8. Analysis of Alternatives for Meeting Future Demand

After the region has studied the water supply and projected future demand for water, the next step in regional water planning is to develop alternatives for meeting the projected water demand. Alternatives are actions that the region can take to increase supply, reduce demand, protect or improve water quality, or better manage water resources so that the water supply of the region continues to be viable. This section provides information on the process used to identify and screen alternatives and analyzes the feasibility of priority alternatives selected by the Steering Committee.

8.1 Identification and Selection of Alternatives

An initial list of potential alternatives was developed at Steering Committee meetings, which are open to the public. This initial list was revised and expanded at a series of community meetings held in Mora, Las Vegas, Pecos, and Santa Rosa. Citizens added to the list of alternatives, and each group identified alternatives that they considered to be most important for the region.

To assist the Steering Committee with prioritizing alternatives, DBS&A prepared an initial assessment of the relative technical, legal, and financial feasibility of each alternative. The assessment consisted of ranking each alternative, by category (technical, legal, and financial), as having (1) no significant obstacles, (2) some complications, or (3) complex issues or obstacles. Alternatives were also ranked according to their estimated hydrological impact: very large, large, moderate, or small amount of water added, saved, or protected. Based on the initial ranking, in conjunction with citizen input, the Steering Committee identified priority alternatives for inclusion in the plan. In particular, input regarding one or two priority alternatives in each county was considered (i.e., even if an alternative was not considered to be top priority throughout the region, if it was very important in a particular area, it was included on the priority list). The alternatives so identified are:

- Municipal conservation, including education, rate structures, and graywater use, to reduce the demand in public water supplies

- Agricultural conservation, including on-farm improvements such as drip irrigation and delivery system efficiencies such as ditch lining, to reduce demands for agricultural use

- Watershed management, which focuses primarily on thinning in upland areas to reduce evapotranspiration and potentially increase water yields

- Non-native vegetation replacement, focusing on removal of salt cedar and re-establishment of lower-water-use native vegetation

- Water quality protection, including development of septic tank monitoring and maintenance or replacement programs

- Development of additional groundwater to provide supplies that are less vulnerable to drought conditions

- Development of additional storage through aquifer storage and recovery, raising the height of existing dams, building new dams, or removing accrued sediment

- Transferring water rights to create a permanent pool of water in Santa Rosa Lake

- Water rights protection, including adoption of acéquia bylaws to prevent out-of-acéquia transfers without the approval of the acéquia

- Water banking, including mechanisms for short-term leasing of water rights within acéquias or within larger geographic areas within the region

- Requiring proof of water availability to ensure that new subdivisions or other growth only occurs when reliable supplies have been secured prior to development

- Completion of 40-year water plans for municipalities and counties within the planning region

- Data collection, metering, measuring, monitoring and management to provide more reliable information for water resources planning

In accordance with the ISC template, these priority alternatives were evaluated with regard to their technical, financial, and political feasibility as well as anticipated hydrological, environmental, social, and cultural impacts. The results of these evaluations are described in Sections 8.2 through 8.14.

In addition to the priority alternatives, the Steering Committee identified water plan implementation methods. One method, citizen participation, was an important component in the successful development of this plan. Implementation issues, including recommendations for an expanded list of alternatives (beyond the priority alternatives) and possible funding sources, are discussed in Section 8.15.

8.2 Municipal Conservation and Management

Water conservation is an important aspect of regional water planning because it allows the region to make efficient use of and extend existing resources. The stakeholders and Steering Committee of the Mora-San Miguel-Guadalupe planning region selected this alternative to help municipalities identify conservation opportunities and sources of inefficiencies, with particular emphasis on rate setting, public education, and graywater use. This alternative shows the largest potential savings if water conservation ordinances are implemented for the municipal suppliers and for the rural public systems and self-supplied domestic wells.

The agricultural sector is the largest water user in the planning region, and thus agricultural conservation probably represents the greatest opportunity for increasing the overall available supply (Section 8.3). As discussed in Section 6, because of the rural nature of much of the planning region, municipal demand is a smaller part of total demand, and municipal conservation will thus not greatly affect the overall water budget in the region. However, controlling municipal demand is important for reasons other than balancing the overall regional water budget:

- Forty-year water plans, which allow municipalities to hold water in reserve for growth and economic development, require consideration of municipal conservation. Entities that can develop 40-year water plans under the Water Code include municipalities, counties, state universities, member-owned community water systems, special water users' associations, and public utilities supplying water to municipalities or counties (Appendix D1, Section D.3).

- The Water Trust Board, New Mexico Finance Authority (NMFA), and other state and federal funding programs for water supply infrastructure also require demonstration of adequate municipal water conservation as a condition of funding. Section 72-14-3.2 of the NMSA 1978 states that any public supply system with diversions of "at least 500 acre-feet annually for domestic, commercial, industrial, or government customers for other than agricultural purposes, may develop, adopt and submit to the State Engineer, by December 31, 2005, a comprehensive water conservation plan, including a drought management plan, and that after December 31, 2005, neither the Water Trust Board nor the New Mexico Finance Authority shall accept an application from a covered entity for financial assistance in the construction of any water diversion, storage, conveyance, water treatment or wastewater treatment facility unless the covered entity includes a copy of its water conservation plan."

- Water conservation can prevent or delay the need for expensive capital expenditures for developing new water supply and acquiring additional water rights.

- Municipal conservation programs can provide benefits to individual systems and raise public awareness of the importance of controlling excessive water use.

- Mutual domestic water suppliers and individuals on shared wells could extend the productive life of their wells using indoor and outdoor conservation measures.

This section focuses on methods of addressing municipal water conservation and management including (1) ordinances that restrict water use, set water rate structures, and require metering to detect water system losses and leaks, (2) voluntary conservation through public education programs, and (3) use of treated wastewater and graywater. These methods could be considered best management practices for water suppliers and for targeting end users. Implementation of water conservation programs using these methods is both technically and legally feasible and has been accomplished in other areas throughout the Southwest. Another important water conservation action is the detection of water system leaks in the water mains between production wells and consumer and the repair of such leaks. Municipalities must continually test and check the water distribution system to reduce such losses. The City of Las Vegas has reduced such losses from 35 percent in 1987 to 8 to 9 percent in 2005 (Frank Armijo, personal communication with Amy Lewis, June 17, 2005).

This alternative description is not a water conservation or drought management plan, nor is it a comprehensive guide to water conservation. To implement successful conservation programs, water suppliers need to obtain the requisite funding to develop a conservation plan for each individual system, which should include detailed information such as the results of a water audit, the estimated water savings for each aspect of the water conservation program, and the development of an implementation scheme, including a task force and drought management coordination.

8.2.1 Technical Feasibility

Developing successful municipal conservation programs requires the use of many different tools ranging from regulations and policies, to programs, to changes in technology. This section introduces some of these tools: conservation ordinances (including rate structures), public education programs, indoor water conservation, municipal wastewater reuse, and graywater use. In addition, it provides references to important municipal conservation guidance information that managers in the planning region could use to develop or expand conservation programs.

To address drought issues, water suppliers should include a drought management plan as part of their conservation plans. Appendix H1 contains a copy of the OSE model drought management plan as guidance for regional water suppliers.

A complete list of water conservation plan requirements and potential water conservation measures for water suppliers such as leak detection and repair programs, utility water audits and rate structures, as well as measures targeting end uses such as public education, indoor plumbing fixture replacements, and landscape design ordinances, is available on the OSE website (http://www.ose.state.nm.us/water-info/conservation/index.html).

Municipalities and water suppliers are well aware of the need for conservation and the vulnerability of surface water supplies to drought. Consequently, many already have undertaken some form of water conservation activity. The City of Las Vegas has a well developed conservation program that includes a water conservation ordinance, large multiyear projects to implement wastewater reuse and replace meters, and an active public education campaign. The City of Santa Rosa has completed a 40-year plan that identifies the steps it will undertake to address conservation needs. Smaller water suppliers, which have not had the funding to develop comprehensive conservation plans, have nevertheless undertaken projects to replace leaking lines and install and replace meters. Table 8-1 summarizes additional recommended municipal conservation activities for the planning region.

Table 8-1. Recommended Municipal Conservation Activities
Mora-San Miguel-Guadalupe Water Planning Region

Water Supplier	Recommendations
City of Las Vegas	Finalize meter replacement Complete wastewater reuse project Continue implementation of water conservation projects and enforcement of water conservation ordinance.
City of Santa Rosa	Consider revising rate structure to implement an increasing block rate structure Adopt and implement water conservation plan Consider water conservation ordinance including drought management planning Obtain funding to implement conservation objectives identified in 40-year plan
Village of Pecos	Consider revising rate structure to implement an increasing block rate structure Continue implementing meter installation and replacement Adopt and implement water conservation plan Consider water conservation ordinance including drought management planning
Wagon Mound	Continue replacing existing lines Obtain funding to implement conservation objectives identified in 40-year plan
Vaughn	Consider revising rate structure to implement an increasing block rate structure Adopt and implement water conservation plan Consider water conservation ordinance including drought management planning

8.2.1.1 Ordinances

Water conservation ordinances are a clear way to engage the public in water conservation activities. The primary topics covered by conservation ordinances, in separate or combined legislation, include the following:

- Prohibiting outdoor water waste (fugitive water) and/or requiring or encouraging low-water-use landscapes

- Changing water rate structures to encourage conservation and reduce water use by residential, industrial, commercial, and institutional customers

These types of ordinances are discussed in Sections 8.4.1.1.1 and 8.4.1.1.2; Section 8.4.1.1.3 discusses the use of water meters to support enforcement of these ordinances. Some of the ordinance provisions discussed in this section are at least partially implemented in several communities in the region.

8.2.1.1.1 Water Waste. Many major conservation issues can be addressed in an ordinance on water waste. The OSE (2001) suggests that water waste can be defined in an ordinance as water that flows or is discharged from a residence or place of business onto an adjacent property. Such discharges occur most often from landscape irrigation or leaking water pipes. In addition to the loss of potable water, these events have safety and maintenance impacts. Water running onto streets, especially when it freezes, can cause vehicle accidents and, if it pools, can damage road surfaces.

A prototype for a water waste ordinance is included in the OSE's guidance for municipal water systems (NM OSE, 2001). This ordinance template provides measures applying to both normal operations and water emergencies and includes the following main elements:

- Types of prohibited water waste:
  - Water running off an area during landscape irrigation
  - Washing of impervious surfaces with a hose (except when needed to protect public health and safety)
  - Water leaks not fixed within eight hours
  - Landscape watering outside prescribed hours (e.g., prescribed hours may be before 10 a.m. and after 6 p.m.)

- Fines and penalties for violations that increase with the number of citations assessed to a property, including:
  - Imposition of a water waste surcharge to any customer in violation
  - Temporary or permanent restriction or discontinuance of flow to a property with recurring violations

- Exceptions, the opportunity to cure violations, and refunds of surcharge

- Administrative appeal process for customers (e.g., appeal to administrative hearing officer, water utility's general manager, or the board of directors)

An emergency water ordinance can include additional measures such as emergency rationing (water allotment to different customer classes) and prioritization of water service according to customer class.

The OSE prototype ordinance assumes implementation and enforcement by the utility general manager and board of directors. If a county-wide enforcement system is developed, a certain amount of coordination is needed to develop and enforce the ordinance.

Examples of municipal water conservation ordinances enacted by other municipalities in New Mexico include the following:

- The City of Albuquerque, which adopted water conservation through a 1995 resolution that outlines a comprehensive water conservation program and other ordinances that define restrictions, create the basis to enforce penalties for violations, and outline water conservation guidelines for large users (COA, 2004).

- The City of Las Cruces, which passed a water conservation ordinance that restricts watering to specific times and days, prohibits water waste, and requires that leaks be repaired within five days. Las Cruces has had an inclining block rate structure (Section 8.2.1.1.2) since 1975, and the steepness of consumption-based rate steps has been increased in accordance with its water conservation ordinance.

- The City of Santa Fe, which implemented a conservation ordinance associated with its water emergency declarations (City of Santa Fe, 2004). Because of the real limits to Santa Fe's water supply, the restrictions are more severe and less voluntary than other case examples. However, by implementing conservation ordinances that restrict watering to three days a week during drought periods, Santa Fe has reduced demand by 22 percent on a per capita basis since 1995.

Although outside of New Mexico, the nearby City of El Paso provides a good example of the potential for consumption reduction through conservation. El Paso, probably the second most aggressive city in the Southwest (after Tucson, Arizona) in implementing conservation and xeriscaping programs, currently has a municipal and municipal-supplied industrial consumption rate of 140 gpcd (Padilla, 2004; Balliew, 2004). El Paso is a good source of conservation information and a key player in the Texas Water Conservation Implementation Task Force, which recently published a set of conservation best management practices with an up-to-date compendium of conservation tools (TWDB, 2004).

Another good source of up-to-date conservation information was recently published by the Pacific Institute (Gleick et al., 2003). The U.S. EPA and the American Water Works Association (AWWA) both provide conservation information on their web sites (<http://www.epa.gov/OW-OWM.html/water-efficiency/index.htm> and <http://www.awwa.org/waterwiser>, respectively).

Conservation ordinances can also establish requirements that apply during times of drought. Generally, the ordinance defines different levels or triggers, which have increasingly strict restrictions on water use. Sample levels and associated requirements are described below.

- Level I is voluntary and is triggered by lower-than-normal precipitation. At this level of restriction, water users are encouraged to minimize landscape irrigation and other activities that consume water.

- Level II is triggered by demand that is greater than available production for two consecutive weeks. It allows outdoor watering on only odd or even days outside of the 10 a.m. to 6 p.m. time bracket, limits refilling of swimming pools, and places restrictions on car washing and other water consuming activity.

- Level III is called a "water crisis" and is again triggered by the relationship between demand and available supply on the system. It is instituted by a declaration from the town manager when an emergency exists in his/her judgment. The level III condition eliminates all outdoor watering and allows the town manager to impose other restrictions as s/he deems necessary.

The City of Las Vegas Water Conservation Ordinance mandates year-round restrictions and drought condition measures. The ordinance includes a public education campaign that communicates information about water supply such as snow pack, reservoir levels, and daily consumption. The city billing department sends water watch stickers with monthly bills to inform customers, and numerous public information announcements are made by city officials (City of Las Vegas, 2001).

Year-round restrictions on irrigation and outdoor watering specify the time of day watering can take place and alternate-day watering for odd- and even-numbered addresses. The ordinance prohibits waste of water and has enforcement measures.

Drought condition measures are divided into three stages and include enforcement provisions. The stages are determined through a consultation process. The "City Manager upon consultation with the Water Director, Water Treatment Plant Supervisor and Water Conservation Specialist shall determine when each stage is implemented based on operational requirements and predicted and actual water supply limitations" (City of Las Vegas, 2001).

8.2.1.1.2 Water Conservation Incentives through Rate Structuring. Nationally, many utilities use pricing as a demand management tool. According to a 1992 AWWA survey, approximately 60 percent of the utilities in the U.S. use a conservation rate structure (NH DES, 2001). Four different types of rate structures can generally be classified as conservation oriented:

- *Uniform commodity rates*: All usage is charged at the same unit rate. Although not often viewed as water efficiency-oriented, uniform rates are an improvement over declining-block rate structures in which the price of water decreases as the volume of water used increases. The City of Santa Rosa has a declining-block rate structure, which means that users with lower consumption pay a higher unit rate (i.e., users of 3,000 to 5,000 gallons per month pay 8 percent more per unit of water than do users of 5,000 to 20,000 gallons per month) (ASCG, 2004).

- *Flat seasonal rates*: This rate structure incorporates two or more different uniform volume charges for different seasons during the year. Generally, a higher rate is charged during the peak water usage season than during the off-peak season.

- *Inverted block rates*: An inverted-block rate structure (also called inclining block) involves the use of increasing rates for units of water consumption at higher levels of usage. As water consumption increases, so does cost. Individuals who want to reduce cost will have an incentive to use less water. The City of Las Vegas has this type of rate structure, which is defined in the City's Water Conservation Ordinance (City of Las Vegas, 2001).

- *Excess use rates*: An excess use rate structure establishes an average base water usage volume during the non-peak period and a corresponding base water usage rate. During the peak period or season, water usage above the base level is charged at the base rate plus an excess use rate. Several variations of the excess use rate structure exist. Some utilities provide an allowance above the base usage during the peak season to recognize an increase in non-discretionary use during peak periods.

Each utility should analyze whether any of the above rate structures can achieve conservation in the local community. If an inverted block or excess use structure is implemented, the amount of water required for "basic human needs" can be determined and kept at an affordable rate for low-income households; thereafter, rates can increase. Some municipalities, such as Albuquerque, provide for an administrative waiver for low-income households that include more members than the number used in the "basic human needs" assumptions.

Conservation rate structures may result in uncertainty in forecasting revenue. Utilities must assess the interrelationships among rates, consumption, and costs and the effect that these issues will have on the revenue requirements of the utility.

8.2.1.1.3 Metering. Metering is an essential element in water conservation. Metering of both production and individual user consumption is the only way to track water use and ensure that conservation goals are being achieved. Comparison of production metering to meter readings for customer water accounts allows determination of “unaccounted-for” water. This unaccounted-for water can result from inaccurate customer water meters, leakage in water mains and distribution lines, and failure to meter all the demands. Many utilities track unaccounted-for water to look for water system problems. A goal of unaccounted-for water below 10 percent is both desirable and achievable. The City of Las Vegas and the Village of Pecos have been installing and replacing meters over the last several years (Sedillo, 2005).

A regulation, resolution, or ordinance should be in place to require the installation and regular reading of meters at all water sources, including import or export points, customer service connections, and public landscape sites. All water provided free of charge for public use, including construction water from fire hydrants, should also be metered to allow the utility to more accurately account for water use. The City of El Paso provides portable fire hydrant metering of construction water use (Padilla, 2004).

8.2.1.2 Public Education

Public education and community outreach are an important part of any water conservation effort. Individuals must know why water conservation is essential and what they can do to save water. *A Water Conservation Guide for Public Utilities* (NM OSE, 2001), which presents a comprehensive water conservation program, recommends two main components of a public education program:

- Use of a wide range of resources to reach the public and assigning staff of the conservation entity (either the local government or local utility) to specific aspects of a public information campaign. The types of resources that should be used for public information dissemination include:
  - News media
  - Speakers programs
  - Public information materials
  - Exhibition, tours, or special events
  - Web site

- Outreach in the public schools. Children who learn about conservation in the classroom will take that information home and educate their own families.

Numerous materials for all types of public education and school outreach programs are available on the OSE water conservation website (<http://www.ose.state.nm.us/water-info/conservation/index.html>). Other websites currently offer interactive water calculators to help users understand how much water they use and where they use it (<http://www.h2ouse.org> and <http://www.tampagov.net/dept_water/conservation_education/Customers/Water_use_calculator.asp>). These web calculators provide a simple method for doing a "home water checkup" and allow individuals to compare their home use with the average use.

8.2.1.3 Indoor Conservation

To gain water demand reductions, it is important to ensure that efficient water use appliances are distributed and installed. The potential water savings can be realized from upgrading the plumbing in existing homes and businesses. A single low-flow toilet (1.6-gallon flush) will save 12,000 to 16,000 gallons of water in a single year when compared to toilets that are more than 10 years old (Ash et al., 2002).

Water audits can be conducted to evaluate the water savings potential on a site. These can be made mandatory for all or selected groups of users. A time period should be established for audits to be completed, commercial and industrial sites should be required to use a certified water auditor, and a report should be submitted to the local and state water authorities. Audits can identify where rebate programs (such as rebates for installing low-flow toilets) can have the most impact.

Retrofits can be required through “retrofit on resale” requirements that mandate the installation of low-flow plumbing devices in residences (with the cost borne by the seller or buyer) as a condition of sale. In addition, financial incentives for installing retrofits and implementing other water-saving measures can be provided through rebates, such as rebates for low-flow plumbing devices for homes and apartments, rebates and/or tax incentives to install rainwater harvesting systems (residential and commercial), or rebates and/or tax incentives for businesses to upgrade plumbing and process water systems.

In addition to retrofitting, planning and design guidelines are needed to ensure that all new development uses water efficiently. Standards for low-flow plumbing devices should be included in all local building codes. Requirements for installation of metering devices should also be included in building codes.

8.2.1.4 Reuse of Municipal Wastewater and Graywater Recycling

Wastewater reclamation and reuse is practiced successfully in many locations in the western U.S. as a means of increasing or supplementing the available supply of water and preserving potable water for drinking water uses. Graywater reuse refers to either residential or commercial reuse of water that does not contain blackwater (from toilets) or kitchen wastes. Water from sinks (excluding kitchens), laundries, bathtubs, or showers is considered to be graywater.

8.2.1.4.1 Wastewater Reuse. The NMED developed policy for the aboveground use of reclaimed wastewater (NMED, 2003e) that is used in the development of groundwater discharge plans. The policy establishes specific quality standards and approved uses of different categories of wastewater depending on public exposure. Communities seeking to conserve water could reuse wastewater in the following ways:

- *To supplement agricultural needs.* Treated wastewater may be pumped directly to agricultural areas for irrigation. This option is only practical if the point from which the treated wastewater is being pumped is within a reasonable distance of the point of return. As an example, the City of Roswell, New Mexico uses all of its treated effluent for irrigation by selling it to nearby farmers during nine months out of the year. In New Mexico, treated wastewater may only be used for non-food crops, such as alfalfa, unless the wastewater does not come into contact with the edible portion of the crop.

  Land application of wastewater for irrigation purposes would require a groundwater discharge plan under the NMWQCC regulations, with the degree of treatment required depending on the types of crops grown. If water would be discharged to a natural waterbody for agricultural use, it must first be dechlorinated or disinfected by an alternative method such as ultraviolet radiation or ozone injection.

- *For recreational uses (landscape irrigation).* The primary recreational use of treated wastewater is for landscape irrigation, such as at parks, schools, and athletic fields, as other recreational uses involve bodily contact and potential human ingestion. As with agricultural uses, reusing wastewater for landscape irrigation is feasible only if the source of treated wastewater is within a reasonable distance of the reuse point. In addition, the wastewater would require secondary treatment, filtration, and disinfection to meet standards required for human and/or groundwater contact.

The primary technical challenge in reusing wastewater is treatment of the water to bring it to an acceptable level of quality. Whether used for agriculture, recreation, landscape watering, aquifer recharge, manufacturing and industry, or return flow credits, wastewater must be treated prior to use to comply with applicable regulatory standards. The degree of treatment and the standards to be met depend upon the end use of the reclaimed water:

- For all reuse options where human contact with the treated wastewater is likely (i.e., landscape irrigation and recreational use), wastewater treatment will likely require secondary and tertiary (filtration and disinfection) treatment to meet the water quality standards.

- For all reuse options where treated wastewater is likely to come in contact with groundwater (e.g., irrigation, landscaping, and aquifer recharge), a New Mexico groundwater discharge permit is necessary. Multiple reuse applications can be covered under the same groundwater discharge plan.

- Returning water to a river for return flow credits requires treatment to meet the standards required by a U.S. EPA Region 6 written and enforced NPDES permit. (NPDES permitting in New Mexico is currently overseen by the U.S. EPA, but the NMED is in the process of trying to acquire responsibility for this process.)

In addition, if treated wastewater is discharged to a stream designated as “impaired” by the NMWQCC, it may need to meet the receiving water quality standards established to meet the designated uses of that particular stream segment.

The treatment standards for a surface water discharge are well defined. However, the applicable standards that would have to be met for some (non-discharge) reuse applications are not as well defined. To date, no federal regulations have been proposed for either nonpotable or potable reuse (Pontius et al., 2002). In 1992, the U.S. EPA published guidelines for water reuse, defining a broad range of reuse applications and presenting guidelines for treatment water quality and implementation; however, these guidelines are not legally binding. Generally, where overlap occurs, U.S. EPA guidelines are similar to or more conservative than NMED guidelines.

The NMED's existing policy for the use of treated wastewater effluent for nonpotable uses was issued in 1985 and updated in August 2003 (NMED, 2003e). The guidelines are intended to be used in conjunction with a groundwater discharge permit for any applications of the reuse water that can result in percolation to an underlying aquifer. This permit, which describes the reuse application (use, flows, etc.) and specifies a water quality monitoring program, must be filed with NMED for each reuse site. NMED guidelines do not allow for reuse of wastewater for potable applications.

8.2.1.4.2 Graywater Recycling. Recycling of graywater at individual residences has received much attention recently in New Mexico. New Mexico allows individual residences to apply up to 250 gallons of graywater per day to household gardening and landscape irrigation without a discharge permit (Sections 74-6-2 and 74-6-4, NMSA 1978). Advantages of reusing graywater include the following:

- Replaces potable water use and therefore lowers water bills and possibly sewer bills for municipal customers
- Increases the life and/or improves performance of on-site septic systems
- When used for outdoor irrigation, may support plant growth (due to the nutrients in graywater)
- Reduces energy and chemical use
- Possibly decreases the need to expand wastewater treatment facilities

Reusing graywater also has some disadvantages:

- May spread disease if system is not properly operated
- May develop odors if stored more than 24 hours
- May adversely impact soil (salt buildup)
- Decreases the amount of wastewater going to treatment plant, which may affect the overall wastewater system
- Lowers availability of reclaimed water for return flow credits (where applicable) or other uses

The standard components of a graywater system include (Little, 2003):

- Conveyance piping to collect water from a source and deliver it to the graywater system
- Surge tank to hold flows (e.g., plastic trash barrel)
- Filter to remove particles such as lint and hair (e.g., sock, sand filter)
- Storage tank to hold water until ready to use
- Three-way valve to allow graywater to go to sewer or septic system
- Pump to move water to distribution point such as irrigation system

A permit is required by NMED for use of more than 250 gallons per day (gpd) of graywater. The permit needed is the same type of permit required for a septic system (Duttle, 1994). In issuing the permit, NMED considers treatment, storage, and disposal of the water (underground leach field versus surface disposal for irrigation).

No permit is required for less than 250 gpd if the following conditions are met:

- System overflow is directed to an existing wastewater system.
- Storage tank is enclosed and access is restricted.
- System is outside the floodway.
- The vertical distance between graywater and the groundwater table is at least 5 feet.
- Pipes for graywater system are marked as nonpotable water.
- Graywater does not leave the property.
- Standing water is minimized and prohibited for more than 24 hours.
- Graywater is never applied by spraying.
- Graywater use complies with local ordinances.

8.2.2 Hydrological Impacts

Successful water conservation ordinances and/or public education programs can reduce the amount of water needed to meet existing demand. This reduced demand will enable communities to extend their water supplies over a longer period of time before they need to develop additional expensive infrastructure (such as new wells or pipelines) or purchase additional water rights to meet the population's needs.

Because municipal water (and wastewater) represents a small portion of the total regional water use, reuse of wastewater will not have a large impact on the overall water situation in the region. However, it could improve efficiency in individual municipalities. When considering opportunities for reuse, the benefits that may accrue from current effluent disposal practices, such as groundwater recharge from arroyo discharge, should be considered.

Understanding both the current community water use patterns of different types of water user groups and the real needs of customers is the first step in developing the best tools to conserve water. The difference between the actual use of water (demand) and the actual need (efficiency level) is the conservation potential. The potential for water savings determines which efforts should be undertaken and when it becomes cost-effective to implement them. Once the water savings potential has been determined for a customer group, a conservation strategy can be developed for each system.

Based on reviews of water use in the region and surrounding communities and on program examples from around the country (i.e., those with proven track records), some communities in the planning region could achieve significant water savings—as much as 32 percent—through an integrated application of a conservation program. The success of a given conservation program will depend upon (1) the accuracy of the data, (2) the commitment of the local leaders, and (3) the thoroughness of the implementation. Communities with conservation programs have had varying levels of success. The City of Las Vegas, New Mexico has reduced water use by 25 percent, from an average of 189 gpcd during 1985 to 1989 to an average of 142 gpcd during 2000 to 2004. Albuquerque has reduced demand by 23 percent, Tucson by 30 percent, Los Angeles by 25 percent, Austin by 27 percent, and Irvine by 54 percent (landscape use) and 12 percent (residential use). Additionally, Santa Fe has reduced demand by 22 percent on a per capita basis since 1995.

Studies show that an incentive water pricing structure significantly affects water use decision making and can determine the effectiveness of conservation programs. Approximate water savings potential is 15 to 30 percent for indoor use and 40 to 50 percent for outdoor use, depending on how wasteful the current uses are.

Graywater reuse has the potential to reduce demand for treated potable water by the amount of graywater that is recycled. The average person generates about 40 gallons of graywater per day (NSFC, 2002), and reuse of this graywater could reduce freshwater use by 20 to 25 percent (Prososki-Marsland, 1995). However, even though the amount of diversions and water passing through a central treatment plant may be reduced, the consumptive use does not change as a result of this alternative. In fact, consumptive use may increase slightly if graywater is cheaper than other water supplies. Graywater reuse can also affect the water supply by decreasing the amount of wastewater returned to the treatment plant by up to 60 percent (Gelt, 2002). If water rights stipulate a return flow requirement or if other users are depending on return flows, those issues must be addressed when implementing graywater reuse.

The projected increase in municipal and domestic demands from the Year 2000 to 2040 is approximately 2,000 ac-ft/yr under the low growth scenario and 4,000 ac-ft/yr under the high growth scenario. A conservation program that uses tools such as rate structures and public education could reduce demand to 150 gpcd in cities and communities (which includes commercial uses) and to 100 gpcd in residential-only areas. A municipal per capita demand of 150 gpcd is relatively low and is based on demand in communities that have implemented a conservation program, such as the New Mexico cities of Las Vegas and Santa Fe. While both Las Vegas and Santa Fe reduced demands below 150 gpcd during the drought period from 2000 to 2004, the lower level of demand represented a hardship in both of these communities.

For planning purposes, communities need tools, in addition to the conservation measures discussed here, that will enable them to respond to future droughts. For instance, in 2002 and 2003 the City of Santa Fe had to reduce outdoor watering to one day per week to meet indoor water demands, which resulted in a per capita demand of 118 gpcd. A per capita demand of 150 gpcd is viewed as an achievable goal for a conservation program; further reduction can be as needed to respond to drought emergencies. As stated earlier, each community will need to assess its water use patterns and set ideal goals for per capita demand.

The ideal demand in self-supplied homes is assumed to be 100 gpcd. This is based on indoor usage of 60 gpcd (with no evaporative cooler) and outdoor usage of 40 gpcd (Wilson, 1996). Using a procedure developed by Wilson (1996), the “ideal” outdoor demand may be closer to 20 gpcd (80 gpcd total) in San Miguel County, if drip irrigation is used for 1000 ft^2 of trees and shrubs, and 200 ft^2 of vegetables and herbs, and if less than 800 ft^2 of buffalo grass is irrigated. For Guadalupe and Mora Counties the outdoor demand is calculated to be 36 and 47 gpcd (96 and 107 gpcd total), respectively. Because the actual irrigated acreage is not well known, the average of 100 gpcd is used as a reasonable goal for conservation. Vickers (2001) indicates that indoor water use for single-family residents in Albuquerque is 95 gpcd. At the extreme, the maximum conservation savings (without recycling gray water) would be realized by prohibiting outdoor watering so that only the 60 gpcd for indoor use are consumed.

To assess potential water savings from the implementation of a conservation program that includes both rate structures (for community systems) and public education, current demands were compared with the achievable goals of 150 gpcd for municipal and 100 gpcd for self-supplied. Because Las Vegas has already reduced usage to below the goal of 150 gpcd through its conservation program, no additional water savings are projected for this community. Santa Rosa, with a current demand of 202 gpcd, can achieve some savings through a conservation program. The communities served by rural water systems (including small towns such as Vaughn) have an average use of 178 gpcd in Guadalupe County and 202 in Mora County, both of which could be reduced through conservation efforts. The average demand in San Miguel County, however, is only 109 gpcd, which leaves no room for significant savings. Individual communities within all three counties may exceed the ideal goal of 150 gpcd.

The average water use of self-supplied homes in each county is based on the metered water use of small water systems serving residential areas only. Using this assumption, self-supplied homes in Guadalupe County use 90 gpcd, already less than the ideal goal of 100 gpcd, while self-supplied residents in San Miguel and Mora Counties use 109 and 117 gpcd, respectively.

If all communities in the planning region reach the goal of 150 gpcd for municipal and 100 gpcd for residential use, the overall reduction in municipal and domestic water demand will be about 9 percent for the region. The actual reduction potential will depend on current water use patterns (i.e., the amount used for landscape watering, tourism, etc.). Figure 8-1 shows the potential reduction of projected demand for both the low and high growth population projections. Under the low growth scenario, demand in 2040 would be reduced by about 600 ac-ft/yr, from a projected 7,900 to 7,300 ac-ft/yr. Under the high growth scenario, the region could reduce water use by about 800 ac-ft/yr, from a projected 9,950 to 9,160 ac-ft/yr.

8.2.3 Financial Feasibility

Sections 8.2.3.1 and 8.2.3.2 discuss the financial feasibility of each of the tools discussed in Section 8.2.1. Conservation ordinances and public education have been grouped together, as the development of these conservation tools is generally funded through one large program.

8.2.3.1 Conservation Ordinances and Public Education

The primary financial burden on local governments associated with implementing water conservation ordinances and public education programs is labor:

- A staff member would be needed to oversee the process of drafting and implementing water conservation ordinances.

- Utility staff would need to be trained and made available to undertake water waste enforcement duties. Existing field staff could be trained and sworn in as water waste officers if they have several hours available each week.

- Staff would be needed to develop and implement new rate structures. Billing would need to be retooled to use the new rates.

- Public education would require at least a part-time person devoted to public and school outreach programs.

A major financial reward of adequate municipal conservation ordinances and education is increased eligibility for many funding programs. Conservation through ordinances, education, and the adoption of a conservation ethic are essential to planning for the future water supply in the Mora-San Miguel-Guadalupe planning region.

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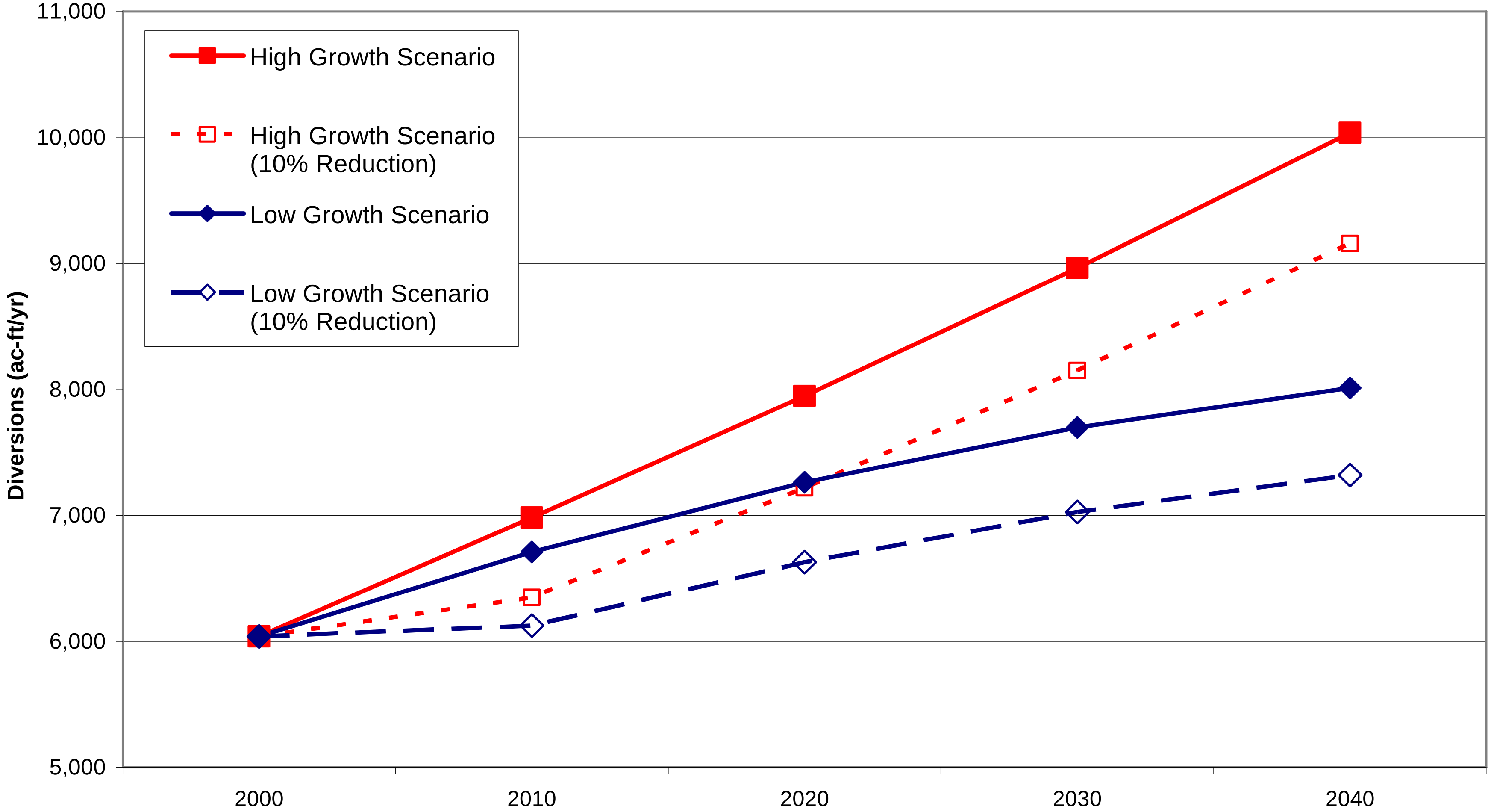


MORA-SAN MIGUEL-GUADALUPE WATER PLANNING REGION

Potential Effects of Municipal Conservation on Regional Water Demand (Diversions)

Figure 8-1

Daniel B. Stephens & Associates, Inc.

7/1/05

8.2.3.2 Municipal Wastewater and Home Graywater Reuse Costs

Costs for both municipal reuse and home graywater reuse can vary considerably, as explained below.

8.2.3.2.1 Municipal Wastewater Reuse. Costs for wastewater reuse alternatives depend on the standards to be met, the volume treated, the end use, the distance treated effluent must be pumped and/or piped, and the cost of permitting. Various costs associated with wastewater reuse include the following:

- Acquisition of raw wastewater supply
- Construction and operation of treatment facilities needed to meet standards for planned end uses
- Construction and operation of storage facilities needed to ensure a reliable supply on a day-to-day basis, accounting for seasonal differences in supply of effluent and use (e.g., turf facilities have peak demand in the summer, and effluent produced in the winter may need to be stored for summer use on these facilities)
- Construction and operation of the transmission and distribution system
- Costs of resolving issues related to diminished return flows for downstream users who have relied upon effluent discharges
- End-user adaptation costs such as on-site hookup and replumbing, special corrosion-resistant equipment, safety and public health practices, and other costs associated with the use of wastewater effluent

Costs are also highly dependent on the type of wastewater treatment process, which differs depending upon the reuse application. Reuse options away from municipalities typically are limited due to a lack of locally generated wastewater and the high cost of conveying wastewater.

8.2.3.2.2 Graywater Reuse. The cost to implement a graywater system varies greatly depending on whether the work is done by the owner or by professionals. The cost to retrofit a graywater system where plumbing is relatively accessible is estimated to range from $135 to $2,000. Costs would be prohibitive for existing structures where plumbing is inaccessible. The cost to build a graywater system during new construction is estimated to range from $65 to $650 (Little, 2003).

The graywater filtering system needs to be cleaned on a regular basis to prevent clogging. Annual maintenance costs are estimated to be less than $100 up to $600 for residential graywater recycling units, depending on whether the work is performed by the owner or under a maintenance contract. This cost would cover disinfectant use, regular cleaning, and replacement of filters throughout the year.

8.2.4 Environmental Impacts

Water conservation tools such as local ordinances and public education efforts can significantly reduce demands on local water supply and treatment facilities. Municipal conservation can contribute to the long-term sustainability of water resources and should be an area of emphasis for larger communities in the planning region. Specific environmental benefits could also be realized if a municipality dedicated the amount of water conserved to the preservation of a particular species or sensitive habitat.

The key environmental issue related to municipal wastewater reuse is the discharge of treated wastewater to the environment. If treatment standards are sufficient, there should be no adverse environmental impact from this alternative. However, if treatment is insufficient, environmental issues could arise. Environmental and public health concerns regarding wastewater reuse often focus on the potential for adverse effects from endocrine disrupters, hormones, antibiotics and other substances that typically are not removed at wastewater plants; however, the potential impacts from these substances exist whether the effluent is reused or discharged. The key issue with municipal reuse is the increased likelihood of human contact, which makes assurance of disinfection effectiveness and reliability very important.

