ☐ Domestic ☐ Monitoring ☐ Heating/Cooling ☐ Irrigation ☐ Community PWS ☐ Industry/Commercial ☐ Test Well ☐ Noncommunity PWS ☐ Remedial ☐ _____		
				CASING Drive Shoe? ☐ Yes ☐ No ☐ Steel ☐ Threaded ☐ Welded ☐ Plastic ☐ _____		
PROPERTY OWNERS NAME Property owner's mailing address if different than well location address indicated above.				CASING DIAMETER WEIGHT _____ in. to _____ ft. _____ lb./ft. _____ in. to _____ ft. _____ in. to _____ ft. _____ lb./ft. _____ in. to _____ ft. _____ in. to _____ ft. _____ lb./ft. _____ in. to _____ ft.		
				SCREEN _____ OPEN HOLE _____ Make _____ from _____ ft. to _____ ft. Type _____ Diam. _____ Slot/Gauge _____ Length _____ Set between _____ ft. and _____ ft. FITTINGS: _____		
WELL OWNERS NAME Well owner's mailing address if different than property owner's address indicated above.				STATIC WATER LEVEL _____ ft. ☐ below ☐ above land surface Date measured _____		
GEOLOGICAL MATERIALS COLOR HARDNESS OF MATERIAL FROM TO				PUMPING LEVEL (below land surface) _____ ft. after _____ hrs. pumping _____ g.p.m.		
				WELL HEAD COMPLETION ☐ Pressure adapter manufacturer _____ Model _____ ☐ Casing Protection _____ ☐ 12 in. above grade ☐ At-grade (Environmental Wells and Borings ONLY)		
Use a second sheet, if needed REMARKS, ELEVATION, SOURCE OF DATA, etc.				GRouting INFORMATION Well grouted? ☐ Yes ☐ No Grout Material ☐ Neat cement ☐ Bentonite ☐ Concrete ☐ High Solids Bentonite from _____ to _____ ft. _____ yds. ☐ bags from _____ to _____ ft. _____ yds. ☐ bags from _____ to _____ ft. _____ yds. ☐ bags		
				NEAREST KNOWN SOURCE OF CONTAMINATION _____ feet direction _____ type _____ Well disinfected upon completion? ☐ Yes ☐ No		
PUMP ☐ Not installed Date installed _____ Manufacturer's name _____ Model number _____ HP _____ Volts _____ Length of drop pipe _____ ft. Capacity _____ g.p.m. Pressure Tank Capacity _____ Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ _____				ABANDONED WELLS Does property have any not in use and not sealed well(s)? ☐ Yes ☐ No		
				VARIANCE Was a variance granted from the MDH for this well? ☐ Yes ☐ No		
WELL CONTRACTOR CERTIFICATION This well was drilled under my supervision and in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.				_____ Licensee Business Name Lic. or Reg. No.		
				_____ Authorized Representative Signature Date		
_____ Name of Owner Date				_____ Date		
				HE-01205-05 (Rev. 1/95)		



WELL DEVELOPMENT

An important step in well construction is the development of the well to maximize well efficiency and the quantity of sand-free water that the aquifer is capable of producing. Development is the process of removing fine material and drill cuttings or residue from the aquifer adjacent to the screen. This will help prevent the water entering the bore hole from carrying sand into the well and pump. Development can be accomplished in many ways. A screened well can be surged using air or water. Air surging involves pressurizing the casing with air, so that the water level is forced down in the well to a level just above the top of the screen. The pressure is then released quickly, which allows the water to rush back into the well, carrying sand with it into the screen where it can then be removed.

Water jetting is another method of developing a screened well. This involves the installation of an air line down to the screen and air nozzles to jet air into the sands surrounding the screen, thereby removing the fine material from the well hole. Note: air jetting has the potential to actually plug an aquifer.

The development of a rock well without a screen (an open-hole well) may differ in that the driller may use the blast-and-bail method. This involves the use of explosives in the hole and the removal of the rubble from the bottom of the hole by the same bailer that was used in the drilling process. Blast-and-bail is used in sandstone or other rock formations to increase the well's yield. Hydraulic fracturing, the process of injecting water at sufficient pressure to fracture the rock, is used in some hard rocks like granite.

