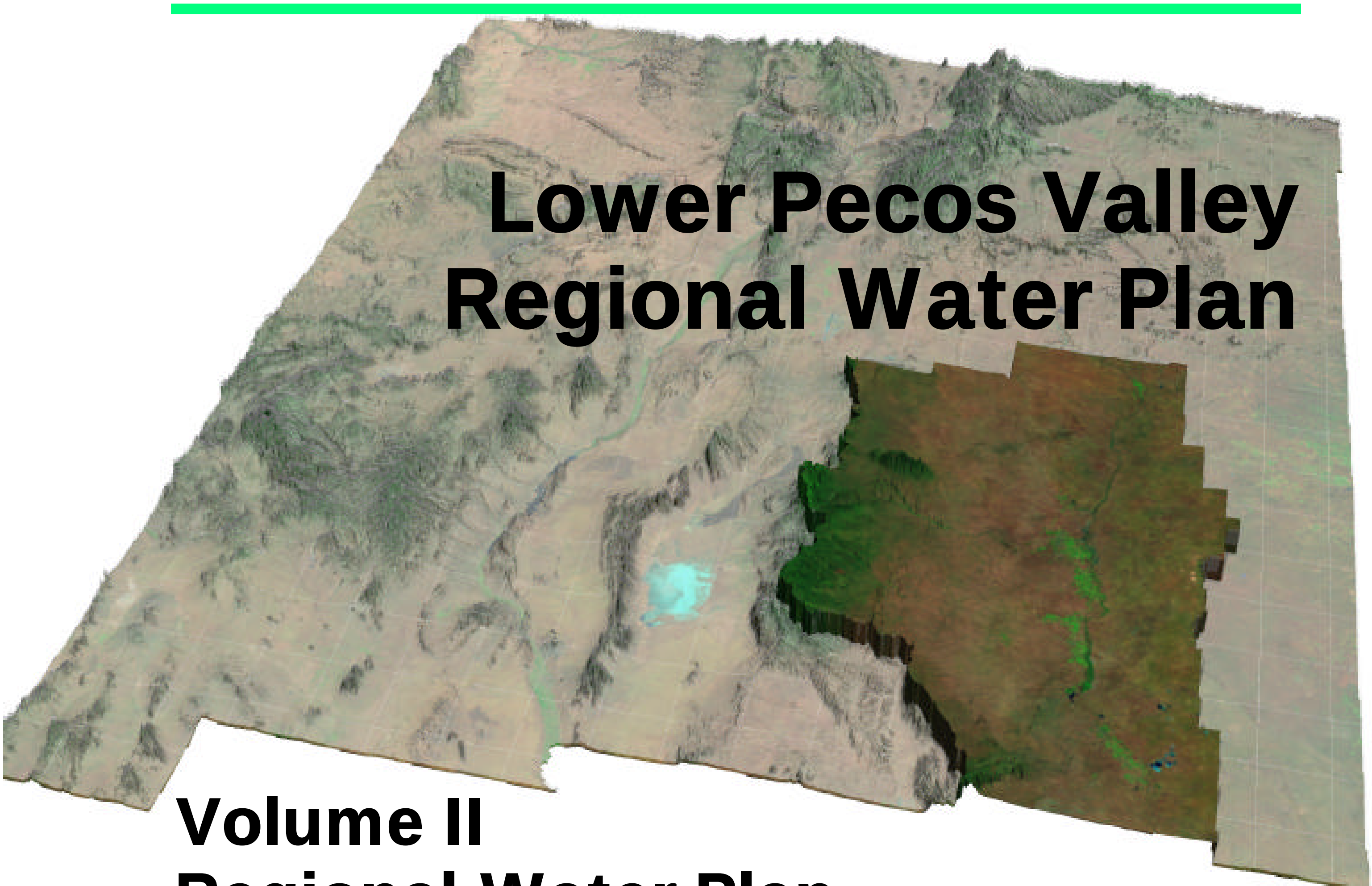
Prepared for:
New Mexico Interstate Stream Commission
Regional Water Planning Program



Lower Pecos Valley Regional Water Plan

Volume II
Regional Water Plan

JULY 2001

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VOLUME II: REGIONAL WATER PLAN

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ACKNOWLEDGMENTS

The Lower Pecos Valley Regional Water Plan contains information that has been compiled and interpreted from data contributed from counties, soil and water conservation districts, municipalities, irrigation and conservancy districts, special study areas and property ownerships. Information has been garnered from official records, personal knowledge from personnel at numerous federal, state and local agencies and many individuals who have spent numerous years in the area and have a wealth of information of offer. Authors of major portions of the report include Woods Houghton, William See, Fred Hennighausen, Peter Balleau, Tom McGuckin and Tom Springer, with important contributions from many committee members and other individuals. The atlas of maps was produced by Steve Silver.

We acknowledge the information and assistance provided for this planning endeavor by the National Forest Service offices in Ruidoso, Cloudcroft and Carlsbad; the Bureau of Land Management offices in Roswell and Carlsbad; the Natural Resource Conservation Service offices in Fort Sumner, Roswell, Capitan, Artesia, Alamogordo and Carlsbad; the De Baca, Chaves, Hagerman-Dexter, Upper Hondo, Central Valley, Peñasco and Carlsbad Soil and Water Conservation Districts; the Fort Sumner Irrigation District; the Pecos Valley Artesian Conservancy District; Hagerman Irrigation Company; the Carlsbad Irrigation District; the Cities of Fort Sumner, Roswell, Hagerman, Dexter, Lake Arthur, Artesia, Hope, Carlsbad, Loving, Capitan, Ruidoso, Ruidoso Downs, Cloudcroft and Mayhill; the U.S. Bureau of Reclamation; New Mexico State Engineer offices in Roswell and Santa Fe; the New Mexico Interstate Stream Commission; the New Mexico State University Extension Service; as well as the many individuals throughout the Pecos River Basin planning area.

The Pecos Valley Water Users Organization would also like to acknowledge the assistance of Ms. Tammy Lee and the rest of the staff of the New Mexico State University Agriculture Science Center in Artesia, New Mexico. They were most helpful in facilitating and assisting in the numerous meetings held at that facility during the course of the preparation of the Regional Water Plan.

Without their assistance, data and knowledge, this Regional Water Plan would have been much more difficult to prepare and much less complete in responding to Lower Pecos Valley water needs.

SECTION I: INTRODUCTION

Background to the Report

In 1987 the New Mexico Legislature declared that "the future water needs of New Mexico can best be met by allowing each region in the state to plan for its water future"[1]. To support this regional planning effort the legislature authorized the New Mexico Interstate Stream Commission (ISC) to make grants to develop regional water plans covering a 40-year period. Through 1999, the New Mexico Legislature has appropriated $1,850,000 for regional water planning. The ISC has funded 22 regional water plans covering most of the state. The ISC envisions a process whereby these plans will be the foundation for a statewide water plan.

The Legislature in 1987 was responding to the growing demand for New Mexico's water by other states. El Paso's threat to appropriate New Mexico groundwater gave New Mexico an urgent reason to look carefully at its own water needs and to determine how it could keep New Mexico water in New Mexico. While the appropriation of New Mexico's water by other states is still a concern, the regional planning effort is also a way to help solve in-state water problems. The Pecos Valley has always been a region limited by available water. The Pecos River and groundwater aquifers in the basin provide limited and variable flow. Potential demands have always exceeded supply. The Pecos River Basin's water problems are more complex today than before because of the addition of new players, such as endangered species, that add new demands on the water resource. There is the additional impact resulting from a U.S. Supreme Court ruling in Texas v. New Mexico. The U.S. Supreme Court amended the 1947 Pecos River Compact (the Compact) placing more stringent requirements on the State of New Mexico to deliver water to Texas. Many water users in the Pecos Valley hope that the planning process will provide alternatives to litigation or to regulatory deadlock by balancing the many claims to water within the planning region.