Although not a general environmental concern, water quality is an issue in graywater reuse, and it should be carefully monitored by the user. Graywater should never contain wastewater from toilets, washing machine loads that contain baby diapers, or kitchen waste. Systems should be turned off when someone in the household is diagnosed with an infectious disease (Office of Arid Lands Studies, Undated). Additionally, household chemicals should never be disposed of in graywater systems.

When used for outdoor irrigation, the nutrients in graywater will support plant growth, but may cause damage to soil from the buildup of salts if graywater use is not rotated with harvested rainwater or fresh water (Prososki-Marsland, 1995). Plants can be damaged from graywater containing sodium, bleach, borax, or liquid fabric softeners (Duttle, 1994). Use of biodegradable soap low in sodium content is recommended as well as selection of plants that are salt-tolerant and not edible (Prososki-Marsland, 1995).

8.2.5 Political Feasibility and Social/Cultural Impacts

The general public tends to support the concept of water conservation. However, individuals are generally less supportive of measures that will curtail their individual water use or increase their own water bills. One concern voiced in the region is that community growth may require stricter conservation; on the whole, residents feel that new developments should be required to bear the brunt of enforced conservation measures.

The tools discussed in Section 8.2.1 will be adopted only if local governmental bodies find them politically acceptable. The public is especially aware of scarce water resource issues after a drought, and the elected officials may find more political acceptance during this period of heightened awareness. Alternatively, if additional or more restrictive ordinances are not politically acceptable, efforts can be focused on conservation education, as discussed in Section 8.2.1.2.

8.3 Agricultural Conservation

In 2000, agriculture accounted for 92 percent of the total withdrawals in the planning region (not including reservoir evaporation), and thus improvements in agricultural efficiency can significantly contribute to optimal water resource management in the planning region. This alternative examines water efficiency and conservation measures that can reduce the quantity of water that must be delivered to a farm to satisfy crop water requirements. Table 8-2 indicates the primary crops and acreages irrigated, by county. Additional information on irrigated lands in the region is presented in Section 6.1.4.

Agricultural conservation methods typically focus on changes in farming practices (on-farm improvements) and on delivery system improvements (off-farm improvements) to increase efficiencies and reduce water losses. In the planning region, almost all of the agriculture depends on surface water; only 1 percent of agricultural water is supplied from groundwater. Improving efficiency often results in a reduced amount of return flow, which can have undesirable consequences such as reducing stream or ditch flow to downstream users and reducing recharge to shallow wells and phreatophytes, such as cottonwood trees, that depend on leakage from acéquias and ditches.

Table 8-2. Irrigated Acreage by Crop, 2002
Mora-San Miguel-Guadalupe Water Planning Region

Crop	Irrigated Acreage by Crop, 2002		
	Mora	San Miguel	Guadalupe
All hay	6,528	4,352	1,118
Corn	0	W	0
Oats	W	30	0
Sorghum	0	0	W
Wheat for grain	0	W	228
Vegetables	W	7	18
Orchards	27	53	16
Total cropland harvested	9,201	4,668	1,394

Source: USDA, 2005 W = Withheld to avoid disclosing data for individual farms

Because irrigation is such a large component of the region's water budget, even modest improvements in on-farm efficiency can translate into significant water conservation. Sections 8.3.1 through 8.3.5 evaluate the technical feasibility, hydrologic impacts, financial feasibility, environmental impacts, and political feasibility and social/cultural impacts associated with implementing known and proven measures that can increase irrigation efficiency.

8.3.1 Technical Feasibility

An important concept in understanding irrigation efficiency is the difference between depletions and diversions. Diversions represent the amount of water diverted from a stream or well (also referred to as project diversion requirements by some authors), and depletions represent the amount of water consumed by a farm from the diverted water (also referred to as the consumptive irrigation requirement plus incidental depletions). For example, under OSE accounting rules, water that percolates past the root zone is assumed to eventually return to the aquifer or surface water system. Because this water is not consumed by the plants, it is not counted as a depletion.

Agricultural conservation can help reduce the amount of water necessary for delivery to the crops as well as the amount of water consumed through incidental depletions, such as evaporation from ponded areas on lands irrigated by flood irrigation. The largest reductions can be achieved in reducing diversion requirements, which is particularly important in drought periods; reductions in consumptive use resulting from agricultural conservation are generally much lower.

Even in the most efficient irrigation systems, significantly more water must be available for diversion than is consumed by plants (i.e., depleted). Currently in the planning region, diversions are more than twice the anticipated depletions (up to 2.6 times in San Miguel County). Under very efficient conditions, diversions can be closer to 1.5 times the depletions.

Off-farm efficiency includes the amount of water that reaches the farm divided by the amount of water that was diverted from the stream. The conveyance efficiencies from unlined ditches in the planning region could be as low as 60 percent and, therefore, losses could be as much as 40 percent.

On-farm water efficiency is a simple ratio of the quantity of water taken up or consumed by crops, including evapotranspiration, divided by the quantity of water delivered to a farm. On-farm irrigation efficiency can be further broken down into two components:

- *Application efficiency:* Ratio of water reaching the soil to water delivered to the farm
- *Consumption efficiency:* Ratio of water used by crops to water applied to the soil

The two general goals of on-farm conservation are to:

- Decrease the amount of diversion required to enable use of an allotted depletion
- Decrease the amount of depletion per amount of crop grown, or per amount of profit gained from the crop

According to Kay (1986), on-farm efficiency is affected by the following factors:

- *Farm layout:* The shape and slope of the farmed areas irrigated by basin (flood) and border irrigation systems affect the farm's ability to promote efficient root zone saturation while diminishing losses to deep percolation.

- *Soil types:* Differing soil types on a farm or in multiple basins can cause uneven watering effectiveness and extremely high losses to deep percolation.

- *Land preparation practices:* Land should be leveled every five to ten years to ensure that water does not pond and that it flows freely in basins.

- *Farm canal condition:* Large amounts of water can be lost to seepage in on-farm canals.

- *On-farm water management:* Supplying crops with the right amount of water at the right time can minimize water waste and save money.

- *Irrigation scheduling:* Informed scheduling of on-farm water deliveries can help maximize crop yields while minimizing evaporative losses.

- *Methods of irrigation:* The choice of irrigation method (e.g., flood [basin], border, furrow, or micro-irrigation) can optimize water use.

- *Crop type:* Different crops require different amounts of water. Emphasis should be placed on growing crops with high values relative to their water consumption.

Several available on-farm technologies can increase the efficiency of production agriculture irrigation systems. However, while these technologies do save significant quantities of water, they are also expensive to implement. Currently, most of the farms in the planning region use flood irrigation.

Background information about irrigation technologies for improving on-farm efficiency is summarized in Sections 8.3.1.1 through 8.3.1.7. Section 8.3.1.8 provides background information on off-farm efficiency. Potential hydrologic and economic impacts of implementing these technologies are described in Sections 8.3.2 and 8.3.3, respectively. Further information on these and other irrigation methods is available in *Selection of Irrigation Methods for Agriculture* (Burt et al., 2000).

8.3.1.1 Sprinkler Systems

Most crops can be irrigated with some type of sprinkler system, although crop characteristics such as height must be considered in system selection. Sprinkler systems are well suited for germinating seed and establishing ground cover for crops like alfalfa and lettuce because they can provide the light, frequent applications that are desirable for this purpose. Most soils can be irrigated with the sprinkler method, although soils with an intake rate below 0.2 inch per hour may require special measures. Sprinkler systems are useful for irrigating soils that are too shallow to permit surface shaping or too variable for efficient surface irrigation. In general, sprinklers can be used on any topography that can be farmed, and land leveling is not normally required.

There are disadvantages to using sprinkler systems for irrigation. Sprinklers may require more pumping energy than other irrigation methods. They also require better quality (or filtered) source water than other surface irrigation methods with the exception of drip/micro-irrigation

(Section 8.3.1.2). Sprinkler systems can be labor-intensive, especially those systems that must be moved manually. If source water is salty, sprinkler methods that apply water to leaves may be unsuitable.

Many types of sprinkler devices and sprinkler systems are available. Sprinkler devices include rotating head sprinklers that apply water in circular pattern, low-pressure spray nozzles (often used on center pivot and linear move systems or in orchards), under-tree rotating heads that keep the spray below tree foliage, and perforated pipe that sprays water from small-diameter holes in pipes. The more common types of systems include:

- *Hand-move or portable sprinkler systems* that consist of a lateral pipeline, typically made of aluminum, with sprinklers installed at regular intervals. The lateral is operated in one location until sufficient water has been applied and is then disassembled and moved to the next position. Initial costs for this type of system are low, but the labor costs associated with moving the lateral lines are fairly high. These systems can be used on variable terrain and for most crops, except tall crops such as corn that make moving the lateral difficult.

- *Side roll systems* have lateral lines mounted on wheels, with the pipe forming an axle that is high enough to clear the crop as it is moved. A drive unit is used to move the system from one irrigation position to another by rolling the wheels. These systems are vulnerable to high winds and may be damaged or pushed long distances if not staked down.

- *Traveling gun systems* use a high-volume, high-pressure sprinkler "gun" mounted on a trailer and are commonly operated as continuous move systems, with the gun sprinkling as the trailer moves. Although appropriate for most crops, these systems are best used on coarse, permeable soils because of the large droplets and high application rates produced.

- *Center pivot systems* consist of a single sprinkler lateral supported by a series of self-propelled towers that allow the lateral to rotate around a pivot point (one end of the lateral) in the center of the irrigated area. A single revolution can range from a half day to many days. The length of the lateral affects the speed at which the end of the lateral travels, as well as the size of the area irrigated by the end section. Because of this, the water application rate must increase with distance from the pivot point to deliver an even application amount, and the high application rate at the outer end of the system may cause runoff on some soils. Also, because of the circular application area, the corners of the field are not irrigated unless special equipment is added to the system. Center pivots, which have moderate initial costs and low labor costs, can be used for most field crops.

- *Linear move systems* are similar to center pivot systems in construction except that neither end of the lateral pipeline is fixed. The whole line moves down the field in a direction perpendicular to the lateral and is designed to irrigate rectangular fields free of tall obstructions. As with the center pivot system, the linear move system can provide very efficient water application. These systems require high capital investments, but labor costs are low.

- *Low energy precision application* (LEPA) systems are similar to linear move irrigation systems except that the lateral line is equipped with drop tubes and very-low-pressure orifice emission devices that discharge water just above the ground surface into furrows. This distribution system is often combined with micro-basin land preparation for improved runoff control (and for retention of rainfall). High-efficiency irrigation is possible, but requires either very high soil intake rates or adequate surface storage in the furrow micro-basins to prevent runoff or non-uniformity along a furrow.

- *Solid set and permanent systems* are similar to the hand-move lateral sprinkler system, except that they include enough laterals placed in the field to avoid the necessity of moving pipe during the season. The solid set system requires significant labor at the beginning and end of the irrigation season, but minimal labor during the irrigation season. A permanent system is a solid set system where the main supply lines and the sprinkler laterals are buried and left in place permanently (this is usually done with polyvinyl chloride [PVC] pipe).

Table 8-3 lists the attainable irrigation efficiencies for different systems. More detailed descriptions of these systems are provided by Burt et al. (2000).

Table 8-3. Attainable On-Farm Irrigation Efficiencies for Various Irrigation Systems

System Type	Efficiency (%)
Flood irrigation	30-40
Sprinkler systems	
Hand-move or portable	65-85
Side roll	65-85
Traveling gun	60-75
Center pivot	75-90
Linear move	75-90
Solid set or permanent	70-80
Low energy precision application	80-93

Source: Burt et al., 2000.

As indicated above, labor requirements vary depending on the degree of automation and mechanization of the equipment used. Hand-move systems require the least degree of operational skill, but the greatest amount of labor. At the other extreme, center pivot, linear move, and LEPA systems require considerable skill in operation and maintenance, but a low overall amount of labor.

8.3.1.2 Drip/Micro-Irrigation Systems

Drip/micro-irrigation methods can conserve water because they deliver water directly to the root zone through emitters placed along a water delivery line (typically a polyethylene hose). Also, in contrast to most other types of irrigation systems, a properly designed and well operated drip/micro-irrigation system:

- Can be used on steep slopes
- Requires minimal land grading
- Can be installed on parcels of land of any size or shape
- Has few, if any, runoff problems or likelihood of excessive over-irrigation

- Has greater distribution uniformity (especially the newer system designs)
- Provides optimal soil moisture through more frequent irrigation
- Allows direct application of fertilizer to the root zone

Systems can be installed permanently (typical for orchards and vineyards) or seasonally (typical for row crops), or they may have permanent main lines with removable or disposable lateral lines. Because drip/micro-irrigation system components typically remain in place for the growing season, the systems can be automated; however, they should be monitored and shut off temporarily as appropriate during rainy periods.

Drip/micro-irrigation systems should be tailored to meet crop needs. For example, water is generally applied to plants through drip/micro-irrigation systems daily or several times per week. However, some crops (such as lettuce) do not yield as well with irrigation that is too frequent, and the watering frequency should be adjusted accordingly. Because emitter devices typically have low flow rates (0.4 to 2.1 gallons per hour [gph]), larger plants such as trees may require multiple emitters (Burt et al., 2000).

Regional and micro-climate conditions should also be considered in the design of drip/micro-irrigation systems. For example, in arid regions emitters are often spaced so that at least 60 percent of the potential root zone volume is wet, thereby providing an adequate moisture reservoir for periods of high evapotranspiration and insurance against several days of breakdowns. A lower percentage of wetted area is common in areas that receive supplemental rainfall.

Drip/micro-irrigation systems are of three main types: (1) aboveground drip systems, (2) buried drip systems, and (3) aboveground microspray and microsprinkler systems. Aboveground drip systems have been used in orchards and vineyards since the 1980s, and a variety of designs can be used depending on the crop, orchard configuration, and available water pressure. Where rows do not exceed 12 or 13 feet in width, one hose is typically used per row, with varying numbers of emitters per tree or vine. Aboveground row crop drip irrigation typically uses a thin-walled hose with built in emitters (drip tape). The drip tape can be installed under plastic, rolled up to allow cultivation and harvest, or buried just below the ground surface (maximum ½ to 2 inches deep) to protect it from the wind (Burt et al., 2000).

Buried drip systems in orchards and vineyards are a relatively new concept that is not yet widely used. However, interest in this technology is high, as it potentially reduces soil evaporation and weeds and allows workers to drive through or cultivate a field at any time, regardless of the irrigation schedule. Drawbacks include potentially extensive soil surface wetting due to low soil hydraulic conductivity or excessive emitter flow rates, pinching of the hose by roots, root intrusion into the emitters, and a high cost of installation. In addition, the proper depth and location of buried emitters with respect to plant trunks is not yet fully understood (Burt et al., 2000).

Buried drip systems are also used for “one-crop” row crops such as strawberries and sugar cane, where the drip can be installed before planting and removed before the plants are disked into the soil. Permanently buried systems are also used commonly in the southwestern U.S., where more than 150,000 acres of high-value crops such as tomatoes, peppers, broccoli, lettuce, and cauliflower are estimated to be irrigated with permanent drip systems (Burt et al., 2000). These systems are designed to be in place for 6 to 10 years; however, special equipment is needed during tilling to ensure that the drip tape is not damaged during removal of the old crops. Also, considerable time must be spent checking the system during the first year or two of operation to ensure proper functioning (Burt et al., 2000).

Microspray systems typically have larger hose diameters than drip because the flow rates of the emissions devices are much higher than for drip. For the same reason, these systems also tend to have smaller hose lengths than drip. Because of the high application rates, a microspray field is often divided into six or more blocks with only one block irrigated at a time, whereas many drip fields are divided into only two blocks. The net result is that microsystems are usually more expensive than drip systems. The exception would be on widely spaced plants such as walnut trees, in which case several drip hoses would be required per tree row compared to only one hose for microspray.

Microspray systems have the advantages of requiring less stringent filtration than drip because of the large and short paths of micro-nozzles. In addition, they result in a larger soil wetted volume than a single hose drip system. In situations where frost protection is important, micro-sprinkler/sprayer designs offer better climate control than do emitters.

Disadvantages of microspray as compared to drip include the higher cost of some designs, the higher evaporation losses (especially if the water extends past the canopy), higher humidity, and inability to easily restrict the wetted area during certain times of the year. Also, some microspray systems have high sprayer flow rates (10.5 to 15.8 gph) and could be classified as low-flow permanent sprinklers rather than micro-irrigation systems (Burt et al., 2000).

The International Arid Lands Consortium has been involved in a demonstration project in Artesia, New Mexico to determine the benefits of drip irrigation technology for alfalfa. In this study they have estimated a 40 percent water use reduction with the use of drip irrigation compared to traditional sprinkler technology, without a reduction in yield (IALC, 2000).

8.3.1.3 Soil Treatments

The amount of water available to plants depends not only on the amount of rainfall and/or irrigation, but also on the physical, chemical, and biological properties of the soil. Soil acts as an absorbent for water from precipitation and irrigation and serves as a reservoir of water for plants in the interval between water applications.

Soil structure is an important physical parameter to consider when trying to increase on-farm efficiency, as soil sealing and soil crusting decrease the infiltration rate of water into the soil. Structureless soil can severely restrict the downward percolation of water. A common constraint to both water filtration and root penetration in the soil is the degree of soil compactness or density. Other soil characteristics that affect water availability to plants include the extent of organic matter in the soil and the types and density of soil organisms present.

In situ moisture conservation is a means of conserving all rainfall where it falls and allowing no runoff. Measures that can be adopted by farmers to optimize the physical, chemical, and biological soil parameters with a view to increasing the water efficiency include the following:

- *Covers or mulches laid down on the surface of the soil and along rows*. This practice is important for water and soil conservation as well as for organic matter preservation. Mulches protect soil structure by reducing the mechanical action of raindrops on soil aggregates, thus preventing runoff and erosion. Mulching dramatically decreases evaporation and improves soil moisture retention capacity; as a result, soil water content is increased. Soil temperature, soil strength, and soil aeration are also improved, thus increasing soil productivity and crop yield.

- *Tilling or physically (manually or mechanically) breaking up the plough layer*. This is a common agronomic practice that can improve the infiltration rate of rainwater, thus conserving soil moisture. Tilling also helps to control soil pests and weeds. The pests are brought up to the surface where they are then killed by radiation and/or predators. This approach therefore reduces the need for pesticides and their attendant use of fairly large quantities of water.

- *Use of soil additives called polyacrylamides that bind the soil together so that water spreads more evenly and percolates less rapidly*. Polyacrylamides are soil additives that are applied to the surface and then mixed into the top soil. They generally have more of a beneficial effect in sandy soils. Polyacrylamides are sold under many different trade names: Terra-Sorb, Hydrosource, Hydro-mulch, water crystals, PAM, copolymer, Moist Soil, Aquasorb, Agrosoke, Smart Soil, Aquacrystals, Bioplex, Agro-diamonds, and others.

- *Planting in small depressions, known as planting pits*. This practice is common in arid areas. Planting pits conserve and concentrate both water and nutrients.

- *Contour cultivation*. This technique slows down the movement of water across the soil surface and also helps to conserve water. Contour cultivation can be achieved by constructing physical barriers such as ridges across the contours to prevent runoff and soil erosion. In contour cultivation, the runoff from the higher elevations is trapped in furrows in the contours, thereby increasing infiltration into the soil.

- *Terracing fields*. Different types of terraces can be constructed (e.g., stone terraces, earth banks, bench terraces, and contour stone) to conserve soil moisture as well as to collect water.

8.3.1.4 Laser Leveling

Laser leveling involves grading and earthmoving to eliminate variation in field gradient; that is, smoothing the field surface and often reducing field slope for fields that are flood irrigated. Laser leveling helps to control water advance and improve uniformity of soil saturation under gravity-flow systems, allowing the grower to apply only the water needed to refill the root zone. For this method to work properly, the volume of water needed for irrigation must be applied as rapidly as possible in order to allow the same time for infiltration throughout the entire field.

Laser-leveling works only in relatively short runs. If the border lengths are too long, it is better to use graded border irrigation. Border distances for laser-level irrigation will depend upon soil type and water quantity, but 300 to 500 feet in length is usually recommended. Laser-level irrigation needs a minimum of 3 inches per application. If a high water flow is used with a laser-leveled field, an erosion control device may be needed at the turnout.

Anecdotal evidence suggests that laser-level irrigation can increase on-farm efficiency by 30 percent and reduce diversion time to 25 percent of that previously required to irrigate the same acreage. Irrigation efficiencies for laser-level irrigation can be as high as 75 to 85 percent, while irrigation efficiencies for normal flood irrigation run about 40 to 50 percent (Vickers, 2001).

8.3.1.5 Surge Valves

Surge valves can be added to increase application efficiencies and reduce deep percolation of irrigation water of some fields that use furrow irrigation. The principle behind surge irrigation is to switch the water back and forth between irrigation sets in an alternating pattern using an automated valve. The valve may be set for different lengths of out-times (times when water is applied to advance water through the length of row). If the out-times and cutback are set correctly, this method of irrigation advances the water more quickly and efficiently through the field than continuous irrigation, thereby minimizing runoff (tailwater) and deep percolation. Surge valves typically improve furrow irrigation efficiency by an average of 10 to 40 percent, depending on soil type, land slope, and the length of the runs; some growers have cut irrigation amounts by as much as 50 percent (Vickers, 2001).

Surge irrigation is relatively inexpensive to employ, given its benefits of increased uniform water distribution, reduced deep percolation, reduced tailwater, and reduced total irrigation. Although surge valves cost approximately $1,000 to 1,500 per valve, the same surge valve may be used on several fields. However, the use of surge valves requires daily adjustment and thus more labor. Laser-leveled fields are also usually required, as the principle behind surge irrigation is to allow water applied uniformly over a given area to percolate before the next application is applied. Thus, irregular topography, which can be covered by flood irrigation, is not compatible with surge techniques.

8.3.1.6 Gated Piping

Pipeline conveyance systems are often installed to reduce labor and maintenance costs, as well as water losses to seepage, evaporation, spills, and non-crop vegetative consumption. Permanently installed underground pipeline is constructed of steel, plastic, or concrete, while aboveground pipeline generally consists of lightweight, portable aluminum, plastic, or flexible rubber-based hose that can be moved. Gated pipe, a form of aboveground pipeline, distributes water to gravity-flow systems from individual gates (valves) along the pipe. One irrigation method (commonly called "cablegation") that uses gated piping employs a moveable plug that passes slowly through a long section of gated pipe, with the rate of movement controlled by a cable and brake. Because the pipe is both oversized and sloped, water will gradually cease flowing into the first rows irrigated as the plug progresses down the pipe. Improved water management is achieved by varying the speed of the plug, which controls of the length of time water flows into each furrow.

8.3.1.7 Crop Management

Crop management provides an extra means of reducing water losses and optimizing water use in any farming system. Crop management considerations include crop water requirements, timing of irrigation, crop selection, crop configuration (plant density, crop mix), and cropping calendar (planting dates, rotation). When used along with properly programmed automatic irrigation systems, crop management techniques can increase on-farm irrigation efficiencies to 85 to 90 percent (Vickers, 2001).

Planting density and crop mix affect the hydrologic characteristics of the system. Increased plant density increases the soil cover by crops and can lead to a decrease in evaporation losses; however, higher planting density can also increase water uptake from the soil. Annual crops and some perennials obtain moisture mainly from the top layer of soil, whereas deep-rooted plants such as trees tap deeper soil moisture that is beyond the reach of the annuals. Additionally, some trees shed their leaves in winter, thereby covering the soil and creating mulch. A synergistic planting may yield more abundant crop production while protecting critical top soils. In addition, mixed cropping systems in particular combinations can help to significantly reduce pest damage. For instance, cabbages grown in alternate rows with either tomatoes or garlic or carrots have been shown to suffer fewer insect attacks, thus improving yield.

8.3.1.8 Off-Farm Conveyance Systems

The conveyance system is a major component of a surface water diversion system; it is the means by which water is moved from the water source to the farm for irrigation purposes. Typically, water is conveyed in an open or closed conduit such as a channel, tunnel, canal, or pipe, and is moved by some driver, typically gravity and/or an energized pump.

Surface water delivery systems that use unlined ditches to convey water from rivers or streams for flood irrigation are often inefficient in terms of water use. Many unlined ditches are used along the Pecos and Canadian Rivers, and improvements to these delivery systems could potentially improve water conservation in these areas. In most cases, however, diversion points are typically either on or near the farms, and conveyance losses often return to the stream system to be used downstream by other water users.

For a variety of reasons, conveyance facilities and systems, when in use, are often a source of water loss. Water escapes from channels through evapotranspiration and leakage. To the extent desired or required, leakage and evapotranspiration can be minimized in man-made or modified natural conveyance structures and systems through appropriate facility planning, design, construction, and operation/maintenance activities. Lining an acéquia, for instance, may improve the delivery of water to end users on a ditch, which is particularly crucial during periods of low flow. However, reduced seepage from the acéquia does not necessarily mean that more water is available for new uses, particularly when flows are low. In some situations it may be possible to prove that the lining of a ditch will actually save water that was not otherwise put to beneficial use. For example, the seepage may have recharged an aquifer in a different watershed or an aquifer that is not used and not connected to a stream system.

Irrigation conveyance systems can be broken down into three classes: main, distributory, and field canals, with each conveying a correspondingly smaller flow. *Main canals* take water for entire irrigated command areas from some source and carry it to *distributory canals;* these, in turn, issue water to *field canals,* which deposit water onto agricultural fields. Each of these canal types lends itself to lining or piping of some sort. The canal lining and pipe replacement necessary to reduce water loss is well understood and practiced worldwide. Available technology includes linings made from compacted impervious earthen material, gunite, soil-cement, concrete, and plastics. Various types of pipe materials and systems are also used for the same application.

The issue is complicated by the effects of canal lining or piping, such as reduction or elimination of useful and aesthetic vegetation and trees that grew along canal alignments where seepage water was previously available. Seepage water from unlined canals may also contribute to shallow groundwater recharge; this is lost once the canal is lined. Also, the installation of canal lining must be planned and implemented thoughtfully to minimize future damage that could be caused by farmers who might want to install or change the location of farm turn-outs, for example.

Pipe conveyance systems can save even more water than lined canals, as piping water virtually eliminates evaporation. When using pipes in irrigation water conveyance, however, other operational issues are introduced, including increased potential for system clogging, reduced infrastructure flexibility, and increased headworks infrastructure (bars, screens) and associated maintenance.

8.3.2 Hydrological Impacts

Improved irrigation efficiency would decrease demands on surface water, lower diversion costs, and potentially leave more water in surface water bodies when supply is adequate. When supply is low, particularly during drought periods, it could increase the amount of water available for other beneficial uses in the planning region. For most techniques, the savings in depletions, or consumptive use, will not be as high as the savings in diversions, but may be more significant. The greatest decrease in consumptive use is associated with a switch to micro-drip irrigation systems, which have negligible incidental depletions, or by converting to lower-water-use crops. Currently, only 50 acres of land are irrigated with micro-irrigation (drip) in the planning region, all in Mora County. Tables 8-4 through 8-6 summarize estimated water savings associated with applicable on-farm water conservation measures for irrigated agriculture for each county in the region; Table 8-7 summarizes the estimated water savings for the entire region.

To estimate the potential gains from improvements in on-farm irrigation efficiency, the on-farm diversions for existing irrigation techniques (flood, sprinkler, and drip) must be identified. The potential improvement from one technique to another is then calculated as the difference in irrigation efficiencies between the two methods. For example, in Mora County, 13,730 acres are currently flood irrigated. Wilson et al. (2003) estimates that 21,144 acre-feet are required for on-farm diversion for these 13,730 acres. If this land were converted from flood to LEPA irrigation, the on-farm efficiency could increase from 55 to 95 percent. This 40 percent increase in efficiency would reduce the amount of diversion water required by 8,460 acre-feet.

The estimates shown in Table 8-7 indicate the maximum possible savings that could be achieved if all of the land currently in production were converted to more efficient on-farm irrigation and management techniques. In actuality, because of financial and logistical constraints, achieving this amount of savings may be difficult. Also, these potential savings represent reduced diversions (as opposed to depletions).

The savings in total consumptive use from reducing incidental depletions are summarized in Table 8-8. For lands that are flood irrigated, the potential savings in consumptive use range from 1,613 ac-ft/yr for conversion to drip irrigation to 1,028 ac-ft/yr for conversion to LEPA systems. For lands currently irrigated with a high-pressure center pivot system, consumptive use could be reduced from losses resulting from incidental depletions of 17 percent (Wilson et al., 2003) to virtually zero for micro-irrigation or to 1 percent losses for LEPA. Total savings from sprinkler irrigation methods would be 589 ac-ft/yr for converting to micro-irrigation or 553 ac-ft/yr for LEPA.

Table 8-4. Estimated Diversion Savings for Irrigated Agriculture, Mora County

Conservation Technique	Potential Reduction in Diversions from Existing Irrigation Methods							Estimated Cost to Implement [b] ($/acre)
	Non-Improved Flood		Sprinkler Irrigation		Micro-Irrigation		Total (ac-ft/yr)	
	%	ac-ft/yr	%	ac-ft/yr	%	ac-ft/yr		
Current irrigated acreage (acres) [a]	*13,730*		*1,100*		*50*		*14,880*	*NA*
Current on-farm diversion amounts (ac-ft/yr) [a]	*21,144*		*1,694*		*50*		*22,888*	*NA*
Current on-farm irrigation efficiencies [a] *(%)*	*55*		*65*		*NA*		*NA*	*NA*
Micro-irrigation (80-95% EF) [c]	40	8,458	30	508	0	0	8,966	1,800
Low-energy precision application (90-98% EF) [c]	40	8,458	30	508	0	0	8,966	250
Laser leveling (75-85% EF) [c]	30	6,343	0	0	0	0	6,343	250
Installation of surge valves (65-80% EF) [c]	25	5,286	0	0	0	0	5,286	185
Gated piping irrigation [d]	10	2,114	0	0	0	0	2,114	250
Soil treatments [e]	10	2,114	10	169	10	5	2,289	500
Crop management (85-90% EF) [c,e]	35	7,400	25	424	5	3	7,826	NE
Total potential reduction in diversions	NA	8,458	NA	508	NA	8	8,973	NA

[a] Wilson et al., 2003
[b] Assumes current irrigation is standard non-improved flood irrigation, based on a 160-acre farm (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate available on EF with gated piping
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
NA = Not applicable
EF = Efficiency
NE = Not estimated, highly variable

Table 8-5. Estimated Diversion Savings for Irrigated Agriculture, San Miguel County

Conservation Technique	Potential Reduction in Diversions from Existing Irrigation Methods							Estimated Cost to Implement [b] ($/acre)
	Non-Improved Flood		Sprinkler Irrigation		Micro-Irrigation		Total (ac-ft/yr)	
	%	ac-ft/yr	%	ac-ft/yr	%	ac-ft/yr		
Current irrigated acreage (acres) [a]	*10,475*		*670*		*0*		*11,145*	*NA*
Current on-farm diversion amounts (ac-ft/yr) [a]	*28,784*		*1,734*		*0*		*30,518*	*NA*
Current on-farm irrigation efficiencies [a] *(%)*	*50*		*65*		*NA*		*NA*	*NA*
Micro-irrigation (80-95% EF) [c]	45	12,953	30	520	0	0	13,473	1,800
Low-energy precision application (90-98% EF) [c]	45	12,953	30	520	0	0	13,473	250
Laser leveling (75-85% EF) [c]	35	10,074	0	0	0	0	10,074	250
Installation of surge valves (65-80% EF) [c]	30	8,635	0	0	0	0	8,635	185
Gated piping irrigation [d]	10	2,878	0	0	0	0	2,878	250
Soil treatments [e]	10	2,878	10	173	0	0	3,052	500
Crop management (85-90% EF) [c,e]	40	11,514	25	434	0	0	11,947	NE
Total potential reduction in diversions	NA	12,953	NA	520	NA	0	13,473	NA

[a] Wilson et al., 2003 (EF ranges from 45 to 55 percent for flood irrigated lands)
[b] Assumes current irrigation is standard non-improved flood irrigation, based on a 160-acre farm (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate available on EF with gated piping
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
NA = Not applicable
EF = Efficiency
NE = Not estimated, highly variable

Table 8-6. Estimated Diversion Savings for Irrigated Agriculture, Guadalupe County

Conservation Technique	Potential Reduction in Diversions from Existing Irrigation Methods							Estimated Cost to Implement [b] ($/acre)
	Non-Improved Flood		Sprinkler Irrigation		Micro-Irrigation		Total (ac-ft/yr)	
	%	ac-ft/yr	%	ac-ft/yr	%	ac-ft/yr		
Current irrigated acreage (acres) [a]	*3,645*		*15*		*0*		*3,660*	*NA*
Current on-farm diversion amounts (ac-ft/yr) [a]	*8,185*		*33*		*0*		*8,218*	*NA*
Current on-farm irrigation efficiencies [a] *(%)*	*55*		*65*		*NA*		*NA*	*NA*
Micro-irrigation (80-95% EF) [c]	40	3,274	30	10	0	0	3,284	1,800
Low-energy precision application (90-98% EF) [c]	40	3,274	30	10	0	0	3,284	250
Laser leveling (75-85% EF) [c]	30	2,456	0	0	0	0	2,456	250
Installation of surge valves (65-80% EF) [c]	25	2,046	0	0	0	0	2,046	185
Gated piping irrigation [d]	10	819	0	0	0	0	819	250
Soil treatments [e]	10	819	10	3	0	0	822	500
Crop management (85-90% EF) [c,e]	35	2,865	25	8	0	0	2,873	NE
Total potential reduction in diversions	NA	3,274	NA	10	NA	0	3,284	NA

[a] Wilson et al., 2003
[b] Assumes current irrigation is standard non-improved flood irrigation, based on a 160-acre farm (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate available on EF with gated piping
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
NA = Not applicable
EF = Efficiency
NE = Not estimated, highly variable

Table 8-7. Estimated Diversion Savings for Irrigated Agriculture, Mora-San Miguel-Guadalupe Water Planning Region

Conservation Technique	Potential Reduction in Diversions from Existing Irrigation Methods: Non-Improved Flood (ac-ft/yr)	Sprinkler Irrigation (ac-ft/yr)	Micro-Irrigation (ac-ft/yr)	Total (ac-ft/yr)	Estimated Cost to Implement [b] ($/acre)
Current irrigated acreage (acres) [a]	*27,850*	*1,785*	*50*	*29,685*	*NA*
Current on-farm diversion amounts (ac-ft/yr) [a]	*58,113*	*3,461*	*50*	*61,624*	*NA*
Current on-farm irrigation efficiencies [a] *(%)*	*50-55*	*65*	*85*	*NA*	*NA*
Micro-irrigation (80-95% EF) [c]	24,684	1,038	0	25,723	1,800
Low-energy precision application (90-98% EF) [c]	24,684	1,038	0	25,723	250
Laser leveling (75-85% EF) [c]	18,873	0	0	18,873	250
Installation of surge valves (65-80% EF) [c]	15,967	0	0	15,967	185
Gated piping irrigation [d]	5,811	0	0	5,811	250
Soil treatments [e]	5,811	346	5	6,162	500
Crop management (85-90% EF) [c,e]	21,779	865	3	22,647	NE
Total potential reduction in diversions	24,684	1,038	8	25,730	NA

[a] Wilson et al., 2003
[b] Assumes current irrigation is standard non-improved flood irrigation, based on a 160-acre farm (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate available on EF with gated piping
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
EF = Efficiency
NE = Not estimated, highly variable

Table 8-8. Potential Savings in Consumptive Use Through Reduced Incidental Depletions Mora-San Miguel-Guadalupe Water Planning Region

Locale	Type of Irrigation [a]	Diversions [b] (ac-ft/yr)	ID Rate (%)	Current Incidental Depletions [c] (ac-ft/yr)	Consumptive Use Savings (ac-ft/yr)	
					Conversion to Micro-Irrigation (ID = 0%)	Conversion to LEPA [d] (ID = 1%)
Mora County						
Scattered	D (GW)	45	0	0	0	0
Scattered	F	21,144	2.75	581	581	370
Scattered	S	1,694	17	288	288	271
Total Mora County		22,883	3.8	869	869	641
San Miguel County						
Canadian River	F	2,389	2.75	66	66	42
Sapello River	F	5,467	2.75	150	150	96
Pecos River Scattered	F	6,067	2.75	167	167	106
Storrie Irrigation Project	F	14,861	2.75	409	409	260
Storrie Irrigation Project	S	1,734	17	295	295	277
Total San Miguel County		30,518	3.56	1,086	1,086	781
Guadalupe County						
Anton Chico	F	6,606	2.75	165	165	105
Colonias	F (GW)	574	2.75	16	16	10
Puerta de Luna	F	1,605	2.75	44	44	28
Scattered	F (GW)	579	2.75	16	16	10
Scattered	S (GW)	33	17	6	6	5
Total Guadalupe County		8,797	2.8	247	247	159
Total Planning Region		62,198	NA	2,202	2,202	1,581

[a] D = Drip
F = Flood irrigation
GW = Groundwater
S = Sprinkler (high-pressure center pivot)
[b] Wilson et al., 2003
[c] Diversion x ID rate
[d] The spigot is 18 inches above ground surface.

ac-ft/yr = Acre-feet per year
ID = Incidental depletions
LEPA = Low-energy precision application
NA = Not applicable

Approximately 94,380 acre-feet of water flows from wells and surface diversions for irrigation within the limits of the planning region. This water is conveyed through canals, ditches, and pipes to agricultural fields. Throughout these conveyance systems, some water is lost through evapotranspiration and infiltration. In 1999, conveyance losses in canals and laterals in the planning region ranged from 30 to 40 percent of the total surface withdrawals for irrigation (Wilson et al., 2003). Table 8-9 shows the potential water savings in terms of the amount of water "lost" to seepage in the region. If the conveyance systems are replaced with pipes, the water that could be saved from evaporation is estimated to be an additional 900 acre-feet or approximately 5 percent of the total estimated losses from unlined canals.

The main causes of the 1999 losses reported by Wilson et al. (2003) were through seepage and excessive vegetative growth. The installation of canal lining systems, such as impervious soils, soil-cement, or concrete blocks, or of piping systems could decrease this total loss by as much as 95 percent.

8.3.3 Financial Feasibility

This alternative deals with two types of agricultural conservation measures:

- On-farm measures, such as improved irrigation and planting techniques
- Off-farm measures, such as improved conveyance systems

Financial considerations for each of these types of measures, including possible sources of funding, are discussed in Sections 8.3.3.1 and 8.3.3.2.

8.3.3.1 On-Farm Conservation Costs

In addition to showing the potential reduction in diversions for this alternative, Tables 8-6 through 8-9 summarize estimated costs associated with applicable on-farm water conservation measures in the planning region. Most of the irrigated acreage in the planning region is not commercial-scale agriculture; many farmers in the area have other employment and grow alfalfa using flood irrigation because it requires less tending than more sophisticated irrigation technologies. These part-time operations do not generate cash flows sufficient to justify

Table 8-9. Potential Reduction in Seepage Losses from Off-Farm Conveyance Systems Mora-San Miguel-Guadalupe Water Planning Region

Locale	Irrigation Method [a]	Total Surface Water Diversions (ac-ft/yr)	Conveyance Efficiency		Potential Savings from Lined Canals (ac-ft/yr)
			Current (%)	Ideal (%)	
Mora County					
Scattered	F	21,144	70	95	5,286
Scattered	S	1,694	70	95	424
Total Mora County		22,838	70	95	5,710
San Miguel County					
Canadian River	F	2,389	70	95	597
Sapello River	F	5,467	70	95	1,367
Pecos River Scattered	F	6,067	60	95	2,123
Storrie Irrigation Project	F	14,861	60	95	5,201
Storrie Irrigation Project [b]	S	1734	85	95	173
Total San Miguel County		30,518	69	95	9,462
Guadalupe County					
Anton Chico	F	6,006	60	95	2,102
Puerta de Luna	F	1,605	60	95	562
Total Guadalupe County		7,611	60	95	2,664
Total Planning Region		60,967	NA	NA	17,836

Source: Wilson et al., 2003 (Table 8)

ac-ft/yr = Acre-feet per year
NA = Not applicable

[a] F = Flood irrigation
S = Sprinkler (high-pressure center pivot)

[b] Wilson shows a conveyance efficiency of 100%, but water is diverted from Gallinas to Storrie, so some losses must occur.

investments in water delivery system improvements. Because the cost of conservation measures is unaffordable for some farmers, funding from other sources is likely to be necessary. Both federal and state funding assistance should be available for the on-farm conservation measures described under this alternative.

