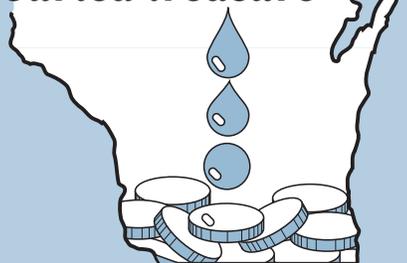


**GROUNDWATER**  
Wisconsin's  
buried treasure



# GROUNDWATER

## STUDY GUIDE

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## Introduction

### To educators

Cool, clear water is a precious and vulnerable resource. In Wisconsin, more than 70 percent of us depend on groundwater for drinking. Agriculture—and thus our food supply—depends on it. Industry depends on it. Yet, until recently, most people rarely thought about this buried treasure. Today we’re becoming more aware of groundwater, mainly because of increasing reports of contamination.

This study guide is designed to help you and your students begin thinking about groundwater — where it comes from, why it’s important, and how it can be conserved and protected. The guide includes a brief overview of groundwater, a glossary, suggested activities, and a list of related Wisconsin Department of Public Instruction (DPI) Wisconsin Model Academic Standards (WMASs) for science, environmental education, health education, social studies and math. The guide is designed to stand alone, yet complements a Wisconsin Department of Natural Resources publication titled *Groundwater: Wisconsin’s Buried Treasure* (PUBL-DG-055 2006) included with the *Groundwater Study Guide* packet.

Talk with your students before beginning your lessons to learn what they already know and think about groundwater. *What is groundwater? Where does it come from? Why is it important? How can it become contaminated? How can we protect it?* By learning your students’ thoughts and opinions about groundwater,

you can help them connect new concepts with what they already know. We encourage you to adapt the activities to meet your students’ needs. You are welcome to reproduce any part of this guide for distribution to students and other educators.

*The groundwater activities in this guide are written for 6th to 9th grade students; however, many of the activities are suitable for older or younger students. You will find a list of relevant DPI Wisconsin Model Academic Standards at the beginning of each activity: Letters identify the appropriate subject or subjects (SC = science, EE = environmental education, SS = social studies, HE=health education, M=Math).*

*As you begin to use the activities in the publication, you should apply all safety guidelines and protocols you typically use in your classroom to each activity. The Department of Natural Resources views science classroom safety as fundamentally important to any laboratory science and feels strongly that the science teacher is the safety expert. The science teacher will provide all needed safety guidelines for each activity.*



## Wisconsin's Buried Treasure

Picture all the water in lakes and streams in the United States. Now, try to imagine 20 times that much water hidden underground, filling cracks and pores in the earth. That's 30–60 quadrillion gallons of water within ½ mile of the earth's surface! However, this vast supply of groundwater isn't evenly distributed. Some areas have ample supplies of usable groundwater, other areas have little.

Wisconsin is water-rich. In fact, our state's name comes from the Chippewa word "Wees-kan-san" which means "gathering of waters." You're probably aware of the large amounts of water in our lakes and rivers, but did you know that 1.2 quadrillion gallons of water—enough to cover the entire state to a depth of over 100 feet—lie hidden underground?

### What is Groundwater?

Groundwater originates as rain or snow. As precipitation falls on the earth's surface, some evaporates, some runs off over land into lakes and streams and some soaks into the ground. A portion of water that enters the soil is taken up and used by plants. (A large, leafy tree can take up a ton of water in a day!) The rest percolates deeper into the earth.

Not all water found in the ground is groundwater. "Groundwater" refers specifically to water that is held in the saturated zone below the water table. Rock and soil material store water in voids or pore spaces, much like a sponge. Imagine two sponges, stacked one on top of the other. The bottom sponge has been soaked in water. It represents the "saturated zone"—all of its pore spaces are filled with water. The top sponge has been wetted, but the water has been squeezed out. This sponge represents the "unsaturated zone"—some of the spaces are filled with water, some are filled with air. The boundary between the two zones represents the "water table." The water in the saturated sponge represents groundwater.

### Where is it Found?

Contrary to popular myths, groundwater doesn't flow in mysterious underground rivers nor is it stored in underground lakes. Most groundwater is found in aquifers—underground layers of porous rock and soil that are saturated with water (like a sponge). Four major aquifers underlie most of our state, but the amount and quality of water they contain is variable.

