ASR-Aquifer Recharge and Aquifer Storage and Recovery

Artificial recharge (AR) and aquifer storage and recovery (ASR) are processes that convey water underground. These processes replenish ground water stored in aquifers for beneficial purposes. Although the terms are often used interchangeably, they are separate processes with distinct objectives.

- ✧ AR is used solely to replenish water in aquifers. (RCM-Rainfall Conservation Module)
- ✧ ASR is used to store water which is later recovered for reuse. (RCW-Rainwater Conservation Mesh Wells System)

Background

Water suppliers seek ways to supplement water sources because of increased demand and local weather changes. For these reasons water suppliers and states are evaluating ASR technology. Objectives of ASR projects are to:

- ✧ Store water when it is readily available
- ✧ Recover water during dry or high demand periods

ASR projects are increasing in number nationwide, especially in areas with potential water shortages. Several methods of introducing water into an aquifer exist. Conventional methods of AR and ASR include:

- ✧ Surface spreading
- ✧ Infiltration pits and basins
- ✧ Injection wells

Injection wells are used for AR and ASR in areas where surface infiltration is impractical.
The sole objective of AR wells is to replenish the water in an aquifer. Injecting water through AR wells can:

- ✧ Prevent salt water intrusion into freshwater aquifers
- ✧ Control land subsidence

In contrast, ASR wells are used to:

- ✧ Store water in the ground
- ✧ Recover the stored water using the same well or nearby injection and recovery wells

ASR wells inject and recover water for:

- ✧ Drinking water supplies
- ✧ Irrigation
- ✧ Ecosystem restoration projects

ASR includes production of the injected water.
AR and ASR wells are frequently found in areas of the United States that have:

- ✧ High population density and proximity to intensive agriculture
- ✧ Dependence and increasing demand on ground water for drinking water and agriculture
- ✧ Limited ground or surface water availability

Construction of AR and ASR wells varies depending upon site-specific conditions and project objectives. Wells may either:

- ✧ Be a deep pit draining into porous layers above an underground source of drinking water (Underground Source of Drinking Water)
- ✧ Use multiple layers of casing and tubing to inject water under pressure directly into a Underground Source of Drinking Water (USDW).

Inventory and geographic distribution

The distribution of AR and ASR wells in the United States varies. Northeastern and midwestern states with relatively abundant drinking water may have not used AR and ASR widely. However, in many southeast, southwest and western states, ASR is a popular option to provide a reliable water supply.

As of 2009, approximately 1,200 AR and ASR wells existed nationwide (see Figures below). The number of AR and ASR wells more than quadrupled between 1999 and 2009. ASR and AR wells have been gaining attention as important water management tools in recent years.

Table - Well Operating Status

Well Type	Capable of Operation	Non-Functional	Plugged &Abandoned	Project Sites Containing Wells
ASR	542	14	65	307
AR	661	0	375	441
Total	1203	14	440	748

Impact on underground sources of drinking water

Water injected into AR and ASR wells includes:

- ✧ Drinking water from a public water treatment system
- ✧ Untreated ground water and surface water
- ✧ Treated effluent
- ✧ Reclaimed or recycled water

The type and quality of injected fluid, called "injectate," and the geology affect the potential for endangering a Underground Source of Drinking Water (USDW). The following examples illustrate potential concerns.

- ✧ If injectate is not disinfected pathogens may enter an aquifer. Some states allow injection of raw water and treated effluent. In these states, the fate of microbes and viruses in an aquifer is relevant.
- ✧ When water is disinfected prior to injection, disinfection byproducts can form in situ. Soluble organic carbon should be removed from the injectate before disinfection. If not, a chlorinated disinfectant may react with the carbon to form contaminating compounds. These contaminants include trihalomethanes and haloacetic acids.
- ✧ Chemical differences between the injectate and the receiving aquifer may create increased health risks when arsenic and radionuclides in the geologic matrix interact with injectate having a high reduction-oxidation potential.
- ✧ Carbonate precipitation in carbonate aquifers can clog wells when the injectate is not sufficiently acidic.

EPA did a study of Class V wells in 1999. The study did not identify cases of USDW contamination by AR and ASR wells. Since 1999, EPA lowered the drinking water standard for arsenic to 0.01 milligrams per liter. Testing at some ASR operations in the 1999 study showed concentrations of arsenic exceeding the current standard.

Some tested ASR operations had manganese and iron concentrations exceeding National Secondary Drinking Water Regulations. Additionally, the presence of disinfection byproducts has occurred in USDWs due to ASR activities. EPA is not aware of exceedances of applicable primary drinking water standards.

AR and ASR injection can have positive impacts on USDWs. Recharge into aquifers of poor quality water has, in some cases, improved ambient water quality.

Aquifer Storage: A Promising Part of Texas Water Solutions

Among the state's water supplies, aquifers are a critical source of water for Texas. According to the Texas Water Development Board, Texas has nine major aquifers that produce large amounts of water over large areas, and 21 minor aquifers.

Beyond supplying water, aquifers may also play a key role in future water management for the state through aquifer storage and recovery (ASR).

With ASR excess water is injected into sand aquifers, and stored there until it's needed in a time of drought.

"ASR is desirable because the storage is underground, and there's no evaporation. Environmentally, it doesn't change the surface of the land. With a surface reservoir, those are big issues — evaporation and environmental challenges," Dr. Calvin Finch, director of the Water Conservation and Technology Center, said in a Texas Water Resources Institute article.

For Texas, ASR is a relatively new technology, but one that holds great promise. According to a 2011 Texas Water Development Board report, Texas will need almost 9 million acre-feet of new water per year by 2060. "It will be difficult for conservation and other traditional strategies, especially expensive, controversial surface reservoirs, to meet all of that demand," the report's executive summary notes. "The capture and storage of water when it is available is critical to sustainable water management. The escalating costs and environmental challenges associated with surface water reservoirs have encouraged water professionals to explore ASR."

Evaporation is a huge hurdle when it comes to surface water storage. During the 2011 drought and heat wave, Lake Travis lost 206,000 acre-feet to evaporation, significantly more than the 166,000 acre-feet the city of Austin drew from the lake. That same drought has spurred 13 study areas around Dallas that could become ASR sites.

Although Texas has not widely adopted ASR, there are two cities that are using it currently: San Antonio and Kerrville.

The San Antonio Water System (SAWS) takes extra, permitted water from the Edwards Aquifer when water levels are high, and pumps it into the sandy Carrizo Aquifer. The Carrizo is a more stable place to hold the water – water in a sand aquifer tends to stay put, or move very slowly. SAWS currently has about 90,000 acre-feet of water stored, and can store up to 120,000 acre-feet. (One acre-foot equals 326,700 gallons).

The city of Kerrville has been storing excess Guadalupe River water in its Lower Trinity Aquifer ASR system since 1990, and the city has two wells. Kerrville's target storage is 4,600 acre-feet.

El Paso also uses a system that is similar to ASR, but instead of using the same wells to take water out and put it back in, the city treats wastewater to drinking water standards, puts it in the aquifer and lets it flow through the aquifer until it comes out of an existing production well.