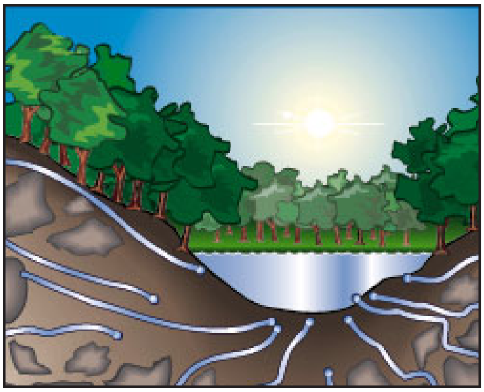

Groundwater & Surface Water: Understanding the Interaction

A Guide for Watershed Partnerships

Second Edition

Know Your Watershed

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GROUNDWATER: A HIDDEN RESOURCE.

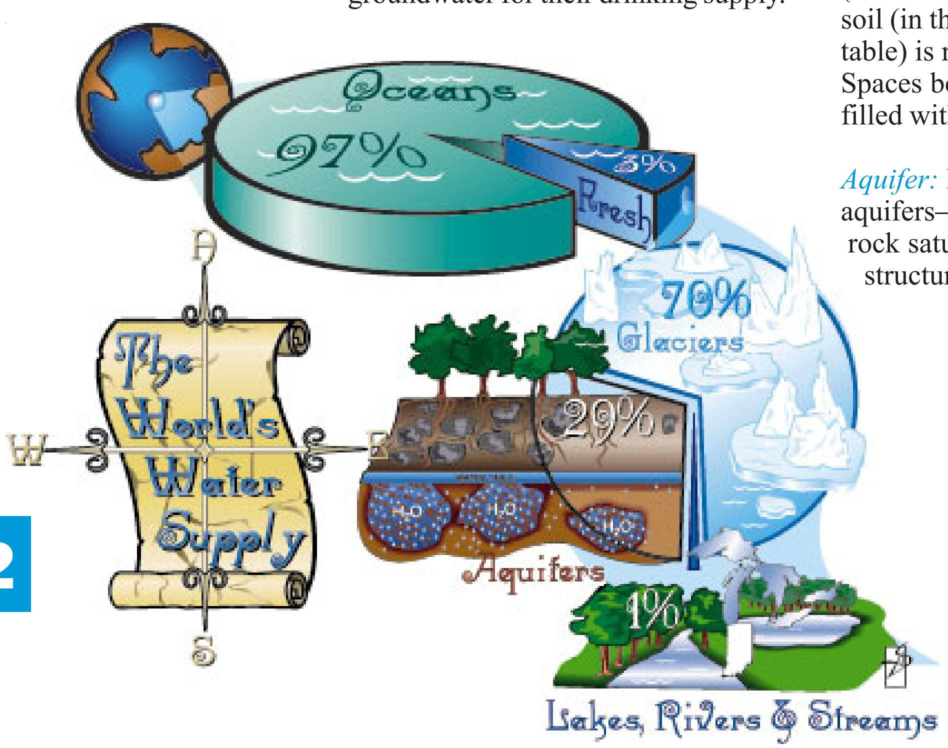
INTRODUCTION.

Water. It's vital for all of us. We depend on its good quality—and quantity—for drinking, recreation, use in industry and growing crops. It's also vital to sustaining the natural systems on and under the earth's surface.

Groundwater is a hidden resource. At one time, its purity and availability were taken for granted. Now, contamination and availability are serious issues.

Some facts to consider...

- Scientists estimate groundwater accounts for more than 95% of all fresh water available for use.
- Approximately 50% of Americans obtain all or part of their drinking water from groundwater.
- Nearly 95% of rural residents rely on groundwater for their drinking supply.



- About half of irrigated cropland uses groundwater.
- Approximately one third of industrial water needs are fulfilled by using groundwater.
- About 40% of river flow nationwide (on average) depends on groundwater.

Thus groundwater is a critical component of management plans developed by an increasing number of watershed partnerships.

GROUNDWATER ABC'S.

Groundwater is the water that saturates the tiny spaces between alluvial material (sand, gravel, silt, clay) or the crevices of fractures in rocks. *(See illustration of groundwater profile.)*

Aeration zone: The zone above the water table is known as the zone of aeration (unsaturated or vadose zone). Water in the soil (in the ground but above the water table) is referred to as soil moisture. Spaces between soil, gravel and rock are filled with water (suspended) and air.

