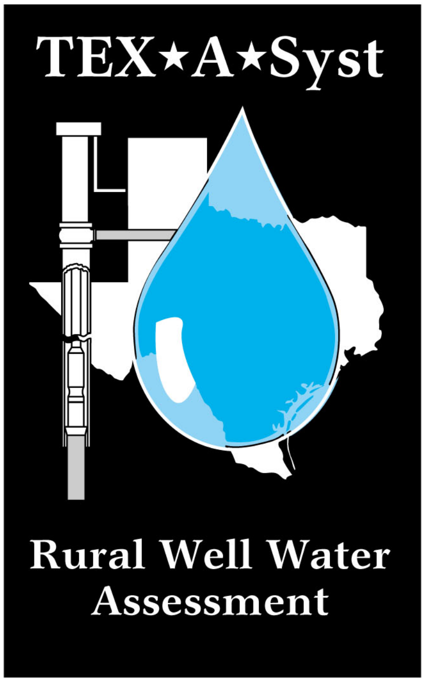
B-6023



Texas A&M AgriLife Extension

Introduction

B. L. Harris, D.W. Hoffman and F. J. Mazac, Jr.*

TEX*A*Syst is a series of publications to help rural residents assess the risk of ground water pollution, and to describe Best Management Practices (BMPs) that can help protect ground water. These TEX*A*Syst bulletins and related materials were developed from the national *Farm*A*Syst* ground water protection program. The TEX*A*Syst system is designed to help the user learn more about the environment, existing environmental policies and regulations, and recommended management practices for household and agricultural activities. With this knowledge the user can voluntarily reduce the pollution risks associated with water wells.

You can help protect well waters by becoming familiar with the ways ground water can become polluted and the management practices that can prevent pollution.

Begin assessing your own water well by completing the questions on the following page. Answering yes to any of these questions may indicate that you have a potential risk that will require further investigation. If you answer yes or are unsure of any of the questions, refer to the publication mentioned at the end of the question.

Each TEX*A*Syst publication contains a questionnaire. This self-analysis will highlight practices that you may want to modify in your operation to reduce the risk of contaminating your ground water supply.

An appendix appears after this introduction. It contains an overview of important characteristics of aquifers and water well sites. You will also find a risk assessment survey to help you determine the potential for ground water pollution based on the characteristics of your property's soil and the subsurface geological materials on your property.

*Professor and Extension Soils Specialist; Research Scientist, Texas Agricultural Experiment Station; and Extension Associate-Water Quality, The Texas A&M University System.

Rural Water Well Assessment

__ yes __ no 1. Are you concerned with the condition, location or age of your existing well; do you plan to drill a new well; or, are there any abandoned wells on your property? (see B-6024)

__ yes __ no 2. Do you mix, apply or store pesticides on your property? (see B-6025)

__ yes __ no 3. Do you handle, apply or store fertilizers on your property? (see B-6026)

__ yes __ no 4. Do you currently store petroleum products, or are you planning to store petroleum products on your property? (see B-6027)

__ yes __ no 5. Do you use or store hazardous household products, wood maintenance cleaners or chemicals, waste oil and filters, grease, anti-freeze, lead batteries, pesticides or pesticide containers on your property? (see B-6028)

__ yes __ no 6. Does your property have a septic tank/soil absorption system, or are you planning to build such a system on your property? (see B-6029)

__ yes __ no 7. Do you store or treat livestock waste on your property, or are there any abandoned livestock waste storage sites located on your property? (see B-6030)

__ yes __no 8. Do you have a livestock confinement or feeding operation on your property, or are there any abandoned livestock pens on your property? (see B-6031)

__ yes __ no 9. Do you have a milking parlor or milk house located on your property? (see B-6032)

Soil and Geologic Overview

Aquifers and Important Water Well Site Characteristics

Ground water is a precious resource in Texas. Many people believe that ground water is made up of underground lakes or flowing streams or rivers like those that occur on the land surface. While some underground caverns in limestone areas are filled with water and are sometimes connected, most ground water does not occur in large pools or as streams. Most ground water simply fills spaces (pore spaces) or voids between particles of gravel, sand or soil, or cracks in rocks. Hence, ground water is subsurface water occurring in fully saturated soils and geologic units called aquifers. *Aquifers* are defined as ground water sources capable of yielding water to springs or wells at rates sufficient to serve as a practical source of water. The portion of the earth between the saturated zone and the land surface often has some pore spaces partially filled with air and water (unsaturated) and is called the *vadose zone* or *zone of aeration*.