The Pecos Valley Water Users Organization (PVWUO) was formed under a joint powers agreement to develop the Regional Water Plan for the Pecos River Basin from existing and available information, along with public input and support. PVWUO represents water consumers located in the Lower Pecos River Basin, in New Mexico. Geographically, the planning region includes parts of De Baca, Chaves, Eddy, Lincoln and Otero counties. Members of the PVWUO consist of primary water consumers, such as municipalities, irrigation districts and development districts that have an economic interest in the region's planning and use of water resources. The PVWUO serves as the representative body of water interests in the basin and as the regional contact for the ISC and the New Mexico Office of the State Engineer (OSE).

[1] New Mexico Law 1987, Chapter 182, p. 1038.

Goals, Objectives and Guiding Principles of the Lower Pecos Valley Water Plan

The goal of this plan is to provide sufficient and economically feasible water to allow continued economic growth to the Pecos River Basin over the 40-year planning period. The plan has the following objectives:

1. To ensure an adequate supply to meet existing water rights,

2. To support the projected growth in municipalities, industry and mining activities in the planning region,

3 To support growth in agricultural water economy by two percent,

4. To meet the Pecos River supply obligations,

5. To maintain or improve the environment for humans, plants and animals and

6. To allocate all future available water for beneficial use in New Mexico.

The Regional Water Plan for the Pecos River Basin planning area identifies the water supplies from all sources, future demands for that supply and presents alternatives to align the supply with demand. This plan demonstrates that all available water is needed to meet water demands for the next 40 years. The plan identifies alternatives to mitigate water-resources problems and the procedures to implement such alternative as actions.

The guiding principle under which this Regional Water Plan has been developed is that a water right is a property right and that future uses of our limited water resource will be determined by economics. The water resources must meet those beneficial uses deemed to be high priority as well as those demands decreed by the courts. Effective long-range water planning must include the adjudication of all water rights on the historical basis of the application of beneficial use (establishment of seniority). After such adjudication, market forces will determine the water's ultimate use.

Individuals Involved in Water Plan Development

This Regional Water Plan was developed by the PVWUO. The PVWUO was established in 1995 with the following membership:

Member	Representative
De Baca County	Frank McRee

Chaves County	Bill Thompson
Eddy County	Louise Tracy
Eddy County	Ray Camp
Lincoln County	Thomas Stewart
New Mexico Association of Conservation Districts	Debbie Hughes
Sureste Resource Conservation Council, Inc.	Janet Cox
Sureste Resource Conservation Council, Inc.	Juan Gauna
Sureste Resource Conservation Council, Inc.	Dick Smith
Pecos Valley Artesian Conservancy District	Wesley Menefee
Pecos Valley Artesian Conservancy District	Fred Hennighausen
Pecos Valley Artesian Conservancy District	Delbert Nelson
City of Roswell	Charlie Sparnon
City of Roswell	Larry Loy
City of Artesia	Carl Barnes
City of Carlsbad	John Waters
City of Carlsbad	Luis Camero
Village of Cloudcroft	Tom Springer
Carlsbad Irrigation District	Tom Davis
Southeastern New Mexico Economic Development Dist.	Mike McCan
Southeastern New Mexico Economic Development Dist.	Tony Elias

Names of individuals who also contributed to the development of the Regional Water Plan for the Pecos River Basin include:

Hagerman Irrigation Company	Dan Lathrop
Individual	Morgan Nelson
County Agent	Woods E. Houghton
Consultant	William H. See
Consultant	Balleau Groundwater, Inc.
Consultant	EnWater Resource Consultants L.L.C.
Secretarial Assistant	Janie Bernard

Previous Water Planning in the Region

Efforts to develop a Regional Water Plan for the Pecos River Basin were initiated in 1989 when the Southeastern New Mexico Economic Development District acquired a grant from the ISC. The awarded funds were used to collect data and prepare a draft water plan for the Pecos River Basin. The initial draft of the water plan revealed a shortage of information regarding agricultural uses of water. At that time a volunteer group was organized to compile such information. The volunteers' efforts were completed in 1994 and their findings were combined with the initial draft. Recognizing that the agricultural sector needed to be included in order to have a more useful and comprehensive plan, Woods Houghton, as a member of the planning committee, volunteered to prepare and add to the report information on the use, demand, and characteristics of the water requirements of the agricultural-related businesses in the region.

In 1995 the PVWUO was formed to update and revise the draft water plan for the Pecos River Basin. Concurrently, the ISC recognized the necessity for the state to have a unified approach to water planning. Thus, the ISC appointed individuals to prepare the Regional Water Planning Handbook (Handbook). The Handbook directs regional water planners in preparing plans that are both useful and uniform by offering assumptions, guidelines and a template to follow.

The PVWUO determined that the Lower Pecos River Basin planning area was too large and contained too great a variation in resources to be described accurately as one entity. The PVWUO made the decision to address resource planning based on the boundaries of the six administratively declared groundwater basins contained within the planning area.

After Mr. Houghton completed a significant addition to the plan, the planning committee decided to organize the plan so that the water issues for each of the six declared underground water basins making up the Lower Pecos Valley planning region could be understood separately. Additional historical data on the hydrological characteristics of each basin, as well as data on water diversions, use and projected future demands by basin, were deemed necessary. In order to carry out this phase of the work, a contract with the Carlsbad Soils and Water Conservation District (CSWCD) was negotiated in 1996. Mr. William See, as Conservationist of the CSWCD, undertook the task of organizing the Regional Water Plan and developing the additional information needed to meet the ISC Regional Water Plan template requirements. The contract with the CSWCD was renewed several times up to 1999 as the work continued. Mr. See's work culminated in the completion and distribution to the planning committee of a comprehensive and extensive draft Regional Water plan document dated January 9, 2000. In addition to his contract work, Mr. See also contributed a considerable amount of personal, volunteer time to the project.

The planning committee decided that the draft plan should be reviewed by a professional hydrologist who could also add basin-wide hydrologic data and develop a comprehensive water budget for the Lower Pecos River area. A contract for this purpose was negotiated with Balleau Groundwater, Inc. (BGW) of Albuquerque in September, 2000. This document is the result of the review, updating, and expanding of the draft Regional Water Plan of January 9, 2000. BGW also assisted in the development of some additional and promising alternatives for offsetting the current and projected water shortfalls in the region.

This Regional Water Plan for the Lower Pecos River Valley follows the Handbook prepared by the ISC to the extent that it is applicable

SECTION II: DOCUMENTATION OF PUBLIC INVOLVEMENT

ISC Sponsored Workshop

A workshop sponsored by the ISC, was held in 1995 in Roswell, New Mexico. The meeting was hosted by the PVWUO and the program was presented by Western Network. The purpose of the meeting was to prepare members of the PVWUO and other interested citizens to conduct the public participation program for the development of the Regional Water Plan. Techniques for involving the public and gaining their participation were presented with examples from other planning efforts. Participants were given an opportunity to role-play to demonstrate techniques. Background data for regional water planning was presented to inform the participants of the purpose of developing regional water plans.

Background for Public Dissemination

Prior to beginning the public participation meetings, a handout pamphlet was developed to provide participants with some background data on the PVWUO and water planning efforts in New Mexico and the Lower Pecos River Basin Regional Water planning area. The contents of that pamphlet are included in Appendix A to document the background data provided to participants of the first series of public meetings. Copies of the Handbook were also made available to those in attendance.

List of Stakeholders and Participants

The major stakeholders in the development of the Regional Water Plan for the Lower Pecos River Basin are represented by the members of the PVWUO listed in the introduction (Section I), members and staff of the ISC and staff of the OSE. Those who have represented the ISC at the public participation meetings are Phil Hazeltine, Phelps White and Hoyt Pattison.

Participants at the 19 public participation meetings are listed below. The first series of seven meetings were held between September 19 and October 24, 1995 with 123 people in attendance. The second series of seven meetings were held between April 2 and April 23, 1996, with 90 people in attendance. The third series of five meetings were held between September 16 and September 19, 1996 with 54 people in attendance. Some of the names may be misspelled or were omitted due to legibility of the signature on the meeting register.

