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Water Quality

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Water quality in Illinois has improved significantly over the past 30 years. The most recent report from the Illinois Environmental Protection Agency rated 61% of the state's streams as good, 35% as fair, and 4% as poor. (For more information see the *Illinois Integrated Water Quality Report and Section 303d List—2008*, available online at www.epa.state.il.us/water/water-quality). Agriculture, however, continues to be identified as a primary source of water-quality impairment. Strategies for protecting water quality include voluntary approaches, incentive-based programs, and increased regulations.

Pesticides and fertilizers are often cited as examples of agricultural contaminants, but soil erosion continues to be a primary cause of water-quality problems. According to Natural Resources Conservation Service estimates, more than 900 million tons of agricultural soils were lost by sheet and rill erosion in 2003. In addition to minimizing agricultural chemical loss, sediment reduction should be a major component of water-protection efforts.

Illinois farmers have a great stake in protecting drinking-water quality because they often consume the water that lies directly under their farming operation. Their domestic water wells are often near agricultural operations or fields and thus must be safeguarded against contamination. In addition, surface water supplies, many of them sources of public drinking water, need to be protected. As a result, appropriate chemical selection and crop management decisions are needed to ensure good water quality.

Drinking-Water Standards

All public water supplies must sample quarterly for regulated contaminants, including several pesticides. Maximum contaminant levels (MCLs) have been established for more than 30 pesticides and pesticide metabolites. For example, the current MCL for atrazine is 3 parts per billion. Eventually, MCLs will be established for all pesticides.

Compliance with the federal standards is based on an average of four quarterly samples. If standards are exceeded, water customers are notified by local media and subsequently on their water bills. If a water source is in violation, no additional water permit extensions can be issued until the problem is addressed. Solutions might include blending with an uncontaminated supply, extensive decontamination treatment, or finding an alternative supply. The additional water-treatment expense can be prohibitive to small communities, underscoring the importance of agriculture management practices that reduce the entry of herbicides and nutrients into the aquatic system.

Results from surface-water and well-water samples suggest that atrazine is the herbicide most likely to appear in surface water, but it does not appear to be widely found in well water at levels above drinking-water standards. Some of this is attributed to increased stewardship, but the decrease in violations also results from communities installing carbon filtration systems to meet water-quality standards. Nitrate contamination is often associated with shallow wells and surface water and may be an indication of movement of fertilizers, manures, and other wastes into these water supplies. In addition, tile drainage is a primary route for nitrate to reach surface water. The greatest challenge facing Illinois producers may be to keep herbicides and nutrients out of surface-water supplies. Management practices that reduce runoff concentration and volume may help.

Consumer Confidence Reports

Since 1999, all public water supplies have been required to provide customers with an annual report on drinking-water quality. These "consumer confidence" reports were developed by the U.S. Environmental Protection Agency (USEPA) in consultation with water suppliers, environmental groups, and individual states. They are intended to provide consumers with important information about the quality of their drinking water.

Each report includes information about the source of drinking water (for example, lake, river, or aquifer) and whether it meets federal drinking-water requirements. It indicates how susceptible this local drinking-water source is to contamination and identifies potential sources of contamination. It lists the contaminants detected in the water supply and outlines the potential health effects of any contaminant found in violation of an EPA health standard. Finally, the report tells consumers where they can go for more information on water quality and how to get a copy of the water system's complete source-water assessment.

In addition, any community water system that serves more than 100,000 people is required to make its consumer confidence report available to customers on a publicly accessible website. A listing by state is available at www.epa.gov/safewater/ccr/whereyoulive.html. More information can be found on the EPA's drinking-water website (www.epa.gov/ogwdw) or from the Safe Drinking Water hotline (800-426-4791).

Testing Private Wells

Although public water supplies are closely regulated and must meet EPA standards, private wells are not required to be tested. If the main source of your drinking water is a private well, it is your responsibility to test the water on a regular basis. Water testing can be done by the Illinois Department of Public Health or by private labs. A list of laboratories accredited by the Illinois EPA to test home drinking water is available at www.epa.state.il.us/well-water/list-accredited-labs.html.

A basic test analyzes water for two common contaminants, coliform bacteria and nitrate. The best time to test for these contaminants is during spring or summer following a period of heavy rainfall. The same testing should also be conducted after repairing or replacing an old well and after installing a new well or pump.

