AQUIFER RECHARGE – A BRIEF INTRODUCTION
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This article is intended to be a brief introduction to understanding aquifers and how they relate to water shortages. It also outlines in general some steps that can be taken to alleviate shortages.

A geologic formation from which groundwater can be pumped for domestic, municipal, or agricultural use is known as an **aquifer**. Often, aquifers are separated from one another by a geological formation that permits little or no water to flow between them. These geological formations can be either less **permeable** than the aquifer or entirely **impermeable**. Describing the diversity of aquifers, the United States Geological Survey (USGS) states that, "an aquifer may be only a few or tens of feet thick to hundreds of feet thick. It may lie a few feet below the land surface to thousands of feet below and may underlie thousands of square miles or just a few acres." *Ground Water,* USGS (1999) at: http://pubs.usgs.gov/gip/gw/how_b.html.

There are two major types of aquifers: **unconfined** and **confined**. An unconfined aquifer has the water table as an upper boundary and allows water to percolate directly into the aquifer from the surface. A confined aquifer, on the other hand, is sandwiched between impenetrable layers such as bedrock or clay. Often, a confined aquifer is pressurized such that drilling a borehole into it will cause the water in the aquifer to rise above the water table level and even, at times, rise above the surface, becoming an artesian well.

Most of the water supply for Anne Arundel County comes from groundwater supplied by the confined Patuxent, Patapsco, Magothy and Aquia aquifers. Groundwater is a variable resource because the circulation of water through the earth and the atmosphere is dynamic. Constant replenishment, changing demand and widely varying environmental conditions mean that actual groundwater availability can only be measured on a site-specific basis. Confined aquifers receive **recharge** from areas where water-bearing formations crop out on the surface, leakage through confining beds, and movement of water from adjacent aquifers. They are much less vulnerable to drought conditions. The **age of the water** in an aquifer is an indication of the **rate** at which the aquifer can be **recharged** or refilled *naturally*. The older the water in the aquifer the longer it will take for the water to build up in the aquifer. This means that it will not be recharged naturally in a short period of time.

The City of Annapolis owns and operates its own water supply system and uses groundwater from the Magothy and Patapsco aquifers. In addition, Fort Meade has its own private water system that includes six groundwater wells. A study by David Andreasen in 2007 indicates that sufficient ground water is available to supply the projected demand through 2040 from the Anne Arundel County Department of Public Works well fields, while at the same time supplying ground water to other users in Anne Arundel County and the surrounding counties (including Baltimore City) at permitted levels which is about 73 million gallons/average day. When **withdrawals** are optimized to minimize drawdown from the wells, the predicted water levels will not fall below the State-mandated management level near the well fields by the end of the study period (2044).

However, demand on the water supplied by the Anne Arundel County Department of Public Works is projected to increase nearly two-fold or more by 2040, with an estimated maximum withdrawal of 140 Mgal/day. An increase of that magnitude could cause significant drawdown resulting in some water levels falling below the regulatory management level, well operational problems and increased pumping costs.

Increasing demand for water has shown that the extensive groundwater reservoirs formed by aquifers are invaluable for water supply and storage. Natural replenishment of this vast supply of groundwater is very slow. Therefore, exploiting groundwater at a rate greater than it can be replenished causes groundwater levels to decline and, if not corrected, eventually leads to the elimination of usable groundwater.

Artificial aquifer recharge (AR) is the enhancement of natural ground water supplies using man-made conveyances such as infiltration basins or injection wells. **Aquifer storage and recovery** (ASR) is a specific type of AR practiced with the purpose of both augmenting ground water resources and recovering the water in the future for various uses.

AR and ASR wells are found in areas of the U.S. that have high population density and proximity to intensive agriculture; increasing demand on ground water for drinking water and agriculture; and/or limited ground or surface water availability. AR wells, for example, have been utilized to deter salt water intrusion into freshwater aquifers and to control land subsidence. While an AR well is used only to replenish the water in an aquifer, ASR wells are used to achieve two objectives: (1) storing water in the ground; and (2) recovering the stored water either using the same well or by pairing injection wells with recovery wells located on the same wellfield. ASR wells have been used to store and recover water for drinking water supplies, irrigation, and more recently, ecosystem restoration projects such as the Comprehensive Everglades Restoration Project. However, injection via wells is regulated by the EPA Underground Injection Control (UIC) Program. Although ASR includes the recovery of the injected water, the UIC program does not regulate recovery.

In this area, the USGS measures groundwater levels in approximately 470 coastal plain aquifer wells in order to understand short-and long-term changes within the water table and confined aquifers. These data help quantify aquifer response to recharge events and various stresses such as drought and groundwater pumping for domestic, public, or industrial supply including withdrawals for power plants in southern Maryland. However, these studies, as of now, do not include artificial methods for recharging the aquifers!

Of course, there are other ways to increase our water supplies. Often, someone suggests a **pipeline** to supply cities with water from rural, wetter regions. Serious proposals for pipelines from Alaska in the 1990s and far Northern California in the 1970s were rejected as too expensive.

The world's largest supply is right off the coast — ocean water. Two **desalination plants** are coming online in Southern California. Making seawater drinkable is expensive because it takes so much energy. Also, the distilled water is so acidic that it must be rebalanced or it will corrode the pipes that carry it.

Treated sewage from a sanitation plant which has been filtered, chemically doctored, and zapped with ultraviolet light has also been suggested. It is most important that the health and regulatory aspects of groundwater recharge with recycled municipal wastewater include practical recommendations to guide decision makers. At present, uncertainties about health risk considerations have limited the use of recycled municipal wastewater for groundwater recharge.

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