Pipeline

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National Small Flows Clearinghouse

Small Community Wastewater Issues Explained to the Public

Water Softener Use Raises Questions for System Owners

Parts of the U.S. have what is commonly referred to as “hard water,” and people who live in these areas battle the problems that hard water creates. The most common defense against hard water, which is a nuisance but not a health hazard, is to install a home water softener.

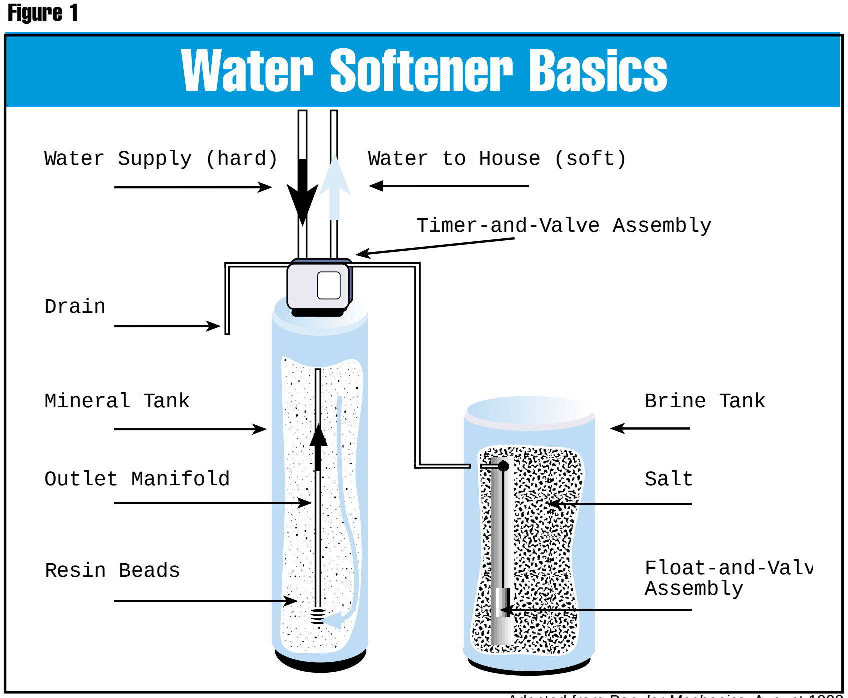
Water softening involves exchanging calcium and magnesium minerals present in the water—which cause the hardness—with sodium. As the water softener processes gallon after gallon of hard water on a daily basis, the treatment capability of the softener becomes depleted and must be recharged or regenerated. (*The complete water softening process is explained beginning on page 2.*)

Regenerating the unit uses a large quantity of sodium-rich water, called “brine,” that must be disposed of. In homes with onsite septic systems, this brine flows into the septic tank and eventually makes its way to the system’s drainfield.

People using home water softeners often wonder whether these units might cause problems for their onsite septic systems. Some common questions consumers ask are:

- Do water softeners hurt the bacteria that work in a septic tank?
- Does the additional amount of water from water softener regeneration affect a septic system’s performance?
- Does the concentrated salt water used in regeneration decrease the drainfield’s ability to absorb wastewater?

Figure 1



Adapted from *Popular Mechanics*, August 1998

Unfortunately, experts don’t all agree on the answers to these questions. Research has been done that resulted in acceptable conclusions to many people in the industry, but some authorities believe that more studies are needed to determine what impact, if any, brine has in a septic system.

Because of these differences of opinion, this *Pipeline* issue is unlike most others. Ordinarily we offer information that gives readers concrete answers. But because water softener brine disposal remains somewhat controversial, *Pipeline* will provide opinions on the research that has been done to date.

We know people want information about this subject. At this point, our mission is to help readers become better educated consumers so that they can make informed decisions when trying to resolve their hard water problems. Some steps that homeowners can take to minimize their concerns about the safe operation of their onsite sewage systems are included.

Readers are encouraged to reprint this issue or any *Pipeline* articles in flyers, newspapers, newsletters, or educational presentations. Please include the name and phone number of the National Small Flows Clearinghouse (NSFC) on the reprinted information and send us a copy for our files.

If you have questions about reprinting articles or about the topics discussed in the newsletter, please contact the NSFC at (800) 624-8301 or (304) 293-4191.

What makes water hard?

And how does it become soft?