Aquifer: Most groundwater is found in aquifers—underground layers of porous rock saturated from above or from structures sloping toward it. Aquifer capacity is determined by the porosity of subsurface material and its area. Under most of the United States, there are two major types of aquifers: confined and unconfined.

Capillary water: Just above the water table, in the aeration zone, is capillary water that moves upward from the water table by capillary action. This water can move slowly in any direction, from a wet particle to a dry one. While most plants rely on moisture from precipitation in the unsaturated zone, their roots may also tap into capillary water or the saturated zone.

Confined aquifers: (also known as artesian or pressure aquifers) exist where the groundwater system is between layers of clay, dense rock, or other materials with very low permeability.

Water in confined aquifers may be very old, even millions of years old. This water is under more pressure than water in unconfined aquifers. Thus, when tapped by a well, water is forced up, sometimes above the soil surface. This is how a flowing artesian well is formed.

Evapotranspiration: Water returned to the atmosphere by evaporation from water and land surfaces, and by the activity of living plants.

Hydrologic cycle: Complete cycle through which water passes from the atmosphere and, eventually, returns to the atmosphere (*See illustration on page 4*).

Impermeable: Having texture that does not permit water to move through quickly.

Infiltration: Movement of water into and through soil.

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

Saturation zone: The portion that's saturated with water is called the zone of saturation. The upper surface of this zone, open to atmospheric pressure, is known as the water table (phreatic surface).

Unconfined aquifers: More common than confined aquifers, unconfined aquifers have a permeable deposit that leads into the aquifert. Water may have arrived by percolating through the land surface. This is why water in an unconfined aquifer is often very young, in geologic time. The top layer of the aquifer is also the water table. Thus, it's affected by atmospheric pressure and changing hydrologic conditions.

Vadose zone: The area of soil and rock just above the water table.

Water-bearing rocks: Several types of rocks can hold water, including...

- Sedimentary deposits (i.e. sand and gravel),
- Channels in carbonate rocks (i.e. limestone),
- Lava tubes or cooling igneous fractures in igneous rocks,
- Fractures in hard rocks.

THE HYDROLOGIC CYCLE.

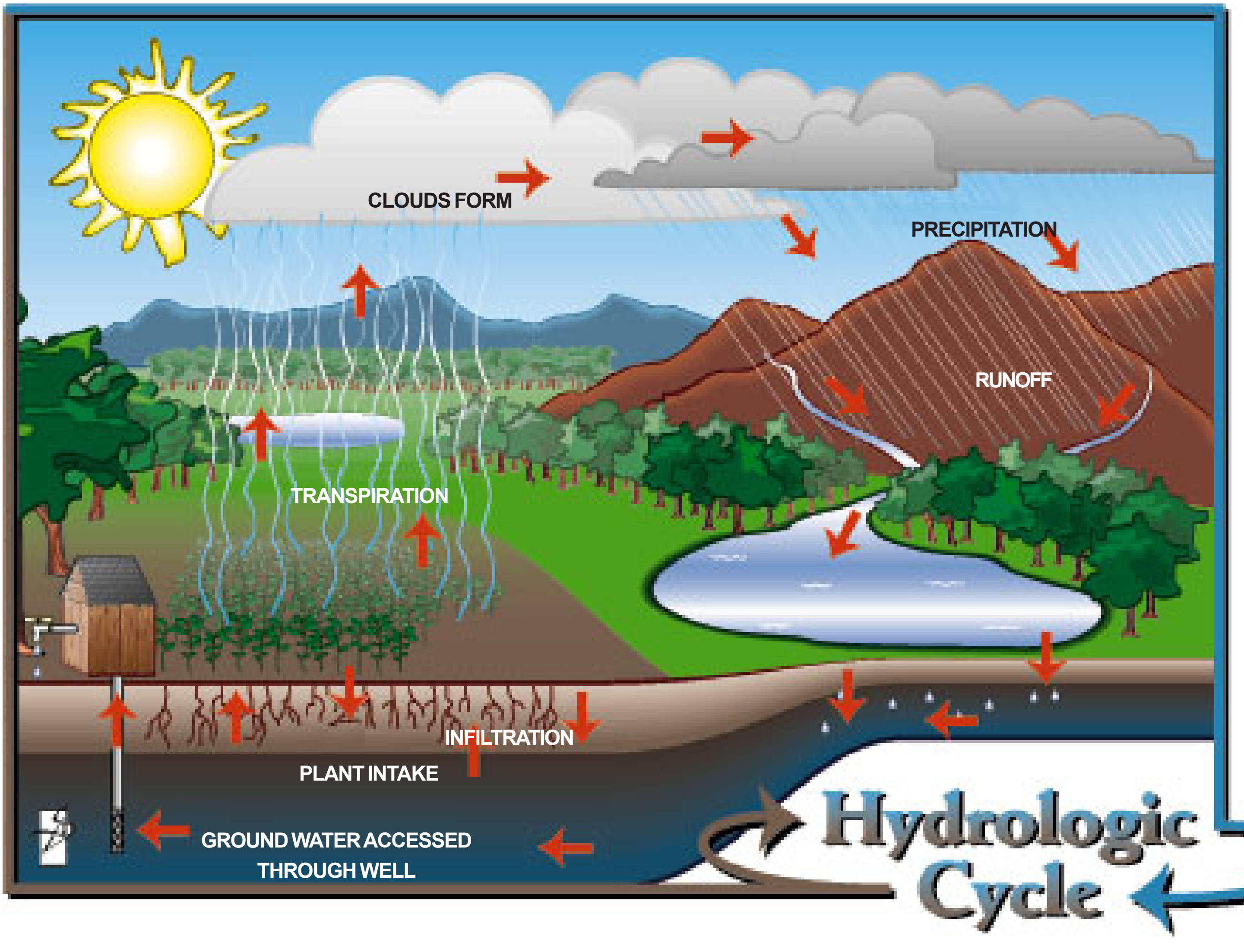
It's crystal clear. Groundwater and surface water are fundamentally interconnected. In fact, it's often difficult to separate the two because they 'feed' each other. This is why one can contaminate the other.