Coliform bacteria are an indicator of overall water quality. If they are detected in a water sample, there is some degree of contamination, and other organisms may also be present. A survey of private drinking-water wells in Illinois found that 44% tested positive for coliform bacteria. Although chemical disinfectants such as chloride tablets or bleach can be used to treat wells, it is important to identify potential sources of contamination. Contamination may come from soil or surface water, or there may be problems with well construction or location. Occasionally, public water supplies may issue a "boil order" if bacterial contamination is suspected. Five minutes of vigorous boiling is an effective way to kill most pathogens.

High nitrate levels in water are a concern for pregnant women and infants under 6 months of age. The standard for nitrate–nitrogen in drinking water is 10 parts per million. Boiling water does not reduce nitrate levels; in fact, it makes the problem worse because some of the water evaporates during boiling and the nitrate concentration in the remaining water increases. If tests show that nitrate–nitrogen levels exceed 10 parts per million, water should not be consumed by pregnant women or infants under the age of 6 months. Use an alternate water source, such as bottled water. Two publications about water testing are available from local University of Illinois Extension offices.

Planning Your Well: Guidelines for Safe, Dependable Drinking Water (Land and Water Publication #14) provides information about water quality, planning and installing a well, and understanding geologic conditions that affect groundwater.

Safe Drinking Water: Testing and Treating Home Drinking Water (Land and Water Publication #17) contains information about water testing, types of contaminants, and treatment devices that are available. Water testing is only part of a well owner's responsibility. Reducing risk from potential contaminants is also important. Septic systems, for example, should be properly maintained to minimize the chance of groundwater contamination.

In some studies, the highest levels of contamination are often from wells near chemical handling sites or known to have been contaminated directly by an accidental point-source introduction of the chemical, such as backsiphoning.

Protecting groundwater drinking sources is critical and achievable; it can be accomplished by attention to these four points:

- preventing point-source contamination of the well
- evaluating groundwater contamination susceptibility, as determined by soil and geologic conditions and the water-management system
- selecting appropriate chemicals and application strategies
- practicing sound agronomy, which uses integrated pest management principles and appropriate yield goals

Preventing Point-Source Contamination

Controlling point-source contamination is one of the most important actions for protecting a groundwater supply. A point source is a well-defined and traceable source of contamination, such as a leaking pesticide container, a pesticide spill, or backsiphoning from spray tanks directly into a well. Because point sources involve high concentrations of contaminants or direct movement of contaminants to the water source, the filtering ability of the soil is bypassed. The following handling practices, based largely on common sense, minimize the potential for groundwater contamination:

- Never mix chemicals near (within 200 feet of) wells, ditches, streams, and other water sources.
- Prevent backsiphoning of mixed pesticides from the spray tank to the well by always keeping the fill hose above the overflow of the spray tank.
- Store pesticides in a secure location a safe distance from both wells and surface waters.
- Triple-rinse pesticide containers and put rinsate back into the spray tank to make up the final spray mixture.
- Identify vulnerable areas and avoid applying pesticides or fertilizers near sinkholes.

Sealing Abandoned Wells

Although the total number of abandoned wells in Illinois is unknown, estimates range from 50,000 to 150,000. Every year, many wells are abandoned when they are replaced with new wells or when homes are connected to community water systems. Abandoned wells pose an immediate threat to human safety and provide a direct route for contaminants to pollute a water supply.

The risk of accidents for humans or domestic animals is greatest with large-diameter or dug wells, but any abandoned or unused well poses a threat to groundwater quality. The upper layers of soil normally act as a filter that effectively removes contaminants. Abandoned wells allow pollutants to bypass this filtering process and provide a direct path from land surface to groundwater.

What if you know there is an abandoned well on your land, but you are not sure of the exact location? Because abandoned wells are not always clearly visible, it may be necessary to contact former property owners or neighbors who might remember well locations. In addition, local well drillers often have site records of previous installations. If old photos are available, they may show windmills, houses, barns, or other buildings that have since been torn down where wells might be located. Finally, the Illinois State Water Survey maintains a database of well records.

Sealing an abandoned well is generally not an expensive process, but it must be done correctly, preferably by a licensed groundwater professional. Farmers have the right to seal their own wells, as long as they accept all responsibility for the sealing in compliance with the Illinois Well Construction Code and all pertinent county codes.

Before beginning any work, you must report the project to the local public health department and have a well-sealing plan approved. The Illinois Department of Public Health has a list of requirements and approved fill materials. After the work is done, you must complete a report and submit it within 30 days. Information on well sealing is also contained in *Sealing an Abandoned Well* (Land and Water Publication #4), 2003.

Groundwater Vulnerability

Site characteristics, including soil and geologic properties, water-table depth, and depth of the well, determine the potential of nonpoint contamination of groundwater. Differently from point sources, nonpoint sources of contamination are difficult to pinpoint, originate from a variety of sources, and are affected by many processes. Contaminants moving into groundwater from routine agricultural use are an example of a nonpoint source. Producers applying pesticides in vulnerable areas should pay strict attention to chemical selection and management practices.