The most applicable federal program for funding on-farm activities is the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program. However, this program is understaffed, which could increase the time needed to process applications and disburse funding. Federal funding sources are not available for operation and maintenance costs.

A number of additional economic assistance and incentive programs are available. One example is the Farm Security and Rural Investment Act of 2002, which provides for the Conservation Security Program. This is a national incentive program that allows farmers who are implementing conservation technologies in fiscal years 2003 through 2007 to receive reimbursements (SWCS, 2003). The New Mexico State Legislature is also considering some initiatives to provide funding for agricultural conservation measures.

8.3.3.2 Off-Farm Conservation Costs

As shown in Table 8-9, if all of the canals that divert surface water in the planning region were lined, a total of 17,800 acre-feet of water could be "saved" from canal seepage. However, most of this water would not actually be saved because the seepage water from unlined canals typically returns to the river system to be rediverted downstream.

8.3.3.2.1 Cost of Upgrading All Canals in Region. To estimate the cost of lining all the canals in the region, it was assumed that each of the 29,100 acres of land irrigated with surface water is fed by 200 feet of irrigation canal, for a total of more than 5.8 million feet of unlined canal. At an average cost of $40 per linear foot, it would cost more than $233 million to line this total canal footage.

These costs do not include annual recurring maintenance or any other costs for planning and managing such a program. Additional capital costs would also be necessary to address nonchannel construction required to improve irrigation delivery systems under such a program. Thus, a rough estimate for lining all ditches in the planning region is $240 to $300 million.

The costs for planning, designing, and installing a piped irrigation system would be generally comparable in magnitude to those for installing canal linings. However, additional water would be saved because of the lack of evaporation.

Considering the cost of this initiative, an existing and or new external funding program would need to be established to assist farmers and acéquia organizations in upgrading conveyance systems. Funds from ISC are available for acéquias to improve their systems while paying only 8 percent of the costs; the State pays another 17 percent of the costs and the federal government pays the remainder. Low interest loans are also available to help the acéquias finance their 8 percent share. Some acéquia organizations do not want to have “Big Brother” involved in their projects; however, the huge backlog in applications (Appendix C2, notes from November 10, 2004 Steering Committee meeting) for these funds suggest that the program is popular.

An alternative to developing and providing an external funding program might involve legislation that requires farmers to reduce seepage and evapotranspiration from their canals by a certain percentage. Tax breaks and subsidies could also be legislated for farmers who comply with such legislation.

8.3.4 Environmental Impacts

Reduction of deep percolation and incidental losses will reduce seepage, thereby affecting groundwater levels and recharge. Changes in recharge to the shallow aquifer due to changes in flows through canals may impact the bosque and other ecosystems that may be established in the irrigation canals and drains. However, flows in these systems are already intermittent due to the seasonal nature of irrigation. Careful planning and design of projects should minimize impacts to ecosystems. Diversion savings will increase the flexibility of water supply management, which should provide more options for supporting endangered species habitat.

Improved management practices will also reduce water quality concerns related to turbidity. Salinity problems resulting from return flow are not an issue in this region; however, impacts from fertilizers would be reduced, although only 25 percent of the farms in San Miguel and Mora County use fertilizers (Easton, 1999).

8.3.5 Political Feasibility and Social/Cultural Impacts

Discussions with the Mora-San Miguel-Guadalupe Water Planning Steering Committee have revealed that the most controversial aspect of implementing agricultural conservation methods centers on the negative impacts from reducing canal leakage. Canal leakage recharges groundwater and supplies water to vegetation that may not otherwise survive. Lining or piping acéquias, in particular, could reduce groundwater recharge in areas where residents rely on shallow domestic wells. Such a program might also result in increased maintenance costs. Resistance to change on the part of irrigators may be an issue to overcome.

However, a program for lining or piping unlined irrigation channels could be planned and designed to have little impact on the social and cultural aspects of the region. Participation of irrigators from start to finish in such a project would also help ameliorate any negative impacts.

With adequate funding, there should be no significant political or social cultural obstacles that would hinder implementation of on-farm conservation techniques for an individual farmer who pursues such an initiative. Indeed, widespread support for the alternative was expressed at public meetings held throughout the region. The primary concern that was voiced in these meetings was that, without economic assistance, the financial burden of implementing conservation measures will be too great for small farmers. As discussed in Section 8.3.3.2, funds are available to assist small farmers who wish to improve on-farm conservation. The motivation, however, for a wholesale shift in improved technology may not occur where weekend farmers do not have the time to tend to a more sophisticated system or pursue funding opportunities.

8.4 Watershed Management

Watershed management involves a variety of activities that can contribute to the health of a watershed, including those that protect or improve water quality, enhance water supply, and/or enhance the ecosystems of the area. Watershed management can also reduce fuel loads, which in turn minimizes the potential for catastrophic forest fires. Ideally, watershed management will provide optimal benefits in all of these areas.

Restoration of riparian areas is another component of watershed management and often involves the removal of non-native riparian vegetation. Because removal of non-native vegetation is very important to the region, it is discussed in Section 8.5 as a separate alternative. Optimal watershed management will integrate objectives for riparian and upland watershed restoration into the watershed planning process.

In the past few decades, vegetation density at higher elevations has generally increased due to the suppression of fire and limited timber harvests. This increased density has likely resulted in a decrease in water yields. Management activities such as forest harvesting or thinning can potentially increase water yields. Also, reduced vegetation density can decrease the risk of severe wildfires. Fires of this scale can greatly increase the size of peak flows and surface erosion rates, thus increasing channel erosion, causing downstream sedimentation, and adversely affecting water quality (Robichaud et al., 2000; Moody and Martin, 2001, as cited by MacDonald et al., 2002; McCord and Winchester, 2001; Burke, 2004). Without efforts to reduce forest density, a continued high risk or a gradually increasing risk of high-severity wildfires can be expected in the planning region.

Watershed restoration projects designed to address forest fire prevention and other watershed concerns such as water quality include the following:

- Thinning and/or prescribed burns that reduce the risk of catastrophic forest fire and potentially increase surface water supplies at higher elevations and/or groundwater recharge at lower elevations

- Management practices for roads, culverts, or other construction projects that minimize erosion and protect water quality from increased sedimentation

- Projects that address water quality issues such as elevated stream temperatures, suspended sediment loads, and impacts from septic systems, mining, or potential contaminant sources

- Grazing practices that minimize water quality degradation, riparian impacts, and impacts to upland watersheds

Watershed restoration projects may be identified and implemented through development of a watershed restoration action strategy, which can be developed through the U.S. EPA's 319 program as implemented by NMED. Alternatively, individual projects may be implemented to address particular areas of concern within a watershed. Ideally, however, watershed restoration programs integrate projects to better improve the water quality, water yields, and ecological health of the watershed.

Watershed efforts often bring together entities and individuals with interests in the watershed. This often includes local, state, and federal agencies that have some jurisdiction in the watershed as well as private landowners and interested citizens. In the Mora-San Miguel-Guadalupe region, many watershed restoration activities are being carried out by SWCDs, the NRCS, the U.S. Forest Service (USFS), NMED 319-funded projects, and other agencies and individuals. Some of the primary watershed activities occurring in the region are listed below:

- The *Gallinas Natural Resource Plan*, which was completed in 1994 (SCS, 1994). The NRCS (formally the Soil Conservation Service [SCS]) led a multi-agency task force, including the USFS, the Tierra y Montes SWCD, and the City of Las Vegas in developing the plan. The objective of the plan was to appraise the economic feasibility and environmental acceptability of methods to reduce accelerated soil erosion while sustaining the social and cultural integrity of the Gallinas watershed. The watershed covers 84 square miles on the east side of the Sangre de Cristo Mountains, down to Montezuma. The plan included recommendations for management practices for cropland, grazing lands, riparian areas, and forest land.

- The *Tierra y Montes SWCD*, which received a grant to conduct watershed restoration activities in the Gallinas Watershed. The project included extensive public education and community involvement. The objective was to improve the health of the watershed while improving the quality and availability of water and sustaining the social, economic, and cultural and resource values of the area (Tierra y Montes SWCD, 1995). The project worked with landowners to implement land management practices such as pre-commercial thinning, riparian fencing, pole plantings, and erosion control structures (rock and brush dams).

- The *Upper Pecos Watershed Natural Resources Plan*, prepared by a coalition of local, state, and federal agencies and interested landowners. The plan identifies a number of watershed concerns, including recreational impacts, water quality issues resulting from mining, grazing, and logging, forest health, and the need for improved zoning and subdivision regulations.

- The *Sapello Watershed Restoration Project*, conducted by the NRCS and the Tierra y Montes SWCD. This project implemented best management practices to address water quality impacts resulting from catastrophic wildfires in 2000. As a result of vegetation loss, erosion became a significant concern. This project identified best management such as fencing to control grazing, diversion structures to control runoff and filter sediment, planting with native species and mulching, and streambank stabilization.

- Several *ongoing projects managed by the Santa Fe and Carson National Forests* (USFS <http://www.fs.fed.us/r3/sfe/projects/projects/index.html>) including the following:

  - Control of non-native species through manual, mechanical, herbicidal, and controlled fire methods as well as controlled grazing with sheep/goats

  - Periodic prescribed burns (e.g., recent burns on 800 acres in Dalton Canyon north of Pecos and 1,900 acres in Sepadilla in the Pecos/Las Vegas Ranger District)

  - Periodic thinning projects such as the Upper Mora Watershed Restoration project, which involves thinning and prescribed burns on 600 acres.

- *New Mexico Highlands University's interdisciplinary Watershed and Forest Institute*. The mission of the institute is to promote collaborative research and the acquisition and dissemination of knowledge about watershed and forest management to promote the conservation of semiarid ecosystems and the sustainable economic development of rural communities.

- The *Gallinas Municipal Watershed Wildlands Interface Project*. Because the Gallinas watershed provides the majority of the water supply for the City of Las Vegas and for many irrigators, protection from wildfire is a critical issue. An environmental assessment for this project has been prepared (USFS, 2004a), which includes fuel reduction by thinning and prescribed burning on 8,800 acres. The purpose of the project is to reduce the potential for the initiation and spread of large-scale, high-intensity crown fires during dry conditions. Thinning, fuel breaks, and low-intensity controlled burns are planned to help clear small trees, brush, and downed wood. The Tierra y Montes SWCD, in association with the Adelante Resource Conservation & Development Council and several other partners, recently received Collaborative Forest Restoration Program (CFRP) funding to conduct thinning near El Porvenir Christian Camp in the Gallinas Watershed.

8.4.1 Technical Feasibility

The watershed management activity with the greatest potential to increase surface water yields is the reduction of vegetation density. Numerous ongoing projects to reduce vegetation density are conducted on a regular basis throughout the western U.S. and there are no technical issues that would prevent implementation of similar projects in the Mora-San Miguel-Guadalupe region. Indeed, as discussed above, a number of watershed restoration programs are already being conducted in the planning region, many of which focus on the reduction of vegetation density. While there are no technical issues that would prevent implementation, there are many technical issues to be addressed in developing an appropriate prescription for treating a watershed. The method of cutting and removing trees, determination of the desired densities, conditions for cutting to avoid bark beetle infestations, conditions for prescribed burns to minimize mortality, risk for uncontrolled burns and smoke, and methods for monitoring water quality and impacts to the environment must be developed as appropriate to the terrain, proximity to urban areas, and traffic patterns (if logs are removed).

Community involvement is essential at the outset of developing a prescription for thinning. In some areas, residents are concerned that a logging project may be disguised as a thinning project. The removal of logs can also present problems where access is limited by narrow streets. One example of community involvement in watershed planning is the following prescription, which was agreed on by the various stakeholders of the Santa Fe Municipal Watershed (USFS, 2001):

- No trees will be harvested commercially.
- Trees up to 16 inches in diameter will be cut and the trunks laid along slope contours to decompose.
- Trees will be cut by feller buncher, except on steep slopes where chainsaws will be used; no new roads will be constructed nor will skidding be allowed.
- Forest canopy cover will be left in a variable density mosaic that mimics natural fire disturbance patterns in a ponderosa pine forest.
- The southern ridge of the watershed will be cut into fuel breaks up to one quarter mile wide to keep erosion out of the canyon and thinned to 20 to 30 large trees per acre or 20 to 30 percent canopy cover.
- Slash piles will be burned once they have dried, approximately 3 to 12 months after the cutting takes place and when humidity is high to avoid an uncontrolled burn.
- Low intensity broadcast burns will be used to reduce density of small trees and surface fuels.
- Monitoring and evaluation will be used to determine treatment effectiveness and environmental effects.

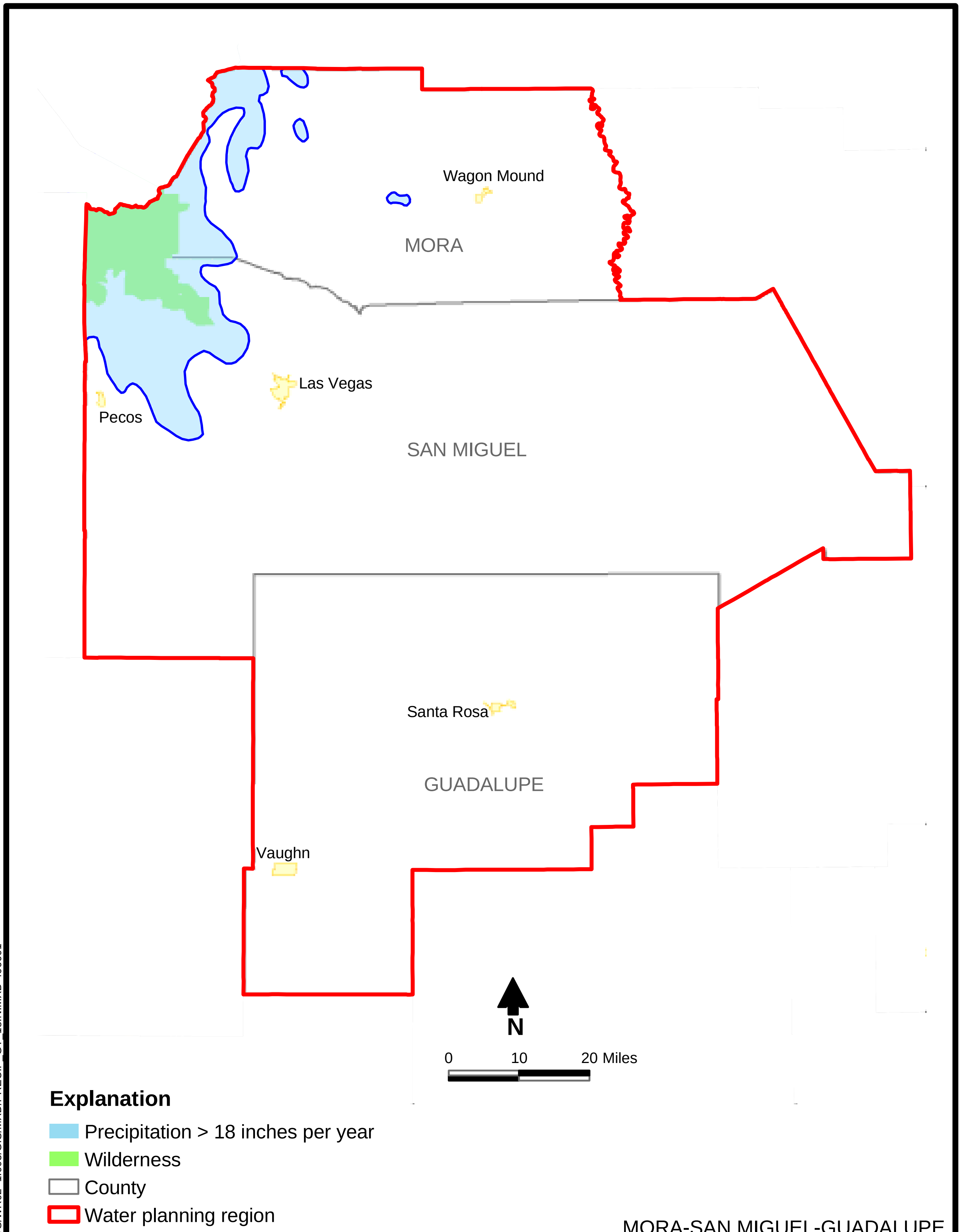
8.4.2 Hydrological Impacts

Thinning the overstory vegetation within a watershed impacts the hydrologic water balance by reducing transpiration, thereby increasing water yield. In addition to increases in yield, vegetation thinning may impact the timing of streamflows by increasing infiltration, thus reducing peak flow volumes and increasing base flow volumes. An important consideration, however, is that the entity conducting the watershed activity does not necessarily have the right to use any new water that results from their activities. Any increases in yield would augment streamflows that are legally apportioned based on existing water rights priority dates.

8.4.2.1 Precipitation Effects

In general, water yield increases from vegetation reduction are proportional to annual precipitation and the proportion of the forest canopy that is removed (Bosch and Hewlett, 1982; Troendle and Kaufmann, 1987, as cited by MacDonald et al., 2002; McCord and Winchester, 2001). Small or no water yield increases can be expected in areas where annual precipitation is less than about 18 to 20 inches (Ffolliott and Thorud, 1975; Bosch and Hewlett, 1982; Stednick, 1996, as cited by MacDonald et al., 2002). Only limited higher elevation areas in and along the Sangre de Cristo Mountains in the northwest part of the planning region have precipitation averaging above 18 inches per year (Figure 8-2).

Large variability in annual precipitation is another important limitation to managing forests for water yield. Data from the Fool Creek study in central Colorado showed that water yield increases from vegetation reduction in dry years were only about one quarter of the increases in wet years (Troendle and King, 1985, as cited by MacDonald et al., 2002). This means that water yield increases from forest harvest would be least in the dry years, when they are most needed, and greatest in the wet years, when they are least needed. Since the relative variability of annual precipitation increases as annual precipitation decreases, the increase in water yield with forest management becomes increasingly variable and therefore increasingly uncertain with low annual precipitation. If vegetation thinning is to be a viable option for increasing water yields, storage will be needed to carry over excess water from wet years.



MORA-SAN MIGUEL-GUADALUPE
WATER PLANNING REGION
Precipitation Greater Than 18 Inches

S:/PROJECTS/WR02-1.003/GIS/MXD/PRECIP_GT_18IN.MXD 406001

Daniel B. Stephens & Associates, Inc.
10-5-04
JN WR02.0036

Figure 8-2

8.4.2.2 Vegetation Effects

Increases in water yield resulting from forest cover reduction have been studied since 1955, when the Hubbard Brook Experimental Forest was established in New England by the USFS Northeastern Research Station as a major center for hydrologic research. A study conducted by Hibbert (1967) at this experimental forest concluded that water yield increases with forest cover reduction. Bosch and Hewlett (1982) complemented Hibbert's findings by analyzing data from 94 catchment experiments, as reported by Huff et al. (2000). The Bosch and Hewlett study generalized that there is about a 1.5-inch change in annual water yield for every 10 percent change in forest cover in excess of a 20 percent minimum threshold of forest cover reduction. Therefore, water yield consistently increases when vegetation cover is removed; however, the magnitude varies with both the annual rainfall of the catchment and the proportion of cover removed (Newson, 1997).

For the purpose of this plan, this alternative considers watershed management activities in the following vegetation zones defined by elevation, precipitation, and therefore, plant species:

- *Mixed conifer forests*. Mixed conifer forests occur at elevations above 6,900 feet, and receive 25 to 30 inches of rainfall annually, more than half of which is snow. Douglas fir, blue spruce, limber pine, white fir, ponderosa pine, and aspen are typical species in these mixed conifer forests.

- *Ponderosa pine forests*. Ponderosa pine forests occur between 5,900 and 8,900 feet in elevation. Precipitation ranges from 19 to 25 inches per year, equally divided as summer rain and winter snow.

- *Piñon-juniper woodlands*. Piñon-pine and juniper woodlands are prevalent in the Mora-San Miguel-Guadalupe region in areas between about 5,000 and 7,000 feet in elevation. Annual precipitation is typically from 10 to about 15 inches in the piñon-juniper woodlands, and tree species in these communities have evolved both drought and cold resistance.

- *Chaparral shrublands*. Chaparral shrublands are found at elevations of 2,900 to 6,500 feet and are dominated by shrub live oak and other shrub species that proliferate following fire or cutting. Annual precipitation varies from 15 to 25 inches.

- *Riparian ecosystems*. Riparian ecosystems occur along river and stream corridors at all elevations. Cottonwood and willow trees form part of the riparian vegetation in these river and canyon bottoms. Many lower elevation riparian ecosystems have been inundated with salt cedar and other non-native species.

Sections 8.4.2.2.1 through 8.4.2.2.4 discuss the results of research on water yield increases resulting from forest management activities in the four highest zones. Riparian ecosystems are discussed in Section 8.5

8.4.2.2.1 Mixed Conifer Forests. Research conducted in mixed conifer forests at Workman Creek in the Sierra Ancha Experimental Forest in central Arizona indicates that increases in streamflow can be obtained by replacing trees with a grass cover on strategically located parts of a watershed or by reducing forest overstory densities (Gottfried et al., 1999a). In the late 1960s, the USFS conducted watershed research in the mixed conifer forests of Willow Creek and Thomas Creek in the White Mountains of eastern Arizona to further test multiple-use forest management treatments (Hibbert and Gottfried, 1987, Gottfried et al., 1999b). Findings from these collective efforts include:

- Clear-cutting the mixed conifer forests on Workman Creek in stages, starting on the wettest and progressing to the driest sites, increased water yields by almost 2.6 inches (72 percent) for the combined treatments over a 20-year period.

- Single-tree selection followed by the conversion of mixed conifer to ponderosa pine forest stands (i.e., the removal of other conifer species and thinning of the residual ponderosa pine forest to a basal area less than 10 square meters per hectare [m^2/ha]) also increased water yields on Workman Creek. This treatment, which affected 83 percent of the treated watershed, resulted in an average annual water yield increase of 4.1 inches (110 percent) over 12 years. However, such a severe thinning treatment is generally not recommended for present-day management because of environmental concerns.

- Bringing the densities of the mixed conifer forests on Willow Creek to optimum stocking conditions by removing mature, over-mature, and high risk trees resulted in a 3.7-inch (54 percent) increase in water yields in the short term. However, the resulting heavy logging and subsequent wind damage to residual trees on the treated watershed compromised the original research objectives. Final treatment conditions on this watershed were similar to a large clear-cut area rather than the intended stands of young-growth, sawtimber-sized trees.

- The implementation of a prototypical operational resource allocation plan on Thomas Creek, involving patch clear-cutting with other single-tree and group selection methods (where appropriate), increased water yields about 1.9 inches (45 percent). The streamflow increases were generated by snowmelt or large rain storms, a phenomenon that was similarly observed during other research efforts in the mixed conifer forests.

Research in Colorado has shown that water yield increases in the higher-elevation lodgepole and spruce-fir forests are directly proportional to the amount of basal area that is removed (Troendle and King, 1987, as cited by MacDonald et al., 2002). This research also indicated that, because of limitations in the accuracy of streamflow measurements and the regressions between paired basins, at least 20 to 25 percent of the basal area within a watershed must be removed to detect a statistically significant change in runoff (Troendle and King, 1987; Troendle et al., 2001, as cited by MacDonald et al., 2002). Smaller reductions in basal area should increase streamflow proportionally, but the magnitude of increases from small changes in forest density cannot be predicted with any confidence.

8.4.2.2.2 Ponderosa Pine Forests. Watershed research on water yield improvement in the low-elevation ponderosa pine forests of the Colorado River Basin was conducted on the Beaver Creek watersheds in north-central Arizona (Baker and Ffolliott, 1999), in the high-elevation ponderosa pine forests on the Castle Creek watersheds in eastern Arizona (Gottfried et al., 1999b), and in the ponderosa pine forests on the Colorado Front Range (Gary, 1975). Results of this research include:

- The potential for increasing water yields in ponderosa pine forests is less than in higher-elevation mixed conifer forests because of the drier conditions of the ponderosa pine forests. However, short-term (up to 10-year) increases of 1 to 3 inches were observed on the Beaver Creek watersheds as a result of varying intensities of overstory thinning, patterns of overstory removal, and combinations of the two treatments. Increases of 0.2 to 1 inch are likely a more realistic expectation of water yield increases within a multiple use management framework, where water, forage, wood, wildlife, and recreation are all considered in the product mix.

- An average water yield increase of 0.5 inch (30 percent) remained stable for 20 years after an irregular-block timber harvest on a watershed at Castle Creek. The initial increase in water yields was attributed largely to reduced evapotranspiration and increased snow accumulations in the created openings. No increase in water yield occurred after a prescribed burn on a second watershed because the fire did not significantly affect the forest overstory conditions or consume much of the litter and duff on the forest floor (Gottfried and DeBano, 1990).

- Low to intermediate stocking levels in two-thirds of the ponderosa pine stands on the Colorado Front Range preclude significant water yield increases from these areas, regardless of the management emphasis (with the exception of clear-cutting).

8.4.2.2.3 Piñon-Juniper Woodlands. The effects of vegetation management practices on water yields in piñon-juniper woodlands have been studied on the Beaver Creek watersheds (Baker and Ffolliott, 1999). Conversion of these open overstories to less water-demanding herbaceous covers by cabling, felling, and herbicide treatments had the following results:

- Cabling or felling of piñon-juniper woodlands had a negligible effect on water yields. Any water yield increase that might be expected from these mechanical methods of conversion is thought to be taken up by herbaceous plants, which increased several-fold.

- The aerial application of a herbicide treatment resulted in a small increase in water yields of less than 0.5 inch. In this treatment, the test watershed was sprayed with the herbicide mixture from a helicopter to kill the trees. The dead trees were removed after 8 years of post-herbicide evaluation in a second-stage of the treatment. Streamflow returned to near pre-treatment levels after the dead trees were removed.

- In 1956, research conducted in Arizona on the removal of piñon and juniper estimated a per-acre yield between 0.5 and 1.0 acre-inch. During the next decade, a considerable number of acres were cleared using mechanical methods. Almost 20 years later, continued research and field results found that chaparral-infested lands that were treated, which had been dismissed by the first study, exhibited significantly more potential for water yield than the treated piñon-juniper acres (Hays, 1998).

- A summary of research into the effects of piñon-juniper management on hydrology was provided by Roundy and Vernon (1999). The studies they surveyed had variable results, depending on watershed conditions, soil types, removal practices (i.e., whether vegetation is left on-site after cutting), and the scale of the projects; they found that the results could not necessarily be generalized to cover broader conditions. Several of the investigations indicated that little usable water would result from piñon-juniper management. Conversely, studies in Oregon and Utah reported some benefits to spring flow and/or increased infiltration in treated piñon-juniper areas.

- A study in the Edwards Aquifer area and its upstream "contributing zone" in south-central Texas is investigating the potential management strategy for increasing streamflow and groundwater recharge in the area (Afinowicz et al., 2004). Much of the region is covered by a dense canopy of juniper and oak, and there is a high level of interest in using brush control as a mechanism to increase recharge. To learn more about the extent to which brush control affects runoff and infiltration, researchers used rainfall simulation equipment to apply approximately 8 inches of rainfall (6,980 gallons) to the site during a period of 51 minutes, yet no surface runoff was observed during or after the rainfall simulation. Preferential flow was observed within a trench, predominantly from soil areas and places with heavy limestone or root fractures, leading to a theory that the water moves below the surface and potentially recharges the aquifer. This ongoing study will allow quantification of a water budget for the area in real time, as well as determination of how much water brush species use and whether brush control is necessary. Field studies of a paired plot that resembles the first research area in slope and soil type, but does not have any brush growth, are also being conducted (Afinowicz et al., 2004) to compare surface and groundwater flow with and without brush. Preliminary results indicate a larger amount of surface runoff when no brush is present.

Investigations of other watersheds resulted in the following conclusions:

- In reviewing piñon-juniper management, Gottfried and Severson (1994) indicated that many control programs failed to produce the increased water yields and better wildlife habitat that had originally been expected.

- Research conducted by Wood and Javed (2001) compared runoff from untreated piñon-juniper stands to runoff from stands where the piñon and juniper were clear-cut and the land was either cleared, burned, or covered with slash. The test plots were monitored from the time of treatment in 1989 until 1999. The findings of this study suggest that treatment of slash following thinning can be used to effect short-term changes in runoff, but that long-term changes are more difficult to achieve. The reestablishment of understory growth may be beneficial for certain land use practices (e.g., cattle grazing, fire suppression), but does not appear to achieve greater water yields.

Management practices that are used to treat piñon-juniper woodlands, including chaining and prescribed burns, are technically feasible, although the impacts of the treatments on yields may be marginal. Natural widespread loss of piñon trees is currently occurring across New Mexico, due to extended drought and impacts of the bark beetle. Though some improvements in the ecological health of the area and the timing of runoff events can be expected, the opportunities for management actions to affect measurable increases in streamflow water yields in the piñon-juniper zone are generally much more limited than in the forested areas.

8.4.2.2.4 Chaparral Shrublands. A research program initiated in 1956 on the Three Bar Wildlife Area near the Theodore Roosevelt Reservoir in central Arizona represented the first major experimental watershed program in the chaparral shrublands of the Colorado River Basin (DeBano et al., 1999a). This early program was followed by research on the Whitespar, Mingus, and Battle Flat watersheds in north-central Arizona to further assess the potential for water yield improvement through chaparral conversion practices (DeBano et al., 1999b). Findings from these research efforts include:

- Increasing streamflow by converting chaparral shrubland to other vegetation is possible on favorable sites where annual precipitation averages 19.5 inches or more. The key to increasing water yields on these sites is the replacement of deep-rooted chaparral shrubs with shallow-rooted grasses and forbs, which use less water, by applications of herbicides, prescribed burning, and combinations of these conversion methods. The expected average increase is 3.9 inches in water yields on areas receiving 22 inches of average precipitation.

- Chaparral shrubs surviving the initial conversion treatments have to be re-treated to control re-sprouting. Post-treatment shrub cover should be maintained at about 10 percent to sustain the water yield increases. However, the threats posed to wildlife, concerns about the environmental effects of herbicides, and increased recognition of the other multiple use values in the chaparral shrublands have restricted large-scale applications of the conversion treatments studied.

8.4.2.3 Scale Effects

The size of a treated area is an important consideration when planning an effort to reduce vegetation. As the thinned area increases, total runoff volume will also increase. However, Huff et al. (2000) suggest that the change in yield relative to expected annual runoff is on the order of 1 percent for large watersheds, which is generally too small to measure. In their modeling study, a 40,000-square-kilometer (km^2) (9,884,000 acres or 15,444 square miles [mi^2])

watershed in the Sierra Madre Mountains of California was assessed for 1-km^2 areas eligible for thinning. Sixty percent of the watershed was found ineligible for consideration because the authors' thinning criteria excluded set-aside, protected, and non-forested land. A minimum remaining vegetation criterion of 135 square feet (ft^2) of basal area was imposed for each 1-km^2 treatment area, which further reduced the thinning operations to 15 percent of the entire study area. For each thinned 1-km^2 area, the modeled annual water yield for average climate conditions ranged from 0 to 6.5 inches. Because only 15 percent of the total 40,000 km^2 was thinned, aggregating the individual 1-km^2 thinned areas produced the watershed-scale thinning simulation. The area weighted watershed increase in water yield from their idealized scenario ranged from 0 to 1.3 inches; at larger hydrologic unit code scales, the water yield ranged from 0 to 0.16 inch. Although the change in water yield per unit area decreases as the size of the area increases, the actual volume of produced water increases.

8.4.2.4 Flow Timing Effects

For any scenario, the timing of the increase in runoff may be out of phase with the timing of peak demand, so storage capacity will be required to obtain the full benefits of any projected increase in streamflow. The timing and quality of streamflow can change substantially after removing piñon-juniper, even though annual water yields remain unchanged. If the removal of the woody vegetation results in a much denser grass and forb cover, runoff processes during high-intensity rainstorms can shift from overland flow with high surface erosion rates to subsurface flow with no surface erosion rates. The increased infiltration reduces stormflow volumes and increases base flow volumes. Drastic changes in runoff timing will be highly site-specific and will depend on a variety of factors, such as soil depth, soil texture, slope, bedrock type, changes in percentage of ground cover, and precipitation amounts and intensities. Sid Goodlow, a rancher in the Capitan area, demonstrated this change by rehabilitating his land, which had become overgrown with piñon and juniper. After he removed the piñon and juniper and established grasses, the once dry arroyos became perennial streams.

8.4.2.5 Ownership of Produced Water

The amount of water that can be gained from watershed restoration throughout the region is affected by New Mexico laws and regulations, which specify that any "additional" runoff created by watershed management becomes part of the public water supply and is subject to the prior appropriation system. This effectively means that any appropriator could obtain the increased water generated, regardless of their role (or lack thereof) in the land management activities leading to the increased supply. No mechanism exists whereby the person or entity that increases the amount of runoff can lay a priority claim to the water produced. Furthermore, any permit obtained to use that water would be a new, very junior water right. The more likely scenario is that no new appropriations would be allowed, but that holders of existing water rights would be more like to receive their full supply each year.

8.4.2.6 Summary

In summary, the average long-term increase in water yield depends on the annual precipitation, the species being treated, the proportion of the canopy that is removed, the regrowth rate, and the length of time between treatments. These variables significantly affect the amount of water yield increase that may be expected.

To approximate the expected yield increase from vegetation removal in the Mora-San Miguel-Guadalupe Region, a simplified calculation was conducted. Non-wilderness areas with precipitation of 18 inches per year or greater (Figure 8-2), which cover approximately 295,000 acres of the region, were used to estimate the potential yield increases in the planning region. The estimated potential yield increases are based on two primary assumptions:

- Based on the previous studies summarized above, it was assumed that yield increases from thinning would be on the order of 0.2 to 0.5 inch over the land treated.

- Because it is probably not realistic to assume that the entire area could be thinned, it was assumed that 30 to 70 percent of the non-wilderness area with precipitation above 18 inches would be thinned.

Table 8-10 illustrates the potential water supply increases in the region. As shown in this table, for the assumed 30 to 70 percent of the high-precipitation area that would be thinned, yield would increase by approximately 1,500 to 8,600 ac-ft/yr. However, as discussed above, this amount would vary from year to year, with lesser yield increases occurring in the dry years.

Table 8-10. Potential Water Supply Increases in the Mora-San Miguel-Guadalupe New Mexico Water Planning Region

Percentage of Total Area Thinned [a]	Area Thinned [b] (acres)	Water Yield Increase (acre-feet)	
		Low-End [c]	High-End [d]
10	29,540	490	1,230
20	59,080	990	2,460
30	88,630	1,480	3,690
40	118,170	1,970	4,920
50	147,710	2,460	6,160
60	177,250	2,950	7,390
70	206,790	3,450	8,620
80	236,330	3,940	9,850
90	265,880	4,430	11,080
100	295,420	4,920	12,310

[a] Within each incremental fraction, at least 25 percent of the basal area (i.e., 25 percent of the vegetation) must be removed to achieve indicated yield.
[b] Total non-wilderness area where precipitation is above 18 inches per year.
[c] Calculations assume that thinning results in 0.2 inch of additional water yield over area thinned.
[d] Calculations assume that thinning results in 0.5 inch of additional water yield over area thinned.

8.4.3 Financial Feasibility

Costs for conducting thinning projects are variable depending on the ease of access, thickness of vegetation, amount of thinning to be done, treatment of slash (i.e., whether it is—in order of increasing cost—scattered, piled, burned, or removed), and techniques used (in order of increasing cost—hand pruning, chainsawing, bulldozing). Current costs for mechanical thinning programs in New Mexico range from about $800 to $1,000 per acre including planning (Boucher, 2004). In wilderness areas, where no mechanical cutting is used, the cost for using wildland fire as a method of restoring forests is about $6 per acre (Boucher, 2004). Recent thinning projects on the Santa Fe Municipal Watershed cost $3 million for 3,200 acres, or about $945 per acre (Van Dorn, 2005).

The primary ongoing cost of forest thinning projects is the need to address regrowth through periodic thinning or prescribed burns. In general, a ponderosa pine forest must be thinned at least every 30 to 40 years or allowed to have low intensity fires every 5 to 7 years to prevent catastrophic fires and to maintain increased water yield. Costs for repeat thinning would be similar to the initial costs (excluding inflation).

Costs for conducting watershed projects that affect water quality are highly variable. A general approach is to identify needed projects in the planning stage and implement those projects as funding becomes available.

Funding for watershed activities can be obtained from a variety of sources:

- U.S. EPA Section 319 nonpoint source grants can potentially be used to form watershed groups, to identify nonpoint source issues, and to implement projects that use best management practices. The focus of these grants is to improve water quality conditions.

- During the past several years, the New Mexico Water Trust Fund issued a request for funding applications in four categories, one of which was watershed management. Depending on legislative appropriations, this is likely to be a continuing source of funding.

- The CFRP provides grants for forest restoration projects that reduce the threat of wildfire, improve watershed conditions, improve the use of small trees thinned from restored lands, and provide jobs and training to local communities. These grants are available for state, local, and tribal governments, educational institutions, landowners, conservation organizations, and other interested public and private entities. Restoration projects must be on federal, tribal, state, county, or municipal forest lands in New Mexico, or any combination thereof. The program does not provide grants for the treatment of private land, but CFRP grants can be used for processing facilities on private land that use small trees from thinning projects on public lands.

Other potential funding sources include NRCS grants (e.g., Conservation Technical Assistance, Small Watershed Program, Environmental Quality Incentives Program, Conservation Reserve Program, Emergency Watershed Protection).

8.4.4 Environmental Impacts

An extensive program of forest harvest or thinning could increase erosion rates and adversely affect water quality (due to increased turbidity and sediment loads), particularly during the thinning operation. The increase in erosion from harvested areas and the accompanying adverse impacts on water quality can usually be minimized through careful design of treatments that use best management practices (MacDonald et al., 2002). The careful design and construction of the road and skid trail system is critical to minimizing overland flow and reducing erosion, and the use of buffer strips along ephemeral and perennial streams is needed to minimize sediment delivery into the stream network. Maintaining riparian vegetation is the best means to minimize increases in water temperatures.

The primary environmental advantage of reducing forest density is the reduced risk of high-severity fires. High-severity fires in coniferous forests can increase runoff and erosion rates by one or more orders of magnitude relative to unburned conditions, and these increases can have severe downstream effects such as flooding, reservoir sedimentation, and adverse effects on aquatic habitat. The effects of prescribed fires on runoff and erosion are generally minimal, as the fire severity is mostly low to moderate and will cause less soil water repellency or highly discontinuous water repellent patches (MacDonald et al., 2002). Areas burned at moderate or low severity also leave less bare ground than high-intensity fires; according to recent research, a lower percentage of bare ground correlates very strongly with lower erosion rates. If the percentage of bare ground is less than about 20 to 30 percent, post-fire erosion rates should be very low and therefore pose little or no threat to water quality and downstream water resources (Benavides-Solorio and MacDonald, 2000; MacDonald et al., 2002).

An important concern in the case of prescribed fire and broadcast burning is the effect on air quality and the potential for the fire to become uncontrolled. Fires in forested areas produce a large number of particulates that are hazardous to human health. Smoke also has an adverse effect on visibility and visual aesthetics. Another environmental impact that has been identified as a potential concern is the logging of old growth forests under the fuel reduction program (George, 2004).

In general, watershed management should have a positive impact on water quality. Watershed groups and public lands managers can work to identify and remediate sources of water quality degradation and to address water quality issues associated with grazing, erosion, septic tanks, or other concerns.

However, thinning activities can have a negative impact on water quality if they are not conducted properly. The primary water quality concern from thinning is increased erosion and sedimentation. This type of impact can be minimized by using best management practices for road installation (if needed) and logging activities.

Management actions taken in the national forests to increase water supply emanating from the forests generally must comply with a number of federal laws, including:

- National Forest Management Act, 16 U.S.C. §1600, et seq.
- National Environmental Policy Act, 42 U.S.C. §4321 et seq.
- Clean Water Act, 33 U.S.C. §1251 et seq.
- Endangered Species Act, 16 U.S.C. §1531 et seq.
- National Historic Preservation Act, 16 U.S.C. §470 et seq., where applicable
- American Indian Religious Freedom Act, 42 U.S.C. §1996, where applicable

The National Forest Management Act (NFMA) directs the USFS to manage national forest lands according to forest plans prepared every 10 to 15 years. This planning process must, according to the NFMA and the National Environmental Policy Act (NEPA), provide for public involvement and allow for incorporation of economic, environmental, or other concerns into the process. Implementation of these forest plans, however, is dependent on funding.