A CLOSER LOOK.

To better understand the connection, take a closer look at the various zones and actions. A logical way to study this is by understanding how water recycles, the hydrologic (water) cycle. (*See illustration*.)

As rain or snow fall to the earth's surface:

- Some water runs off the land to rivers, lakes, streams, and oceans (surface water).
- Some water returns to the atmosphere by evaporation or transporation.
- Some water infiltrates the soil where it can...
  - Be absorbed by plant roots, or
  - Continue to move down to become groundwater, or
  - Move down and then sideways (laterally) or backup (via capillary action) to become surface water



through wells, natural springs, marshes, streams, etc.

- Although its rate of movement varies, groundwater very slowly moves toward low areas (including streams and lakes) where it is discharged.
- Here it becomes surface water again.
- And, upon evaporation, it completes the cycle.

This movement of water between the earth and the atmosphere through runoff and infiltration, evaporation, transpiration, and precipitation is continuous.

How unconfined aquifers can 'feed' surface water.

One of the most commonly used forms of groundwater comes from unconfined shallow water table aquifers.

These aquifers are major sources of drinking and irrigation water. They also interact closely with streams, sometimes flowing (discharging) water into a stream or lake and sometimes receiving water from the stream or lake.

Gaining streams.
An unconfined aquifer that feeds streams provides the stream's baseflow. This is called a gaining stream.

In fact, groundwater can be responsible for maintaining the hydrologic balance of surface streams, springs, lakes, wetlands, and marshes.

This is why successful watershed partnerships take a special interest in the unconfined aquifer adjacent to the stream, lake or other surface waterbody.

How surface water can 'feed' an unconfied aquifer.

The source of groundwater (recharge) is through precipitation or surface water that percolates downward. Approximately 5-50% (depending on climate, land use and many other factors) of annual precipitation results in groundwater recharge.

Losing streams.
In some areas, streams literally recharge the aquifer through stream bed infiltration. These are called losing streams.

Achieving balance.

Left untouched, groundwater naturally achieves balance—discharging and recharging—depending on hydrologic conditions. In fact, some streams are gaining streams at times and losing streams at other times.

INTEGRATING DELINEATIONS*.

THE QUESTION OF BOUNDARIES.

Partnerships using the watershed approach to protect natural resources identify and understand the individual resources—water, soil, air, plants, animals and people—early in the process.

This is why watershed partnerships delineate boundaries to address all natural resources—not just one. They realize that groundwater, surface water, air quality, wildlife and human activities all interact with each other.

