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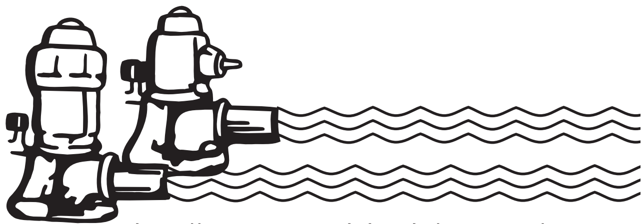

http://www.ext.nodak.edu/extnews/snouts

water spouts

No. 199 SEPTEMBER 2002

Coping with "Hard" Soils

Is there anything I can do to amend my "hard" soils? This question is frequently brought up by irrigators. Hard soils are usually affected by sodium (Na) naturally or by application with irrigation water containing sodium. Unfortunately, most of the irrigation waters that come from aquifers in North Dakota contain varying amounts of sodium.

The first step in dealing with soils that have a tendency to harden with irrigation is to have the irrigation water analyzed for salts and sodium and to have a soil-water compatibility determination made. One place to have this done is the NDSU Soil and Water Environmental Laboratory. This will be the first indication of whether hardening problems may be due to the irrigation water or the soils. Soils vary greatly in their ability to tolerate salts and sodium. Information can be found in NDSU publication EB-68 "Compatibility of North Dakota Soils for Irrigation." North Dakota soils with the lowest tolerance can tolerate salt levels up to 1000 micromhos per centimeter (umhos/cm) and S.A.R. levels up to six. The S.A.R. is the ratio of sodium to calcium (Ca) and magnesium (Mg) in the irrigation water. Soils with the best tolerance can tolerate salt levels of 3000 umhos/cm and an S.A.R. of 12.

It is important to keep in mind that under natural conditions about 1 of 10 acres in North Dakota is affected by salts or sodium. This means that the salts and sodium are naturally a part of the geological materials that soils have formed from and that hard soils do occur in nature without human intervention.

Soil hardening is due to a dispersion of the soil particles by sodium when it displaces calcium and magnesium ions that normally saturate the soil and help maintain its structure. Calcium and magnesium are both soil nutrients that carry 2 positive (+) electrical charges. The soil particles are predominantly negatively (-) charged. Consequently, the opposite charges are attracted and the calcium and magnesium can form "bridges" between soil particles that help maintain soil structure. Sodium, on the other hand, has only one positive (+) charge. It is unable to form the bridges between soil particles and consequently, the soil structure deteriorates.

To regain the soil structure, calcium must be added to the soil to displace the sodium. This sounds simple but is difficult to do effectively. First, a soluble source of calcium must be used in large enough quantities to displace the excess sodium from the soil particles. Once the sodium is displaced, it must be removed by leaching the soil with excess water. Here two problems exist.

Many North Dakota soils have a water table within 6 feet of the soil surface. Under these conditions, salts and sodium are carried up to the soil surface by capillary rise of water from the water table. As water evaporates from the soil surface or is used by crops, the salts and sodium are left behind in the crop rooting zone. Attempting to leach salts and sodium under these conditions is often futile unless the soils are mechanically drained. In undrained soils, the salts can be leached to the water table but again rise to the soil surface after the irrigation is ended and the soils begin to dry and crops begin using the water.

The second problem is that often the hardness is due to a high sodium content of the irrigation water. As additional irrigation water is used, more and more salts and sodium are added to the soil and the problem may become worse.

Amending soils with calcium-containing materials can be successfully accomplished only if adequate subsurface drainage exists to substantially lower the water table and remove the excess irrigation water containing the leached salts and sodium.

Often products are sold that purport to “soften” hardened soils. Most of these are ineffective because proper subsurface drainage in not available for problem soils and the quality of the irrigation water is such that the salts and sodium in the water nullify any beneficial effects of these products.

The best ways to deal with soils that have a tendency to “harden” are:

1. Avoid irrigating soils that have inherently high levels of sodium.
2. Do not use waters with high levels of sodium for irrigation.
3. Irrigate the most tolerant soils with the best quality water available.

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Variable Speed Pump Controller for Irrigation Research

Precision agriculture means the applying of the right amount of inputs at the right time and the right place. Variable-rate fertilizer applications, yield monitors on harvesting equipment, the use of Global Positioning Systems (GPS) and Geographical Information Systems (GIS) is changing the way agricultural research is perceived and conducted. Quantifying the scale and magnitude of variability of water, nutrients, weeds, insects and diseases is a daunting task. The precise application of irrigation water is attempted and is the subject of this article.

Pump and power unit

A pump is the heart of most irrigation systems. A pump converts mechanical energy into hydraulic energy. The hydraulic energy is necessary to distribute water to different locations. The essential requirement in the selection and design of a pump is to ensure that the irrigation system requirements match the pump output. The pump flow rate is expressed in gallons per minute (gpm) and pressure in pounds per square inch (psi). When a pump delivers water you get both gpm and psi — the two terms are inseparable. The most common irrigation pumps are vertical turbines, submersible and centrifugal.

