7 PLANNING ALTERNATIVES

REGIONAL WATER PLAN · RIO CHAMA WATERSHED

CHAPTER 7

CONTENTS

Findings of the Water Plan **1**
Public Welfare **2**
Goals in Water Planning - Principal concerns and unmet needs **3**
Alternatives: discussion and evaluation **4**

GOAL: KEEP WATER RIGHTS WITHIN THE REGION 5
Strategy: Be vigilant about proposed water rights transfers 5
Strategy: Provide County support for water rights and infrastructure 6

GOAL: PRESERVE THE ACEQUIA SYSTEM 6
Strategy: Insulate acequias from excessive economic pressures 7
Evaluation *8*
Strategy: Implement appropriate-scale water banking 9
Evaluation *9*
Strategy: Maintain and repair acequia systems appropriately 11
Evaluation *11*
Strategy: Modify the adjudication process 12
Evaluation *13*

GOAL: ENHANCE GROWING SEASON STREAMFLOWS 13
Strategy: Improve high-altitude upper watershed management 14
Strategy: Enhance grass cover and infiltration in lower-altitude areas 15
Evaluation *15*
Strategy: Reservoir storage 18
Evaluation *19*
Strategy: Aquifer storage and recovery 23
Evaluation *23*
Strategy: Appropriate flood or wet-year flows 24
Evaluation *24*

GOAL: SUPPORT LOCAL AGRICULTURE 25
Strategy: Enhance marketing opportunities 25
Strategy: Help finance local agriculture 26
Strategy: Help with information sharing and technical assistance 26
Strategy: Collaborate widely 26
Evaluation *27*

GOAL: PROVIDE RELIABLE COMMUNITY WATER SUPPLIES 28
Strategy: Consolidate community water systems if appropriate 28
Strategy: Develop alternatives for additional water rights where needed 28
Strategy: Optimize locations and depths of community wells 28

Strategy: Consider other water supply alternatives 28
Strategy: Conserve water and audit water use in community systems 29
Strategy: Ensure adequate water supplies for firefighting 29
Strategy: Protect existing communities from unsustainable water use 29
Strategy: Provide additional support resources for community systems 30
Strategy: Collect basic information about our water resources 30
Evaluation . . . . . *.30*

GOAL: PROTECT WATER QUALITY 31
Strategy: Consider and encourage community waste water treatment 32
Evaluation . . . . . *.32*
Strategy: Encourage or require better individual liquid waste treatment 33
Evaluation . . . . . *.34*
Strategy: Control non-point-source and agricultural pollution 35
Evaluation . . . . . *.36*
Strategy: Regulate and discourage development in upper watershed areas 37
Evaluation . . . . . *.37*

GOAL: CONSERVE AND REUSE WATER RESOURCES 38
Evaluation . . . . . *.39*

GOAL: PROTECT AND RESTORE OUR WATERSHEDS 40

***Moving forward* 41**

FINDINGS OF THE WATER PLAN

Some of the most important characteristics of our water supply and how we use it in the Rio Chama watershed are summarized below. These points form a backdrop to discussions about water planning in the region, and establish a framework within which our planning goals, and alternative strategies to achieve these goals, must be evaluated.

- **Current and projected water needs in the region are met mostly by surface water**. Surface water depletions make up approximately 92 percent of current intentional human consumptive use, while ground water depletions account for 8 percent.

- **Essentially all surface water use takes place on acequia systems, which are a vital part of community fabric, local political structure, and cultural patterns.** Preserving the acequia system is perhaps the single most important water planning goal in the region.

- **Total depletions in the region are a small fraction of total Rio Chama flows**. Total average annual depletions of 26,700 acre-feet for intentional human uses are about 7 percent of total average annual stream flow out of the region, or 6.4 percent of total watershed yield.

- **Usable water supply is primarily constrained by water rights and by lack of storage, rather than by lack of total annual streamflow.** As noted above, we use a small fraction of the total amount of water available in the Rio Chama and its tributaries. The barriers to expanding the water supply are low streamflow during the growing season, and water rights held by outside entities (including Rio Grande Compact requirements).

- **Despite local water use being a small fraction of total potential supply, water shortages are a chronic problem**. Irrigation supplies are limited by low and highly variable summer streamflow, while ground water supplies (which provide approximately 90 percent of domestic and community supplies) are severely limited in many places by aquifer characteristics. Runoff is mostly dependent on winter precipitation, which varies widely from year to year. Water actually available for irrigation during the growing season is often considerably less than that needed to irrigate all the land.

- **Surface water and ground water are usually closely connected**. In most of the region aquifers tapped for human use are shallow and close to the Rio Chama or its tributaries, so that significant ground water pumping will affect stream flows relatively quickly. Ground water and surface water should be managed conjunctively.

- **No evidence suggests large undeveloped ground water reserves in the region.** Most aquifers in the Rio Chama watershed are neither extensive nor very productive, and it seems unlikely that future ground water development can offset any significant fraction of surface water use or provide water supplies outside the region. Only the lower Chama area, within the Española Basin, is generally characterized by productive aquifers.

- **Reservoir evaporation nearly equals all intentional consumptive uses of water.** Even though evaporation rates are less in the Chama Valley than at lower elevations, reservoir evaporation is still a significant fraction of total water depletion in the region, and is appreciably higher at Abiquiu Reservoir than at Heron or El Vado reservoirs.

PUBLIC WELFARE

Public welfare in our Planning Region, as it relates to water, requires a safe and adequate water supply for domestic use, adequate water for agriculture and livestock, and a proper method of treating wastewater to prevent contamination of surface or underground water resources.

The most important objective expressed by residents in public meetings on the water plan was to keep existing water rights in the region to maintain the rural acequia agricultural lifestyle and provide safe drinking water while protecting the environment. The Alternatives discussed below in the Water Plan address this issue by providing ways to accommodate normal and appropriate increases in population. It is clear that the region cannot sustain a vast increase in population without importing water from outside the region or appropriating significant additional water within the region.

It is imperative that Federal and State agencies work with Rio Arriba County, the village of Chama, acequias, Native American tribes and Pueblos, mutual domestic water associations, and individual stake holders in a non-adversarial climate to achieve the public welfare objectives of the regional water plan.

The U.S. Environmental Protection Agency is mandated to enforce the Safe Drinking Water Act and its regulations for public water providers to ensure a safe drinking water supply for the public welfare. It should also provide funding to those entities to help comply with the Safe Drinking Water Act. The Bureau of Reclamation and the Army Corps of engineers should provide additional San Juan-Chama water and storage space to rural communities for domestic and agricultural use in the region as specified in the purpose of the San Juan-Chama Project Act of 1962.

The Environmental Department of the State of New Mexico should continue to work closely with public water providers to ensure that residents have access to a safe drinking water supply. The Office of the State Engineer should work with acequias and public water providers to ensure that existing water rights in the region are preserved and used in the region. Water transfers and leases within the region between entities or individuals that utilize existing water rights in the most beneficial manner should be approved only after public notice and opportunity to protest. Acequia associations should strive to keep their water rights permanently tied to the land, but have options to lease and store unused water for beneficial use in the region.

All water users in the region (municipalities, acequias, Mutual Domestic associations, Native American tribes and Pueblos) should have conservation programs to use water in the most efficient manner. Conserved water should be made available for other uses within the region.

The New Mexico State Water Plan, adopted by the New Mexico Interstate Stream Commission on December 17, 2003, explicitly recognizes the importance of acequias and supports several goals that are supportive and compatible with the acequia culture and systems of the Rio Chama watershed. Examples of some of these goals are as follows:

- Provision of safe and adequate drinking water supplies, page 6 of 78
- Promotion of conservation and the efficient use of water, page 8 of 78;
- Protection of the acequias' senior water rights, pages 9-10 of 78;
- Completion of water rights adjudications, page 11 of 78; and
- Management of water by acequias, recognizing water sharing customs and water banks for preservation of cultural and local uses, pages 15-16 of 78.

The New Mexico State Water Plan strongly supports the goal of diversity in its policy statements, which is of particular importance to the Rio Chama watershed. Section C-9, page 44 of 78, New Mexico State Water Plan states that the plan should:

> "Consider water rights transfer policies that balance the need to protect the customs, culture, environment and economic health and stability of the state's diverse communities while providing for timely and efficient transfers of water between uses to meet both short-term shortages and long-term economic development needs."

Section C-13, page 52 of 78, establishes the goal: "Identify water-related infrastructure and management and investment needs and opportunities to leverage federal and other funding."

Appendix C, paragraph 3 of page 8, notes that the State Water Plan Act requires that the plan "identify and reflect the common priorities, goals and objectives that will have a positive impact on the public welfare of the state's waters." In addition, regional water plans are required to "provide for ...adequate review of...the effect of public welfare statements into their regional plans."

Appendix G, "Comment Synthesis Document," page 48, under "values and ethics," notes the strong sentiment of New Mexico citizens that "traditional uses of water have value" and that "water is the only thing keeping rural communities viable."

In addition, the Constitution of New Mexico provides that "The rights, privileges, and immunities, civil, political, and religious guaranteed to the people of New Mexico by the Treaty of Guadalupe Hidalgo shall be preserved inviolate".

An important aspect of protecting public welfare in a larger sense is the legal requirement that the State Engineer consider it when deciding whether to approve an application to change the place and/or purpose of use of a water right. In view of the State policies noted above, this Water Plan incorporates the following statement regarding how to protect public welfare in State Engineer decision-making:

In the Rio Chama Planning Region, public welfare depends on the stability and vitality of our communities that contribute historically unique and economically valuable tradition, culture, and landscape to New Mexico. There are three key principles critical to maintaining our community stability and vitality:

- **Keep water within our region for our future needs**
- **Provide safe, adequate, and reliable domestic and community water supplies**
- **Protect the culture as well as the physical infrastructure of the acequia system**

Flexibility to meet changing needs is essential, but must be balanced against the protection needed to maintain our culture and community structure. Most importantly, the extensive experience and local expertise of acequia and community water system officers should be given great deference by the State Engineer in considering transfer requests. Local communities are in the best position to determine what degree of flexibility in water rights transfers, and what kinds of new uses, may improve our economy and rural way of life without destabilizing long-standing and essential practices and traditions. Local background and expertise must be accorded very significant respect in the State Engineer's deliberations.

GOALS IN WATER PLANNING: PRINCIPAL CONCERNS AND UNMET NEEDS

In the Rio Chama region, the goals for water planners for the next 40 years and beyond are to get water where and when it is needed most, and to ensure that the existing needs for water are recognized and protected. It is important to preserve agricultural infrastructure so people will have the option to live on the land and the region will have potential agricultural capacity in the future. Although we have an expanding population and some communities need more domestic water supplies, our water needs are not as population-driven as those in most of New Mexico. In one sense we have always lived with a shortage of water. Our needs primarily involve protecting the water rights and water infrastructure we have, while finding ways to make the water we have serve our needs better in some areas.

Concerns and priorities for future water planning have emerged from discussions with residents and stakeholders that have taken place in many different venues over several years. Discussions have taken place in Advisory Committee meetings, at meetings of acequia commissioners and parciantes, at meetings conducted to gather input

for Rio Arriba County general planning, at meetings held specifically to discuss regional water planning in communities around the Rio Chama watershed, and in individual meetings with key stakeholders such as elected officials, water system operators, acequia association officials, and County staff. Notes and summaries of discussions from reg ional water planning meetings are included in Appendix A to the Water Plan. Questionnaires were distributed at meetings and by mail throughout the region, and responses to these questionnaires are also provided in Appendix A.

In all the discussions and feedback we have received over nine years, participants have said over and over that there is one main objective we need to achieve before any other goals will matter: **We need to keep the water (and water rights) we have within our communities and our region.**

If we can't keep water rights within the region our other water planning goals will serve little purpose. We need water to provide for growing communities, to make local economic development possible, and to preserve and enhance the agricultural opportunities in the Rio Chama watershed. Already 90 percent of the water produced in our watershed is available for use elsewhere, and we need to keep what we have.

To help do this, and make sure water is available when and where we need it, there are seven principal goals that the water plan seeks to address:

- **Preserve the acequia system and strengthen its role in community life;**
- **Enhance growing season streamflows (by increasing storage or other means) so that agriculture is less limited by low peak-season flows;**
- **Develop local agriculture with information, marketing, and financial support;**
- **Provide reliable water supplies to community water systems;**
- **Protect water quality;**
- **Conserve and reuse water resources where appropriate; and**
- **Protect and restore upper watershed areas**

If these goals can be met, water use and management within the Rio Chama watershed may offer some opportunities for win-win situations that could benefit users in other areas, but only if there are genuine benefits to communities within the region.

The importance attached by planning participants to protecting our water rights and the acequia system, not only as a means of delivering water but also as a vital part of every community in the region, can hardly be overstated. The highest planning priority, based on all discussions that have taken place in the region, is to maintain the agricultural way of life in the Rio Chama watershed and the acequia system that makes it possible. To accomplish this, we will need to preserve both our rights to use water and the physical infrastructure to deliver it where and when we need it.

Another major priority that was mentioned in virtually every discussion about water issues was to protect, or restore where needed, our upper watershed areas. It is an important goal of water management and planning in its own right; but it is also a powerful technique that can contribute to the achievement of the other goals listed above.

ALTERNATIVES: DISCUSSION AND EVALUATION

A number of alternative actions can be taken to help meet the region's goals. Specific alternative strategies are discussed below in relation to the planning goals they may help to achieve. The strategies are evaluated in terms of their technical, political, and financial feasibility; their social and physical impacts, and potential implementation schedule. Some strategies are evaluated individually while in other cases related strategies are evaluated collectively.

This Water Plan points out where problems and opportunities exist, and suggests the kinds of action that can be taken to protect or improve our water supplies. To be useful, it must be a living document that will be modified and developed in greater detail in the future. It has not been possible within the scope of water planning so far to analyze situations in each individual community or to provide detailed solutions to particular problems. The intent of the

Water Plan is to suggest the kinds of solutions that can help achieve our goals, but the administration and elected officials of Rio Arriba County, along with the residents of each community in the region, still need to decide which of these alternatives may be best, and how to implement them in their situation.

GOAL: KEEP WATER RIGHTS WITHIN THE REGION

The most basic water planning goal in our region is to keep our water rights within the region to provide for growing communities and to maintain agricultural opportunities. If we lose our water rights, our other water-related goals will be impossible or moot. Residents of the region understand that downstream communities also face pressing needs for water, but it is shortsighted in the extreme to look to water transfers from the Rio Chama to solve problems of urban growth in other areas. Every drop of water used in our region would not satisfy the long-term water needs of the state's major urban areas. Even if taking water from the acequias and communities of the Rio Chama would temporarily assuage the impending shortages in Albuquerque, Santa Fe, or other areas, the fundamental issues of growing demand for a finite resource would remain and the problems would be just as pressing. Transferring water from our region would only put off the time when fundamental limits to growing water demand have to be recognized – and the delay would be short.

One critical need in preserving traditional water rights is legal recognition for the physical fact that acequia water use varies dramatically from year to year, and acequias have a right to use the additional flows that occur in wet years. The aggregate total of valid water rights held within the region is significantly greater than reported average water use. As our region was settled, acequias were built and land brought under irrigation in a way that permitted flexible use of the highly variable runoff. Our field and acequia system evolved to allow farmers to take advantage of relatively high runoff to grow more food on more land, but still permit the system to work on a smaller total acreage in dry years. Accordingly, the total acreage irrigated and total water use varies with the weather and available streamflow. Acequias and parciantes hold valid water rights to irrigate the land that can be irrigated in times of adequate streamflow, even though not all that land is irrigated every year. Reported average water use figures take the diminished water use during dry years into account, and understate the quantity of water needed and used in periods of higher streamflow. In other words, even if reported average irrigation use within the region is 24,000 acre-feet per year, irrigators have a right to use significantly more water than that and water planning must recognize the larger need and use during wetter years.