Texas aquifers vary in water depth from a few feet to thousands of feet, and in size from a few acres to hundreds of acres. They vary in depth from the surface from a few inches to thousands of feet, but they are generally less than 2,500 feet beneath the surface. Volume estimates range from 35 quadrillion to 100 quadrillion gallons.

There are two types of aquifers: *unconfined* and *confined*. Unconfined aquifers generally occur near the land surface and are sometimes called *water table aquifers*. This is because the upper surface of the unconfined water is the water table, which is also the top of the saturated zone. The lower boundary is an impermeable layer of rock or clay. Recharge to these aquifers occurs naturally as precipitation falls on the ground surface, infiltrates and moves downward to the water table. The water in the aquifer moves in the direction of the slope of the water table, but this may not always be similar to the direction of the land surface slope.

A confined aquifer is more popularly called an *artesian aquifer*; it is bounded on both the top and bottom by clay layers or rock. The water in this type of aquifer is under pressures greater than atmospheric pressure. When a well is drilled into an artesian aquifer, the water rises in the casing until the pressure becomes equal. In some cases the water is forced up into the air, thus creating a free flowing well. Water enters such aquifers in areas called *recharge zones*. These zones may be many miles from the point where a water well is drilled into the aquifer. Pollutants cannot move through the soil into an artesian aquifer near a properly constructed artesian well, but pollutants may enter an artesian aquifer in the recharge zone. The well owner may have little or no control over the management of the recharge zone, but he should know where the recharge zone is for his aquifer.

In some cases a localized area of water saturation may occur within the zone of aeration above the regional water table. This is called a *perched aquifer*. Generally, these aquifers are small and shallow, and they are not reliable water sources for extended time periods.

Aquifers vary widely in the characteristics that determine rates of water movement and potential water yield. Sand or gravel aquifers have high porosity and allow large volumes of water to be extracted. Some fractured rocks or cavernous limestones likewise allow for large amounts of water to be pumped. However, clay and other fine-grained aquifers permit only slow water movement and supply little water when pumped. Ground water movement rates vary from a few feet per year to hundreds of feet per year. Generally, the movement is from upland recharge areas to lowland discharge sites, such as springs, streams or wetlands.

Most areas of Texas have multiple layers of different kinds of rocks and sedimentary materials between the surface and at least one major aquifer. Some areas of the state do not have developable aquifers. In those areas that have several separate aquifers, significant zones of saturation are separated from one another by zones of unsaturated materials. Such areas frequently have artesian aquifers. These conditions are common in much of the eastern half of Texas.

Contaminated water percolating through the soil near a poorly constructed well may pollute a shallow aquifer. However, if the well is properly constructed or the aquifer is deep, water quality may be unaffected. Proper well construction by a reputable professional is very important. Improperly constructed and poorly managed wells may become contaminated by pollutants flowing downward along the casing directly into the aquifer.

It is important to know the characteristics of your well site and well in order to prevent ground water pollution. Information about aquifers is available from the USDA Natural Resources Conservation Service (NRCS) and the Texas Water Development Board.

Soil and Geologic Assessment

One way to determine what practices to follow to protect your water well is to better understand the soil characteristics and subsurface geological materials of your property.

Soil characteristics are very important in determining whether a contaminant breaks down to harmless compounds or leaches into ground water. Because most contaminant breakdowns or absorption (physical attachment) occurs in the soil, the potential for ground water contamination is greater in areas where contaminants are able to move quickly through the soil.