8.4.5 Political Feasibility and Social/Cultural Impacts

Efforts to harvest or thin public forest lands often elicit opposition at first. However, by informing and educating the public, watershed managers can create support for activities that can substantially reduce the risk of high-severity wildfires while having minimal effect on water quality. Strong public support for watershed management was expressed at public meetings held throughout the Mora-San Miguel-Guadalupe planning region. There are some public concerns regarding thinning in old-growth forests and potential road building activities. Also, prescribed burning programs often encounter considerable public resistance due to the adverse effect of associated smoke on visibility and visual aesthetics, as well as concerns about the ability to control prescribed fires. An extended period of prescribed fire could also raise issues such as the potential effect on tourism.

Designing restoration and management plans in collaborative consultation with affected local communities helps to enlist local support and involvement and to integrate valuable knowledge about local resources. Direct socioeconomic and cultural benefits would flow from contracting with local communities and small-scale local enterprises for forest thinning and fire management, riparian system enhancement, erosion control, and/or other stewardship work.

8.5 Non-Native Vegetation Replacement

This alternative involves the removal of invasive non-native vegetation from riparian areas followed by management to prevent regrowth of the exotic phreatophytes. Such management may include revegetating an area with native species. The main invasive species targeted for removal is salt cedar, but Russian olive may be targeted as well. Although evapotranspiration varies depending on vegetation type and density, soil types, and depth to water, in most cases exotic vegetation such as salt cedar consumes more water than non-native vegetation.

Salt cedar, or tamarisk, is common along the Pecos and Canadian Rivers and their tributaries (USFS, 2004b) within the planning region. This plant, native to the Middle East, was introduced into Texas in the late 1800s and has since spread throughout the Southwest. Its rapid growth and reproduction, combined with its ability to replace native vegetation and tap groundwater, has earned it the classification of a noxious weed. The removal of salt cedar is the major focus of this alternative.

8.5.1 Technical Feasibility

Salt cedar removal projects have been ongoing in New Mexico for many years. From 1967 to 1971, under the Pecos River Basin Water Salvage Project, the USBR cleared 53,950 acres of salt cedar along 370 miles of the Pecos River between Lake Sumner, New Mexico, and Pecos, Texas (USBR, 2005). Plowing, tree crushing, mowing, bulldozing, chaining, and herbicide applications were the main methods of removal. Regrowth was managed mainly by periodic root plowing in which heavy equipment cut and removed roots 10 to 18 inches below the surface. Though the program was temporarily discontinued, salt cedar clearing by the USBR on the Pecos River has continued since 1995, but is limited to about 30,000 acres in New Mexico. Other recent efforts in the Pecos basin and around New Mexico include:

- *Mechanical removal*. Phreatophytes may be removed by bulldozers, mulchers, digging (root-ball extraction) and/or axes, machetes, and chainsaws, all of which cut, destroy, and/or remove the plant itself. The most effective methods are those that affect the plant roots, which can resprout even after the plant stem or trunk is destroyed. In addition to current USBR efforts, mechanical removal of salt cedar is occurring at Bitter Lake National Wildlife Refuge near Roswell by the USFWS, where it is being replaced by native cottonwood and willow (USFWS, 2005). The Santa Fe and Carson National Forests have recently completed an environmental impact statement for invasive plant control (USFS, 2004c) through mechanical as well as other methods. Of the invasive plants targeted, 28 percent are salt cedar and Siberian elm.

- *Aerial herbicide application*. To date, 9,100 acres along 185 river miles from Guadalupe County to the New Mexico-Texas state line, including 32 miles in Guadalupe County, have been treated using funding from the New Mexico State Legislature (U.S. Senate Committee on Energy and Natural Resources, 2003). Additionally, New Mexico State University (NMSU) has partnered with the U.S. Department of Agriculture (USDA) to spray salt cedar on the Canadian River in Quay County (NMSU, 2004). Once dead, vegetation sprayed with herbicides may remain in place or may be mechanically removed or burned.

- *Cut stump treatment*. This method involves (1) mechanical removal of phreatophytes and (2) immediate application of herbicide directly to the freshly exposed stump, usually by hand. The timing of herbicide application can have a significant effect on its success. Leaving the cut stump for more than two days before herbicide treatment reduces the success rate. Additional herbicides may be effective when applied to the stump in the autumn as the plant will then draw its fluids downward, carrying the herbicide to the roots and effectively killing it. As of June 2003 in Guadalupe County, 20 acres had been treated with the cut stump technique by private landowners, and 30 to 35 acres were slated for treatment by the Guadalupe SWCD (NMACD, 2003).

- *Biocontrol*. Though salt cedar has no natural predators in the Southwest, several species have been targeted as possible rapid consumers of the plant. A leaf beetle that preys upon salt cedar in its native Asia has been used for control of the species in Nevada (Bryan, 2003). The local success of the leaf beetle is currently being tested on the Pecos River near Artesia, where about 600 leaf beetles were released in August 2003 by NMSU in cooperation with the USDA and USFWS. Furthermore, goats are being used to control phreatophyte growth on the Canadian River in Quay County (NMSU, 2004). Goats are not necessarily able to remove large salt cedar trees, but could reduce the cost of mechanical removal by clearing thinner branches and new growth and stripping bark from plants (USDA, 2005).

- *Fire*. Outside of New Mexico, controlled burns have been used to clear areas heavily infested with salt cedar (Deuser, 1996; NPS, 2003). Salt cedar is relatively fire resistant, however, and tends to resprout following fires (Muzika and Searingen, 1999).

- *Flooding*. Flooding can be used to control salt cedar, though root crowns must remain submerged for three months in order to kill the plant (Muzika and Searingen, 1999).

- *Replacement with native vegetation*. Once non-native phreatophytes are removed, native vegetation may naturally take over a treated area. This process may be slow and may not favor the desired species, however (e.g., grasses rather than forbs/weeds), due to interference from root plowing or other continuing management practices to hinder salt cedar regrowth (Welder, 1988). To ensure that salt cedar does not quickly revegetate a cleared area, optimally native vegetation should be established through pole planting or other means, and ongoing maintenance of the cleared site should occur.

As this list of ongoing activities shows, many methods of salt cedar removal have been developed, tested, and executed with varying levels of success in New Mexico during the past four decades. Significant phreatophyte removal has already occurred downstream of the planning region on both the Pecos and Canadian Rivers, but phreatophyte removal projects are relatively new within the planning region itself. However, technical feasibility should not be a problem based on the number of salt cedar removal projects successfully implemented elsewhere in New Mexico and the Southwest.

8.5.2 Hydrological Impacts

Historically, reduced water consumption resulting from salt cedar removal has been difficult to measure. In New Mexico, two studies of water savings were conducted in the late 1980s based on data from the area between Acme and Artesia that was mechanically cleared of salt cedar under the Pecos Basin Water Salvage Project:

- Weeks (1987) noted that an early unpublished base-flow analysis based on Pecos River gaging data could not reliably attribute a gain in river base-flow gain to salt cedar removal. However, Weeks explained that this base-flow gain could have been due to potentially large variations in groundwater recharge (based on precipitation) and metered pumping in the years immediately following salt cedar removal. In an attempt to quantify water salvage by directly measuring phreatophyte water consumption, Weeks compared the evapotranspiration of various stages of salt cedar regrowth after clearing (old growth, burned, and mowed) to replacement vegetation using the eddy-correlation and energy budget methods during the time period from 1980 to 1982. Though he encountered some difficulties with field equipment, Weeks estimated that salt cedar consumed 2 to 3.6 feet per year (ft/yr) and the replacement vegetation (forbs and grasses) consumed 1.3 to 2.3 ft/yr. Thus, he estimated that salt cedar removal resulted in a water savings of 0.66 to 1.3 ft/yr. Though the rates differ, the savings is comparable to savings estimated for the Middle Rio Grande (Cleverly, 2003) of about 1 ac-ft/yr difference in evapotranspiration between dense salt cedar stands and cottonwood-willow bosque.

- Welder (1988) performed an extensive base-flow analysis based on 34 years of Pecos River gaging data and pumping records that spanned the removal of salt cedar on 19,000 acres. He observed a slight decrease in base-flow to the river immediately after the salt cedar removal, followed by a moderate increase that leveled off within a range of 15,850 to 24,700 ac-ft/yr for the 19,000-acre area. This corresponds to a gain of about 1 ac-ft/yr per acre of salt cedar cleared. An unquantified rise in the water table was also observed after salt cedar removal, suggesting a reduction in evapotranspirative consumption. However, Welder cautions that the change in base-flow conditions could be partially accounted for by other concurrent events, including an observed reduction in metered groundwater pumping and a measured increase in precipitation from the drought in the 1950s to a wetter period at the end of the study.

Though both the Weeks (1987) and Welder (1988) studies acknowledge the inherent difficulties in measuring water savings under transient precipitation and groundwater development conditions, both researchers suggest consumptive reduction of about 1 ac-ft/yr per acre of salt cedar removal on the lower Pecos River in New Mexico. In areas of the planning region where the climate is milder, it is anticipated that total evapotranspiration by all types of vegetation is less than in the cited studies, and it is thus unclear whether the difference in evapotranspiration rates between salt cedar and shallowly rooted replacement vegetation would have the same magnitude in the planning region as in the study areas. Unfortunately, no evapotranspiration studies applicable to phreatophyte removal projects have been conducted in the planning region, so anticipated hydrologic impacts from this alternative must be extrapolated from the Weeks and Welder studies.

To develop an accurate estimate of savings due to phreatophyte removal, the following factors need to be considered:

- If the area is not revegetated with native riparian species, (1) non-natives will recolonize the area, resulting in no long-term water savings, or (2) the water table may rise, resulting in saturated soils or increased bare soil evaporation, which can negate the effects of the reduced evapotranspiration.

- In some areas the water table may decline with the addition of drainage such that the area ceases to be riparian habitat (i.e., once vegetation is removed and drainage installed, the area will become scrub or grassland with little or no direct evaporative loss). In such cases, the evaporative savings will be on the order of 4 acre-feet per acre, the average evapotranspiration loss from salt-cedar (King and Bawazir, 2000). However, adding this type of drainage is infeasible in many cases.

Assuming that the water table does not decline and cause the area to return to scrub or grassland, and that native vegetation is successfully established and maintained, a rate of 1 acre-foot for each acre successfully restored can be assumed. Based on estimates from aerial photographs, there are 135,600 acres of riparian vegetation in the planning region. If 10 percent or more this riparian area were restored to native vegetation, the overall savings would be about 13,600 ac-ft/yr. If 50 percent of the riparian area were restored to native vegetation, approximately 68,000 ac-ft/yr could be saved. However, it is important to understand that this type of savings can be realized only if projects are carefully designed and executed to ensure water table control and maintenance so that non-native vegetation does not recolonize.

8.5.3 Financial Feasibility

Costs for successful phreatophyte removal and replacement with native vegetation must consider initial costs as well as costs for long-term maintenance. Welder (1988) observed that salt cedar regrowth on 19,000 acres between Acme and Artesia, New Mexico was halted after an initial clearing and two root plowing events in the Pecos Basin Water Salvage Project, requiring 9 years of maintenance. In 2002, The New Mexico state legislature appropriated $2.5 million to local SWCDs for non-native phreatophyte removal on the Pecos River, indicating the level of funding necessary to undertake phreatophyte removal activities (NMACD, 2003). Typical project costs are summarized in Table 8-11.

Table 8-11. Estimated Cost and Percent Control for Salt Cedar Treatments

Control Treatment	Cost per Acre ($)	Percent Control
Individual Plant Treatments		
Manual removal (immature plants)	0 – 5,000	95 – 100
Mechanical grubbing	40 – 300	97– 99
Low-volume herbicide application	30 – 60	80 – 95
Cut-stump herbicide application	1,600 – 2,500 [a]	60 – 80
Ground-based foliar herbicide	40 – 300	97 – 99
Large-Scale Control		
Mechanical	700	97 – 99
Airplane herbicide-burn	300	93
Helicopter herbicide-burn	240	89
Airplane herbicide-shred [b]	400	97 – 99
Helicopter herbicide-shred	510	97 – 99
Airplane herbicide-burn-mechanical	380	97 – 99
Helicopter herbicide-burn-mechanical	490	97 – 99

Source: USFS, 2004b (Table 3)
[a] Most of the cost is for tree cutting and removal or chipping; the herbicide cost varies from $20 to $60 per acre.
[b] Includes two years of followup using ground-based herbicide treatment

8.5.4 Environmental Impacts

Phreatophyte removal activities can have both positive and negative impacts on ecosystems. When non-native phreatophytes are removed, ecosystems benefit from a reduced risk of forest fire hazard in riparian areas due to reduction in understory density. Salinization of soil and water has also been attributed to salt cedar, so its removal is thought to improve soil and water quality. The removal of non-native species and re-establishment of native cottonwood willow bosque can provide habitat for many native species. Conversely, mechanical methods of phreatophyte removal may damage soil. Furthermore, aerial herbicide application may kill unintended native species. Though herbicides are chosen to target non-native phreatophytes, in areas where cottonwoods and other sensitive species exist, a different removal method may be recommended. Additionally, because the vegetation in question grows along waterways, herbicides must be chosen with care and registered for aquatic application (Muzika and Swearingen, 1999). Two herbicides currently in use are Arsenal, which is used particularly for aerial application, and Garlon IV.

As the dominant riparian phreatophyte, salt cedar provides habitat to numerous other native and non-native wildlife species, particularly birds. After the removal of salt cedar, it is assumed that such species would adapt to the replacement vegetation or could be accommodated in the remaining uncleared areas of salt cedar. Certainly the possibility exists that stress would be put on species that are dependent upon the dense understory that salt cedar provides. However, these habitat modifications would not affect any listed, threatened, or endangered species in the Pecos or Canadian River valleys.

Salt cedar was originally introduced to the Southwest to stabilize river banks and prevent erosion. Removal of this phreatophyte has attendant benefits and drawbacks associated with bank destabilization. On the positive side, flood risk may be reduced because the riverbed will be less entrenched and a more dynamic geomorphology could accommodate higher streamflows. On the other hand, increased mobility of bank sediments may result in increased sedimentation rates. Increased river turbidity may also occur with increased erosion. However, if salt cedar is replaced with other relatively deeply rooted desirable vegetation such as cottonwood, and if clearing projects are well designed and executed, bank stability and erosion rates may not be significant affected.

8.5.5 Political Feasibility and Social/Cultural Impacts

At meetings held throughout the planning region, there was widespread support for clearing of non-native vegetation and improving riparian habitat. Three potential political/social/cultural issues related to this alternative are:

- Concern regarding water quality and human health impacts related to the use of herbicides.

- Right to water saved as a result of removal activities. Under the New Mexico doctrine of prior appropriation, water saved from consumptive use by replacement of non-native species with native vegetation would become available to fulfill existing water rights. Effects of phreatophyte removal would be seen in the form of increased flows downstream of the treated areas, possibly increasing the ability to fulfill downstream water rights and to store water in downstream reservoirs. Thus, while there may be an overall beneficial impact related to the alternative, the persons or entities funding or carrying out the removal projects do not necessarily have a water right to use any additional water produced.

- Use of local crews to carry out removal projects, which would have positive socio-economic impacts on the region.

8.6 Water Quality Protection

Protecting water resources from potential water quality degradation can help ensure viable water supplies to meet the future needs of the region. Accordingly, this alternative would identify and implement programs to protect water resources within areas of the region that are vulnerable to contamination. As discussed in Section 5.4, many potential sources, such as underground storage tanks, landfills, mines, and facilities with discharge permits, can be specifically identified (point sources). These sources are already monitored and characterized by NMED. Other potential threats to water quality are spread over large areas (nonpoint sources) and include agriculture, livestock, erosion, road construction, and—of particular interest in this region—septic tanks. The impacts from these nonpoint sources are less well characterized and monitored.

Both point and nonpoint sources can contribute significantly to water quality degradation. Point source contamination is typically from more identifiable and specifically regulated sources than contamination from nonpoint sources and therefore attracts more attention and funding; however, nonpoint source contamination is often more chronic and difficult to address. A successful water quality protection program will identify all potential sources, both point and nonpoint, and promote shifts in practices and land use that decrease the threats to local and regional water supplies.

This alternative focuses on the largest water quality problem in the planning region: nonpoint contamination from septic tanks (Easton, 1999). Poorly designed and/or maintained septic systems can contaminate groundwater. The region has over 9,000 septic tanks (or cesspools);

these can threaten water quality and public health when there is inadequate treatment of wastewater effluent, improper disposal of wastes to septic tanks, and surfacing of sewage where systems are undersized. Several towns in the region, such as Tecolote, North San Isidro, San Miguel, Watrous, Guadalupita, and Mora, have high nitrates in their water supply (Easton, 1999).

8.6.1 Technical Feasibility

All the major identified point sources of contamination located within the region are under the jurisdiction of NMED regulatory programs (Sections 5.4 and 8.14). Additional efforts to identify and monitor contaminant point sources would be largely redundant. It may, however, be desirable and beneficial for the region to review the NMED's monitoring, permitting, or remediation activities for listed sites to ensure that regional concerns are being adequately addressed. One potential mechanism for accomplishing this would be to set up a water quality steering committee. Groups involved in watershed management activities, such as the Tierra y Montes SWCD, should be considered for inclusion.

The water quality steering committee could review existing NMED programs, including:

- Monitoring of UST sites, overseen by the NMED Petroleum Storage Tank Bureau
- Monitoring of active and closed landfills, overseen by the NMED Solid Waste Bureau
- Monitoring of hazardous waste generators and hazardous waste treatment, storage, and disposal facilities, overseen by the NMED Hazardous Waste Bureau
- Monitoring of mining sites and groundwater discharge plans, overseen by the NMED Groundwater Quality Bureau
- Monitoring of Superfund sites, overseen by the U.S. EPA in conjunction with the NMED Groundwater Quality Bureau
- Monitoring of NPDES permits, overseen by the U.S. EPA in conjunction with the NMED Surface Water Quality Bureau

The New Mexico Source Water Assessment and Protection Program (SWAPP) could help address contamination from septic tanks. This federally funded program, which is overseen by the U.S. EPA, assists communities in protecting their drinking water supplies. SWAPP can be used to address monitoring and control of potential sources of contamination near public water supplies. Specifically, SWAPP can assist local communities in the following:

- Determining the source water protection area for the water system
- Taking inventory of actual and potential contaminant sources within the source water protection area
- Determining the susceptibility of the source area and water system to contamination
- Reporting the SWAPP findings to the water utility, its customers, and the community
- Working with the community and other stakeholders to implement source water protection measures that safeguard and sustain the water supply into the future

Thus, SWAPP can be used to address water quality issues with minimal additional cost to the local community. To participate in this program, communities can contact SWAPP (<http://www.nmenv.state.nm.us/dwb/swapp.html>). Domestic well owners can get their wells tested by NMED for fluoride, iron, nitrate, and electrical conductivity at no cost. Instructions for well testing are provided on the NMED web site (<http:/www.nmenv.state.nm.us/fod/LiquidWaste/>). The development of source water or wellhead protection plans for the planning region may require hiring or contracting technical personnel to work with the SWAPP.

Because nonpoint source contamination such as septic tanks, agricultural runoff, or livestock are often not fully addressed by any of the NMED programs, the region would likely benefit the most from focusing on these sources, with SWAPP assistance. The main nonpoint contaminant in the region is on-site domestic wastewater treatment systems (i.e., septic tanks). An estimated 9,000 septic tanks serve 22,000 people in the region; only about one-third of these are permitted by NMED. Septic systems are most likely to cause significant impacts to water quality where higher population centers coincide with shallow groundwater or surface water bodies. For instance, only 150 of the 290 homes in the town of Mora are hooked up to the wastewater treatment system. The remaining 140 homes use septic tanks and cesspools in an area where the depth to water is shallow.

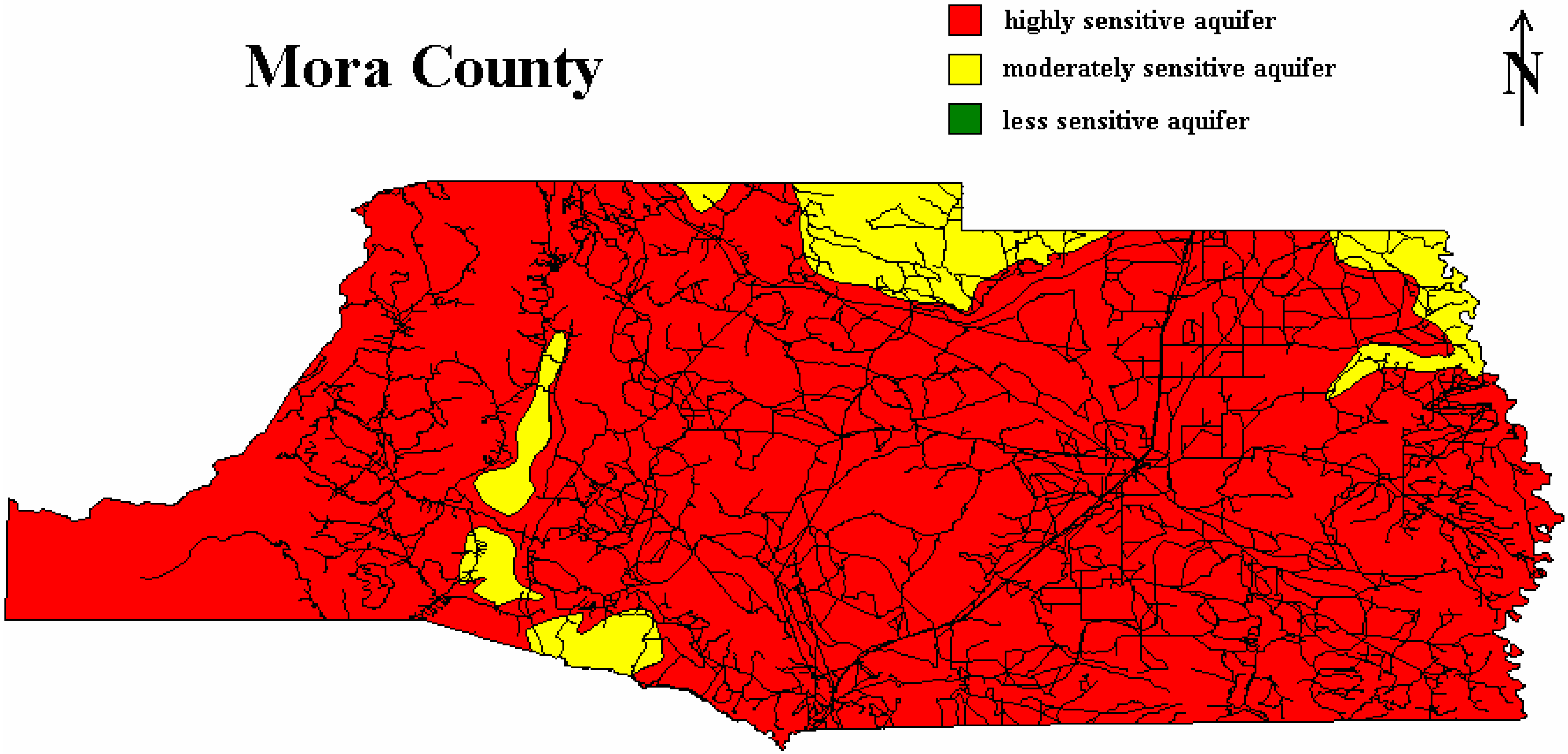
The NMED is currently considering proposed amendments to the State Liquid Waste Disposal Regulations (20.7.3 NMAC), which regulate domestic leachfield or septic systems. The proposed changes would require modifications to existing systems as well as the design, set-back, and maintenance of new systems. In NMED-designated “areas of concern,” new systems on less than ¾ acre would require installation of “advanced treatment” systems. These systems are defined by NMED as septic systems capable of treating biological oxygen demand (BOD) to less than 30 mg/L and total nitrogen to an average of 20 mg/L or less, prior to discharge.

The NMED areas of concern are defined locations where groundwater is most vulnerable to contamination; Figures 8-3 through 8-5 present the NMED’s mapping of aquifer sensitivity for each county in the region. The areas of concern (in red) indicate where depth to water is less than 100 feet and TDS are less than 2,000 mg/L.

By definition, an area of concern has one or more of the following characteristics:

- Overlies an aquifer within 100 feet of ground surface
- Lies within 1 mile of a known groundwater contamination plume that contains anthropogenic anoxic conditions or nitrate contamination
- Lies above an aquifer that is overlain by fractured rock
- Lies above an alluvial aquifer that discharges to a gaining stream located within 200 feet of the proposed septic system

The proposed septic system/leachfield regulations can be accessed on the NMED web site (<http://www.nmenv.state.nm.us/fod/LiquidWaste/LWDR.latest.draft.pdf>). NMED will update the maps to include current depth-to-groundwater information, as well as areas of karst and fractured bedrock, known contamination sites, and gaining streams. Liquid waste permit applications for conventional septic systems on lots smaller than ¾ acre within an area of concern will receive greater scrutiny in order to protect public health and prevent degradation of a body of water, in accordance with agency guidance.



Source: NMED, 2005

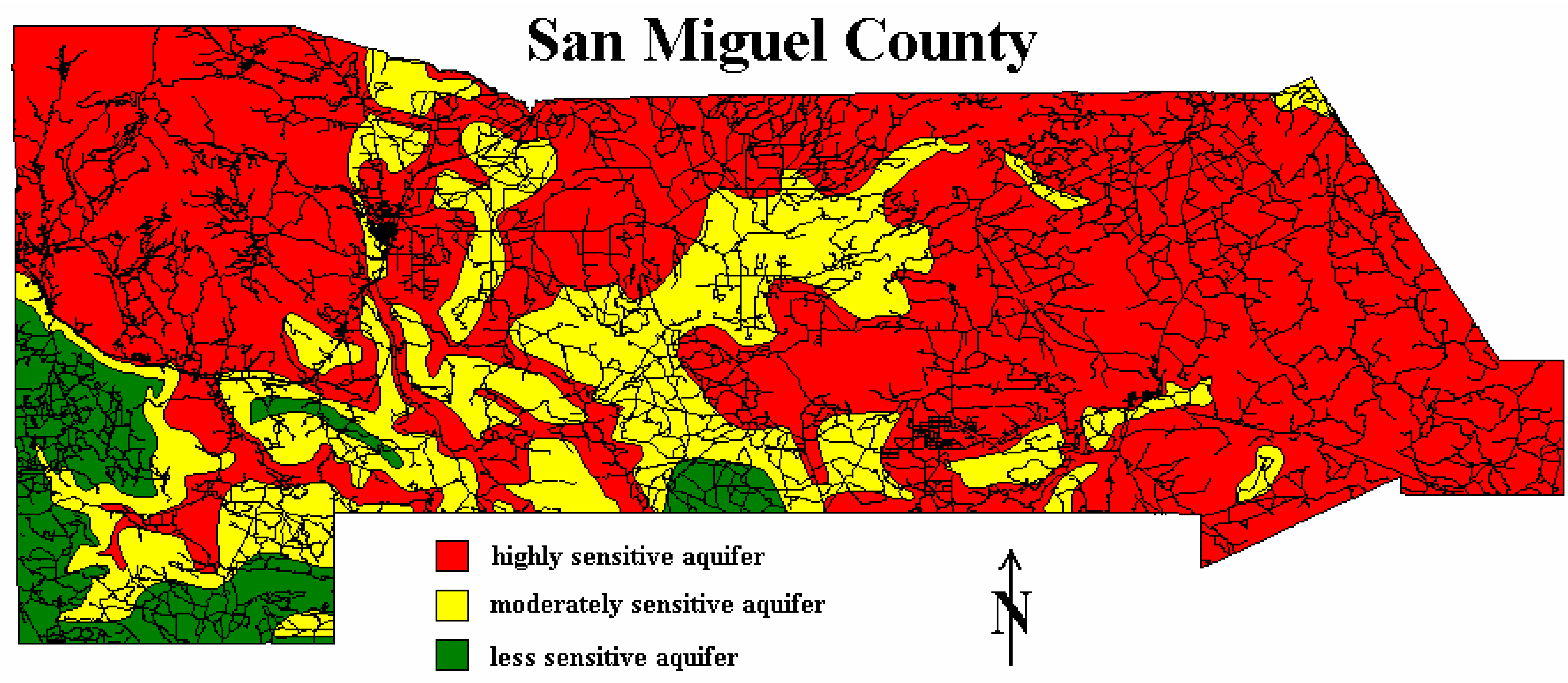
MORA-SAN MIGUEL-GUADALUPE WATER PLANNING REGION

Mora County Aquifer Sensitivity

Daniel B. Stephens & Associates, Inc.

7/1/05

Figure 8-3



Source: NMED, 2005

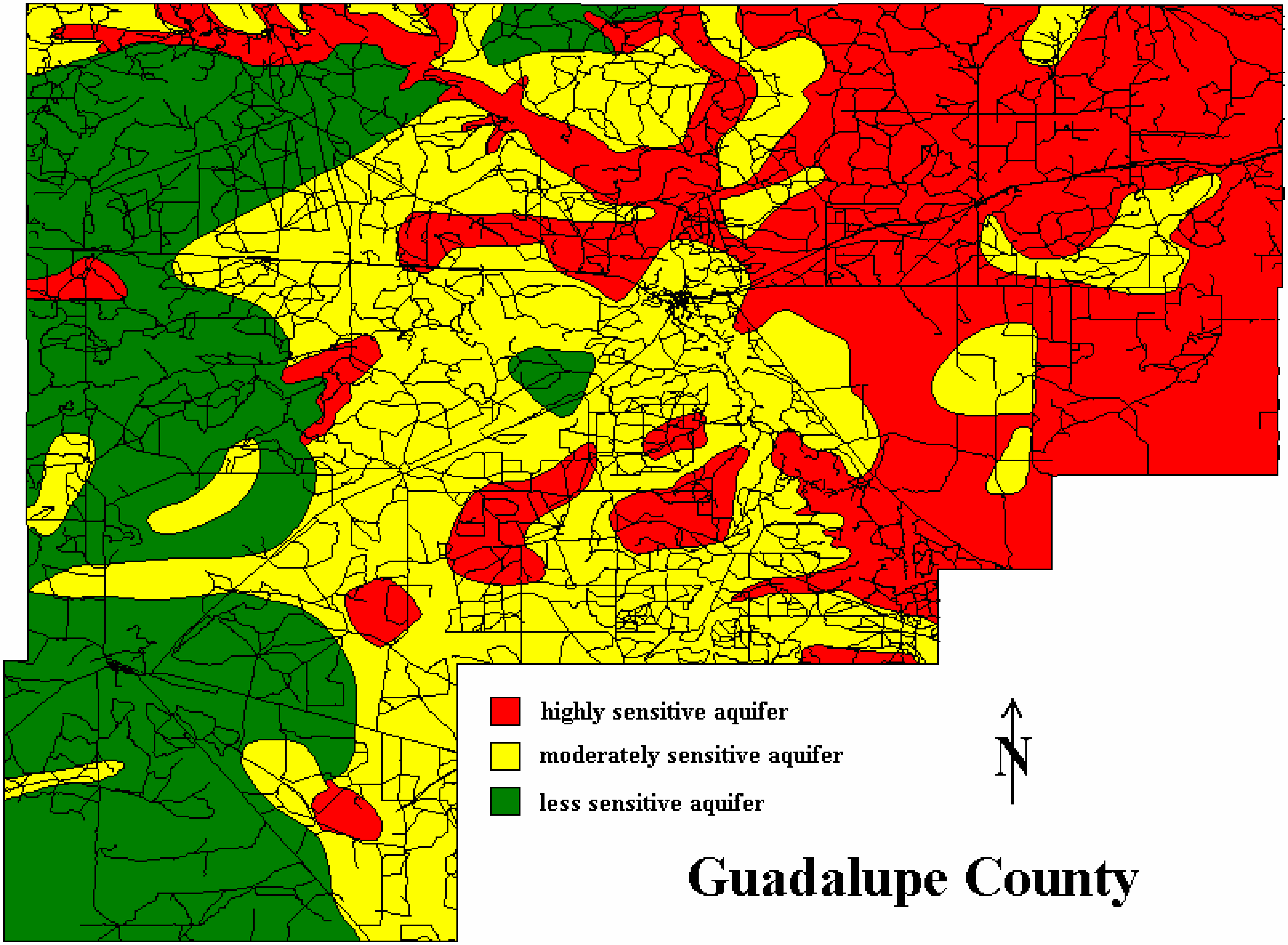
MORA-SAN MIGUEL-GUADALUPE WATER PLANNING REGION

San Miguel County Aquifer Sensitivity

Daniel B. Stephens & Associates, Inc.

7/1/05

Figure 8-4



Source: NMED, 2005

MORA-SAN MIGUEL-GUADALUPE WATER PLANNING REGION

Guadalupe County Aquifer Sensitivity

Figure 8-5

Daniel B. Stephens & Associates, Inc.

7/1/05

In addition to NMED regulatory requirements, administrative and public participation efforts may be required to develop and implement enhanced on-site wastewater treatment ordinances in the planning region. Existing ordinances can serve as models for these efforts. For example, Bernalillo County recently enacted a strengthened wastewater ordinance (Bernalillo County Municipal Code, 2001) to address private septic systems, and this ordinance could be used as an initial model for Mora, San Miguel, and Guadalupe Counties. The Bernalillo County ordinance is performance-based: treatment requirements are determined by on-site physical conditions and an assessment of the potential risk for groundwater contamination posed by the septic system.

A better understanding of water quality deterioration from septic tanks is needed, particularly in areas with fractured granite or basalt, shallow depth to groundwater, or other conditions that reduce natural denitrification processes. Once the problem is better characterized, contamination could be addressed through (1) extending service to homes from local or regional wastewater treatment plants, (2) installing upgraded on-site treatment systems, or (3) establishing regular maintenance plans to provide routine pumping and inspection of septic tanks. The specific options under this alternative are:

- *Connect to existing wastewater infrastructure*. The communities of Las Vegas, Pecos, Mora, Wagon Mound, Vaughn, Santa Rosa, and Rio Pecos Villa have central wastewater collection and treatment facilities; however, 10 to 50 percent of their residents continue to rely on septic tanks. If these residents are hooked into existing wastewater collection and treatment systems, the treatment capacity of the plants may need to be expanded to accommodate the added effluent.

- *Construct regional wastewater treatment systems for wastewater reuse*. Under this option, communities that currently have a water system but no wastewater system would build central collection, treatment, and disposal facilities. The central collection system could be a traditional single gravity-fed system that serves the entire community or "decentralized" systems that serve clusters of homes. After treatment, the wastewater could be reused by reinjecting the effluent to the groundwater or transmitting the effluent to a golf course, ranch, or some other facility that currently uses surface water and/or groundwater.

- *Use alternative on-site wastewater treatment*. Innovative on-site approaches are available as alternatives to conventional septic tank/leach field wastewater disposal and could be used in communities that are not currently served by a water system or where populations are more dispersed. These advanced on-site methods to treat wastewater are intended to produce a higher-quality effluent and thus protect soils, groundwater, and human health. For example, a combination gray/black wastewater system separates individual on-site residential waste streams so that higher-quality wastewater (e.g., from showers and kitchen use) can be stored and used for landscaping or garden watering, while sanitary wastes are segregated and directed to an on-site (or off-site) wastewater treatment system. This approach greatly reduces the daily volume of residential wastewater that, after treatment, is discharged to surface or groundwater. Some advanced systems incorporate disposal processes that include evaporation of some effluent.

- *Establish a regular maintenance program for septic tanks.* Under this option, communities could set up a system to service septic tanks on a regular basis. Where home density is less than one house per 2 acres, this may be an effective method of protecting water quality and public health; however, if the density is greater, a centralized system would better protect water quality. Residents would be assessed an annual fee for this maintenance and education about the "do's and don'ts" of septic tanks would be a key component of this program. Homeowner associations, mutual domestic well associations, or county governments could implement this type of program, although programs for homeowner and domestic well associations would have to be voluntary for existing members.

The technology exists to collect, centrally treat, and dispose of all wastewater now generated by rural residents of the planning area. In the normal course of an area's growth, it is not unusual for housing units to become denser and for wastewater treatment eventually to be centralized. The decision to centralize wastewater treatment is normally made for public safety and health and environmental protection as well as for economic reasons. In some parts of the planning area the density of rural housing lends itself to this consideration now.

About 1,500 of the 9,000 septic tanks in the region are located within municipalities that have centralized wastewater treatment facilities; another 1,600 are in communities that have water systems, but no wastewater treatment systems. The nearly 6,000 remaining septic tanks (or cesspools) serve rural residents who are supplied by domestic wells. Table 8-12 lists the communities in the region with water systems and shows the estimated effluent generated by each community. Communities without a groundwater discharge plan or a NPDES permit were assumed to rely on septic tanks to treat wastewater.

8.6.2 Hydrologic Impacts

Replacing septic tanks with improved wastewater collection and treatment systems would improve water quality in groundwater and streams that are currently impacted by septic tanks. Nitrate levels in groundwater would not immediately decrease, but would improve over time depending on the depth to water and flow rate in the aquifer. The replacement of cesspools or poorly maintained septic tanks with improved wastewater disposal systems would reduce public health concerns, particularly in situations where sewage had previously been surfacing. A program of regular maintenance of septic tanks may be an appropriate option where the density of septic tanks in the area is less than one house per 2 acres.

Another possible benefit of this alternative is increased water supply. If septic tanks are replaced with a centralized system or designed to allow for reuse of treated wastewater, a reduced amount of water would be withdrawn for consumptive uses such as landscape, garden, stock, and/or ranch land watering.

In New Mexico, there are hundreds of small water systems that serve small communities (30 to 1,500 residents). There are approximately 27 such small systems serving a total of about 7,850 people in the Mora-San Miguel-Guadalupe Water Planning Region. Only 5 of these small water communities have a central wastewater collection, treatment, and disposal system; the remaining 22 communities rely upon septic tanks/leachfields for wastewater treatment and disposal. If approved by the OSE, these community water systems could count water that is currently treated by septic tanks as a return flow. A consolidated waste stream flowing from conventional centralized collection and treatment systems could effectively increase the amount of obtainable return flow credits.