TEST PUMPING

After the well has been developed, it must be pumped to ensure that it does not produce sand and that it will give the required amount of water. Test pumping involves the installation of a pump large enough to withdraw water at a volume above the required flow expected from the well. For example, for a 1,500 gallon per minute (gpm) well, a 2,000-to-2,500 gpm test pump with a control valve would be installed so that the pumping level could be controlled at any level up to the capacity of the pump. The test pump will usually be driven by a variable-speed engine rather than by an electric motor. This allows the operator to vary the speed of the pump. The test pump is initially run at a low flow and increased as needed until either the pumping level is reached or the well has met capacity. The water being pumped from the well should be monitored for sand and turbidity, and pumped until the turbidity is removed from the water. Once the turbidity is removed, the pumping rate should be increased until the desired capacity has been reached, or until the well has failed to meet the desired yield due to either an unacceptable sand concentration, or an unacceptable low pumping level.

With the test pumping completed, the production pump should be selected for the well. At this point, the information that was gained in the test pumping becomes important. The level at which the well pumped at a specific rate dictates where the pump should be set. The test pumping will also provide information about what size head the pump will have to pump against and the horsepower needed to pump the required amount of water. Generally, the production pump will be sized at 75 percent of the test pump level, although this can vary. The pump will usually be sized to the capacity of the well based on the test pump data. Normally an open-hole, sedimentary-rock well yields 50 to 75 percent of capacity. A screened well in glacial drift usually yields 50 percent of capacity.



DISINFECTION

The Well Code requires that a new, repaired, or reconditioned well must be disinfected with at least 50 parts per million (ppm) chlorine solution in all parts of the well for a period of at least two hours. Effectiveness in killing living organisms increases as either the concentration of chlorine or the contact time increases. For a well-repair operation, the Code permits the alternative of applying 200 ppm chlorine when beginning the repair, in effect disinfecting throughout the operation.

It is important to flush the well surfaces above the static water level with the chlorine solution. Contamination on these surfaces would not otherwise be contacted by the disinfectant but could later be washed down by condensation moisture, fluctuations in static levels, or water returned through “bleeder” systems.

Disinfection is necessary after any work on a well, because it is virtually impossible to avoid microbiological contamination during drilling or repair. Pipe and other materials are not sterile when purchased. They are often coated with greases or other compounds which are residuals from manufacturing processes or are deliberately added to retard rust during storage. Tools and pipes pick up bacteria from the ground surface. It is a common, but dangerous, assumption that all the bacteria introduced into the well during drilling are only “harmless, vegetative types.” Bird and animal wastes contain organisms harmful to man and are scattered everywhere on the ground surface.

It is equally dangerous to assume that cleanliness is unimportant since disinfection takes care of everything. Iron bacteria are non-pathogenic organisms that cause severe staining, plugging, taste, and odor problems. They are nearly impossible to eliminate if allowed to become established in a well. They can be carried from well to well on the driller’s tools. Any water used in drilling must be chlorinated clear water, must contain a free chlorine residual at time of use, and should be conveyed in clean sanitary containers or water lines. Drilling fluids should have a free chlorine residual at all times. By eliminating contamination as fast as it is introduced, the driller maintains a clean well and greatly improves the probability that bacteriological tests on the completed well will be satisfactory.

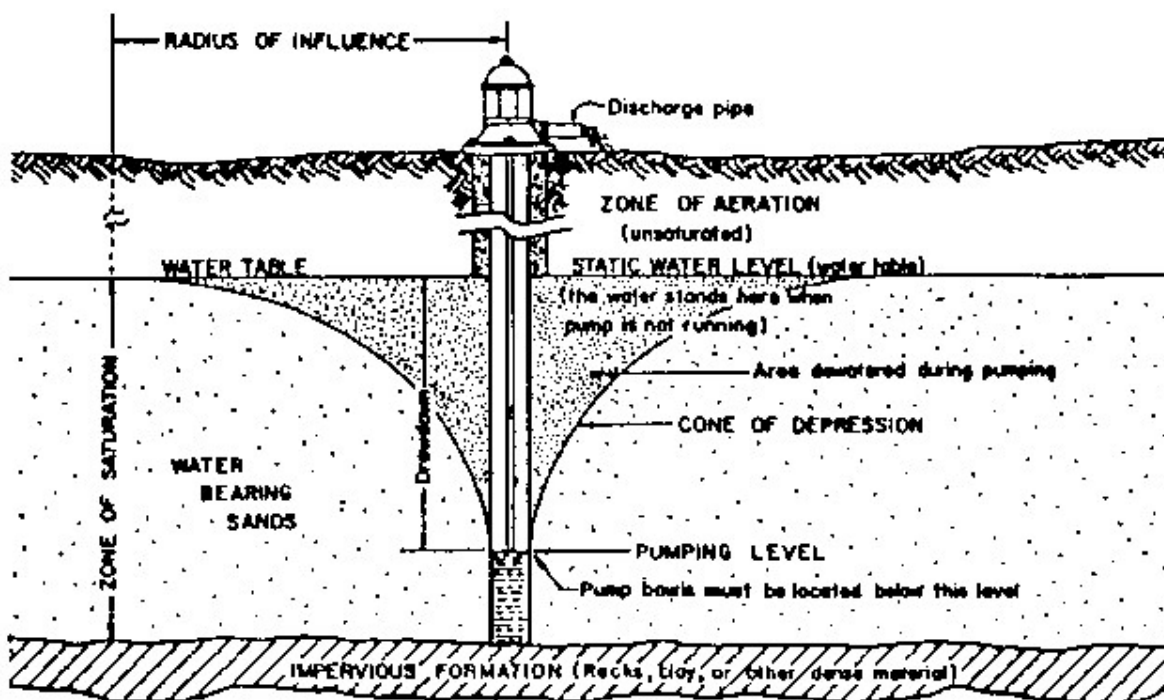
A chlorine solution is the simplest and most effective means of disinfecting all parts of the water system.