Occasionally watershed partnerships run into difficulty with differing boundaries of watersheds and groundwater. If this occurs, consider combining surface and groundwater into a single, larger area. In other situations—like the transfer of water to reach distant users—there can, and should be, two distinct areas.

Thus, watershed partnerships' boundaries may combine the wellhead area, aquifer, watershed, and many other areas into one.

**A deliniation is the process of determining the boundary of an area. In the guide it generally refers how you differentiate the direction that water travels.*

COMMON BOUNDARIES.

The boundaries of aquifers are often difficult to map. It requires someone with an understanding of the geology and surface drainage above the aquifer.

An unconfined aquifer area often extends to the surface waterbody's (i.e. lake, river, estuary) watershed. When determining an aquifer protection area, pumping (working) wells are not considered.

The biggest risk to an unconfined aquifer is the water, potentially carrying contaminants, moving through the permeable materials directly above it. This area is known as the primary recharge area. Depending on the depth and overlying geologic characteristics, travel time from the surface to the aquifer can be rapid.

Less permeable deposits located at higher elevation than the aquifer form a secondary recharge area. These areas also recharge the aquifer through both overland runoff and groundwater flow. Because they are less permeable and tend to be a greater distance from the aquifer, the deposits often lessen contaminants.

Additional recharge areas to consider include an adjacent stream that potentially contributes to the aquifer through infiltration. When pumping wells are close to a stream, infiltration can be increased. Infiltrating streams typically

provide an aquifer with large quantities of water *and* a pathway for bacteria and viruses.

A confined aquifer area may be limited to the outcrop of the aquifer unit and its immediate contributing area. This area may actually be isolated from the location of water supply wells within the aquifer. *Semi-confined aquifers* may receive water from both outcrop areas and overlying aquifers. Delineating the aquifer protection area can be extensive and complex.

Sole-source aquifers are delineated based on aquifer type—confined, semi-confined or unconfined—and local geologic and hydrologic conditions. Defined as providing a minimum of 50% of the water used by its users, sole-source aquifers usually exist only where there are simply no viable alternative water sources.

Wellhead protection areas (also known as zone of contribution and contributing areas) are the surface and subsurface areas surrounding a well or field of wells (wellfield), supplying a public water system.

The area is calculated by determining the distance contaminants are reasonably likely to move before reaching a well. Some common methods for determining the wellhead protection area include:

- Arbitrary fixed radius,
- Calculated fixed radius,
- Simplified variable shapes,
- Analytical method,
- Numerical method,
- Hydrogeologic mapping.

When selecting the best method, consider available funds and the level of concern. Also be sure to consider the cone of depression and drawdown.

Surface waterbody watershed areas have been delineated through a simple process of identifying the highest elevations in land that drains to the surface waterbody (i.e. lake, pond, river, estuary, etc.). Watersheds are in all shapes and sizes, ranging from just a few acres to several million acres ... many smaller watersheds 'nested' inside a larger watershed.

Most successful watershed partnerships work with the smallest size feasible yet encompass all the different, but integrated, areas. This enables faster measurable progress and stronger ties between stakeholders and the waterbodies their actions affect ... positively or negatively.

WHO MAPS WATERSHEDS?

The larger sizes—ranging from the entire Missouri or Ohio River Basins—to three nested steps smaller are mapped by U.S. Geologic Survey (USGS).

Even smaller areas, like a creek's or small lake's watershed, have been deliniated and catalogued in many states. The State Geological Survey, USDA Natural Resources Conservation Service, USDI Fish & Wildlife Service, and USDI Bureau of Reclamation are all agencies that may have mapped these. Call your local office for details.

THREATS TO GROUNDWATER.

QUANTITY.

To meet demands of a growing population and other uses, an increased amount of groundwater has been used. Some typical threats to water quantity include overdraft, drawdown, and subsidence.

Overdraft occurs when groundwater is removed faster than recharge can replace it. This can result in...

- A permanent loss of a portion of its storage capacity.
- A gradual change that can cause water of unusable quality to contaminate good water.
- In coastal basins, salt water intrusion can occur.

Generally, any withdrawal in excess of safe yield (the amount that can be withdrawn without producing an undesirable result) is an overdraft.

Drawdown differs significantly from overdraft. Results in a temporarily lowered water table generally caused by pumping. In this situation, water table recovers when supply is replenished.