Table 8-12. Estimate of Population Served by Septic Tanks
Mora-San Miguel-Guadalupe Water Planning Region
Page 1 of 3

Water Supplier	Population Served [a,b]	Water Use [b] (gpcd)	Water Accounts [c]	Sewer Accounts [c]	Percentage Not on Sewer [d]	Population on Septic Tanks [e]	Number of Septic Tanks [f]	Effluent Currently Treated by Septic Tanks (gpd) [g]
Mora County *Average household size (based on 2000 Census): 2.54*								
Rural self supplied	3,854	80	---	---	100	3,854	1,517	308,320
El Alto MDWCA	85	223	---	---	100	85	33	11,373
Holman	110	59	---	---	100	110	43	6,490
La Cordillera	50	74	---	---	100	50	20	2,220
Mora MDWCA	680	286	290	150	48.3	328	140	93,887
Upper Holman	110	34	---	---	100	110	43	3,740
Wagon Mound MDWCA	316	140	---	---	50	158	62	13,272
San Miguel County *Average household size (based on 2000 Census): 2.58*								
Rural self supplied	10,639	80	---	---	100	10,639	4,124	851,120
Big Mesa Water Co-op	500	150	---	---	100	500	194	45,000
Conchas Dam	400	207	---	---	100	400	155	49,680
Pendaries Water System	300	103	---	---	100	300	116	18,540
East Pecos MDWCA (1990)	600	69	---	---	100	600	233	41,400

[a] Yellow highlight indicates communities with a central wastewater treatment plant
Blue highlight indicates the population self-supplied for water and sewer
No highlighting indicates communities with central water but no wastewater treatment plant

[b] Wilson et al., 2003

[c] Personal communication with municipalities

[d] Difference between number of sewer accounts and number of water accounts divided by number of water accounts, or 100 percent if no wastewater treatment plant

[e] Population served by septic tanks

[f] Population served by septic tanks divided by the average household size

[g] Effluent amount is based on 60 percent of water diverted unless per capita demand is less than or equal to 80 gpd, in which case effluent is estimated to be equal to water diversions.

gpcd = Gallons per capita per day
gpd = Gallons per day
MDWCA = Mutual Domestic Water Consumers Association
WUA = Water Users Association
--- = No information available

Table 8-12. Estimate of Population Served by Septic Tanks
Mora-San Miguel-Guadalupe Water Planning Region
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Water Supplier	Population Served [a,b]	Water Use [b] (gpcd)	Water Accounts [c]	Sewer Accounts [c]	Percentage Not on Sewer [d]	Population on Septic Tanks [e]	Number of Septic Tanks [f]	Effluent Currently Treated by Septic Tanks (gpd) [g]
San Miguel County (continued) *Average household size (based on 2000 Census): 2.58*								
El Coruco Domestic (est)	100	80	---	---	100	100	39	8,000
Ilfield MDWCA	160	99	---	---	100	160	62	9,504
La Pasada MDWCA	150	51	---	---	100	150	58	7,650
Las Vegas Water Supply System	14,565	146	6,500	5,560	14.5	2,106	940	184,514
Pecos Water System	1,441	121	740	552	25.4	366	188	26,578
Ribera MDWCA	140	75	---	---	100	140	54	10,500
Rowe MDWCA	103	76	---	---	100	103	40	7,828
San Jose MDWCA	160	51	---	---	100	160	62	8,160
San Miguel	40	97	---	---	100	40	16	2,328
Sena Water System	55	193	---	---	100	55	21	6,369
Tecolote Domestic Water Users Association	120	124	---	---	100	120	47	8,928
Tecolotito MDWCA	250	75	---	---	100	250	97	18,750

[a] Yellow highlight indicates communities with a central wastewater treatment plant
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No highlighting indicates communities with central water but no wastewater treatment plant

[b] Wilson et al., 2003

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Table 8-12. Estimate of Population Served by Septic Tanks
Mora-San Miguel-Guadalupe Water Planning Region
Page 3 of 3

Water Supplier	Population Served [a,b]	Water Use [b] (gpcd)	Water Accounts [c]	Sewer Accounts [c]	Percentage Not on Sewer [d]	Population on Septic Tanks [e]	Number of Septic Tanks [f]	Effluent Currently Treated by Septic Tanks (gpd) [g]
Guadalupe County *Average household size (based on 2000 Census): 2.51*								
Rural self-supplied homes	695	80	---	---	100	695	277	55,600
Anton Chico MDWCA	300	58	---	---	100	300	120	17,400
Los Sisneros MDWCA	35	50	---	---	100	35	14	1,750
Puerta de Luna MDWCA	210	138	---	---	100	210	84	17,388
Rio Pecos Villa WUA	30	91	---	---	10	3	1	164
Sangre de Cristo MDWCA	100	99	---	---	100	100	40	5,940
Santa Rosa Water Supply	2,744	202	900	797	11.4	314	103	38,074
Vaughn Water System (serves 135 residents outside of MSMG Region)	717	144	---	---	10	58	23	5,028
Total	40,172					22,600	8,965	1,889,589

[a] Yellow highlight indicates communities with a central wastewater treatment plant
Blue highlight indicates the population self-supplied for water and sewer
No highlighting indicates communities with central water but no wastewater treatment plant

[b] Wilson et al., 2003

[c] Personal communication with municipalities

[d] Difference between number of sewer accounts and number of water accounts divided by number of water accounts, or 100 percent if no wastewater treatment plant

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About 3,300 people living in communities with a wastewater treatment plant are not connected to the sewer system; these residents rely on about 1,500 septic tanks or cesspools for wastewater disposal. The communities that hook up these residents could use the added effluent for turf irrigation or other wastewater reuse applications.

An additional estimated 15,200 people in the planning region, who rely on 5,920 septic tanks, obtain their water from individual domestic wells rather than from central water systems. Domestic well water rights are not eligible for return flow credits from septic tank wastewater effluent.

The total amount of effluent currently discharged to the 9,000 septic tanks in the planning region is about 1,500 ac-ft/yr.

8.6.3 Financial Feasibility

Costs for developing wastewater ordinances are minimal. Existing government employees in Mora, San Miguel, and Guadalupe Counties can work with the SWAPP to develop source water/wellhead protection plans and to develop and implement enhanced on-site wastewater treatment ordinances. Using other ordinances as models will minimize these efforts.

The costs to replace or upgrade existing septic tanks and cesspools can be significant. These estimated costs are provided below for the four options discussed in Section 8.6.1: (1) hooking up to existing wastewater systems, (2) building centralized wastewater systems in communities with a centralized water system but no existing wastewater facility, (3) building more advanced on-site wastewater treatment systems, and (4) developing a management program to address regular maintenance and inspection of septic tanks.

The costs to replace the estimated 9,000 septic tank/leachfield systems in the region with either regional wastewater treatment systems or other on-site technologies is estimated by assuming that (1) 1,500 septic systems would be connected to existing municipal systems, (2) 1,600 septic systems would be replaced within 22 communities with existing water systems, and (3) 5,950 septic systems would be upgraded to on-site treatment systems or managed under a regular maintenance program.

8.6.3.1 Connection to Existing Wastewater Treatment Systems

The cost to connect a residence to an existing sewer system ranges from $2,000 to $4,000, depending on the distance to an existing sewer line. This cost would be borne by the customer. A total of $3 to $6 million could be needed to hook up the 1,500 residences now served by septic tanks in Las Vegas, Pecos, Village of Mora, Wagon Mound, Vaughn, and Santa Rosa. Individual communities would also need to assess the capacity of their existing treatment plant to handle the additional input from new customers.

8.6.3.2 Regional Wastewater Treatment Systems

The cost to plan, design, build, operate, and maintain a small community system for wastewater collection, treatment, and disposal would be high. As an example, assume that the 22 communities with central water systems build conventional, gravity-fed wastewater treatment plants to replace the existing 1,600 septic systems. If these new centralized systems included only conventional secondary treatment, conventional gravity-type collection systems, and disposal to groundwater or to some other existing water user, this alternative would cost an estimated $20,000 per house or $32 million. If a “decentralized” wastewater system were used, where septic tanks continue to be part of the system and wastewater is diverted from the septic tanks in clusters of homes, the costs would be about half, or $16 million over a 20-year period (Van Lenten, 2003). In either case, the true cost of such a project may vary depending on right-of-way acquisition expenses.

At least some of the costs of developing and operating central wastewater collection and treatment systems would be passed onto rural residents. Residents who now have relatively low and periodic ongoing costs associated with conventional septic tanks would receive a monthly wastewater bill, estimated to be about $5 per month, to cover their share of the management, operations, and maintenance of the new small central systems (Van Lenten, 2003).

8.6.3.3 Alternate On-Site Wastewater Treatment Solutions

The cost to bring new alternate on-site systems on-line as a result of new home construction would be between $6,000 and $10,000 per household, which is higher than a conventional septic tank/leachfield system cost of approximately $2,400. The conversion of existing residences to alternative on-site treatment systems would be similar to the low end of the estimated cost range for new systems. At a cost of $6,000 each, the costs to upgrade all of the 5,920 septic tank/leachfield systems in the planning area that are not near existing community water or wastewater systems to advanced on-site systems would be more than $35.5 million. Costs to operate and maintain improved on-site wastewater systems range from $10 to $25 per month (UNM, 2001). If additional water quality monitoring programs are established and monitor wells are installed, periodic sampling and water quality analyses will also be needed. Costs for these analyses may range from approximately $200 to $1,000 per sample, depending on the required analyses.

In contrast to regional wastewater systems, the costs of replacing septic systems with advanced on-site treatment systems would likely be borne entirely by individual property owners, although external funding is available for some small community on-site projects. Grant funding may be available to implement some programs, even providing new septic tanks to homeowners where it can be shown that the community as a whole would benefit. In this situation, the village or community would own the septic tank or water treatment system (Rose, 2004).

The value of groundwater improvements and human health and safety benefits associated with system upgrades might be the deciding factor in adopting mandates for advanced on-site treatment. In his paper, “Septic Tanks, Good or Evil,” Dr. Richard Rose, P.E., of the NMED Construction Programs Bureau, notes:

> . . . decentralized management has captured national attention and is promoted by EPA because of the potential for substantial reduction in wastewater construction costs. It can provide both short and long term protection of the environment and does not preclude “Big Pipe” options in the future. Funding for the decentralized approach is available from mainstream funding agencies, such as NMED and USDA Rural Utility Service.

Rose (2001) also discusses in detail the debate regarding on-site versus centralized treatment and describes a U.S. EPA-funded, NMED-implemented demonstration project in Willard, New Mexico. A detailed description of this project is presented by Van Lenten (2003), who also provides many of the funding options available for designing and implementing a wastewater system.

The NMED Construction Programs Bureau can assist communities in writing grants and obtaining necessary funds for proposed projects. Sources of funding for community wastewater facilities include the Rural Community Assistance Corporation, the State revolving fund loan, State appropriation, the New Mexico Finance Authority, the Community Development Block Grants, the U.S. EPA one-time hardship grant, U.S. EPA demonstration grants, and the State Drinking Water Bureau.

8.6.3.4 Regular Maintenance

Instituting a wastewater ordinance requiring that septic systems be replaced with alternative on-site wastewater systems would result in much higher costs ($6,000 to $10,000) than the option to enforce regular maintenance of existing septic tank systems. However, this conclusion assumes that the costs of maintaining a failing septic tank system—which does not include any costs to clean up contaminated water—is commensurate with the maintenance cost for a functioning advanced system.

A program to provide regular maintenance of septic tanks has been implemented in two areas of New Mexico: the Estancia Basin (implemented by Entranosa Water and Wastewater and operated for the past 5 years) and Peña Blanca (operated for about 13 years). The Entranosa program includes about 1,000 homeowners who are charged $5.25 per month, which includes pumping the septic tank once every three years. In Peña Blanca, the cost is $10 per month for each homeowner and the tanks are pumped every two years (Rose, 2004).

8.6.4 Environmental Impacts

Replacement of septic tanks with a regional treatment system would likely have NEPA implications in archaeological and biological terms, but these would not be significant enough to stop the projects. Cultural remains and endangered species habitat would have to be identified and avoided. Some floodway, floodplain, and perhaps wetlands issues under Section 404 of the CWA would be associated with the construction of regional wastewater treatment systems.

Considering the fact that many rural septic systems are faulty and often located too close to surface water and wells, replacing septic tanks would reduce contamination of surface water and groundwater and therefore enhance human health and safety. Constructing regional wastewater treatment systems would yield greater streamflow downstream, but would reduce locally available water by diminishing local groundwater recharge and seepage to surface water. If alternative wastewater treatment systems are local and small-scale, the discharge could increase local surface streamflow.

In Willard, the three treatment systems were installed below ground to minimize odors and visual aesthetic issues (Rose, 2004); this approach could be used elsewhere.

8.6.5 Political Feasibility and Social/Cultural Impacts

The political feasibility of this alternative varies depending on which option is pursued. Hooking up residents in existing communities with existing centralized wastewater treatment facilities would have the greatest political feasibility and the fewest social or cultural impacts. However, changing a community from one with no current administration to one with a centralized administration that supports a program of regular maintenance or a centralized wastewater treatment facility will require an initiative by a village-administered management utility, homeowners association, mutual domestic well association, or county government.

Van Lenten (2003) and Rose (2004) suggest conducting a house-to-house survey to get an accurate description of baseline physical conditions and to document existing health hazards. This survey information could be presented in public meetings to illustrate the connection between the water the community is drinking and the wastewater and how residents could benefit by protecting water. A group community effort is more likely to get funding and, therefore, result in lower costs for the residents. It is important to provide options with costs for residents to consider to ensure political support. Community involvement will also help reduce negative social or cultural impacts. Even so, any community project will need a full-time champion to move the project forward and to work with NMED to obtain funding.

8.7 Development of Additional Groundwater

Meeting the future water supply demands for growing populations such as the City of Las Vegas may require further development of groundwater reserves. This is a particular concern given the recent history of drought conditions in the region that have limited the supply of surface water. Development of additional groundwater would provide a more reliable supply during drought periods. However, groundwater quantity and quality vary throughout the region, and extracting usable quantities of water from some areas may be difficult due to topographic, hydrogeologic, and demographic constraints. Furthermore, the acquisition and development of new groundwater reserves depends on technical, legal, and financial factors as well as a consideration of the potential hydrological and environmental impacts of development. In particular, the Pecos River Compact restricts any groundwater withdrawals that could affect surface flows in the Pecos River or its tributaries. Sections 8.7.1 through 8.7.4 analyze these aspects of groundwater development.

8.7.1 Technical Feasibility

Obtaining water rights to divert groundwater is the first step in groundwater development. While owners of domestic wells only need to file for a permit, operators of a community or municipal well must transfer an existing water right to the desired point of diversion. Once the necessary water rights and financing have been acquired, the installation of new wells is readily accomplished. Well installation involves the following steps:

- Evaluating hydrogeologic conditions
- Determining appropriate well spacings to avoid excessive pumping interference
- Designing new wells
- Constructing wells
- Performing well yield and water quality testing
- Connecting the well(s) to conveyance systems for distribution

The hydrogeologic conditions must be evaluated to determine if additional groundwater development in a particular area is feasible. The other well installation activities do not necessary limit the development of additional reserves, but are important factors in optimizing development. The following sections discuss the technical issues pertaining to each of these activities.

8.7.1.1 Hydrogeologic Conditions

The occurrence and availability of groundwater within the Mora-San Miguel-Guadalupe Region is controlled by rock type, structural geology, occurrence of alluvial deposits, surface water features, and the extent of outcrop available for recharge. Groundwater quality and quantity is highly variable; the hydrogeologic conditions for various parts of the region are described below.

8.7.1.1.1 Western Mora County. Alluvial aquifers associated with the Mora River are a primary source of groundwater in western Mora County (Mercer and Lappala, 1970, 1972; Mercer et al., 1970; GEI Consultants, 1990). Only localized portions of the alluvial aquifer, including Mora Valley and the Watrous area, have been identified as suitable for irrigation purposes (Mercer and Lappala, 1970, 1972). The thinner alluvium deposits in the upper alluvial valleys above Watrous (not including Mora Valley) provide well yields suitable only for domestic use. Recharge to the alluvial aquifers is primarily from surface water sources such as streams and leaky irrigation canals, and also from precipitation. Storage in the alluvial aquifer is limited. In 1990, an investigation to evaluate the feasibility of using the aquifer in the Mora Valley to supply a fish hatchery was performed (GEI, 1990). The study indicated that the aquifer has high transmissivity and low storage volumes; consequently, withdrawal over an extended period of time should be limited to the recharge received by the aquifer to avoid excessive drawdown (GEI, 1990). The maximum thickness of the unconsolidated sediments in the Mora Valley is estimated to be about 300 feet (Geohydrology Associates, 1989).

In this area, bedrock aquifers are generally too deep to be economically developed, have low yields, or contain water of low quality. Bedrock units that are sources of water supplies in the region include the Sandia Formation, the Santa Rosa Sandstone, and the Dakota Sandstone (Mercer et al., 1970). However, the Santa Rosa and Dakota Sandstones are generally tightly cemented with low yields in this area (Mercer and Lappala, 1972). The Taylor well field, which is used as a supplemental water supply for the City of Las Vegas to the south of this area, obtains water from sandstone units including the Glorieta and Santa Rosa Sandstones; faulting and fracturing within those units is responsible for the relatively high well yields. Faults have been mapped in the Mora region, and with further hydrologic investigation it may be possible to identify fractured bedrock aquifers with good quality water, reasonably high yields, and at economically accessible depths. However, at this point there has been insufficient investigation to accurately assess the potential of bedrock aquifers in western Mora County.

8.7.1.1.2 Las Vegas Region. Groundwater reserves in the Las Vegas region are found in alluvial and bedrock aquifers. The area covered by alluvium is small and the alluvial aquifers are tapped for domestic and stock uses. The alluvium may also act as a source of recharge for underlying bedrock aquifers. Bedrock aquifers in the area have been developed for water supplies. The Dakota Sandstone is the principal source of groundwater for shallow wells in the Las Vegas basin. Although the City of Las Vegas obtains the majority of its municipal water supply from the Gallinas River, reservoir storage and groundwater obtained from the Taylor well field are used as a backup during periods of drought. The Taylor well field taps into faulted and fractured portions of the middle Chinle Formation and the Glorieta and Santa Rosa Sandstones. Recharge to the rock units is primarily from surface water flowing across fractured outcrop and, to a lesser extent, from direct precipitation on outcrops.

Results from pumping tests conducted on the Taylor well field wells indicate that they are completed in aquifers that are bounded by impermeable hydrologic boundaries or are limited aquifers (Lazarus and Drakos, 1997). Groundwater reserves were evaluated about 2 miles south of the Taylor well field for a site that is geologically similar. Water quality was considered excellent, and estimated transmissivities were high. Well yields were found to increase to the east within the Chinle Formation. During periods of drought, when the Taylor well field wells would be most needed, aquifer recharge would be reduced and mining of groundwater may occur throughout the region.

Groundwater reserves to the east of Las Vegas have not been fully explored, especially within the undeclared portions of San Miguel County. However, development of groundwater reserves this area may be difficult due to financial and legal issues as well as hydrogeologic considerations.

8.7.1.1.3 Guadalupe County. Water-bearing units in the Santa Rosa area include the Chinle Formation, Santa Rosa Sandstone, Bernal Formation, San Andres Limestone, and Glorieta Sandstone. Productive zones generally coincide with fracturing and, in the case of the San Andres Limestone, the dissolution and collapse of evaporite beds in the aquifer (USGS, 1987).

Most of the domestic and irrigation wells in the vicinity of the City of Santa Rosa are less than 200 feet deep and are completed in the Triassic-age Santa Rosa Sandstone. Wells completed in the Santa Rosa Sandstone generally have low yields of less than 10 gpm, but can yield in excess of 100 gpm near the City of Santa Rosa. Yields from the Bernal Formation underlying the Santa Rosa Sandstone are also low, generally less than 5 gpm; localized yields of up to 90 gpm are most likely associated with fracture zones and solution channels. Underlying the Bernal Formation is the San Andres Limestone, with reported yields in excess of 400 gpm. The high yields of the San Andres Limestone are the result of higher-transmissivity zones created by dissolution of the formation (ASCG, 2004). The low yield of one well in the Taylor well field may be a result of the well not intersecting extensive fractures or cavernous zones known to be present in other wells in the well field. The deeper Glorieta Sandstone has yields generally less than 10 gpm.

Recharge to the bedrock aquifers occurs through seepage from rivers and lakes, precipitation on outcrops, and leakage from adjacent formations. Near the City of Santa Rosa, the San Andres-Glorieta Aquifer, the Bernal Formation, and the Santa Rosa Sandstone all contribute to flow in the Pecos River.

Another possibility for potential development in Guadalupe County is expansion of the Vaughn well field, which has generally good production in this area. However, because this well field is distant from population centers, it would likely be expensive to pipe the water to potential consumers.

8.7.1.1.4 Undeclared Portions of San Miguel and Guadalupe Counties. Undeclared groundwater reserves exist in portions of San Miguel and Guadalupe Counties to the east of Las Vegas and to the northeast of Santa Rosa. Only a few wells have been developed in this region, leaving the groundwater reserves virtually undeveloped. The middle Chinle Formation and the Glorieta and Santa Rosa Sandstones underlie the Dakota Sandstone to the east of Las Vegas; however, groundwater yields within these units depend on the extent of fractures, and water quality varies from area to area. Also, sustainable yields depend on recharge conditions. Thus, as the distance from known recharge areas to the west increases, yields may depend on available storage, and groundwater mining may occur depending on the rate of withdrawal. In addition to legal and financial feasibility studies, hydrologic investigations would be needed to determine the availability of groundwater reserves in the undeclared areas.

8.7.1.2 Well Field Design

Well field design involves the determination of effective well spacing to create cost-effective pumping and conveyance systems. The same design considerations apply to municipal and domestic wells, although efficient design is generally more critical for municipal wells due to their higher pumping rates. Determination of appropriate well spacing is primarily dependent upon the transmissivity and storage coefficient of the aquifer and the locations, pumping rates, and depths of the wells.

Hantush (1964) discusses well field design in terms of interference between pumping wells. When a well pumps water from an aquifer, the aquifer material near the well is dewatered (or depressured) and a cone of depression forms around the well. Well interference occurs when the cones of depression caused by multiple wells overlap. This condition results in more drawdown than would occur where only one well (and one cone of depression) is present.

When well interference occurs, the water levels drop and additional pumping capacity is needed to maintain yield. Wells should be spaced far enough apart so that the effects of interference are minimal; however, if the wells are too far apart, conveyance and pumping system costs may be prohibitive. In practice, a certain amount of interference is usually accepted to maintain reasonable short-term costs for infrastructure.

Efficient well field design will result in smaller drawdowns over larger regions, which will minimize aquifer compaction and associated reduction in well capacity. If significant drawdowns persist sufficiently long, land subsidence and earth fissures are likely to occur.

As municipalities expand their well fields, their water departments would expand their management duties to include the new well field. As the number of domestic wells increases, especially in those areas of the planning region with growing populations, problems such as excessive well interference, localized drawdown, or the drying up of older, shallower wells may occur. Some form of collective management is needed to prevent, or at least minimize, these occurrences.

One alternative to having homeowners drill individual wells is the formation of community or mutual domestic water associations to manage small water systems that serve 15 households or less. NMED defines a community water system as a "public water supply system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents" (20 NMAC 7.1). Because much of the planning region is rural, additional small community water systems could help to pool resources to develop and manage groundwater resources. Community systems are required to test water quality periodically, which will increase costs but also will provide protection from potential exposure to contamination. An added benefit of this approach is that water use can be more easily quantified (e.g., metered) through such systems, and metering will lead to more accurate data for long-range planning decisions.

8.7.1.3 Well Design and Construction

Well construction would be needed for development of new well fields. Design of supply wells should follow the procedures and standards presented by the U.S. EPA (1975) and the AWWA (1997). Roscoe Moss Company (1990) and Driscoll (1986) also present standard practices of well design and construction. Specific well designs should be developed based on the hydrogeologic conditions of the well field, the water quality of the area, the required demand, and cost constraints.

8.7.1.4 Well Testing

When a well is installed, yield and water quality tests are performed. Well yield is determined through a series of pumping tests over a given amount of time. The data collected are used to calculate pumping rates and project drawdown in the well and in the surrounding aquifer. These calculations are also used to determine well interference within the well field.

Water quality testing must be completed before the water is distributed to consumers. Expansion of domestic well fields may raise water quality issues in areas where septic tanks are relied on for domestic wastewater treatment. TDS, nitrate, and fluoride in groundwater may be of concern in certain areas. Higher TDS is found in some bedrock aquifers and generally reflects longer residence times and increased distance from the recharge area. Lazarus and Drakos (1997) state that the Glorieta Sandstone generally produces good-quality water. However, degradation of water quality in the Pecos River between Anton Chico and Puerto de Luna has been attributed to the inflow of lower-quality groundwater from the San Andres-Glorieta Aquifer (ASCG, 2004). Groundwater from wells in the Mora River drainage is generally hard to very hard, with TDS higher in bedrock wells compared to alluvial wells. High fluoride concentrations have also been detected at some locations in the Mora River drainage (Mercer and Lappala, 1972).

8.7.1.5 Water Distribution

Water distribution consists of conveyance systems to deliver water from the point of diversion (wells) to treatment facilities, if needed, and then to the consumer. Generally, conveyance infrastructure includes (1) the pumping system in the well or pump station to pressurize the water and deliver it to the storage tanks, and (2) the conveyance system that transports the stored water to users. Treatment, if needed, usually includes disinfection by chlorination and possibly filtering to remove unwanted constituents such as dissolved solids, arsenic, sulfate, or uranium.

8.7.1.6 Legal Constraints to Groundwater Development

In addition to the technical issues, the availability of water rights is a key component of evaluating the potential for groundwater development in the region. As discussed in Section 4, New Mexico is required under the Pecos Compact to deliver water to Texas, and the Canadian and Pecos River Basins are fully appropriated and no new water rights are available. Development of groundwater resources in these areas would require an analysis of the groundwater pumping impacts on the Canadian or Pecos Rivers or their tributaries, and surface water rights would have to be transferred to offset pumping impacts. Each transfer must be evaluated based on potential impairment and effects on public welfare or conservation.

In the undeclared portion of the region, there are no legal or water rights restrictions on groundwater development.

8.7.2 Hydrological Impacts

Development of additional groundwater in the region would potentially provide more water to meet the future needs of the region. However, most of the groundwater in the region is hydraulically connected to surface water supplies. Development of such groundwater supplies would constitute a shift from surface water to groundwater use, rather than providing an entirely new water supply. The shift to groundwater could provide a more reliable supply in times of drought, but an evaluation of the impacts of groundwater pumping during drought on senior water rights holders would be needed before a supply could be developed.

Extensive additional groundwater development could result in water level declines, an indication that groundwater is being mined at those locations. Reduction in spring flows may also be an indicator that groundwater mining is occurring. Localized declines in aquifer water levels can result in aquifer compaction and loss of aquifer storage capacity, which in turn can result in a permanent decline in yield. Drought conditions reduce recharge to aquifers and can either increase the effects of mining on the aquifer, leading to an accelerated decline in water levels, or change an aquifer that was previously in equilibrium (i.e., recharge equals or exceeds pumping) to one that is being mined (i.e., pumping exceeds recharge).

Closely spaced wells may cause well interference that exacerbates water level declines. Efforts to reduce well interference have been implemented in other basins. These efforts include pumping restrictions based on allowable rates of drawdown in the aquifer and the regulation of domestic well spacing through requirements for minimum lot sizes and water availability beneath the lots.

For short-term supplies, as in the case of a drought, groundwater storage may be adequate, depending on the extent of fracturing within the sandstone units. Groundwater recharge is generally low and has been estimated in the range of 0.2 to 2 in/yr in the mountain foothill areas in the vicinity of the Taylor well field near the City of Las Vegas (Molzen-Corbin and Lee Wilson, 1985). Risser (1987) estimated recharge of 0.18 to 0.3 in/yr near Santa Rosa. Recharge may decrease to the east with increased distance from the mountains. Additional information on recharge in the region is presented in Section 5.3.3.

8.7.3 Financial Feasibility

The costs for developing water supplies include the hydrologic investigations and models that may be necessary to obtain approval from the OSE for water right transfers, as well as the costs of feasibility studies, wells, and conveyance structures.

Hydrologic investigations are necessary to identify the exact location of favorable groundwater resources and sites for wells or well fields. To obtain the site-specific data required to evaluate the feasibility of a groundwater appropriation, applicants may need to examine existing well logs, interview well owners, and drill test wells and collect water quality samples in selected locations. Due to the scarcity of data in much of the Mora-San Miguel-Guadalupe Region, a significant test well drilling program will likely be required prior to development of additional resources.

The applicants will be required to prove that the appropriation would not impair existing rights or New Mexico's delivery obligations under the Pecos River Compact. Depending on local conditions, a study may be limited to a simple analytical model or may entail a complex numerical model. Costs for such models can range from $50,000 to $200,000.

Increasing infrastructure is fairly straightforward, and financing is available for municipalities and community water associations through, for example, community development block grants or the New Mexico Finance Authority. Another option is to pass the costs on to the consumer. Domestic well owners must seek their own financing to pay for a new well.

The magnitude of water well costs varies with the quantity of water that an owner expects to pump from a well. Municipalities in the planning region may need relatively deep wells capable of producing 400 to 500 gpm. A large municipal well requires the services of an experienced hydrologist or engineer capable of designing, overseeing construction of, and testing the new well. Costs for municipal water wells in the alluvial valley of the planning region, including estimates for submersible pumps and a well house, are shown in Table 8-13.

A community well should yield between 50 and 150 gpm and will not need to be as deep as a municipal well. A community would benefit from the services of an experienced hydrologist or engineer for well design and construction oversight. A local driller may also provide insight for well design based on local experience. Costs for community wells, including estimates for submersible pumps and a modest well house, are shown in Table 8-14.

Domestic wells are generally designed and installed by a local well driller. Most domestic wells are intended to produce less than 50 gpm. Table 8-15 presents estimated costs for installation of domestic supply wells.

If a pipeline is needed to bring a new water supply into use, engineering and environmental studies will be required. For example, if the City of Las Vegas determined that groundwater could be developed from the undeclared groundwater basin east of the City, a pipeline would have to be constructed to deliver the water to the City. The cost for this would be considerable. Preliminary feasibility studies alone could cost from $200,000 to $1,000,000, and construction costs would be significantly higher.

8.7.4 Environmental Impacts

Groundwater pumping near perennial stream systems may lower the local water table and impact the flows of streams and springs. This condition may cause perennial streams to become ephemeral and local springs to dry up. The implications are not only aesthetic, but may impact natural habitat and threatened or endangered species and the designated uses of streams and springs. However, in parts of the region that are considerable distances from perennial stream systems, pumping impacts to streams and associated environmental impacts should be negligible.

Table 8-13. Cost Estimate for Construction of Municipal Water Supply Wells in the Mora-San Miguel-Guadalupe Water Planning Region

Item	Unit	Unit Cost ($)	Quantity	Total ($)
Well Installation [a]				
Mobilization	Lump sum	90,000	1	90,000
Drill pilot hole, 8-inch	Linear feet	45	500	22,500
Geophysical logs (electric logs)	Lump sum	9,500	1	9,500
Ream pilot hole for surface casing, 30-inch	Feet	125	80	10,000
Conductor casing, 30-inch installed	Feet	140	80	11,200
Ream pilot hole, 26-inch	Feet	50	420	21,000
Blank casing, 16-inch, in place	Feet	65	300	19,500
Casing, perforated, 16-inch, in place	Feet	100	200	20,000
Gravel feed line, in place	Feet	8	300	2,400
Gauge line, in place	Feet	6	300	1,800
Gravel, in place	Cubic yard	300	40	12,000
Cement annular seal, in place	Cubic yard	220	35	7,700
Development by zoned air-lift pumping and swabbing	Hour	225	72	16,200
Furnish, install, and remove test pump	Lump sum	10,000	1	10,000
Development and test pumping	Hour	175	100	17,500
Video survey	Lump sum	800	1	800
Disinfection	Each	500	1	500
Water quality testing	Lump sum	2,000	1	2,000
Design and oversight [b]	Lump sum	27,500	1	27,500
			Well installation subtotal	302,060
Well House and Pumping Equipment				
Pumping equipment and controls, installed	Lump sum	110,000 – 150,000	1	110,000 – 150,000
Disinfection equipment, installed	Lump sum	40,000	1	40,000
Piping and valves, installed	Lump sum	35,000	1	35,000
Well house with climate control	Square foot	100	625	62,500
Well house foundation	Square foot	15	625	9,375
Utilities (electrical and alternative power supply)	Lump sum	20,000 – 75,000	1	20,000 – 75,000
Site fencing	Lump sum	7,500	1	7,500
Grading and drainage	Lump sum	12,500	1	12,500
Energy dissipater	Lump sum	25,000	1	25,000
Engineering design, specifications, and oversight	Lump sum	40,000	1	30,000 – 40,000
			Well house and pumping equipment subtotal	351,875 – 456,875
			Total	653,935 – 758,935

[a] Quantities and costs assume that most municipal wells will be drilled to approximately 500 feet.
[b] Design and oversight includes well design, permitting, geological logging, and construction oversight.

Table 8-14. Cost Estimate for Construction of Community Wells
Mora-San Miguel-Guadalupe Water Planning Region

Item	Unit	Unit Cost ($)	Quantity	Total ($)
Mobilization and demobilization	Lump sum	15,000	1	15,000
Drill 7 7/8-inch hole	Linear feet	30	385	11,550
Geophysical logging	Lump sum	3,500	1	3,500
Casing, blank, 6 5/8-inch, Roscoe Moss, in place	Linear feet	6	320	1,984
Casing, perforated, 6 5/8-inch, 0.188-inch wall, in place	Linear feet	37	60	2,205
Cement annular seal, in place	Linear feet	9	80	720
Development, air lift	Hours	180	8	1,440
Well disinfection	Lump sum	750	1	750
Goulds 70J10, 10-HP pump and motor	Lump sum	3,240	1	3,240
Install pump	Lump sum	1,500	1	1,500
Column pipe for pump, 3-inch, low carbon steel, galvanized	Linear feet	6	300	1,800
Pitless adaptor, spool type	Lump sum	600	1	600
Pump panel/starter box, single phase	Lump sum	670	1	670
Pressure tank, 119-gallon	Lump sum	800	2	1,600
Development and test pumping	Hours	85	30	2,550
Water quality testing	Lump sum	1,500	1	1,500
Well house	Lump sum	4,000	1	4,000
Well house pad	Lump sum	2,000	1	2,000
			Total	56,600

Table 8-15. Cost Estimate for Construction of Domestic Wells
Mora-San Miguel-Guadalupe Water Planning Region

Item	Unit	Unit Cost ($)	Quantity	Total ($)
Well installation: 8-inch boring, 6-inch PVC well, total depth of 350 feet [a]	Lump sum	5,250	1	5,250
Submersible pump: 3-HP pump and motor, installed	Lump sum	1,600	1	1,600
Pitless adaptor, spool type	Lump sum	600	1	600
Pump panel/starter box, single phase	Lump sum	670	1	670
Pressure tank, 119-gallon	Lump sum	800	1	800
Water quality testing	Lump sum	200	1	200
			Total	9,120

[a] Well installation includes mobilization, drilling, casing, screen, annular seal, gravel pack, and development.

The installation of new wells may result in surface impacts, particularly if new roads are constructed. The construction of pipelines to convey water could also have environmental implications.

As with any construction project, ground will be disturbed. Well drill rigs must have access or easement with enough room for support trucks and equipment. Any projects that include federal funding must conform to NEPA requirements to consider the environmental impacts of the action; such compliance may involve environmental impact statements and endangered species evaluations.

All wells must be sited to avoid contaminated groundwater or surface conditions. Wells must be properly constructed to minimize the potential for surface contaminants traveling through the borehole to the water table. Sites should be located such that wells are protected from flooding, surface contamination, and vandalism.

8.7.5 Political Feasibility and Social/Cultural Impacts

If technical, legal, and financial issues are resolved and additional groundwater development occurs, there should be positive social/cultural benefits in the region. The key benefit would be reduced drought vulnerability resulting from increased regional reliance on groundwater. Political feasibility is tied largely to potential impairment of existing well owners. It is also tied to financing, and this alternative will be most feasible if funding is obtained that can help minimize local costs for groundwater exploration and development.

8.8 Development of Additional Storage

With surface water providing over 96 percent of its water supply, the Mora-San Miguel-Guadalupe Region is vulnerable to supply variability, both seasonally and annually. Storage of surface water helps to mitigate the impacts of this variability. The region’s surface water supply is provided by two stream systems and their tributaries: the Pecos and the Canadian Rivers. Within the planning region, the Pecos River is dammed by the Santa Rosa Dam and the Fort Sumner Dam, which impound water for use primarily outside the planning region. The Bradner and Peterson Dams impound water for the City of Las Vegas on a tributary to the Gallinas River, which flows to the Pecos River. Storrie Lake is a privately owned reservoir that stores water from the Gallinas River for irrigation, wildlife, and recreation, with 500 acre-feet of storage leased to the City of Las Vegas. Conchas Dam, built in 1939, impounds Canadian River water for use outside of the planning region. Lake Isabel holds water on the Sapello River, a tributary to the Canadian River. Numerous other small lakes exist in the planning region, as summarized in Section 5.2.2.

This alternative discusses the feasibility, costs, and other impacts associated with increasing surface water storage through four methods:

- Aquifer storage and recovery (ASR)
- Raising the height of existing reservoirs
- Building new reservoirs
- Removing sediment from existing reservoirs

It is most important to understand that new water is not created by increasing the amount of water stored on a stream system and that others may have claim to the water. Although the Pecos River Compact does not prohibit additional storage, New Mexico cannot "deplete by man's activities the flow of the Pecos River at the New Mexico-Texas state line below an amount which will give Texas a quantity of water equivalent to that available to Texas under the 1947 condition" (NMSA 1978 §§ 72-15-19). Since the Pecos river stream system is fully appropriated, additional rights for storage would have to be (1) transferred by permit from another use or (2) obtained by appropriating currently unappropriated flood flows, if they exist.

The Pecos River Compact allows New Mexico to construct additional reservoir storage for unappropriated flood flows and salvaged water, but only with the approval of the Compact Commission. The compact also allows New Mexico to construct additional storage capacity for the purpose of making "more efficient use" of water apportioned by the compact, but this action would also require the approval of the Compact Commission. Therefore, any increase in storage on the Pecos River System would have to be approved by the State Engineer, the State of Texas, the Carlsbad Irrigation District, and the USBR or USACE.

The Canadian River Compact provides free and unrestricted "use" of water upstream of Conchas Reservoir. However, the assumption at the time the Compact was written, although it is not stated in the Compact, is that no new depletions would occur (*Oklahoma v. New Mexico*, 501 U.S. 221 (1991)). Therefore, a water right with a priority date senior to the 1951 date of the Compact (NMSA 72-15-2) can be stored as long as downstream senior water rights holders are not impaired. Impairment would be likely on the Canadian River: the Arch Hurley Irrigation District (organized in 1941) and supplied by Conchas Reservoir, is chronically short of water and would be very opposed to any new storage upstream. Texas and Oklahoma would also have to agree to increase the amount of storage on the Canadian River.

8.8.1 Technical Feasibility

The following sections discuss issues related to the technical feasibility of each of the four options under this alternative.

8.8.1.1 Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) involves recharge to and recovery of water from an aquifer, that is, both artificial recharge of the aquifer and recovery of the water for subsequent use.

ASR is being used increasingly in the U.S. to help manage water resources, particularly in the arid Southwest. For example, more than 20 full-scale artificial recharge projects are currently operating in the vicinity of Phoenix, Arizona, with several of these having storage capacities in excess of 100,000 acre-feet (Unangst et al., 1999). Source water for some of these projects is surface water derived from the Colorado River; other projects recharge treated wastewater effluent. In New Mexico, the City of Alamogordo developed an ASR pilot study in which 500 gpm of excess surface springtime water flows was injected into an existing well for a period of about 30 days during 1996.

Potential benefits of ASR and artificial recharge include:

- Seasonal and long-term storage of excess surface water
- Minimization of surface storage costs

- Method of accommodating supply and demand peaks
- Disposal and storage of excess stormwater
- Disposal of treated wastewater effluent (zero discharge)
- Replenishment of groundwater supply
- Improved water quality (soil-aquifer treatment)
- Minimization of evaporative water losses (vs. surface storage)
- Opportunity to obtain return flow credits
- Reduction of land subsidence rates

Because existing water/water rights must be used for ASR, new water is not created to meet growing demand. ASR will, however, provide a mechanism for reusing effluent or storing other water rights when surface water rights and supply exceed current demand.

The technical feasibility of ASR within the study area depends primarily on (1) locating a suitable water source and (2) identifying a suitable recharge site. The planning region includes many areas where suitable hydrogeologic conditions exist to implement ASR. In particular, arroyos and stream channels containing thick sequences of coarse-grained alluvium are ideal candidates. Site-specific hydrogeologic studies would be required within a given sub-basin to identify the preferred sites.

The City of Las Vegas, New Mexico, is evaluating the potential for ASR in the Taylor well field. Currently about 30 to 50 percent of the City's water stored in lakes is lost to evaporation (JSAI, 2004). The City's Taylor well field has experienced declining yields due to long-term drawdown effects. For instance, water levels have dropped 92 feet over a 40-year period at the Taylor well field (JSAI, 2004). Injecting treated surface water into the aquifer would increase the capacity of the well field, and the City could conserve water that might otherwise be lost to evaporation if stored as surface water. A pilot study will be conducted for the City through funds provided by the Governor's Water Innovation Fund.

Assuming that a suitable water source is available, the technical feasibility of ASR depends largely on hydrogeologic conditions underlying the area of interest. In most situations, pilot testing of a small-scale recharge facility is required to ensure that the chosen design (e.g., infiltration basin) will work at the chosen site and to provide information necessary for developing a full-scale system. Pilot testing also provides insurance against “fatal flaws” in the site conceptual model and can provide useful information regarding hydraulic capacities, water table responses, water travel times, and water quality changes that may occur in the vadose (unsaturated) zone.

The Ground Water Storage and Recovery Act (NMSA 1978, §72-5A-2) (Act), provides the legal mechanism for ASR. In enacting the Act, the Legislature specifically found that the “conjunctive use and administration of both surface and ground waters are essential to the effective and efficient use of the state’s limited water supplies” and that groundwater recharge, storage, and recovery have the potential to reduce the rate of aquifer decline, promote conservation, serve public welfare, and lead to more effective use of water resources.

Storage of water under the Act would also have to comply with all requirements of New Mexico’s Underground Injection Control (UIC) Program, as implemented through the Water Quality Act (NMSA 1978, §74-6-1 *et seq.*) and the UIC regulations (20.6.2.5000 NMAC). The UIC regulations control discharges from UIC wells to protect groundwater that has an existing concentration of 10,000 mg/L or less of TDS. Pursuant to the UIC regulations, a groundwater discharge permit must be obtained from the NMED prior to use of a groundwater management injection well.

Artificial recharge facilities include infiltration basins (spreading basins), infiltration galleries (recharge trenches), vadose zone recharge wells (dry wells), and combination groundwater recharge/recovery wells (Bouwer, 1996).

