GROUND WATER
A SOURCE OF WONDER

Drinking Water From Wells

American Ground Water Trust
Consumer Awareness Information Pamphlet # 12

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Bas/c *introductory* *ground water information* ***prepared by the*** *American Ground Water Trust.*

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GROUND "WATER or GROUNDWATER

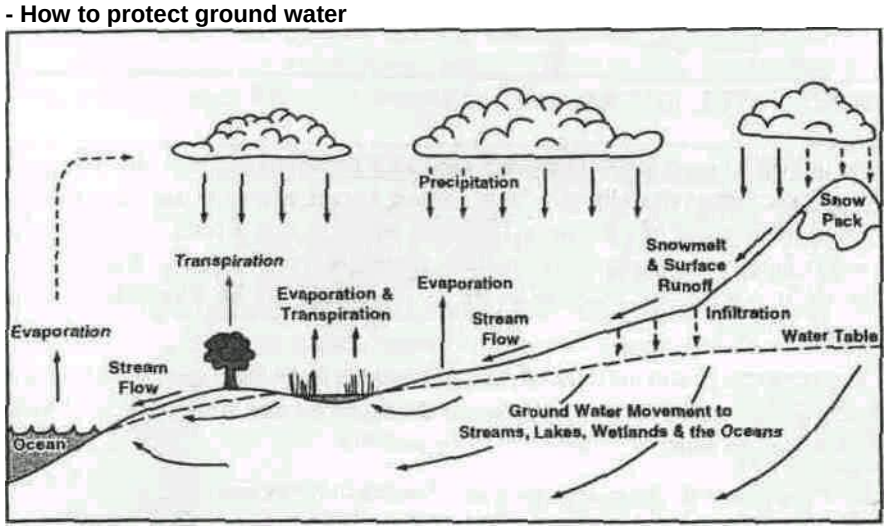
-You -will sometimes see groundwater as one word and sometimes ground-water is written as two words! Scientists can't agree which way is comet! Don't worry, either way will do just fine. What is important, is that you know that this precious resource is of great value to us all, andthatyou -work hard to ensure that it is protected and used sensibly.

THE EARTH'S WONDERFUL HYDROLOGIC SYSTEM

Everybody knows that water is a marvelous substance. We need water for just about everything. Life could not exist without water. Safe drinking water is important for all of us. Did you know that more than half of all the drinking water in the USA comes from wells? These water wells reach down underground so we can pump water from layers of sand and gravel that contain water and from solid rocks that have cracks or fractures filled with water. The name used to describe the water found beneath the Earth's surface is **ground water.**

If we are to protect our ground water so that we can enjoy safe reliable supplies of drinking water we need to know something about:

- **How ground water is linked with water in rivers, lakes and wetlands**
- **How and where ground water moves underground**
- **Where ground water reaches the surface as springs**
- **How water wells are constructed**
- **Why we should protect and conserve ground water**
- **Possible sources of ground water contamination**
- **How to protect ground water**



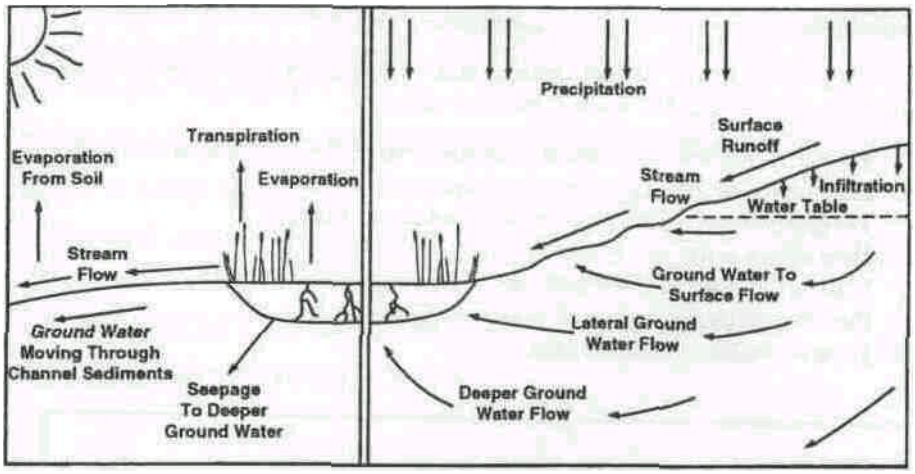
THE HYDROLOGIC SYSTEM

All the world's water is linked as part of the water system. Ground water is just a part of this water system, sometimes called the hydrologic system or the hydrologic cycle. (The word hydrology means the study of water).