Participants of the first series of meetings:

James Walterschied
Monica McInuney
LeRoy Lang
Frank McRee
Yates Salgen
Dean Lee
Eddie Livingston
Donald Gray
Greg Haussler
Luis Camero
Dave Barrett
Bob Boebinger
Alan Briley
Richard Sanchez
Fred Hennighausen
John Hemphill
Don Cox
George Teel
Richard Watts
Benny Coker
Bill Thompson
Bill Van Pelt
Bill Weddige
Bob Schneider
Bryan Arrant
Carl Barnes
Carl Stubbs
Cecil Pollard
Chester Walker
Dale Taylor
Dan Lathrop
Dan Trotten
Dave Parsons
Don Alam
Frances Sherrill
George Cassebone
Gladys Nosker
Howard Shanks
Bob Bruce
Edward A. Sena
E.T. Fallen
James Freland
Tony Elias
Dick Smith
Rebecca Barela
John Waters
Bill Schwettmann
Earnest McDaniel
Chester Wolven
Louise Tracy
Charlie Sparnon
Richard Franzel
Jack Black
Nick Carter
Leon Gregory
Mel Fritschy
Tom Davis
Cowboy Thompson
Debbie Hughes
Bill Featherstone
S.A. Gunn
Janet Cox
J.E. Spitz
Jim Ogden
Shana Cleaver
Lindell Andrews
Johnny West
Bill Canada
J.W Gemmich
Leila KifeWoods Houghton
Blaine Haines
Richard Vaughan
Sherman Galloway
Mike Cassebone
Morgan Nelson
Johnny Jackson
Dick Foster
J. Paul Frost
Janie Bernard
Jerry Sparks
Jesse Rayroux
Jim Edwards
Jim Harrison
Joe Cox
Joe Higgins
John McMillan
Joyce Laumbach
Juan Guana
Kevin Graham
Leland Tillman
Leonard McCutcheon
Leslie Armstrong
Louis Q. Garcia
Mary Elizabeth Dresser
Max Vasquez
Mel Richey
Mike McCan
Phil Hazeltine
Philip Peed
Ralph Dunlap
Raymond E. Drake
Robert Salas
Sandra Shank
Shelby Gilmore
Van Shamblin
Wesley Menefee
William See
Nick Vaughan
Opal Lee
Patsy Sauehey
Pete Laumbach
Phelps White
Leila KifeWoods Houghton
Steven J. Nunez
Rex Buck

Participants of the second series of meetings:

Barry Herd
Bill Thompson
Bob Horner
Juan Gauna
Mark McCollum
John Waters
James W. West
Lewis Derrick
Maxine Horner

Carl Barnes
Charles Lathrop
Curtis Schrader
David Drennan
Dean Lee
Debbie Hughes
Dub Cox
Eugene V. Haley
Evelyn Leonard
Greg Haussler
Helen Richardson
Janet Cox
John Conner
Kenneth Baker
Leonard McCutcheon
Lowell Nosker
Mary Helen Foley
Mike McCan
Morgan Nelson
Neal Vaughan
Phil Hazeltine
Raymond E. Drake
Richard Vaughan
Rob Walters
Sherman E. Galloway
Vergil Haley
Wayne Stensrud
Aida Lopez
Tony Elias
Van Shamblin
Donald E. Sweet
John Heaton
Louis Q. Garcia
Hoyt Pattison
Rebacca Barela
Earnest McDaniel
R. R. Richardson
R. D. Brooks
Alan Briley
Gladys Nosker
Ken Nosker
Luis Camero
Robert Dockray
Dave Parsons
Grace Coleman
Louise Tracy
William See
Edward A. Sena
J.E. Spitz
Frank McRee
Bill Bonham
Hubert Quintana
Jack Black
Bill Route
Woods E. Houghton
C.W. Nelson
John A. McMillan
Bill Weddige
Jan Brooks
Philip Peed
Chester Wolven
Monte Baker
Howard Shanks
Bill Schwettmann
Jenney Cox
John Hemphill
Margaret E. Merritt
Jim Edwards
Marjarie Curtis
Charles F. Clene
Bill Leonard
Irwin Coleman
Leslie Armstrong
Charlotte Gabbtel
Robert Graham
Wesley Menefee
George Westall
Dan Lathrop
Clifford D. Kenyan

Participants of the third series of meetings:

Alan Briley
Bill Schwettmann
Carl Barnes
Dub Head
Edward R. Sena
Frank McRee
Frank Potter
Glenda Tipper
Greek Economides
Hershel Stone
Jack Black
Janet Cox
Jesse Rayroux
Jim Edwards
Jim Tully
Patsy Sanchez
Ken Nesker
Scott Vail
Tom Davis
Debbie Hughes
Dick Foster
Howard Shanks
John McMillan
J.W. Spitz
Charlie Sparnon
George Annis
Tracy E. Mathews
Linda Annis
Bill Thompson
William See
Brice Storey
Albert Carter
Morgan Nelson
Tony Elias
Ray Camp
Leslie Thomas
Joe M. Stell
John Heaton
John Waters
Louise Tarcy
Sandra Shank
Steve Massey
Wesley Menefee

Items of Concern from Public Participation Meetings

During the first series of public participation meetings, the participants were asked to express their concerns on water issues and the process of regional water planning. The content of this plan has attempted to address the concerns that fall within the limits of the regional water planning guidelines. All concerns were discussed in the meetings and are recorded in the minutes as supporting data.

The items of concern from each meeting are listed below:

Items of Concern - De Baca County Public Participation Meeting
September 19, 1995, Fort Sumner, New Mexico

1. Need protection from the endangered species act
2. What is the affect on junior water rights?
3. Need to be given credit for water conservation
4. Increase brush control
   A. Salt Cedar
   B. Mesquite
5. Need to clarify the definition on water rights ownership
6. Need a clear definition of water conservation
7. What is beneficial use?
8. How will this plan effect business?
9. Improve continued cost-sharing services by contacting congressman
10. What are water users' rights in subdivision development?

Items of Concern-Eddy County Public Participation Meeting
September 27, 1995, Artesia, New Mexico

1. Recreational uses of water must be considered
2. Irrigation uses of water must be considered
3. Population census—increasing population vs. decreasing population
4. Effects of WIPP—A. Interstate Highway should be four lanes
5. Applying for higher water uses
6. What's causing the population projections?
   A. Retirement
   B. Industry
7. AARP interests in water planning
   A. Quality of water
   B. Protection of groundwater
      1. Runoff 80 percent
      2. Source
      3. Control

8. Protection of agricultural water base
9. There is a sea of salt water beneath us, we need to plan to use it
10. Need to stop water right infringement
11. Consider endangered species vs. human population
12. Water is the limitation of the water resource
13. What effects will this have on area economics?

Items of Concern-Eddy County Public Participation Meeting
October 4, 1995, Carlsbad, New Mexico

1. If plan is completed is it the last word?
   (e.g., acquiring more water rights)
2. How will this plan affect water rights owned in different basins? Make sure this is addressed in the plan
3. If there is a conflict between water consumers, would this plan set priorities? State Engineer has final authority in conjunction with State Legislature
4. Address rural water-coop needs
5. Possibility of using alternative water source for oil and gas drilling instead of fresh water (quality)
6. Explore new sources for lower-quality water
   (e.g., underground sea) and the use of it
7. New technology in water-use needs to be looked at
8. Recycling of river water for city use
   (e.g., lawns, parks and recreation)
9. Who is source for water quality?
10. City of Carlsbad
    A. Water-rights protection
       1. Lea County Ogallala water rights
       2. Pecos River rights
       3. Capitan Reef water rights
11. Conservation
    (e.g., cement ditches, agriculture conservation, phreatophyte control)
12. Recognize existing water rights and State water laws
13. Where did population statistics for Eddy County come from
14. Well water-quality underground protection against contamination
15. Coordination between entities to supply each other with water in cases of emergency
16. Non-point pollution
17. Over-pumping of water reduces quality
18. Identification and protection of water recharge areas
19. Monitoring of disposal water
20. Is all water use to be addressed?