- Infiltration basins, also know as spreading basins, are shallow ponds with leaky bottoms that are designed to maximize the downward infiltration of water. Where favorable geology exists, infiltration basins are perhaps the least costly means of recharging groundwater. Basins require (1) the presence of permeable soils or sediments at or near the land surface and (2) an unconfined aquifer beneath.

- Galleries or trenches for recharge purposes are typically excavated using a backhoe to depths of up to 15 or 20 feet below surface. The trench is backfilled with permeable coarse sand or fine gravel. Perforated or slotted pipe laid on top of the backfill in the trench allows the introduction of water along its length. Similar to infiltration basins, seepage trenches require the presence of permeable soil close to land surface, although trenches can be excavated deeper than basins, exposing more permeable sediments below the low-permeability clayey soils that can exist at the surface.

- Vadose zone recharge wells, also known as dry wells, are large-diameter wells completed above the water table that are designed to optimize infiltration of water. Recharge water is delivered to a vertical well screen or perforated pipe that permits water to enter permeable sediments within the vadose (unsaturated) zone. Well diameters of 3 or 4 feet are common, and well depths may be up to 150 or 200 feet. Thus, dry wells can be used where permeable sediments are not present at the shallower depths required for basins or trenches. Special drilling methods (e.g., bucket auger drilling) are used to drill the large-diameter holes without introduction of drilling muds, and the wells are backfilled with fine gravel.

- Groundwater recharge wells penetrate an aquifer and can be used either for injection or withdrawal of water (Pyne, 1998). Because of their greater depth, they are more expensive to install than any of the shallower technologies. It is possible, however, to convert inactive water supply wells to groundwater recharge wells, resulting in considerable cost savings.

8.8.1.2 Increase Height of Existing Reservoirs

Increasing the height of an existing reservoir is technically feasible where the geologic and topographic conditions allow for a stable abutment and minimize the surface area of the stored water as compared to the amount of water stored. For instance, the dam height of Storrie Lake could be raised, but because the area surrounding the existing lake is relatively flat, the dam would have to be very large, a nearby highway would need to be raised, and the evaporative losses would be enormous.

The *Mora-San Miguel Regional Water Plan, Phase II* (Romero, 1994) summarized the options associated with raising Bradner Dam. The first alternative proposed raising the maximum pool elevation from 6,772 to 6,786 feet by expanding the existing impoundments which would increase the storage capacity by 343 acre-feet. A second alternative involved increasing storage capacity by 593 acre-feet by raising the dam to 6,795 feet, the maximum allowable pool elevation that would not interrupt gravity flow of water into Peterson Dam. The third alternative proposed raising Bradner Dam to 6,800 feet and increasing storage capacity by 752 acre-feet, which would involve constructing a gravity bypass line around Peterson Dam.

8.8.1.3 Build New Reservoirs

Where there are ample supplies of surface water and favorable site conditions, new reservoirs (both large and small) can be constructed. Water storage can be seasonal (for annual needs such as irrigation) or multiyear (for drought cycle water supplies.) The “water cost” of storing water is incurred through surface water evaporation, associated evapotranspiration by vegetation, and seepage.

From an engineering standpoint, there are inevitable technological challenges to constructing new reservoirs, but few absolute barriers that cannot be overcome through investments of additional funds. The engineering barriers to any given dam site are dictated by geologic conditions such as the lack of stable abutments and footings for the dam, high seismic risk, or unfavorable geology in the reservoir area that would result in excessive seepage losses.

The City of Las Vegas examined the potential of Sebastian Canyon, north of Bradner and Peterson Dams, as a site for a new reservoir (Romero, 1994). A dam with a maximum pool elevation of 6,800 feet would have storage capacity of 1,614 acre-feet.

Construction of new reservoirs and major expansion of existing reservoirs would present the greatest legal hurdles of the four methods discussed here. Any increase in the amount of water already permitted to be stored would require a new permit from the OSE. If storage results in increased depletions, the party proposing to increase storage would have to transfer water rights to offset the new depletions or would have to obtain an OSE permit to appropriate water in the amount of the new depletions. To transfer (i.e., to change the point of diversion and/or place and/or purpose or use of) a water right, an applicant must show that the transfer (1) will not impair other water rights, (2) is not contrary to conservation, and (3) is not detrimental to public welfare (§§72-5-23, 72-12-7 NMSA 1978 (1997 Repl.)). Generally, the surface waters of the planning region are considered to be fully appropriated, and therefore the OSE is not likely to issue a permit to appropriate additional amounts of water, except perhaps, for potentially available flood flows.

Construction of dams is also regulated by the State Engineer (§72-5-32 NMSA 1978 (1997 Repl.)). Before constructing a dam, one must obtain a permit from the OSE (and meet the statutory criteria: not cause impairment of any existing water rights, not be detrimental to the public welfare, and not be contrary to the conservation of water) (§72-5-6 NMSA 1978 (1997 Repl.)). Dams that are exempted from OSE permitting include "erosion control structures whose maximum storage capacity does not exceed ten acre-feet and are constructed for the sole purpose of sediment control. An erosion control structure shall not impound surface water in any amount for fishing, fish propagation, recreation, or aesthetic purpose, which shall require a permit pursuant to Section 72-5-1 NMSA 1978" (NMSA 72-5-32). (Until 1997, no dams that were less than 10 feet in height and that impounded less than 10 acre-feet were subject to OSE regulation. In 1997, the legislature amended §72-5-32 NMSA to greatly restrict that exemption).

A new or expanded reservoir would require authorization from the affected landowner, which in most cases would be the federal government. In the national forests, dam construction and reservoir expansion or creation must comply with the NFMA (16 U.S.C. §1600, et seq.). In addition, other federal laws would apply: NEPA (42 U.S.C. §4321 et seq.), CWA (33 U.S.C. §1251 et seq.), ESA (16 U.S.C. §1531 et seq.), and possibly the National Historic Preservation Act (16 U.S.C. §470 et seq.).

Most of the constraints placed by these laws relate to process, studies, and planning that must be done before there can be any significant surface-disturbing work. There will, however, also be substantive constraints on how much earthmoving, logging, and road-building is allowed. NFMA places limits on the methods used and locations of this type of activity (e.g., limiting clear-cuts and similarly extreme methods of logging, prohibiting logging on very steep slopes, limiting logging adjacent to rivers). The ESA may limit these actions where species listed as threatened or endangered are located. The CWA applies because dams or dikes or any diversions that are constructed in arroyos or streams, which are considered "waters of the

United States," are subject to CWA jurisdiction and will require a permit from the USACE under §404 (33 U.S.C. §1344). The greater the land disturbance, the more onerous the permit conditions will be. In addition, the American Indian Religious Freedom Act and NFMA may limit land disturbance near sites of religious, cultural, or historical significance.

8.8.1.4 Remove Sediment

A reservoir's water capacity diminishes over time due to the entrapment of sediments. The reduction of water storage volume is dependent upon the age of the reservoir and the rate of sediment deposition. Effective water storage can be increased by removing sediments from the reservoir.

There are no technological barriers to removing sediment from a reservoir basin. Several methods of removal are possible:

- The water could be drained to expose the sediments, which would then be excavated using conventional heavy equipment. The sediment would be hauled away and disposed in an upland area. Access roads to the removal and disposal sites would likely have to be constructed.

- Dredging could be done "in the wet," that is, with water still in the reservoir.

- Sediments could be sluiced through the dam's outlet works. This method requires partial or complete drainage of the reservoir, followed by the release of large quantities of water at velocities high enough to transport the exposed sediment. A relatively small proportion of the total sediments in the reservoir basin would be moved by this method.

The drainage of a reservoir to facilitate the removal of sediments should be scheduled when the reservoir level is low, thereby reducing water losses. In some cases, sediment accumulation causes the storage capacity of a reservoir to decrease below the permitted storage amount. If dredging can be used to return the reservoir to its permitted capacity, no water rights permitting should be required. As a result, this option may be easier to implement than the other methods for increasing surface storage.

8.8.2 Hydrological Impacts

The following sections discuss the hydrological impacts of each of the four options under this alternative.

8.8.2.1 Aquifer Storage and Recovery

The effectiveness of ASR at other sites around the U.S. and the world is well documented. While ASR does not provide a new source of water, it is an effective means of storing large volumes of water underground for subsequent use at costs that are much less than the equivalent storage in surface reservoirs. The hydrologic impact of ASR is that evaporative losses are nearly eliminated. As discussed in Section 6, reservoir evaporation is the second highest consumptive use of water in the region; consequently, reductions in evaporation could significantly affect the regional water budget. Stormwater flood flows represent another potential water source for recharge of aquifers using ASR (Bouwer and Rice, 2001). Moreover, if permitting issues for the recharge of treated effluent can be resolved, ASR provides an inexpensive and effective means of "polishing" water quality.

8.8.2.2 Increase Height of Existing Reservoirs

The modification of existing reservoirs would be effective in increasing storage space to hold existing water rights, but would not create new water. The storage of additional water would be limited to those periods when spring runoff or precipitation events generated water in excess of current storage capacity, and when such storage would not negatively impact downstream water right users. Such conditions occur only periodically in this region, which is chronically short of water and often unable to fill existing reservoirs, as illustrated by the 25-year history of storage and inflow at Santa Rosa Lake (Section 8.9).

8.8.2.3 Build New Reservoirs

The construction of new reservoirs would be effective in increasing storage space to hold existing water rights, but would not create new water. The storage of additional water would be limited to those periods when spring runoff or precipitation events generated water in excess of current storage capacity and when such storage would not negatively impact downstream water rights users. As discussed above, such conditions occur only periodically in the region.

8.8.2.4 Remove Sediment

Sediment accumulations, particularly in smaller reservoirs, can significantly reduce the available storage capacity. For every acre-foot of sediment removed from a reservoir, there would be an acre-foot of additional water storage space. No estimates are available for the current sediment accumulations in the smaller reservoirs, such as Storrie Lake or Bradner or Peterson Reservoirs. However, Storrie Lake currently has sufficient storage capacity to hold spring runoff (Pacheco, 2005), and in most years streamflow is inadequate to take advantage of the existing storage space. Even so, during periodic flood flow conditions, additional storage space could be useful.

8.8.3 Financial Feasibility

The following sections discuss the financial implications of each of the four options under this alternative.

8.8.3.1 Aquifer Storage and Recovery

The cost to implement ASR will depend on many site-specific factors, including site hydrogeology and the water quality of the proposed influent. Infiltration basins are generally the least expensive option, followed by recharge trenches and vadose zone wells. Groundwater recharge wells are the most costly option.

Costs to implement ASR at a given location may include:

- Pilot testing costs
- Land acquisition costs
- Influent water pretreatment costs
- Environmental permitting costs
- Design and construction costs
- Operation and maintenance costs

The costs for pilot testing of the proposed technology at the site must be included in any ASR plan. Information gained from pilot testing can result in much larger savings during implementation of full-scale ASR. The cost for the ongoing pilot ASR project for the City of Las Vegas, New Mexico is $750,000.

Costs to obtain environmental permits from regulatory agencies can be significant for treated wastewater effluent because its use raises concerns over the potential for contamination of aquifers. Such projects must comply with the requirements of the New Mexico Underground Storage and Recovery Regulations and UIC regulations. Even if the water meets all drinking water standards, concerns persist over the possible presence of pharmaceutical compounds in the treated effluent and the need for reverse osmosis to remove them (Sedlak, 1999).

The design and construction costs for a system of infiltration basins may be better understood by considering three active projects in Arizona, as outlined in Table 8-16.

Table 8-16. Example Costs for Three Arizona Infiltration Basins

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	1,300,000	8,000,000	NA
Sweetwater [c]	4	14	14,000	500,000	1, 500,000	NA

[a] Does not include delivery pipeline, recovery wells, monitoring network, or O&M costs.
[b] Granite Reef Underground Storage Project (Lluria, 1999; Bouwer, 2002.)
[c] Central Aura Valley Storage and Recovery Project (CAVSARP) and Sweetwater Project information from Light, 1999.

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

8.8.3.2 Increase Height of Existing Reservoirs

Costs for raising the height of Bradner Dam, which currently serves the City of Las Vegas, have been updated for the three alternative configurations provided by Romero (1994). These costs are summarized in Table 8-17 and indexed to 2005 dollars. Also included in this table are the proposed costs by the USBR for raising the height of Santa Cruz Dam in Rio Arriba County and the actual costs for raising the height of McClure Dam on the Santa Fe River. The costs in each of these alternatives range from $2,300 to $10,000 per acre-foot.

Table 8-17. Estimated Costs to Raise Dam Heights

Alternative	Dam Height Increase (feet)	Storage Capacity Increase (acre-feet)	Cost ($, indexed to 2005 dollars)	
			Total	Unit (per acre-foot)
Bradner Alternative 1 [a]	14	343	1,550,000	4,500
Bradner Alternative 2 [a]	23	593	2,680,000	4,500
Bradner Alternative 3 [a]	28	752	5,400,000	7,100
Santa Cruz Dam Alt 1 [b]	13	1,310	13,050,000	10,000
Santa Cruz Dam Alt 2 [b]	23	2,600	14,500,000	5,600
McClure Dam [c]	--- [d]	500	1,100,000	2,300

Source:
[a] Romero, 1994
[b] Leutheuser et al., 2002
[c] Leutheuser et al., 2002; Bailey, 2002

[d] The spillway height was raised by 6.5 feet

8.8.3.3 Build New Reservoirs

Because the construction costs for a dam are determined by its specific site, it is impossible to estimate the costs of constructing new dams in unspecified areas. For example, the evaluation of a dam in Sebastian Canyon was estimated to cost $7.2 million, indexed to 2005 dollars (Romero, 1994). In contrast, the original construction costs of Nambe Falls Dam/ Reservoir and Heron Dam/Reservoir in Rio Arriba County, indexed to Year 2005 dollars, were about $34 million and $57 million, respectively (Leutheuser et al., 2002).

8.8.3.4 Remove Sediment

A feasibility study would have to be completed to review the inflow hydrology to any reservoir under consideration for sediment removal. The study would calculate project costs, identify and quantify the benefits of the increased water supply, evaluate funding sources, and identify related issues. Costs for a feasibility study would be in the neighborhood of $50,000 to $200,000, and the study would take about one year to complete.

Based upon a USBR study of the Santa Cruz Dam and Reservoir (outside the planning region in northern New Mexico), in Year 2000 dollars, sediment removal would cost about $14,500 per acre-foot (e.g., removal of 1,000 acre-feet of sediment would cost about $14.5 million). At the time the study was completed, the USBR determined that sediment removal was not a financially practical solution (USBR, 1983).

8.8.4 Environmental Impacts

The environmental impacts of each of the four options under this alternative are discussed below.

8.8.4.1 Aquifer Storage and Recovery

The environmental implications of ASR projects depend largely on the quality of the proposed influent water. Regulatory agencies are understandably much less concerned about clean water ASR projects, such as stormwater recharge, than about projects involving reuse or recharge of wastewater effluent. On the other hand, public perception of wastewater reuse is increasingly favorable, especially if the project does not involve "toilet to tap" connections. In this regard, ASR is quite attractive in that it offers the possibility that treated effluent will undergo some degree of cleansing and blending with natural groundwater in the subsurface prior to reuse (Bouwer, 1991, 1992). Two major 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, some public concerns may be raised about the prudence of blending treated wastewater with a limited supply of clean groundwater.

8.8.4.2 Increase Height of Existing Reservoirs

Raising the height of a dam and reservoir would inundate land that could contain protected habitats, historic communities, or highways. Increasing the amount of water in storage would affect downstream conditions by decreasing streamflow and impacting the river morphology, which may or may not be detrimental depending on the amount of additional water that is stored compared to the streamflow. If only flood flows are stored, the impacts may be negligible. If remaining small flows are stored, the stream may become ephemeral or temperatures may become too high to support existing aquatic life. The cost of mitigating adverse environmental impacts would be included in the construction and operation and maintenance costs.

8.8.4.3 Build New Reservoirs

A wide range of environmental issues are associated with the construction of a new dam. Beyond the immediate effects of the dam and reservoir on the environment, a new dam would affect downstream conditions such as hydrography, sediment, water temperature, water quality, and river morphology. The cost of mitigating adverse environmental impacts would be included in the construction and operation and maintenance costs.

8.8.4.4 Remove Sediment

There are numerous environmental considerations associated with the mechanical removal of sediments from reservoirs. These include, but are not limited to, mobilization of potential contaminants, physical destruction of riparian vegetation and habitats, construction of access and haul roads, and environmental impacts to disposal sites.

If removed sediment were sluiced through the dam's outlet works, the impacts of the increased sediment load on the downstream waterway would be significant and would likely prove to be unacceptable. A Section 404 permit (CWA) would need to be obtained before a sediment removal project could be completed.

8.8.5 Political Feasibility and Social/Cultural Impacts

Each of the four options under this alternative has associated social and cultural impacts and other characteristics that may affect the political feasibility of implementation. These issues are discussed below, by option.

8.8.5.1 Aquifer Storage and Recovery

This alternative would increase the water available to more populous urban areas. An important indirect socioeconomic and cultural benefit would be a decreased desire for and pressure on upstream rural and agricultural surface water rights to support municipal and industrial needs. In addition, an increase in available water would probably reduce costs for all water users. On the negative side, less streamflow could be available for downstream water right owners because of reduced stormwater spikes or discharge from wastewater treatment facilities.

8.8.5.2 Increase Height of Existing Reservoirs

Increasing allowable reservoir storage could negatively impact downstream water users by diverting water that would otherwise have flowed downstream. Also, proposed increases to the storage capacity of an existing reservoir would likely encounter public resistance if the surface area covered by the reservoir were to increase significantly.

8.8.5.3 Build New Reservoirs

Constructing new reservoirs could impact downstream water users by creating a larger water surface area that would increase evaporative losses and reduce downstream flow. Local communities are likely to resist the building of a new reservoir unless they reap a direct benefit in the form of more water.

With growing environmental sensibilities among the public, new large reservoirs would likely encounter significant public opinion hurdles and probably strident opposition. In addition, public financing may be difficult to obtain, and the cost of new reservoirs would likely be passed on to consumers, increasing the cost of water.

8.8.5.4 Remove Sediment

Social and cultural impacts from sediment removal would be negligible, but the feasibility of obtaining political support for funding this activity may be difficult.

8.9 Creation of Permanent Pool in Santa Rosa Reservoir

The City of Santa Rosa and Guadalupe County derive considerable economic benefit from recreation. The Santa Rosa Reservoir, on the Pecos River, is a major recreational area; ensuring sufficient water in the reservoir to allow for recreation throughout the summer would provide increased benefits the local economy. The objective of this alternative is to determine if water rights held or purchased by parties within the planning region could be transferred to storage rights in Santa Rosa Reservoir, thus increasing the pool of water available for recreation.

8.9.1 Technical Feasibility

Currently, the Carlsbad Irrigation District (CID) owns all storage rights for the four existing reservoirs on the Pecos River: Santa Rosa, Fort Sumner, Brantley, and Avalon (Rhoton, 2004).

The Santa Rosa Reservoir has a total storage capacity of about 718,000 acre-feet. Since the reservoir began operating in late 1983, its average annual reservoir storage has reached a maximum of about 120,000 acre-feet. Thus, the Santa Rosa Reservoir has used only 20 percent or less of its storage capacity during the past 20 years (Figure 8-6). This indicates that average inflows into the reservoir are not sufficient to greatly increase the amount of storage, though in some years increases would be technically feasible.

The most significant concern related to implementation of this alternative stems from the legal restrictions imposed by the Pecos River Compact (NMSA 1978 §§ 72-15-19). In 1948, New Mexico and Texas entered into this agreement, which was ratified by Congress and the legislatures of New Mexico and Texas (Section 4.5.1). The Compact primarily apportions the waters of the Pecos River between the two states, and to a lesser degree provides for allowable storage on the river. Although the Pecos River Compact does not *prohibit* additional storage, New Mexico cannot "deplete by man's activities the flow of the Pecos River at the New Mexico-Texas state line below an amount which will give Texas a quantity of water equivalent to that available to Texas under the 1947 condition." Since the Pecos River stream system is fully appropriated, additional rights for storage would have to be (1) transferred by permit from another use or (2) obtained by appropriating unappropriated flood flows, if they exist. On the Pecos River system, any increased storage would have to be approved by the OSE, the State of Texas, the CID, and the USBR or USACE. The implications of increased storage on senior water rights would have to be considered, and the River Master Manual would have to be modified to adjust the accounting to the 1947 condition. These complexities indicate that increasing storage rights would be very difficult, if not impossible, to successfully implement.

Another, potentially more feasible, option would be for parties interested in creating a permanent pool of water to negotiate with the CID to determine if storage of water in Santa Rosa Reservoir until later in the irrigation season could be arranged on a voluntary basis, at least in some cases. If increased recreation is the objective, it may be possible to retain more water upstream in Santa Rosa Reservoir until such time that the CID needs the water. Evaporative losses would be lower if water were stored in Santa Rosa rather than Brantley Reservoir.

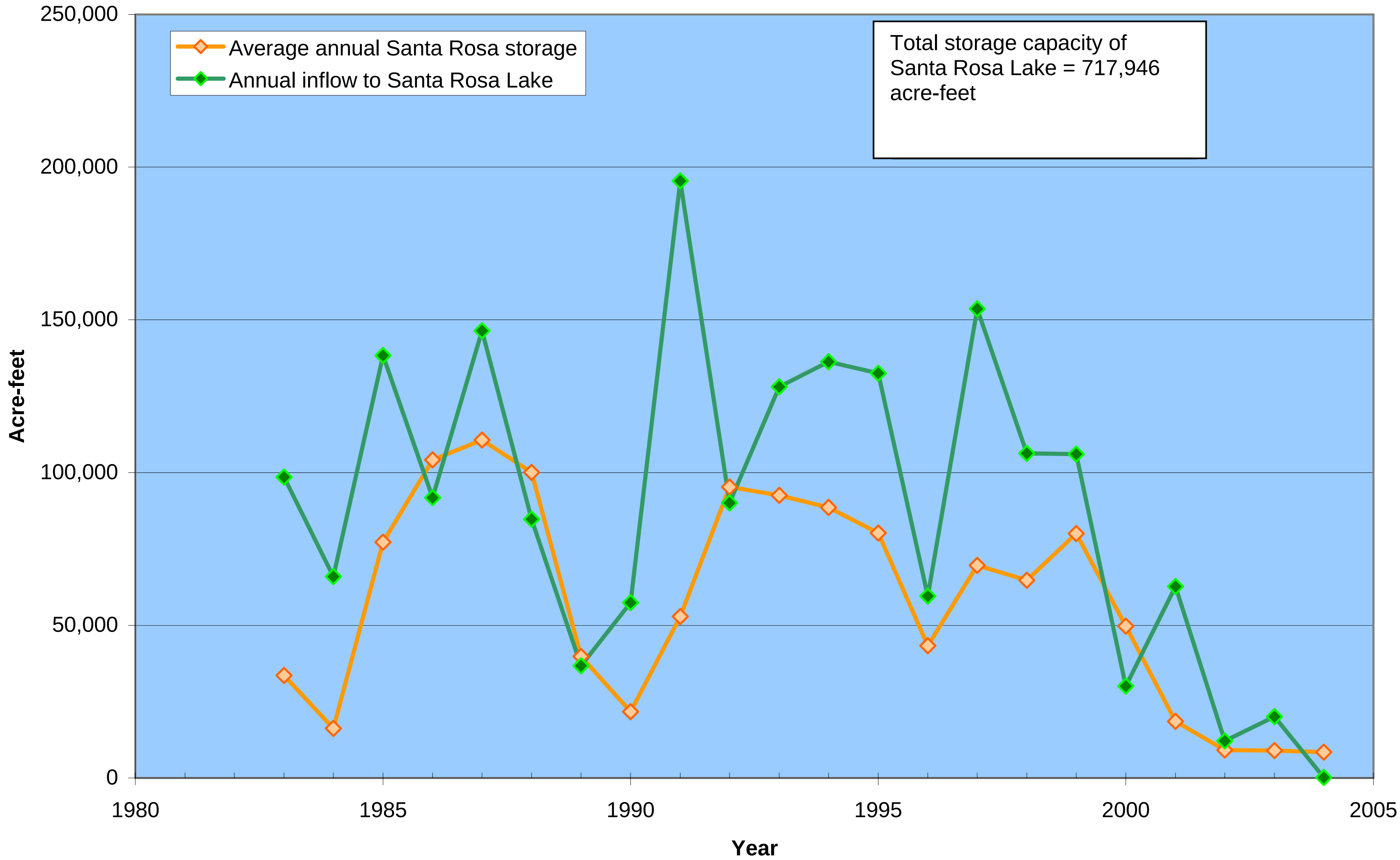

Figure 8-6

Daniel B. Stephens & Associates, Inc.

7/1/05

MORA-SAN MIGUEL-GUADALUPE WATER PLANNING REGION

Annual Santa Rosa Lake Storage and Inflow

8.9.2 Hydrological Impacts

The hydrologic impacts from creating a permanent storage pool in Santa Rosa Reservoir would depend on what rights were transferred to storage and the priority date(s) of those rights. If water rights were transferred from upstream of Santa Rosa Reservoir, the hydrologic impact would be negligible downstream. However, if rights were transferred from a downstream area—for example, from below Roswell—the result would be less water in the stream below Santa Rosa Reservoir. If CID water needed downstream was held in the Santa Rosa Reservoir for a longer period of time, there would be decreased evaporative losses. Specific proposals to modify the flow regime could be evaluated using the River Ware model developed by the ISC, USACE, and USBR under the NEPA operating procedures.

8.9.3 Financial Feasibility

The costs to implement this alternative would depend on the value of the water rights and/or terms and conditions negotiated with the CID. Legal fees could be significant if modifications to the compact were required. This considerable legal expense could be indirectly offset by increased local economic benefits from greater recreational opportunities. Even so, local communities would need to contribute very significant financial resources to accomplish the required legal work.

8.9.4 Environmental Impacts

As discussed in Section 8.9.2, if water that is currently consumptively used upstream of the reservoir were transferred to storage, there would likely be negligible effects on the stream system. However, increasing the amount of water in storage with water that otherwise would have flowed downstream of the reservoir could decrease the downstream streamflow and impact the river morphology. Such impacts may or may not be detrimental, depending on the amount of additional water that is stored compared to the overall streamflow. If only flood flows are stored, the impacts may be negligible. If remaining small flows are stored, the stream may become ephemeral or temperatures may become too high to support existing aquatic life. If the amount of storage does not change, but the timing is altered to hold water upstream in Santa

Rosa Reservoir until later in the irrigation season, no significant negative environmental impacts would be expected.

Of particular concern for any flow regime modification is its potential impact on the Pecos bluntnose shiner, listed as threatened on February 20, 1987. Currently, federal and state agencies are developing an operating procedure through the NEPA process for the Carlsbad Project Water Operations and Water Supply Conservation Environmental Impact Statement (EIS) (Myers and Kehmeier, 2004). Any impacts to the two designated critical habitat reaches for the Pecos bluntnose shiner would likely be opposed. These designated reaches are the upper critical reach, located south of Fort Sumner and north of Roswell, and the lower critical reach, between Hagerman and Artesia. The timing of releases from the reservoirs has presented a conflict between the needs of CID and the riparian habitat. In the past, CID preferred to deliver water in large quantities to minimize evaporative losses; however, this practice resulted in periods when the river was dry. Current operational policy involves a gradual ramping up and down of release volumes and an increased number of releases to minimize dry periods (Rhoton, 2004).

8.9.5 Political Feasibility and Social/Cultural Impacts

Increased opportunities for recreation within the region should provide a positive benefit for residents of the region. Because of the very low volumes of water in storage in recent times, however, creating a permanent pool of water for recreation may not be compatible with competing interests on the stream. For instance, in September of 2003 the total amount of stored water in all four of the Pecos River reservoirs was 10,000 acre-feet, which is less than 2 percent of the storage capacity of Santa Rosa Reservoir. During dry periods, the water is simply not available for storage. In wetter years, storage in Santa Rosa Reservoir may be politically feasible.

The social and cultural impacts of retaining a permanent pool of water in Santa Rosa Reservoir would be increased recreational use and related recreation-dependent business. However, businesses may have a difficult time adjusting to the ups and downs of the recreational market.

8.10 Water Rights Protection

This section discusses several different approaches for encouraging water rights holders in Mora, San Miguel, and Guadalupe Counties to protect regional water rights and resist pressure to sell to out-of-region buyers. The tools discussed under this alternative can be used during water rights transactions or as part of land use management and planning. Water rights transactions tools are mechanisms to influence whether a transfer occurs or, in cases where a water transfer is inevitable, actions to offset the negative impacts from water being transferred out of agriculture and/or out of the region. A land use approach is any effort to keep land in agriculture as a means of keeping agricultural water rights in regional agricultural use

In the western U.S., most water rights have been used in the agricultural sector and most new water for municipal use has been transferred out of agriculture (Tarlock, 1999). Agriculture represents the largest use of water in the Mora-San Miguel-Guadalupe Region (excluding reservoir evaporation) and would therefore be a potential source of water for new uses as demand increases. Farming can be a low–profit occupation, and farmers experiencing financial difficulties often have few assets other than their land and the associated water rights. In a market where water rights have a high dollar value, it may be very difficult for these farmers to turn down a purchase offer. This alternative focuses on ways to counterbalance such pressures.

The two most important tools for the planning region are the laws recently passed giving acéquias and community ditches broader water management authority with respect to water transfers and water banking. These two laws, as well as other potential mechanisms for protecting water rights, are discussed in Sections 8.10.1 through 8.10.5.

8.10.1 Technical Feasibility

Potential avenues to protect water rights and keep them within the region include the following:

- Acéquia bylaws that implement NMSA 73-3-4.1
- Acéquia water banking (NMSA 73-2-55.1)

- Efforts to influence water rights transactions
- Area-of-origin protections
- Conservation easements
- Transfer of development rights

These approaches are discussed in the following sections.

8.10.1.1 Acéquia Bylaws that Implement NMSA 73-4.1

Until recently, acéquias (and community ditches) did not have the legal authority to block transfers of water from land located within acéquia boundaries. As a result, individuals within an acéquia could sell their water rights, which in some cases could cause difficulties for the rest of the community. The New Mexico legislature created new powers for acéquias in 2003. Acéquias and community ditches may now pass bylaws requiring that transfers or changes in location of water rights sought by individual water users on a ditch or acéquia be subject to approval by the acéquia or ditch commissioners. The commissioners can deny such transfers if they find that the change would be "detrimental to the acéquia or community ditch or its members" (NMSA 1978, § 73-3-4.1). The statute provides no definition of "detrimental" and it appears that the commissioners have discretion to determine the meaning of this term on a case-by-case basis. Further, the OSE is prohibited from approving applications for changes or transfers of water rights in acéquias and community ditch associations if the applicant has not complied with existing rules of the acéquia or association (NMSA 1978, § 72-5-24.1).

8.10.1.2 Acéquia Water Banking NMSA 73-2-55.1

In recently passed legislation, acéquias and community ditches gained the authority to establish a water bank "for the purpose of temporarily reallocating water without change of purpose or use or point of diversion to augment the water supplies available for the places of use served by the acéquias or community ditch" (NMSA 1978, §73-2-55.1). Water rights placed in a water bank are not subject to forfeiture for non-use. State Engineer approval is not required for these temporary transfers. Neither OSE nor ISC recognition nor approval is required for acéquia or community ditch water banks.

Technical resources to assist acéquias with developing new bylaws regarding transfers and water banking are available from the New Mexico Acéquia Association (<http://www.acequiaweb.org>; tel. 505-995-5644) and from the Northern New Mexico Legal Services (tel. 505-982-25040). These organizations jointly prepared model amendments for acéquias to use in implementing a water right transfer approval process and in establishing a water bank. Copies of these documents can be found in Appendix H2.

8.10.1.3 Efforts to Influence Water Rights Transactions

Water right transfers taking place outside an acéquia or community ditch are governed by the water code, which allows transfers unless the transfer will impair existing water rights or is contrary to conservation or public welfare. New Mexico water law does allow individuals to protest a transaction. However, the OSE will generally not deny an application or condition a permit unless the protestant can make a compelling case that his or her existing water right will be impaired by the transaction. Even a decline in the groundwater levels of existing wells does not necessarily support a claim of impairment (*City of Roswell v. Berry*, 80 NM 110 (1969)). Individual protestants often do not have the resources to engage in protracted proceedings or to critique the technical evidence presented by the water right applicant. Thus, while protests may be effective in blocking specific transfers, they do not provide an efficient or reliable method of protecting water rights throughout the region.

8.10.1.4 Area of Origin Protections

The transfer of water out of the region can have negative impacts on the local economy and way of life (Howe, 2000) and on the viability of acéquia communities (New Mexico Acéquia Association, 2002). Legislating area-of-origin protections to offset those impacts may provide some benefits to the region, even if the water is transferred elsewhere.

A recent study addressing interbasin transfers proposed a set of 22 criteria to be considered by the state agency granting water rights before it grants a permit for an interbasin transfer (Interbasin Transfer Working Group, 2002). Many of these provisions are applicable to interregional transfers and could be useful for implementing this alternative. The following criteria for use in water rights application reviews, based on the Interbasin Transfer Working Group list (slight modifications were made to tailor it to the region), might be proposed for area-of-origin legislation:

- Protection of the present uses and consideration of projected uses of the region of origin, including but not limited to current agricultural, municipal, industrial, and instream uses and assimilative needs, with special concern for low-flow conditions
- Protection of the water quality in the region of origin at low-flow conditions
- Impacts of the proposed permit on the region-of-origin economy, cost effectiveness, and the environment in relation to alternative sources of water supply
- Imposition of a mitigation fee to offset adverse impacts of an out-of-region transfer
- Overall current water demand and the reasonably foreseeable future water needs of the region of origin
- Presently available supply of water to the receiving region, as well as the overall current water demand and the reasonably foreseeable future water needs of the receiving region, including methods of water use, conservation, and efficiency of use
- Beneficial impact of any proposed transfer and the capability of the applicant to effectively implement its responsibilities under the requested permit
- Nature of the applicant's use of the water, to determine whether the use is reasonable and beneficial
- Verification that the receiving region has implemented all reasonable efforts to promote conservation
- Verification that the proposed project uses all available methods, programs, and incentives to promote conservation of water
- Requirements of other state or federal agencies with authority relating to water resources
- Availability of water to respond to emergencies, including drought, in the region of origin and in the receiving region

- The quantity, quality, location, and timing of water returned to the region of origin, receiving region, or a downstream region
- Climatic conditions
- Number of downstream river miles from which water will be diverted as a result of the transfer
- Concerns of local governments affected by the proposed transport and use
- Cumulative effect on the donor and receiving regions of any water transfer or consumptive water use that is authorized or projected

To implement this alternative, the region would need to convince legislators to draft legislation adopting these or similar permit review criteria.

8.10.1.5 Conservation Easements

In the West, many non-profit organizations dedicated to farmland protection (e.g., American Farmland Trust, Rio Grande Agricultural Land Trust) advocate the use of conservation easements to keep land in agriculture. Land use easements are permanent restrictions on the use or development of the land so that its conservation values remain intact. Under the New Mexico Land Use Easement Act, a conservation easement is defined as "a holder's non-possessory interest in real property imposing any limitation or affirmative obligation the purpose of which includes retaining or protecting the natural or open space values of real property assuring the availability of real property for agricultural, forest, recreational or open space use or protecting natural resources" (NMSA 47-12-2(B)). New Mexico law allows the granting of land use easements to "preserve the availability of real property for agriculture" as well as "the protection of natural resources" (NMSA 47-12-2(A)).

Conservation easements can be valid only if an owner willingly grants the easement (NMSA 47 12-3(E)). In many parts of the country, farmers are compensated for granting these easements through local, state, and federal programs. However, in New Mexico, the only program currently available to compensate farmers for conservation easements is the federal Farmland Protection Program, which was created as part of the 1996 Farm Bill. An alternative to selling conservation easements is to donate them to a qualifying land trust, which provides the donor with significant tax benefits.

Whether an easement can be granted to restrict the use of a water right to one particular sector is unclear. The New Mexico Constitution requires that water be used beneficially, and agriculture is considered a beneficial use. However the Land Use Easement Act contains the following provision: ". . . no application or permit for a change in point of diversion place or purpose of use of a water right at any time shall be impaired, invalidated or in any way adversely affected by reason of any provision of that act" (NMSA 47-12-6(C)).

This provision appears to allow an owner of property with a valid land use easement to convey the water rights. If economically feasible, the land could remain in dryland farming (thus still in agriculture), with the water right transaction still occurring. To attempt to block a water right transfer by claiming that it violates an existing conservation easement would appear to be contrary to this provision. No New Mexico case law addresses this provision of the act.

Conservation easements are useful for farmers who wish to protect the future use of their agricultural lands. If a willing buyer of the easement can be found, the farmer will obtain compensation without having to sell his or her land or water rights. Regional (e.g., the Taos Land Trust), statewide (e.g., New Mexico Land Conservation Collaborative), and national (e.g., American Farmland Trust) land trusts have many resources to assist farmers in protecting and retaining their land in agriculture. If the water is not being put to beneficial use through active farming, it would be beneficial to have a local water bank in place that leases water rights only within the region so that regional water rights are protected (see <http://www.rgalt.org>, <http://www.lta.org/findlandtrust/NM2.htm>, or <http://www.farmland.org/rocky_mountain/new mexico.htm> for more information).

8.10.1.6 Transfer of Development Rights

This mechanism allows for the transfer of development rights for one parcel of land to another parcel of land. Generally, this is implemented through local zoning ordinances. To protect agricultural lands, implementation of this concept involves moving development rights of agricultural land to other lands located closer to the areas of growth, thereby preventing the conversion of agricultural land to residential or commercial developments. The owner of the parcel of land receiving the development rights can generally build at a higher density than is allowed under existing zoning, while the owner of the agricultural land derives some financial gain from the development potential of his/her land without taking it out of agriculture.

New Mexico has no legislation in place that specifically permits this type of transaction to protect agricultural lands. A bill proposing this concept (House Bill 363) was introduced in the 2001 New Mexico legislature, but was not passed. In other areas where this type of transaction is allowed, its implementation has met with limited success (Hanly-Forde et al., Undated). Challenges faced when implementing this type of program include insufficient local support, difficulties in administering the program, changing land use needs, and the need for cooperation across jurisdictional boundaries.

8.10.2 Hydrologic Impacts

Retaining water within the region can have several hydrologic benefits. Continuing the use of water within an irrigation system, be it an acéquia or community ditch, will help retain flows and seepage that contribute to local hydrology. Retaining water rights within the region will help to ensure that water remains in uses that support the local economy.

In complex hydrologic systems, the movement of one water right generally has a more significant impact in the move-to location (the location where the water right is transferred to and pumping will occur), where pumping from a proposed new well is likely to affect existing well owners in that area or a proposed new diversion may affect other surface water users. However, the following impacts can occur at the move-from location:

- If a surface water right, particularly on smaller systems, is transferred from the downstream end to a reach further upstream, the downstream reach will have less water.

- In a ditch system, where participation in ditch maintenance is essential for all users, fallow land can present a problem because owners of this land will no longer participate in ditch maintenance.

- When landowners fallow their land, less water is diverted through the ditch system. This may reduce the hydraulic head to the point where not enough water will reach destinations at the tail end of the ditch.

Seepage from ditch systems helps maintain shallow groundwater levels. If seepage is reduced because of decreased diversion to the ditch system, the domestic wells drawing from this part of the aquifer may be impacted.

8.10.3 Financial Feasibility

As discussed previously, implementation of acéquia bylaws to require approval of transfers out of the acéquia and to allow for water banking are the mechanisms most likely to be immediately beneficial to the region. Since example bylaws are available (Appendix H2), the cost for adopting the bylaws for an individual acéquia is minimal. However, because of the many acéquias in the region, it would be beneficial to conduct an outreach and education program to ensure that all acéquias have the information needed to make an informed decision about bylaw adoption. Funding would be required to support an outreach coordinator, who could work in conjunction with county extension agents or through other programs. The cost for an acéquia outreach and education program could be on the order of $30,000 to $100,000.

Several federal programs, many of which are managed by the NRCS, indirectly support the preservation of agricultural land and retention of water rights by providing funding to farmers for a variety of tasks that range from granting conservation easements to improving and protecting wetlands and wildlife habitat on their land (the NRCS web site at <http://www.nm.nrcs.usda.gov/farmers.html> has more information about these programs). In many cases, demand for these programs outweighs the supply of funds available. Because these programs generally involve a cost-sharing component, farmers must have private financing to take advantage of these funds.