It is also vital to protect existing communities and water users from unsustainable demands or water transfers by new development that is not supported by adequate water rights and real, viable water delivery infrastructure.

Strategies to keep both domestic and agricultural water rights in the region overlap with many of those needed to preserve and strengthen the acequia system, since the two goals are closely interrelated. In particular, the strategies that will help insulate acequias from undue economic pressures and promote local water banking will also help keep water rights within the region. A number of these alternatives are discussed and evaluated below. In addition, however, Rio Arriba County along with residents, parciantes, and water users throughout the region should be vigilant, stay aware of proposed water rights transfers, and use all legal means to protest harmful transfers.

Strategy: Be vigilant about proposed water rights transfers

Individual residents, parciantes and officials of acequias, associations of acequias, and Rio Arriba County officials should pay attention to legal notices and any other means of staying informed about proposed water rights transfers and evaluate the effects of any proposed transfers. In addition, it is important to stay abreast of proposed legislation or changes to policies or regulations at the Office of the State Engineer, the Interstate Stream Commission, the Environment Department, or other agencies. One constructive way to do this is to participate in the water planning process as it continues into the future.

Legal and political avenues exist to protest and resist water rights transfers that would be harmful to the region, and to influence proposed legislation or regulatory changes. Water rights transfers can be challenged (or supported) in hearings before the State Engineer, or in district court. Legislation and regulatory changes can

be influenced by contacting elected representatives, by testifying at legislative committee hearings, by lobbying legislators, by correspondence, and by organized political activity. However, none of these avenues will be effective unless we as a region can stay informed about what's going on.

The results we might hope for from this kind of involvement in the regulatory and political processes are discussed in detail below in terms of the strategies that could help achieve our water planning goals. The effects of these strategies are evaluated as appropriate in the remainder of this section of the water plan.

Strategy: Provide County support for water rights and infrastructure

Rio Arriba County, as the only government jurisdiction with responsibilities throughout the planning region, is uniquely positioned to help preserve our water rights as well as to assist with water-related infrastructure. Some County actions that seem most likely to be useful include:

- Hire or retain a hydrologist to provide in-house expertise for the County and its water users, including acequias, Mutual Domestic water systems, and communities faced with decisions about water supplies, and County staff and elected officials.

- Establish a Water Resource Commission of residents with background and interest in water affairs, to make recommendations to the County Commission and staff on matters affecting our water supplies and use, such as reviewing water rights and infrastructure proposals in development applications and providing input to State Engineer staff on water rights transfer requests.

- Purchase or otherwise acquire water rights that could be stored and/or banked among water users within the region to assist with times of water shortage.

- Help coordinate and perhaps provide administrative assistance for water sharing or water banking agreements among water users.

- Consider funding assistance for water infrastructure by issuing bonds and helping to coordinate or leverage other funding opportunities.

- Establish a Public Lands Commission to negotiate with and provide input to Federal and State agencies that affect the County and its residents.

GOAL: PRESERVE THE ACEQUIA SYSTEM

Acequias, existing in every community in the region, are the mechanism for irrigation water delivery, part of the fabric of community, and a political subdivision of government in New Mexico. For these reasons, along with their historic significance and their role in maintaining the landscape of northern New Mexico, residents in the region feel strongly that their preservation is one of the most important water planning goals. The acequia system is vulnerable to the prospect of piecemeal transfers of water rights because (1) acequias depend on participation in cleaning and maintenance activities by everyone along the ditch, and this need would still exist even if certain parcels no longer had water rights; and (2) because a certain volume of water is needed to ensure adequate flows for all parciantes. If a significant number of parciantes were to transfer water rights elsewhere, there might not be enough flow in the ditches to reach downstream properties. In addition, the physical and cultural fabric of a rural and agricultural community would be damaged if a patchwork of fields were to dry up and too few people were left with the skills and knowledge to maintain the acequias.

Perhaps the most pressing danger to the acequia system comes from economic demand for acequia water in growing urban areas. Advisory Committee members, along with everyone else who voiced an opinion in water planning discussions, believe strongly that the unique cultural position of acequias in northern New Mexico, along with their unique political position as subdivisions of government, mean that acequia water rights should not be regarded simply as economic commodities to be bought and sold at will. Committee members support the idea that acequias should be entitled to a special legal status in water law. The economic position of acequias and their parciantes makes it difficult for them to participate effectively in a cash-driven water market, even though the economic and cultural values of acequias in their communities is immense. Concerns discussed above about piecemeal transfers of water rights out of an acequia further argue for the idea that acequia water rights should not simply be

available to the highest bidder. At the same time, transferring water within or outside of acequia systems while maintaining water rights – water banking – may help keep some acequia systems sustainable.

Planning alternatives considered below would all serve the goal of preserving and strengthening acequias and their community functions.

Strategy: Insulate acequias from excessive economic pressures

Several social and institutional approaches could help insulate acequia water rights from an aggressive water market, without precluding the operation of water markets in other parts of the state. Some already exist, for instance the administrative bar to water transfers above or below Otowi Gage and the ability of acequias to prevent water transfers outside the acequia. These strategies or alternatives include:

- **Don't transfer water uses past Otowi Gage.** The de facto prohibition on moving the point of diversion of water uses across the Otowi streamgage should be maintained. The situation now, where water currently diverted above Otowi cannot be transferred to a diversion point below Otowi, effectively insulates water rights holders above Otowi from demand for their rights in the state's major urban areas. This administrative practice helps to maintain the traditional structure of water uses in the region, and should be kept in place and vigorously supported. Acequias, acequia associations, and individual water-rights holders should endorse this position to the State Engineer and the Interstate Stream Commission.

- **Keep water within acequias.** Individual-parcel water rights should not be transferred away from an acequia system. An acequia could, however, make an exception if a transfer would benefit local communities, such as augmenting Mutual Domestic water system rights.

  Since acequia commissions were given the legal authority by the 2002 Legislature to deny, under appropriate standards, transfer of water rights outside the acequia, this is the most readily available mechanism to achieve the widely supported goal of ensuring that acequias continue to have enough flow to maintain operation.

  Terms of leases for acequia water (if any were approved by particular Commissioners) are limited by statute to ten years. This limit could be maintained, made more restrictive, or otherwise modified.

- **Keep control of transfers, and monetary proceeds, in the community.** An acequia-based entity could be established to administer any approved transfers of acequia water and to disburse any funds relating to water transfers. A board or commission accountable to the acequia community would help to ensure that benefits of water leases or other arrangements accrued to communities, in a way that made lasting investments, rather than simply accruing to one acequia or individual parciante. This would prevent inappropriate incentives to transfer water away for short-term financial gain that offered little or no community benefit.

  Payments to individuals for water rights might be attractive in the short term, but loss of community water would have serious long-term effects for which communities would receive no compensation. Payments (if any water leases or similar arrangements were made) to acequias might be substantial enough to provide some useful community investment; and aggregated compensation to acequia associations or to an entity representing acequias in the county or the Rio Chama watershed could be large enough to provide a useful source of community investment (for instance, in water infrastructure, agricultural investment or outreach services, marketing assistance, or similar projects providing lasting benefit to entire communities).

- **Protect public welfare.** Consideration of public welfare in decisions about approval of water rights transfers may require denial or limitation of proposed transfers where there may be a detrimental effect on communities. The State OSE administrative procedures should specifically reflect this and address concerns of the parciantes to continue to support acequia operations and maintenance, as discussed beginning on p. 7-2.

Evaluation: Insulate acequias from excessive economic pressures

Technical feasibility

No significant technical impediments exist to implementing any or all of the alternatives discussed above for insulating acequias from outside economic pressures.

Political feasibility

Within the region there is widespread and strongly held political support for the goal of ensuring continued acequia viability, and preventing widespread or large-scale water transfers from acequias. The importance of bylaws allowing acequia approval of any water transfers can hardly be over-emphasized as the primary means of protecting acequias from damaging water transfers. Acequias already have this ability and exercising it, along with technical or legal support from acequia associations or Rio Arriba County, is probably the most fundamental protection available from undesirable water transfers.

A number of acequias have already adopted bylaws prohibiting transfers out of the acequia. In general the political acceptability of any of the alternatives would be good and the controversy minimal. The possibility of a community-accountable entity to supervise potential out-of-area water transfers and to administer or distribute any financial proceeds from such transactions in ways that would benefit communities (for instance, investments in acequia or agricultural infrastructure, agricultural development training or loans, etc.) has not been widely discussed and would need an independent process of consideration by residents and elected officials before it could actually be implemented.

Financial feasibility

The direct cost of implementing any of the alternatives discussed would be negligible. It could be argued that preventing transfers of water from acequias to other uses involves an economic cost in the sense of lost income, but it can equally be argued that preventing such transfers protects social and community values that would at least equal the market value of any transferred water rights. Attempting to quantify the net economic value of either income from water rights or non-market values of keeping the water in the region is beyond the scope of the Water Plan and quite possibly beyond any acceptable valuation in monetary terms.

Social and cultural impacts

The social impacts of allowing acequia systems to fall into disuse or to lose unacceptable amounts of water would be disastrous. The impacts of any of the alternatives for acequia economic protection would be minimal in comparison, and the ideas are widely supported and considered not only culturally appropriate, but vitally needed.

It can hardly be overstated that allowing water transfers without adequately considering the effects on communities would be a highly damaging example of allowing private gain at the expense of serious uncompensated public costs, and is something to be carefully avoided.

Physical, hydrological, and environmental impacts

As with social and cultural impacts, the potential hydrological and environmental impacts of failing to protect acequias from outside economic pressures are likely to be much greater than the impacts of implementing the alternatives listed above. If the local aquifer recharge effects of acequias were lost, many local residents would probably encounter diminished production in domestic or community wells. A considerable amount of songbird, mammal, and raptor habitat would probably disappear; the landscape of the Chama Valley would be drastically altered, and significant additional soil erosion and water quality damage potential would emerge as fields dried up. Abandoned fields are frequently ideal locations for weeds, particularly invasive non-native plants like Russian olives, saltcedars, and invasive thistles that can cause widespread damage throughout the region and even the State. Implementing the alternatives for acequia protection would simply protect the principal hydrologic and environmental features of the Rio Chama and its tributaries as they are today.

Implementation

The Otowi Gage transfer prohibition is already in effect and the alternative discussed simply proposes keeping it in place. A number of acequias have already adopted provisions in their bylaws preventing out-of-acequia transfers. Many others are likely to follow shortly. County officials should strongly encourage this. Similarly, the 10-year limit on lease term for acequia water is already in

place. The State Engineer is required by law to consider public welfare in reviewing water rights transfer applications, and should explicitly consider local effects on acequias and related community values when reviewing transfer requests within the region. Only the idea of setting up an institutional mechanism for ensuring that any water transfer proceeds are re-invested in ways that specifically benefit communities as distinct from individuals would involve any real departure from practices already in place or in process of implementation. Such a mechanism for community re-investment could, however, offer a significant source of funding for agricultural development that might be important in the long-term survival or acequias and farming in the region.

Strategy: Implement appropriate-scale water banking

Water banking is simply a process where water not used at some time by a particular right-holder is temporarily used by someone else, without loss or permanent transfer of the water right. Within a given acequia, the practice has gone on informally forever, but the 2003 legislature passed a law legally recognizing that an acequia parciante may allow others on the same acequia to use his or her water right without fear of losing that right through abandonment or forfeiture. The State Engineer does not have to act officially to recognize or approve this kind of water banking, and there are no particular impediments to doing it at any time, although good record-keeping is important to protect water rights. This provision is an important way for acequias to cope with variable water supplies and drought, and it should be used by acequias. It could also be a mechanism for providing additional water rights to Mutual Domestic water systems in some situations. If more storage options were available, water banking opportunities would increase proportionally.

Acequias and their parciantes should avail themselves of the opportunities that exist to bank and share water, to help manage water shortages and other challenges of water use in our region. On the other hand, an uncontrolled statewide or other large-scale water banking system that led to water from Rio Chama acequias becoming available in effect for auction outside local areas would be very harmful to our region and would be strenuously opposed. Water banking should be essentially a local management tool, although the appropriate definition of "local" has some flexibility. The discussion is still open as to what an appropriate scale for water banking would be, but it may well be advantageous to work with the Office of the State Engineer and the legislature to legally recognize a procedure for banking water within a tributary watershed (among acequias along, say, the Rio Brazos or El Rito) or among an association of acequias (like the Rio Chama Acequias Association or Acequias Norteñas, for example).

Whether or not water rights are fully adjudicated is not really relevant to transfers within a single acequia, but could be a limiting factor if transfers between acequias or from an acequia to another use are contemplated. Adjudicated water rights, or some other agreed-upon basis, is needed to establish how much water is available for banking in the first place. Inter-acequia water banking (on whatever scale) would in practice also require more accurate and documented measurements and water accounting than banking within a single acequia, and may require formal administrative approval from the State Engineer.

While it is quite helpful for parciantes on an acequia to be able to share water among themselves, it would be a great deal more helpful if unused water from one year could be stored for use in another year. This could in principle be easily achieved on the lower Chama by physical storage in Abiquiu Reservoir, but would be more difficult in other parts of the region because of the lack of existing storage facilities.

Evaluation: Appropriate water banking

Technical feasibility

No technical impediments exist to banking water among parciantes of an acequia at present. Banking water among different acequias or otherwise beyond a single acequia would require adequate water accounting, which could require additional measurements of diversions and/or return flows beyond current practice.

The possibilities and benefits of water banking within the region could be expanded greatly if it were possible to physically store banked water, or to make firm arrangements with other water users so that water banked in one year could be used in another. There are technical issues surrounding the construction of additional reservoirs or other means of physical storage (discussed in more detail below), but on the other hand there are few if any technical difficulties in making small additions to the storage pool at Abiquiu Reservoir for banked acequia water. Storage issues at Abiquiu would involve authorization and accounting rather than the physical presence of banked water.

Political feasibility

Water banking is widely viewed within the region as a two-edged sword. Banking on a local scale, within a single acequia or perhaps a somewhat larger local area, is widely supported, has always been done informally, and is an important drought management strategy. On the other hand, an unlimited statewide or large-area water bank is generally seen as an inappropriate way to "raid" local water that would operate to the detriment of local communities and acequias, and would probably be opposed by most residents of the Rio Chama watershed.

Financial feasibility

Small-scale local water banking would involve few if any additional costs. Banking within an acequia could generally be handled by acequia officials along with their other routine management duties and would probably not add too much to their workloads. Banking between acequias, however, might well require some form of accounting and measurement that no one is now responsible for. Acequia associations could logically assume this role for their area, but someone may have to be paid to do it.

Social and cultural impacts

The impacts of intra-acequia banking are viewed as positive, but the issues become more complex if the idea of water banking expands to include sharing water outside a single acequia. The impacts of large-scale inter-regional water banking to the culture and social fabric of the Rio Chama valley would certainly be viewed as seriously harmful.

However, water banking alternatives could be intermediate in scale between the single-acequia banking now possible and an unlimited statewide water bank. For instance, water banking could be allowed within a local watershed (such as among the acequias on El Rito or the Rio Brazos). Water banking could also be allowed within a larger but still locally defined area such as within an association of acequias, or on the Rio Chama, or above Otowi Gage. Participation in any kind of inter-acequia banking could also be subject to additional limits such as the duration of transfer, the percentage of water transferred, or a requirement that part of any financial proceeds from water transfers be invested in a community rather than being paid to private individuals.