* Water may occur as liquid, solid (ice) or as a gas (water vapor). Apart from small amounts of water that may arrive from outer space, planet Earth has always had the same amount of water. The **hydrologic system** consists of water moving in the atmosphere, soils, plants, rocks, wetlands, rivers, lakes, oceans and glacial ice.

WHERE HAS THAT WATER MOLECULE BEEN?

Some tiny part of the water you drink today could once have been in the hot breath of a T-Rex Dinosaur, part of a cup of wine drunk by Cleopatra, a piece of the Titanic iceberg, as water in the steam boiler of the first transcontinental locomotive, or a drip of water on a leaf in the Amazon rain forest.



GROUND WATER, RIVERS AND LAKES

* An individual particle of water (often called a water molecule) may move through *the* hydrologic system (for example, from a cloud, to rain, to a river, and then back to the ocean) in the space of a few days. However, in some cases a water molecule may take a very long time to complete its journey within the hydrological system because it may be in storage (for example as ice **or** ground water) for hundreds **or even** thousands of years.

* The sun's energy and the force of gravity power the hydrologic system. Movement of water by evaporation to the atmosphere is driven by the sun's energy. The force of gravity moves water:

across the landscape as water flowing in rivers and streams downward through the soil layers as it soaks into the ground, **and** beneath the surface as ground water flow in sand and gravel **and** in the cracks and spaces in solid rocks.

> * Water can move up and out of the soil because plants use it. As water leaves the
> plant it changes from liquid water to water vapor and is carried away in the air. This
> process is called plant **transpiration.** Water may also be directly evaporated from the soil. Much rain, snow, hail **(precipitation)** does *not* end up in rivers or aquife'rs. It spends a short time in the soil as **soil moisture** before being **evaporated** or **transpired** back to the atmosphere.

* Some snow and rain may never even reach the ground! It is caught by leaves and grass (interception) and evaporated back into the air. When snow is on the ground some of it melts to become liquid water and does soak into the ground, but often some of the snow is evaporated back to the air. When snow or ice turns directly from solid to water vapor the process is called **sublimation.**

* Most rivers and streams **(surface flow)** receive water from ground water **(subsurface flow).** In fact, nearly half of all the water in America's rivers (including the Mississippi) was once ground water before it reached the river.

*** Ground water** is that part of the hydrologic system that occurs in a geologic environment. It is the water in saturated sand and/or gravel, or in fractures, fissures or pore spaces in solid rocks.

* Most ground water is always on the move, but very slowly, and is usually traveling towards a river valley, lake, wetland or the coast line. Deep ground water may take hundreds of years before it reaches a river or lake. Most wetlands are areas where ground water reaches the surface. In a few instances water may move from wetlands and lakes into underlying rocks, but most wetlands are wet because of the constant outflow of ground water.

* The sand and gravel in river channels and many river valleys are called alluvial sediments or **alluvium.** In dry areas, or in any area during a drought, ground water may continue to move in a downstream direction in the gravelly and sandy sediments of river valleys; even if the river dries up.

WATER UNDERGROUND

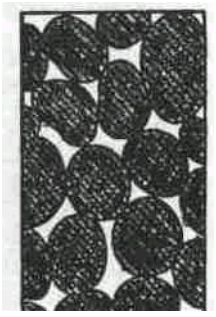
* Ground water is really underground water! The French word for ground water, *eau souterraine*, *is* more accurate; it means literally "water beneath the ground." Ground water can fill spaces between sediment grains of sand and gravel, and it can occur in the cracks, fissures and fractures in solid rocks. Some solid rocks, such as sandstone, may also have ground water in tiny spaces between grains of sediment in

Ground water is found:

In spaces between grains of sand

and

In cracks and fissures in solid rock.



GROUND WATER THROUGH A MAGNIFYING GLASS

the rock. Most of it gets there when rainfall or melting snow trickles down from Overlying soil layers.

*** Infiltration** is the word used to describe water moving downwards through the soil. Much of the water that infiltrates the soil is used by plants or evaporated back into the air. When infiltrating water reaches down and adds to stores of ground water, the process is called ground water **recharge.**

* Not all saturated rocks and sediments hold the same amount of water. The word **porosity** is used to describe how much water sediments and rocks can hold. The word **permeability** is used to describe how easily water can move through a rock. How much moves through a rock or sediment depends on how well the spaces are connected and the size of the spaces.

* Some rocks may have hardly any porosity or permeability except where they are weathered or fractured. Rocks that are weathered are often crumbly because their minerals have started to decompose. Fractures and fissures in rocks may have been made way back in geologic time by movements of the earth's rock layers such as earthquakes.