Items of Concern-Chaves County Public Participation Meeting
October 6, 1995, Roswell, New Mexico

1. Be careful trying to tie population projections to water use
2. Look at mix of different vegetation and amounts of water they use
3. Address phreatophyte control, water quality, and conservation
4. Know what water is available and prioritize the uses
5. Laws have to be defended and considered
6. Water quality must be protected
7. Need to investigate technology that could use lower-quality water for beneficial use
8. Need to educate the public to the need of maintaining water quality
9. Protection of existing water rights as a property right
10. Emphasize use of water— A. (Beneficial use)
11. Use of water that is not considered beneficial needs to be defined (possible law changes)

Items of Concern-Chaves County Public Participation Meeting
October 17, 1995, Hagerman, New Mexico

1. Population figures do not appear to incorporate influx of dairies
2. Bonita Lake is in the Pecos watershed
3. Need to account for the minimum and the maximum rainfall years
4. Need to look at the highest economic use
5. Water rights should be analyzed with respect to population
6. Water-planning organization should be working hand-in-hand with Legislature
7. Each entity, private, farmers, industry, commercial should pay for their water; if they can't, don't buy it
8. Does endangered species have anything to do with our water in the Lower Pecos Valley?

Items of Concern-Lincoln County Public Participation Meeting
October 24, 1995, Village Hall, Ruidoso Downs, New Mexico

1. Population fluctuations due to summer homes and tourism in Lincoln County
2. 1990 census figures appear to be inaccurate due to time census conducted
3. Rainfall is not reaching the aquifers—runoff is high. Amount of snow affects runoff and recharge
4. Need to encourage water conservation and reuse or recycle water for commercial, industrial and homes
5. Double-dipping of water use and new wells on land that has sold the water rights
6. Restrictions needed on subdivisions and water allocations

7. Maintain and protect the agriculture base on water use
8. Water quality needs to be maintained and improved
9. Instream water-flow issues and environmental concerns
10. Meters on all water usage
11. Watershed health—brush control

Items of Concern-Otero/Eddy County Public Participation Meeting
October 10, 1995, Hope, New Mexico

1. Federal government ownership of water rights through means not available to individuals
2. Water development in unincorporated areas (possible over development)
3. Need to review the permitting process for water rights
4. Protect economic viability of small communities
5. Loss of the seal in streambeds in tributaries due to Forest Service policy of "No fires"
6. Change in the spruce-aspen ponderosa pine vegetation and juniper invasion
7. Need cooperative effort by land managing agencies to restore watersheds (basically control of vegetation through natural fires and controlled burns to seal tributaries and ground)
8. Look at Mescalero plan for vegetation control
9. Non-native vegetation control (salt cedar)
10. Control of willow trees
11. Maintain delivery system control
12. Desalinization processes developed and explored for use in area that do not have enough water
13. Technology development for underground salt water
14. Conservation of water and education on use of water
15. How do you appropriate water in a dynamic variable, ever changing, non-static system?

Upon completion and delivery of the final draft Regional Water Plan, as prepared by BGW on May 11, a series of five public meetings was planned and conducted to obtain comments from residents who live in the planning region. At each meeting an overview of the plan was presented and a request was made for questions, suggestions, and general comments on the plan and especially the alternatives. One meeting at each of the following locations was held: Artesia, Carlsbad, Fort Sumner, Roswell, and Ruidoso.

Participants at the meeting in Artesia on May 17, 2001 were:

Garth Grizzle
Phil Burch

Patrick Fox
Debbie Crockett
Ed Loya
Art Gall
Donna Loya
Tom Springer
David Barrett

The following comments and suggestions were offered:

1. The cost of the "Time of Day/Day of Use" option appears too high ($250 per AF). The City of Artesia does not feel that it is necessary to hire people to administer and monitor the option.

2. The alternatives related to conservation in agriculture may not, in fact, result in any water being available for other uses. One individual's opinion is that laser leveling, sprinkler systems, and ditch lining may result in less water being available for other uses, and that flood irrigation is the most efficient from an overall basin viewpoint.

3. From the Table entitled "Summary of Alternatives, Costs, and Yields" it appears the laser leveling does not have any recurring (O&M) costs. In the view of one individual, this is not correct.

The participants at the meeting held in Fort Sumner, New Mexico, on May 29, 2001, were:

Woods Houghton	Carlsbad
G.A. Gunn	County Commissioner, De Baca County
Allen Sparks	Fort Sumner
Michael Mack	Fort Sumner
Frank McCree	Fort Sumner
Edward Sena	Fort Sumner
Dub Head	Fort Sumner
Leslie Armstrong	President, Fort Sumner Irrigation District
Rex Buckman	County Agent

The meeting lasted from 7:00 p.m. to 10:00 p.m. and the following comments and suggestions were offered:

1. There is not enough emphasis on watershed management.

2. The 50-foot strip of salt cedar that is required to be left on the river needs to be appealed.

3. The Compact requirement does not vary as much as the input does. Precipitation varies as much as 45 percent. The Compact variation is only 14 percent. They should be the same.

4. The value of water is incorrect. The federal government paid $300 per AF last year when the water was needed and was in short supply. As demand increases and supply stays the same, the value will increase according to economic theory of supply and demand. Therefore, when evaluating the alternatives, the projected 2040 value of water should be used because, if we do not do anything to reduce demand or increase supply, that will be the value of water.

5. Fort Sumner return flows from the sewer plant are not accounted for, nor is credit given for that flow.

6. The plan was better before BGW, Inc. made all of the fancy artwork. It was in terms a layman could understand and now it is in engineers language and difficult for laymen to comprehend and use.

7. The use of a realistic value for water is an important item and should not be overlooked in the Regional Water Plan.

Public meetings in July and August of 2001 are to be documented in a supplement to this report.

The concerns from the public participation meetings and the template from the ISC Handbook have been addressed to the extent practical in this Lower Pecos Valley Regional Water Plan.

SECTION III: STRATEGY CHOSEN TO MAXIMIZE PUBLIC INVOLVEMENT

In an effort to increase public awareness and input during the various phases of the Regional Water Plan, the PVWUO developed an extensive Citizen Participation Plan (CPP). This CPP outlined the PVWUO's objectives, strategies and a timeline for public information meetings and the completion of the Regional Water Plan. A copy of the CPP is in Appendix B.

Use of Media and Press Releases

Information notifying the public about the regional water planning process and meeting times and places was communicated primarily through local newspapers. Examples of public meeting notices from local newspapers are provided in Appendix C. Radio stations were used to announce dates and times of public participation meetings.

Public Meetings

A series of four meetings held throughout the Pecos River Basin regional planning area are outlined in the CPP. Primary meeting locations included Artesia, Carlsbad, Fort Sumner and Roswell. Secondary locations included Dexter/Hagerman, Hope/Mayhill and Ruidoso/Capitan. A description of the purpose of the first three meetings follows. These meetings were held in all primary and secondary locations.

The objective of the first series of meeting was to inform the public about the formation and purpose of the PVWUO and provide background information on the regional water planning process. Data collection efforts were initiated during these first meetings.

The focus of the second series of meetings was to review the data that had been gathered for the water plan. Participants were asked to provide their opinions on the content of the Regional Water Plan and help identify pertinent data that had not yet been located.

The third series of meetings were designed to gain input on completed sections of the draft Regional Water Plan. The public had been notified previously, through newspapers and radio announcements, of locations within their communities where the draft Regional Water Plan was available for review.

The dates, locations and attendance levels for each meeting are listed below.