As water flows through layers of rock underground, it picks up loose particles and dissolves minerals from its surroundings. Because of this characteristic and the kind of rock common in many aquifers, calcium and magnesium minerals are frequently found in household water. Water with substantial amounts of calcium and magnesium is referred to as "hard water."

Hard water minerals reduce water's ability to function effectively in our homes. For instance, bath soap combines with the minerals and forms a pasty scum that accumulates on bathtubs and sinks. Homeowners must use more soap and detergent in washing, so expense for these products increases.

These minerals also combine with soap in the laundry, and the residue doesn't rinse well from fabric, leaving clothes dull. Hard water spots appear on everything that is washed in and around the home—from dishes and silverware to the family car.

Hard water not only affects household cleaning, but the minerals also can build up on the inside of pipes in the plumbing system. And in water heaters, the minerals settle on the heating element, the walls of the tank, in the hot water pipes, and in faucets where they produce a scale (similar to the original rock) that reduces the efficiency and life of the hot water system.

Water Softeners Make Water Work Better

Water softeners combat this nuisance by eliminating the minerals that cause hard water. The most common kind of water softener is a mechanical appliance plumbed directly into the home's water supply intake. (*See figure 1 on page 1.*) The water softener exchanges calcium and magnesium with sodium in a process called ion exchange.

The water softening system consists of a mineral tank and a brine tank. The water supply pipe is connected to the mineral tank so that water coming into the house must pass through the tank before it can be used.

The mineral tank holds small beads (also known as resin) that carry a negative electrical charge. The positively charged calcium and magnesium (called ions) are attracted to the negatively charged beads. This attraction makes the minerals stick to the beads as the hard water passes through the mineral tank. (*See figure 3 on page 3.*)

continued on next page

Home septic systems

Knowing how a septic system works helps homeowners understand why adding something like water softener regeneration brine may cause problems.

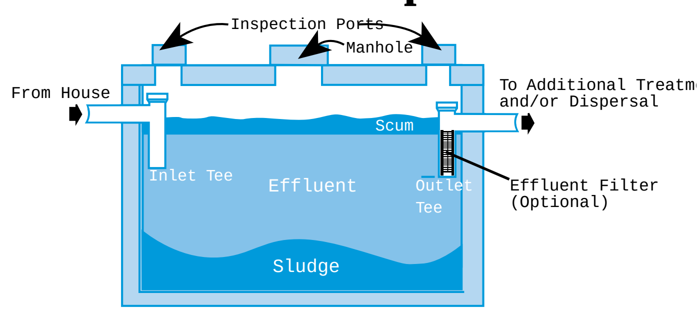
A conventional septic system consists of a septic tank, a distribution box, and a drainfield, all connected by pipes. When wastewater flows from the house, it is temporarily held in the septic tank where heavy solids (sludge) settle to the bottom. Lighter materials float on the surface of the water in the tank and are called the scum layer. This separation is known as *primary treatment*.

The solids that collect in the bottom of the tank and the materials that float in the scum layer are partially decomposed with the help of bacteria that occur naturally in human waste. The liquid between the solids and the scum flows out of the tank through a baffle (or a tee) and into a distribution box. The distribution box evenly separates the flow into a network of drainfield pipes. Each pipe has holes in its underside that allow the water to drain into gravel-filled trenches. The water slowly seeps into the soil beneath the trenches where it is further treated. This process is called *secondary treatment*.

Important note: As sludge accumulates in the bottom of the tank and its level rises, new wastewater coming from the house has less time for suspended particles to settle into the sludge layer. These suspended particles can flow into the absorption field.

The septic tank must be pumped out periodically to remove the accumulated sludge and scum and to prevent clogging the drainfield.

Conventional Septic Tank



Single Compartment Septic Tank

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Eventually the surfaces of the beads in the mineral tank become coated with the calcium and magnesium minerals. To clean the beads, a strong sodium (salt) solution held in the brine tank is flushed through the mineral tank. Sodium ions also have a positive electrical charge, just not quite as strong as that of calcium and magnesium. This large volume of sodium ions overpowers the calcium and magnesium ions and drives them off of the beads and into the solution. The sodium solution carrying the minerals is then drained out of the unit. Some sodium ions remain in the tank attached to the surfaces of the beads.