Well drillers frequently use calcium hypochlorite, which is 65 percent available chlorine and is available as a dry powder, granules, or tablets. The material is relatively stable and maintains 90 percent of its strength over several months if stored in a cool, dry location. The tablets can be dumped directly into the well prior to pump installation to ensure that the deepest part of the well is disinfected. However, for purposes of well disinfection that is required by the Well Code, any solid chlorine product must first be mixed with water. A chlorine/water solution is necessary to flush down the casing above the water level and, after the pump is installed, to negotiate small passages through the pitless unit and between a submersible pump and the casing. Because solutions diffuse very slowly, they may not reach all parts of the well in a reasonable time unless mixed by some means, such as alternately starting and stopping the pump.

If the well driller does not install the pump or if there is a delay between well construction and pump installation and/or connection to the distribution piping, the well should be disinfected after each stage. Bacteria should never be given an opportunity to grow and gain a foothold anywhere in the water system.

MEASURING LEVELS IN WELLS

One of the most important pieces of information the water-system operator needs is the water levels in the well before startup (static level) and the water level after the pump has run and the well has reached a stable condition (pumping level). The pumping water level has been reached when the water level in the well has stopped dropping. In most cases, this takes at least one hour and can often take much longer. The level will drop rapidly right after the pump starts and then slow considerably, dropping to an inch per hour or less, until the drop stops. What has happened is that the pump has lowered the head pressure exerted by the aquifer in the vicinity of the well. This area of depression is called the cone of depression. It extends from the well out to a point at which the pressure equalizes and returns to normal. If wells are located too close together, the cones will intersect and cause a drop in pumping capacity.





There are a number of different ways that the operator can find the static and pumping-water levels in the well. They include the use of:

An air line

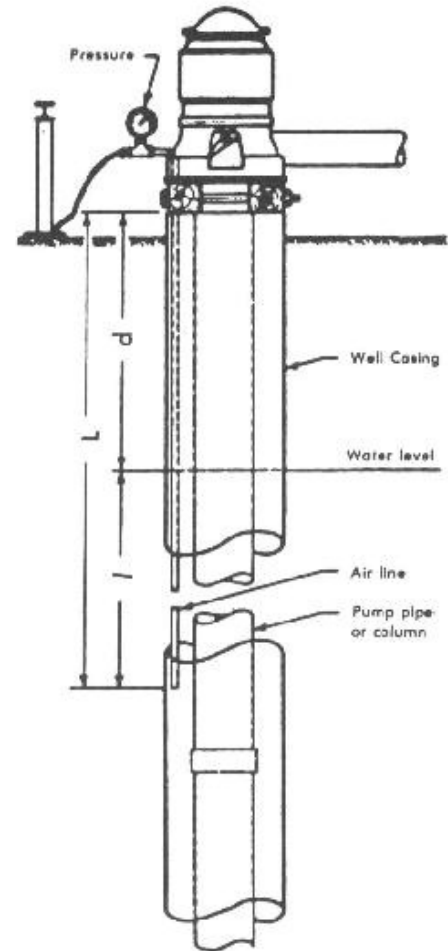
The air line, which is often installed permanently in the well, consists of 1/8- or 1/4-inch copper tubing, plastic tubing, or iron pipe and is long enough to extend from the surface to below the lowest water expected in the well. The air line may be fastened to the pump column when the pump is installed. Care must be taken in the installation of the line to make sure it is air tight. The vertical length of the air line, from the pressure gauge to the bottom, must be carefully measured at the time of installation.