Pumps of various designs and sizes are used to meet different pressure and flow rate configurations. Pressure and flow rates are inversely related. Irrigation pumps which produce high-pressure usually have lower flow rates than pumps which produce large flow rates at low pressure. The flow rate, pressure and the power needed to drive the pump are related to the impeller diameter and the rotational speed of the pump. The relationships between these parameters are called the affinity laws for pump performance. Theoretically, varying the pump speed will change the flow rate and have a domino effect on pressure and brake horsepower requirement. If the pump speed is increased or decreased flow rates will proportionally increase or decrease. As an example, if the speed of the pump is reduced by 10 percent, flow rate will decrease by 10 percent. However, the pressure will decrease by 19 percent and the brake horsepower required will decrease by 27 percent.

Variable speed controller

The power units used in irrigation systems are various types of electric motors and internal combustion engines. Electric motors are designed and rated for constant loads. Internal combustion engines are often derated when used on constant loads for long periods. Typically, an irrigation load is constant. In a research setting the irrigation load may be not constant. Such a situation arose at the NDSU Carrington Research Extension Center.

A two-tower, high-speed, high-volume pivot system was installed in 1999. The pivot sprinkler system is divided into three independently controlled zones that cover equal areas under the pivot. The pivot can be programmed to operate any combination of zones at any location in the field. This affects the power use of the pump because the flow rate and pressure can vary significantly. Water is supplied by a submersible pump rated to deliver 200 gpm at 72 psi. In addition to the pivot, the pump can supply water to a gravity system and a hand-moved solid-set sprinkler system. In the future, the pump may also be used to supply water to a pressurized pipeline for micro-irrigation systems. To solve the problem of varying flow rates and pressures, a variable-speed motor controller was installed to provide the operational flexibility.

The variable-speed motor controller was purchased with a grant from the U.S. Bureau of Reclamation’s Water Conservation Field Services Program. This program demonstrates water conservation methods that can be implemented by irrigators. Installation assistance was provided by Dakota Pumps and Controls of Watertown, South Dakota. ITT Industries, manufacturers of the Goulds submersible pump, provided the AQUAVAR II variable-speed pump controller. A pressure transducer attached to the pipeline about 15 feet from the pump provided a feedback signal to the controller.

We tested the system with a portable power meter and an ultrasonic flow meter. The two-tower pivot has three zones that we can program to turn off or on. First, we tested the system as it is currently run, at full pressure without the controller. The results are shown in Table 1.

Table 1. Flow rates, power use, and pressure at different zones of the two-tower pivot system.

Number of Zones on	Flow Rate	Pump Power Use	Pressure at Pump
	(gpm)	(kW)	(psi)
3	200	11.8	70
2	146	10.6	90
1	88	9.4	97

Then we tested the system in the same way but with the variable-speed motor controller programmed to maintain pipeline pressure at 40 psi. The results are shown in Table 2.

Table 2. Flow rates, power use, and motor frequency with the variable speed motor controller set to run at constant 40-psi pressure at the pump.

Number of Zones on	Flow Rate	Power Use	Motor Frequency
	(gpm)	(kW)	(Hz)
3	200	8.4	53
2	146	6.2	48
1	88	4.9	44

The test revealed that the controller operated at constant pressure with different zones open. Based on these results, over the course of a growing season, there should be a considerable reduction in power costs.

Benefits

Installation of the variable-speed motor controller was simple and the operation relatively easy. The menu-driven step-by-step programming is user friendly. The safety features to protect against low voltage and phase loss are added features. Because the speed of the pump impeller determines the pump pressure, flow rate and energy consumption, reducing the speed decreases energy use. By keeping the pump pressure constant, operational flexibility is enhanced. In the future, the hand-moved sprinkler and micro-irrigation systems could be run at the same time as the pivot zones with a single pump.

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Annual Chlorination Keeps Wells Productive

Keeping the well productive is the key to an efficient irrigation system when the water source is groundwater. Most groundwater in North Dakota contains small amounts of iron, which provide energy for the growth and development of iron bacteria. These bacteria form a slimy, gelatinous mass on the well screen, casing, pump and in the aquifer surrounding the well screen. If your irrigation equipment has a rust color due to the water or the water has a rotten egg smell, then growth of iron bacteria in the well is a good possibility.

As iron bacteria spread in the well, they reduce the amount of open area of the screen and the open area of the spaces in the aquifer formation, thus reducing the well yield. Reduced well yield will affect the operation of the irrigation system and could reduce yields, especially with high value crops like potatoes. The only way to effectively control iron bacteria is by chlorinating the well on an annual basis.

The object of well chlorination is to raise the chlorine level in the well to 500 parts per million (ppm) and hold it there for at least 24 hours to allow the chlorine to attack and kill the bacteria. It is especially important to also get the chlorine out into the aquifer material surrounding the well screen, Figure 1.