Any kind of water banking will only work if water rights are clearly protected from forfeiture while banked, either within an acequia or between different acequias. It would be helpful if this were unequivocally recognized by the Office of the State Engineer in a timely way.

Given appropriate limitations and safeguards to the scale and effects of water banking, some form of water banking among regional acequias might be possible that would have beneficial social and cultural impacts, but the system would have to be thought through carefully and implemented cautiously, if any attempt were made to expand water banking beyond the headgates of individual acequias.

Physical, hydrological, and environmental impacts

The physical and environmental impacts of the scale of water banking envisioned within the region by any planning participants would be negligible, since relatively small amounts of water would be moved small distances. The overall operation of acequia systems and their relationship to the streams that supply them would not be altered except in details of water distribution and timing. However if large amounts of water were transferred out of the region, likely results would include lowering local water tables; displacement of wildlife populations; alteration of the landscape; and possible soil erosion and deterioration of water quality.

Implementation

Any of the water banking options considered here could

be implemented immediately, except for alternatives involving additional physical water storage. Providing additional storage could be a lengthy process if it involves new construction. It would be easier at Abiquiu Reservoir, but will require at least authorization and cooperation from federal agencies and the State Engineer. Water banking outside a single acequia would help to manage for drought and protect water rights, but this protection from forfeiture needs to be recognized by the State Engineer in a timely and efficient way.

Strategy: Maintain and repair acequia systems appropriately

Acequia maintenance is always needed and is frequently a cause for concern. The need for diligent and frequent maintenance is one of the principal reasons that individual water rights and upkeep responsibilities cannot be transferred away from an acequia system without harming the remaining parciantes. Many acequias manage these maintenance requirements reasonably comfortably and need little outside assistance at present. Others face especially difficult situations and would benefit immensely from outside assistance, which may be available although not easy to find (for instance, from the Corps of Engineers, the Office of the State Engineer, or legislative appropriation). The principal problems for which some acequias need help include:

- **Repairing certain ditch sections chronically prone to washouts, excessive leakage, or overtopping**
- **Designing and constructing headgates appropriately to withstand flooding**
- **Ensuring that enough active parciantes remain on an acequia to maintain an adequate labor and financial base.**

Acequias in our region are not interested in, and will vigorously oppose, any attempt at widespread or indiscriminate ditch lining or piping. There are undoubtedly certain locations where there are excessive ditch losses, or where water chronically leaks over or washes out a ditch, and targeted repairs would be beneficial in these locations. In general, however, water "lost" or "leaked" from acequia systems is not lost to the Rio Chama hydrologic system and serves important functions in recharging local aquifers, maintaining ground water levels, contributing to ecological and wildlife habitat values, and maintaining a valued and historic local landscape. Much of the water that might appear to be "saved' by ditch lining already recharges streams as baseflow from shallow local aquifers, so that the net effect of massive ditch lining would be little or no increase in Rio Chama streamflow. Streams, acequias, and irrigated floodplains in our region should be thought of as a single relatively interrelated riparian/ecological system, and a desirable landscape, rather than separate water conveyance devices; and "efficiency" must be considered carefully in the light of the entire system. Excessive attempts to make acequias more "efficient" by lining ditches, constructing intrusive, large-scale headgate works, and similar engineering approaches would do more harm than good in maintaining this integrated system.

Evaluation: Acequia repairs

Technical feasibility

Most acequia repairs are straightforward and relatively simple, and techniques for accomplishing them are well understood. However, techniques for building appropriate-scale headgates and diversion dams that can survive spring runoff or summer monsoon peak flows, and abrupt changes in dam release levels, would be valuable to regional acequias.

Political feasibility

There is widespread local political support for these alternatives, and opposition to wholesale ditch lining or other major physical alterations to acequias.

Financial feasibility

Some acequias are coping with their maintenance needs quite adequately with no outside financial support, but others, with more intractable problems and/or more limited membership, may need outside financial assistance. Funds are potentially available from the Interstate Stream Commission (in collaboration with the Army Corps of Engineers) or from the Water Trust Board.

Social and cultural impacts

Impacts from necessary repairs and maintenance are positive. Impacts to the landscape and to the kinds of ditch maintenance required from parciantes resulting from inappropriate modifications would be viewed negatively, as would additional costs or maintenance requirements for unwanted modifications.

Physical, hydrological, and environmental impacts

In some cases there could be noticeable and beneficial hydrologic impacts from carefully targeted ditch repairs – for instance, where chronic washouts could be prevented, or a section of ditch where gopher or other animal damage causes excessive and chronic leakage, or where a particular reach of ditch requires a disproportionate head of water just to reach downstream users. In general, however, ditches function reasonably well in supplying water without excessive losses. Water that does infiltrate beneath ditches generally recharges a shallow, transmissive riparian aquifer that is closely connected with surface flows, and any losses from a ditch can be expected to be offset by additional baseflow into the stream within a relatively short time. In these situations, indiscriminate lining or piping would probably have little or no hydrologic impact on overall Rio Chama flows, but would have considerable negative impact to the historic, aesthetic, and ecological values of the existing acequias.

Implementation

Implementation of these alternatives requires only participation by acequias themselves, and in some cases access to outside funding. State and/or federal agencies could be of great assistance in helping with the design of appropriate-technology, locally-built headgate and diversion structures. Measures described in detail elsewhere that prohibit individual transfers of rights away from acequias will also be beneficial in ensuring that an adequate number of parciantes remain on a ditch to ensure that maintenance can continue to be done.

Strategy: Modify the adjudication process

It would help complete the adjudication process much faster if the adjudication process could be modified to be more cooperative and less adversarial, cumbersome, lengthy, and judicial. The amounts of water in question for most parciantes are small in relation to the administrative and legal burdens on the State Engineer as well as on the individuals attempting to defend their rights. The existing process is highly disruptive, especially for small parciantes, and it is unreasonable that families and individuals should have to face the legal hurdles now placed before them.

The State Engineer and the acequias could work on a much more collaborative basis to quantify and adjudicate water rights. For instance, an administrative policy should be adopted to accept the validity of individual water rights within an acequia if the acequia agrees with the claim. Challenges should be prioritized to stop wasting resources on tiny claims, and to stop imposing unrealistic legal burdens on small right holders. A policy could be adopted to limit the resources expended on any individual subfile proceeding, for example, or not to challenge rights to irrigate less than a certain acreage (say half an acre). In addition, the OSE should accept the assistance of an acequia, its legal counsel and other expertise in subfile proceedings. The OSE and acequias could collaboratively develop other procedures that promote a less cumbersome process for resolving issues such as errors and omissions, priority dates, and customs of use. There should be an effective ombudsman or liason within the OSE who could be an effective advocate for acequias and their parciantes in the adjudication process.

Adjudication proceedings should recognize the unique legal status of acequias. Acequias are legal subdivisions of state government, local political systems, instruments of community cohesion, and historic monumentsæas well as water conveyance systems. They are also recognized under the Treaty of Guadalupe Hidalgo, and usually have quite senior water rights.

It is also important for the State Engineer and the adjudication process to recognize that acequia irrigation is by nature variable with the available runoff. Acequias and parciantes have valid water rights to use more water in wet years than they use on average.

Evaluation: Modify the adjudication process

Technical feasibility
Advances in the technology available to the Hydrographic Survey (such as more efficient and accurate aerial imaging and mapping) have made it possible to greatly speed up the ground work behind the adjudication process. The procedural changes recommended here would work well to take advantage of and build on the increased technical efficiency now available. Procedural streamlining and a more collaborative approach to the adjudication itself would require nothing new technologically, but could leverage the benefits of new technology.

Political feasibility
This alternative would enjoy widespread and enthusiastic political support.

Financial feasibility
The social and economic costs of the current adjudication system offer great savings potential. The existing system is inefficient and imposes disproportionate burdens on small rights holders. Transaction costs associated with litigating a multitude of small water rights claims probably far exceed any realistic market value for the rights themselves. Financial savings could be considerable if lengthy and expensive legal proceedings could be streamlined.

Social and cultural impacts
Within the region it would be considered beneficial if water rights could be adjudicated more expeditiously and with fewer burdens on small right holders. Residents of the region do recognize that the adjudication process must be considered fair in a statewide context, but the legal and hydrological situation pertaining to acequia irrigation is also unique to historically-settled parts of New Mexico and the amounts of water involved, even in aggregate, are not large so that it seems likely that a streamlined adjudication process, undertaken more collaboratively with the acequias and their commissions, could achieve both generally recognized fairness and greater efficiency. Families and individuals should not have to face the costs and legal challenges now required to defend small historic water rights claims.

Physical, hydrological, and environmental impacts
There are no direct physical impacts of the adjudication process per se. There could of course be physical and hydrological impacts if a substantial fraction of any existing water uses were ruled not to be valid, or if, after adjudication, there were substantial changes in point of diversion or use – but neither of these scenarios seems likely, and any such effects would be independent of the process of adjudication.

Implementation
Discussions have already taken place between acequia or acequia association representatives and staff in the Office of the State Engineer, but acequia interests have found past attempts at communication ineffective. Suggestions made have so far not been implemented, and developing a more efficient process will require a genuine commitment on the part of the OSE to make improvements.

GOAL: ENHANCE GROWING SEASON STREAMFLOWS

In most locations within our region, the factor that most severely limits effective water availability is the streamflow during the peak of the summer growing season, when irrigation demand is greatest and streamflows are usually near minimum. Increases in peak growing season flow rates will require changes in water storage upstream of the reaches where water is needed. Two basic approaches could potentially be taken to store more water throughout the year and make it available during the summer. Watershed management approaches seek to maximize the infiltration of water into the ground for "passive" or non-engineered water storage in soil and aquifers, so that water emerges gradually as streamflow rather than running off all at once torrentially. In contrast, engineered structures like dams and reservoirs or aquifer storage and recovery systems permit on-demand deliveries and could perhaps be built in a number of locations in the region. Local water users on the Rio Chama would benefit from being able to store water in existing reservoirs, which could be done easily. Tributary communities in particular would welcome additional water storage, and a number of small reservoirs or impoundments higher in tributary

watersheds might offer significant water storage benefits for local communities with minimal adverse effects (perhaps even environmental benefits) and reasonable cost. Neither approach will yield additional water quickly or inexpensively, neither can realistically be done without any outside assistance, and both would require significant maintenance over time. Nevertheless, benefits could be significant also.

About 85 percent of all the water that falls on the Rio Chama watershed evaporates more or less immediately where it falls, or is used by plants before it reaches either a ground water aquifer or a surface stream. An average of about 2,800,000 acre-feet per year of water evaporates or is transpired in this way from the Rio Chama watershed, so even a small increase in the fraction that enters the hydrologic system, whether as surface or ground water, could be significant. Unfortunately, many complex, interrelated, poorly understood, and difficult-to-measure processes affect precipitation and its fate in the hydrologic system. Simply cutting or burning some trees will not necessarily give us more water. However, there is evidence that how we manage the vegetation in our watersheds can affect not only the total quantity of water that flows out of the watershed, but perhaps even more importantly the timing of flows, the speed of runoff, and how long water is stored in the system. Paying attention to the hydrologic effects of vegetation may offer significant advantages anywhere in the watershed, but somewhat different approaches are useful depending on altitude and vegetation cover. Watershed management for hydrologic purposes at higher elevations focuses more on forest thinning, while at lower elevations the key is maximizing infiltration and minimizing surface runoff. At all elevations, it is critically important to maintain good grass cover, or establish it if necessary to promote infiltration and prevent erosion. It is also critically important to protect stream banks and riparian areas to protect water quality and ecological values. In some places it will be necessary to construct swales, check dams, or similar structures to stabilize the soil for vegetation to get established.

Strategy: Improve high-altitude upper watershed management

In higher-altitude areas, attention to hydrologic management of watersheds usually focuses on reducing overall tree density in hopes of reducing the amount of water transpired and increasing the amount of water that enters shallow aquifers and re-emerges as streamflow nearby. Thinning dense forests, so long as good ground cover is maintained, can increase total runoff and more importantly hold moisture in the ground and allow for runoff to take place gradually so that off-peak flows in the summer and fall are relatively greater. This kind of forest management, if carried out correctly in places where existing trees are dense, can reduce erosion and flooding, enhance some wildlife habitat values, and reduce wildfire risks while simultaneously enhancing stream flows and reducing the seasonal variation in flows.

There are many related factors that influence whether tree-thinning is an appropriate watershed management practice, even from a purely hydrologic perspective – including species composition, tree density, regrowth rates, ground cover, slope, soil, climate, geologic characteristics, altitude, and fire ecology. Other ecological, economic, and cultural factors in forest management may be as important or more important than hydrology in any given situation, as well.

To augment watershed management strategies involving fire, thinning, or other kinds of vegetation management, it may be advantageous to construct swales, check dams, or multiple small water impoundments to augment the effects of forest thinning or other vegetation management so that more water will soak into the ground and be stored in shallow aquifers for gradual release. These techniques are often associated with lower-altitude watershed restoration for erosion control, but they may be useful at higher altitudes to provide some of the benefits of engineered reservoir storage without the cost and difficulties of constructing major dams and reservoirs. Beaver dams at higher elevations can have a similar effect, suggesting encouragement for existing or re-introduced beaver populations. Relatively small-scale storage reservoirs serving local acequias or communities can be easily integrated into the kind of watershed management strategy envisioned here. Anywhere in the region, in fact, it will also be helpful to do anything possible to slow runoff, reduce erosion, and enhance infiltration of rain and snowmelt.

Size, location, and cumulative effects of stock tanks or similar small impoundments need to be evaluated carefully for each particular location, since instances have been reported of too many stock tanks impairing flows on acequias with senior water rights.

Watershed management approaches will of course need to be worked out in collaboration with the Carson and Santa Fe National Forests, since the Forests control the headwaters and upper watersheds of the region. The Organic Act that created the National Forest system stipulated that providing water for local communities was one of the basic purposes of a National Forest. Many watershed management techniques that work on National Forest land are applicable on private and land grant property as well.

Strategy: Enhance grass cover and infiltration in lower-altitude areas

Vegetation covering the soil surface, especially grass cover, is the single most effective means to control erosion and runoff and to encourage infiltration of rain and snowmelt that will become baseflow in springs, streams and arroyos. This is true at all altitudes and in all kinds of watersheds, but grass and other vegetation cover is much more often sparse at lower altitudes. Inadequate grass cover results in rapid runoff of rain or snowmelt, resulting in erosion damage to land and structures, excessive sediment and turbidity in streams, and drastically reduced infiltration of water into the soil and ground water aquifers. There are documented instances in New Mexico and other parts of the world of enhanced grass cover transforming seriously eroded arroyos that carried only flash floods into perennial streams with thriving riparian vegetation. This kind of watershed restoration, if it can be done on a significant scale throughout the region, could make a dramatic difference in the timing and quantity of surface water available, especially in smaller watercourses.

Structural erosion control measures including check dams, swales, or vegetated channels may be needed in some places to keep soil in place long enough for plant cover to become established. These structures reduce the velocity of the flowing water, filter or capture sediment, stabilize the soil, and help grass get started. Diverted runoff can be intercepted into diversion dikes, swales, or even storage ponds. Incentives and assistance are available to help landowners establish grass cover and install erosion control structures.

Evaluation: Improved watershed management

Technical feasibility

The first technical requirement for a successful watershed management program is accurate information on existing hydrological and ecological conditions, from which appropriate activities can be planned. Data are needed, at a minimum, on tree density and demographics, other vegetation cover, representative or indicator wildlife species populations, slope, soil type, and underlying geology.