A pressure gauge is attached to the air line at the surface together with a method for introducing air, such as from a tire pump or air compressor. The depth to the water is calculated by pumping air into the line until the maximum reading on the gauge is obtained. This reading is equal to the pressure exerted by the column of water standing outside the airline. It is customary to use an altitude gauge that is graduated in feet of water. If the gauge reads in pounds per square inch (psi), the reading can be multiplied by 2.31 feet per square inch to convert the reading to feet.

Example:

What is the depth to water if the air line is 125 feet long and the maximum gauge reading is 50 feet?

Answer: 75 feet (Depth = 125 feet of air line - 50 feet, gauge reading)



An electric measuring line

A single conductor insulated wire can be used to accurately measure water levels in pumping wells. One end of the wire is bared and enclosed in a slotted or perforated pipe, which prevents it from touching the casing or pump when lowered into the well. The pipe also serves as a weight when lowering the wire. Transducers are now more common. There are a variety of tools used for measuring water levels electronically, and they can measure continuously.



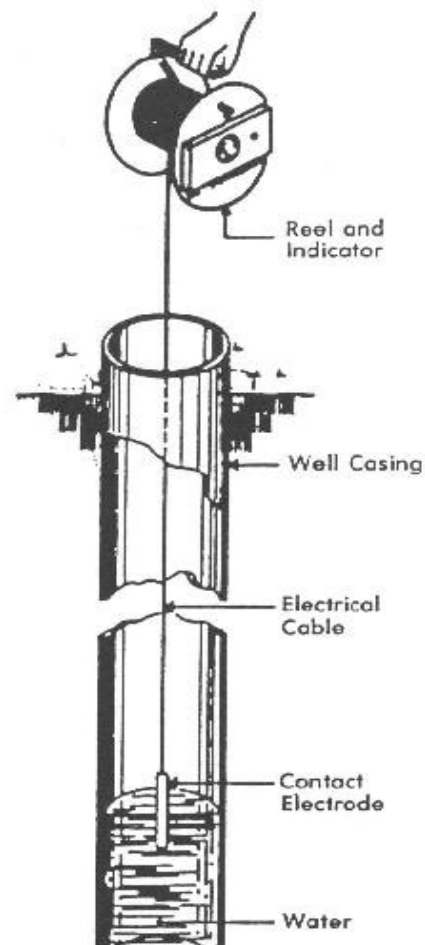
The other end of the wire is attached to the casing or to some other part of the metal pump assembly. A battery is connected in series with a meter or other indicator. The circuit is completed when the end of the wire in the well touches the water. At this point, the meter reading is steady. The depth of the water is determined by measuring the amount of wire in the well. The wire can be marked at ten-foot intervals to help make the measurement. A small, hand-operated reel with a brush takeoff for the battery circuit makes it easier to handle the wire. A double conductor wire can also be used. This will eliminate the return circuit through the pump or casing, but it also increases the diameter of the wire.

One of the disadvantages of the electrical measuring line is that the wire may lodge or hook under a coupling or other obstruction in the well. The wire can then be loosened by tying it off and waiting for the pump to operate.