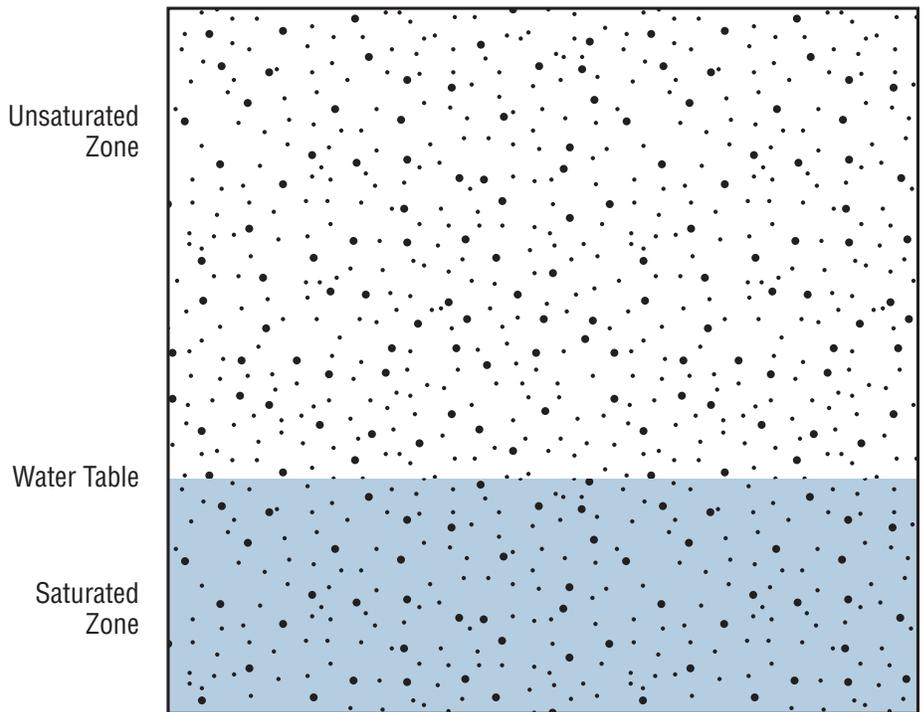
The composition of soil—clay, loam, silt, sand or rock—generally determines the amount of groundwater and the depth at which it is found in a given area. Coarse materials such as sand and gravel, which have large spaces between grains, allow for excellent storage and movement of water. On the other hand, fine-grained materials such as clay or shale restrict water movement.

Like surface water, groundwater flows from higher to lower elevations, moving through connected spaces in soil material. But, unlike water in rivers and streams, groundwater moves slowly—from a few inches to a few feet per day. Variation in rainfall and pumping from wells can affect the rate and direction of groundwater flow.

### Why is it Important?

Water has helped shape Wisconsin's geography, history and industry. More than 70 percent of Wisconsin's homes use groundwater. An average family of four uses 220 gallons of water/day. Over 200 million gallons per day is withdrawn for use in our homes. Nearly 300 million gallons/day is used for irrigation and other agricultural activities. Wisconsin industries like cheese making, beer brewing and paper manufacturing all require lots of water. All together, we use over 800 million gallons of groundwater in Wisconsin each day (*Water Use in Wisconsin, 2000, U. S. Geological Survey Open File Report 02-356*).

Groundwater is also valuable as a source of water for our lakes, rivers, wetlands and springs. It provides the baseflow for most streams and rivers and is the primary source of water for most lakes and wetlands. So it's important to wildlife and to recreation such as fishing, boating and swimming.



## How Does Groundwater Become Contaminated?

Groundwater is never a pure combination of hydrogen and oxygen atoms (H<sub>2</sub>O). As water soaks into the ground, it dissolves minerals and gases from the rock material it encounters. “Natural” groundwater contains many dissolved minerals and gases that may give it a particular taste, odor or color. Typical concentrations of most naturally-occurring contaminants pose no health risk.

Percolating groundwater can also carry human-made pollutants. Contamination can be serious if groundwater contains substances (natural or human-made) that pose a health threat—bacteria, viruses, nitrate, metals such as mercury or lead, pesticides and other synthetic organic compounds. Carelessness and lack of understanding can lead to groundwater contamination from a variety of sources including:

- ❖ leaking underground petroleum pipes and tanks
- ❖ use and storage of road salt
- ❖ improper use, disposal and storage of hazardous materials
- ❖ improper disposal of solid waste
- ❖ practices such as over-application of fertilizers and pesticides
- ❖ improper management of animal wastes

Since groundwater flow is generally slow, pollution may take decades to show up in a well, lake or stream. Removal of contaminants is expensive and difficult (if not impossible), so **prevention** of contamination is the key to maintaining groundwater quality.

