Water Facts

State of California
The Resources Agency
Department of
Water Resources

Ground Water

Groundwater has been used in California since the first inhabitants began using water that seeped from springs. As more people settled in California, they used more groundwater and eventually established an agricultural, municipal and industrial economy that is heavily dependent on the use of groundwater and groundwater basins.

In some areas, use of that resource is threatened by high rates of extraction and inadequate recharge, or by contamination of aquifers as a result of land use practices. Management of groundwater resources is more complex than management of surface water resources, because groundwater is not visible. Harold E. Thomas said, "The science of hydrology would be relatively simple if water were unable to penetrate below the Earth's surface."

Despite the complexity of evaluating groundwater movement through rocks, the occurrence and movement of groundwater through rocks and sediments in groundwater basins can be explained by the same natural and physical laws that govern surface water.

Eleven frequently talked-about groundwater topics are discussed in this Water Facts.

Water Facts *are short reports on water resources issues of general interest. They are published periodically by the California Department of Water Resources and can be obtained free by contacting DWR Bulletins & Reports, P.O. Box 942836, Sacramento, CA 94236-0001; 916/653-1097.*

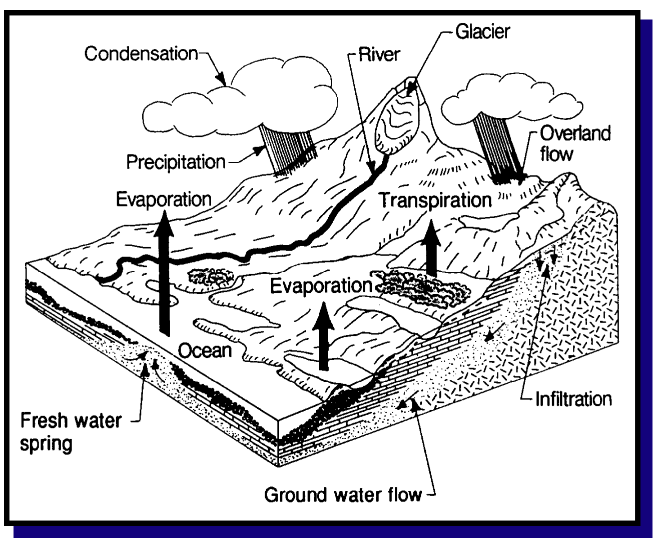
1 Groundwater and surface water are NOT two separate water sources.

When water flows through a watershed, it is a part of the total water budget for that watershed whether it is on the surface or below the ground surface. If a volume of groundwater is extracted and exported from the basin, that export, or debit, will be replaced eventually by surface water that recharges, or refills, the groundwater basin. The water budget equation,

Inflow - Outflow = Change in Storage

includes all the water in the watershed, including surface water and any water below the ground surface.

Despite this physical and natural reality, use of water in California is governed by two different sets of laws—the State Water Code regulates surface water use, and case law from various court decisions regulates groundwater use. This institutional complexity provides many opportunities for differing legal interpretations.



The Hydrologic Cycle

2 If there is neither precipitation nor imported surface water for intentional recharge, and extraction continues, the amount of available groundwater will decrease.

A ground water basin can be called a groundwater reservoir because it operates just like a surface water reservoir—if you take out more water than goes in, the water level in the reservoir declines.

Groundwater reservoirs are recharged by precipitation, surface runoff, irrigation, in some cases by imported water, and by using surface water to irrigate in lieu of groundwater. When there is no rainfall or snowfall, no irrigation, and no source of imported water, there is no surface water to recharge the aquifers in the groundwater reservoir.

3 Groundwater does not occur in underground rivers and lakes in California, except in areas of carbonate rocks or some volcanic rocks.

There are no underground rivers that flow from the Sierra Nevada or Lake Tahoe to San Francisco, Los Angeles, or any other locations in California.

Groundwater cannot be seen, but known geologic facts and evidence from all the water wells and petroleum wells that have been drilled in the Central Valley and elsewhere provide no evidence for such underground rivers. On the contrary, all the evidence denies the existence of such underground conduits.