- ★ Sandy soils have large “pore” spaces between individual particles, and the particles have relatively little surface area to adsorb contaminants. Large amounts of rainfall can percolate through these soils, and dissolved contaminants can move rapidly through the soil and into ground water.
- ★ Clayey soils, on the other hand, are made up of extremely small particles that slow the movement of water and dissolved contaminants through the soil. Many contaminants also stick tightly to clay surfaces.

While held securely to soil particles, many contaminants are broken down by bacteria and other soil organisms and by chemical and physical reactions with minerals in the soil. Most of this physical, chemical and biological breakdown process takes place in the upper soil layer, where the soil tends to be warm, moist, higher in organic matter and well aerated. This moist soil is also where microorganisms grow best. Soil organic matter is important in this process because it provides an excellent environment for chemical and biological breakdowns before contaminants can reach ground water.

Unfortunately, the natural purification capability of the soil is limited. Under certain conditions, heavy rainfall, chemical spills, or excessive loadings of waste can exceed the soil's purification capacity and allow leaching to occur. In such cases, the subsurface geologic material and the distance a contaminant must travel to ground water are important factors in determining whether a contaminant reaches the ground water.

Using the following soil and geologic material assessments will enable you to determine your property's risk for ground water contamination. Then you may be able to reduce the risk by altering existing practices or developing new ones.

Begin your well assessment by locating a USDA Soil Survey for your county. Such surveys can be obtained from your county Extension office or the Natural Resources Conservation Service. Both offices may prove to be invaluable sources of information during your assessment process. With soil survey in hand, you will be able to complete the following evaluation of your soil and geologic features associated with your property.

Step 1:

Locate your property on the aerial photos in the soil survey, note the soil mapping unit indicated on the photo and look up information related to that soil in the written section of the soil survey report. If you have more than one soil mapping unit on your property, complete the evaluation of each soil individually.

This evaluation system considers soil in native, undisturbed conditions. If your soil has been altered by human activities such as tilling or ditching, contact your county Extension agent or local NRCS office for assistance.

Do not skip any parts of the evaluation. If you are not familiar with using soil surveys, you may need help completing the evaluation. Ask your Extension agent or the local NRCS office to help you find the following information:

- ★ Location of property on the map and on aerial photographs provided in the soil survey.
- ★ Soil mapping unit and soil series from the legend provided in the soil survey report.
- ★ Soil series and/or soil mapping unit, including the profile description, and other information in the report regarding depth to bedrock, depth to water table, and organic matter content.
- ★ Classification of the soil series, including family, subgroup and order. Soil surveys published prior to 1965 will not include the soil classification; therefore, you will have to get this information from your local NRCS office.

Step 2:

With this information in hand, you are ready to rank your soil according to several characteristics to determine the soil's capability to protect your water well and ground water against pollution. For each of the characteristics in the left column, find information about your soils in the soil survey. Next, match your soil description with the appropriate description found under one of the Risk columns. By properly comparing each soil characteristic, you will be able to determine how well your soil protects ground water from contamination.

Soil Characteristics Assessment

	Low Risk	Low-Moderate Risk	Moderate-High Risk	High Risk
Texture of surface soil: (A Horizon)	clay, sandy clay, silty clay, clay loam, silty clay loam	loam, silt loam, sandy clay loam, silt	loamy fine sand, loamy very fine sand, fine sandy loam, very fine sandy loam	sand, loamy sand, sandy loam, organic materials (all O Horizons) and all texture classes with coarse fragment modifiers (gravelly)
Texture of subsoil: (B Horizon). If there is no B Horizon, consider the character of materials within approximately 2 feet below the A Horizon.	clay, sandy clay, silty clay, silt	sandy clay loam, loam, silt loam, clay loam, silty clay loam	loamy fine sand, loamy very fine sand, fine sandy loam, very fine sandy loam	sand, loamy sand, sandy loam, organic materials and all texture classes with fragment modifiers
pH-Surface: (A Horizon)	6.6 or greater (A Horizon description will include one of the following terms neutral, mildly alkaline, moderately alkaline, or strongly alkaline.)		less than 6.6 (The A Horizon will include one of the following terms: slightly acid, moderately acid or strongly acid.)	
Depth of soil solum (depth of A and B Horizons, minus inches of erosion from surface layer as noted in soil survey)	greater than 60 inches	40 to 60 inches	30 to 40 inches	less than 30 inches
Soil drainage class	well drained	well to moderately well drained	moderately well to somewhat poorly drained	poorly and very poorly drained; somewhat excessively and excessively drained
Permeability of subsoil horizon a. If your soil series description indicates that bedrock is found within 20 inches of the surface or if bedrock is present in the soil mapping unit within 40 inches of the surface, use this section to rank your soil.			bedrock at 20 to 40 inches	bedrock within 20 inches