## How Can You Help?

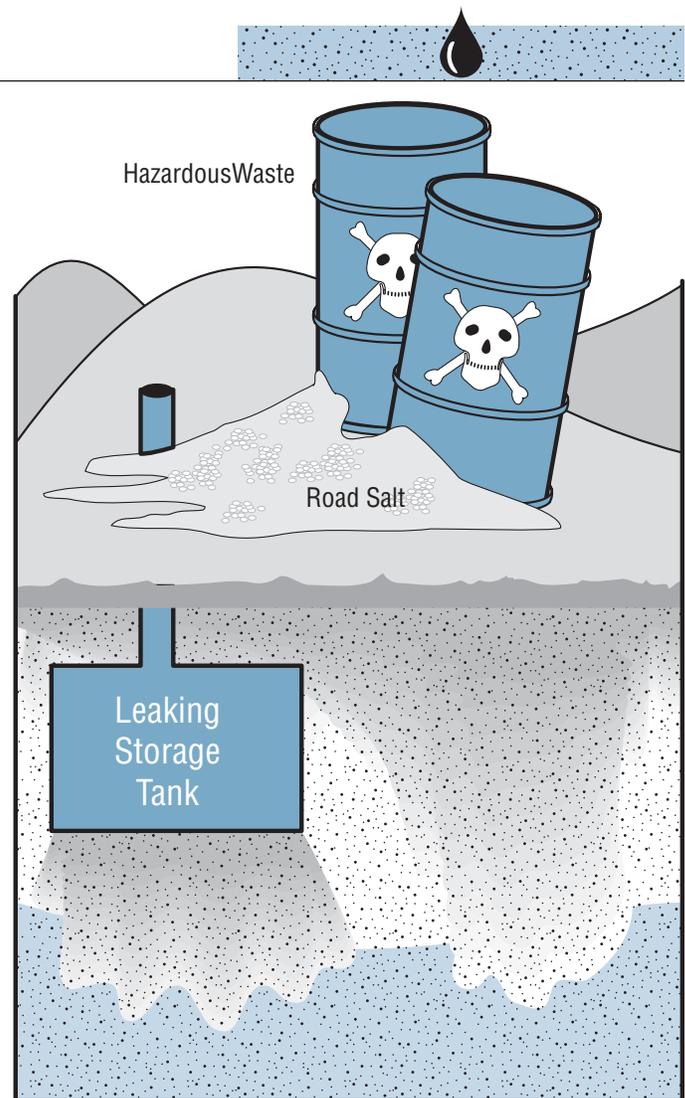
By doing one or more of the exercises in this Study Guide, you and your students will gain a better understanding of groundwater principles and the importance of protecting our “Buried Treasure.” In addition, here are some other ideas for you and your students:

- ❖ Follow local groundwater issues so you’re aware of what the concerns are in your area. Consider with your

students how activities going on locally can affect groundwater quantity or quality.

- ❖ If your school has its own well, consider the recommendations for protecting that well contained in a letter to schools at [dnr.wi.gov/org/water/dwg/gw/whp/whpschools.pdf](http://dnr.wi.gov/org/water/dwg/gw/whp/whpschools.pdf).
- ❖ If your school gets water from a municipal water utility, ask the water utility if it has completed a wellhead protection plan to protect its well or wells from contamination. For more information on wellhead protection, go to [dnr.wi.gov/org/water/dwg/gw/wellhead.htm](http://dnr.wi.gov/org/water/dwg/gw/wellhead.htm).