The Softening Process

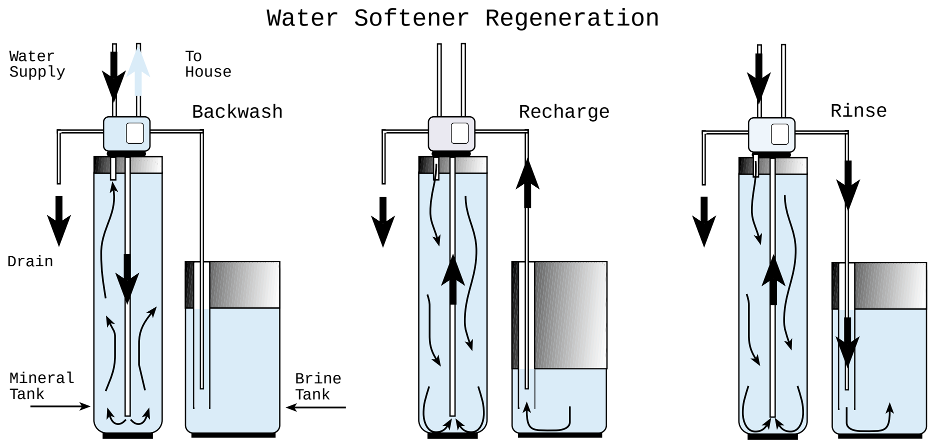
The normal water softening cycle operates like this:

Hard water enters the mineral tank. Inside the tank, the calcium and magnesium ions carried in the water attach themselves to the beads. The surfaces of the beads eventually hold their limit of calcium and magnesium and can't remove any more from the water. At this point the water softener must be "regenerated." (*See figure 2 this page.*) The three-step regeneration cycle can be scheduled according to a timer or by a flow detection meter.

The first step, called the backwash phase, reverses the water's flow and flushes any accumulated dirt particles out of the tank and down the drain. Next, in the regeneration or recharge phase, the sodium-rich brine solution flows from the brine tank into and through the mineral tank. The brine washes the calcium and magnesium off the beads. In the final phase, the mineral tank is flushed of the excess brine, which now also holds the calcium and magnesium, and the solution is disposed of down the drain.

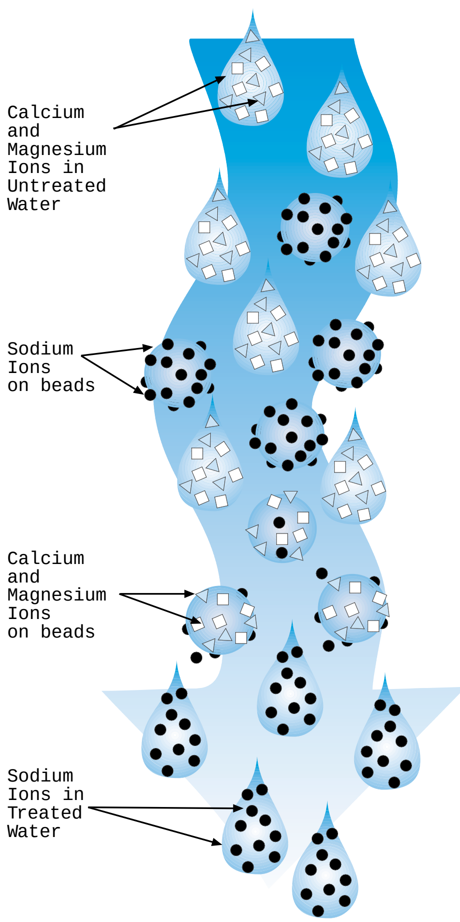
Sodium ions from the previous regeneration cycle cling to the beads. Now when the hard water flows into the mineral tank, the calcium and magnesium ions change places with the sodium ions on the resin. The displaced sodium ions remain dissolved in the water.

Figure 2



Adapted from *Popular Mechanics*, August 1998

Figure 3



Reducing regeneration brine flow

- Install a water softener whose backwash/regeneration cycle is based on need, not on a timer. A water softener operated by a time clock regenerates the mineral tank on a regular schedule, regardless of how much water has been used. A softening unit that is regulated by a flow detection meter measures the amount of water that has been used and regenerates the water softener accordingly. These units can cost $100 to $450 more than timer-regulated water softeners.

- Buy a water softener with a large mineral tank. The larger tank may cost more initially, but it will not have to be recharged as frequently as a smaller tank.