	Low Risk	Low-Moderate Risk	Moderate-High Risk	High Risk
b. For soils other than those listed above in a., look in the "family" column of the "Classification of Soil Series" table to determine permeability of the subsoil horizon. Use the particle-size class (such as "fine silty" over "sandy" or "sandy-skeletal"). If your soil survey was published before 1965, seek help from a soil specialist or soil scientist.	moderately low, low to very low (fine, very fine, clayey, clayey-skeletal)	moderate (fine loamy, fine silty, coarse silty, loamy-skeletal)	high (sandy or sandy-skeletal, coarse loamy)	very high (coarse sand, fragmental, sandy; of psammentic suborder)
Organic matter content of A Horizon or 0- to 6-inch depth of soil. Refer to "Classification of Soil Series" in Soil Survey. Note: If your soil does not fall in one of the Soil Orders listed, refer to the chart "Soil Properties Significant to Engineering" in the Soil Survey, or contact your NRCS county office.	high % organic matter of 4 to10% or soil order-mollisols	medium % organic matter of 2 to 4% or soil order-vertisols	moderately low % organic matter of 1 to 2% or soil orders-alfisols, inceptisols or entisols	low % organic matter of 0.5 to 1% or soil orders-spodosols, aridisols, histosols, aquic suborder, or lithic, aquollic and aquic subgroups

Note: If your soil has characteristics that are not specifically covered in the assessment tables above, you may find it helpful to consult your county Extension office or NRCS office.

Risk (as determined by the most common response you selected for each soil characteristic)	**Your Soil's Potential to Protect Groundwater**
Low	Best
Low-Moderate	Good
Moderate-High	Marginal
High	Poor

Understanding Your Soil Risk Assessment

A soil described as mostly low risk is probably a deep, medium- or fine-textured, well-drained soil that contains a high amount of organic matter. Potential contaminants move slowly through the soil, allowing them to become attached to soil particles. Sunlight, air and microorganisms then can break down the contaminant into harmless compounds. This soil would be the best type for protecting ground water.

A soil described as mostly high risk is probably a coarse, sandy, extremely well-drained soil with less than 1 percent organic matter. Such a soil would enable most contaminants to move rapidly downward; therefore, this soil would not protect ground water very well.

Where you have a choice in locating a new well, select a site with the lowest risks possible. For existing wells, the risks listed will help explain contamination problems or the potential for problems.

Evaluating Subsurface Geologic Material on Your Property

This evaluation will allow you to rank how well the subsurface geologic material beneath your property's soils can protect ground water. Completing the worksheet will give you a much clearer picture of your property's potential for keeping pollutants out of ground water.

For example, the soil evaluation may have indicated a low to moderate risk of ground water contamination. However, if the soils are fairly shallow and lie over fractured bedrock, particularly in limestone areas, the risk of contamination is probably higher than the soil evaluation alone may indicate.

This evaluation requires the following two items of information:

1) your site's subsurface geologic material; and

2) the depth to the ground water.

Unfortunately, information on subsurface geologic material, as well as depth to water, is often difficult to obtain. Begin with the soil survey report for your county (not included in every county soil survey report) and your well construction report.

Additional information can be obtained from other well construction reports in your area, or from hydrogeological reports and ground water flow maps for some counties (available from the U.S. Geological Survey, Texas Water Development Board or the Texas Natural Resource Conservation Commission). However, these are generalized maps and may not accurately reflect the depth to ground water or direction of water flow at your property.

Try not to skip any of the steps of this evaluation. Ask your county Extension agent, NRCS or other agency personnel to help you gather the appropriate information to complete this evaluation.