- ❖ Consider installing a rain garden on school property to promote recharge to groundwater. Check out the following links for more information: [clean-water.uwex.edu/pubs/raingarden](http://clean-water.uwex.edu/pubs/raingarden) and [dnr.wi.gov/org/water/wm/nps/rg/index.htm](http://dnr.wi.gov/org/water/wm/nps/rg/index.htm).
- ❖ Consider becoming a “Green and Healthy School”. Learn about it at [dnr.wi.gov/greenandhealthyschools](http://dnr.wi.gov/greenandhealthyschools).
- ❖ Work with your students to identify ways to reduce the amount of materials going to landfills so that fewer landfills are needed. If your county has a Clean Sweep program, encourage students and their families to take advantage of this opportunity to recycle hazardous chemicals. Visit the Department of Agriculture, Trade and Consumer Protection Clean Sweep website at [datcp.state.wi.us/arm/agriculture/pest-fert/pesticides/clean-sweep/index.jsp](http://datcp.state.wi.us/arm/agriculture/pest-fert/pesticides/clean-sweep/index.jsp) for more information.



- ❖ If your students have private wells, ask them to check to see if there are potential contaminant sources near their well and whether the well is tested annually for bacteria and nitrate levels. For more information, visit [dnr.wi.gov/org/water/dwg/wells.htm](http://dnr.wi.gov/org/water/dwg/wells.htm).
- ❖ Work with your students to identify ways to share information with their parents or the community about the importance of groundwater protection and water conservation at home and in the community. Consider becoming a Groundwater Guardian community. Go to [groundwater.org](http://groundwater.org) for more information.

For additional ideas on protecting groundwater, see *Groundwater: Wisconsin's Buried Treasure* and *Better Homes and Groundwater* included with the *Groundwater Study Guide* packet.

We should all treat water as if our lives depend on it—they do!



# Buried Treasure

- 💧 Wisconsin’s groundwater would cover the state’s 36 million acres to a depth of 105 feet
- 💧 More than 70% of us drink groundwater in our homes
- 💧 There are more than 800,000 private or municipal wells in Wisconsin
- 💧 Wisconsin uses over 800 million gallons of groundwater each day
- 💧 25% of Wisconsin’s groundwater is used in our homes for bathing, cooking, etc.
- 💧 20% of Wisconsin’s groundwater is used by industry
- 💧 Groundwater discharges to lakes, rivers, wetlands and springs

## Glossary

**Aquifer:** A rock or soil layer capable of storing, transmitting and yielding water to wells.

**Artesian:** A condition referring to groundwater that is under enough pressure to rise above the aquifer containing it. Sometimes artesian wells will flow at the surface.

**Baseflow:** That part of stream discharge from groundwater seeping into the stream.

**Dolomite:** Calcium magnesium carbonate, a common rock-forming mineral. Many rocks in Wisconsin generally referred to as limestone are actually dolomite.

**Evaporation:** The process by which water is changed from a liquid or solid into a vapor.

**Groundwater:** Water beneath the surface of the ground in a saturated zone.

**Hazardous waste:** Waste that causes special problems for living organisms or the environment because it is poisonous, explosive, dissolves flesh or metal, ignites easily (with or without a flame) or carries disease.

**Infiltration:** The movement of water into and through soil.

**Leachate:** A liquid formed by water percolating through soluble waste material. Leachate from a landfill has a high content of organic substances and dissolved minerals.

**Limestone:** A sedimentary rock consisting chiefly of the mineral calcite (calcium carbonate).

**Permeability:** The capacity of soil or rock to transmit a fluid, usually water.

**pH:** From the phrase p(otential) of H(ydrogen), pH is a measure of acidity or alkalinity. As a solution becomes more acidic, its pH decreases; as it becomes less acidic its pH increases. A solution with a pH of 7 is considered neutral; a pH less than 7 is acidic and a pH greater than 7 is considered alkaline.

**Porosity:** The amount of open space in a rock or soil sample, normally expressed as the percentage of the total rock or soil volume.

**Sanitary landfill:** A specially engineered site for disposing solid waste on land.

Constructed in a way that reduces hazards to health and safety.

**Spring:** A natural discharge of water at the ground’s surface.

**Static water level:** The elevation above sea level of the surface of water in monitoring wells. Used to determine the direction of groundwater flow.

**Transpiration:** The release of water vapor and waste products through the pores (stomata) of plants.

**Water cycle (or hydrologic cycle):** The complete cycle of phases through which water passes from the atmosphere to the earth and back to the atmosphere.

**Water table:** The level below which the soil or rock is saturated with water. The upper surface of the saturated zone.

**Well:** A vertical excavation that taps an underground formation; in Wisconsin, usually to obtain a source of water, to monitor the quality of groundwater or to determine the elevation of the water table.

*Note: Words or phrases italicized in the exercises are defined in the glossary.*