Soil Characteristics

Water-holding capacity, permeability, and organic matter content are important soil properties that determine a soil's ability to detain surface-applied pesticides in the crop root zone. Fine-textured, dark prairie soils have large water-holding capacities and large organic matter contents, which reduce the likelihood of pesticide leaching due to reduced water flow or increased binding of pesticides. The forest soils that dominate the landscape in western and southern Illinois are slightly lower in organic matter and thus may be less effective at binding pesticides. The most vulnerable soils for groundwater contamination are the sandy soils that lie along the major river valleys. Sandy soils are highly permeable, have low organic matter content, and often are irrigated. All of these factors represent increased risks to groundwater quality. Extra precautions should be taken in these vulnerable soils regarding chemical selection and application methods. Irrigators, in particular, should pay attention to groundwater advisory warnings that restrict the use of some herbicides on sandy soils.

Geology

The geologic strata beneath a farming operation may be important in determining the risk of nonpoint-source contamination. One type of hazardous geology for groundwater pollution is the karst, or limestone region, that occurs along the margins of the Mississippi River and in the northwestern part of the state. Sinkholes and fractures that occur in the bedrock in these areas may extend to the soil surface, providing access for runoff directly to the groundwater. Water moving into these access points bypasses the natural treatment provided by percolation through soil. Karst areas should be farmed carefully, with attention to buffer zones around sinkholes to prevent runoff entry to the groundwater. Agronomic practices that minimize runoff reduce the potential for pesticide movement to the groundwater.

Groundwater and Well Depths

Deep aquifers that lie under impermeable geologic formations are the sites most protected from contamination by surface activities. In contrast, shallow-water-table aquifers are more vulnerable to contamination because of their proximity to the surface. Shallowly dug wells in sandy soils or areas with shallow aquifers are also more vulnerable, due to typically inadequate wellhead protection.

Precautions for Irrigators

Chemigation refers to the application of fertilizers and pesticides through an irrigation system. As a management tool, it has benefits and potential drawbacks for groundwater protection. The greatest benefit is for *fertigation*, which is the application of fertilizers, particularly nitrogen, through the irrigation system. Nitrogen can be more carefully applied during the vegetative growth period of grain crops, thereby minimizing the susceptibility to leaching. Chemigation systems must be equipped with devices to prevent backflow. These devices greatly reduce the threat of backsiphoning undiluted chemicals into the irrigation well. Backflow-prevention devices are mandatory on irrigation systems that inject fertilizers and pesticides.

Chemical Properties and Selection

The selection of agricultural chemicals is critical for producers on vulnerable soils and geologic sites. Herbicide selection is a complex task that must take into account the crop, the tillage system, the target species, and a host of other variables. Chemical properties of the herbicide are important to consider when evaluating their potential to leach to the groundwater. The three most important pesticide characteristics that influence leaching potential are solubility in water, ability to bind with the soil (adsorption), and the rate at which the pesticide breaks down in the soil. High solubility (a pesticide that dissolves readily), low binding ability, and slow breakdown all increase a pesticide's ability to move to the groundwater. Among the frequently used herbicides that have a greater potential to leach are those that contain acetochlor, atrazine, sulfentrazone, acifluorfen, dimethenamid, chloransulam, flumetsulam, simazine, metribuzin, and clopyralid (**Table 7.1**). These products are labeled with groundwater advisories.

Of all the herbicides used commercially on corn and soybean, more than 60% carry a groundwater advisory because they contain one or more of the components listed previously. Within this large group of herbicides, some contain only small quantities of a component that has a groundwater advisory. For the vast majority of dark-colored prairie soils in Illinois, leaching to potable groundwater is less common than on either sandy soils or over karst topography. For many of these vulnerable areas, herbicides with groundwater advisories are not labeled for use. Of the herbicides that have groundwater advisories, only atrazine has been detected in groundwater with any appreciable frequency.

Surface-Water Contamination

Although groundwater protection is an important priority, surface-water quality is generally at greater risk. Monitoring efforts have documented the temporary occurrence of high pesticide concentrations in surface water. Numerous studies have shown that chemical losses are often greatest when heavy rainstorms closely follow pesticide applications.

Similarly, state, regional, and national water monitoring efforts have identified elevated concentrations of nitrogen and phosphorus during periods of high rainfall in the spring. Addressing the impacts of agriculture on surface water continues to be one of the biggest challenges facing the industry.