POROUS - PERMEABLE

How much water can sediments and rocks hold? A block of granite bedrock 1-foot x 1-footx 1-foot in size may only hold a few drops of water. A block of sandstone the same size could hold a gallon or more of water. In this example, the sandstone is more porous than the granite.

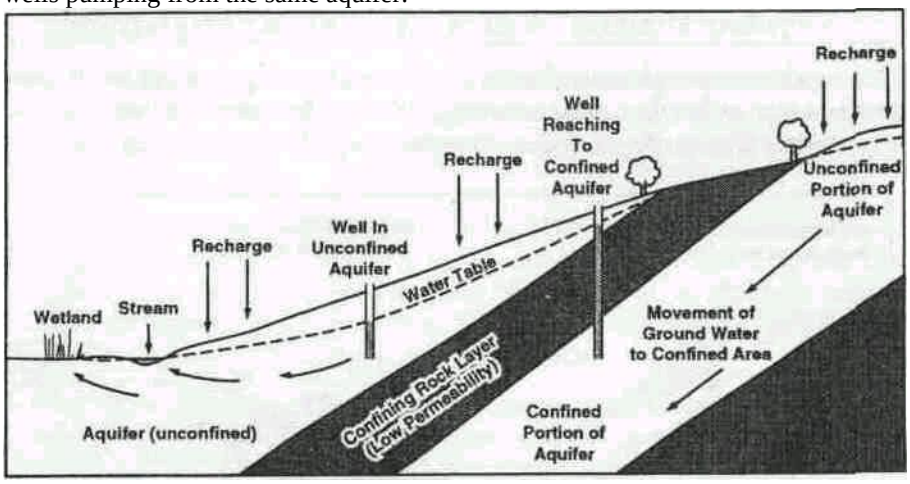
It is important to understand the difference between the words porous and permeable. For example, clays are porous (good for storing water) but they are not very permeable (not good for getting water out). Sand and gravel are porous and permeable. For that reason, geologists and engineers looking for a good place for a well, prefer areas where there is sand. In some cases, a mixture of sand and clay layers is good. The clay layers for water storage, and the sand layers as a good place to put the well.

* The word **aquifer** is used to describe saturated sand and gravel or rock layers **in** which ground water occurs in sufficient quantities to be used as a water supply source. Aquifers may be deep down or near the surface. They may extend for many miles (sometimes hundreds of miles) or they may extend only a few hundred feet before there is a boundary caused by an impermeable rock.

* Where overlying impermeable rock layers "trap" ground water under pressure they are called **confined aquifers.** Where there is enough pressure to cause water from a well to overflow without pumping, we call it an **artesian well.** Depending on the geology and the slope of the land, ground water may be confined in one place and unconfined in another!

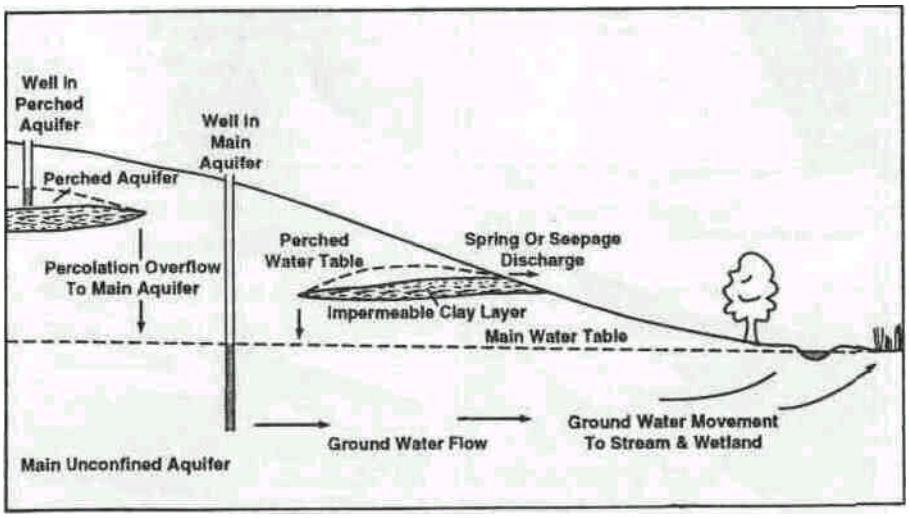
* The top surface of the ground water is called the **water table.** Water table levels will rise when aquifers are recharged and will slowly get lower as the ground water

moves to springs, rivers or wetlands. There could be problems if there are too many wells pumping from the same aquifer.