Once you have the necessary information, match the information on your site's geology to one of the descriptions in the left column in the following table. *It is important to note that you will be choosing only one description from the entire table that follows.*

If your well construction report describes more than two types of geologic material, ask for assistance from your local Extension agent or NRCS office.

When you have chosen the description that best matches your site's geology, read across to the right, select the appropriate depth to ground water, and circle that level of risk. Note that L will represent low risk; L-M, low to moderate risk; M-H, moderate to high risk; and H, high risk.

Example: You have determined from your well construction report that geologic material beneath your property consists of 30 feet of coarse-textured, unconsolidated material over fractured limestone and that the depth to ground water is 15 feet. Look down the left side of the evaluation chart to locate the coarse-textured, unconsolidated materials over fractured bedrock (33 to 45 feet of material). As you scan to the right, you will see that this geologic material would receive a risk level ranking of H (for high risk).

Geologic Assessment

Geological Material (more than 5 feet below ground)	Depth to Ground Water (in feet)			
	0 to 10	11 to 30	31 to 50	51 or more feet
Fine-textured materials (silt, clay or shale)	L-M	L-M	L	L
Dense- or fine-textured (unsorted)	M-L	M-L	L	L
Medium- to coarse-textured (unsorted)	H	M-H	L-M	L
Unweathered or unfractured metamorphic, igneous, limestone or sandstone	M-H	M-H	L-M	L
Medium- to fine-textured, unconsolidated materials over fractured bedrock				
33-45 feet of material	H	H	M-H	L-M
21-32 feet of material	M-H	M-H	L-M	L-M
6-20 feet of material	H	H	M-H	M-H
0-5 feet of material	H	H	H	H
Coarse-textured, unconsolidated materials over fractured bedrock				
33-45 feet of material	H	H	M-H	M-H
21-32 feet of material	H	H	H	M-H
0-20 feet of material	H	H	H	H
Sand and gravel (more than 45 feet of materials)				
greater than 12% silt or clay (sorted)	H	H	M-H	M-H
less than 12% silt or clay (sorted)	H	H	H	H
Karst, highly permeable or fractured rock (more than 45 feet of materials)	H	H	H	H

Note: Some types of materials do not fall into the above categories, such as unconsolidated materials over limestone/shale/sandstone sequence. Assigning a level of risk for such situations may require assistance from your county Extension agent, local NRCS office or other agencies.

Understanding Your Geologic Assessment

The following table will help you correlate the level of risk to ground water with the ranking that you selected.

Rank	Level of Risk of Groundwater Contamination
L	Low
L-M	Low to Moderate
M-H	Moderate to High
H	High

A ranking of "L" indicates that the subsurface materials have the best potential to protect ground water. This material has small pore spaces, ground water is at least 30 feet from the surface, and the risk of ground water contamination is low.

A ranking of "H" indicates a material with poor potential to protect ground water. Its large pore spaces allow contaminants to move downward easily, thus increasing the risk of ground water contamination. In highly fractured rock or in very coarse-textured, unconsolidated materials, the depth to ground water is less important because some contaminants will flow through the pore spaces rapidly.

Overall, the more L scores you have, the more likely it is that your property's geologic conditions and depth to ground water will help reduce the risk of ground water contamination from your management practices.

Constructing A Property Diagram

Sketching a diagram of your property can provide useful information to help you understand how the physical layout and site characteristics of your property may contribute to or lessen the effects of possible contaminants reaching your drinking water.

The diagrams can show the location of wells; septic drainfields; chemical, pesticide or manure storage areas; the direction of ground and surface water flow; and the locations of buildings and other activities that may contribute potential contaminants. Along with the soil and geologic assessments, the diagram will help point out aspects of your property that may present a hazard to your drinking water.

Step 1:

Begin sketching your diagram by looking at the sample diagram on the following pages.

