Technical and Physical Feasibility Fact Sheet

Alternative 46: Aquifer Storage

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1. Definition of Alternative

A-46: Inject water treated to drinking water standards for aquifer storage in appropriate locations throughout the water planning region.

2. Summary of the Alternative Analysis

Aquifer storage and recovery (ASR) applications could potentially prove beneficial for water supply in the Middle Rio Grande (MRG) planning region. ASR is traditionally defined as the injection and recovery of water using dual-purpose ASR wells (Pyne, 1995). However, this analysis considers a broader definition of ASR applications, including additional approaches to increase aquifer recharge that have been implemented successfully in ASR projects nationwide.

ASR can be used as a tool for better management of existing supplies, such as saving water lost to evaporation or reusing treated wastewater. In general, water in the Rio Grande is fully appropriated; however, ASR approaches may help to improve the management of available supplies.

3. Alternative Evaluation

3.1 Technical Feasibility

Enabling New Technologies and Status

ASR is being used increasingly in the U.S. to assist in managing water resources, particularly in the arid southwest and in coastal areas. In the southwest, projects have been implemented in El Paso, Texas; Phoenix and Tucson, Arizona; Orange County, California; Las Vegas, Nevada;

and Salt Lake City, Utah. ASR has not yet been implemented on a large scale in New Mexico, but the Cities of Albuquerque and Alamogordo have ASR projects in the planning stage. In the coming years, ASR is likely to become increasingly important in New Mexico, as it has in other parts of the southwest.

ASR can provide a tool for conjunctive use of groundwater and surface water resources, and can offer the following advantages for improved water management:

- Replenishment of aquifer depletions
- Reduction of land subsidence rates
- Storage of excess surface water including flood flows
- Storage of water during low-demand seasons for use during high-demand seasons
- Reuse of treated wastewater effluent
- Storage of water without the evaporative losses of surface reservoir storage
- Acquisition of return flow credits to groundwater
- Improved water quality during the transport of water through a porous geologic medium

Enabling legislation that allows for ASR was passed by the New Mexico Legislature in 1999. The Ground Water Storage and Recovery Act (NMSA 1978, §72-5A-20) provides the legal mechanism for public entities to retain rights to withdraw water that is recharged to an aquifer. Water can be stored and recovered only by permit (NMSA 1978, §72-5A-6).

ASR must be conducted in conformance with the permit requirements of the New Mexico Office of the State Engineer (OSE) Underground Storage and Recovery Regulations (19.25.8 NMAC, effective January 31, 2001). The OSE decides whether recharged water is fully recoverable or whether an unrecoverable loss occurs. The OSE will also have to approve appropriations and/or examine possible surface flow impacts, depending on the type of ASR project.

Infrastructure Development Requirements

ASR involves artificial recharge to an aquifer and subsequent recovery of the water for later use. Various types of artificial recharge facilities are described below.

Infiltration basins: Infiltration basins (spreading basins or recharge basins) are shallow ponds with permeable bottoms that are designed to maximize downward infiltration of water. Infiltration basins also provide a beneficial effect on water quality as a result of soil-aquifer treatment (SAT) (Bouwer, 1992), and infiltration basins are the most common recharge method for treated municipal wastewater. Although evaporation is sometimes perceived as a drawback of infiltration basins, evaporative losses for properly functioning infiltration basins total no more than 1 to 2 percent of inflow. Enhanced recharge along surface water channels using in-channel or off-channel infiltration basins is successful at many locations in Arizona and California.

Injection wells: Injection wells may be used for aquifer recharge and groundwater recovery (Bouwer, 1996). Injection wells are categorized into three basic types:

- *Vadose zone wells* (also called “dry wells”) are large-diameter wells completed above the water table.
- *Infiltration galleries* (also called seepage trenches) are trenches backfilled with permeable, coarse gravel with perforated pipe to introduce water.
- *Groundwater injection/withdrawal wells* (also called ASR wells) are dual-purpose wells, which can be converted from existing supply wells.

Water injected directly into an aquifer must comply with U.S. Environmental Protection Agency (EPA) drinking water standards and New Mexico Water Quality Control Commission (NMWQCC) groundwater standards. To meet these standards, water from various surface water or wastewater sources will require various levels of treatment prior to injection.

Total Time to Implement

Because of the importance of site-specific hydrogeologic variables, ASR projects are best implemented using a phased approach that begins with pilot studies and progresses to implementation of the full-scale system (ADWR, 1999). A pilot scale project is required under the OSE regulations (19.25.8 NMAC) prior to full-scale implementation.