Fractured carbonate rocks with cavities that have been dissolved by undergroundwater occur in California on the McCloud River, in a number of locations in the Sierra Nevada foothills, and in various parts of the Mojave Desert and Death Valley area. Subsurface water in the carbonate rocks in these areas dissolves the rocks, forming cavities. As more rock is dissolved, these cavities become bigger until caverns are formed through which undergroundwater can flow. Flow of water in these underground cavities is limited to these local areas of carbonate rock.

Lava tubes in volcanic rocks may also contain flowing water that appears to be an underground river. These tubes were not formed by the dissolving action of water, but were formed by molten lava that continued to flow after a crust on the lava surface had cooled and hardened. Eventually the eruption of lava stopped, the lava in the tube flowed out, and the empty tube was left behind, much like a tunnel. Occasionally water flows through these tubes.

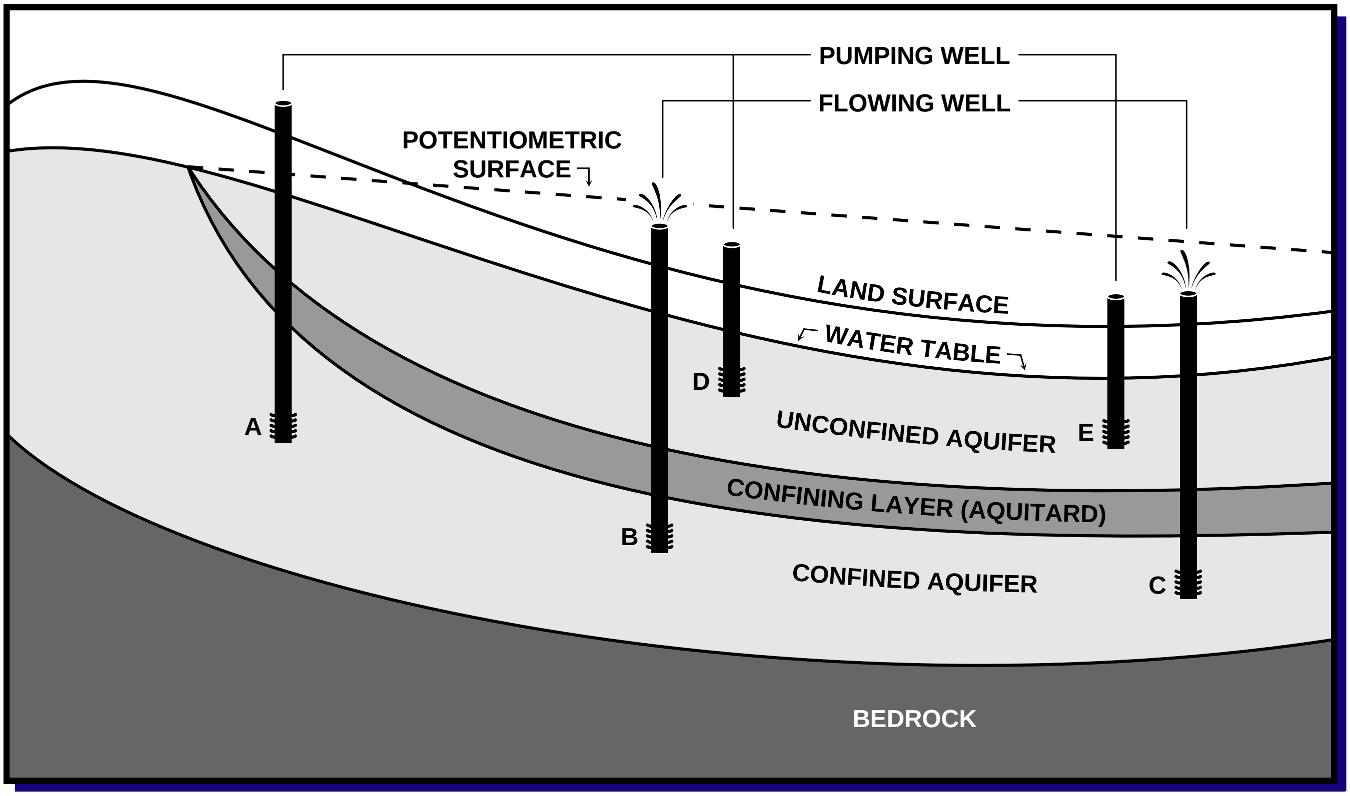
In areas of California with other types of rocks, groundwater occurs only in the pore spaces and fractures within those rocks. In fractured hard rock typical of the Sierra foothills, water is present only in the joints and fractures within the rock. As a result, groundwater may not be found in all locations. Where it is found in fractured hard rock, the yield may be quite low and there is usually not a large amount of groundwater in storage.