Subsidence (sinkhole) is one dramatic result from overpumping. As the water table declines, water pressure is reduced. This causes fine materials that held water to become compacted. In addition to permanently reducing storage capacity, land above the aquifer can sink ... from a few inches to several feet.

WHAT'S A WATER USE?

The Clean Water Act defines water uses for groundwater, surface waters, and wetlands as fishable, swimmable, drinkable, capable of supporting recreation, etc.

But what does that mean in 'real' terms?

Each state defines standards for these uses and specifies water use(s) for individual waterbodies. For example, while most rivers are assigned to be used for fishing, a few river sections are assigned to be used for drinking water.

The same is true for groundwater. Uses are defined and standards identified. A few groundwater uses and corresponding standards are:

Groundwater Use	Water Standards
Drinking water	*Meet MCL for pollutants (Quality)*
Industrial process	*Quality & quantity criteria vary*
Stream baseflow	*Discharge quantity & quality criteria vary*

Note: For *most* water uses both quality *and* quantity are important.

QUALITY.

Inorganic compounds, pathogens and organic compounds can negatively affect water quality. Scientists continually learn about contaminants, sources, and prevention practices.

Inorganic Compounds include all compounds that do not containing carbon. Nutrients (nitrogen and phosphorus) and heavy metals are two examples.

- *Nitrates* can cause problems in drinking water or marine waters.
- *Phosphorus* can reduce uses of fresh surface waters.
- *Heavy metals* include selenium, arsenic, iron, manganese, cadmium and chromium and others.

Various levels of some inorganic compounds, like iron, manganese, arsenic, nitrogen, and phosphorus, occur naturally. Therefore, naturally occuring levels must be considered when addressing these compounds.

Pathogens including bacteria and viruses, have been attributed for more than 50% of the waterborne disease outbreaks in the U.S. *Cryptosporidium parvum* and *Giardia* both commonly cause illnesses when consumed.

Organic Compounds include Volatile Organic Compounds (VOCs) like benzene, toluene, xylene, etc.; and Semi-Volatile Organic Compounds (SVOCs) like napthaline and phenol; PCB's and pesticides.

POTENTIAL SOURCES.

Point sources are easily identified. Examples: sewage treatment plants, large injection wells, certain industrial plants, certain livestock facilities, landfills, and others. They are regulated by the state water quality agency and the EPA, and are issued a National Pollutant Discharge Elimination System (NPDES) permit when they meet regulations.

Point sources established generations ago are often 'grandfathered' into compliance with some areas of the law. Hence, you may find some point sources located in what would now be considered an inappropriate location.

Nonpoint sources refer to widespread, seemingly insignificant amounts of contaminates which, cumulatively, threaten water quality. Examples: septic systems, road drainage, agricultural runoff, lawn fertilizers, underground fuel storage tanks, and small businesses.
Most are not required to have a permit. Individually, each may not be a serious threat, but together they may be a significant threat.

Petroleum stored in underground storage systems is one of the greatest threats to groundwater quality. Although a large number of systems have been removed or upgraded, a significant number remain.

Septic system tanks, where separation of solids and liquids takes place, allow liquids (effluent) to flow through the leach field. While the leach field removes some contaminants, a few can remain. These include nitrogen, phosphorus, sodium, chloride, VOC's, and pathogens. When concentrations are very high, groundwater contamination can occur.

Agricultural pest, nutrient and manure management practices can also threaten groundwater quality. Potential contamination depends on the type, method, amount, and timing of application, soil qualities, and hydrologic conditions. Using management practices can dramatically reduce risk of contamination.

Large and small industries and businesses like dry cleaners and automotive repair shops can also threaten groundwater with a wide variety of potentially contaminating substances.

POTENTIAL CONTAMINANT SOURCES

Potential Source	*Potential Contaminant*
Salting practices & storage	*Chlorides*
Snow dumping	*Chlorides*
Agricultural fertilizers	*Nitrates*
Manure handling	*Nitrates, pathogens*
Home fertilizer	*Nitrates*
Septic systems	*Nitrates, pathogens*
Urban landscapes	*Hydrocarbons, pesticides, pathogens*
Agricultural dealers	*Hydrocarbons, pesticides,nitrates*
Agricultural feedlots	*Nitrates, pathogens*
Solid waste landfills	*Hazardous materials*
Industrial uses RCRA 'C'	*Hazardous materials*
Industrial uses RCRA 'D'	*Hazardous materials*
Small quantity generators	*Hazardous materials*
Households	*Hazardous materials*
Gas stations	*Hydrocarbons*
Auto repair shops	*Hydrocarbons*
Recycling facilities	*Hydrocarbons*
Auto salvage yards	*Hydrocarbons*
Underground storage tanks	*Hydrocarbons*
Industrial floor drains	*Hydrocarbons*
Injection wells	*Hydrocarbons*
Junkyards	*Hydrocarbons*

MANAGEMENT APPROACHES.