It would be ideal to identify promising areas for watershed management pilot projects, such as areas where existing tree densities present substantial fire danger and stunt forest stand development, slopes are not too steep, and soil types would support good ground cover and provide opportunities for reasonably good infiltration. Limited-area thinning and/or burning projects could be designed for these areas, and the hydrological and ecological effects must be monitored to document the effects of the project. Successful projects could then be replicated and expanded in other appropriate locations.

It is important to understand that simply cutting or burning a lot of forest will not likely give the desired result of moderating hydrograph peaks and enhancing perennial streamflows – a real potential exists for flash flooding, massive erosion and sediment deposition followed by decades of poor forest cover if watershed manipulations are done incorrectly.

Restoration techniques for developing and maintaining adequate soil cover are generally easy, low-tech, well understood, and eminently feasible to implement. The goal is to get appropriate vegetation, usually grasses, started under the right conditions so that seeds sprout and develop into mature plants when there is enough moisture, and are not obliterated by poorly-timed or excessive grazing. Grazing can in fact be used as a potent restoration tool, if timing and intensity can be properly managed. Supplementary soil stabilization techniques like constructing swales on hillslopes or check dams in eroding arroyos can help keep soil in place in difficult locations long enough for vegetation to get established and begin protecting soil itself.

Both local communities and any potential watershed management projects would benefit from close community involvement in planning as well as carrying out project activities. Local residents have detailed local knowledge that could be helpful in planning and locating successful projects, as well as important perspectives and opinions on what projects should try to achieve. Local residents can and should also be involved both in working on actual forestry, grassland restoration, or other activities; and in monitoring their effects.

Political feasibility

Few region residents would have any problem with the goals of improved watershed management, but education and outreach is needed to build informed local support and get meaningful community involvement. Since the kind of activities that would make a difference in local water supply are generally beyond the scope of small communities and need to take place on federal land, it will be vital to build partnerships and compete effectively for funds. One of the most effective ways to attract funding assistance is a strong demonstration of local support for projects like these. To build this kind of articulate support will take continued, persistent personal communication, so that local communities have a comfortable understanding of the principles of sustainable (rather than purely extractive) resource use, and how these principles can provide tangible local benefits.

Financial feasibility

The costs of this kind of work are substantial, and outside financial support is essential. Watershed management in our region will need to be a collaborative effort involving local communities and the Forest Service and/or Bureau of Land Management. Many project possibilities will simply depend on agency budgets, and community political support for a clearly articulated goal, in concert with agency managers, will be the most effective way of funding watershed management activities. Other funding sources do exist, however, such as Clean Water Act section 319(h) funds, the Forest Service's Collaborative Forest Restoration Program, Natural Resources Conservation Service programs, or special appropriations from either federal or state legislatures. Many of these funding sources involve a local cost match, so even a relatively small dollar amount of local support, augmented by in-kind services, can leverage a large amount of outside funding.

Social and cultural impacts

The benefits of an appropriate watershed management strategy, carried out systematically and consistently over time, could be both positive and substantial in many ways other than a more stable water supply. Forest and rangeland management could provide stable local employment and contribute to community economic stability. Grazing management that contributes to overall watershed management could augment direct employment and financial benefits from forestry or grassland restoration. Forest and rangeland restoration, if done correctly, could augment wildlife habitat and promote ecological diversity, as well as helping to maintain a healthy and appealing landscape in northern New Mexico, with benefits extending far beyond the boundaries of local communities. Not least, a program of forest thinning and/or controlled burning in the right places could minimize the danger of large-scale uncontrolled wildfires.

Lasting and helpful watershed management will be less difficult, and overall benefits greater, if local community representatives along with agency personnel, grazing associations, acequias, environmental interests, and other stakeholders can all participate in articulating a vision of sustainable community interaction with the land and ecosystems of the Rio Chama watershed. We can make a living from the land in a way that enhances its ecological values and the benefits to our communities from a healthy landscape – the immediate need is to map out concrete steps we can take to move in the right direction.

Physical, hydrological, and environmental impacts

Forest thinning for the purpose of increasing water yield is best conducted at higher elevations where the precipitation rate is higher, where vegetation has slower regrowth rates, and where geologic conditions permit some appreciable soil or shallow-aquifer water storage. The mixed conifer forests at lower elevations have faster regrowth rates, higher consumptive use upon re-growth, and therefore greater need for frequent re-thinning if water yields are to be maintained. Unfortunately, water yield increases in thinned forests are greatest in wet years and lowest in dry years (when they are needed the most). Studies conducted in Colorado showed that forest thinning in dry years resulted in water yield increases that were only about one-quarter of the increases in wet

years. Additional water yield that results from thinning trees will diminish with time as the forest re-grows, unless thinned conditions are maintained.

The expected increase in water yield generally depends on annual precipitation, the types of vegetation, the proportion of canopy that is removed, and the re-growth rate of the vegetation. Based on work conducted in various forest thinning projects in the western states, up to one inch of additional water may be yielded over the thinned area in suitable forest land.

Forest thinning can have adverse effects such as higher peak flows and more destructive runoff if carried out incorrectly. These higher peak-flows increase surface and channel erosion, cause massive sediment movement, and degrade water quality. Further study is needed to determine the potential gains from and optimum locations for forest thinning, as well as the costs and potential adverse effects from alternative management strategies.

Building many small impoundments, swales, check dams, or encouraging beaver dams would not necessarily require engineered water release works, but would operate "passively" to detain water during peak flows that would infiltrate into shallow aquifers for gradual release back into streams as local baseflow. This kind of dam or impoundment should be thought of more as an augmentation of watershed management strategies rather than dam and reservoir construction in the traditional sense; but such techniques do have the potential to moderate the flashiness of runoff patterns and result in more steady flows during low-flow periods such as peak irrigation season. Detention ponds decrease the potential for downstream flooding and stream bank erosion and also improve water quality by decreasing the suspended sediments and turbidity. The most favorable locations for these small ponds are in recharge reaches that are permeable and encourage infiltration into local aquifers, which in turn discharge relatively rapidly back into streams. Cumulative effects of constructing impoundments should be assessed carefully and monitored to ensure that the desired effects of infiltration, storage, and gradual release are being achieved rather than excessive evaporation or other impairment of flows that may have senior rights. This kind of small-scale detention pond construction can complement revegetation efforts wherever needed, at all altitudes and in all kinds of watershed geography.

Implementation

Ground work to build community capacity to participate in planning watershed management options with the Forest Service or other federal agencies could begin tomorrow, and in fact has already begun with the process of envisioning and adopting a Rio Arriba County general plan. A catalyzing entity, such as the County or perhaps acequia associations or Northern New Mexico Community College, will be needed to convene meetings, help make information available, guide discussions, and make sure that all parties are heard and concerns addressed.

Beyond community education and empowerment to participate in formulating appropriate watershed management strategies, a more formalized venue for collaborating with the Forest Service and other stakeholders in designing and implementing specific activities will be needed. A formally recognized watershed association or collaborative local consensus group may be desirable; or alternatively more loosely structured consultation among stakeholders (including community members) and agency management may be adequate if it is taken seriously by all parties and continues over time.

Both community participation and agency cooperation might be catalyzed effectively around preparing a proposal for watershed restoration to be funded by the Environmental Protection Agency or the Forest Service (or perhaps other funding sources). Programs like Clean Water Act section 319 or the Collaborative Forest Restoration Program can provide tangible incentives for undertaking the kind of community work needed, and can build the bridges between stakeholders and between communities and federal agencies that can continue beyond the particular projects that might be funded.

Many laws regulate actions such as forest thinning and other surface disturbances conducted on federal land. These include the National Forest Management Act, the Federal Lands Policy and Management Act, the National Environmental Policy Act, the Clean Water Act, the Endangered Species Act, and the National Historic Preservation Act. It is important for local communities and non-federal stakeholders to recognize that federal land managers have to operate within these legal requirements, cumbersome as they may seem at times.

Strategy: Reservoir storage

Many irrigators and acequia parciantes have mentioned the limitations imposed by low summer streamflows, and the need for additional water storage. There are three general reservoir-storage alternatives: storing water in existing reservoirs, building multiple small-scale new reservoirs on acequias and/or Rio Chama tributaries, or constructing a new reservoir or multiple new reservoirs high in the watershed.

- ***Water storage in existing reservoirs***

Acequias and farmers below Abiquiu Dam would benefit from storing relatively small quantities of water in Abiquiu Reservoir. In theory, no new storage space is available in Abiquiu Reservoir without congressional authorization, and any significant quantity of additional storage could impact both private landowners and the Wild and Scenic reach of the Rio Chama above the reservoir (water stored in the reservoir cannot legally cover the protected part of the river, except for emergency flood control storage). However, storage of a few thousand acre-feet of water would be technically feasible, would make up an insignificant fraction of Abiquiu's total storage easement of 184,000 acre-feet, and could in practice be done within existing storage easement allocations by subcontracting with current contract holders such as the City of Albuquerque.

In addition, a considerable amount of storage space has been lost in Abiquiu Reservoir due to siltation, and dredging the reservoir could make additional storage space available.

Rio Arriba County should purchase or otherwise arrange for water rights and storage space in Abiquiu Reservoir for the benefit of water users throughout the area below the reservoir.

Storage in Heron Reservoir is reserved for San Juan-Chama Project water, but the congressional authorization setting this limitation could in principle be changed, as could the current allocation of Project water that provides for essentially no deliveries within the entire Rio Chama watershed. Even if no diverted Project water as such is made available within the region, additional useful water supplies could be made available by allowing some native water storage in Heron Reservoir. Similarly, some storage space might perhaps be made available at El Vado Reservoir under certain conditions through negotiations with the Middle Rio Grande Conservancy District or the Bureau of Reclamation.

- ***Multiple small-scale local reservoirs on acequias or tributaries***

It would be possible to construct a number of relatively small reservoirs or impoundments on the upper reaches of many Rio Chama tributary streams, in collaboration with or at least with the approval of the Forest Service; or along acequias almost anywhere in the region where appropriate locations exist (similar to the reservoir serving acequias in Talpa, for instance). None of the reservoirs would need to be very large and they could successfully complement other watershed management improvements aimed at controlling rapid runoff and encouraging infiltration. However, they could be equipped with controllable outlet works and could supplement summertime stream and acequia flows.

In addition to the benefits of storing water, reservoirs along acequias or tributary streams would expand the opportunities already present for small-scale hydropower generation along acequias.

In contrast to controllable water storage that would benefit acequia and community water supplies, irrigators in the region have expressed concerns regarding the use of nominal "stock tanks" for essentially aesthetic or recreational purposes, and have suggested that such impoundments, or perhaps all impoundments, could be required to have outlets to release water when needed by acequias or senior rights-holders.

- ***Larger-scale reservoir storage***

It may also be feasible to construct somewhat larger dam(s) and reservoir(s) (similar in scale to Morphy Lake near Mora, for example) in the upper reaches of the watershed, probably on the Rio Chama or the Rio Brazos, which could make water available for irrigators above Abiquiu and perhaps for users in other parts of the region.

Evaluation: Reservoir storage

Technical feasibility

STORAGE IN EXISTING RESERVOIRS

Storing water in existing reservoirs would pose no appreciable technical problems. The impediments to storing water in Abiquiu or El Vado Reservoirs are the control of all storage rights by entities outside the region, but these entities (principally the City of Albuquerque for Abiquiu Reservoir and the Middle Rio Grande Conservancy District for El Vado Reservoir) could be approached for cooperative agreements allowing local users to store some water within the existing storage right structure.

NEW SMALL-SCALE RESERVOIRS

The first technical requirement for engineered water storage – dams and reservoirs of any size – would be appropriate siting, in terms of geological suitability for both the dam and the water it would impound. Considerations include, of course, dam safety; and also potential leakage into surrounding geological formations, potential storage capacity, environmental damage, and construction access issues. These are important even for small impoundments on acequias or upper headwaters, but the issues are likely to be easier and much less expensive to resolve for relatively small storage ponds or reservoirs (from perhaps 50 to 500 acre-feet) than for larger dams and reservoirs. A series of small storage reservoirs designed to release water at a controlled outlet would need the same basic geological conditions as a large reservoir, although on a much smaller scale. For small ponds that would operate "passively" by temporarily detaining water and maximizing infiltration recharge of shallow aquifers, "leakage" is the whole point and more water would actually be stored in soil and aquifer material than in open water, which would reduce evaporation losses.

NEW LARGER-SCALE RESERVOIR(S)

The same geological considerations – underlying geology, infiltration rates, storage capacity, and access issues that affect small-scale detention/infiltration ponds would be vital information for larger dams and reservoirs, Hydrologic characteristics of the watershed and stream system to be impounded would also need to be well understood in planning a larger-scale reservoir. The potential volume of water flowing past the proposed dam site would have to be known, as a long-term average as well as minimum and maximum expected annual water production and maximum/minimum streamflows. The effects of storage, release, and evaporation of water in a proposed reservoir or series of ponds would have to be quantified accurately to assess the effects on water rights holders and Compact deliveries. Virtually none of the information needed, either on hydrology and water supply for potential reservoirs or infiltration projects, or on project area geology, is now available. The first step in any water storage project would be a substantial investment in field data gathering and analysis.

Construction per se of either large or small dams/impoundments would not likely present unusual technical difficulties in Rio Chama watersheds, but much of the area where any such construction would take place is quite remote, and sheer access for equipment could be difficult and expensive, to say nothing of the potential for environmental damage in providing road access to remote wild areas.

Political feasibility

While there is certainly political support within the region for additional water storage, so long as local users actually reap the benefits, there are hurdles to overcome before new water storage structures could be constructed anywhere in northern New Mexico. One of the most significant would be the limitations imposed on any new reservoirs by the Rio Grande Compact, and this limitation may apply to water storage on any scale. A large new reservoir would also face the need for a major federal appropriation, with the political uncertainty and possible strings attached to such a project.

The Rio Grande Compact provides that New Mexico cannot store any additional water, in any reservoir built after 1929, unless a certain minimum quantity of water is held in storage in Elephant Butte Reservoir. In many dry years the water stored in Elephant Butte is not adequate to permit any additional water storage in Rio Grande Basin reservoirs, and therefore the investment in any new reservoirs could be for nothing in those years – precisely when the water would be most needed. Ponds or reservoirs holding less that 10 acre-feet are exempt from the Compact storage requirements, but much more than 10 acre-feet would be needed to make any difference to

flows in an acequia, and multiple 10-acre-foot impoundments built sequentially might be considered as one structure by Compact commissioners.

Apart from that provision in the Compact, any additional evaporation of water held in storage (and there would be some, even at higher altitudes) would add to the difficulties that already exist in meeting New Mexico's Compact delivery obligations. For small reservoirs serving a single community or acequia, evaporation could probably be offset by retiring certain irrigated areas, or perhaps by small allocations of San Juan-Chama water. Additional storage available for Rio Grande water at higher altitudes than Elephant Butte, Cochiti, or even Abiquiu Reservoirs could in principle result in lower overall evaporation losses if water could be stored higher in the basin, but the practicality of this option would have to be evaluated very carefully in the light of existing legal requirements for storage in Elephant Butte or Cochiti Reservoirs, and the actual capacity of any potential high-altitude reservoirs that might be built.

STORAGE IN EXISTING RESERVOIRS

Storing water in Abiquiu Reservoir for use by lower Chama acequias, if it can be done within existing storage allocations, would need no federal political action and should be quite politically feasible. For water users in the region to have storage rights themselves, without having to depend on surplus capacity in other entities' allotments, would require changes in operating policy by the Corps of Engineers and/or the Bureau of Reclamation, and might require federal legislative action.