In many valleys and basins in California, water in river channels of the distant past has deposited large amounts of highly porous sand and gravel. These deposits, found below the ground surface, constitute major aquifers and provide large amounts of groundwater to wells. Such aquifers exist in the Central Valley, southern California, parts of the desert, Salinas River Valley, and in the San Francisco bay area.

Sands and gravels have also been deposited in alluvial fans formed where smaller streams have flowed into valleys throughout California. Where these alluvial fan deposits are buried at some depth below the land surface, they also constitute major aquifers.

The groundwater in these aquifers is recharged naturally by percolation of surface water through the ground surface directly above the aquifer or from a nearby area from which groundwater can percolate into the aquifer.

4 Wells that flow at the surface can be explained by simple laws of nature.



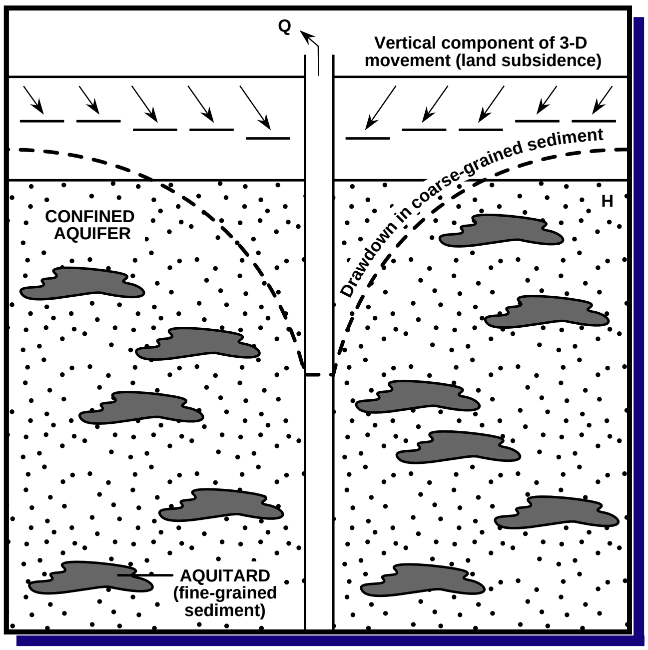
Wells A, B, and C are perforated in the confined aquifer. Ground water in these 3 wells rises to the level of the potentiometric surface. All 3 wells are ***artesian*** *wells. However, in well A the potentiometric surface is below the ground surface, so artesian well A does not flow at the surface. In wells B and C the potentiometric surface is above the ground surface so they are* ***flowing*** *artesian wells. Wells D and E are perforated in the unconfined aquifer. Ground water levels in these 2 wells reflect the level of the water table.*

Like surface water, groundwater flows only from higher level to lower level. When water flows from a well without having to be pumped, the recharge area for that well is at a level that is higher than the discharge point of the well. The difference in level provides enough pressure to push the water out of the discharge point of the well. This type of well is commonly referred to as a flowing artesian well.

5 Water witching has never been scientifically proven to be effec–tive in locating groundwater.

Many people believe that a good location for a high-yield water well can be found by a water witch or a water dowser using a forked stick or some other “divining” implement. While many people believe in the effectiveness of dowsing, such beliefs have never been supported by scientific proof that dowsing increases the probability of locating a good well.

6 When land subsidence occurs because groundwater extraction lowers groundwater levels, the usable storage capacity of the aquifer is not decreased.



Cross-section of confined aquifer containing finer material that consolidates or compacts when groundwater extraction lowers water pressure.