THE WATERSHED APPROACH.

A quick review of key components of the local, voluntary watershed approach to protecting natural resources will help you evaluate groundwater management approaches and how they may be used in your particular situation.

Key watershed management approach components include:

- All natural resources—soil, water, air, plants, animals, and people—including groundwater are assessed and addressed by stakeholders.
- Measurable objectives—based on local environmental, economic and social goals—are developed by stakeholders.
- Solutions are identified and implementation strategies are agreed upon by stakeholders.
- Implementation is carried out by the stakeholders.

Some of these activities, as they pertain to groundwater, are described in this guide. For example:

- Boundary delineation is typically part of assessment.
- The discussion of uses (current and future) is part of setting goals.
- Contaminant information is part of assessment, goal setting and solution identification.
- Understanding various tools is part of identifying and implementing solutions.

GROUNDWATER PROGRAMS.

Over the past 20 years many federal and state programs have been developed to improve management of groundwater. Four of the most useful can also easily be incorporated into your watershed plan. These include:

- *Comprehensive State Groundwater Protection Program,*
- *Sole Source Aquifer Program*,
- *Source Water Protection Program*,
- *Wellhead Protection Program*.

These programs can be used in a complimentary fashion to manage all resources, including groundwater, for multiple uses—ranging from human consumption to industrial processes to maintaining the hydrologic regime (geologic structure as it effects the travel of water) and ecological integrity of a wetland.

Comprehensive State Groundwater Protection Program is a statewide program that looks at groundwater's uses (in addition to drinking water use) to consider the role of groundwater in sustaining the health of surface waterbodies (rivers, streams, wetlands, marshes).

The Sole Source Aquifer Program, Source Water Protection Program, and Wellhead Protection Program all are intended to protect a drinking water supply. The programs generally are compatible with the *Comprehensive State Groundwater Protection Program*, but are applied to very defined geographic areas...

- *Sole Source Aquifer Program* applies to the aquifer boundaries.
- *Source Water Protection Program* applies to watersheds that drain into a waterbody used as a drinking water source (reservoirs, intake areas, etc.).
- *Wellhead Protection Program* applies to defined wellhead areas.

Special issues.

Although groundwater programs are often used within the watershed framework, there are some problematic issues that may arise as you attempt to completely integrate them.

These issues have been listed below simply to make you aware of them. Each is best addressed through cooperation and consensus.

- Water quality use designations often do not reflect the presence of groundwater intakes for drinking water.
- Water quality criteria and drinking water maximum contaminant levels (MCLs) often are not consistent in terms of chemical specific values and parameters.
- Minor dischargers and permitted management measures under the NPDES program may not sufficiently reduce the risk to making a significant impact to drinking water intakes.
- Where agriculture activities are reducing drinking water quality, changes in management practices may take a long time to result in water quality improvements.
- Source water areas for groundwater drinking supplies (wellhead areas) generally do not coincide with surface water drainage areas.
- Long-term drinking water treatment may be necessary for certain public water supply systems because of the nature of the contaminant sources and the size of the contributing area.

MANAGEMENT TOOLS.

There are many, many tools that can be used to manage groundwater resources. Although your partnership may not use any of them, they will help start discussion over viable options.

Zoning: Regulations used to segregate different, and possibly conflicting, activities into different areas of a community. This approach can be limited in its ability to protect groundwater due to grandfathering provisions.