- Be more conservative with household water use. Less water used in the home means that less water will be measured going through the softener process; therefore, a unit with a flow detection meter won't have to regenerate as often.

Researchers Look for Answers

The Water Quality Research Council and the Water Quality Association (WQA) supported two studies in the late 1970s: one by the National Sanitation Foundation (NSF International) in Ann Arbor, Michigan, and the other conducted by the Small Scale Waste Management Project (SSWMP) at the University of Wisconsin in Madison. Both studies compared the performance of home sewage treatment systems with and without added water softener brine.

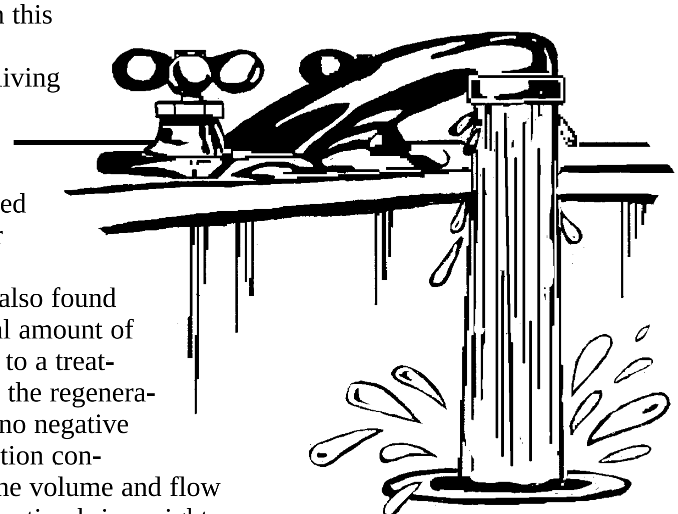
The two studies were designed to help answer questions consumers ask about their water softeners. The SSWMP research sought to determine if a water softener's brine affects a drainfield's ability to absorb wastewater. NSF investigated whether the influx of brine from a water softener's regeneration phase affects the processes that occur in a sewage treatment tank. Researchers also wanted to find out if the additional water discharged during backwash and regeneration (up to an extra 50 gallons) plus that water's flow rate into the septic tank interfere with the settling and floatation processes.

NSF's researchers used individual aerobic wastewater treatment units to study possible effects the brine might have on treatment processes in the tank. (*See the Winter 1996* Pipeline *for details about aerobic treatment units.*) The normal performance of both septic tanks and aerobic tanks depends on the presence of active bacteria living in the system. These bacteria help break down the solids in the wastewater.

An aerobic treatment system uses bacteria that require oxygen to live; whereas, an anaerobic system, such as a conventional septic tank, treats wastewater by using bacteria that thrive in conditions lacking air. If high doses of sodium from water softener regeneration and other household products flow into the tank, the bacteria could be affected. If the bacteria are negatively affected, the system might not operate at its full potential, and some of the solids might not fully decompose.

Research Results

Researchers from NSF found that brine wastes had no negative effects on the bacterial population living in the aerobic treatment tank, even when the system was loaded with twice the normal amount of brine. The tests determined that water softener wastes actually help with treatment processes. WQA's final report states that the wastewater has "a beneficial influence on a septic tank system by stimulating biological action in the septic tank and caused no operational problems in the typical anaerobic or the new aerobic septic tanks." In other words, the researchers in this study found that microorganisms living and working in a home aerobic treatment system are not harmed by water softener salts.



Researchers also found that the additional amount of water discharged to a treatment tank during the regeneration process had no negative impact. The question concerned whether the volume and flow rate of the regeneration brine might overload the system and cause carryover of solids into the drainfield. The study found that the volume of water discharged was comparable to or less than that from many automatic washing machines and other household appliances. Researchers also found that the wastewater flowed into the treatment tank slowly enough so that it caused minimal disturbance.

The study at the University of Wisconsin-Madison examined whether regeneration brine affected the soil in a septic system's drainfield. This research was prompted by the common knowledge that sodium causes some soil particles to swell, thereby reducing water's ability to seep readily through the soil. Researchers found that the water softener regeneration brine did not reduce the percolation rate of water in the absorption field of a normally operating septic system. This conclusion was reached because the brine contains sodium, but it also includes significant amounts of calcium and magnesium. The calcium in the brine acts similarly to gypsum, a calcium-rich substance routinely used to increase the porosity of clay soils in agriculture. The research report stated that calcium, therefore, helps counteract any negative effects of the sodium.