The processes that lead to land subsidence as a result of fluid extraction are explained by the principles of soil mechanics. The sediments that compact when groundwater levels are lowered are the fine-grained sediments, consisting of clays and silts.

The compaction consists of elastic and inelastic components. Elastic compaction is recoverable. Instruments that measure subsidence of the land surface, called extensometers, have recorded subsidence as groundwater was extracted and groundwater levels declined. When extraction stopped and recharge occurred, groundwater levels rose again and the land surface returned to its original altitude.

In contrast, inelastic compaction is not recoverable. Once overlying stresses exceed the elastic component, deformation of the fines begins. This deformation, or inelastic compaction, results in compaction of the clays and silts in the aquifer system and land surface subsidence.

After compaction, these finer sediments have a lower porosity, or storage capacity for water. However, the original permeability of these sediments was so low that the groundwater stored within them before compaction was not readily available to water wells. The pore space reduction caused by compaction of these fine sediments is not recoverable and the groundwater that drained from them will never be available again.

The coarser sediments of the aquifer continue to store the same amount of groundwater as before while the finer-grained material within the aquifer stores less.

Land subsidence can adversely affect roads, buildings, wells, canal gradients, doors and windows, irrigated land gradients, and low-lying coastal areas. Where groundwater constitutes a part of the water supply, local water management agencies and local government must decide how much, if any, land subsidence is acceptable. Once that decision is made by local agencies, a management program may include:

- installing extensometers to measure the change in thickness between the land surface and various depths below the surface;
- measuring changes in groundwater levels;
- determining the altitude of the land surface at periodic intervals to detect any change;
- recording the amount of groundwater extracted;
- recharging the aquifer to control subsidence; and
- determining when extraction must be decreased or stopped.

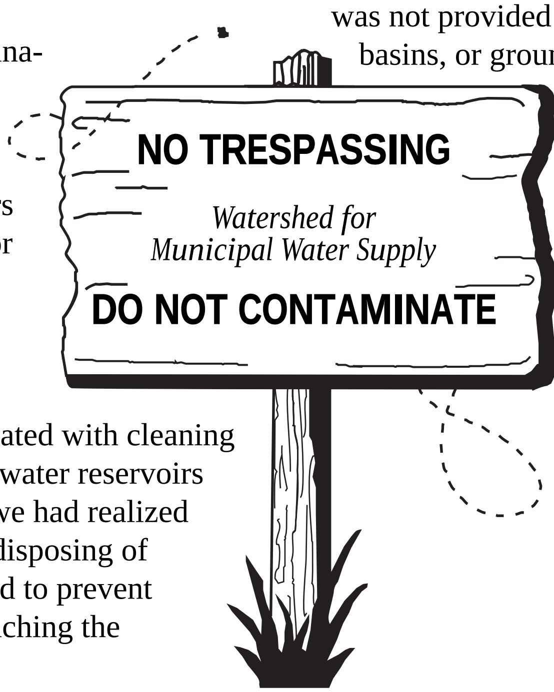
With this program the management agency can manage groundwater extraction to minimize subsidence.

7 The rule for protecting the quality of groundwater is PREVENT, PREVENT, and PREVENT contamination!

In the past, conventional wisdom said that anything could be dumped on the ground and whatever it was would be cleansed by flowing through the ground. We have learned how untrue this "wisdom" is only after discovering the extent of contamination of our groundwater basins. Most of this contamination is the result of indiscriminate but accepted legal practices for handling chemicals and disposing of chemical wastes. As a result, we are faced with costs of millions or billions of dollars and many, many years to clean up groundwater basins that have been contaminated.

It may take thousands of years for some water in a large groundwater basin or reservoir to move from the recharge area to the discharge area. As a result, it may take many years before the presence of contaminants in the groundwater reservoir is detected. This is not true in a surface water reservoir where detection of a contaminant occurs almost immediately.

Unfortunately, once contamination is detected in a groundwater reservoir, it is costly and difficult to remove. Many groundwater reservoirs may remain contaminated for hundreds of years, or even forever, once they are contaminated.