Date	Place	Attendance
September 19, 1995	Fort Sumner	30
September 27, 1995	Artesia	23
October 4, 1995	Carlsbad	25
October 6, 1995	Roswell	28
October 10, 1995	Hope	17
October 17, 1995	Hagerman	15
October 24, 1995	Village of Ruidoso Downs	25
April 2, 1996	Fort Sumner	19
April 3, 1996	Roswell	22
April 5, 1996	Artesia	13
April 9, 1996	Carlsbad	12
April 18, 1996	Dexter	8
April 19, 1996	Mayhill	17
April 23, 1996	Village of Ruidoso Downs	22
September 16, 1996	Artesia	8
September 17, 1996	Carlsbad	15
September 18, 1996	Fort Sumner	8
September 19, 1996	Village of Ruidoso Downs	15
September 19, 1996	Roswell	8

SECTION IV: BACKGROUND INFORMATION

Setting of the Lower Pecos River Basin

The planning area for the Regional Water Plan is in De Baca, Chaves, Eddy, Lincoln and Otero Counties in the southeastern portion of New Mexico (Plate 1). The planning area includes the Pecos River reach from Sumner Dam in De Baca County in the north and extends 180 miles to the state line below Eddy County separating New Mexico and Texas. A portion of the Pecos River Basin drainage in New Mexico and Texas is included in this area. The largest area of drainage lies west of the Pecos River Basin and extends to the watershed divide in Lincoln and Otero Counties. The eastern boundary of the planning area coincides with the eastern county lines of De Baca, Chaves and Eddy Counties. Plate 1 shows the Lower Pecos River Basin planning area, the location of the five counties and the OSE declared underground water basins.[2] The topographic relief and drainage basins defined in U.S. Geological Survey (USGS) hydrologic units are on Plate 2. Plate 3 is a LANDSAT photograph of the planning area. Plate 4 shows the townships, ranges and sections. The planning area is 16,800 square miles.

The planning area contains a diverse terrain. Elevation ranges from 12,000 feet above sea level in the mountains to the west to 2870 feet at the Pecos River where it crosses the New Mexico-Texas border. The western portion contains steep forested mountains. The southern and eastern areas support desert shrubs and desert grasslands. The northern and central portions of the planning area are covered with rolling hills and high plains grasslands.

The climate throughout the planning area is as varied as the landscape. The mountainous areas have a short growing season with mild days and cool nights. The mountains usually acquire snow cover during the winter months with temperatures dropping as low as 15° F. The southern desert areas are characterized by growing seasons that sometimes exceed 200 days with hot, dry days and warm nights. Although winters in the desert area are generally mild, temperatures can drop as low as 29° F. In contrast to the desert portion of the planning area, the plains area experiences a slightly shorter growing season and temperatures typically five to 15 degrees cooler.[3]

The planning area contains soils ranging from some of the best in New Mexico, to some of the worst, such as the gypsum sands and large outcrops of bare rock in the

[2] New Mexico Office of the State Engineer, 1995, Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Ground Water in New Mexico.
[3] U.S. Weather Bureau Climatalogical Data New Mexico, 1990 – 1995 New Mexico Climate Manual - Chapter 3.

limestone hills. The better soils produce stands of grasses, trees, shrubs and succulents that are used for forage, timber production and wildlife habitat.

The planning area has an abundance of mineral resources. Potash was discovered in the southeastern part of the planning area in 1924. The mines were first put into production between 1929 and 1931 and were later developed to become one of the largest potash mining industries in the United States. Gold and silver have been mined in the western areas. Gas and oil production began in the planning area in 1918 and is a major industry in the region today.

Large populations of wildlife are found throughout the planning area including elk, deer, antelope, quail, dove and waterfowl. An abundance of non-game species such as songbirds, reptiles and predator species (coyotes, foxes, bobcats and bears) are found in the area. Warm-water fisheries are found along the Pecos River and its tributaries and also at lower elevation lakes. Cold-water fisheries are present in the western tributaries and lakes at higher elevations.

Water users in the planning area rely on water supplies from both surface water and groundwater sources. Surface waters are diverted directly from the Pecos River and its major tributaries, such as the Rio Hondo, Rio Ruidoso, Rio Peñasco, Black River and Rio Bonito. Surface water is stored in reservoirs both outside and within the planning area. Ponds on intermittent streams are a water source for both livestock and wildlife. Groundwater is pumped from geological formations that yield from 5000 to less than one gallon of water per minute (gpm).

There are six administratively (OSE) declared groundwater basins in the planning area, including (Plate 1):

Fort Sumner Groundwater Basin
Roswell Groundwater Basin
Hondo Groundwater Basin
Peñasco Groundwater Basin
Carlsbad Groundwater Basin
Capitan Groundwater Basin

The OSE declared Roswell Groundwater Basin is the largest developed groundwater resource providing flowing and non-flowing wells. The Lower Pecos Valley Regional Water Plan is based on the associated surface streams and aquifer resources available from these six basins.

The year 2000 population of 139,000 is distributed throughout the planning area as shown in Plate 5. The northern section contains one incorporated community, Fort Sumner. The population of Fort Sumner is projected to remain stable for the next

20 years.[4] Decline is projected between 2020 and 2040. The section of the planning area below Fort Sumner and east of the Pecos River Basin does not support an incorporated community. The population within this region is concentrated around mineral resource developments or scattered ranches throughout the area. The largest centers of population are located along the lower part of the Pecos River in Chaves and Eddy Counties. The population in these areas is expected to double by the end of the 40-year planning period. Recreational opportunities in the mountain regions of the planning area attract visitors and retirees. Mountain communities have proven to be the fastest growing sites in the planning area and are expected to continue growing throughout the 40-year planning period.[4 above]

The economic base of the planning area is primarily mineral resource development, agricultural-related business, recreation and tourism. Some industry and manufacturing have been developed in the larger communities in the planning area. Recreational opportunities have been developed in the mountain areas and around bodies of water and are one of the fastest growing industries in the area. The many state and national parks and public lands attract people to the planning area.

Land use throughout the planning area is shown in Plate 6. Land falls under a wide array of owners and types of use (Plate 7 and Table 1). The northern part of the planning area is comprised mostly of privately-owned lands with some state and federally controlled sections. The land-ownership patterns become more diverse in the central and southern portions of the planning area with the Bureau of Land Management (BLM) controlling a major portion of this section. The southern portion is occupied by urban and recreational centers. The National Park Service manages Carlsbad Caverns National Park in the southwestern portion of the planning area and the U.S. Bureau of Reclamation (BOR) controls lands throughout the basin. The western section features national forests controlled by the United States Forest Service. The Mescalero Apache Indian Reservation occupies 500 square miles of Sacramento Mountain slope in the west-central area. Other land uses include recreation in state parks and development of mineral resources. With a diverse representation of ownership throughout the planning area, the majority of land is used as rangelands for livestock and wildlife, grazing purposes and irrigated agriculture.

Water has been a critical resource in the planning area as evidenced by the historic and prehistoric sites developed around permanent water sources. The early population used water resources for domestic purposes and for watering livestock. They developed some irrigation along the river valleys where they could divert the water. As additional settlers moved into these valleys they began to expand the

[4] Alcantara, A., 1996 Historical and Projected Population Trends for Water Planning Districts in New Mexico 1960 – 2060: Bureau of Business and Economic Research, University of New Mexico.

existing irrigation systems and to construct new ones. The earliest record of irrigation in the mountain valleys is in the early 1800s.[5]

Table 1. Land Ownership in the Planning Area

Owner	Area (Mi^2)
Private	7760
Bureau of Land Management	4683
State	2425
U.S. Forest Service	1251
Tribal	489
National Park Service	73
NM Department of Game and Fish	55
Fish and Wildlife Service	38
Bureau of Reclamation	21
State Parks	7
Military	6
Total	16,808

Diversions were constructed on the Pecos River and on those tributaries that could support irrigation development. The diversion at Fort Sumner was constructed between 1862 and 1868 by Native Americans at Bosque Redondo. Diversions in the Carlsbad area were constructed in 1887 by a group of individuals interested in developing agriculture in that area. Later the project was sold to BOR. Presently the Carlsbad area contains the largest irrigated area using surface water from the Pecos River.[6] Irrigation began in the Roswell/Artesia area sometime around 1867 when diversions from the Pecos River tributaries were developed. As irrigation practices appropriated the reliable streamflow, landowners began seeking alternative supplies. With the discovery of artesian water in the planning area, wells were developed to supplement streamflows and expand agriculture.[7] Groundwater supplies currently satisfy the majority of water demands in the planning area. In addition to agriculture, water is used by the potash and gas and oil industries and by other industries located in the area. Urban and domestic uses also require large quantities of water. The beneficial use of surface water and groundwater resources in the planning area is impacted by existing water rights, adjudication proceedings and legal issues surrounding the Compact. Water rights have been decreed or are in the process of adjudication throughout much of the planning area as shown on Plate 8.