CONFINED AND UNCONFINED AQUIFERS

* Many sedimentary rock formations contain **impermeable** layers (layers that water can't pass through). For example, layers of clay or shale can create a **perched aquifer** by causing ground water to "perch" above deeper aquifers. In areas with perched aquifers, two wells drilled close together may encounter water at different depths.

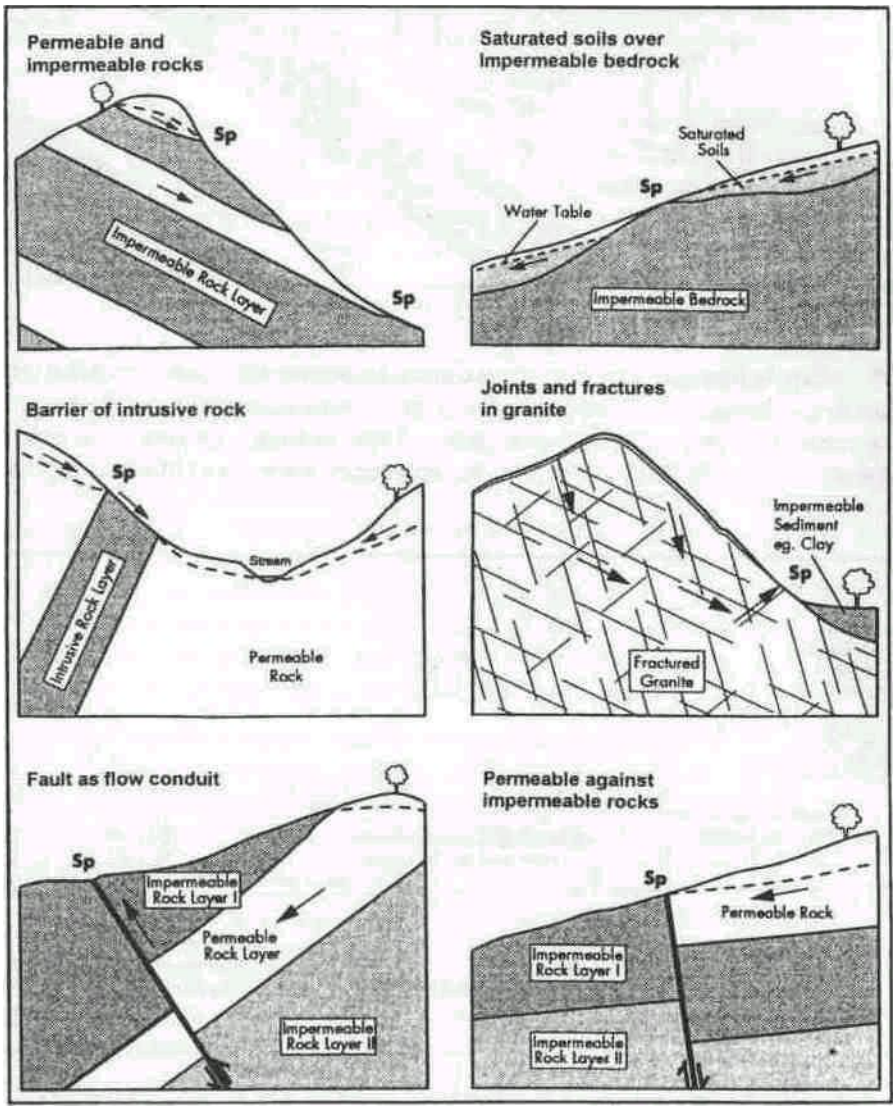


PERCHED AQUIFER

* Perched aquifers may only have limited amounts of ground water and the chemical quality of ground water in a perched aquifer may be different from the water quality in deeper rock formations.

INATURAL SPRINGS - WHERE THE WATER COMES FROM|

There is always an explanation for the existence of a spring. **Springs** occur where ground water reaches the surface as a flow of water. Many wetlands and rivers also receive water from surface seepages of ground water. The geologic explanation for



GROUND WATER EMERGING AS SPRINGS

a seepage may be the same as for the occurrence of a spring, but **seepages** do not have enough flow to be called a spring.

* The flow of water in most springs is part of a local aquifer system, although some springs with a strong flow of water may be an outflow point for a large aquifer system.

* Springs may appear to come up out of the ground, but most springs result from ground water moving sideways through rock formations. However, where there are faults or fractures in the underlying geology there may be upward (vertical) flow of ground water to springs.