Step 2:

Next, diagram your property on the blank grid provided on the following pages. Include all of the following that apply:

- ★ All buildings and other structures (home, barn, machine shed, garage)
- ★ Operative wells and unused wells
- ★ Septic system (tank, dry well, absorption field and/or ditch)
- ★ Livestock yard
- ★ Garden
- ★ Manure storage (temporary and permanent)
- ★ Underground petroleum and/or above-ground petroleum storage tanks
- ★ Pesticide and fertilizer storage, mixing and handling areas
- ★ Silage storage
- ★ Milkhouse waste disposal system (tank, field and/or ditch)
- ★ Dumps
- ★ Trash burning piles
- ★ Abandoned vehicles or equipment
- ★ Gray water discharge areas
- ★ Vehicle maintenance areas
- ★ Liquid disposal areas (oil, anti-freeze, etc.)
- ★ Tiles, surface intakes, open ditches and dikes

You can use the same diagram to indicate surface water (ponds and streams), direction of landslope, ground and surface water flow, and the different soil types found around your property. In most cases, ground water follows topography and moves downhill toward surface water.

Step 3:

Use your diagram to note which activities or structures on your property have a greater likelihood of allowing contaminants to reach ground water. This information should help you make better management decisions to reduce ground water contamination.

A Few Final Words

After doing all you can to reduce the risk of ground water contamination on your property, you may still have well test results showing high levels of some contaminants. There are several possible reasons for this. Nitrates could be leaching from nearby fields or from somewhere in your recharge zone, which may be miles away from your property and its well. Depending on the geology of the area, activities miles away can result in ground water contamination flowing slowly toward your property and the ground water you drink. It may take years for a spill on someone else's land to show up in your well. Leaking petroleum tanks, farm dumps and waste pits away from your property all can affect your drinking water, just as activities on your property can affect the drinking water of your neighbors and others miles away from you. You may want to keep track of potential sources of ground water contamination beyond your property. You may also want to encourage your neighbors to use this assessment system for their operations.

Even if your water quality tests are quite good, your worksheet results may show the need for changes. Your well may be upslope from your home, so the water drawn from that area is not affected by your activities. That does not mean, however, that contaminants are not entering the ground water and affecting someone else's drinking water. You need to be careful about property management, especially if your property is on land vulnerable to ground water contamination.

You may have quite a few high-risk pollution rankings, or you may be concerned about your well water quality test results and want to know more about how your activities might have influenced them. If so, after completing the TEX*A*Syst assessment, you may want to have a professional complete a detailed site analysis of your property and management practices to more closely identify causes of contamination.

Glossary

Igneous: Rock formed by cooling and solidification of molten rock, usually associated with volcanoes.

Karst: Topography formed over limestone or dolomite where there are sinkholes, caverns and springs.

Metamorphic: Rock formed by recrystalization of igneous or sedimentary rock under great pressure or heat.

Organic matter: Matter containing compounds of plant or animal origin, measured by organic carbon content.

Permeability: The quality that enables soil or rock to transmit water.

Sedimentary: Rock formed by precipitation from water or from depositions of gravel, sand, silt and clay.

Soil classification: A shorthand system to provide detailed soil descriptions. It includes such groupings as order, suborder, subgroup and family.

Soil drainage class: The frequency and duration of periods of saturation or partial saturation that exist in the soil now and during the development of the soils, as opposed to human-altered drainage. Different classes are described by such terms as excessively drained, well-drained and poorly drained.

Soil horizon: A layer of soil, approximately parallel to the land surface, that has distinct characteristics such as color, structure and texture. Described in shorthand form by letters such as A, B and C.

Soil mapping unit: A soil or combination of soils delineated on a map and, where possible, named to show the taxonomic unit or units included.

Soil series: The basic unit of classification, consisting of soils that are essentially alike in all major profile characteristics.

Soil solum: The upper and most weathered part of the soil profile, consisting of the surface and subsoil horizons.

Soil texture: The relative proportions of the various soil separates (sand, silt and clay) in a soil. Described by such terms as sandy loam and silty clay.

Subsoil: The B Horizon, or roughly the part of the solum below the depth of plowing.

Surficial deposit: A general term to describe the various water and wind transported materials found in a location. It may also include unconsolidated materials formed by the break down of rock materials in place.

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