The timeframe to implement an ASR project varies depending on the nature and scale of the project. General implementation times are as follows:

- Enhanced arroyo recharge: 1 to 2 years
- Recharge treated municipal or industrial wastewater through infiltration basins: 4 to 6 years
- Recharge treated Rio Grande water through ASR wells: 5 to 10 years

The City of Albuquerque is about midway through a seven-year schedule for an ASR project using treated San Juan-Chama Project water injected and recovered using existing supply wells (COA Public Works, 2002).

3.1.1 Physical and Hydrological Impacts

Effect on Water Demand

ASR will not affect water demand.

Effect on Water Supply (surface and groundwater)

ASR may enable improved management of water supplies within the MRG planning region. Water sources that may be used for ASR in the region include:

- San Juan-Chama Project water
- Seasonal surface water and storm water flow
- Water transferred from surface reservoirs to subsurface storage
- Treated municipal and/or industrial wastewater

The effect of using these sources for ASR is described in the Water Saved/Lost section.

Water Saved/Lost (consumption and depletions)

The effectiveness of ASR at sites around the U.S. and the world is well documented. ASR can save and store water that would otherwise be lost to evaporation or would be lost downstream during flood events (Bouwer and Rice, 2001).

There may be legal limitations (i.e., Rio Grande Compact and water rights) to the use of water from ASR projects, as discussed in the legal fact sheets (*Evaluation of Alternative Actions for Legal Implications, Issues, and Solutions)*. The estimates provided in this section address only the physical availability of additional supplies. The amount of water saved depends on the type and scale of the ASR project:

- Small-scale enhanced recharge projects can potentially provide recharge on the order of 100 to 10,000 acre-feet per year (ac-ft/yr), a fraction of the annual flow measured in some of the region's larger arroyos (Thorn et. al., 1993). These savings are based on the assumption that any recharged water results in additional water supply to the MRG planning region, since normally much of the water is lost to evaporation without reaching the Rio Grande or groundwater supplies. Hence any additional supply from this alternative represents a net gain.
- Large-scale ASR projects can potentially recharge approximately 100,000 ac-ft/yr. This is comparable to the difference in evaporative losses from Elephant Butte Reservoir at low lake levels (50,000 ac-ft/yr evaporation) and at high lake levels (250,000 ac-ft/yr evaporation) (S.S. Papadopulos & Associates, Inc., 2000).
- ASR is one method of storing excess water that may be available during Elephant Butte spill years. Discussion of the magnitude of spills is provided in Alternative 38, Surface Modeling.

Impacts to Water Quality (and mitigations)

Treatment requirements for stored water must meet drinking water standards at the point of use in the aquifer. This can be done in two ways:

- Water that will be injected directly to an aquifer through recharge wells must be treated to meet drinking water standards before injection, or
- Water that will recharge through infiltration basins will be "polished" to achieve drinking water quality at the compliance point in the aquifer (Bouwer, 1996; Amy et. al., 1993).

Aquifer storage must comply with the requirements of the NMWQCC and the Underground Injection Control (UIC) Program. These regulatory requirements are administered by the New Mexico Environment Department (NMED) under the Water Quality Act (NMSA 1978, §74-6-1 et seq.), and the NMWQCC and UIC regulations (20.6.2.5000 NMAC). If the water source contains contaminants that could potentially impact groundwater (as determined by NMED), an approved groundwater discharge plan is required.

Two major health effects studies in California have shown that a potable water supply that contains an appreciable component of reclaimed water has no adverse human health effects (Nellor et al., 1984; Sloss et al., 1996). However, even if the treated influent water meets all drinking water standards, there may still be concerns over the possible presence of pharmaceuticals and endocrine disrupting chemicals, and consideration of the need for reverse osmosis treatment to remove them (Sedlak, 1999). In the MRG region, the recent analyses of Rio Grande surface water and City of Albuquerque wastewater effluent has shown the concentration of nearly all measurable synthetic organic compounds to be below detection limits (Thompson and Chwirka, 2002).

Watershed/Geologic Impacts

ASR can offset water level declines and reduce land subsidence rates (Bouwer, 2002). Areas with significant drawdown will benefit from increased recharge. These areas also provide water table conditions that are conducive to ASR, because recharged water will be fully captured (Thorn et al., 1993).

3.1.2 Environmental Impacts

Impact to Ecosystems

ASR could impact flows in the Rio Grande and its tributaries, and specific projects should evaluate these impacts. Using ASR to replace storage in surface reservoirs will impact the habitat associated with the reservoir.