The tremendous costs associated with cleaning up (remediating) our groundwater reservoirs could have been avoided if we had realized that it is important to avoid disposing of such chemicals on the ground to prevent such contamination from reaching the groundwater. Rather than using our groundwater basins as waste disposal systems, we should prevent those contaminants from reaching the groundwater. In some areas of California this is still not being accomplished.

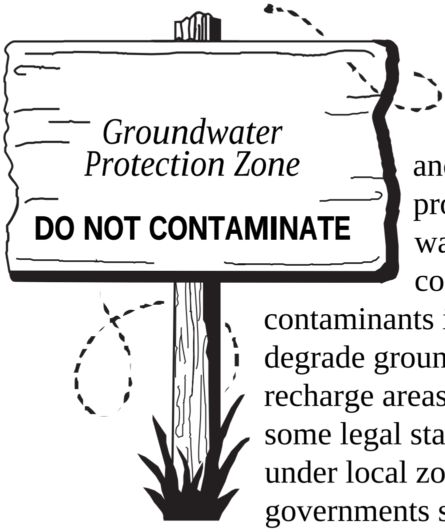
It is much cheaper to prevent contamination of groundwater basins in the first place than to remediate them after contamination is discovered.

8 Groundwater should be protected just like surface water to prevent contamination and to ensure an abundant, usable supply.

Since the inception of municipal water supply reservoirs in the late 1800s, western countries have mandated that surface water reservoirs be protected from contamination by man-made pollutants. In contrast, it was thought that similar protection was unnecessary for groundwater reservoirs because it was widely believed that all contaminants, including chemicals, were removed by percolation through soil and sediment. As a result, until the 1970s it was thought that contaminants did not migrate into the groundwater. Therefore, protection was not provided for California's groundwater basins, or groundwater reservoirs.

It has since been learned that a large variety of contaminants, including chemicals, can enter the groundwater. Many people now realize that groundwater supplies, like surface water supplies, must also be carefully protected from contamination.

9 Land use practices should prevent contamination in recharge areas.



Recharge areas for wells and aquifers should be mapped and delineated, and protected so the ground-water reservoir is not contaminated. Because contaminants in recharge areas degrade groundwater quality, recharge areas should be given some legal status for protection under local zoning codes. Local governments should re-evaluate land use zoning and the industrial, residential, and chemical practices that are allowed in recharge areas.

Similarly, delineation of well head protection areas, the local area that contributes recharge directly to a single operating water well, would help to protect groundwater quality. Certain types of activities should be prohibited or carefully regulated within each publicly identified well head protection area.

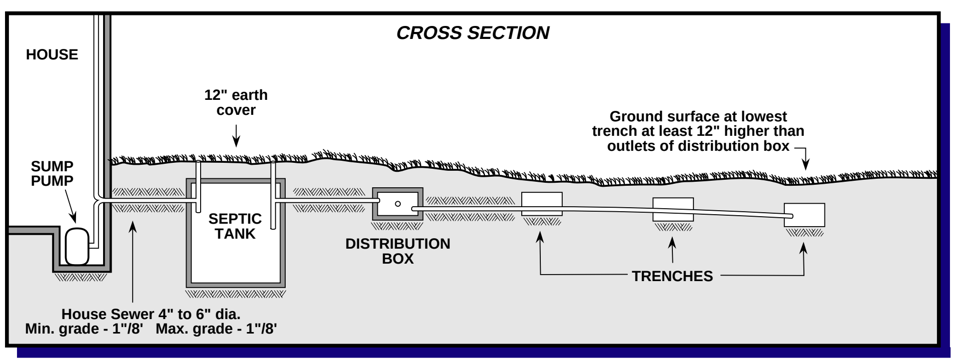
In some areas, on-site sewage disposal systems have been identified as one source of nitrate in ground water. A second source is application of fertilizer on crops, and a third source is dairies and cattle feed lots.