SMALL-SCALE RESERVOIRS

Building numerous small storage ponds would be a much smaller-scale undertaking than construction of a major dam and reservoir, and may well be more realistic as a result. It may be possible for such a series of small ponds or impoundments to be constructed using largely local resources, as was done in building the Talpa acequia reservoir in the 1920's. Alternatively, Natural Resources Conservation Service or other government funding might be available in the right circumstances. Forest Service agreement would be necessary if any impoundments were located within a National Forest, but moderate additional storage in the upper watersheds of Rio Chama tributaries would help maintain streamflows and could be helpful in achieving forest management goals such as riparian ecological restoration or maintaining streamflow levels.

LARGER-SCALE RESERVOIR(S)

It would of course be a lengthy process demanding sustained local support to secure the kind of federal funding that would be needed to build a substantial new dam in the upper Chama Valley. Bigger investments have already been made in many other places, and nothing prevents Congress from deciding to fund such a project. However, it would be naive not to recognize that the political climate for such major water development projects is more difficult now than it has been in the past. Even if federal funding were potentially forthcoming, non-federal cost-sharing and /or at least partial cost repayment might well be required. Local communities should evaluate carefully whether the formation of irrigation districts or similar legal entities with taxation powers and collective debt repayment obligations would be in their best interest in the long run, if that were the price of dam construction.

Since most of the potential sites for any new reservoirs are federally owned, agency and congressional approval would be required, regardless of funding source; and federal environmental laws such as the National Environmental Policy Act, the Clean Water Act, and the Endangered Species Act would come into play. New Mexico water law would also require offsetting water rights for any water losses (like evaporation) resulting from new water storage.

It is difficult to gauge the scale of environmental damage that might result from new reservoir construction, or the reaction to any such proposal that might be forthcoming from the environmental community within or outside New Mexico. If any such large-scale dam and reservoir were proposed, local community interests would need to be considered carefully and adequately protected. Local political support would likely exist for new water storage in the area, so long as there were genuine and reasonably wide-spread local benefits. National environmental groups, and their position on any proposed large dam in the Chama Valley, would need to be considered as part of the political outlook for such a project.

Financial feasibility

Storage in existing reservoirs would entail no appreciable extra costs or financial difficulties.

Smaller-scale pond, swale, and check dam structures in upper watersheds would be much cheaper to construct than a major dam and reservoir, but also might well require federal and/or state participation. This could take the form of a special legislative appropriation for particular projects, and/or funding by existing programs through agencies like the Environmental Protection Agency, the Forest Service, the Corps of Engineers, or the Natural Resources Conservation Service.

The important points about financing a large new dam have been discussed above: the need for substantial federal appropriations subject to the vagaries of the political process, and the possibility of strings being attached to the appropriations in the form of repayment or other obligations. New large-scale reservoir storage certainly could be financially feasible, but only if the federal government chooses to become involved.

Social and cultural impacts

Additional summertime irrigation water from any of the alternative sources would certainly have beneficial effects for the agricultural communities along the Rio Chama. Local communities feel that they were unfairly excluded from the benefits provided by the San Juan-Chama project, and that additional water storage provided by some other means would help redress that situation. However, these benefits would have to be weighted against possible negative effects of any additional financial obligations imposed on communities or individuals, or of any requirements to form conservancy districts or other legal structures that do not exist at present.

Storage in existing reservoirs

No negative social or cultural impacts are anticipated if local users were provided storage space in any of the existing reservoirs. Local benefits would be immediate and appreciated, in proportion to the amount of water that could actually be stored.

Small-scale reservoirs

Some of the potentially problematic impacts of a large reservoir would be much diminished for smaller storage impoundments. It seems much less likely that legal requirements such as formation of conservancy districts would be necessary, and recreational complications or other outside influences would be less. Smaller reservoirs serving individual acequias could quite possibly be built with local effort and financing, which could simplify the entire undertaking.

Larger-scale reservoir(s)

Dam and reservoir construction would provide jobs while structures were being built, but would provide few long-term jobs once completed. An additional effect, positive or negative, arising from a large reservoir would be an increase in flatwater recreational opportunities. These would offer some employment possibilities and other economic opportunities, and also some attendant changes to the character of affected communities. It is difficult to quantify or evaluate objectively, but residents might well feel a generally increased sense of outside and government presence in local communities as a concomitant of building any major water infrastructure in the area.

Physical, hydrological, and environmental impacts

The intended effects of additional water storage would be principally an increase in available irrigation water during peak needs, and in some circumstances additional or more dependable community domestic water supplies. There would also be some increase in open-water evaporation losses.

Storage in existing reservoirs

Physical effects of additional storage in region reservoirs for local users would be negligible, apart from the benefits of additional water availability. The reservoirs do have a maximum capacity, so the real issue is apportioning the available storage between the various parties involved.

Small-scale reservoirs

The total volume of water that could realistically be stored in a series of small ponds on acequias or tributary streams would be smaller than that potentially available in a large reservoir, but (depending on the particular stream and acequias to be served) even a few hundred acre-feet of storage from May to August could make quite a difference in the reliability of acequia irrigation in midsummer, and could provide water later into the growing season. Storage on this scale, and at relatively high altitude, would minimize the amount of water lost to evaporation. Relatively small impoundments would also minimize the negative impacts of constructing additional water storage, such as destruction of existing river reach-

es and riparian areas. Small impoundments, especially if many were built, could also help maintain stream flows for aquatic organisms and other wildlife downstream, as well as moderating storm runoff. Storage reservoirs or ponds on acequias could be constructed entirely away from stream channels and riparian areas and therefore cause no negative stream impacts at all.

Morphy Lake, on the eastern slopes of the Sangre de Cristo Mountains near Mora, provides an interesting example of what might be called an intermediate-scale reservoir. It is created by impounding a stream with a dam, but is much smaller than any of the reservoirs in our region. The environmental impacts caused by fluctuating water levels typical of storage reservoirs are mitigated at Morphy Lake by an agreement with the New Mexico Department of Game and Fish to maintain a minimum pool level, and the lake is in fact used as a State Park
.

LARGER-SCALE RESERVOIR(S)

The total volume of water available in a large-scale reservoir or reservoirs, perhaps cumulatively similar to El Vado in size, could be much greater than that available at any given time in a series of smaller reservoirs, or made available to region users in existing reservoirs. However, the potential for unintended or less welcome effects would also be more of an issue with a new large reservoir. These effects include the loss of significant high-altitude riparian area, loss of high-quality coldwater fish habitat, environmental and water quality effects from roadbuilding and other construction activities, possible impacts to endangered species, and diminished total streamflow. It is important to realize that the total volume of water in the Rio Chama stream system, on a long-term basis, will be diminished by any additional evaporation caused by new reservoir storage – even if the timing of water availability is improved by reservoir storage and controlled release. On the other hand, total net evaporation on the Rio Grande system might possibly be reduced by storage of water at higher elevations with lower evaporation rates, if that storage replaced some current storage at low-elevation reservoirs like Cochiti or Elephant Butte. The tradeoff in considering a new large-scale reservoir is between increased usability of the water supply available to us, and diminished total streamflow with some degree of environmental loss.

Another tradeoff that even now affects region water users is the ongoing damage to headgates and other irrigation works that results from water movement down the Rio Chama from existing reservoirs to downstream destinations. This problem would have to be carefully considered if additional large-scale water storage were to be proposed for the Rio Chama system. At the same time, it must be recognized that native cottonwood bosque riparian ecology along the Rio Chama, as with any southwestern stream, cannot be maintained in the absence of periodic inundation of the floodplain and some degree of geomorphological mobility of the stream channel that periodically creates new gravel bars and meander patterns.

Implementation

Additional storage at Abiquiu Reservoir could be implemented quickly, from a technical viewpoint, and would only require cooperating with an existing storage contractor. In the long run, it might be advantageous to secure storage space allocated to acequias in their own right, but for the time being storage could be implemented without this step.

None of the water storage alternatives that require new construction could be implemented quickly. Most would require some outside assistance and approval. Larger dams and reservoirs would be major undertakings done by the federal government only after congressional authorization and appropriation. Even smaller structures, if they were located on National Forest land, would probably be a largely federal undertaking and their implementation would be a political process. Small reservoirs on acequias could potentially be designed and implemented locally with minimal need for outside involvement, apart from arrangements with the State Engineer for water storage rights.

Strategy: Aquifer storage and recovery

There is an alternative to storing water in open reservoirs where an appreciable fraction evaporates – water can, in the right circumstances, be infiltrated or pumped into aquifer material, stored there underground, and pumped out later. This alternative can be expensive and requires a great deal of hydrological, geological, and engineering input; but offers the advantage of avoiding some of the evaporation losses associated with reservoir storage. It may not be a realistic option for most of the Rio Chama watershed because of geological constraints, could perhaps be used in the Española basin along the lower Rio Chama, and would be especially helpful if it were possible in the rest of the region where ground water resources are often limited.

Evaluation: Aquifer storage and recovery

Technical feasibility

Most of the technical requirements for information on geology and hydrology discussed above for reservoir storage would be needed for aquifer storage and recovery also. However, leakage into the subsurface is a problem for reservoir storage but is the key requirement for aquifer storage and recovery. Unfortunately, the geology of the upper Rio Chama watershed – crystalline, volcanic rock or Chama Basin sedimentary rock – is in general fairly impermeable and would appear to offer few if any possibilities for storing appreciable volumes of water underground. An exception to this generalization could occur if a substantial zone of permeable aquifer material was contained within the generally impermeable surrounding geology. The less consolidated sediments of the Española Basin towards the downstream end of the watershed seem more likely to be suitable for aquifer storage and recovery. Geographically the Española basin makes up a small part of the region, but it is relatively densely settled and smaller-scale aquifer storage and recovery projects might provide useful water storage for growing communities like Hernandez, Rio Chama, or Medanales. On the basis of the limited geological information available, it would seem that the opportunities for aquifer storage and recovery tend to occur where the overall need is least, but intensive local geological analysis would be needed to determine if a project were feasible in any particular location.

The New Mexico Water Quality Act regulates the quality of water that can be allowed to enter the aquifers of the state, and any injection of water into an aquifer storage and recovery system would be regulated by the Environment Department under the Act. In principle, any water allowed to mingle with naturally potable ground water must be drinkable itself, so water injected into an aquifer for later recovery would probably have to be treated to drinking water standards.

Political feasibility

Like other large-scale water storage possibilities, large-scale aquifer storage and recovery would basically be done by some outside entity, likely the federal government; and would require a political decision to fund the project. New Mexico water law does recognize the unique situation of aquifer storage and recovery in terms of water rights, but many of the same constraints and political issues (water rights, Rio Grande Compact compliance, geological information needed, outside political involvement) surrounding reservoir storage would apply to aquifer storage as well, even if a suitable project location could be found.

Financial feasibility

As with reservoir storage, financing for aquifer storage and recovery would probably have to come from outside the region and would depend on political decisions. It is possible that a smaller-scale aquifer storage and recovery system could be developed for local community needs that would be less technologically and financially daunting, but to date existing systems and conceptual designs have been large and complex.

Social and cultural impacts

In general, the same tradeoffs between the benefits of additional water versus the problems associated with an increased outside governmental presence in the cultural and political life of the region, and potential strings attached to a project, would apply to aquifer storage as to reservoir projects.

Physical, hydrological, and environmental impacts

In principle, the surface disturbance from aquifer storage and recovery could be less than that caused by a dam and reservoir, and water stored underground would not be subject to evaporative losses. There would be losses associated with capillary attraction to previously dry aquifer material – a certain amount of water would be lost in wetting soil, sand, gravel, or rock and would not be recoverable by pumping – but this would be more or less a one-time (and fairly small) loss rather than a continuing and potentially large one. There would be surface disturbance for road access, pumping and injection or infiltration facilities, and piping or other distribution systems, and the extent of the disturbance would depend on the scale of the project and the nature of the aquifer and overlying material. In general, an aquifer storage project would probably store a smaller volume of water at any given time than a reservoir, and account would have to be taken of the potential for movement of water downgradient in the aquifer.

Implementation

Aquifer storage and recovery, like reservoir construction, would require a lengthy process of study and political consideration in advance of any possible implementation of a major project. Extensive test drilling into potentially suitable aquifer material to verify its extent and hydraulic properties would also be needed.

Strategy: Appropriate flood or wet-year flows

As already mentioned, precipitation and streamflow in our watershed are highly variable, and the acequia system has evolved to take this into account. It is important for acequias and parciantes within the region to make it clear that they hold valid water rights to flows considerably in excess of average calculated water use. Historically, acequias have utilized enough water to irrigate all the land served by the acequia system, even though in many years streamflows are not adequate to irrigate all this land. **What may seem like "excess" water during wet years should not necessarily be thought of as unappropriated water available for use, since existing acequias already have rights to much of it**.

It still might seem attractive to apply to the State Engineer for rights to any genuinely excess flows (greater than can be used for irrigation) that occur during wet years or occasionally during flood events like summer thunderstorms. Unfortunately, there are two major obstacles to doing this: lack of storage, and whether any unappropriated water even exists.

Evaluation: Appropriation of flood flows

Technical feasibility

The main problem with appropriating any excess streamflow is the lack of storage space. While both Abiquiu and El Vado Reservoirs could potentially store additional water sometimes, storage rights in both reservoirs are entirely controlled by interests outside our region. There could be physical limits to reservoir storage capacity for flood flows, depending on prior storage volume and flow rates. In general, a relatively large reservoir would be need for any useful storage of wet-year flows, since to be useful they would likely need to be stored over a period of at least a year or two.

Political feasibility

The difficulties in finding storage for additional water are more political than technical in that the problem is getting authorization to use the existing reservoirs. In addition, any new application for wet-period flows would be junior to existing applications, which in practice makes it even more difficult to secure any "wet water".

Financial feasibility

If the storage and water rights issues could somehow be overcome, there would be minimal financial costs associated with capturing excess flows. There could be charges for storage, and perhaps for water accounting and distribution, however.

Social and cultural impacts

There would be few if any negative impacts to offset the benefits of additional water, if this alternative could be implemented.

Physical, hydrological, and environmental impacts

Additional water supplies from wet-period flows would of course be welcome, but would be by nature erratic and unpredictable. Stored water would be subject to evaporative losses, which could be quite substantial if water were stored over multiple years. Storage of wet-period flows would take place within the authorized storage pool at Abiquiu reservoir, but should be noted that storage issues at Abiquiu Reservoir are complicated by the need to maintain room for flood-control storage and the need to avoid impacting the wild and scenic reach of the Rio Chama, which is legally protected and extensively used for river recreation.

Improved watershed management, such as better ground surface vegetation or detention structures like check dams or swales, would make it possible to store some water that now becomes surface runoff in the soil and shallow aquifers for gradual release into streams later. This could offer some of the benefits of above-ground storage of wet-period flows without the impediments discussed above, and would increase total water storage in the hydrologic system in both wet and dry years.

Implementation

Impediments to implementation are the lack of storage, and water rights priorities, as discussed above. If these issues were somehow resolved, implementation could begin the next time there were any excess flows.

GOAL: SUPPORT LOCAL AGRICULTURE

Agriculture in our region, as in much of New Mexico, may not currently be a well-paid occupation but nearly 1000 farms contribute over $17 million a year to the Rio Arriba County economy. The preservation of workable agricultural infrastructure and the option of an agricultural way of life is a deeply felt and widely shared goal. Agriculture is a crucial part of life in our region and offers great future promise, both as a way of life and structure for our communities and as an important supplier of quality food for growing urban areas in New Mexico and southern Colorado. There are many opportunities for growth and development. Agriculture is inextricably intertwined with the acequia system and the fabric of our communities, because without our acequias farming would be nearly impossible, while at the same time the future of the acequias themselves is doubtful if there are no farms for them to serve. The strategies outlined below highlight the highest priorities for local agricultural development and assistance.

