Water Basics

The perpetual movement of water between the atmosphere, the ocean and land is called the hydrologic or water cycle. About 97% of the earth's water is contained in the oceans; more than 2% is frozen in glaciers and ice sheets; less than 1% is in streams, lakes, rivers or underground storage features called aquifers. The atmosphere holds only 0.001% of the earth's entire supply of water at any given time, but serves as the key hydrological medium between ocean and land.

In its pure state water, the "universal solvent", is one of the most aggressive substances known to man. Given enough time, water will dissolve (to some degree or another) almost anything to which it is exposed. When we make water very pure by removing impurities and charged particles, it becomes especially aggressive. When exposed to other environmental substances, it will attempt to dissolve them in order to reach equilibrium. Water is said to be saturated when it dissolves an amount of substance to the point it reaches equilibrium between itself and the substance to which it is exposed - the point at which no higher level of solid can be dissolved at a given temperature and pressure (STP).

Super-saturation is an unnatural state that occurs when a liquid has an excessive amount of dissolved substance. An example of a super-saturated solution is RO filtrate, resulting from the deliberate concentrating of unwanted salts onto one side of a semi-permeable RO membrane under pressure, creating reverse osmosis and the resultant accumulation of brine.

Common contaminants found in water include atmospheric gases, minerals and organic material (e.g. bacteria). Importantly for our discussion, materials used to convey or store water may also be dissolved and become contaminants.

At the right temperature, atmospheric moisture condenses on particles such as dust and eventually returns to the earth's surface as some form of precipitation - rain, sleet, or snow. As this precipitation nears the ground, it may pick up additional airborne particulate matter such as plant spores, bacteria, and emissions from numerous other sources. These increase the number and type of contaminants.

The hydrologic cycle (Illustration 1) illustrates the process of natural water purification and sources of contamination.

Water enters the atmosphere as it evaporates from geographic surface features such as lakes, rivers and streams and transpires in the form of water vapor from vegetation. The evaporated water returns to the earth as it condenses in the cooler air of the upper atmosphere where it dissolves other gases such as nitrogen, carbon dioxide, sulfuric oxides, and carbon monoxide. One result of these dissolved gases in water vapor is usually a mildly acidic

condition, what is today called "acid" fog or rain, that may have a pH as low as 4.5. In today's industrialized countries, typical rainwater has a pH of 5 to 7.

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As precipitation occurs, most water evaporates after reaching the earth's surface. Some falls into the ocean and what reaches land replenishes groundwater aquifers and surface water supplies. Water that percolates down through the porous upper crust of the earth is "filtered" during that process. Most of the particulate matter is removed, and most organic contamination is consumed by bacterial activity in the soil. A relatively clean, mildly acidic solution remains.

This acidic condition allows the water to dissolve many minerals, especially limestone ($CaCO_3$), which contributes calcium. Other geologic substances the water may come into contact with contribute magnesium, iron, sulfates and chlorides. The addition of these minerals generally raises the water's pH to a range of 7 to 8.5 or neutral to slightly basic.

This mineral-bearing water is stored in natural underground aquifers, which are a source of water wells used by homes, industries, and municipalities.

Geographic surface features such as rivers, lakes, and reservoirs, typically contain less mineral contamination, but may hold higher levels of organic and particulate contaminants. This is because the water did not benefit from the normal filtering effect described above as precipitation passes through the earth's topsoil, gravel and rock.

When water on the surface percolates through the soil under force of gravity, it reaches a zone where the pores in rocks and sediments are saturated with water. The water table is the area where the saturated and unsaturated zones meet. The water table follows the general slope of the land above it. In some places the water table meets the land surface, and springs, marshes, ponds and lakes may occur.

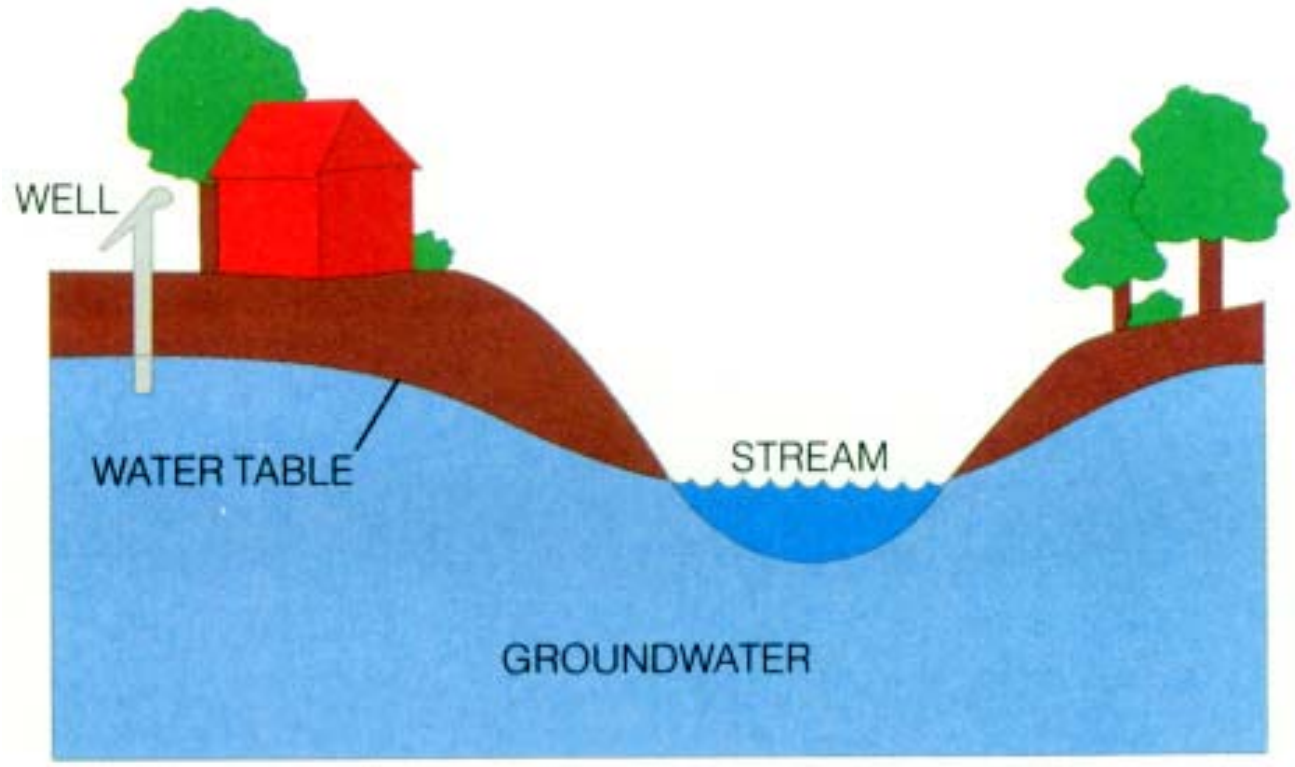

Illustration 2 - Water Table

Human activities can affect water table levels. Farmers often build drains or drill wells to lower the water table so they can grow crops in swampy soils. In some arid regions, increased demand for water can cause groundwater to be withdrawn faster than nature can replenish it. This lowers the water table and reduces the amount of groundwater available for use.