[5] *Brief History of the Pecos River in New Mexico - Author Unknown.*
[6] Hufstetler, M. and Johnson, L., 1993, Watering the Land – The Turbulent History of the Carlsbad Irrigation District: Denver National Park Service, Rocky Mountain Region.
[7] Karnes, D., 1985, A History of the Pecos Valley: From the Files and Archives of the Pecos Valley Artesian Conservancy District.

The sections that follow describe each of the declared groundwater basins in detail.

OSE Declared Groundwater Basins

Fort Sumner Groundwater Basin

Description of the Basin. The Fort Sumner Groundwater Basin encompasses 4924 square miles; 2531 square miles are within the planning area, constituting 15 percent of the planning area (Plate 1).[8]

The basin was declared by the OSE in 1964. The basin was expanded in 1970 and again in 1993 and includes all but the southwestern corner of De Baca County and a portion of the north end of Chaves County. The basin extends into portions of Guadalupe, Quay, Roosevelt and Torrance Counties that lie outside the planning area.[2 above]

Most of the groundwater basin is in the Pecos-Canadian Plains and Valleys Land Resource Area[9]. The basin consists of a gently rolling landscape of grasslands and mixed shrub vegetation broken by the desert stream landscape of the Pecos River Valley. Farming occurs along the Pecos River in the vicinity of Fort Sumner. The basin ranges in elevation from 3700 to 5500 feet above mean sea level and the land generally slopes from north to south. All drainage in the basin is to the Pecos River.

The climate throughout the Fort Sumner Groundwater Basin is mild. Summer temperatures average from 60° to 90° Fahrenheit (F) while winter temperatures range between 25° and 50° F. On average, the growing season is 190 days and annual precipitation averages 12 inches. Most of the precipitation comes from intense summer rains that produce significant runoff. Precipitation records for selected stations in the Fort Sumner Basin are shown in Appendix D.[3 above]

The soil types found in the Fort Sumner Groundwater Basin vary from clays to deep sands and from shallow rocky soils to very deep loams. Soils in agricultural production areas consist of loams and sandy loams. The soils west of the Pecos River range from sandy to deep sands. Loams, clays and shallow soils comprise the remainder of the basin. Stands of grass, mesquite and other mixed shrubs occupying much of the open land within the basin are used for forage production, farming and wildlife habitat.

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[8] New Mexico Office of the State Engineer, 1997, Declared Underground Water Basins State of New Mexico, map.
[9] *Natural Resource Conservation Service Technical Guide - Fort Sumner Field Office.*

Mineral resources in this basin are limited to sand, gravel and caliche. Some gas and oil exploration and production also takes place in the basin.

The primary wildlife populations in the basin consist of antelope and mule deer. Quail, waterfowl, dove and a limited population of pheasant are also found throughout the basin, along with rabbits, small rodents, reptiles and predator species. In addition to wildlife, the basin is home to Sumner Lake and the Pecos River, which support warm-water fisheries and serve as popular recreation sites.

Both surface water and groundwater are utilized in the Fort Sumner Groundwater Basin. The major supply of surface water is diverted from the Pecos River for irrigation of farmlands around Fort Sumner. Water that is captured by small impoundment dams and playa lakes, as well as springs that occur along the tributaries of the river, provide water for livestock and wildlife.

Groundwater supplies are derived from several geological formations including the Glorieta, San Andres, Artesia and Santa Rosa Formations and alluvium and terrace deposits. Wellfields have been developed north and southwest of Fort Sumner. These wells produce between 250 and 1500 gpm. Other wells in the basin yield one to 200 gpm and are used for domestic, livestock and urban purposes. The quality of the surface water and groundwater ranges from fresh to brackish.

The basin is the second least-populated area in the planning area. The area was first settled in the mid-1800s. Population in the area grew steadily until the mid-1900s and has remained between 2500 and 2700 since that time. Fort Sumner is the only incorporated community in the basin and has approximately 1400 citizens. The balance of the population is scattered throughout the basin. However, there is a concentration of summer and/or recreation homes located on the west side of Sumner Lake just outside of the planning area.

The economic base within the basin is agriculture and agricultural-related businesses. Recreation and tourism contribute to the economy of the area.[10] Fort Sumner's economic base was formerly derived from the railroad industry and military bases. Presently, however, neither contributes largely to the economy of the area.

Land ownership in the basin is divided in the following manner (see Plate 7 and Table 1): 75 percent is privately owned, 15 percent is owned by the State of New Mexico, five percent of the land is under public domain and controlled by various Federal agencies and the remaining five percent is owned and controlled by a variety of entities. The largest portion of the land in the basin, 97 percent, is devoted to grazing

[10] Dennis Engineering Company, 1995, De Baca County Overall Development Plan Fort Sumner New Mexico.

purposes and for domestic livestock (see Plate 6). One percent of the land is used for farming. One percent is used for urbanization, roads, recreational development and water bodies. The remaining one percent serves a variety of other uses.

Historical Overview. The use of surface water in the basin began in prehistoric times when these waters were used for domestic purposes. Limited evidence supports extensive use of water for irrigation or other domestic uses prior to the mid-1800s. The Spanish explorers noted inhabitants growing squash, corn and beans. Development of the water resources began around the Fort Sumner area in the mid-to late 1800s with the establishment of the Fort Sumner Military Fort. The first major irrigation efforts began in 1863 with the construction of a main canal by the Mescalero Apache Indians. This irrigation system included a diversion dam located five to six miles above the military post. Captain John B. Shinnery recorded this development in 1866, while conducting the first survey of the Bosque Redondo under the direct order of General Ulysses S. Grant. Navajos under the supervision of Captain Calloway, a Native American farm superintendent, were able to dig a new ditch in a little over a month using only 50 spades. A field study conducted in 1984 substantiates the mileage and course of the Acequia Madre (the main canal) as documented by Major Wallen.

Lucien B. Maxwell purchased the military fort buildings in October of 1870 for $5000. He conducted extensive farming using the existing canal system. It is documented that 25 to 30 families relocated to Fort Sumner and each was assigned 40 acres of irrigated land by Maxwell himself. The irrigation works, as they exist today, are maintained and operated by the Fort Sumner Irrigation District (FSID).[11]

A title search conducted by Mr. Chapman of BOR produced the following timeline.

1862 - 1868	The basic system of ditches was constructed.
1869 - 1890	The U.S. Army abandoned the irrigation system and the Real Bosque Reservation.
1903	Fort Sumner Land and Development Company was formed. The name was later changed to Fort Sumner Land and Canal Company.
1908	Fort Sumner Land and Canal Company went bankrupt. During the next several years the company sold parcels of land to individuals. Title was assigned subject to easements for ditches and canals. All of the company's land was eventually sold.
1919	Mr. Fishbeck sold the company to the newly formed FSID. This gave title and the right to condemn to the district.[12]

[11] *History of the Fort Sumner Irrigation District* - *Author Unknown.*
[12] Chapman, T., Date Unknown, Title Search Time Line Fort Sumner Irrigation District: U.S. Bureau of Reclamation.

The development and use of groundwater resources most likely began with the settlement of the area by livestock owners. The first recorded development and use of groundwater occurred in the late 1870s when Sunnyside Springs in Truchas Creek was developed to provide water to the community of Sunnyside and the surrounding areas. Water from these springs was used in Fort Sumner and a second Sunnyside community adjoining Fort Sumner.