Strategy: Enhance marketing opportunities

Several local producers of both livestock and vegetables are successfully marketing a wide variety of agricultural products already, but the (mostly) prosperous and expanding urban areas of Los Alamos, Espanola, Santa Fe and Albuquerque, to say nothing of places further away, offer huge potential markets for local producers. There are also both government and private entities that can offer help to farmers with marketing ideas and other information. However, a need exists for coordination among the various sources of help to make sure that growers have access to the assistance they could most use and information is as widely available as possible. It would be helpful to have a contact person or office in Rio Arriba County, accessible and accountable to local growers, with the responsibility of coordinating locally relevant agricultural support services.

Such a person or staff could assist with coordinated marketing to local institutional buyers such as school districts, Los Alamos National Laboratory, Northern New Mexico Community College, Santa Fe Community College, or local food retailers.

One of the best long-range options for increasing the market opportunities for local growers would be to encourage food processing industry in the region, including particularly USDA approved meat-processing facilities, to expand the market for processed agricultural products outside the local area. This effort would involve working with local government, the New Mexico Economic Development Department, local growers, potential processors, and perhaps financial institutions including national social-investment organizations.

We should certainly not overlook the potential for supporting and investing in existing opportunities like farmers' markets or local retailers or restaurants willing to sell local produce. These outlets are already significant revenue sources for some growers and could be expanded.

Strategy: Help finance local agriculture

Operating or investment capital may not be a bottleneck for some established growers in the area, but it is certainly a substantial impediment to getting started in agriculture here as elsewhere, and little quantitative information is available on local agricultural capital needs. It would be helpful to survey the regional agricultural community to get a better idea what financial needs really are, so that targeted efforts could be made to address the real needs.

Several avenues could be open to providing additional capital or financial advice and support for local growers, depending on the scale and timing of financial needs. These avenues include local banks and credit unions, foundations, national social-service or socially responsible investment programs, government revenue bonds, loan guarantee arrangements, or even entirely new programs catalyzed or administered through Rio Arriba County or a local board or commission. One potential example of such a program could be a mechanism to invest proceeds from temporary leases or water-banking arrangements into local agricultural development as small grants or low-interest loans to growers within the region.

Strategy: Help with information sharing and technical assistance

A wealth of information is available on almost any imaginable agricultural topic, but finding the right information for real-world needs at the right time is at least as difficult for farmers as for anyone else in the information-overload age. Nevertheless, it can be extremely valuable to know what has worked or not worked for someone in a situation similar to one's own. A locally accessible person or staff could be very helpful in sorting through available information and sources of assistance to help local growers find answers to real-world questions and problems. Agricultural extension agents, in particular, already go a long way in providing this kind of service, but face severely limited personnel and resources. There is still a need for County-level program to assist in information sharing and technical assistance, and plenty of scope for getting the word out on relevant success stories, lessons learned (so they don't have to be re-learned by everyone), and techniques that work.

Another very important way to support agriculture in the future is to help find ways to involve younger people, beginning in high school or earlier, in local agriculture. This could be done with educational programs in school, mentorships, summer work such as YCC or similar programs, and encouragement to participate in farmers' markets. Within the school system, ways could be found to train teachers about water, acequia, and agricultural issues. Help could be provided with curriculum ideas, visits to classrooms by outside presenters who can explain aspects of these areas, field trips by classes to local farms, or perhaps a mobile exhibit on water and farming in our region.

It would also be helpful to have a centralized, easy access source for information on grant opportunities or other assistance, and help in completing application paperwork.

Northern New Mexico Community College could be well positioned to be a key player in providing this kind of information-sharing service.

Strategy: Collaborate widely

There are good people and organizations involved in many aspects of the agricultural support mentioned in the strategies just discussed. It is important not to duplicate efforts or inadvertently try to supplant valuable work already being done. At the same time, it can be bewildering to try to find the right place to look for help when it's needed, and some opportunities that could significantly expand local agricultural possibilities (like fostering increased local food processing) by nature require networking and collaboration to catalyze the desired results. It is hard to overemphasize the value of a "spark plug" in the form of an individual or effective small staff of people who can help connect existing sources of help, recognize the gaps, and get in touch with the right resources to fill the gaps. As an indication of the nature of the job that needs doing, the list below includes some of the principal entities that could play

significant roles in developing agricultural prospects and prosperity in our region:

- Northern New Mexico Community College
- University of New Mexico community planning program
- UNM-Los Alamos
- USDA Natural Resources Conservation Service
- USDA Rural Development Agency
- NMSU Agricultural Extension Service
- New Mexico Department of Agriculture
- New Mexico Department of Economic Development
- Small Business Administration
- Los Alamos National Laboratory
- Local financial institutions
- National socially responsible investment entities
- Non-profit social service organizations like the American Friends Service Committee
- Local and national foundations
- Existing local farm-support organizations, like the Southwest Marketing Network
- Local food retailers, wholesalers, and brokers
- Local or regional food processors
- Farmers' markets
- Local restaurants
- State and federal legislators
- Rio Arriba County
- City of Española

What's missing is largely just someone with vision and enthusiasm whose job is to put the pieces together.

Evaluation: Support local agriculture

Technical feasibility

There are no technical impediments to the kinds of agricultural support strategies proposed. There are technical aspects to some of the strategies, such as providing technical advice to growers, and perhaps some areas where technical research could be helpful, but the strategies proposed are completely feasible technically.

Political feasibility

There would be widespread political support for these kinds of initiatives within the region, and no known opposition externally. As discussed below, there would be some costs involved and there could be political opposition to incurring additional public spending.

Financial feasibility

None of the proposed strategies would involve any appreciable costs beyond staff or contractor compensation and office expenses. This, like any other public expenditure, would need to be weighed against the benefits it could provide and a decision made as to whether it is a high enough priority to justify spending public money. It would also be possible to seek partial or even total funding through private foundations, fees for services, and/or government grant programs.

Social and cultural impacts

The social impacts of successfully enhancing and expanding agricultural income and opportunities in the region would be dramatic and positive. Anticipated impacts include increased local income, additional support for local economies, additional opportunities for young people to find satisfactory employment locally (both on the land and in off-farm employment), more high-quality local food, and support for and maintenance of the agricultural community fabric that is highly valued. Economic support for an agricultural way of life has a great deal of cultural value even for community residents who are not directly involved in agriculture.

Physical, hydrological, and environmental impacts

The principal physical or hydrological impact would be to help provide resources and economic underpinning for maintaining the acequia system in working order. This will also help in maintaining skills and interest in using acequias, and help in keeping water rights in use.

Implementation

Implementation could begin immediately if Rio Arriba County chooses to hire someone to begin doing the job. Alternatively, funding could be sought from one of the alternative sources mentioned above before hiring someone for the position.

GOAL: PROVIDE RELIABLE COMMUNITY WATER SUPPLIES

Some communities in the Region have difficulty meeting their water needs while other communities have ample water for both present and projected needs. About fifteen out of twenty-two community water systems (68 percent – Cipriano Martinez, personal communication, 2002) cannot always produce sufficient water to meet community needs. About half of these systems draw water from aquifers in the north-central and northwestern parts of the watershed (within the Mancos, Dakota, Morrison, and Chinle aquifer systems); while the other half draw water from alluvial deposits with limited extent or thickness. In some cases water supplies might be improved by consolidating small water systems, transferring irrigation water rights to community water systems, or by optimizing the locations and depths of community wells. Other alternatives exist also, like collecting rain or snowmelt, enhancing aquifer recharge from surface water sources, or constructing surface water treatment systems, but these alternatives would be much more costly and/or less reliable than existing (generally ground water) systems.

Strategy: Consolidate community water systems if appropriate

In some cases, it may be beneficial for neighboring communities to consolidate or interconnect water systems to improve reliability or take advantage of opportunities that may not be cost-effective for a single small system. This alternative would most likely be beneficial where a consolidated system could afford new or relocated wells or other new water sources that single, smaller systems cannot afford (the Agua Sana water system is a good example). The feasibility of this alternative depends on water supplies, population density, engineering constraints such as elevation and piping design, and cooperation between communities.

Strategy: Develop alternatives for additional water rights where needed

Where a community's water supply is constrained by a lack of water rights, it may be necessary to transfer water rights from some willing provider to the community system. One alternative would be to explore water banking possibilities in the local area (usually, but not necessarily, involving a transfer from surface to ground water diversion). This alternative will only help in instances where there is additional "wet water" available in aquifers or otherwise, and the only limiting factor is the legal right to use it. If the problem is a physical shortage of water, that will have to be addressed separately from water rights. It is worth noting that if a local acequia or group of acequias finds it possible to make some fraction of its water rights available to a community water system, it provides an important mechanism for increased local control over growth rates and development patterns in that community.

It should remain possible to transfer water rights from individual wells to Mutual Domestic associations where the mutual system will supply water that would otherwise have been pumped to households from individual wells. In addition to maintaining this provision, however, it should be investigated, in collaboration with the State Engineer, whether a different mechanism can be found to enable some transfer of water rights into a Mutual Domestic system without necessarily requiring potential members to drill a well they have no need for apart from securing rights to transfer into the community system.

Strategy: Optimize locations and depths of community wells

Some communities in the region have already drilled new or additional wells to augment water supplies. There are likely opportunities for more communities to benefit from doing this, but the probabilities have to be evaluated on a case-by-case basis, with appropriate hydrological and engineering expertise, since regional geology is highly variable. Opportunities are generally best in the southern part of the watershed where the aquifers tend to consist of more permeable material and are deeper and more extensive. Finding better well locations or depths in the Chama Basin or in areas with volcanic bedrock will be more challenging, but may still be possible in some places.

Strategy: Consider other water supply alternatives

Most water systems in the region get their water from wells, although a few make use of springs or surface

water collected from streams. Treatment requirements for well water are less stringent than for surface water, making this alternative cheaper and easier where possible. Difficulties arise where aquifers simply cannot produce enough water for community needs, and other alternatives may have to be considered. So far, the cost and/or complexity of other means of providing water have been too great, but some alternatives that may be worth considering in the future include:

- Cisterns for catching rain or snowmelt from roofs at individual houses, to supplement community supplies;
- Enhancing recharge of shallow aquifers using water from acequias or other sources; and
- Constructing surface water intakes and treatment works directly on the Rio Chama or perennial tributaries.

Strategy: Conserve water and audit water use in community systems

Since, in our region, the great majority (over 94 percent) of water use is for irrigation, and in general little community system water is used for landscape watering, the total potential water savings from reducing the water depleted in domestic or community systems is much smaller than in other places where there is more outdoor water use. However, water saved in community systems may still be extremely valuable, especially in times of shortage. Even though some of the procedures listed below are now routinely done by many water systems, operators should consider performing comprehensive water audits, if possible, including procedures such as:

- Inventory available water rights, and explore ways to acquire additional rights if they will be needed in the foreseeable future;
- Assemble, or begin collecting, pumping records for community wells;
- Install and/or make sure of accuracy of meters on community wells;
- Consider installing meters at individual connections;
- Perform leak tests on the system as a whole (by comparing meter records for water pumped as compared to the total of water delivered through meters at individual connections, if possible); or on specific sections of distribution piping using listening equipment or other technology; and
- Systematically measure water levels in wells, so that trends in water table elevation over time can be observed.

Even before an audit is performed, some of these techniques for water conservation may benefit communities here just as elsewhere:

- Leak testing and repair on water system piping as well as on individual household plumbing, including evaporative coolers;
- Low-flow shower heads, toilets, and faucets;
- Low water use appliances, especially front-loading clothes washers;
- Gray water use in households where domestic water is used for landscape watering.

Strategy: Ensure adequate water supplies for firefighting

Firefighting does not use any appreciable volume of water as a percentage of total use, but does require some water in storage at all times. Additional storage could help many small water systems cope with fluctuating supply rates from marginal aquifers or springs, and would help ensure adequate firefighting supplies as well. In cases where adequate tank storage cannot be provided, all-weather access to streams ("dry hydrants") can be an important source of water for fire departments.

Strategy: Protect existing communities from unsustainable water use

In our region as in most of New Mexico, water is a limited resource – sometimes severely limited and used to its limits already. It is vitally important to ensure that existing residents and community water systems are not adversely affected by new water users, by regulating new housing development. Rio Arriba County must help enforce state subdivision regulations that require thorough hydrologic analysis to verify the existence of adequate water supplies prior to new development. The County should employ a staff or contract hydrologist of its own to evaluate the water supply impacts of proposed developments or water transfers.

Strategy: Provide additional support resources for community systems

Community water systems face many challenges in providing for their members, but they are crucial to the viability of many communities in our region. Many suffer from aging infrastructure and difficulties in coping with droughts if not operations in normal times. In particular, the new national drinking water standards for arsenic will affect some community systems and treatment alternatives are quite expensive. Some outside assistance will be required to deal with this situation. The New Mexico Rural Water Association can be very helpful in identifying funding or assistance sources and helping with regulatory or other requirements that complicate operating or upgrading water systems.

Strategy: Collect basic information about our water resources

One of the most effective ways to help region residents enjoy more secure and abundant household water supplies would be to begin systematically collecting some of the basic hydrological data that is still unknown for most communities in the Rio Chama watershed, like ground water depths and trends, or well production. Rio Arriba County itself could collect a great deal of useful information just by monitoring the depth to water in selected community wells, or in the U.S. Geological Survey monitor wells that have been drilled in several places throughout the region but are not monitored on a regular basis. Additional useful information that could be collected relatively inexpensively includes evaluation of well drilling logs, video assessment of well condition and depth for community systems, keeping well production records (which would require meter installation), and even installing remotely-monitored flow recorders on selected stream reaches. This kind of data, collected by County personnel or contractors directly or in collaboration with other agencies like the U.S. Geological Survey, would enhance our ability to plan effectively for future water supplies. Useful data could probably be collected for as little as $10,000 or $20,000 per year.

One particularly useful area for investigation would be a better understanding of the interactions between the Rio Chama (and perhaps principal tributaries) and the alluvial aquifers near the river. It seems likely that the river-aquifer system alternates between gaining and losing reaches a number of times as it flows through the watershed, but quantitative data are unavailable. This information would help in understanding surface water use and availability along the river, and also in understanding the connection between the river and the shallow aquifers that supply a number of communities in the region.

Evaluation: Provide reliable community water supplies

Technical feasibility

Technical constraints and possibilities for the various alternatives discussed depend on specific conditions in each community or situation and are difficult to discuss in an overall way. Techniques and engineering solutions are readily available, in general, for all the alternatives considered, although many options will not be suitable in any given situation, and cost will usually be the determining factor in selecting alternatives. The "Other alternatives" discussed are likely to be more expensive or problematic per gallon of water delivered in comparison to simply drilling wells and distributing water, but may be increasingly attractive in situations where ground water resources are questionable or inadequate.

Political feasibility

No particular political or legal difficulties would stand in the way of implementing any of these alternatives. Approval of the State Engineer would be needed for any transfers of water rights or changes in place or purpose of diversion (such as changing from acequia to community water supplies, or constructing new water diversions), or drilling new wells.

Financial feasibility

Paying for water supplies is often a challenge for small communities. Many of the alternatives considered would entail costs that could be substantial for small communities, except for those that involve actions by other entities, such as collecting hydrologic data or protecting existing water users from impairment by potential new develop-

ment. Transfer of water rights to a mutual domestic water users' association would not involve direct on-the-ground costs, but would likely require professional-quality hydrological assistance to prepare the required applications and supporting studies. Financial assistance is available for community water systems, including special appropriations from the New Mexico Legislature, and funds from the Water Trust Board, the NM Finance Authority, Environment Department, Department of Finance and Administration, the USDA Rural Utilities Service (formerly Farmers Home Administration), Corps of Engineers, and other sources. Community Development Block Grants and low-interest loans may also be available.