Groundwater Protection Tools

Technique	Tool
Zoning Districts	Overlay Groundwater protection Prohibit Various Land Uses Special Permitting Large Lot Zoning Transfer of Development Rights Cluster/PUD Design Growth Controls/Timing Performance Standards Geographic Information Systems Overlay Wetlands Identify Local Wellhead Protection Areas
Subdivision Control	Drainage Requirements Growth Management in Sensitive Areas
Health Regulations	Underground Fuel Storage Systems Small Sewage Treatment Plants Septic Cleaner Bans Septic System Upgrades Toxic & Hazardous Material Regulations Private Well Protection
Voluntary Restrictions	Sale or Donation Conservation Easements Limited Development
Other Nonregulatory	Monitoring Contingency Plans Hazardous Waste Collection Public Education Land Banking

Overlay Water Resource Protection Districts: These ordinances and bylaws are similar to zoning regulations in their goals of defining the resource by mapping zones of contributing boundaries and enacting specific legislation for land uses and development within these boundaries.

Prohibition of Some Land Uses: These are not typically considered very creative tools. However, prohibition of land uses such as gas stations, sewage treatment plants, landfills, or the use/storage/transport of toxic materials is a first step towards the development of a comprehensive groundwater protection strategy.

Special Permitting: The special permitting process can be used to regulate uses and structures that may potentially degrade water and land quality.

Large Lot Zoning: Large lot zoning seeks to limit groundwater resource degradation by reducing the number of buildings and septic systems within a groundwater protection area.

Eliminating Septic Systems: By extending or developing a community sewage treatment system, septic system problems can be reduced.

Transfer of Development Rights: A government entity prepares a plan that designates land parcels from which development rights can be transferred to other areas. This allows land uses to be protected (i.e. for a gas station) while assuring that these uses are outside sensitive areas.

Growth Control/Timing: Growth controls are used to slow or guide a community's growth, ideally in concert with its ability to support growth. One important component is in regards to groundwater's carrying capacity.

Performance Standards: This assumes that any given resource has a threshold, beyond which it deteriorates to an unacceptable level. Performance standards assume that most uses are allowable in a designated area, provided that the use or uses do not and will not overload the resource. With performance standards, it is important to establish critical threshold limits as the bottom line for acceptability.

Underground Storage Tanks: Three additional protection measures are often adopted to enhance local water resource protection, include:

- Prohibit new residential underground storage tanks,
- Remove existing residential underground storage tanks, and
- Prohibit all new underground storage tank installation in groundwater and surface water management areas.

Septic System Maintenance: Septic system maintenance is frequently overlooked. Many times, the system will not function properly, causing "breakout" of solids at the surface. This can lead to bacterial contamination. In addition, when systems fail, any additives used can become contaminants.

Land Donations: Land owners are often in the position of being able to donate some land to the community or to a local land trust.

Conservation Easements: Conservation easements allow for a limited right to use the land. Easements can effectively protect critical lands from development.

Purchase Lands: Many communities purchase selected parcels of land that are deemed significant for resource protection.

Well Construction/Closure Standards: A direct conduit to groundwater, standards for new well construction as well as identification and closure of abandoned wells can make a big difference.

Groundwater Management Practices

Purpose	*Management Practices*
Groundwater recharge	*Impervious area restrictions* *Artificial wetlands* *Grass lined channels* *Impoundment structures (ponds)* *Subsurface drains (tiles)* *Infiltration trenches* *Native tree and shrub plantings*
Pollutant reduction	*Buffer strips* *Filter strips* *Riparian zones*
Pollution prevention	*Soil nitrate testing* *Integrated pest management* *Manure testing* *Variable rate applications* *Abandoned well closure*

GROUNDWATER IQ QUIZ ANSWERS.

TEST YOUR GROUNDWATER IQ.

1. Which way(s) can groundwater move?
- *a. Up*
- *b. Down*
- *c. Sideway*
- *d. All of the above*

2. How is the speed of groundwater movement measured?
- *a. Feet per day*
- *b. Feet per week*
- *c. Feet per month*
- *d. Feet per year*

3. How is stream flow usually measured?
- *a. Feet per second*
- *b. Feet per minute*
- *c. Feet per hour*
- *d. Yards per hour*

4. What determines how fast groundwater moves?
- *a. Temperature*
- *b. Air pressure*
- *c. Depth of water table*
- *d. Size of materials*

5. Can the water table elevation change often?
- *a. Yes*
- *b. No*

ANSWERS.

1. d. All of the above

Although most movement is lateral (sideways), it can move straight up or down. You see, groundwater simply follows the path of least resistance by moving from higher pressure zones to lower pressure zones.

2. d. Feet per year

Groundwater movement is usually measured in feet per year. This is why a pollutant that enters groundwater requires many years before it purifies itself or before it's carried to a monitored well.