The first recorded well in Fort Sumner was named the Dug Well. This well, according to Atchison, Topeka and Santa Fe Railway records, was established in 1905 and was 30 feet in diameter and 20 feet deep. Other documentation by the railroad references this same well as Dug Well No. 2. This second well is further documented to have been 81 feet southeast of a similar well, identified as Dug Well No. 1. Both wells derived water from the Quaternary alluvium and are recorded to be in existence on March 2, 1908. In 1911, Mr. Haskell increased the depth of Dug Well No. 2 to 210 feet. This well was a major source of water for the Village of Fort Sumner until August 1936.[13]

The development of irrigation wells first began in the 1950s in an area south of Fort Sumner along the Pecos River. Some of the wells produced as much as 2000 gpm. Approximately 2200 acres of farmland are irrigated from these wells. In 1965, a second area of groundwater was developed for irrigation north of Fort Sumner and east of Sumner Lake. This area includes about 4100 acres of farmland irrigated mainly by sprinkler systems. Since 1965, other small areas of groundwater irrigation have also been developed.

Roswell Groundwater Basin

Description of the Basin. The Roswell Groundwater Basin is the largest declared basin constituting 60 percent of the planning area and encompassing 10,779 square miles, 10,033 square miles of which are within the planning area (Plate 1).[8 above] It is located in the central portion of the planning area and includes most of Chaves County. The basin includes parts of Torrance, Guadalupe and Roosevelt Counties, which lie outside the planning area.[2 above] The Pecos River runs through the eastern side of the basin from north to south. Several large tributaries drain from the west to the east. This basin offers a wide variety of terrain which includes the Pecos-Canadian Plains and Valleys, Southern Desertic Basins, Plains, Arizona and New Mexico Mountains Major Land Resource Areas. The landscape ranges from level to gently rolling in the lower elevations of the southern desert and central plains, to low hills and arroyo valleys, to high rugged mountains. The vegetation throughout the basin is equally diverse. It ranges from the desert shrubs and grasslands to the open grass stands of the plains, and from the piñon-juniper and mixed shrub areas to the conifer forests in the higher

[13] Galloway, S.E., and Perrin, K.D., 1987, Summary of Water Rights Village of Fort Sumner De Baca County, New Mexico: Shamas and Perrin Law Office.

elevations. Farmland is found throughout the basin in areas where adequate water supplies are available. Elevations range from 3300 feet where the Pecos River flows out of the basin, to 10,080 feet in the El Capitan Mountains, located in the northwestern area.[14]

The basin encompasses both desert and high mountain climates. Summer temperatures in and around Roswell and Artesia range from an average high of 95° F to an average low of 45° F. Average winter temperatures range between 23° F and 65° F. The summer temperatures around the Capitan Mountains range between 45° F and 80° F, while winter temperatures range between 17° F and 50° F. Temperatures for other areas in the basin fall between these ranges. The growing season in Roswell and Artesia is approximately 208 days. Precipitation averages 12 inches per year, most coming from intense summer rains that produce significant runoff. The growing season in the mountain areas is approximately 110 days; the average annual precipitation is 25 inches, 35 percent of which falls as snow. Precipitation records for selected stations in the Roswell Basin are shown in Appendix D.[3 above]

The soil types found in the Roswell Groundwater Basin include deep fertile loams, deep sands and clays, very shallow, poor-quality soils and areas of bare rock. The lands under cultivation consist mostly of loams, sandy loams and some clay loams. Sandier soils are found in the eastern part of the basin, while bare-rock outcrops and bluffs occur in the hills and mountains in the western portion of the basin. Vegetation supported by these soils include open grasslands, a mixture of grasses and shrubs, piñon-juniper stands and conifer forests. These areas are used for forage productions, farming, and wildlife habitat and recreation, while they also provide aesthetic and watershed benefits. Mineral resources in the basin include gas, oil, sand, gravel, caliche and minor amounts of gold and silver.

Wildlife populations in the basin include elk, deer, antelope, bear, lion and Barbary sheep. Turkey, ducks, geese, quail, dove and a few pheasant are found in this area, as well as other birds, rodents, reptiles and predator species. This basin supports several threatened and endangered species. Additionally, the Pecos River and several small lakes support warm-water fisheries while serving as popular recreation areas.

Water users in the basin rely on both surface water and groundwater. Surface water is diverted from the river's tributaries along Spring Creek and the Hondo, Felix and Peñasco Rivers. Some surface water is also pumped from the Pecos River. Most surface water in the basin is used for irrigation purposes.

Some surface water from small arroyos and from spring discharge is collected in impoundment dams and playa lakes to provide water for livestock and wildlife.

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[14] *Natural Resource Conservation Service Technical Guide - Roswell Field Office.*

Groundwater supplies are derived from several geological formations including the Yeso and San Andres Formations, the Artesia Group, the Glorieta Sandstone and alluvium and terrace deposits. The two major aquifers that provide the largest supplies of water are the Permian artesian aquifer and the shallow-water aquifer located in the alluvium deposits and terraces.[15] These two aquifers provide water for the Cities of Roswell, Artesia, Dexter, Lake Arthur and Hagerman. Irrigation wells have been developed throughout the basin. The largest concentration is located in the Pecos River Valley between Roswell and Seven Rivers. Wells developed for irrigation purposes yield between 300 and 5000 gpm. Wells developed for other purposes in various formations throughout the basin yield between one and 1000 gpm. The quality of both surface water and groundwater is wide-ranged. Chloride and sulfate are the most common constituents that degrade water quality in the Roswell Basin.[16]

The basin is the most populated region in the planning area. Europeans first settled around 1865 near Artesia. Cities and their population levels include: Roswell (pop. 44,654), Artesia (pop. 10,610), Dexter (pop. 898), Hagerman (pop. 961), Lake Arthur (pop. 336) and Hope (pop. 101).[4 above] Other communities are scattered throughout the basin, particularly near farming areas.

A major economic base of this area is agriculture. A contributor to the basin's economic base is the development of mineral resources, primarily gas and oil. Recreation and tourism, as well as manufacturing and government, also contribute to the economy of the basin.

Land ownership (see Plate 7 and Table 1) in the basin is divided as follows: 43 percent is privately owned, 15 percent is owned by the State of New Mexico, 33 percent is public land controlled by the BLM, five percent is federally owned and maintained by the Forest Service and the remaining four percent is owned and controlled by a variety of entities. The largest portion of the land in the basin, 94 percent, is devoted to grazing purposes for domestic livestock (see Plate 6). Approximately three percent is used for irrigated agriculture. One percent of the land in the basin is occupied by cities, villages and other developed areas. The remaining land, approximately two percent, is used for roads, recreational areas, water bodies and various other uses.

Historical Overview. Prior to the establishment of settlements, there is little evidence to substantiate the use of surface water and groundwater in the basin. Early records indicate that Spanish expeditions traveled through the area as early as 1583. The first record of interest for water claims in the basin followed the Civil War. At this

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[15] Hantush, M.S., 1957, Preliminary Quantitative Study of the Roswell Ground Water Reservoir New Mexico: New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining & Technology.

[16] Fiedler, A.G., and Nye, S.S., 1933, Geology and Ground - Water Resources of the Roswell Artesian Basin New Mexico: U.S. Geological Survey Water Supply Paper 639.

time cattlemen drove their herds from south Texas into eastern New Mexico and Colorado to supply forts and Indian reservations with meat. People like John Chisum, Charles Goodnight and Oliver Loving relied on the rivers and springs to water their cattle as they moved through the area.[17]

Irrigation of small farms began in the mid-1800s as Europeans occupied the area extensively. At that time water was so plentiful that little effort was made to record its diversion or rights. Records such as survey notes, diaries and old newspaper articles only make infrequent, passing comments regarding water development during this time period.

One of the first records of irrigation in the basin is from La Plaza de San Jose, also known as Missouri Bottom or Missouri Plaza. This community was founded about 1867, 15 to 17 miles west of Roswell on the banks of the Hondo River. Water was diverted from the Hondo River to irrigate small farms in the area. This community was later abandoned in 1872 when water in the river became insufficient to support the farms.