Most manufacturers and many industry experts agree with the WQA's position.

Some Experts Don't Agree

As with most scientific research, these two studies answered each of the proposed questions under the specific conditions of the research project. Because other variables exist that weren't part of the study's setup (e.g., problems that might occur because of a poorly functioning home water softening unit) some people feel that more research needs to be done to completely resolve the disputed issues.

The NSF study, for example, used an aerobic treatment tank rather than an anaerobic tank (a conventional septic tank). Conventional septic systems are much more common than aerobic treatment units. An aerobic system often has a pretreatment tank to settle out much of the solids. Aerobic systems require air to be injected into the tank to support the growth of the suspended aerobic bacteria that digest solids in the wastewater. The wastewater in the tank is constantly stirred to mix in the air.

On the other hand, a conventional septic tank separates solids from wastewater by settling. In a properly functioning conventional system, most of the solids sink to the bottom of the tank leaving the liquid portion relatively clear. The anaerobic bacteria do their work without the wastewater in the tank being agitated.

Would the same results have been found if a conventional septic tank had been used? National Small Flows Clearinghouse Senior Engineering Scientist David Pask remains skeptical. He tells of residential drainfield failures that he has seen where the distribution pipes were plugged with "a noxious fibrous mass" that, under microscopic inspection, appeared to be made up of grease and cellulose fibers—identical to fibers from toilet paper.

Pask said the homes all had ion exchange water softeners connected to their water supplies, and softener brine discharged into each home's septic system. His discussion of the situation with colleagues led him to question if the sodium in the "plug flow" of brine might cause metabolic shock to the bacteria in the septic tank. This shock could cause the bacteria to be less able to digest the cellulose fibers, which then might be carried over into a septic system's drainfield.

"I still believe that the case for discharge of softener wash to the septic tank is unproven and that some research is justified," Pask said. "As for research needs . . . I would add to the list the effects of plug flow of brine on the digestion of cellulose and scum components in a standard septic tank."

Terry Bounds, an engineer and respected expert in the wastewater industry, also would like to see more research done before any conclusive statements are made about the effects of water softener regeneration brines in septic systems. In the summer 1994 issue of *Small Flows* (the precursor of the *Small Flows Quarterly* magazine) Bounds stated that in his work he has seen noticeable differences between septic tanks with and without water softener brine discharges in septic tank effluent pump (STEP) systems (an alternative wastewater collection and treatment method) and in conventional systems. Bounds said that in the tanks with added water softener discharge, he saw reduced scum layer development, carryover of solids and grease to the pressure sewer collection system, and a less distinguishable "clear zone" that might mean solids remain suspended instead of settling in the tank.

Today, Bounds contends that research has focused on water softener discharge of regeneration brine under ideal conditions. Water softeners that malfunction or are not used correctly (i.e., timed to regenerate too frequently) may cause septic system problems.

"Our experience with regard to the operation and maintenance of systems that discharge water softener backwash to septic tanks is that it has a detrimental effect on the effluent that is discharged," Bounds said. "As a researcher, I believe that when 'all' the variables and processes are evaluated and monitored, measured performance and science will share close results. So far, I have seen no research that compares to typical environmental engineering sciences in anaerobic digesters. Most of the reports that I've seen suggest that this research still needs to be done."

CONTACTS

National Small Flows Clearinghouse (NSFC)

The NSFC offers a variety of technical assistance and free and low-cost information and materials about wastewater technologies for small communities. Just a few of the NSFC's many resources and services are mentioned in this newsletter. Call the NSFC at (800) 624-8301 or (304) 293-4191 or visit our Web site at *www.nsfc.wvu.edu* for more information.

Water Quality Association

The Water Quality Association (WQA) is the international trade association representing the household, commercial, industrial, and small community water treatment industry. WQA is a resource of information, product testing, and professional certification for all water users. Contact the WQA at (630) 505-0160 or visit their Web site at *www.wqa.org*.

NSF International

(formerly called the National Sanitation Foundation)

NSF International is a private, nonprofit organization devoted to research, education, service, and training. NSF tests and publishes standards for products related to public health and the environment. Contact them at (800) 673-6275 or visit their Web site at *www.nsf.org*.