In the private sector, the number of sellers of conservation easements is greater than the number of buyers with sufficient funding. Buyers for conservation easements usually include private land trusts or organizations like the Nature Conservancy that use donations to purchase land and easements. Because these nonprofit organizations have limited resources, the financial feasibility of this alternative is limited, and in all likelihood, the number of willing buyers for water rights dwarfs the number of buyers for conservation easements. For example, organizations in the State of Colorado can purchase only a limited number of the conservation easements that sellers have offered, even though Colorado has a state-funded lottery grant program that provides matching funds for conservation easements to nonprofit organizations such as land trusts.

When a conservation easement has been donated or sold, landowners can take advantage of fiscal benefits offered through state and federal tax law.

- Donated conservation easements may be treated as a charitable gift under the federal tax code (IRS 170(h)). Donors can deduct an amount equal to 30 percent of their taxable income the year of the gift. Donations valued in excess of that amount can be carried forward and applied against their taxable income for up to six years in the future.

- The New Mexico Land Conservation Incentive Tax Credit Act allows donors of land for conservation easements and/or to qualified nonprofit conservation organizations and government open space programs to deduct up to half of the appraised value of their donation, not to exceed $100,000.

- For estate tax purposes, the conservation easement will keep the land in a lower property tax value, possibly preventing heirs from being forced to sell the land or water rights in order to afford the estate tax.

- Federal legislation passed in 1997 created an estate tax incentive for landowners to grant conservation easements. Executors can exclude 40 percent of the value of land subject to a donated qualified conservation easement from the taxable estate (I.R.C. § 2031(c)).

8.10.4 Environmental Impacts

Retaining land and appurtenant water rights in agriculture could provide environmental benefits for the Mora-San Miguel-Guadalupe planning region:

- Retaining land in agriculture would ensure continued availability of habitat for local and migrating wildlife.

- Groundwater seepage from irrigation canals would continue to recharge the shallow aquifer and help sustain the local riparian habitat.

8.10.5 Political Feasibility and Social/Cultural Impacts

Efforts to retain water in the region are designed to benefit the local economy, water suppliers, and other water rights holders in the region. Retaining water in agriculture means that local businesses supplying that sector will continue to thrive. Other agricultural water rights holders will benefit from a system-wide continued use of water, especially in small systems where ditch maintenance is often the collective responsibility of the farmers who use it. Finally, the local economy and municipalities will benefit if they can find sources of water to meet future demand within the region.

In addition to the economic implications, agriculture is a vital component of the planning region; implementation of this alternative will help preserve agricultural lands and the local character and culture of the region. From an aesthetic perspective, the retention of agricultural lands enhances the quality of life for the surrounding area by creating a greenbelt in an otherwise desert landscape. However, those interested in transferring water outside of the region will likely oppose efforts to keep water in agriculture or other uses within the region.

8.11 Water Banking

Water banking, as presented in this alternative, refers to a streamlined method of reallocating or transferring the use of water through a centralized management entity. Rather than attempting to find buyers or lessees for a particular water right, water rights holders “deposit” their water rights in a “bank,” which then leases the water rights to third parties. The water rights holder is protected from forfeiture of the water right and benefits from revenues obtained for use of the water by a third party. Buyers or lessees of water rights can apply directly to the water banking organization and request a certain amount of water without having to research what water rights are available on the open market.

Other forms of water banking not considered in this alternative include the following:

- *An information clearinghouse that allows buyers and sellers of water rights to identify and find one another*. This arrangement can be initiated by a governmental entity (such as in the State of Idaho) or by private brokers who list water rights on an internet database that can be consulted by the general public.

- *A facility such as a reservoir where water can be stored or banked for future use*. For example, the Arizona Water Banking Authority operates the water bank associated with the Central Arizona Project (CAP).

- *Groundwater storage, which could serve the same function as an aboveground reservoir.* New Mexico law allows the use of groundwater aquifers to store water for future use through the Groundwater Storage and Recovery Act (NMSA 72-5A-1 through 17). Legislative changes would be necessary to use such storage as a water bank since the current law does not allow water stored in aquifers to be transferred or leased to other entities. Only the existing permit holder has the right to use the water in the future (Belin et al., 2002).

8.11.1 Technical Feasibility

The concept of moving water among users to optimize use or address shortages is not new. Water users within irrigation and conservancy districts informally transfer water and regularly enter into agreements regarding transfers and the fallowing of fields. Acéquias and community ditches now have the authority to operate such a water bank as well (NMSA 73-2-55.1). As long as the purpose and use remain the same and the transfer is within the acéquia or district boundaries, OSE and ISC approval is not necessary. However, a regional water bank would involve moving water from existing uses to new uses and would occur throughout a stream system or basin. Several technical feasibility issues are associated with a regional water bank:

- Overcoming legal impediments to water banking
- Establishing and managing a water bank, including the following activities:
  - Setting up the water bank agency or entity
  - Drafting water bank rules
  - Administering the water bank
  - Training staff
- Implementing water banking in Mora, San Miguel, and Guadalupe Counties

8.11.1.1 Legal Impediments to Water Banking

Water banking is new to New Mexico, and for the moment, no comprehensive water banking legislation exists that would allow for a regionally operated water bank. Attempts to pass statewide water banking legislation have failed in the past. Significant opposition to water banking comes from representatives of certain acéquias throughout New Mexico (New Mexico Acéquia Association, 2000).

Nevertheless, a limited local water banking initiative was successfully passed in 2002 (NMSA 72-1-2.3) for an area (the Pecos River) that excluded any acéquias. Under this statute, the only entities with the authority to create water banks are irrigation districts, conservancy districts, artesian conservancy districts, community ditches, and water users' associations in the lower Pecos River Basin below Sumner Lake. The water banks can be set up only for purposes of compliance with the Pecos River Compact (NMSA 72-1-2.3A). The legislation allows the water bank to create (with ISC support) expedited transfer procedures that would be submitted to the OSE for approval. Once approved, these procedures would allow for the water bank to "temporarily transfer deposited water to new purposes and places of use and points of diversion without formal proceedings before the State Engineer" (NMSA 72-1-2.3A(4)). If this initiative is successfully implemented, it may encourage lawmakers to consider broader water banking legislation in the state.

8.11.1.1.1 Water Rights Transfer Process. The existing water rights transfer process serves the important purpose of protecting water rights holders from impairment due to changes in the location or use of water. However, it acts as an impediment to successful water banking and marketing. Under New Mexico water law, water rights sales or leases are subject to notice, publication, and protest and must be approved by the OSE. While transfers taking place within the boundaries of an irrigation or conservancy district are not subject to OSE approval (NMSA 73 13-4 and 73-14-47), transfers outside such boundaries are complicated transactions that can take a year or more to complete and are therefore not conducive to addressing short-term water needs unless arranged ahead of time. Temporary transfers of up to 3 acre-feet are allowed under the New Mexico law, but this limited amount is insufficient for public water supplies or irrigated agriculture needs. No existing statute allows for expedited transfers of larger amounts of water rights. A key component of adopting legislation for the Mora-San Miguel-Guadalupe Region would be to develop agreement among water bank participants regarding models or technical analyses that would be used to define impairment and to determine under what conditions banking could proceed without additional analysis of potential impairment.

Section 72-5-28(G) of the Water Code provides that periods of non-use of water rights that are placed in an OSE-approved water conservation program shall not be computed as part of the four-year statutory forfeiture period. This provision allows qualifying entities—including an individual, acéquia or community ditch association, conservancy district, irrigation district, SWCD, or the ISC—to conserve water yet avoid the “use it or lose it” dilemma. The ISC has used this provision to lease water rights in order to increase surface water flows on the Pecos River.

8.11.1.1.2 Efforts by the OSE to Facilitate Water Banking. In recently approved, albeit controversial, active water resource management regulations, the OSE sets out an “expedited marketing and leasing” process (NMAC 19.25.13). Petitioners seeking to invalidate these regulations initiated litigation in January 2005 (Petition for Writ of Certiorari - D-0725-CV-05-03, January 3, 2005).

The expedited marketing and leasing process is available after the OSE establishes water master districts and appoints a water master in any drainage area of the state pursuant to existing authority. The OSE must then adopt “appropriate hydrologic models for the (water master) district" through a public rule-making process (NMAC 19.25.13.7(O); NMAC 19.25.13.32). The approved model or models are also referred to as a "generalized hydrologic model" and "take into account existing surface and groundwater diversions and the combined effect of groundwater and surface water uses on the basin groundwater and surface water system" (NMAC 19.25.13.32).

If an applicant agrees to the use of the approved hydrologic model, then the OSE may expedite the application review. Relying on the model, the OSE will determine whether the proposed transfer will impair existing water rights or be contrary to public welfare and conservation. With adoption of a generalized model, less time is required by OSE staff to review the accuracy of the models proposed by individual applicants and their experts. As a result, application processing time should be reduced. Water rights holders may still protest the application and claim impairment. However, since the model will have been approved through a public rule-making process and will have been closely scrutinized by experts, it will be difficult for a protestant to demonstrate that the model is inaccurate. The expedited marketing and leasing rules do not apply to acéquias or community ditches.

It is unlikely that expedited marketing and leasing will be available to the planning region or other areas of the state for many years. Numerous studies and steps are required of the OSE before it may establish this process. In addition, the outcome of the pending litigation may affect the OSE's ability to implement expedited marketing and leasing.

8.11.1.2 Establishing and Managing a Water Bank

If all legal impediments to water banking were overcome, establishing and managing the water bank would technically feasible.

The first steps in the process would involve establishing the legal structure of the organization, hiring and training staff, and locating facilities. A water bank would operate under rules and regulations that comply with New Mexico water law. If the Pecos model were followed, the OSE would draft a set of rules under which a regional water bank could be chartered and operated. Acéquias could use the model guidelines included in Appendix H to set up an acéquia water bank.

Administration of day-to-day transactions would be overseen by the director of the water bank. These activities could be implemented easily once water banking is allowed under New Mexico law.

Other tasks to be undertaken by the water bank would include developing an inventory of water rights available for transfer or lease, setting price and transaction fees, defining eligibility requirements, administering leases and contracts (including obtaining metering data), and resolving disputes. Additional functions required for successful water banking, such as verification of water right validity and quantity in areas where no adjudication has taken place, would be carried out by the OSE under the current legal framework.

Administration of a water bank in basins where water rights have been fully adjudicated would proceed more quickly than in unadjudicated basins. Depending on the water banking rules in place, it is likely that only adjudicated or licensed water rights would be allowed to be deposited in the water bank. In cases where a water right has not been adjudicated, the OSE would first review the water right to determine if it is a valid and transferable water right.

8.11.1.3 Water Banking in Mora, San Miguel, and Guadalupe Counties

Several factors make the Mora-San Miguel-Guadalupe Water Planning Region conducive to water banking:

- Dependence on surface water
- Adjudicated water rights (in the Gallinas)
- Reservoirs on the Pecos River

When surface water availability is low, water banking could be a useful mechanism to move water among users or uses. For example, acéquias could use the water bank to store water from farmers who agree to fallow certain lands. This water could then be used for other lands within the acéquia that may produce a higher-value crop or whose crop may be more vulnerable to drought (e.g., fruit trees). Thus, the farmers producing a lower-value crop would receive some payment for fallowing their lands, while the higher-value crop producer could continue to farm.

A regional water bank would also be useful for temporarily moving water from one use to another. For example, if downstream municipalities cannot meet demand due to drought, upstream farmers might agree to temporarily fallow lands in order to provide water to the municipalities. A great deal of cooperation and trust would be needed to set up this type of regional water bank. At present, this type of regional water bank is not possible because all transfers at a regional level are subject to State Engineer approval.

A second factor contributing to the viability of a regional water bank is the fact that many water rights in the region have been or are being adjudicated. An adjudicated water right is a proven water right. No further evaluation of beneficial use is required to determine whether the water right exists. Unadjudicated water rights, however, must be reviewed by the OSE before they can be transferred or leased in order to determine whether the water right is valid and what amount of consumptive use is associated with that right. This can be a lengthy process.

Finally, the presence of numerous reservoirs would also contribute to the viability of a regional water bank. If storage space is available, water could be physically banked and stored for future use. For example, Santa Rosa Reservoir is, on average, filled to only 20 percent of its capacity. If the water rights holders were willing, water could be kept in storage for future use by downstream users. However, the location of Santa Rosa Reservoir near the downstream end of the region would limit its potential for serving as a water bank for the entire area.

8.11.2 Hydrological Impacts

Water transfers and water banking should not alter the water supply or the hydrologic balance in the planning region. A water transfer would move an existing adjudicated water right from its current place of use to a different location. In some cases, the change in location of use of a surface water right may alter the timing or amount of flows in certain river reaches; however, unless the water right was very large, the change in the amount of overall streamflow would likely be minimal.

In small-volume systems such as springs, small streams, or ditches, transferring a water right out of the system could alter the flows more significantly or reduce the effectiveness of a conveyance by reducing the volume of the flow. However, for impacts such as these to occur, a significant percentage of the water would have to be moved to a different location. Additionally, if such a change in the water flow had the potential to impair the rights of other water users on that system, the transfer might not be allowed or could be conditioned in a way that protects existing uses.

Additionally, transfers involving groundwater may not impair the water rights of surrounding well owners. The OSE may deny a transfer if the additional groundwater pumping in the move-to location will result in impairment.

8.11.3 Financial Feasibility

The price of a water rights transfer is determined by market forces. Prices vary depending on the location and seniority of the water right being transferred. In addition to the cost of the water right, transfers include transaction costs such as application and attorney fees. Finally, if the question of impairment arises, a complex hydrologic evaluation, which could cost anywhere from $50,000 to $200,000, may be necessary.

Water banking would facilitate water rights transactions and perhaps reduce the cost of finding an available water right. However, the water bank would have initial setup costs and annual budget requirements as well as transaction fees, and these would be borne in part by the buyers and sellers of water rights. Consequently, the prices per acre-foot for water rights could increase. However, the risk of litigation and its attendant costs would be greatly reduced.

Setting up the water bank, hiring employees, and purchasing necessary computer and other equipment constitute the initial startup costs for a water bank. Ongoing, recurring costs include salaries and personnel training and operation and maintenance of existing equipment and facilities.

Assuming that a regional water bank would be housed in local government offices, equipment could come from existing inventory. However, two additional full-time employees would likely be necessary. These employees would review existing water rights in the adjudicated areas to update current records of ownership; training would be required for them to perform the duties of the new positions.

Based on these assumptions, the first year's costs for starting a water banking program would be $150,000 to $200,000, depending on the geographic extent of the bank. If surface and/or groundwater modeling were required to evaluate potential impairment, the costs could be triple this amount. Recurring costs would be approximately $125,000 annually.

Various potential sources of funding or financing for these costs exist:

- Legislative appropriations to the agency housing the water bank
- Income from transaction fees
- General obligation bonds
- Federal or state funding sources (e.g., New Mexico Water Trust Fund)

8.11.4 Environmental Impacts

The environmental impacts resulting from water rights transfers or leases, or from establishing a water bank, depend on the move-from and move-to locations. For example, if a water use is moved from a downstream location to an upstream place of use, the streamflow below the new (upstream) point of diversion will be diminished. Depending on the percentage of overall streamflow that the diversion represents, as well as the variations in climatic conditions, these types of transfers could have negligible impacts, or conversely, could adversely impact streamflow and aquatic and riparian habitat.

Water transfers implemented for environmental purposes, such as ensuring minimum streamflows, could have positive impacts in stream systems.

8.11.5 Political Feasibility and Social/Cultural Impacts

Public policy concerns are central to the debate around water banking. The main concern of rural agricultural water rights holders is that water banking will remove water from traditional agriculture communities to fast-growing urban areas, thereby causing significant impacts to the economy and quality of life in acéquia communities. Acéquias now have the ability, through implementing bylaws, to review and block transfers, thus preventing harm to the local community. Also, water banking can be used for temporary changes in use, but not to permanently move water from one use to another. To successfully implement this alternative in a regional manner (that is, at a level other than acéquia water banking within an individual ditch system), agreements regarding compensation, evaluation of impairment, and other issues would need to be reached among the water bank participants. While this is feasible, it could be politically difficult in some cases and may require a lengthy mediated process to be completed.

Nevertheless, water banking offers opportunities to better manage water shortages by allowing water rights holders to quickly lease their water to other users, avoiding forfeiture and generating income. Many western states have created water banks, and studies show that implementing certain water banking policies and requirements can offset some of the potential negative effects of the water transfers (Interbasin Transfer Working Group, 2002). Proponents of water banking cite the potential economic gain from banking water and the fact that it would provide a means to secure water for economic development.

8.12 Requiring Proof of Sustainable Water Supply for Approval of New Developments

Although the State of New Mexico recognizes the need to provide adequate water supplies for new development, the responsibility of developing and implementing ordinances that require proof of available water supply lie with counties and municipalities. However, the lack of a technical definition of a long-term water supply, inconsistent standards among counties, and insufficient requirements for municipalities results in varying degrees of water supply protection related to new development. The purpose of this alternative is to evaluate the potential for improved water resource management by requiring that adequate water supplies are available before development can proceed.

8.12.1 Technical Feasibility

The New Mexico Subdivision Act mandates that counties pass subdivision ordinances requiring developers to demonstrate that a proposed subdivision will have water supplies of sufficient quantity and quality to meet demand (NMSA 47-6-11 (F)). As part of the approval process, both the OSE and the NMED must review water availability documentation supplied by the subdivider.

8.12.1.1 County Role in Determining Water Availability

Each county within the planning region addresses subdivision requirements similarly. In San Miguel, Mora, and Guadalupe Counties, subdivision regulations require proof of a 40-year water supply and the counties rely on the OSE to determine whether that condition has been met.

For example, San Miguel County mandates water conservation measures through its subdivision regulations (San Miguel County Subdivision Regulations Governing Water Supply Requirements [SMCSR]: (Parts 1 & 2)). These measures include the following:

- Installation of water-saving fixtures in all residential and non-residential buildings
- Low water use landscaping (xeriscaping)
- Pressure testing of water distribution mains
- Pressure reduction valves on certain types of customer service connections
- Limitation of the maximum area of irrigated landscape on any one parcel to 1,600 square feet or less
- Prohibition of swimming pools and other outdoor water features

Limitations to the Subdivision Act requirements stem from numerous exemptions and the lack of consistency in how counties comply with the statute in enacting their ordinances. The Act excludes 13 types of land divisions from the definition of subdivision (NMSA 47-6-2). No proof of water availability is required for development on lands that fall under these exemptions. Two examples of exemptions include bequests of land to family members and parcels donated to not-for-profit corporations including schools, universities, and religious organizations. As mentioned, all counties in the region require a 40-year water supply before development can proceed. However, some counties in New Mexico have chosen to require proof of water for up to 70 years. Outside New Mexico, some counties or states require proof of water availability for up to 100 years or more. Depending on existing and projected cumulative use and local hydrology, the 40-year time frame may not be sufficient.

The definition of “adequate” water supplies can vary, and many counties in New Mexico have not developed a technical definition for water availability. San Miguel County requires that the subdivider “shall demonstrate a forty year supply.” The regulations do not, however, provide a technical definition of this term. Subdividers are required to prepare a 40-year schedule of effects, which includes calculating existing demands and adding in the effects of the proposed subdivision (SMCSR Part 5(C) (3)). The regulations do not define “existing demand,” so it is unclear whether cumulative effects over large geographic areas are considered.

Even the OSE does not necessarily evaluate cumulative effects. In some cases where models exist, the OSE may evaluate cumulative impacts of development. However, in more rural areas, the OSE typically reviews pump tests for the proposed well to determine whether that well has sufficient water to continue pumping during the length of time specified in the county subdivision act. This process does not take into consideration the cumulative impacts on the entire groundwater basin of the proposed additional pumping, and the OSE often does not have the data to make that determination because they receive individual permit requests rather than a comprehensive development plan. Furthermore, the effects of long-term drought may not be considered unless a model is in use that can be adjusted to simulate lower recharge.

Finally, when a subdivider applies for a water right, impacts to neighboring wells or surface diversions are addressed through the protest process. However, if the proposed water right has only minor impacts, then the OSE may find that no impairment exists, even though the cumulative, long-term impact of numerous developments may be significant.

Consistent technical definitions of water availability for the counties in the region, as well as a consistent means of evaluating the cumulative impact on water supplies of multiple subdivisions over time, are technical issues that should be resolved to ensure that development proceeds based on long-term, reliable water supplies. In 2001 the State of California passed legislation

(SB 221) that addressed this problem and created a technical definition of “sufficient water supply” at the state level. The text of the bill defines "sufficient water supply” as "the total water supplies available during normal, single-dry, and multiple-dry years within a 20-year projection that will meet the projected demand associated with the proposed subdivision in addition to existing and planned future uses, including but not limited to, agricultural and industrial uses.” For implementation of this alternative to be technically feasible, the counties need to have sufficient financial resources to hire technical staff who can develop models and thoroughly evaluate applications for water use.

Two other aspects of the Subdivision Act hamper comprehensive planning for water availability: (1) developers can avoid compliance with county subdivision regulations, and (2) domestic wells are exempt from the regulations.

The existence of county regulations does not necessarily mean that subdivisions will be required to comply with the water availability requirements. Cases have occurred in which the OSE has issued a negative opinion about the water supply availability for a proposed subdivision, yet the county commission has nevertheless approved the subdivision (Drennan, 1997). Additionally, developers can take advantage of lax municipal water supply requirements. In cases where the county commission has denied a permit, developers have convinced nearby municipalities to annex the subdivision in order to allow the subdivision to move forward. Efforts to protect water supplies for future use will require the cooperation of informed county commissions, municipalities, and other planning agencies

Domestic wells are exempt from the Subdivision Act, and neither the immediate or cumulative impacts of these wells are considered in determining available water supply. Even when agricultural water rights are transferred to another location, the land may be developed for housing using domestic wells. This practice allows for increased withdrawals that could impair other water users, yet there is no opportunity for protest or evaluation of impairment. There have been attempts to address this issue with legislation, but none of them have yet succeeded.

8.12.1.2 Role of Municipal Water Suppliers

The Subdivision Act does not apply to municipalities, although they do have the power to adopt city ordinances governing land platting, planning, and zoning (NMSA 3-19-1 through 12; 3-20-1 through 3-20-16). Specifically, municipal subdivision regulations may govern the extent and manner in which water will be provided to the subdivision as a condition of plat approval (NMSA 3-19-6 (B)(5)(b)).

New subdivisions within municipalities are typically served by a municipal system, and a municipality could include consideration of system capacity in its land use regulations. For example, a municipality could require, for any proposed development project, a written statement of water and sewer availability for building permits, site plan, or subdivision approval. Again, a jurisdiction that ties approvals to system capacity should have a sound technical basis for evaluating development and implementing such regulations.

In areas where an existing water system will supply new subdivisions, infrastructure development requirements that would tie development approvals to existing or planned system capacity could address water supply availability. Local governments could better link capital improvements to the timing of new development by identifying growth areas in advance and providing new publicly funded infrastructure to serve these areas in a timely manner. Alternately, some local governments have established concurrency ordinances which require that new development is restricted to areas where infrastructure capacity exists or will be available within a specified period of time. This approach may not alter the type or cost of improvements, but would affect the timing of construction.

If water suppliers do not have the capacity to serve new development, they may either increase capacity through system expansion or refuse to provide services. If a water supplier does not provide service and local governments have no provision for private utilities, then development will go elsewhere. Planning in a rational way for system expansion and for an equitable sharing of cost between developers and existing ratepayers may be the preferable method of directing growth in the region.

Typically, a public water supplier provides a master plan for its system without any change to existing laws. However, cost sharing would be defined through the supplier's rate structure and modifications to local subdivision and/or other ordinances. To meet future capacity needs, the water supplier must also determine that funding will be available as needed through revenues, developer fees, and other sources. Outside funding sources might include state and federal loans and grants.

8.12.1.3 Summary of Technical Impacts

To implement this activity in the planning region, it would be helpful to have new legislation at the state level that better defines terminology such as "adequate" water supplies, perhaps using California's legislation (Senate Bill 221) as a model. Another issue that could be tackled by the State is the development of legislation that would address the problem of developers who sidestep the Subdivision Act by using domestic wells to supply new developments. Counties within the region need to clarify their regulations (i.e., San Miguel County should clarify what is needed to "demonstrate" supply). Such clarification may help prevent developers from circumnavigating compliance with county regulations, but only if (1) regulations are adequately enforced and (2) counties and municipalities cooperate to protect water supplies from overdevelopment.

8.12.2 Hydrological Impacts

If this alternative is not implemented and growth occurs without adequate water supplies, there may be long-term effects such as depletion of groundwater, falling water levels, and wells going dry. For surface water supplies, the long-term effect could be extremely severe water restrictions during drought, when supplies are insufficient to supply all of the new development.

No new water would be made available to the region as a result of this alternative, but senior water rights would be better protected. Instituting more protections regarding water supply will protect the region from development that is faced with future water shortages. Demand for water will be reduced if developments that do not have an adequate long-term supply are denied. However, as the objective of this alternative is to make sure that development proceeds responsibly, rather than to stop or slow development, the overall impacts to the regional water demand will likely not be significant.

8.12.3 Financial Feasibility

If wide-scale development is allowed to occur without ensuring adequate water supply, costly projects will be required to (1) import water or deepen wells or (2) purchase surface water rights and develop additional supplies.

The cost of developing new legislation at the state level or regulations at the county level to further refine the technical aspects of proof of water availability will be commensurate with the time and materials expended in this effort. In general, a county could likely hire a consultant to help develop new, more explicit regulations for approximately $50,000.

The greatest expense for requiring proof of adequate water supplies is likely to be the technical evaluations required for a rigorous analysis. None of the three counties in the planning region currently has the resources and staff needed to evaluate the adequacies of water supplies. Consequently, they must continue to rely on the OSE, which is often too busy to perform a thorough evaluation of all the technical factors involved in proof of supply. Thus, if the counties were to implement this alternative, they could (1) hire full-additional staff to help with technical evaluations or (2) contract with technical experts to help with these evaluations. Hiring new staff is a viable option if the amount of work justifies the position; the cost would depend on the expertise and experience of the staff but might be in the range of $50,000 to $75,000 per year. The cost of contracting with a consultant is estimated at approximately $25,000 per evaluation.

8.12.4 Environmental Impacts

This alternative is not expected to create any environmental impacts. By ensuring that development proceeds only when adequate water supplies have been secured, it should protect against potential undesirable impacts to the environment that may result from groundwater overdraft or surface water shortages, especially during drought conditions.

8.12.5 Political Feasibility and Social/Cultural Impacts

Ensuring sufficient water supplies for new development while taking into account existing demand would benefit all residents in the region by protecting their water supplies. However, initiatives that are perceived to slow growth and development or provide added regulation tend to generate significant political opposition. Additionally, developers will likely oppose any attempts to limit their ability to construct new developments at will, and their financial resources to fight proposed legislation are usually greater than those of the local governments, nonprofit groups, and other interested parties who would support increased proof of water availability. Opinions expressed at Steering Committee and public meetings by residents within the region who are required to comply with severe water restrictions, such as in Las Vegas, indicate that new development should not be allowed if it will create additional restrictions on existing residents. One suggestion was that if new development does occur, there should be tiered conservation that places the most severe water restrictions on the newer residents.

8.13 Development of 40-Year Water Plans and Appropriation of Water to Meet Future Demand

Acquiring and holding water rights for future use is an integral part of water planning in New Mexico. Through the use of 40-year water plans, specific water users can acquire and hold unused water rights for up to 40 years (NMSA 72-1-9). Qualifying water users include municipalities, counties, state universities, member-owned water systems, municipal water users' associations, and public utilities (NMSA 72-1-9A). This legislatively created planning tool allows counties and municipalities to take advantage of existing opportunities to purchase, lease, or appropriate water rights for future use. Additionally, 40-year plans allow qualifying water rights holders to thoroughly examine current water management practices and identify opportunities to maximize efficient use of their water supplies. Finally, communities with 40-year water plans that demonstrate the need for water rights or system improvements provide a justification for communities to seek funding from available state and federal funding sources. In particular, applicants with 40-year plans would likely have a more competitive proposal when applying for funding for water supply development from the State Water Trust fund.

8.13.1 Technical Feasibility

A 40-year plan can be developed at any time. Generally a 40-year plan is prepared in conjunction with a water rights transfer. For example, if an entity is acquiring water rights for future use, the 40-year water plan will be submitted to the OSE to justify the need for that water and explain why the water will not be put to beneficial use in the short term. Also, entities with existing water rights that are not currently used, but that need to be protected for future use, may develop 40-year water plans to protect these existing rights.

A water plan should be sufficiently rigorous to withstand scrutiny in the event it is challenged. If possible, plans should be reviewed and updated every five to ten years. To document the future need for water, a water plan typically contains the following information:

- Physical water supply and current water rights held by the entity
- Current and future water demand
- Approach for meeting future water supply
- Conservation and drought management plan

Although the 40-year planning statute does not require a conservation plan, the OSE will request detailed information about conservation in accordance with statutory requirements that water transfers must not be contrary to conservation (NMSA 72-5-7, 72-12-3(E). In addition, new legislation passed in 2003 states that water suppliers that provide over 500 ac-ft/yr for domestic, commercial, industrial, or government customers for non-agricultural purposes may develop, adopt, and submit to the OSE by December 31, 2005 a comprehensive water conservation plan, including a drought management plan (NMSA 73-14-3.2(A). Although this appears to be a voluntary action on the part of the water suppliers, after December 31, 2005, neither the Water Trust Board nor the New Mexico Finance Authority are allowed to accept an application from a water supplier for financial assistance in the construction of any water diversion, storage, conveyance, water treatment or wastewater treatment facility unless a copy of a water conservation plan is included with the application (NMSA 73-14-3.2(G).

Thus, entities should also include in the 40-year plan a detailed water conservation plan (see Section 8.2 for a detailed discussion of water conservation requirements).

Few water suppliers in the planning region have prepared 40-year plans The City of Santa Rosa and the Village of Wagon Mound recently completed a 40-year plan and the Town of

Vaughn is considering developing a plan in the future depending on funding availability. Other incorporated communities, including Las Vegas and Pecos, have not yet completed 40-year plans. In addition to these municipalities, mutual domestic water associations in the region may benefit from plan preparation.

8.13.2 Hydrological Impacts

Because a 40-year plan identifies water supply system improvement opportunities, it lays the foundation for water to be managed more efficiently. Although the water supply does not increase as a result of the plan, the ability of the community to meet demand with available supply would improve. Additionally, conservation measures implemented as a result of 40-year plans could result in water savings.

8.13.3 Financial Feasibility

As 40-year plans can range from very simple documents to complex evaluations, the cost of preparing such plans is variable. The fact that Mora, San Miguel, and Guadalupe Counties have developed a comprehensive regional water plan that contains some of the information required in a 40-year plan should reduce the cost to qualifying water users of developing a 40-year plan. However, the 40-year plan must still provide information about the individual water right status, water supply, and water system information for the planning entity as well as conservation and drought management. On this basis, the cost of 40-year plans for water suppliers in the region will likely range from about $20,000 to $40,000.

8.13.4 Environmental Impacts

In general, preparation of a 40-year water plan should have no environmental implications. Planning for future water needs should allow communities to factor environmental concerns into the planning process to help mitigate the potential negative environmental impacts of unplanned water use and development.

8.13.5 Political Feasibility and Social/Cultural Impacts

In general, 40-year planning documents do not have political or social/cultural implications. However, the lack of a 40-year plan may have negative implications because failure to plan for future water needs could affect future economic development initiatives. The following factors, which include social and cultural implications, should be considered by all entities that reserve water for the future through the 40-year planning process:

- Forty-year plans should be periodically reviewed to ensure that they continue to reflect population changes, the completion of water supply projects, and implementation of water conservation measures as well as community needs.
- It can be costly to fund plans without community development block grants (administered by the U.S. Department of Housing and Urban Development) or other grants.
- Without plans, unused water may be subject to forfeiture.
- Public welfare should be considered as a part of all water plans.
- Individual transactions to purchase or lease water for the future are subject to protest and must not be contrary to conservation and public welfare.
- Water rights transfers inherently address impacts to existing users through an evaluation of impairment.

8.14 Data Collection, Metering, Measuring, Monitoring, and Management

This alternative examines the implementation of improved data collection including (1) metering of water diversions, return flows, and groundwater usage, and (2) measuring streamflows, groundwater levels, and water quality. Basic information about the supply and use of water resources is necessary to protect and improve the management of the water resources in the planning region. The region's legislators have requested funds for data collection (see House Bill for 2002) and other basic studies of the aquifers in the region, but these requests have been denied. This analysis provides information to help educate decision makers about the need for and associated costs of data collection.

8.14.1 Ongoing Monitoring Efforts

To provide a background for understanding this alternative, this section provides a summary of existing monitoring efforts to indicate which areas currently have metering and measuring data and to highlight data gaps.

8.14.1.1 Streamflows and Surface Diversions Measurements

The City of Las Vegas is currently the only entity on the Gallinas River that meters its diversions. Because of this, insufficient data are available to understand where and how much water is diverted from this stream system. Diversions for irrigation are estimated from indirect methods, such as the volume of crops harvested.

A total of 15 stream gages for monitoring streamflow and water quality are currently operated in the region (Table 8-18) by the USGS with some funding from the OSE. Stream gages measure streamflow every 15 minutes.

Table 8-18. Active USGS Monitoring Stations
Mora-San Miguel-Guadalupe Water Planning Region

County	Number of Active Monitoring Wells for Water Level [a]	Number of Streamflow Gages		Number of Active Water Quality Sites	
		Active	Inactive	Groundwater	Surface Water
Mora	0	3	26	0	0
San Miguel	2	5	8	0	0
Guadalupe	1 [b]	7	0	0	2
Total	3	15	34	0	2

Source: USGS, 2003
[a] San Miguel water levels measured semiannually, Guadalupe County well is measured monthly.
[b] Seven additional wells in Guadalupe County are monitored every 5 to 10 years.

8.14.1.2 Well Metering

Municipal and other public supply wells are metered and the usage is reported to the OSE, which summarizes usage in reports every five years. Diversions from domestic wells are estimated based on the population not served by water supply systems and an assumed average per capita demand of 80 to 100 gpcd (Wilson et al., 2003).

8.14.1.3 Groundwater Levels

The USGS, with funding from the OSE, measures monthly water levels in only one well in Guadalupe County (Table 8-18). Seven additional wells in Guadalupe County are measured every 5 to 10 years; the last measurement for these wells was made in 1995. Beginning in 1999, the USGS started measuring levels in two wells in San Miguel County on a semiannual basis. No wells are monitored for water levels by the USGS in Mora County.

8.14.1.4 Water Quality Monitoring

Public water systems, with oversight from the NMED Drinking Water Bureau, sample public supply wells for contaminants of concern based on the U.S. EPA's standardized monitoring framework. Public systems are tested for a variety of constituents on a frequency that is appropriate for each constituent. For instance, turbidity is tested every four hours in surface water systems, whereas volatile organics are tested once every five years in wells that have showed concentrations below detection. The Safe Drinking Water Act regulations for drinking water contaminants apply to both privately and publicly owned systems that serve at least 25 people or 15 service connections (e.g., homes and businesses) at least 60 days per year. Table 8-19 lists the number of wells in each county that are monitored by the NMED Drinking Water Bureau, which includes rest areas, parks, and restaurants that are self supplied.

Table 8-19. Number of Regularly Sampled Community Water Systems Mora-San Miguel-Guadalupe Water Planning Region

County	Number of Water Supply Systems Sampled
Mora	23
San Miguel	40
Guadalupe	16
Total	79

The NMED Surface Water Quality Bureau also monitors surface water quality to assess the quality of water to support designated uses. Table 8-20 shows the monitoring schedule for specific waterbodies in the Canadian and Pecos River Basins, as proposed by the NMED.

Table 8-20. New Mexico Environment Department Surface Water Quality Bureau Sampling Schedule
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Surface Water Body	Assessed Date	Monitoring Schedule
Canadian River Basin		
Canadian River	1998	2006
Conchas Reservoir	2003	2013
Conchas River		
Coyote Creek		
Encantada (Enchanted) Lake	1998	2006
La Jara Creek	2003	2013
Little Coyote Creek		
Manueles Creek		
Manuelitas Creek		
Middle Fork Lake of Rio de la Casa	1998	2006
Mora River	2003	2006 & 2013
Morphy (Murphy) Lake	2003	2006
North Fork Lake of Rio de las Casa	1998	2006
Ocate Creek		
Pacheco Lake		2005
Rio la Casa	2003	2013
Rito Cebolla		
Rito Morphé		
Rito San Jose		
Santiago Creek		
Sapello River		
Wagon Mound Salt Lake	1998	2005
Wheaton Creek	2003	2013
Wolf Creek		
Pecos River Basin		
Beaver Creek	2002	2009
Blue Creek		
Brown's Marsh		
Bull Creek		
Burro Canyon		
Cow Creek		
Dalton Canyon		
El Rito		
Gallinas River		

Source: NMWQCC, 2005a, 2005b

Table 8-20. New Mexico Environment Department Surface Water Quality Bureau Sampling Schedule
Page 2 of 2

Surface Water Body	Assessed Date	Monitoring Schedule
Glorieta Creek	2002	2009
Hollinger Creek		
Holy Ghost Creek		
Indian Creek		
Jack's Creek		
Lake Bentley		
Lake Katherine		
Lost Bear Lake		
Macho Canyon Creek		
McAllister Lake		
Monastery Lake		
Panchuela Creek		
Pecos Arroyo		
Pecos Baldy Lake		
Pecos River		
Porvenir Creek		
Power Dam Lake	-----	2006
Rio Mora	2002	2009
Rito del Oso		
Santa Rosa Reservoir		
Spirit Lake		
Stewart Lake		
Storrie Lake		
Sumner Reservoir		
Tecolote Creek		

Source: NMWQCC, 2005a, 2005b

The NMED Ground Water Bureau monitors water quality at sites with a groundwater discharge plan permit. Most of the sites are monitored for nitrate concentrations in groundwater originating from municipal and domestic wastewater. Table 8-21 lists the number and types of facilities in each county where groundwater is monitored for impacts from disposal of wastewater.

Table 8-21. Number of Groundwater Discharge Plans Mora-San Miguel-Guadalupe Water Planning Region

County	Facility Type	Number of Groundwater Discharge Plans
Guadalupe	Industrial	1
	Municipal/domestic wastewater	5
Mora	Municipal/domestic wastewater	2
San Miguel	Mining	1
	Industrial	4
	Municipal/domestic wastewater	14
Total		27

8.14.1.5 Summary of Data Collection Gaps

The largest gaps in data collection appear to be those concerning (1) measurement of surface water flow and diversions, (2) measurement of groundwater diversions, (3) measurement of water levels in groundwater, and (4) monitoring of septic tank impacts to groundwater. Currently, data collection is performed in a piecemeal manner by a number of different organizations. Because each type of data is collected for a specific purpose, development of a single monitoring plan is unlikely.

8.14.2 Technical Feasibility

This section examines the approach to improve existing monitoring and data collection for the following:

- Stream gaging and surface diversion measuring, under the jurisdiction of the OSE
- Domestic well monitoring, under the jurisdiction of the county or OSE

- Water level measurements, under the jurisdiction of the county or OSE
- Monitoring of groundwater quality in the vicinity of septic tanks, under the jurisdiction of the county or NMED

8.14.2.1 Stream Gaging and Surface Diversion Measuring

Stream gaging and measurement of surface diversions is technically feasible where the flow is controlled and unchanging. The control can be created by natural site conditions, such as a rock outcrop, or by an artificial structure, such as a weir or flume. A weir resembles a dam placed across an open channel, and a flume is a specially shaped portion of the open channel. The USGS (2002b) states that controls need to be both (1) stable, such that it is unchanging in time, and (2) sensitive, such that a change in discharge produces a significant change in stage.

Desirable attributes of artificial controls have been listed by Rantz et al. (1982) as follows:

- The control should have structural stability and should be permanent. Seepage under and around the structure must be prevented, and high flows should not bypass the structure.

- The crest should be sufficiently high to eliminate or minimize the effects of backwater from downstream.

- The shape and height of the control structure should allow the passage of water without undesirable disturbances in the channel either upstream or downstream from the control.

- The control should be sensitive at low stages and, if intended as a full range control, should facilitate extrapolation of the rating to flood stages.

- The control should be self-cleaning. This is especially true if sediment loads are high.

Flumes are a better choice for measuring canals than weirs because they are naturally more self-cleaning than weirs. Flumes are also a good choice because they can be designed to be effective throughout the restricted flow range that exists in canals. However, according to the

USGS (2002b), weirs are often more appropriate for measuring natural rivers for the following reasons:

- Weirs are easier and less expensive to build.
- Weirs can be designed to be sensitive at low flows without sacrificing the range of discharge over which it is effective.
- The high end of the rating can be extended beyond the stages for which the control is effective with more confidence for a weir than for a flume. The stage-discharge relation for a flume becomes uncertain when any part of the structure upstream from the stage sensor is overtopped. The stage-discharge relation for a weir becomes uncertain only when flow bypasses the weir.