* Most hot springs result from ground water that circulates deep underground. This deeper ground water can become heated because of the geologic heat in the Earth's crust and then returns to the surface as hot water. If it gets hot enough to make steam, a **geyser** may occur. Old Faithful in Yellowstone Park is the world's most famous geyser. The water it jets up into the air is hot ground water.

* A properly constructed water well is the best way to access safe drinking water, but for some homes and communities year-round springs are important drinking water sources.

IHOW WATER WELLS ARE CONSTRUCTED|

* Special water well drilling machines, usually called drill rigs, are used to make an "engineered hole" through the soil. sediments and rock layers to reach ground water. The cost of a modem drilling machine and support vehicles can be as much as $500.000. Not all water wells are drilled the same way, but **rotary drilling** is the most common method.

* Six thousand new water wells are drilled in America every week and there are over 15 million water wells in use every day in America for individual homes and farms. Ground water is the source of daily drinking water for nearly 150 million Americans.

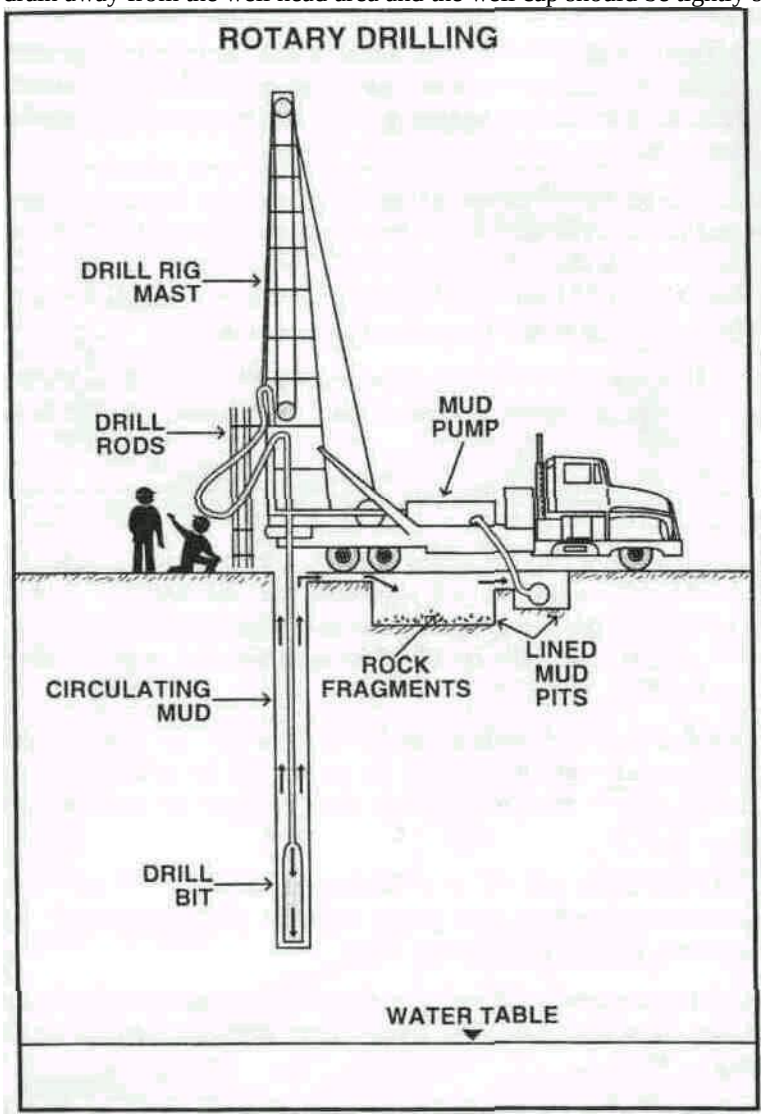
* There are still nearly one million old-fashioned "dug-wells" in use. These are very difficult to keep free from water quality problems. Deep drilled wells are much more reliable and provide safer drinking water.

**• Most rural water supply utilities in rural areas use ground water for their supply source. About 110 million Americans get their drinking water from utilities that use water wells.

* Steel or plastic **casing** (sometimes called a liner) is put in the well to stop the hole collapsing and to prevent the risk of surface water getting into the well. A clay or cement seal. called **grout,** is often placed between the casing and the drilled hole to stop any surface water moving down outside the casing.