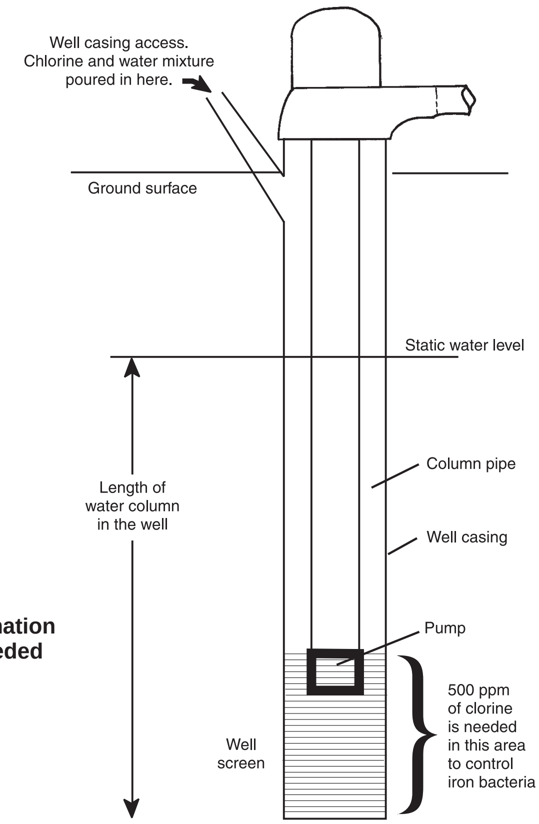

Figure 1. Annual chlorination of a well is needed to control iron bacteria.

The two common sources of chlorine used in well chlorination are household bleach, which contains about 6 percent chlorine, and a dry form of calcium hypochlorite sometimes called HTH. The dry form can be pellets, granules or powder and often contains about 70 percent available chlorine. It can be purchased from swimming pool companies, well drillers and some irrigation dealers. I recommend using common household bleach for a couple of reasons. Chlorine is a noxious and dangerous gas. Household bleach is the safest form of chlorine to handle because of its low level of chlorine. Second, it is easy to obtain as almost all grocery and convenience stores have it in stock.

Irrigators with oil-lubricated, deep-well turbine pumps should be especially careful if they use the dry form to chlorinate their wells. It is common for these wells to have a layer of oil on top of the water. Mixing chlorine and oil can have explosive results, therefore if a granulated or pellet form of chlorine is used for chlorination, mix it with a suitable amount of water before pouring into the well.

It is important to chlorinate the well before you pump out your pipelines for the winter. Use the following procedure to chlorinate your well(s).

1. Determine the depth of water standing in the well. This is the total well depth minus the depth to static water.
2. From Table 1, determine the amount of chlorine needed. For example; if you have a 12-inch diameter well 100 feet deep and the static water level is at 20 feet. The column of water is 80 feet deep. The amount of chlorine bleach

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Table 1. Quantities of chlorine material to use for each 10 feet of water in the irrigation well.

Well Diameter	Gallons of Water in a 10-ft column	HTH 70% Chlorine	Bleach 6% Chlorine
(inches)		(pounds/10 ft)	(gallons/10 ft)
6	15	0.1	0.1
8	26	0.16	0.2
10	41	0.24	0.3
12	59	0.35	0.5
14	80	0.5	0.7
16	105	0.6	0.9
18	133	0.8	1.1
20	164	1.0	1.3
24	235	1.4	1.9

needed is 8 x 0.5 gal/10 ft or 4 gallons. The amount of HTH needed would be 8 x 0.35 pounds/10 ft or 2.8 pounds.

3. Introduce the chlorine into the well. Use protective gloves and goggles because chlorine solutions this strong can cause skin burns.
   a. If you are using liquid bleach, mix with at least 50 gallons of water and pour into the well. Add another 100 gallons of water or more to distribute the chlorine mixture throughout the well.
   b. If you are using chlorine pellets, **granules or powder**; dissolve slowly by mixing with 50 gallons of water or more. Pour slowly into the well. Add another 100 gallons of water or more to distribute the chlorine mixture throughout the well.
4. Surge the water in the well by starting and stopping the pump. Don't allow much water to discharge from the well. This action is called "rawhiding" a well. Do this at least four times. **Caution:** Don't start the pump while it is rotating in the reverse direction.
5. **Let the chlorine stand in the well for 24 hours. Chlorine needs time to kill iron bacteria.**
6. Surge the well at least two more times then pump the water to waste. This water can be quite dirty and might plug sprinklers or pressure regulators on center pivots. If you pump it through a center pivot, remove the sand trap plug. Stand upwind because the chlorine smell could be strong. Pump until the odor of chlorine is gone.

By chlorinating your well annually the production of the well should stay close the production to when it was drilled.

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