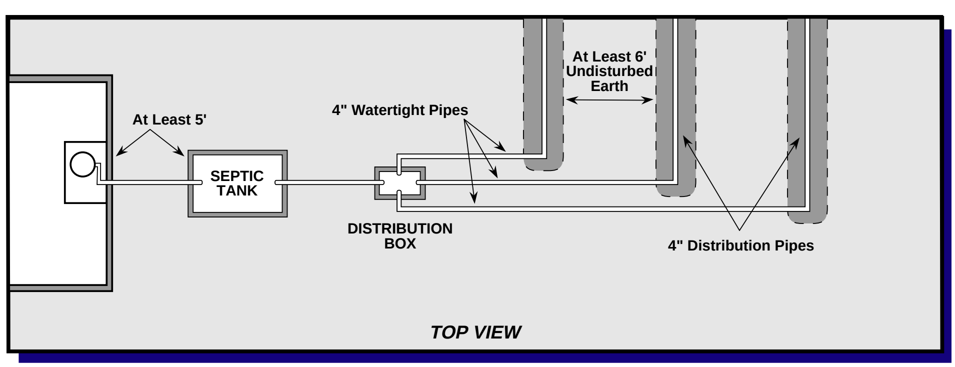
10 Undersized, overloaded, or incorrectly built septic tanks, septic pits, cesspools, and leach line systems for sewage disposal will contaminate groundwater.

In most rural areas of California, sewage from single residences is disposed of on-site. On-site waste disposal systems that are adequately sized and properly built can be very effective.

On-site sewage disposal is effective as long as the septic tank and the leach field are not overloaded, as long as the cesspool and septic pits are not in direct contact with groundwater, and as long as the number of such disposal systems does not exceed the area's capacity.

Septic tanks should be inspected every one or two years and pumped, if necessary, to maintain proper operation of the sewage disposal system.





11 Not all contaminants are removed from water when it percolates through sand and clay. Wastes disposed of on the ground or in "dry wells" frequently contaminate groundwater supplies.

Filtration is effective for treatment of human sewage but when chemical products such as oil, organic solvents or pesticides are disposed of on the ground, those chemicals interact in different ways with the organic particles and the inorganic clay, silt, sand, and gravel particles through which the fluid flows. Chemicals disposed of on the ground may:

- become attached to some particles;
- float on top of the water table;
- dissolve in groundwater;
- pass completely through to the bottom of the aquifer;
- decompose or alter to other chemical compounds.

When these synthetic chemicals are disposed of in dry wells, a shallow hole in the ground, the chemicals may remain in the sediment near the surface and contaminate water that flows through those sediments, or the chemicals may flow directly into the groundwater and contaminate it.

For Further Information About Groundwater...

There is no question that groundwater will become an even more important component of California's total water resources. With an expected population increase each year of almost 700,000 persons (over 2 percent increase per year), more water will be needed continually for urban, agricultural and environmental uses.

The primary goal of California water managers must be to effectively manage groundwater, in conjunction with surface water, to maximize the available water supply. Such management will play a major role in California's future.

Groundwater publications are available free from Bulletins and Reports, California Department of Water Resources, P. O. Box 942836, Sacramento, California 94236-0001, telephone (916) 653-1097:

California Laws for Water Wells, Monitoring Wells, Cathodic Protection Wells

Water Facts—Groundwater in Fractured Hard Rock—Number 1

Water Facts—7-Steps for Managing Groundwater Supplies —Number 2

Water Facts—Adjudicated Groundwater Basins—Number 3

Water Facts—Groundwater Management Districts or Agencies in California—Number 4

Water Facts—California Well Standards, Questions and Answers—Number 5

Where do you get more Information?

For further information on ground water management in California, contact any one of the following California Department of Water Resources' offices:

Northern District **(916) 527-6530**
2440 Main Street
Red Bluff, CA 96080

Central District **(916) 322-7164**
3251 S Street
Sacramento, CA 95816-7017

San Joaquin District **(209) 445-5481**
3374 E. Shield Avenue
Fresno, CA 93726

Southern District **(818) 543-4600**
770 Fairmont Avenue
Glendale, CA 91203-1035 or

P.O. Box 29068
Glendale, CA 91209-9068

Division of Local Assistance **(916) 327-8861**
1020 9th Street
Sacramento, CA 95814

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