Social and cultural impacts

Mutual domestic water systems are important institutions in our region. In many communities, individual wells would be completely impractical as a water supply because historic settlements are clustered closely together. In many instances today, community water supplies are more reliable and less polluted than individual wells would be, and community systems would be preferable to individual wells as a way to serve any new development. It will be much easier to evaluate and regulate water supplies for new development, and to ensure that long-term supplies are adequate for the existing population, if domestic water is provided through community systems. Accordingly, it is an important goal to help community water systems work as well as possible and serve their members adequately. It should be emphasized that the County has an obligation to ensure adequate water supplies for existing residents and communities before allowing new development to make water demands.

Physical, hydrological, and environmental impacts

Overall hydrological effects of water system operation within the Rio Chama watershed are negligible because domestic water uses are such a small fraction of total water use. Optimization of water system operations would make even less difference in the overall picture. However, within the hydrologic system of a given local community, the point of enhancing community water supplies is to ensure that local demands do not outstrip supplies and make the most efficient use possible of the water available in a particular place. Since water supplies available to any particular community in the region are often limited, optimizing their use can be quite important.

Implementation

Initial steps towards implementing any of the alternatives proposed could begin immediately. Complete implementation of more complex alternatives like relocating wells or consolidating water systems would require considerable study and probably outside funding.

GOAL: PROTECT WATER QUALITY

We are fortunate in the Chama watershed in that there are no major point sources of water pollution, and water quality is generally good compared to many parts of the state. However, there are three principal causes for concern about our water quality: ground water contamination from septic tank effluent, surface water contamination from eroded sediment, and potential contamination of both surface and ground water from agricultural chemicals.

There are thousands of individual septic tank and leach field systems throughout the watershed, and these systems are a cause of ground water contamination in many areas. Installing community wastewater treatment in some areas would protect drinking water supplies and decrease possible exposures to disease organisms, nitrates, and other contaminants. The response so far to instances of widespread or serious ground water contamination (for instance, in Chamita) has been to provide alternative water supplies from so-far uncontaminated aquifers. This approach provides cheaper immediate relief from the problem, but in the long run it will be less expensive to stop ground water contamination in the first place than to search farther and farther for clean water, or to provide increasing levels of drinking water treatment to remove contaminants.

It should be noted that a few instances exist where ground water supplies naturally exceed the new EPA drinking water standards for arsenic, and even though this is not a result of pollution or any human activity, treatment of some sort may be required for community water systems in these areas. This kind of treatment is technologically complex, expensive, and will undoubtedly require some kind of government funding, such as the public assistance now provided to small water systems for water testing.

Strategy: Consider and encourage community wastewater treatment

Two principal options are available for centralized community wastewater treatment: small-scale standardized package plants that would replace individual septic tanks and leach fields, or centralized secondary or tertiary treatment that would replace individual leach fields and clean up effluent from existing septic tanks that would be left in place. Both options would require extensive excavation and piping, and trained operators to monitor the treatment plants. However, the communities of Chama and Abiquiu currently have centralized wastewater treatment plants, and other communities could easily follow their lead.

Evaluation: Community wastewater treatment

Technical feasibility

Wastewater treatment systems consist of two main treatments: primary treatment removes grit and larger material by screening, grinding, flocculation, and sedimentation; secondary treatment degrades and breaks down biological material using microorganisms. Some treatment systems also provide tertiary treatment that removes dissolved nutrients like nitrogen before releasing treated effluent.

Two kinds of wastewater treatment systems would be feasible for some more densely settled regions of the watershed. A conventional wastewater treatment system or "package plant" uses manmade structures and tanks for primary and secondary treatment. Treated effluent is either discharged to surface water under a Clean Water Act permit, or could be used for other purposes such as irrigating non-edible crops under a New Mexico Water Quality Act permit. A second type of treatment plan uses a constructed wetland for secondary treatment. Constructed wetlands can be either subsurface flow systems, where water percolates through a permeable medium (typically soil, sand, gravel or crushed rock) below the surface and is treated by the action of microbes on soil particles and plant roots, or open water systems that simulate natural wetlands with shallow open surface water.

Both conventional package plants and treatment systems with constructed wetlands are well understood, easily adapted to varying sizes, and highly feasible technically. The only real constraints to installing centralized wastewater treatment plants in small communities are the overall economics of plant and operator financing, and the need for extensive trenching and piping to connect relatively dispersed housing to the plant.

Political feasibility

There is widespread support for protecting water quality and even for the idea of community wastewater treatment. There might be significant resistance, however, to additional fees for financing centralized wastewater treatment. The level of user fees needed and hence resistance to community wastewater treatment might be minimized by selecting a relatively densely settled area where per-capita costs would be less. Residents in areas with shallow ground water have strong incentives to protect ground water quality for their own health, and this factor – along with a chance to avoid having to find and pay for distant, alternative water sources – argues in favor of community wastewater treatment.

Financial feasibility

Just as with improvements to community water supply systems, wastewater treatment will not be cheap. There would be significant costs for engineering design as well as for construction, and subsequently there would be some costs for operation of the system, which would have to be overseen by a licensed utility operator. Many of the same potential funding sources for water supply system needs may also be able to help with wastewater treatment: the New Mexico Legislature, the Water Trust Board, the New Mexico Finance Authority, Environment Department, and Department of Finance and Administration, the USDA Rural Utilities Service (formerly the Farmers Home Administration), the Corps of Engineers, Community Development Block Grants and low-interest loans. The New Mexico Rural Water Association can help in this area as well as with water supplies.

Social and cultural impacts

Centralized wastewater treatment facilities are beneficial to communities for many reasons. First of all, water resources are better protected from pollutants. These treatment facilities are monitored and work well, while individual septic tank/leach field systems have already caused ground water pollution in many parts of the region. The treated discharge from a wastewater facility can be used for other purposes. This water could be used to irrigate non-edible crops (as is done in other parts of the state), or could be used instead of high-quality water for other purposes. Once a wastewater treatment facility is in place, it helps encourage housing growth in a centralized, denser pattern instead of maximizing sprawl. This in turn reduces the cost of the community wastewater treatment as well as community water supplies and other infrastructure systems.

Many community members in the Rio Chama region have expressed interest in installing wastewater treatment systems. Where individual septic tank/leach field systems continue to be used, existing regulations on septic tank construction and location must be enforced more effectively. Wastewater treatment facilities would work best in areas of higher population densities. These are areas where the contamination problems are greatest, and where it is more feasible to implement a centralized system because piping installation would involve the shortest distances and therefore would be more cost-effective.

Physical, hydrological, and environmental impacts

The principal anticipated hydrological effect would of course be a decrease in current and future water pollution from inadequately treated sewage effluent. The potential for significant unintended hydrologic consequences from wastewater treatment seems small, although flow patterns in streams could be changed, for instance, or wetlands created, if wastewater that is now discharged underground to many dispersed leach fields were to be discharged to the surface at a single discharge point.

It would be necessary to find an appropriate place to locate community wastewater treatment facilities, ideally where flow to the facility would not have to be pumped and treated effluent could be discharged nearby. There would be some land disturbance and inconvenience to residents during the process of excavating and laying pipes to a new wastewater plant, and perhaps some impacts from construction, although the footprint of a wastewater treatment facility itself would be fairly small. There would be some potential for odors from the plant as well, even though the fugitive odor from a plant is relatively minor when it is operating correctly, and a subsurface wetland is generally odorless. Constructed wetlands for wastewater treatment can be a viable alternative, but surface wetlands present operational challenges in our climate where summer and winter temperatures vary greatly. Subsurface-flow wetlands, where water does not normally appear at the ground surface but rather flows through the wetland a foot or two below grade, often work better.

Implementation

The first step in implementing any community wastewater treatment would be to identify the communities where the need was greatest and the potential impediments (for instance, facility siting and trenching problems) least; and to put together possible financing for the project. If support were forthcoming from the community or communities in question, there would not likely be any other extraordinary problems in implementing any of these alternatives.

Strategy: Encourage or require better individual liquid waste treatment

In the many parts of the region where community wastewater treatment will not be practical in the foreseeable future, there are still options for better protecting our water quality from damage by inadequately treated liquid waste. A conventional septic tank and leach field can adequately protect ground water quality when properly constructed and used in the right circumstances. It is important for the system to be properly sized and installed only in areas where there is a substantial depth of soil between the leach field and the water table, so that there is plenty of opportunity for filtration of the effluent water, neutralization of pathogens, and removal of nitrogen. In many settled areas of the region, the water table is quite near the land surface and septic systems do not work properly at all. Community wastewater treatment is often the best alternative in these situations, from a technical viewpoint, but

there are other individual wastewater treatment alternatives available that may be better than poorly-functioning septic systems. Some of these are:

- Subsurface flow constructed wetlands instead of conventional leach fields;
- Pumice-filled leach field trenches to enhance aerobic treatment processes and make effluent more available for plant use;
- Elevated leach fields to provide more distance above the water table;
- Aerobic waste decomposition; and
- Composting toilets.

The first step in protecting our water supplies from human waste contamination should be to bring existing systems at least into compliance with the law, since there are many existing residences in the region that are not equipped with legally approvable septic systems. These may be old cesspools that provide little waste treatment, deficient septic systems, or septic systems installed in illegal locations (usually too close to the water table or to domestic wells).

Rio Arriba County will likely need to play a more active role in collaborating with the Environment Department in enforcing liquid waste treatment regulations to protect drinking water and public health. The County and/or the State should seriously consider the value of providing incentives (or at least aggressive outreach and education) for installing some of the alternative treatment systems mentioned above in appropriate locations where centralized wastewater treatment is infeasible.

Evaluation: Better individual wastewater treatment

Technical feasibility

Proper septic systems design and installation is well understood and readily available. It isn't free, but qualified contractors can be found throughout the region. While information is certainly available on more "alternative" systems, it is not as easy to find qualified designers or installers. Regulatory approval may be harder to obtain for some alternatives, even though there are provisions in State liquid waste regulations for variances and alternative designs. In some cases design by a professional engineer may be required. Some non-traditional alternatives, like composting toilets, may require more maintenance than conventional septic systems, but there are certainly working, feasible examples. It is also true that there have been instances of poorly functioning alternative systems, and extra care must be taken in their design and construction.

Political feasibility

Responsibility for enforcing existing New Mexico liquid waste regulations lies with the State Environment Department, which is generally understaffed and underfunded for the job. New Mexico Counties are not typically involved in wastewater management and regulation, but it may well fall to Rio Arriba County to act as a catalyst in moving towards a solution to these problems, and perhaps to actively support additional resources for the Environment Department or other state agencies. Enforcement of building or sanitary codes is one way to address the problem, but it may also be possible to encourage replacement of defective systems or better treatment alternatives using some kind of incentive system, or at least to provide public education and outreach to make residents aware of what needs to be done and what alternatives they have.

Financial feasibility

Waste treatment does cost money. In most cases costs must be borne by individual homeowners, and the cheapest alternative (or, hopefully, at least the cheapest legal alternative) will be chosen. To a great extent building officials (state or county) set the standard that must be met. The cost of meeting it is part of the cost of a house. In situations where conventional septic systems cannot meet water protection standards, other technologies (or community treatment) become cost-effective.

It may be worth considering, however, whether it would be in the county's or state's interest to provide some degree of financial incentive, such as reduced building permit fees, tax credits, or low-interest loans, to encourage property owners to voluntarily upgrade or use better technology for new construction.

Social and cultural impacts
Liquid waste regulation and enforcement is unfortunately still considered an infringement on personal freedom by some. However, restriction of individual freedom has to be weighed against the interest of entire communities in avoiding waterborne disease. The social impacts of undrinkable ground water are generally considered severely undesirable. It is, of course, necessary to prioritize areas and instances where alternative or more stringent liquid waste treatment is most needed.

Physical, hydrological, and environmental impacts
All of the techniques mentioned above, including septic tanks and leach fields in the right circumstances, can adequately protect water supplies. In general, the shallower the ground water, the more difficult it is to achieve adequate waste treatment and the easier it is to pollute ground water. Wastewater discharge to excessively shallow ground water should be prevented, whether by prohibiting dwelling construction, providing centralized treatment, or requiring more stringent and "alternative" treatment technology.

Implementation
Any of the alternatives mentioned can be implemented at any time, subject to regulatory approval as necessary.

Strategy: Control non-point-source and agricultural pollution

Surface water quality problems in the region stem primarily from excessive sediment in runoff water caused by erosion from land surfaces and arroyos where there is little or no ground cover vegetation. There are no documented instances of contamination from agricultural chemicals in the region, but our water supplies are highly vulnerable to agrichemical contamination because irrigated fields are located in former floodplains where ground water is shallow and soils are highly permeable. If pesticides or intensively applied fertilizers were to be used in any quantities, severe pollution problems would result rapidly.

Non-point source water pollution by sediment and turbidity are simply the result of poor watershed management that has led to poor ground cover and erosion. Solutions are described above in the section on watershed management, and the benefits include reduced water pollution as well as increased water production and less flash-flood runoff.

Some of the best ways to reduce non–point-source water pollution (which also help enhance our water supply by promoting stormwater retention and infiltration) are:

- Establish and maintain good grass cover on the land;
- Build swales and check dams where needed to help vegetation get started;
- Build roads and ditches so as to prevent excessive erosion, using water bars, proper ditching, proper culvert construction, and minimal land disturbance;
- Protect stream banks from damage by inappropriate grazing, vehicles, or other uses that damage riparian vegetation; and
- Provide places (like ponds or vegetated areas) for stormwater runoff from impervious surfaces like parking lots or large roofs to soak into the ground instead of running off all at once.

In addition to techniques for minimizing erosion and sediment-related water pollution, organic or at least chemical-free farming practices would help protect water quality from nutrient and chemical contamination, and would likely be more profitable for local growers.

The Federal Environmental Protection Agency and the New Mexico Environment Department (NMED) are in the process of developing Total Maximum Daily Load (TMDL) standards for non-point source pollution for many Rio Chama tributaries, and the TMDLs will include a plan for eventual achievement of standards and designated uses. For the foreseeable future, however, major efforts to improve non-point-source water quality are focused on grants made through the NMED Surface Water Quality Bureau and other agencies for projects that demonstrate good ways to reduce non-point source pollutants. Rio Arriba County (or the State) could enact and enforce more stringent requirements for constructing roads in ways that minimize undesirable runoff patterns and resultant erosion, and/or consider incentives for improved road construction.

Evaluation: Reduce non-point-source pollution

Technical feasibility

Techniques for preventing or minimizing runoff-related pollution (and associated erosion) are generally low-tech and highly feasible. A more detailed discussion of some of these options can be found in the evaluation of watershed management techniques for increased water production, beginning on page 7-13 above. Much of what needs to be done is to get better grass cover established and not obliterated by poorly-timed or excessive grazing. Grazing can in fact be used as a potent restoration tool, if timing and intensity are properly managed. Supplementary soil stabilization techniques like constructing swales on hillslopes or check dams in eroding arroyos can help keep soil in place in difficult locations long enough for vegetation to get established and begin protecting the soil.

Political feasibility

Widespread support has been expressed for the goal of erosion minimization and watershed protection. Community education is still needed to explain the techniques, where to use them, and to reinforce the idea that action in this area can make a large cumulative difference. It may be particularly advantageous to work with local ranchers and grazing associations on this issue, to develop and implement grazing management that enhances grass cover.