Implications to Endangered Species

ASR projects should not have a direct impact on endangered species. However, depending on the source water and the timing of releases to and from storage, endangered species in the Rio Grande may be positively or negatively impacted. Reduced flows in the Rio Grande could affect endangered species and should be managed to avoid adverse affects. Conversely, endangered species could benefit from an ASR project to transfer Elephant Butte evaporative savings to aquifer storage, by including an option to pump water to the river during low flow periods.

3.2 Financial Feasibility

3.2.1 Initial Cost to Implement

The cost to implement an ASR project will depend on many site-specific factors, including site hydrogeology and the water quality of the proposed influent. Costs to implement ASR at a given location may include expenditures associated with:

- Pilot testing
- Land acquisition
- Influent water pretreatment
- Permitting
- Design and construction

Table 46-1 outlines costs for three active projects in Arizona. These costs can be used to approximate design and construction costs for a system of infiltration basins.

Table 46-1. Example Infiltration Basin Costs

Project Name	No. of Basins	Total Basin Acreage	Infiltration Rate (ac-ft/yr)	Approximate Project Costs [a] ($)		
				Design	Construction	O&M
GRUSP [b]	6	211	100,000	NA	NA	250,000/yr
CAVSARP [c]	9	290	100,000	1.3 million	8.0 million	NA
Sweetwater [c]	4	14	14,000	0.5 million	1.5 million	NA

[a] Does not include delivery pipeline, recovery wells, or monitoring network.
[b] Granite Reef Underground Storage Project (Lluria, 1999; Bouwer, 2002.)
[c] Central Avra Valley Storage and Recovery Project (CAVSARP) and Sweetwater Project information from Marie Light (Tucson Water), personal communication, 1999.

ac-ft/yr = Acre-feet per year
O&M = Operation and maintenance
NA = Information not available

3.2.2 Potential Funding Source

- New Mexico Legislative appropriation
- New Mexico Finance Authority loan
- NMED Construction Programs Bureau loan
- U.S. Department of Agriculture Rural Utilities Service
- Local financing (revenue bonds)

3.2.3 Ongoing Cost for Operation and Maintenance

Operation and maintenance (O&M) costs for the Granite Reef Underground Storage Project infiltration basins in Arizona are $250,000 per year for 100,000 ac-ft/yr recharged or $2.50 per ac-ft/yr. Additional O&M cost details are provided below.

Cost Evaluation Scenarios

To provide a preliminary basis for determining the cost feasibility for ASR projects in the MRG planning region, a variety of cost evaluation scenarios were established for a range of possible small- and large-scale projects. These cost evaluation scenarios are not intended as the basis for a complete feasibility analysis. The scenarios are described below, and Table 46-2 summarizes preliminary project cost estimates.

Comment: Table 46-2 Preliminary Cost Projection, Cost Evaluation Scenarios for Aquifer Storage and Recovery Projects, Mid-Region Council of Governments

Enhanced arroyo recharge. The cost evaluation scenario for enhanced arroyo recharge considers capture of storm water along one or more major arroyos in the MRG planning region. Infiltration basins would be constructed adjacent to the arroyo(s) and small diversion structures would be used to divert storm flows into the basin. An OSE diversion permit would be required to capture the storm water. The project would benefit the aquifer and reduce groundwater depletions. The enhanced arroyo recharge scenario includes costs for the following project components:

- Infiltration basins covering 4 acres with a storage capacity of 50 ac-ft for recharge and a 0.5-acre sedimentation basin
- Diversion structure across the arroyo to route storm water into the infiltration basin
- Purchase of a 10-acre tract of land
- Engineering design and permitting
- Operation and maintenance to clean accumulated sediments

Enhanced arroyo recharge could provide significantly higher recharge to the underlying aquifer than is experienced under natural infiltration through arroyo bottoms. Previous studies of recharge from arroyos show that short-duration storm events contribute little recharge, but the impoundment of water in deeper basins can recharge significant volumes (Hansen and Gorbach, 1997). Large arroyos in the region that are gaged have average annual flows of a few hundred to a few thousand ac-ft/yr (Thorn et. al., 1993), and a significant fraction of the storm flow in an arroyo might be captured and converted to recharge.