3. a. Feet per second

Water flow in streams/rivers is measured in feet per second.

4. d. Size of materials

Coarse materials like sand and gravel allow water to move rapidly. (They also form excellent aquifers because of their holding capacity.) In contrast, fine-grained materials, like clay or shale, are very difficult for water to move through. Thus, water moves very, very slowly in these materials.

5. a. Yes

Water table elevations often fluctuate because of recharge and discharge variations. They generally peak in the winter and spring due to recharge from rains and snow melt. Throughout the summer the water table commonly declines due to evaporation; uptake by plants (transpiration); increased public us; industrial use; and crop, golf course and lawn irrigation. Elevations commonly reach their lowest point in early fall.

SOURCES OF INFORMATION.

To start down the road toward an effective local watershed partnership, you may want to read some of these other guides from the Conservation Technology Information Center by calling 765-494-9555. A $2.00 fee is charged to cover postage and handling.

- ***Getting to Know Your Watershed***
- ***Building Local Partnerships***
- ***Putting Together a Watershed Plan***
- ***Water Monitoring: The Basics***
- ***Reflecting on Lakes***
- ***Wetlands: A Key Link in Watershed Management***
- ***Leading & Communicating***
- ***Managing Conflict***
- ***State & Regional Watershed Contacts/NPS Directory***

For additional assistance...

Contact your...
- Local or state water quality agency
- State lake association
- Local natural resources agency
- Local conservation district
- Local extension office
- Local water utility

OTHER SOURCES.

The author acknowledges some of the following sources of information were used in developing this guide. You may also find these publications helpful, too. There may be fees for some publications.

Layperson's Guide to Ground Water, 1993, Water Education Foundation, 717 K Street, Ste 517, Sacramento, CA 95814.

A Primer on Ground Water, US Geological Survey Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225.

Citizen's Guide to Ground Water Protection, April 1990, EPA 440/6-90-004, U.S. EPA Office of Water, RC-4100, 401 M Street SW, Washington, DC 20460. Order from NCEPI, 11029 Kenwood Rd, Bldg 5, Cincinnati, OH 45242. Fax: 513-489-8695.

Managing Ground Water Contamination Sources in Wellhead Protection Areas: A Priority Setting Approach, October 1991, EPA 570/9-91-023, U.S. EPA, RC-4100, 401 M Street SW, Washington, DC 20460. Order from NCEPI, 11029 Kenwood Rd, Bldg 5, Cincinnati, OH 45242. Fax: 513-489-8695.

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National Water Quality Inventory: 1996 Report to Congress, April 1998. EPA 841-F-97-003. U.S. EPA Office of Water, 401 M Street SW, Washington, DC 20460. Order from NCEPI, 11029 Kenwood Rd, Bldg 5, Cincinnati, OH 45242. Fax: 513-489-8695.

Groundwater: Protecting Wisconsin's Buried Treasure;
Wisconsin Department of Natural Resources, Tel: 608-267-7375

About this guide...

Because the characteristics of each watershed are unique; you may wish to select and use the portions of this guide that are applicable to your particular situation.

This guide is one of a series of guides for people who want to organize a local partnership to protect their watershed. The series is designed to provide guidance for going through the process of building a voluntary partnership, developing a watershed management plan and implementing that plan.

The series of guides will not solve all your problems and will not replace the collective minds of partners who, together, represent of those with a stake in your watershed and the technical advice available through local government agencies.

Although this series is written for watershed-based planning, the ideas and process can be used for developing other types of plans (such as wildlife areas) to match the concerns of the partnership. Regardless of the area, remember a long-term, integrated perspective — based on a systematic, scientific assessment — can be used to address more than one concern at a time.

Special thanks...

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Illustrations were provided by Stephan Adduci, Sudio d'addici, Los Galos, California.

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Darlene Vogel
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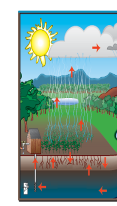

The Know Your Watershed campaign is coordinated by the Conservation Technology Information Center (CTIC), a nonprofit public/private partnership dedicated to the advancement of environmentally beneficial and economically viable natural resource systems. It provides information and data about agricultural and natural resource management systems, practices and technologies. The center was established in 1982 under the charter of the National Association of Conservation Districts.

Know Your Watershed

Conserv. Tech. Info. Center
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