Financial feasibility

Non-point source pollution reduction in our region will certainly involve some collaborative efforts between local communities and the Forest Service and/or Bureau of Land Management. Inevitably many project possibilities will simply depend on agency budgets, and community political support for a clearly articulated goal, in concert with agency managers, will be the most effective way of funding watershed management activities. Other funding sources do exist, however, such as Clean Water Act section 319(h) funds, the Forest Service's Collaborative Forest Restoration Program, Natural Resources Conservation Service programs, or special appropriations from either federal or state legislatures. Many of these funding sources involve a local cost match, so even a relatively small dollar amount of local support, augmented by in-kind services, can leverage a large amount of outside funding.

Social and cultural impacts

There are significant potential benefits from watershed restoration in addition to better water quality and a more stable water supply. Forest and rangeland management could provide stable local employment and contribute to community economic stability. Grazing management that contributes to overall watershed management goals could augment direct employment and financial benefits from forestry or grassland restoration, and increase ranching profitability. Forest and rangeland restoration and management, if designed correctly, could augment wildlife habitat values and promote ecological diversity, as well as helping to maintain a healthy and appealing landscape in northern New Mexico, with benefits like cleaner water, reduced erosion, and better rangeland productivity extending far beyond the boundaries of local communities.

Achievement of lasting and helpful watershed management will be less difficult, and yield greater benefits, if local community representatives along with agency personnel, grazing associations, acequias, environmental interests, and other stakeholders can all participate in articulating a vision of sustainable community interaction with the land and ecosystems of the Rio Chama watershed. We need to understand how we can live in and make a living from the land in a way that enhances its ecological values and the benefits to our communities from a healthy landscape – so we can take concrete steps to move in the right direction.

Physical, hydrological, and environmental impacts

The environmental and hydrological effects of restoring and protecting a healthy soil cover of grass and other plants go far beyond just reducing erosion and its attendant pollution and sediment transport problems. In some watersheds in New Mexico, sustained efforts to enhance grass cover (done by ranchers using properly managed grazing as a restoration tool) have transformed barren, eroding landscapes into healthy grasslands supporting many times their original stocking rate. This kind of grassland restoration has also transformed massively eroding arroyos that carried only occasional roiling flash floods into well-vegetated perennial streams. The effects of protecting our soil cover can be truly dramatic.

Implementation
Both community participation and agency cooperation might be catalyzed effectively around preparing a proposal for watershed restoration to be funded by EPA or the Forest Service (or perhaps other funding sources). Programs like Clean Water Act section 319 or the Collaborative Forest Restoration Program can provide tangible incentives for undertaking the kind of community work needed, and can build the bridges between stakeholders and between communities and federal agencies that can continue beyond the particular projects that might be funded.

Strategy: Regulate and discourage development in upper watershed areas

The upper reaches of the Rio Chama mainstem and tributary watersheds are sensitive areas and need to be carefully managed. Land practices in these upper reaches have large impacts on the quality and quantity of water that reaches the streams and acequias within the entire watershed. There is general agreement in the region to restrict (or even prohibit) development in these areas. If development is allowed, it is very important to stringently regulate road design, implement runoff catchment structures, require terrain management to prevent excessive runoff, and re-vegetate all disturbed areas. Revegetation and erosion control requirements should be stringently enforced in all instances of disturbance, including non- construction activities such as utility installation or logging. Adequate road construction standards are important here as everywhere. In most upper watershed areas we need to preserve the ability to use fire as a watershed management tool to maintain forest health and watershed productivity without fear of damaging inappropriately-sited structures. This would tend to argue for prohibiting any development in these areas.

Evaluation: Protect upper watersheds

Technical feasibility
Techniques for minimizing hydrologic and soil erosion impacts from development are well understood and quite feasible. However, one of the principal reasons for restricting development in forested watershed areas is to avoid political pressure to protect dwellings from forest fires that are ecologically and hydrologically necessary. In these cases the mere presence of a house or structure, rather than any other impact, becomes the main problem.

Political feasibility
The undesirability of residential development in forested watershed areas was frequently mentioned in public meetings on the water plan. There seems to be general political agreement that in most cases it should not be allowed. Certainly it will be politically easier and more palatable to restrict or prevent such development before it happens than to deal with its effects if it is allowed.

Financial feasibility
Direct financial costs of protecting sensitive watershed areas would be minimal, requiring little beyond County staff time to develop and enforce regulations. Additional requirements of developers or homeowners to prevent runoff or other water quality problems would have some financial impact on these affected individuals, but such requirements are routinely imposed by local jurisdictions in other parts of New Mexico and around the country, and are not necessarily excessive. As with political acceptability, the financial costs of preventing development in inappropriate areas or of preventing hydrological or other problems before they happen are much less than the costs of trying to fix them after the fact.

Social and cultural impacts
Aside from the intended effect of protecting water quality and preserving the ability of forest managers to use fire as a watershed management tool, restrictions on development in sensitive watershed areas would probably have the effect of curbing or discouraging vacation home development, which would be seen as a positive effect by most participants at water planning meetings (and probably by most region residents).

Physical, hydrological, and environmental impacts

One of the principal problems associated with homes sprinkled among lovely high-altitude forests is the resulting demand to protect these homes from forest fires. As we are increasingly coming to understand, fire is a natural part of the ecology of most of our forests, and requirements to suppress forest fires generally result in trading frequent small fires for infrequent large ones. Given the role of fire in maintaining forest health and also perhaps the desired hydrological properties of watersheds, it would be highly counterproductive if any substantial forested area were effectively required to be fire-free. It is also impossible for anyone or any agency to guarantee that forest fires can be prevented, even if that is desired; and the attempt is generally extremely expensive – imposing a major potential burden on taxpayers to subsidize forest homeowners.

The other major environmental or hydrological effects associated with development in forest areas (and exponentially more pronounced the greater the slope of the land) are increased concentration of runoff water caused by buildings, parking areas, driveways, and roads. While techniques exist to mitigate all these effects, they can be costly and in some instances it may well make more sense simply not to build in these areas, and more particularly not to build roads there.

Implementation

Implementation of land use restrictions generally falls to County administration in our region, since no other government entity has jurisdiction except in the Village of Chama, our only municipality, and the Jicarilla Apache Tribe. County staff would need to draw up an ordinance, to be enacted by the County Commission; and the County would need to assume responsibility and allocate funding for enforcement.

While Rio Arriba County has no authority to regulate land use and development within the Jicarilla Apache Reservation, it is hoped that the Tribe would similarly protect these sensitive upper watershed areas.

GOAL: CONSERVE AND REUSE WATER RESOURCES

Community members have expressed a willingness to find ways to use less water in order to help the community and acequias. Since agriculture is by far the largest use of water in the region, conservation of irrigation water would have the largest impact.

Changes in use that reduce the amount of water depleted can result in additional water being made available for other uses. An example of this would be changing cropping patterns to grow crops that require less water, or converting domestic or commercial landscaping from lawn to native shrubs. There is little incentive at present for a water right holder to make these kinds of changes, however, for two reasons:

- In much of the region, water rights are not yet adjudicated, so the final quantity of rights held is still uncertain. Because of this, any reduction in water use prior to adjudication may reduce a right holder's final decreed water right.
- Even if rights were finally adjudicated, there is little incentive for voluntary reduction in water depletion, and in fact some right holders may well feel a disincentive to reduce water use in their home or community if they believe the only beneficiaries will be users elsewhere.

With our existing system of water rights, perhaps the first step in encouraging water conservation would be to complete the adjudication process, in as expeditious a way as possible while protecting local water rights and handling the process in a reasonably non-adversarial way, as discussed above on page 7-12. In the absence of adjudicated water rights, anyone who voluntarily reduces water consumption is almost guaranteed to lose part of their original right. Once water rights are adjudicated and it is clear how much water each acequia is entitled to, it will also be essential to ensure that there are appropriate incentives for acequias to consider water conservation options and implement those that serve their interests.

If rights to any water made available by reducing depletions can stay within our communities and our region, they may be very helpful in meeting growing water needs and in sharing water in times of shortage. Where available

rights are the only limit to using water, rights to water conserved by reducing depletions should be able to be banked, lent, or leased to other local users. Where actual physical water availability is also an issue, additional investment in infrastructure like wells, piping, treatment facilities, and storage will also be needed before additional water can really be used.

The incentives and possibilities for water conservation will be greater if any water saved can also be stored for later use, either physically in reservoirs or aquifers, or by water exchanges or banking arrangements that permit water saved at one time to be used at a subsequent time. The lack of physical water storage is a significant disincentive to conservation in our region. Some water could easily be stored in existing reservoirs, and limited-scale aquifer storage and recovery projects might offer evaporation-free storage for quantities of water that would be useful for acequias or communities.

If appropriate incentives and safeguards to water rights were in place, several options exist that would enable farmers, ranchers, and other parciantes to reduce water consumption and still maintain agricultural production and acequia integrity in some circumstances:

- Field leveling and other on-farm water management efficiencies;
- Repair of chronic or excessive leakage from certain acequia sections;
- More active water management, including soil moisture testing or additional flow measurement;
- Water banking that allows unneeded water to be used elsewhere without loss of rights, and enables greater flexibility in responding to drought;
- Agricultural research and extension outreach assistance to grow and market less water-consumptive crops;
- More intensive management by mayordomos to ensure that water isn't wasted or used inappropriately; and
- Making information available and/or supporting research into alternatives for water re-use and conservation, such as gray water systems, rooftop runoff collection, wetlands, or effluent re-use from community wastewater treatment where it may be implemented.

If communities had centralized wastewater treatment plants, the treated effluent from the plants could be reused for watering non-edible crops (such as feed for animals), providing another opportunity for more efficient water use.

Evaluation: Water conservation alternatives

Technical feasibility

Conservation techniques are readily available and highly feasible. The only alternative mentioned that is not necessarily available "off the shelf" would be agricultural extension services to assist with choosing, raising, and marketing more water-efficient crops, where they are practical.

Political feasibility

Political acceptance of water conservation within the acequia system will largely depend on ensuring that conservation doesn't involve a loss of water rights, and on structuring any incentives for conservation so that local acequias and communities have the opportunity to use and/or benefit from any water saved by conservation. If local communities feel that water conservation involves sacrifice on their part for the benefit of others, conservation will not be successful.

Financial feasibility

Some conservation techniques, like more intensive management by acequia mayordomos, on-farm soil moisture testing, or water banking, can be done by acequias or parciantes without enormous expense – although there is still a question of return on investment, and why effort and investment would be spent on water conservation unless there were incentives for doing so. Other techniques, like agricultural extension, perhaps field leveling, and some kinds of acequia repairs or flow measurement, would need some kind of outside financial assistance.

Social and cultural impacts

Water conservation could provide helpful local social impacts, such as additional water for community water systems (perhaps in conjunction with other improvements like enhanced groundwater recharge using acequia water, or water treatment to drinking water standards). Water banking during periods of shortage can also help

deal with drought in the least painful way. The difficult issues arise in considering water conservation that might be expected to make water available for uses outside the places where the savings were made (whether within or outside our region). At one extreme, participants in the planning process were nearly unanimous in expressing strong disapproval (to put it mildly) of the idea of "saving" water in Rio Chama watershed communities so that it could flow downstream to urban areas or other water consumers. The social and cultural impacts, and political acceptability, of such policies would be extremely negative to say the least.

On the other hand, it may be possible to devise a cultural, economic, and political arrangement whereby some limited quantity of water could be made available by conservation within our region for users elsewhere, if the financial returns were substantial enough to permit meaningful investments in agricultural infrastructure, extension, marketing, and education that could help ensure the long-term viability of agriculture, and the acequias that make it possible, in the Rio Chama watershed.

Physical, hydrological, and environmental impacts

The most important issue here may well be to avoid the kinds of impact that could result from inadvisable attempts at conservation – like wholesale ditch lining, as discussed above on page 7-10. A good deal of water conservation could be put into place without serious adverse consequences, but it is important to remember that streams, floodplains, and acequias form parts of a fairly integrated hydrological, cultural, and ecological system and it is likely to be counterproductive to focus too intensely on any single part of the system in looking for efficiency rather than considering the system as a whole.

Implementation

There is little reason for anything to be done until there is some reward for saving water, as discussed above. State water administration, the Office of the State Engineer and the Interstate Stream Commission, will probably need to take the lead in moving towards a system of appropriate incentives for water conservation that protect local water rights and community interests. Given appropriate incentives, acequias and parciantes may be able to implement actual conservation measures quite successfully.

GOAL: PROTECT AND RESTORE OUR WATERSHEDS

Managing watersheds to enhance both ecological health and hydrologic function will help achieve all our water planning goals. Good watershed management can help with acequia water supplies, enhance community and individual water security, protect water quality, make acequia maintenance easier, and even contribute to the long-term viability of the entire acequia system. At the same time, properly restored watersheds would offer environmental advantages in terms of wildlife habitat, forage, ecological diversity, rangeland productivity, and reduced danger of damaging large-scale forest fires.

The strategies that will protect and restore our watersheds are the same ones that will enhance our water supplies and reduce water pollution. These are discussed and evaluated above in reference to these goals. It may seem redundant to give watershed protection and restoration the status of a separate water planning goal, but it deserves such recognition both because it unites many concerns and strategies for better managing water in our region, and because it was mentioned frequently and passionately by local residents in many water planning meetings.

There are opportunities for significant improvements in watershed management throughout the region. Higher altitude areas can benefit from improved fire management, forest thinning, beaver re-introduction, better grazing management in forest areas, and development restrictions in critical areas. At lower altitudes, erosion control structures and grass cover enhancement are needed almost everywhere, along with management of the timing and intensity of grazing so livestock can enhance soil cover. Better road construction and other kinds of runoff management offer advantages throughout the region. Specific techniques and opportunities are discussed in detail above. The unifying theme among many of the alternatives that would help us the most is enhancing and protecting our watersheds to store as much water as possible in the soil and shallow aquifers rather than letting it run off quickly and erosively.

MOVING FORWARD

Many of the alternatives discussed above can be used in combination to benefit communities, the entire region, and all of New Mexico. One of the most important issues for our region is ensuring that local residents benefit from watershed restoration or other water management alternatives, with sustainable land-based employment, more stable water supplies, and enhanced environmental quality. These benefits may be shared outside the region, but proposed actions need to genuinely involve and benefit local communities.

Bold leadership and creative thinking are needed to implement both this Regional Water Plan and the State Water Plan. Vision and leadership are needed by commissioners of acequias, County officials, State water managers, the Governor, and Legislative Leaders to protect and defend traditional water use, while allowing planned growth. Traditional uses of water, by Native Americans, parciantes of acequias, and community water systems, should in general be "off the table" for the commercial water market. The environmental and cultural values embodied in traditional water uses, and our future agricultural possibilities, are worth far more than quick profits for a few generated by sprawling, uncontrolled population growth.

To implement this Water Plan, Rio Arriba County critically needs at least two people within the Planning Department with specific skills: a hydrologist and one or more agricultural and natural resource specialist(s). Hydrological expertise is needed to evaluate the effects of proposed development of all kinds and to represent the interests of the County and the planning region with the Office of the State Engineer and other agencies. The Region and the County also need a locally accountable staff member with a vision for agriculture and natural resources in northern New Mexico. For local agricultural producers, the County needs to help coordinate existing sources of assistance, find additional funding, and work with State and Federal Agencies, private enterprises, the State L egislature, and the U.S. Congress to expand agricultural opportunities and success in our region. Coordination and advocacy are also needed at the County level in sustainable watershed management, both in upland forest areas that may need thinning or controlled burning; and in lower-altitude areas that may need erosion control and revegetation.

New Mexico has a unique water history that includes international and interstate treaties and growing, thirsty urban areas. We do not have to become a battleground or a statewide water auction. With creative leadership and active cooperation, New Mexico can be an exporter of innovative ways of dealing with a growing worldwide problem.