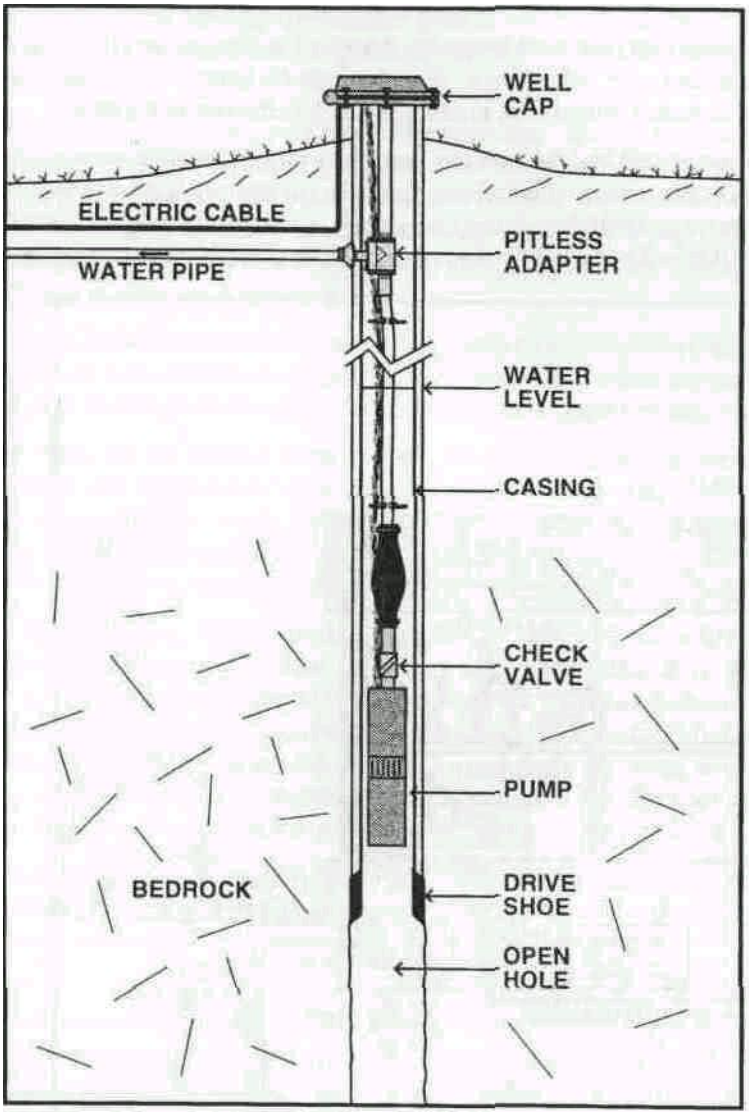
* In any area where there is frost, the water pipe for a home well comes from the well to the house through a **pitless adapter** below ground level. In warmer climates

there is no need to use a pitless adapter; the water pipe can come out of the top of the well. To make sure that no contamination can get into the well, surface water should drain away from the well head area and the well cap should be tightly sealed.



DRILLING A WATER WELL

* Well casing should extend at least 1 foot above ground surface, even higher if the area might be flooded. The top of the well casing must be capped, but don't cover your well casing with soil and build a flower garden! Dug wells should be replaced. They are too vulnerable to surface contamination.