Treated municipal wastewater recharged via infiltration basins. The cost evaluation scenario for recharging treated municipal wastewater using infiltration basins considers the addition of tertiary treatment capabilities to an existing wastewater treatment plant, construction of infiltration basins, and installation of extraction wells to recover the recharged water. The cost evaluation for this scenario considers the following project components:

- Tertiary wastewater treatment upgrades to produce 5 million gallons per day (mgd) at an existing wastewater treatment plant
- 5-mile conveyance pipeline to carry treated wastewater to the infiltration basins
- Infiltration basins covering 15 acres, subdivided by interbasin berms to provide operating flexibility
- Six extraction wells, each capable of producing 1,000 gallons per minute (gpm) to recover the recharged groundwater
- Purchase of a 40-acre tract of land
- Engineering design and permitting
- Operation and maintenance including: operation of the tertiary wastewater treatment system, effluent pumping, pipeline maintenance, cyclic flooding and drying of the basins, and groundwater pumping.

ASR with treated wastewater potentially provides a method to use wastewater for future groundwater supply, following additional polishing of the water through SAT. This scenario describes a mid-sized project with a total flow to the infiltration basins of 5,600 ac-ft/yr. Evaporative losses are expected to be in the range of 50 to 100 ac-ft/yr, or 1 to 2 percent of total flow. For a site in the Middle Rio Grande Basin, where potable groundwater is present in the aquifer, the entire recharge volume is expected to be recoverable from the aquifer (Pyne, 1995). Treated wastewater ASR projects of various sizes may potentially be feasible, depending on the wastewater flow rates available in a give community and the community's balance of groundwater rights and return flow requirements to surface water.

Aquifer storage for Elephant Butte evaporation savings and Rio Grande flood waters. This cost evaluation scenario envisions a significant change in water management practices for the MRG planning region. The scenario involves lowering the average Elephant Butte lake level to reduce average reservoir storage by approximately 1,000,000 ac-ft, which would provide an average evaporative savings of approximately 100,000 ac-ft/yr. This would result in lake levels similar to the average level for the 30-year period from about 1950 to 1980 (S.S. Papadopulos, 2000). In addition, under this scenario some supplemental water might be captured from excess flood flows in the Rio Grande during years when spills are forecast at Elephant Butte dam and no Compact credit or debit is computed.

The estimated evaporative savings and period flood waters would be diverted from the middle Rio Grande far upstream of the reservoir, and recharged in the Albuquerque Basin aquifer. New production wells would be needed to deliver water from aquifer storage to the Rio Grande during times of low flow, to meet Compact obligations and make up for reduced surface reservoir storage. The cost evaluation scenario considers the following project components:

- 7 miles of infiltration galleries to collect Rio Grande water from shallow alluvium near the river
- Five conveyance pipelines, each 10 miles long and capable of carrying 22,000 ac-ft/yr (20 mgd) to the infiltration basins
- Five infiltration basins each covering 50 acres to recharge the aquifer.
- 40 extraction wells, each capable of producing 1,000 gpm to deliver storage to the Rio Grande during times of low flow.
- Purchase of five 100-acre tracts of land
- Engineering design and permitting
- Operation and maintenance including: infiltration gallery and pipeline pumping and maintenance, cyclic flooding and drying of the basins, and periodic groundwater pumping to the Rio Grande during low-flow years.

In addition to the costs listed above, there would also be costs to address institutional, legal, economic, and social issues that would result from a large-scale water management change of this type.

The elimination of 100,000 ac-ft/yr in evaporative losses represents a 25 percent increase in available water supply over the average allocation to the MRG region under Compact delivery requirements (400,000 ac-ft/yr) (S.S. Papadopulos, 2000). To implement this alternative, significant legal and Compact issues would need to be addressed to establish the MRG region's right to use evaporative savings for actual wet-water uses. Additionally, concerns regarding recreational use of the Elephant Butte supply and economic impacts to the area surrounding the reservoir would need to be addressed.

Cost Summary

The cost evaluation scenarios are summarized in Table 46-2. This preliminary evaluation of the costs for ASR projects provides an initial estimate of the expected cost range. The two lowest cost scenarios are for enhanced arroyo recharge and transfer of Elephant Butte evaporation savings and flood waters to aquifer storage. These costs scenarios would provide water storage, but do not include pumping of the water to put the water to use. For aquifer storage, these scenarios have costs in the range of $0.24 to $0.31 per 1,000 gallons ($78 to $101 per ac-ft). The scenario for treated municipal wastewater recharged via infiltration basins includes extraction wells that deliver produced water for use. The cost projection for this scenario is $2.38 per 1,000-gallons ($775 per ac-ft).

The cost estimates are intended only for the purpose of a preliminary evaluation of the ASR option as compared to other water supply alternatives considered. Therefore, the cost estimates for each alternative are for 2003 costs, and adjustments for present worth have not been considered. Much additional study is needed to develop ASR plans more fully before a complete feasibility analysis can be made for specific projects.

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