Rantz et al. (1982) list the following conditions when a flume may be more appropriate than a weir for measuring streamflow:

- For streams with heavy sediment loads, because a weir will generally trap the sediment, which will alter the velocity and stream measurement
- For streams with a steep channel when the velocity approach is too high for a weir
- For situations when backwater is undesirable, because flumes create less backwater than weirs

To improve streamflow monitoring and measure surface diversions, stream gaging equipment could be installed at the sites listed in Table 8-22. A total of 14 stream gages and 213 irrigation diversions are included in this table; this provides a rough idea of the level of effort required to measure surface water supply and surface water use in the region. A thorough survey of the existing condition of ditches and potential measuring points would be required before designing a system. The OSE is the logical organization to oversee this work and to contract specific surface water flow and diversion measurement activities to the USGS or others.

Table 8-22. Potential Locations for Installation of New Streamflow Measuring Equipment Mora-San Miguel-Guadalupe Water Planning Region Page 1 of 2

River/Stream	Location of Recommended Measuring Point	Number of Measuring Sites [a]	Comments [b]
Pecos River Basin			
Gallinas River	Gallinas River near Lourdes	1	1951-63 data for discontinued USGS gage
	Storrie feeder canal	1	1949-52 data for discontinued USGS gage
	Diversions for irrigation on Gallinas River other than Storrie Lake Project	22	2,463 acres irrigated (from OSE GIS)
Tecolote Creek	River flow above irrigation diversions	1	
	Irrigation diversions from Tecolote and Tres Hermanos Creeks	5	306 acres irrigated
	River flow at confluence with Pecos River	1	
Tres Hermanas	River flow at confluence with Tecolote Creek	1	
Cow Creek, Bull Creek, and Sebedilla Creek	Irrigation diversions	8	162 acres irrigated
Pecos River	Diversions for irrigation on Pecos River	37	4,211 acres irrigated
Canadian River Basin			
Ocate Creek	River flow at confluence with Canadian River	1	Two discontinued USGS gages on Ocate 1914-1928
Ocate Creek and Tributaries	Irrigation diversions	15	2,864 acres irrigated
Piedra Lumbre	River flow at confluence with Canadian River	1	
Carrizo Creek	River flow at confluence with Canadian River	1	
Santiago Creek and Rito Morphé	Irrigation diversions	12	4,335 acres irrigated
Rio de la Casa	River flow near Cleveland	1	1956-1970 data for discontinued gage
Rio de la Casa and Tributaries	Irrigation diversions	30	6,966 acres irrigated
Sapella River and tributaries	Irrigation diversions	48	4,284 acres irrigated
Sapella River	River flow at Sapella	1	1956-1970 data for discontinued gage

[a] Number of diversion points based on number of active ditches surveyed by Martinez (1990)
[b] Acres irrigated based on Martinez (1990) survey in 1989, unless otherwise noted

Table 8-22. Potential Locations for Installation of New Streamflow Measuring Equipment Mora-San Miguel-Guadalupe Water Planning Region Page 2 of 2

River/Stream	Location of Recommended Measuring Point	Number of Measuring Sites [a]	Comments [b]
Canadian River Basin (continued)			
Mora River	Irrigation diversions	25	7,675 acres irrigated
Mora River	River flow near Shomaker	1	1935-1996 data for discontinued gage
Mora River	River flow at confluence with Canadian River	1	
Coyote Creek	Irrigation diversions	10	3,855 acres irrigated
Canyon Largo	River flow at confluence with Canadian River	1	
Trementina Creek	River flow at confluence with Canadian River	1	
Conchas River	River flow at Verjadero	1	1936-1996 data for discontinued gage
Little Cuervo Creek	River flow at confluence with Canadian River	1	
	Total number of stream gages	15	
	Total number of irrigation diversions	213	

[a] Number of diversion points based on number of active ditches surveyed by Martinez (1990)
[b] Acres irrigated based on Martinez (1990) survey in 1989, unless otherwise noted

Monitoring return flow may be possible in some locations where return flow is captured by drains. Otherwise, irrigation return flow is very difficult to measure.

8.14.2.2 Domestic Well Metering

The metering and collection of data from domestic wells would first require access to these wells to install meters with remote recording devices as well as equipment and staff to record the data. The technology is available to meter domestic wells and already occurs in public systems that monitor individual domestic use and bill customers based on their water use. Santa Fe County, to the west of the planning region, requires that all homes install a meter before they can obtain a building permit. The Santa Fe County ordinance also requires that meters be tested for accuracy every 10 years and replaced if necessary. Enforcement of the metering and reporting of meter reading is not part of the Santa Fe County program.

The monitoring of domestic well diversions after meters are installed would require staff to collect meter readings. An estimated 1.5 full-time employees would be needed just to collect readings for the entire region. An additional 1.5 full-time employees would be needed to review the data and, if needed, enforce any overuse regulations. These new staff could be employed by county governments and would work in cooperation with the OSE.

8.14.2.3 Water Level Measurements

When plotted over time in a single well or mapped over a large area from multiple wells, well water levels provide information about the changes in the amount of groundwater available over time and the direction of groundwater flow (very important in investigating groundwater contamination). These measurements are taken from properly screened wells at intervals across the specific aquifer being measured. Groundwater flow has both a horizontal and a vertical component, and therefore, the ideal method of examining groundwater elevations is to measure the hydraulic head at various depths at each location.

The current understanding of the groundwater elevations in aquifers in the planning region is very poor. To develop a water level monitoring network, a three-phase approach would be necessary. Such a study would require the services of a hydrologist to design and implement a field investigation. The county in which the work was being done or OSE would be the most suitable agency to oversee this work.

- *Phase 1: Conduct reconnaissance investigation using existing wells*. To improve upon the current knowledge of the region's groundwater resources and begin to characterize regional flow paths, a field investigation using existing domestic wells could be conducted. This phase would involve compilation and analysis of existing well logs and measurement of water levels, depths, and locations of existing domestic, stock, or irrigation wells (preferably in the winter, when pumping is at a minimum).

- *Phase 2: Drill additional monitor wells to establish vertical and horizontal control in critical areas*. This phase would involve installing monitoring wells in critical locations to better define flow directions.

- Phase 3: *Measure a network of wells quarterly*. Once a better understanding of the flow regime is developed, a quarterly and annual program of groundwater monitoring could be established to monitor changes over time.

8.14.2.4 Monitoring of Groundwater Quality near Septic Tanks

Approximately 6,000 septic tanks in the planning region are located near private domestic wells that are not routinely monitored for water quality. Ideally, county governments would conduct an assessment of the areas where septic tanks are impacting water quality to help prioritize areas that need changes to the land use codes. Wells should be tested for nitrate, TDS, chloride, manganese, sulfide, and total coliforms. The county governments, working in cooperation with the NMED, could be responsible for the monitoring program. Additional information on septic tank issues is provided in Section 8.6.

8.14.3 Hydrological Impacts

Measuring water levels, streamflow, and water quality will not have a direct hydrologic impact. However, the data collected could ultimately help improve the management of water resources. Measuring surface diversions could help reduce overuse and ensure that senior water rights are given priority use of water. The metering of domestic wells is unlikely to have a hydrologic impact, except in very extreme cases where a homeowner is diverting more than 3 ac-ft/yr, which is about 12 times the average domestic use. Monitor well installation and improved groundwater monitoring could help to ensure that future groundwater development is optimized and does not adversely affect existing users. Septic tank monitoring can help protect the quality of rural drinking water supplies.

8.14.4 Financial Feasibility

The financial feasibility of enhancing the monitoring network is discussed for each of the types of data measurement.

8.14.4.1 Stream Gaging and Surface Diversion Measuring

The cost to install stream gages averages about $36,000 per gage based on USGS Fiscal Year 2004 costs (Garcia, 2005). This includes telemetry at each site. Annual costs for operation and maintenance average about $13,150 per site, not including major maintenance or replacement of equipment lost in floods or otherwise damaged (Garcia, 2005). The capital costs to measure surface diversions averages about $14,000 per site based on a reconnaissance evaluation of the Rio Gallinas Irrigation Facilities (Laiho, 2004). The total cost to instrument the 14 new stream gages and 213 irrigation ditches listed in Table 8-22 is $3.5 million, as shown in Table 8-23.

**Table 8-23. Estimated Costs for New Streamflow Measurement and Irrigation Diversion Equipment
Mora-San Miguel-Guadalupe Water Planning Region**

River Basin	Flow Measured	Number of Sites	Capital Costs ($)	O&M Costs ($)
Pecos River	Streamflow	4	144,000	52,600
	Irrigation diversions	73	1,022,000	73,000
Canadian River	Streamflow	11	396,000	144,650
	Irrigation diversions	140	1,960,000	1,400,000
Subtotal	Streamflow	15	540,000	197,250
	Irrigation diversions	213	2,968,000	2,130,000
	Total	227	3,522,000	2,327,250

O&M = Operation and maintenance

8.14.4.2 Domestic Well Metering

The metering of the 5,900 domestic wells in the region is estimated to cost about $2.4 million. The capital costs for installing the meters and necessary remote equipment would be about $412 per well, as summarized in Table 8-24. Most of those costs could be borne by the customer, particularly for new wells, by requiring meters as part of the building permit. Annual operating expenses would be about $120,000: $60,000 to collect the data and another $60,000 to review and enforce fines or penalties for overuse of water. This cost is relatively high compared to the potential water savings that could be realized, because domestic wells represent a much smaller component of water use than surface diversions within the planning region.

8.14.4.3 Water Level Measurements

An expanded network of water level measurements would involve three phases:

- *Phase 1: Conduct reconnaissance investigation using existing wells*. This phase would involve measuring water levels, depths, and locations of existing domestic, stock, or irrigation wells (preferably in the winter, when pumping is at a minimum). Estimated costs for this phase range from $50,000 to 200,000.

- *Phase 2: Drill additional monitor wells to establish vertical and horizontal control in critical areas*. Monitor wells can range from $5,000 to 20,000 for each shallow well (about 100 feet deep) or $150,000 for a well about 1,000 feet deep.

- *Phase 3: Measure a network of wells quarterly*. Cost will vary depending on the number of wells and the distance between them. The USGS currently estimates a cost of about $160 per measurement for a 500-foot-deep well (Garcia, 2005).

8.14.4.4 Monitoring of Groundwater Quality Near Septic Tanks

The estimated costs for a program to test 10 percent of the approximately 6,000 domestic wells in the region (600 wells) for possible impacts from septic tanks are provided in Table 8-25.

Table 8-24. Estimated Costs for Metering Domestic Wells
Mora-San Miguel-Guadalupe Water Planning Region

Item	Per Well	Mora County	San Miguel County	Guadalupe County	Total
Population on domestic wells [a]	---	*3,854*	*10,639*	*695*	*15,188*
Number of domestic wells [b]	---	*1,517*	*4,124*	*277*	*5,918*
Equipment costs ($)					
Meters [c]	300	455,197	1,237,093	83,068	1,775,358
Remote radio [d]	100	151,732	412,364	27,689	591,786
Meter reading equipment [d,e]	---	3,000	8,000	1,000	12,000
Total capital costs ($)	412 [i]	609,929	1,657,457	111,757	2,438,322
Personnel costs					
Time to read meter (hours) [d,f]	*0.06*	*91*	*247*	*17*	---
Number of full-time meter readers [g]	*0.24*	*0.4*	*1*	*0.07*	*1.5*
Meter reader annual salary [h] ($)	10	15,173	41,236	2,769	59,179
Administrative salary costs ($)	10	15,173	41,236	2,769	59,179
Total annual costs ($)	20	30,346	82,473	5,538	118,357

[a] DBS&A calculation from 2000 Census; see Section 6
[b] Population divided by housing size: 2.54, 2.58, and 2.51 for Mora, San Miguel, and Guadalupe Counties, respectively
[c] Wust, 2005
[d] Vail, 2005
[e] $8,000 for electronic package to read meters (San Miguel County); $4,000 for each additional meter (shared by Mora and Guadalupe Counties).
[f] Triple time to check meters in Sunlit Hills and La Pasada, based on greater distance between wells
[g] For quarterly meter checking, assumes 960 hours equals 1 full-time employee
[h] Salary with benefits for government employee at $40,000 per full-time employee
[i] Total capital costs for all three counties divided by total number of wells.
--- = Not applicable

Table 8-25. Estimated Costs for Program to Test Domestic Wells Near Septic Tanks Mora-San Miguel-Guadalupe Water Planning Region

Constituent	Cost per Sample ($)	Total Cost for 600 Wells ($)
Nitrate	15	9,000
Chloride	15	9,000
Manganese	20	12,000
Hydrogen sulfide (test is for sulfide)	40	24,000
Iron (ferrous)	20	12,000
Total dissolved solids	15	9,000
Coliforms, total / fecal	41 / 48	24,600 / 28,800
Total	166 / 173 [a]	99,600 / 103,800 [a]

Source: 2005 Fee Schedule for Hall Environmental Analysis Laboratory
[a] Difference in cost reflects the type of coliform test used.

Costs to collect the samples and analyze results could range from $100,000 to $200,000. County governments could get grants from the U.S. EPA for nonpoint source pollution to help fund a program to assess water quality degradation from septic tanks. If impacts from septic tanks are observed, additional testing for organic compounds would be recommended.

Domestic well owners can get their wells tested by NMED for fluoride, iron, nitrate, and electrical conductivity at no cost. Instructions for well testing are provided at the NMED web site (<http:/www.nmenv.state.nm.us/fod/LiquidWaste/>).

8.14.5 Environmental Impacts

Temporary environmental impacts from improved measurements and data collection could result from the installation of wells or stream gages, but the overall impacts would be positive as a result of improved understanding and protection of the water resources.

8.14.6 Political Feasibility and Social/Cultural Impacts

The anticipated political feasibility and social/cultural impacts for each of the activities associated with this alternative are provided in Sections 8.14.6.1 through 8.14.6.4.

8.14.6.1 Stream Gaging and Surface Diversion Measuring

Streamflow gaging usually meets with little public resistance; however, the measurement of water use often faces opposition. In 1967, when the State Engineer implemented a program of metering irrigation in wells in the Roswell Basin, the Water Master wore a gun for protection. Part of the public resistance to water measurement is due to the "use it or lose it" aspect of New Mexico water law. If an irrigator is not taking full advantage of his water right (often because the water is not available), he does not want to have this record available when the time comes to adjudicate or sell the water right. Ultimately, however, the social and cultural impacts from measuring diversions should be very minimal.

8.14.6.2 Domestic Well Metering

Domestic well metering has been implemented in a few areas where water use is limited, such as in the Tesuque and Pojoaque Creeks as part of the Aamodt Adjudication suit in Santa Fe and Rio Arriba Counties. Although metering of domestic wells may not be politically feasible because the counties or the OSE may not have a source of funding to implement such a program, the impacts to the social and cultural aspects of rural life should be very minimal. It is unlikely that water use would actually be restricted, except in a few extreme cases of excessive water use, and therefore, little change would occur in water use or people's lifestyles. Nevertheless, concerns regarding this alternative have been raised at public meetings, and many people object to the idea of government monitoring of private water supplies.

8.14.6.3 Water Level Measurements

The political feasibility of funding an expanded effort for water level measurements has been a roadblock in the past, but this could change with increased interest in understanding the groundwater resources in the region. Although the monitoring program itself may not be opposed, it also may not be considered a priority for the use of limited State funds.

8.14.6.4 Monitoring of Groundwater Quality Near Septic Tanks

Monitoring of groundwater quality in areas near septic tanks should be politically feasible, particularly if the program begins by targeting high priority areas. Funding could potentially be obtained from U.S. EPA nonpoint source grants. No negative impacts of monitoring water quality are anticipated; however, some homeowners may object to having their well sampled.

8.15 Summary Recommendations and Implementation Schedule

As discussed in Section 8.1, a list of potential alternatives was developed at Steering Committee meetings, which are open to the public, and at a series of community meetings held in Mora, Las Vegas, Pecos, and Santa Rosa. The list was prioritized based on input from the public meetings, and the priority alternatives are analyzed in Sections 8.2 through 8.14. The other alternatives on the comprehensive list are also part of the long-term planning strategy for the Mora-San Miguel-Guadalupe Water Planning Region.

One of the priority alternatives identified was citizen participation as part of implementation. Because this alternative focuses on how the other alternatives are implemented, rather than on actions to ensure that the water supply of the region continues to be viable, it was not analyzed according to the ISC template (i.e., for technical, financial, and political feasibility as well as anticipated hydrological, environmental, social, and cultural impacts). Rather, the Steering Committee met to discuss how the planning region would be able to carry out the implementation of the regional water plan while including diverse representation from citizens, designated representatives appointed by the governing bodies, SWCDs, and others.

The Steering Committee decided that keeping the region together through a regional water planning council would serve the needs of the area. Accordingly, the Steering Committee selected interim leadership, identified volunteers willing to help the leadership team, and developed some guiding principles:

- *Consensual decision making.* The Steering Committee felt strongly that council decisions should be reached by consensus and that they should examine recommendations made to decision makers.

- *Use of Memorandums of Understanding (MOUs).* The three counties should develop MOUs to use among themselves as well as among the incorporated municipalities of Pecos, Las Vegas, Vaughn, Santa Rosa, and Wagon Mound.

- *Resolutions for plan acceptance and implementation.* All involved entities should draft resolutions and present these resolutions to their respective councils or commissions to ensure formal acceptance of the plan and commitment to its implementation.

- *Continued Council administration by the Tierra y Montes SWCD.* The District offered their continued services for administering the Council and for meeting space.

The Steering Committee also developed a draft implementation schedule, which identifies responsible parties and the relative time frame to begin implementation of each alternative. The schedule included both those alternatives analyzed in detail in this plan and the other alternatives originally identified by the group. A copy of the implementation schedule is included as Table 8-26.

Funding for projects is expected to be most successful if the region works together as a whole, taking advantage of the numerous opportunities such as CWA Section 319 grants, Water Trust Board grants, CFRP grants, and others. Potential funding sources for alternative implementation are included in Table 8-27.

The larger the projected gap between demand and supply is, the greater the need for implementing alternatives. While all communities will benefit from alternatives that protect and restore water supplies, communities in San Miguel County are projected to face the largest gap between existing supply and future demand. These communities in particular need to plan for future growth. Table 8-28 shows the projected demand for the municipal, domestic, commercial, and industrial use sectors by county for the low and high growth projections (Section 6). As shown in this table, the gap (i.e., projected new water use that is not currently associated with a water right or specified source) in San Miguel County under the high projection is about 3,400 acre-feet. The combined projected gap in 2040 in Mora and Guadalupe Counties is less than 1,000 acre-feet.

Table 8-26. Draft Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
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Alternative [a]	Implementation Priority [b]	Action	Responsible Party [c]
Infrastructure Development / Water Supply Development			
Develop additional groundwater	2	• Conduct aquifer mapping/resource assessments • Drill test wells in key areas that have not been tested previously	Cities of Las Vegas, and Santa Rosa, Town of Vaughn, counties in conjunction with State or federal agencies
Desalinate groundwater	3	• Address high-sulfur groundwater	State and/or federal government, developers
Drill new domestic wells	3	• Before relying on more domestic wells, address impairment of existing users by developing Critical Management Areas	Counties and State
Install new community water systems	2	• Conduct feasibility study for Romeroville/Sheridan and other critical areas • Develop county ordinances requiring community systems where the density is sufficient to support them	• El Creston, other mutual domestic water users associations • Counties
Treat and reuse wastewater	1	• Continue to implement wastewater treatment and reuse programs	Water suppliers (municipalities [d], associations)
Encourage the use of gray water	2	• Consider including gray water reuse infrastructure in building codes • Conduct education program	Water suppliers (municipalities [d], neighborhood and domestic water users associations)
Harvest rainwater	1	• Establish building codes requiring water harvesting	Counties, municipalities [d]

[a] Shaded alternatives identified as priority alternatives
[b] 1 = Begin implementing immediately (within 1 to 3 years)
2 = Begin implementing in 4 to 10 years
3 = Begin implementing in 11 to 40 years

[c] Primary responsible parties; others may also be involved.
[d] Municipalities = Pecos, Las Vegas, Vaughn, Wagon Mound, Santa Rosa
[e] Limited analysis

ASR = Aquifer storage and recovery
NMED = New Mexico Environment Department
OSE = Office of the State Engineer
SWCD = Soil and water conservation district

Table 8-26. Draft Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
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Alternative [a]	Implementation Priority [b]	Action	Responsible Party [c]
Develop additional storage (consider also aquifer storage and recovery)	1	• Conduct feasibility study for storage of Canadian River water for Las Vegas area • Conduct feasibility study for ASR • Survey sediment content and potential for removal in all reservoirs	City of Las Vegas, San Miguel County, OSE, reservoir owners
Watershed management	1	• Continue and expand existing watershed programs • Conduct public education regarding watershed activities	SWCDs; municipalities [d]; counties, U.S. Forest Service, watershed associations (if any)
Implement cloud seeding program	3	• Monitor results of cloud seeding in other areas to consider for future applicability to the region	State and/or federal government
Create permanent pool of water in Santa Rosa Lake	2	• Conduct preliminary discussions with attorneys/OSE to evaluate whether to proceed	City of Santa Rosa; Guadalupe County
Exotic vegetation replacement	1	• Continue existing programs • Develop quantitative measurements of benefits of existing/new programs	SWCDs
Install snow fences	2	• Conduct pilot study / pilot installations to evaluate potential for the program	SWCDs, large ranchers
Develop Mora County drinking water reservoir	3	• Conduct feasibility study	Mora County
Develop dirt tanks	3	• Educate ranchers on permit requirements/possibilities for development	Ranchers
Use nonpotable water for construction, parks, and recreation	1	• Review NMED policy for nonpotable use	Local governments

[a] Shaded alternatives identified as priority alternatives
[b] 1 = Begin implementing immediately (within 1 to 3 years)
2 = Begin implementing in 4 to 10 years
3 = Begin implementing in 11 to 40 years
[c] Primary responsible parties; others may also be involved.
[d] Municipalities = Pecos, Las Vegas, Vaughn, Wagon Mound, Santa Rosa
[e] Limited analysis

ASR = Aquifer storage and recovery
NMED = New Mexico Environment Department
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Table 8-26. Draft Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
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Alternative [a]	Implementation Priority [b]	Action	Responsible Party [c]
Water Conservation			
Agricultural conservation / delivery system efficiencies (i.e., line ditches, install pipes)	1	• Determine where lining is beneficial and not detrimental • Support state legislation for agricultural conservation programs • Obtain funding to assist farmers in implementing on-farm conservation measures	Acéquias; SWCDs, NRCS
Municipal conservation / education (including gray water use)	1	• Provide technical assistance to the mutual domestic water users associations • Develop and implement education programs • Implement rate structures and other incentives to reduce water use	Cities, mutual domestic water users associations
Water Resources Management			
Establish a regional water management authority	3	• Consider feasibility in the future, as the region grows	Counties, City of Las Vegas
Adjudicate water rights	2	• Monitor and participate in OSE adjudications	OSE
Water rights protection	1	• Develop and implement education program • Establish Critical Management Areas • Fund legal and technical representation	Acéquias, OSE, county extension agents
Improve problem solving methods	2	• Facilitate discussions regarding specific issues and overall strategies for addressing water resource problems	Local governments, State
Change state water law regarding use it or lose it policy	2	• Educate the public regarding recent changes to law • Support future legislative efforts to encourage conservation	State legislation, agricultural water users associations, acéquias

[a] Shaded alternatives identified as priority alternatives
[b] 1 = Begin implementing immediately (within 1 to 3 years)
2 = Begin implementing in 4 to 10 years
3 = Begin implementing in 11 to 40 years

[c] Primary responsible parties; others may also be involved.
[d] Municipalities = Pecos, Las Vegas, Vaughn, Wagon Mound, Santa Rosa
[e] Limited analysis

ASR = Aquifer storage and recovery
NMED = New Mexico Environment Department
OSE = Office of the State Engineer
SWCD = Soil and water conservation district

Table 8-26. Draft Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
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Alternative [a]	Implementation Priority [b]	Action	Responsible Party [c]
Remove sediment from reservoirs	1	• Assess amount of sediment in each reservoir • Obtain funding for sediment removal programs	Reservoir owners
Reduce reservoir evaporation	2	• Monitor current research • Fund research and development for techniques to reduce evaporation from open water surfaces	State and federal government; reservoir owners
Address impacts of recreational/stock ponds on downstream senior water rights holders	1	• Calculate total recreation pond depletions and evaluate them in relation to senior water rights	SWCDs
Require proof of water availability (for new subdivisions; consider other growth controls)	1	• Update county and municipal subdivision ordinances to provide for stronger subdivision review and ongoing monitoring • Obtain funding/technical assistance for evaluating the sustainability of water supplies	Counties, municipalities [d]
Water banking (may be combined with water rights protection), including acéquia water banks	1	• Conduct facilitated process (without attorneys) to define objectives and structure for a water bank • Develop a shortage sharing agreement	Acéquias, Cities of Las Vegas and Santa Rosa
Data collection, metering, measuring, monitoring and management	1	• Develop detailed monitoring/metering plan • Educate legislature on need to obtain funding • Install meters on domestic wells	OSE, legislators, USGS, acéquias, local governments, individuals
Control growth	2	• Develop regional growth management plans	Local governments working together
Limit the water use of new users/hookups by giving them a lower priority than current residents	1	• Explore possible ordinances to protect existing users	Municipalities [d]

[a] Shaded alternatives identified as priority alternatives

[b] 1 = Begin implementing immediately (within 1 to 3 years)
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Table 8-26. Draft Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
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Alternative [a]	Implementation Priority [b]	Action	Responsible Party [c]
Restrict domestic wells	1	• Develop county ordinances that restrict the amount of use and locations (e.g., lot size) for domestic well installations • Alternatively, develop Critical Management Areas with the OSE	Counties, OSE
Declare groundwater in OSE under-declared groundwater basins	2	• Support future OSE efforts to declare groundwater	OSE, regional water planning group
Complete 40-year water plans [e]	1	Provide funding and technical assistance for plan completion	Municipalities [d], counties, mutual domestic water users associations
Develop drought contingency plans	1	• Develop plan at community level	Municipalities [d], counties, mutual domestic water users associations
Develop flood contingency plans	1	• Develop plan at community level	Municipalities [d], counties, mutual domestic water users associations
Water plan implementation [e]	1	• Continue to meet and pursue implementation	Regional water planning council, local governments
Citizen participation as part of implementation [e]	1	• Continue to meet and pursue implementation	Regional water planning council

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Table 8-26. Draft Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
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Alternative [a]	Implementation Priority [b]	Action	Responsible Party [c]
Water Quality			
Water quality protection (including septic tanks)	1	• Conduct an inventory/assessment of septic locations and identified water quality problems • Develop county septic ordinances or modify NMED regulations • Require regional wastewater systems or program of pumping septic tanks to improve performance	Counties, NMED
Identify, protect, and monitor groundwater and surface water vulnerable to contamination	1	• Review existing NMED regulations • Make improvements to discharge plan monitoring as needed	• Regional water planning council • NMED
Provide assistance with water quality testing for domestic users	2	• Implement mobile water testing unit • Provide information on other water quality testing available to domestic users	• NMED • Regional water planning council
Control development that may affect water quality	2	• Review municipal and county subdivision ordinances and evaluate/update water quality protections	County, municipalities
Preserve wetlands	1	• Evaluate effects of wetlands on groundwater recharge • Support policies that preserve and protect wetlands	State and federal government
Preserve instream flow and riparian ecosystems	2	• Develop voluntary programs to purchase water rights for instream flow. • Conduct riparian restoration projects	SWCDs

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Table 8-27. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Area: Water Supply Conservation	Funding Area: Development and Infrastructure	Funding Area: Water Supply Protection	Funding Area: Water Resources Management	Description
General Information					
Catalog of Federal Domestic Assistance http://www.cfda.gov/	■	■	■	■	Good information about funding sources, grant writing, etc.
Federal Grants Search www.grants.gov	■	■	■	■	Searches all federal agency sources for grant information
Federal Drought Programs http://www.iwr.usace.army.mil/iwr/drought/ feddrghtprogs.htm	■	■	■	■	Summary of federal funding sources available for drought programs.
Catalog of Federal Funding Sources for Watershed Protection http://cfpub.epa.gov/fedfund/			■		Topical listing of funding sources related to watershed protection.
Links to private funding sources http://www.epa.gov/owow/nps/capacity/funding.htm	■	■	■	■	List of links for private funding sources for various areas.
Funding Programs					
New Mexico Clean Water State Revolving Fund *New Mexico Environment Department*, *Construction Programs Bureau* Santa Fe: 505-827-2806 http://www.nmenv.state.nm.us/cpb/cpbtop.html http://www.nmenv.state.nm.us *New Mexico Water Trust Board* Contact New Mexico Finance Authority (NMFA) U.S. *Environmental Protection Agency (EPA)* http://www.epa.gov/owm/cwfinance/cwsrf/	■	■	■	■	Eligible projects include water supply development, conservation, watershed management, and infrastructure. Water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management.

[a] Web site address as of November 2002; address and information found there is subject to change.

Table 8-27. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Area: Water Supply Conservation	Funding Area: Development and Infrastructure	Funding Area: Water Supply Protection	Funding Area: Water Resources Management	Description
Community Development Block Grants *Department of Housing and Urban Development* http://www.state.nm.us/clients/dfa/Files/LGD/CDB/index.html				■	Funding source for 40-year plans.
Community Facilities (CF) Direct Loans and Grants *U.S. Department of Agriculture (USDA)* http://www.rurdev.usda.gov/rhs/cf/cp_dir_grant.htm		■			Provides loans for the development of essential community facilities for public use in rural areas and towns with a population of 20,000 or less.
Emergency Community Water Assistance Grants *USDA Rural Utility Services (RUS)* Albuquerque: 505-761-4955 Las Vegas: 505-425-3594 x4 http://www.rurdev.usda.gov/nm/ http://www.usda.gov/rus/water/programs.htm#EMERGENCY http://www.usda.gov/rus/water/		■	■		Assists rural communities that have had a significant decline in quantity or quality of drinking water.
Irrigation Works Construction Loan Fund *New Mexico Interstate Stream Commission* Santa Fe: 505-827-6160 Fax 505-827-6188 http://nmlocalgov.net/plan/pdf/seall.pdf		■			Makes loans to entities such as irrigation districts, community ditch associations, and municipalities for engineering and design, construction, or rehabilitation of irrigation works.
Acequia Restoration and Rehabilitation Program *U.S. Army Corps of Engineers, Albuquerque office* *New Mexico Interstate Stream Commission* Santa Fe: 505-827-6160 Fax 505-827-6188		■			Joint program with U.S. Army Corps of Engineers (COE); provides eligible acequias with COE grants that fund up to 75% of a project's cost with 25% acequia funding. Matching requirements may be met through state grants (17.5%) and loans (7.5%).

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Table 8-27. State and Federal Funding Sources

Program Title / *Agency* / Web Site or Contact [a]	Funding Area: Water Supply Conservation	Funding Area: Development and Infrastructure	Funding Area: Water Supply Protection	Funding Area: Water Resources Management	Description
Ditch Rehabilitation Grant Program *Office of the State Engineer* Santa Fe: 505-827-6191 Fax 505-827-6188		■			Joint program with U.S. Soil Conservation Service; provides grants to community ditches for construction, repair, and improvement of ditches, dams, reservoirs, flumes, and appurtenances.
Planning Assistance to States *U.S. Army Corps of Engineers* Albuquerque*: (505) 342-3109* http://www.spa.usace.army.mil	■	■	■	■	Assists in planning for the development, utilization, and conservation of water and related land resources and ecosystems.
Reclamation States Emergency Drought Relief Act of 1991 - Title II *U.S. Bureau of Reclamation* Albuquerque Area Office: 505-248-5323 http://www.uc.usbr.gov/progact/waterconsv/wtr_wmp.html http://nris.state.mt.us/drought2001/reports/DRTBuRecDrRelief.html	■	■	■	■	Assistance in the construction and planning of projects that mitigate effects of drought.
Conservation Technical Assistance *USDA Natural Resource Conservation Service* Las Vegas: 505-425-3594 Albuquerque Office: 761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/cta/			■	■	Planning and implementation of solutions to natural resource concerns, including drought.

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Table 8-27. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Area: Water Supply Conservation	Funding Area: Development and Infrastructure	Funding Area: Water Supply Protection	Funding Area: Water Resources Management	Description
Safe Drinking Water Act Revolving Loan Program *New Mexico Environment Department, Construction Programs Bureau* Santa Fe: 505-827-2806 http://www.nmenv.state.nm.us/cpb/cpbtop.html http://www.nmenv.state.nm.us *U.S. EPA* http://www.epa.gov/safewater/dwsrf.html		■	■		Water infrastructure improvements, for small and disadvantaged communities and for pollution prevention to ensure safe drinking water.
Water and Waste Loans and Grants *USDA Rural Development* Albuquerque: 505-761-4955 Las Vegas: 505-425-3594 http://www.rurdev.usda.gov/nm/ http://www.usda.gov/rus/water/programs.htm		■	■		Development or improvement of water or wastewater disposal systems in rural areas.
Snow Survey and Water Supply Forecasting Program *USDA Natural Resources Conservation Service* Las Vegas: 505-425-3594 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov. http://www.nrcs.usda.gov/programs/snowsurvey/				■	Monitoring of climatic and hydrologic elements necessary to produce water supply forecasts.
Reclamation Water Reclamation and Reuse Program *U.S. Bureau of Reclamation* Albuquerque: 505-248-5323 http://www.cfda.gov (Search using keyword: groundwater or wastewater) http://www.usbr.gov/pmts/writing/guidelines/	■	■			Appraisal and feasibility studies on water reclamation and reuse projects.

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Table 8-27. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Area: Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	Description
Small Watershed Program *USDA Natural Resources Conservation Service* Las Vegas: 505-425-3594 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/watershed/	■		■	■	Agricultural water management, municipal and industrial water supply, groundwater recharge, and watershed protection projects.
Conservation Partnership Initiative *USDA Natural Resources Conservation Service* Las Vegas: 505-425-3594 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/cpi/			■		Funds projects that promote terrestrial and freshwater aquatic wildlife habitat and address invasive species (such as noxious weeds). (See guidance for additional non-watershed related project eligibility)
Environmental Quality Incentives Program (EQIP) *USDA Natural Resources Conservation Service* Las Vegas: 505-425-3594 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/eqip/	■		■		Practices to address soil, water, and related natural resource concerns on farm and ranch lands.
Emergency Water Supplies *USDA Rural Development* Santa Fe: 505-476-9600 http://www.dps.nm.org/emergency/index.htm	■		■		Provision of emergency water supplies to communities that may run out of adequate drinking water.
Finance Authority Emergency Funding and Water and Wastewater Grant Program *NMFA* Contact: NMFA at (505) 984-1454 toll free, 1-877-ask-nmfa		■			Provision of emergency water supplies.

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Table 8-27. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Area: Water Supply Conservation	Funding Area: Development and Infrastructure	Funding Area: Water Supply Protection	Funding Area: Water Resources Management	Description
Emergency Conservation Program *USDA Farm Services* Las Vegas: 505-425-3594 x2 Albuquerque *:* 505-761-4407; 1-800-410-2067 http://disaster.fsa.usda.gov/ecp.htm	■				Rehabilitation of farm lands and conservation facilities.
Public Assistance /Emergency Measures Program *New Mexico Emergency Management Center* Regional Office Main Number (940) 898-5399 Santa Fe: 505-476-9600 http://www.dps.nm.org/emergency/index.htm http://www.fema.gov/regions/vi/index.shtm		■		■	Activities to alleviate consequences of the subject of a Presidential Emergency or Major Disaster Declaration (such as drought).
Economic Adjustment Program: Sudden and Severe Economic Dislocation Components *U.S. Department of Commerce EDA* http://www.osec.doc.gov/eda/				■	Prevention of serious economic dislocations or reestablishment of employment opportunities after a sudden and significant dislocation.
Conservation Reserve Program *USDA Natural Resources Conservation Service* http://www.nrcs.usda.gov/programs/crp/ Las Vegas: 505-425-3594	■				Helps farmers and ranchers address water resource concerns on their lands.
Emergency Watershed Protection *USDA Natural Resources Conservation Service* http://www.nrcs.usda.gov/programs/ewp/ Las Vegas: 505-425-3594			■	■	Emergency recovery measures to relieve imminent hazards to life and property as a result of natural disasters.

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Table 8-27. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Area: Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	Description
Emergency Well Construction and Water Transport *USACE* *U.S. Army Corps of Engineers Albuquerque District Office* Albuquerque: 505-342-3109 http://www.spa.usace.army.mil		■	■		Construction of wells or transport of water drought-distressed areas.
Water Quality Program *USDA CSREES* http://www.csrees.usda.gov/nea/nre/in_focus/ water_if_waterquality.html			■		Provide watershed- based information for assessing and improving sources of water quality impairment in targeted watersheds.
Unsolicited proposals *U.S. Geological Survey* http://www.usgs.gov/contracts/grants/unsolbk.html	■			■	Research proposals in many earth science areas, including hydrology and conservation.
State-EPA NPS Partnership *U.S. Environmental Protection Agency* http://www.epa.gov/owow/nps/partnership.html			■		Focus on nonpoint source topic-specific needs including: watershed planning and implementation.
Land and Water Conservation Fund Grants to States *National Park Service* http://www.nps.gov/ncrc/programs/lwcf/			■		Matching grants to states and local governments for the acquisition and development of public outdoor recreation areas and facilities.
Water Reclamation and Reuse Program *U.S. Bureau of Reclamation* http://www.usbr.gov/pmts/writing/guidelines/		■			Projects for reclamation and reuse of municipal and other wastewaters and naturally impaired waters.

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Table 8-28. Projected Water Use (Withdrawal) for Municipal, Domestic, Commercial and Industrial Uses

County	Water Use in 2000 [a] (ac-ft)	Projection	Projected Water Use [a] (ac-ft)				Gap in 2040 [b] (ac-ft)
			2010	2020	2030	2040	
Mora	815	Low	878	923	946	961	146
		High	971	1,118	1,235	1,326	511
San Miguel	4,593	Low	5,169	5,706	6,144	6,468	1,875
		High	5,237	6,009	6,920	7,972	3,379
Guadalupe	994	Low	1,008	1,019	1,025	1,028	34
		High	1,144	1,248	1,305	1,323	330
Total	6,402	Low	7,055	7,647	8,116	8,457	2,055
		High	7,352	8,375	9,460	10,621	4,219

[a] Withdrawals for municipal, domestic, commercial and industrial uses
[b] Difference between projected water use in 2040 and year 2000 water use (signifies gap only due to new water uses; additional gaps may occur due to drought conditions).

ac-ft = Acre-feet

In San Miguel County, the gap in 2040 can be reduced by about 260 acre-feet through implementation of municipal conservation (Section 8.2), which represents only about a 4 percent reduction in municipal and domestic demand. In contrast, Mora and Guadalupe Counties could reduce their projected gap by about 240 and 280 acre-feet in 2040, respectively, a 19 and 22 percent reduction in municipal and domestic demand. The reason for this difference is that the City of Las Vegas, the primary municipal water user in San Miguel County, has already implemented an effective water conservation program and conducts regular repair of water system mains, thereby reducing demand considerably over the past decade. Even with these conservation measures in place, all three counties will need to identify new sources and acquire water rights to meet the projected increases.

Even without additional growth, water problems exist. Because of the large dependence on surface water, a supply that fluctuates with variability in precipitation, the region is vulnerable to drought. Reducing this vulnerability can be achieved by pursuing the strategies described in Sections 8.2 through 8.13:

- Restoring and protecting the watersheds and riparian areas that produce the surface water supplies for the region
- Protecting groundwater supplies from contamination from septic tanks
- Developing groundwater to reduce drought vulnerability
- Implementing conservation programs to limit demand during drought
- Developing additional storage to reduce drought vulnerability
- Optimizing water management through mechanisms such as water banking, protection of water rights, and development of 40-year water plans

As discussed in Section 8.14, expanded monitoring of both groundwater and surface water supply and use will also aid in improved management of the planning region's water resources.

Some of the actions identified in this plan, as summarized on Table 8-26, can be carried out by individual water providers. Other actions, such as watershed management, exploration of groundwater resources, water banking, and development of additional storage are best pursued on a regional level. The ongoing involvement of a regional planning council to oversee implementation of these alternatives will be key to successfully moving forward with this plan to protect the resources of the region.