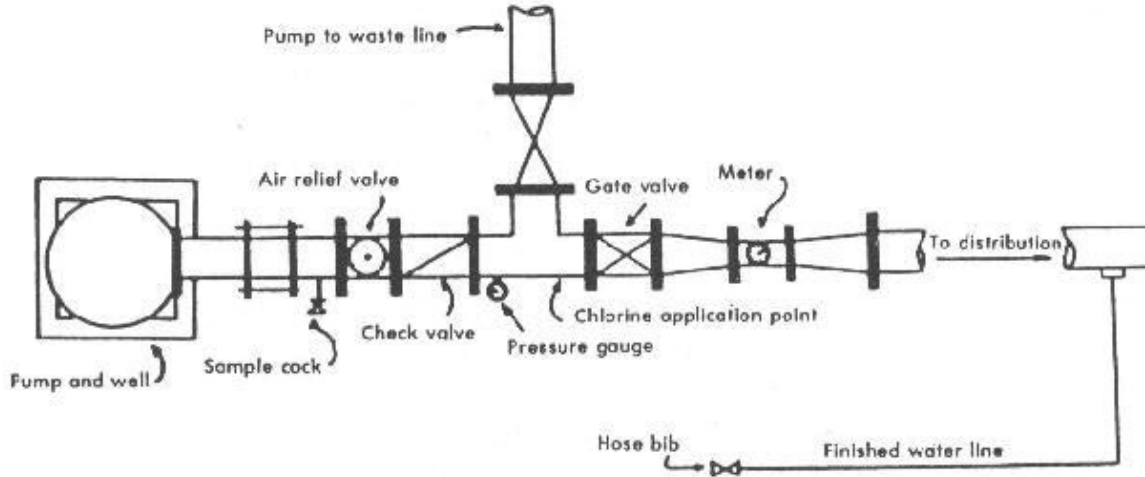
A steel tape

Water levels can be measured accurately with a flat steel measuring tape that has a weight attached to the end. The tape and weight are lowered into the well until the weighted end is below the water level and an even foot mark is opposite some reference point, such as the casing vent or pump base. The tape is removed and the wetted length is subtracted from the foot mark held at the measuring point which gives the depth to water. Carpenter's chalk can be rubbed onto several feet of the tape in advance to make it easier to determine the exact length of the wetted part.

This method should not be used when the pump is operating, when the casing leaks, or when some other problem causes splashing or running water in the well. This can make the water mark on the tape difficult to read.



After the operator has measured the static level of the water in the well, the pump should be run for a time to let the water stabilize and then the pumping level should be taken. It is also important to measure the flow in gallons per minute (gpm) that the pump is producing.



The drawdown is found by subtracting the pumping level from the static level. A historical record of the drawdown can help the operator in deciding on the condition of the well and when maintenance is required. Water yield can change for a variety of reasons, among them the wear of the pump impellers due to sand pumping. Wear on the impellers can cause the pump to move less water. Consequently, the pumping level rises. A decline in the water yield, and a lowering in the pumping level, would indicate that the problem is with the well. A clogged screen or the cave-in of an open-hole well are examples of this type of problem.

The specific yield, or specific capacity, of the well is figured by dividing the flow from the well by the feet of drawdown. An average well will have a yield of 15-40 gpm/foot of drawdown while a poor well will be less than 10 gpm/foot. Rapid change in this yield or a decrease of 75 percent from the original yield indicates that the well needs maintenance. Additional reduction in the yield may leave the well unrepairable.

WELL DISCLOSURE

Before a property is sold or transferred, the seller must disclose the number, location, and status of all wells on the property to the buyer. A Well Disclosure Certificate is filed with the deed at the time of recording. The certificate informs the buyer about wells on the property. A copy of the certificate is sent to the Minnesota Department of Health. If wells are identified that are not in use, the new owner must either have the wells sealed, start using them again, or obtain maintenance permits.

Well Disclosure Statement and Certificate are shown on the following pages.



MINNESOTA DEPARTMENT OF HEALTH

Well Management Unit PO Box 64975. St Paul. Minnesota 55164-0975 (612) 215-0819 or -800-383-9808

WELL DISCLOSURE CERTIFICATE

PLEASE TYPE OR PRINT ALL INFORMATION

Person filing deed must attach a \$20 fee payable to the county recorder.

A. PROPERTY DESCRIPTION

Attach a legal description of the property if the property does not have a lot number, block number, and addition name .

COUNTY	LOT NUMBER	BLOCK NUMBER	ADDITION NAME
STREET ADDRESS			
CITY	STATE	ZIP CODE	P.IN. NO. (OPTIONAL)

B. PROPERTY BUYER MAILING ADDRESS AFTER CLOSING

FIRST NAME	MIDDLE INITIAL	LAST NAME	
COMPANY NAME (IF APPLICABLE)			
ADDRESS			
ADDRESS			
CITY	STATE	ZIP CODE	TELEPHONE NUMBER

C. CERTIFICATION BY SELLER

I certify that the information provided on this certificate is accurate and complete to the best of my knowledge.

Signature of Seller or Designated Representative of Seller _____ Date _____

D. CERTIFICATION BY BUYER

The buyer or person authorized to act on behalf of the buyer, must sign a Well Disclosure Certificate for all deeds given in fulfillment of a contract for deed if there is a well on the property.

In the absence of a seller's signature, the buyer, or person authorized to act on behalf of the buyer may sign this well certificate. No signature is required by the buyer if the seller has signed above.

Based on disclosure information provided to me by the seller or other available information, I certify that the information on this certificate is accurate and complete to the best of my knowledge.