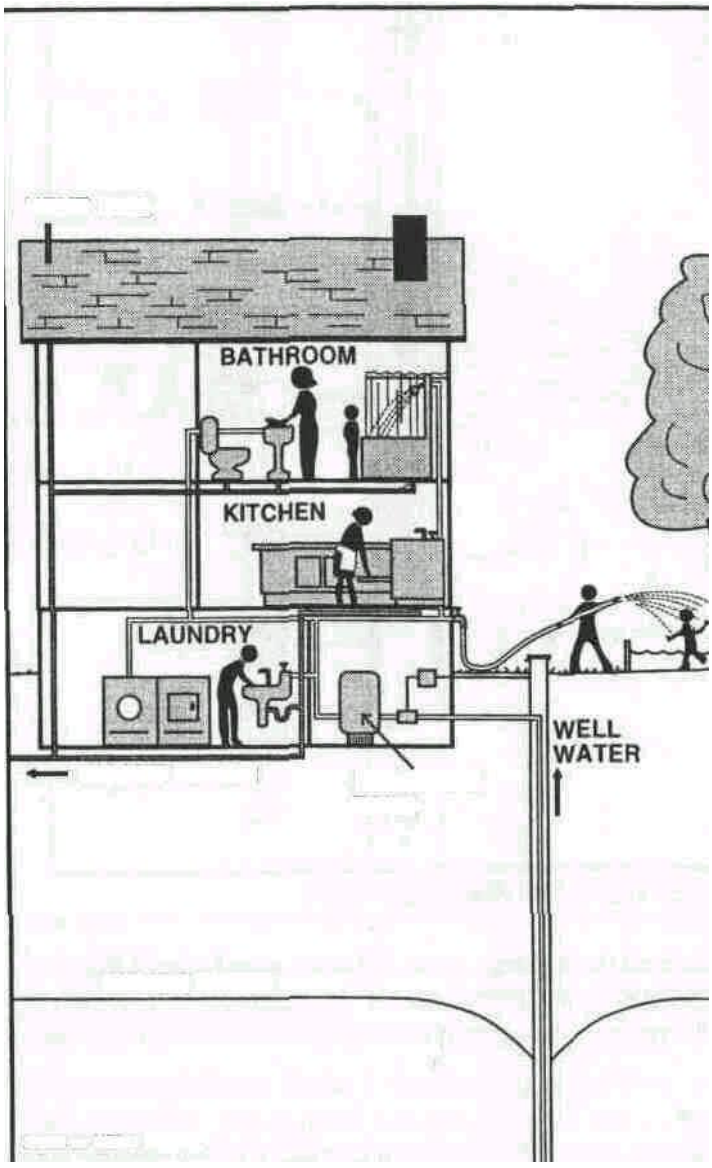
EQUIPMENT USED IN A WATER WELL

* The most common well pumps in use for homes are **submersible pumps.** They are powered by electricity and push the water up to the surface. [Irrigation and large municipal wells may use turbine pumps with a powerful diesel or electric motor at the surface. 1

PROTECT AND CONSERVE GROUND WATER

* We all use water for many purposes. Most of the time we turn the tap and never think where the water comes from. We often take for granted that our homes have safe reliable water for use in the kitchen, laundry, bathroom and garden.

* Is the water safe to drink? Water supplied by a water utility is regularly tested to make sure that it meets drinking standards. In a home with a private well, it is the homeowner's responsibility to test the water. A test once a year is a good idea. Homes with a well and a public supply must never connect the two systems.



WATER USE IN THE HOME

THE FIRST GROUND WATER PROTECTION RULE IN AMERICA

"There shall be no man or woman dare to wash any unclean linen, ...nor rinse or make clean any kettle, pot or pan, ...within twenty feet of the well"

The year was 1610. This was about 400 years ago! The rule was made by the Military Governor at Jamestown where early settlers had set up a military fort. The rule was made because of the need to protect the quality of the well water. We knew all those years ago that the best way to protect drinking water is to keep contamination away from the well. The same is just as true today as it was then.

* Whether drinking water comes from a home well or from a utility pipeline, some people may use water conditioning equipment, for example to reduce iron or hardness. Homeowners should check that these systems are kept in good working order.

* Most wells do not require chemicals for treatment because the water moves straight from the underground geologic formations via the well into the house. Because of longer travel times, deep ground water is more likely to be free from organisms than water from shallow wells. Untreated surface water from a lake or river almost always contains bacteria and other organisms.

* We each use about 75 gallons of water a day. A family of four will need about 300 gallons for all uses in the bathroom, kitchen and laundry. [Outside lawn watering will use a lot more.) In a drilled well, with the hole six inches in diameter, there are one and a half gallons of water stored in each foot of well column. A well with 200 feet of depth below the water table can store 300 gallons. As you pump the water that you need from the well, it will fill again because more water will flow in from the aquifer. A well that only provides half a gallon a minute can supply over 700 gallons a day!

* It makes sense not to waste water whether your home is on a well or a public system. Even if you have plenty of water available it costs money to pump it and there will be extra wastewater to be disposed of.

SOME THREATS TO GROUND WATER

* Many **factories and industry** produce waste material that can cause contamination. Over the last 200 years, we have foolishly dumped tons and tons of toxic waste around our urban and industrial areas. We are now making efforts to clean-up some of the worst areas, and politicians have passed strict environmental laws to stop further contamination. Some polluted sites are so bad that they can never be cleaned up.

* In **agricultural areas,** fertilizers and chemicals can cause widespread ground water contamination. High levels **of** nitrate in ground water can be caused by fertilizers. An additional threat occurs from the vast amount of manure that can accumulate when livestock are concentrated in big feedlots. The soil can naturally treat a certain amount of added manure. When the concentration is too much then

excess nitrate and other chemicals can contaminate **the water** that is recharging aquifers. Farmers now try to use "Best Management Practices" **but** there are still many environmental problems to be solved.