Total Maximum Daily Loads

A total maximum daily load (TMDL) is the allowable amount of a single pollutant that a water body can receive from all contributing sources and still meet water-quality standards or designated uses. Although this definition seems fairly simple, determining "allowable amounts" and the steps needed to achieve "designated uses" are less clear. In addition, implementation plans, recommended practices, and the cost of establishing these TMDLs are still being examined. For a current map of the watersheds and expected completion dates, refer to the Illinois EPA website (www.epa.state.il.us/water/tmdl). Although the fi-

Table 7.1. Herbicides carrying label statements about groundwater contamination.

Trade name	Common name
2,4-D Amine (many)	2,4-D amine
AAtrex, Atrazine (many)	atrazine
Authority MTZ	sufentrazone + metribuzin
Balance Pro	isoxaflutole
Banvel	dicamba
Basagran	bentazon
Bicep II Magnum, Bicep Lite II Magnum	S-metolachlor + atrazine
Boundary	S-metolachlor + metribuzin
Breakfree	acetochlor
Breakfree ATZ	acetochlor + atrazine
Buctril + atrazine	bromoxynil + atrazine
Camix	S-metolachlor + mesotrione
Celebrity Plus	nicosulfuron + dicamba + diflufenzopyr
Clarity	dicamba
Define	flufenacet
Degree	acetochlor
Degree Xtra	acetochlor + atrazine
Distinct, Status	dicamba + diflufenzopyr
Dual II Magnum	S-metolachlor
Expert	S-metolachlor + atrazine + glyphosate
FieldMaster	acetochlor + atrazine + glyphosate
FirstRate	cloransulam
FulTime	acetochlor + atrazine
G-Max Lite, Guardsman Max	dimethenamid-P + atrazine
Halex GT	S-metolachlor + glyphosate + mesotrione
Harness	acetochlor
Harness Xtra	acetochlor + atrazine
Hornet WDG	flumetsulam + clopyralid
Hyvar X, XL	bromacil
IntRRo	alachlor
Keystone, Keystone LA	acetochlor + atrazine

Trade name	Common name
Krovar	bromacil + diuron
Laddok S-12	atrazine + bentazon
Lightning	imazethapyr + imazapyr
Lumax, Lexar	S-metolachlor + atrazine + mesotrione
Marksman	dicamba + atrazine
Micro-Tech	alachlor
Northstar	primisulfuron + dicamba
Outlook	dimethenamid-P
Paramount	quinclorac
Pathway	picloram + 2,4-D
Prefix	S-metolachlor + fomesafen
Princep	simazine
Python	flumetsulam
Radius	flufenacet + isoxaflutole
Sencor	metribuzin
Sequence	S-metolachlor + glyphosate
Shotgun	atrazine + 2,4-D
Sim-Trol	simazine
Sonic, Authority First	cloransulam + sulfentrazone
Spartan	sulfentrazone
Spirit	primisulfuron + prosulfuron
Steadfast ATZ	nicosulfuron + rimsulfuron + atrazine
Stinger	clopyralid
Storm	bentazon + acifluorfen
SureStart	acetochlor + flumetsulam + clopyralid
Surpass	acetochlor
TopNotch	acetochlor
Tordon 101	picloram
Tordon K	picloram
Tordon RTU	picloram + 2,4-D
Ultra Blazer	acifluorfen
Yukon	halosulfuron + dicamba

nal TMDL rules may change, it seems very likely that any implementation strategies for improving water quality will include the use of "best management practices" (BMPs). Voluntary programs that adopt BMPs can be implemented today, without waiting for the final wording of a federal document.

Nutrient Standards

In 2000, the USEPA published ambient water quality criteria recommendations for rivers and streams and directed states to set water quality standards "to protect the physical, biological and chemical integrity of their waters." The recommended criteria were developed for 14 different ecoregions in the United States, and reference conditions were proposed for total phosphorus, total nitrogen, chlorophyll "a," and turbidity.

Since the reference conditions were based on the 25th percentile for all nutrient data, they did not account for local site conditions that may have significant impacts on water quality. Most streams in Illinois would exceed the proposed nutrient criteria, including some of the best waters that support a rich diversity of aquatic species.

Developing water quality standards for nutrients is a challenge facing Illinois and many other states. The USEPA did allow for individual states to adopt other scientifically defensible criteria or adjust them to better reflect state-specific conditions. In Illinois, a collaborative research program was organized to help provide the basis for standard development. This strategic research initiative (SRI) was funded by the State of Illinois through the Illinois Council on Food and Agricultural Research (C-FAR).