Thank You!

Thank you to all who responded to *Pipeline's* readership survey. Your answers, observations, and suggestions will help determine how we can best serve you in the future.

Michelle Moore, Editor

An Alternative to Softening with Sodium

If you are concerned about water softening brine and its possible effects on your septic system (and the environment), an alternative chemical can be used. Potassium chloride is as effective as sodium chloride for water softening in both residential and commercial processes. Plus, using potassium chloride has several benefits: it reduces the amount of sodium in drinking water; the treated water contributes potassium to people's diets; and it eliminates the addition of sodium from water softeners into a household's septic system tank and drainfield.

Potassium chloride works exactly the same way that sodium does in the water softening process. The mineral tank is flushed with potassium (instead of sodium) from the brine tank to coat the resin beads. With its positive electrical charge, the potassium clings to the negatively charged resin beads in the tank. As hard water passes through the softener's mineral tank, the calcium and magnesium in the water change places with the potassium on the beads.

The treated water now has a small amount of potassium in it. The mineral tank will eventually need to be regenerated when most of the potassium adhering to the resin beads has been exchanged for the calcium and magnesium carried in the water.

The regeneration process flushes the mineral tank with a potassium chloride solution that drives the calcium and magnesium minerals off the resin beads. The excess potassium-, calcium-, and magnesium-rich water in the tank is then discharged into the home's drain pipes and into the septic system.

The regeneration brine mixes with the standing water in the tank, then eventually flows into the system's drainfield. Potassium is an essential mineral for plants; whereas, sodium can damage plant tissues. Because sodium is replaced by potassium, this diluted wastewater is beneficial to a grass-covered drainfield.

> *"Sodium really has no redeeming value in the environment outside of saltwater or brackish water ecosystems. If alternatives to sodium chloride for water treatment can be developed, they should be used. Potassium chloride is a logical choice to reduce sodium discharge from water softening systems, to provide additional potassium in human diets, and to serve as a nutrient source for plants."*
>
> *From "Potassium Chloride: Alternative Regenerant for Softening Water" by Dr. Kim Polizotto and Dr. Charles Harms*

Wastewater from water softeners that use potassium chloride in their regeneration brine can be recycled to irrigate agricultural land. An article titled "Potassium Chloride . . . Alternative Regenerant for Softening Water," written by Dr. Kim Polizotto and Dr. Charles Harms for the Potash and Phosphate Institute's *Better Crops with Plant Food* (Fall 1993), suggests using potassium in water softening units and then recycling the diluted wastewater as an alternative to disposing of it.

Polizotto and Harms mention that several cities in California, Florida, and Michigan have called upon the water softener industry to help reduce sodium and chloride discharge into municipal sewage treatment facilities. Reduction of these chemicals is necessary to meet discharge standards set to decrease groundwater pollution in those communities.

These researchers also tell of other towns that want to develop secondary markets for their wastewater, such as selling it to farmers for irrigation purposes. Because sodium may harm some plants' growth, wastewater from treatment plants might not be marketable if sodium chloride is the predominant salt used for water conditioning in the community.

Cost may be the only drawback in switching from the standard sodium chloride used in most water softeners to potassium chloride. Both can be found in most retail home improvement centers, but the potassium chloride can cost up to twice as much (even more on the West Coast) as the sodium chloride. The average price of sodium chloride (in the East) is around $4 for a 40-pound bag, and potassium chloride costs approximately $9 for 40 pounds. However, consumer group studies show that, for many potential users, the health and environmental benefits of potassium chloride outweigh the price difference.

Priddis Greens Golf Course Case Study

Photo courtesy of Priddis Greens Golf and Country Club

One of Canada's premier golf courses, Priddis Greens Golf and Country Club near Calgary, Alberta, was having trouble keeping its north course greens up to par. The grass growing on this nine-hole stretch of the golf course just wasn't growing as well as the turf on the rest of the property.

The water supply for the golf community comes from nearby Priddis Creek and from an aquifer-fed well on the property. Some of the greens also are irrigated from a 7.2 million-gallon holding pond located at the golf course. It was discovered that the poorly growing grass on the north course was being watered from this pond.

The holding pond contains recycled water collected from the 116 homes bordering the golf course. The golf community's small sewage treatment plant upgrades the quality of the residential wastewater to a standard that is suitable for irrigation.