Signature of Buyer or Designated Representative of Buyer

Date

INSTRUCTIONS FOR COMPLETING THE WELL DISCLOSURE CERTIFICATE

A \$20 FEE MUST BE ATTACHED TO THIS FORM WHEN SUBMITTING THIS FORM TO THE COUNTY RECORDER'S OFFICE. THE FEE IS TO BE PAID BY THE BUYER OR PERSON FILING THE DEED. PLEASE MAKE THE CHECK PAYABLE TO THE COUNTY RECORDER.



BUYER, SELLER, AND PROPERTY INFORMATION

- A. **PROPERTY DESCRIPTION** — provide the county, house number, street name, street type, street direction (if applicable), city, and zip code; and, if applicable, the lot number, block number, and addition name (for example, White Pine Addition, block 4, lot 12). If the property is located in a rural area without a lot number, block number, and addition name, attach a complete legal description of the property.
- B. **PROPERTY BUYER MAILING ADDRESS AFTER CLOSING** — provide the buyer's full name (or company name, if buyer is a company), full address, and phone number (including area code). Be sure to include a complete mailing address. If the property is jointly owned, provide the name of a contact person.
- C. **CERTIFICATION BY SELLER OR BUYER** — The seller should sign this certificate before it is submitted to the county recorder's office. If the seller is unable to sign the document, the buyer may sign the certificate before it is submitted to the county recorder's office.

Where deeds are given in fulfillment of a **CONTRACT FOR DEED** the well disclosure certificate **MUST** be signed by the **BUYER**.

WELL INFORMATION

Provide the following information for **EACH WELL BEING DISCLOSED**.

WELL LOCATION

Provide the county name, quartile (one quarter section is required), section number, township number, and range number.

WELL STATUS INFORMATION

Indicate the status of each well. **CHECK ONLY 1 BOX**.

In Use — A well is "in use" if the well is operated on a daily, regular, or seasonal basis. A well in use includes a well that operates for the purpose of irrigation, fire protection, or emergency pumping.

Not In Use — A well is "not in use" if the well does not meet the definition of "in use" above and has not been sealed by a licensed well contractor.

Sealed — A well is "sealed" if a licensed contractor has completely filled a well by pumping grout material throughout the entire bore hole after removal of any obstructions from the well. A well is "capped" if it has a metal or plastic cap or cover which is threaded, bolted, or welded into the top of the well to prevent entry into the well. A "capped" well is not a "sealed" well.

If the well described has been sealed by a licensed well contractor, indicate the year when the well was sealed, if known. If the well is not in use and has not been sealed by a licensed well contractor or a licensed well sealing contractor, check the well status as not in use.

SKETCH MAP

Complete the sketch map as instructed.

NOTE: It a well is not in use it must be SEALED by a licensed well contractor or a well owner must obtain a MAINTENANCE PERMIT from the Minnesota Department of Health and pay an annual maintenance fee of \$100. Maintenance permits are not transferable. If a well is operable and properly maintained, a maintenance permit is not required.



WELL SEALING

Any well no longer in use must be sealed by a licensed well contractor or by a person with a limited well-sealing contractor's license obtained from the Minnesota Department of Health (MDH) unless it is made operable or unless a maintenance permit is obtained from MDH. See Chapter 7 "Rules Related to Wells and Borings" for the specific well sealing requirements. Before sealing a well, the contractor is required to notify the MDH. The contractor has to prepare a Well and Boring Sealing Record and submit it to MDH.

115201



MINNESOTA DEPARTMENT OF HEALTH
WELL SEALING NOTIFICATION
Minnesota Statutes, Chapter 103I

Minnesota Unique No. or W-series No.
(Leave blank if not known)

Minnesota Well and Boring Sealing No.

H

Send or fax notification to: **Minnesota Department of Health, Well Management Unit, P.O. Box 64975, St. Paul, Minnesota 55164-0975**

WELL INFORMATION	County		Township Name		Township No.	Range No.	Section No.	Fraction (etc. → 1/4)		
	Well Location Address					City		State	Zip Code	File Number
	Estimated Depth	Casing Depth	Casing Diameter(s)		Casing Type		Estimated Date of Sealing			
PROPERTY OWNER	Well/Property Owner Name (Print)							Daytime Telephone Number ()		
	Property Owner Street Address					City		State	Zip Code	
CONTRACTOR	Licensed or Registered Contractor (Print)			Contractor Signature			Date		Lic. or Reg. No.	

Notification is required prior to sealing any well. Notification is not required prior to sealing a boring.

HE-01434-02
MDH Fax Number (612) 215-0978
10/95 II