The C-FAR strategic research initiative has provided valuable insight on the development of nutrient standards. It has also raised additional questions and identified other factors that may have greater impacts on biotic integrity than nutrient concentration alone. Factors such as physical habitat, sediment, light availability, temperature, and hydrology are part of a complex relationship affecting biotic responses in rivers and streams.

Cause-and-effect relationships are sometimes difficult to establish because Illinois lacks a wide range of nutrient conditions, and nutrients are almost never the primary limiting factor to algal production. The challenge remains for regulators to adopt practical and effective nutrient standards, but developing partnerships with the research community is an important first step.

In October 2007, researchers in the Water Quality SRI participated in a Nutrient Standards Forum at the University of Illinois at Springfield. Each research team presented key findings and summarized their work. Information about the meeting and copies of all presentations are available on the C-FAR website (www.ilcfar.org/research/waterqualityforum.html).

Best Management Practices

BMPs are designed to minimize adverse effects of pesticide use on surface water and groundwater quality. In addition to protecting the environment, these practices must be economically sound. In most cases, a combination of BMPs is required to achieve water-quality goals, and the suggested practices may vary depending on soils, topography, and the individual farm operation.

Soil testing is a basic foundation for fertilizer recommendations. Testing manures for nutrient content allows accurate crediting for fertilizer replacement. A sound nitrogen-management program for grain crops that emphasizes appropriate yield goals and credit for prior legumes optimizes the amount of nitrogen fertilizer introduced to the field. Splitting nitrogen applications on sandy, irrigated soils is wise because it reduces the chances for excessive leaching that might occur with a single application. Use of a nitrification inhibitor on fine-textured soils where nitrogen is fall-applied may reduce leaching of nitrate–nitrogen. Adding nitrapyrin (N-Serve) to fall-applied nitrogen reduced nitrate leaching an average of 10% to 15% in a Minnesota study. Even less nitrate leaching occurred when nitrogen was spring-applied.

Integrated pest management (IPM) plays a vital role in protecting water resources. Regular monitoring of crop conditions and pest populations helps a producer make the most informed production decision about pesticide applications. Applications based on economic thresholds optimize grower profits while reducing environmental hazards. When possible, select the pesticide that is least likely to run off into surface water or leach to groundwater.

Proper handling and disposal of pesticides can reduce the potential for point-source contamination of water resources. Spills or improper disposal of excess spray can overload the soil's ability to hold and degrade pesticides, with resulting water contamination. If sprayers are dumped or washed out in the same place over the years, concentrated sources of herbicides may be created.

Conservation tillage practices reduce sediment loading and also reduce or slow water runoff. Because many herbicides can move from treated fields dissolved in runoff water, conservation tillage practices that increase water infiltration into the soil profile should help control herbicide runoff into surface water. Establish grass waterways in areas of concentrated water flow. These waterways will trap sediment and reduce the velocity of runoff flow, allowing greater infiltration of dissolved chemicals. Similarly, grass filter strips have been shown to effectively reduce the amount of herbicide runoff.

A cover crop such as a small grain or legume may provide water-quality benefits from several standpoints. The effectiveness of cover crops in controlling erosion is well documented, and controlling erosion is an important component of protecting the quality of surface water. Small-grain cover crops have shown some efficiency at retrieving residual nitrogen from the soil following fertilized corn or vegetable crops. This feature may be important on sandy irrigated soils where winter rainfall leaches much of the residual nitrogen. Match herbicide application rate to field characteristics and weed populations. Carefully review product labels, and follow setback requirements for perennial and intermittent streams and around tile inlets.

Consider a split application of soil-applied products to reduce the risk that heavy rainfall will cause extensive runoff. Select postemergence herbicides with physical and chemical characteristics that have less potential for surface runoff. Band-apply herbicides and use mechanical control when appropriate. Rotate crops and use a combination of weed management practices. In addition to helping achieve water-quality goals, these practices will reduce the chance for developing herbicide-resistant weeds.

Consider delaying herbicide application if heavy rains are forecast for the next few days. Research has shown that heavy rainfall shortly after herbicide application can cause significant chemical loss. Finally, some individual BMPs may not be appropriate as part of an overall cropping system. Incorporation of herbicides, for example, has been shown to decrease the amount of chemical runoff in surface water. Obviously, this practice is not compatible with a no-till system, and the balance between controlling soil erosion and reducing pesticide movement must be considered.

Local involvement at the watershed level is a part of any successful program. Some of the most effective water-protection efforts have been developed locally. Best management practices that are specific to a watershed appear to be more effective than treating every acre in a uniform way. Because most management practices need to be cost-effective before they are widely adopted, dealers and growers should be involved early in the planning process.