*** Trash** and toxic materials may leave our homes as garbage but they may stay in the community (in the local landfill), and could impact ground water quality. The less we dump the better. Recycling is beneficial to ground water because it reduces need for more landfills, conserves resources and keeps contaminants from existing landfills. Landfills can cause ground water contamination problems when infiltrating water moves through garbage or if heavy rains cause the water table rising beneath the landfill and reach the garbage. Once ground water has been in contact with garbage, it can become really nasty. In most homes at any given time, there will typically be about 100 pounds of hazardous materials in closets, garages, garden sheds and basements (paint, polish, old medicines, lawn mower gas. etc.). In the US, there is about 1.6 million tons of hazardous waste generated each year. Most towns have an annual household hazardous waste collection day. Use this opportunity to clear out your basement! Don't put toxic items in the regular garbage.

TRASH - *The US produces more trash than any other nation, (4-6 Ibs. per person day). How much did you produce today?*

* Many gas stations have had problems with **leaking underground storage tanks.** For many years, nobody noticed! There are now strict rules for storage tanks and most all of the old tanks have been replaced. Gasoline, and the extra chemicals added to it. can cause real ground water pollution problems. All the major gas stations are now checked regularly.

* Maintaining an efficient **septic system,** and keeping contaminants away from the well are priority tasks for homeowners. Toxic material put down the drain can prevent septic systems working and contaminants could end up in aquifers. Septic systems in good working order should present no problems for ground water quality because movement of liquids through the leach field and in percolation down to the water table should give natural processes time to remove harmful disease causing organisms.

Don't put toxic materials in septic systems because they may destroy the "good" organisms that provide natural breakdown of waste. Also, do not overload the septic with too much wastewater at once. If the natural system is overloaded, then untreated waste can pass into the soil and underlying rocks. If toxic materials are poured down a household drain, they will end up in a public sewer system or a home septic system. Sewer treatment plants may not be able to deal with concentrations of toxic materials and the contaminated water may end up in a river.

*** Road salt** is needed for highway de-icing safety but can cause problems to nearby wells. The salty water soaks into the ground and pollutes the ground water. Roads also accumulate automobile contaminants and city streets can be littered with trash. Storm runoff that could wash oil and debris from streets into creeks or ponds should be piped away from aquifers.

*** Garden chemicals,** fertilizers, pesticides, weed killers etc. can impact ground water quality. Children should never touch garden chemicals. Adults should always read instructions and be very careful where they mix the chemicals. Proper storage and handling is important. Chemicals should always be used according to the instructions. Do not apply any chemicals if heavy **rain is** expected. Never store chemicals or fuel near a water well.

GARDEN LAWNS - *Did you know that there **are more acres of garden** lawn in America than any agricultural crop?*

* There is nothing wrong with fixing your own car, but driveway oil changes are a real risk for ground water. Used oil ("waste oil") contains heavy metals such as cadmium, chromium and lead. Other automotive fluids also contain really nasty chemicals.

AUTOMOBILE OIL - *In the US some 80% or more of 200 million gallons per year of used motor oil drained by car owners is not recycled. Where does it go?*

GROUND WATER PROTECTION

* Individual behavior can impact ground water quality. If we know the causes, we **have** the power to prevent and reduce negative impacts. We have not taken very good care of our environment over the last 100 years. We now know better. We have the power to change behavior in our homes and to give support to local efforts to protect our community's ground water. The principle **of wellhead protection is** to keep contaminants away from the aquifer. Once an aquifer is contaminated, it is difficult and often impossible to fix.

* The hydrologic system is really one big water system; all parts are connected. The same is true for contamination! If contamination sources come in contact with the hydrologic system, the result could be ground water contamination. Contaminated ground water can also affect the quality of water in rivers and lakes. Contaminants on the ground and in the soil may be picked up by rainfall and infiltration and become incorporated in the water. Even **air pollutants** can be caught in rain and end up in ground water.

* People living in communities dependent on well water should be very concerned about ground water protection. We all need to be vigilant and aware about the possibility of threats to ground water quality.

"An ounce of prevention is worth a ton of clean-up."

AMERICAN GROUND WATER TRUST

Independent Authority on Ground Water

The American Ground Water Trust is a 501(c)(3) non-profit membership organization. The mission of the Trust is to protect America's ground water, promote public awareness of the environmental and economic importance of ground water and provide accurate information to assist public participation in water resources decisions.

To learn more about how you can protect your ground water:

- **Call** the Trust's consumer information line (800) 423-7748.
- **Join** the American Ground Water Trust. [Home owners are important Trust members.]
- **Contact** the Trust about ground water issues and concerns in your town, region or state. The Trust will respond to your questions and recommend a course of action.
- **Volunteer** to help with educational programs and special events in your area.
- **Request** a list of Trust Educational Products.

AMERICAN GROUND WATER TRUST

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