The golf course superintendent checked a water analysis from the pond and found a high proportion of sodium in the water, 376 milligrams per liter (mg/L). In contrast, well water on the property had a sodium content of 35 mg/L. The superintendent suspected that sodium discharge from residential water softeners caused the sodium problem in the irrigation water, which in turn caused the problems with the north course's turf.

Priddis Greens maintains a cooperative service arrangement between the residents and the golf course, and they knew the quality of the irrigation water had to improve. They decided that individual water softening units in the golf community's homes significantly added to the buildup of sodium in the recycled water due to these factors:

- using older, inefficient water softener models;
- setting softeners to regenerate more frequently than necessary; resulting in excess sodium being discharged; and
- using timers instead of demand-initiated regeneration.

The service management of Priddis Greens decided to remove all the water softeners from the individual homes in the golf community. Instead, a central softening system at their water utility plant would supply residents and the club house with soft water. And with the change to a central softening system, Priddis Greens began softening their water with potassium chloride instead of sodium chloride.

Soil and water samples were taken before the switch to potassium chloride and again three years after the change. These tests showed a decline in sodium content in the irrigation water from the treatment plant, as well as in the water from the well on the golf course property. (*See figure 4.*) The sodium content in the softened water dropped slightly also, indicating that the potassium on the resin of the softening system was removing some sodium from the well water.

Ultimately, the change from the less efficient residential water softeners to a central softening system, plus the switch from sodium chloride to potassium chloride, helped this golf community. People living in the community—and the grass growing on the north course—had less salt added to their diets, which is beneficial to both. And since potassium is a major plant nutrient, the golf course greens now receive additional potassium when they are irrigated with the recycled water from the homes. This nutrient contribution has subsequently reduced the golf course's fertilizer program cost.

Figure 4

Analysis of Irrigation Water for Priddis Greens' North Course

Component (mg/L)	Before KCl	After KCl	Surface Water
Chlorine	486	68	33
Sodium	376	66	14
Potassium	35	107	12
Calcium	81	42	74
Magnesium	28	11	22
Total dissolved solids	1586	738	475

(KCl=Potassium chloride)

Information taken from "Priddis Greens Golf and Country Club Recycled Water Irrigation Research Project" presented at the Pacific Water Quality Association mid-year conference, May 2000.

RESOURCES AVAILABLE FROM NSFC

To order any of the following products, call the National Small Flows Clearinghouse (NSFC) at (800) 624-8301 or (304) 293-4191, fax (304) 293-3161, e-mail nsfc_orders@mail.estd.wvu.edu, *or write NSFC, West Virginia University, P.O. Box 6064, Morgantown, WV 26506-6064. Be sure to request each item by number and title. A shipping charge will apply.*

Wastewater Products Catalog

This newly updated catalog lists and describes the many products and services that the NSFC offers. The catalog may also be downloaded from the NSFC Web site at *http://www.nsfc.wvu.edu* or is available free upon request. Item #WWCAT.

Potential Effects of Water Softener Use on Septic Tank Soil Absorption Onsite Wastewater Systems

These two research projects were performed to see if the salt-brine discharge from water softener regeneration is harmful to bacteria in septic tanks and if the brine reduces the percolation of water through the soil in drainage fields. Both studies found that water softener recharge wastes caused no adverse effects to onsite treatment systems. The cost for the 100-page book is $7.60 cents. Item #WWBKRE21.

Your Septic System: A Guide for Homeowners

This 11-minute video discusses conventional septic system components, operation, and maintenance. It covers 10 basic rules for homeowners to follow.The videotape costs $10. Item #WWVTPE16.

The Care and Feeding of Your Septic System

This free NSFC brochure describes septic tanks and absorption fields and provides guidelines to prolong their usefulness, such as when to have your septic tank pumped and ways to reduce the flow of wastewater. Item #WWBRPE20.

Groundwater Protection and Your Septic System

Along with ways to prevent contaminants from reaching the groundwater, this free brochure discusses groundwater protection based on proper septic system sizing and location. Item #WWBRPE21.

Your Septic System: A Reference Guide for Homeowners

This free brochure for homeowners describes a conventional septic system and how it should be cared for to achieve optimal results. Tips for trouble-free operation are provided. Item #WWBRPE17.

PIPELINE

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