The vision to dam the Hondo River is credited to Pat Garrett. In 1889, Pat Garrett built the Hagerman Canal System, which today is the largest ditch company in Roswell and the surrounding area. The system diverts water from tributaries to the Pecos River. The Hope Irrigation System was established in the 1890s and is located west of Artesia near Hope. This large irrigation development diverts water from the Peñasco River and currently includes 3200 acres. At the peak of surface-water development, about 120 individual and community ditches diverted water from tributaries of the Pecos River.

The first Reclamation Service (later, BOR) project in New Mexico was the Hondo Project. It began as a private project in the mid 1880s. Reclamation Service took over in 1902 after the flood of 1893 suspended construction. The project consisted of an off-channel reservoir nine-miles southwest of Roswell that was supposed to have stored floodlflow for irrigation. The project failed because of the leaky nature of the formation underlying the reservoir.

Fiedler and Nye[16 above] wrote, "By 1880 the original irrigation systems in the vicinity of Roswell derived their water supply from the North and South Springs Rivers and the Berrendo Creek. The ditches from these streams were gradually extended by the landowners until most of the water from these sources was diverted for irrigation farming. With the development of artesian water the flow of the North and South Springs Rivers and Berrendo Creek gradually declined and as a result most of the early ditches have been abandoned due to inadequate water supply."

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[17] *Brief History of the Pecos River in New Mexico - Author Unknown.*

Groundwater was first appropriated from shallow wells and used for livestock and domestic purposes. The first full-scale attempt to discover artesian water in the Pecos River Valley was conducted by Captain John Pope. Pope, a topographical engineer in the U.S. Army, was assigned to survey a route for the Pacific Railroad. In January of 1855, the U.S. Army War Department authorized Captain Pope to organize an expedition to drill for flowing artesian wells. Although his attempts failed, the idea was introduced to the valley.

Successful construction of the first artesian well in the basin is attributed to Nathan Jaffa. In 1892, finding the water from his shallow well detrimental to his health, Jaffa decided to dig a deeper well in search of purer water. At a depth of 250 feet, much to Jaffa's surprise, he discovered artesian water. At this great news, people traveled from miles around to see the well.

Soon after the discovery of the Nathan Jaffa's well, others began drilling deep wells. By 1900 approximately 83 wells had been developed and were in use. Thus began the water boom. In an effort to promote economic progress, towns raised money to finance the development of artesian wells. Artesian water provided the opportunity to develop cultivated lands that irrigation canals could not reach. Soon, the farming communities of Dexter, East Grand Plains, Lake Arthur and Artesia were founded and growing.[7 above]

Over the years, inefficient use and the lack of regulation took their toll on water supplies. The original area of the artesian flow covered approximately 633 square miles. By 1916 the size of the artesian area had decreased to 499 square miles and by 1926, artesian flow was limited to only 228 square miles, 36 percent of the original area. By 1927 the number of developed artesian wells had reached 424. As the aquifer pressure declined, many towns such as Dayton and Atoka on the perimeter of the artesian flow were abandoned.

Evidence shows that each of these groundwater booms ended with the basin's water supply progressively further out of balance. The ultimate goal of regulation has been to reestablish that balance. From 1905 to 1925, the Territorial and State Legislature responded to local pressure and passed artesian regulatory acts tied specifically to Chaves and Eddy Counties. These acts prohibited surface waste of artesian waters, required control valves and proper casing practices and established a local supervisory agency or official to oversee the situation.

In 1927 the New Mexico State Legislature passed the State's first groundwater control statute. This statute was amended in 1929 and a second statute allowing the creation of artesian conservancy districts was passed. The Pecos Valley Artesian Conservancy District (PVACD) was organized in 1932 to help conserve water in the declared basin and bring the aquifer back into balance. Water development continued to occur outside the basin and the New Mexico State Engineer, with the encouragement of the conservancy district, extended the boundaries of the declared basin at least five times by 1940.

The last major phase of groundwater development occurred between 1941 and 1959. Since that time, through water rights retirement programs, adjudication and metering of wells, the two major groundwater aquifers (the shallow-water aquifer and the artesian aquifer) have slowly been brought closer into balance between recharge and discharge. Current information indicates that the basin is approaching conditions that existed in the early stages of development of these water resources.[7 above]

The City of Artesia initiated the development of a municipal water system in the Roswell Groundwater Basin in 1903. This was followed by water systems being developed in Lake Arthur, Hagerman, Dexter and Roswell in the early 1900s. Hope developed a water system in 1954. All of these water systems rely on groundwater aquifers for their supplies.

Commercial development of water resources has been limited to light manufacturing and food processing. The establishment of Walker Air Force Base in the l930s effected available water resources within the basin. However, this base was closed in 1966 and present military activity has only a slight impact on water resources. During the early 1970s and 1980s, the gas and oil industry made dramatic increases in their development, increasing their water demands significantly. Although still a viable industry in the basin, oil and gas activities have declined in recent years. Some historical and modern photographs of the Roswell area are presented in Figures 1 through 3. [18,19]

[18] *Figure 1, Courtesy of Clara G. Wilkerson.*
[19] *Figure 2, Photo from Pecos Valley Collection Chaves County Historical Museum.*

Figure 1. Historic Photo of Haynes Dream Lake, 1918

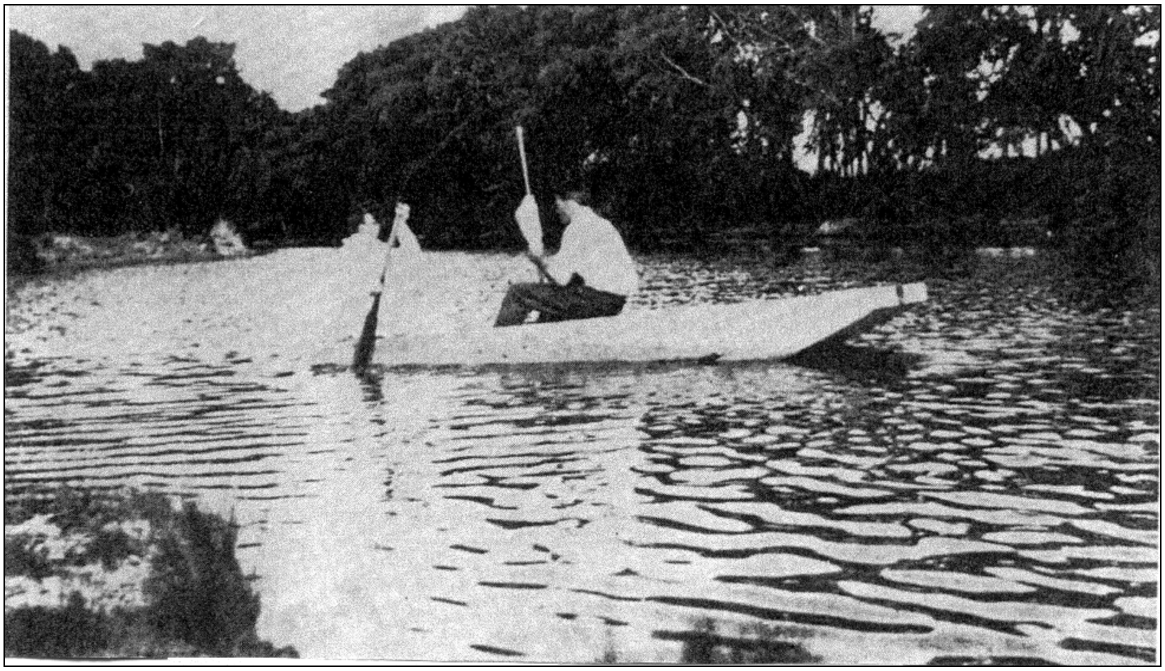


Figure 2. Site of Historic Photo of Spring River Dam and Spillway Near the Swimming Pool

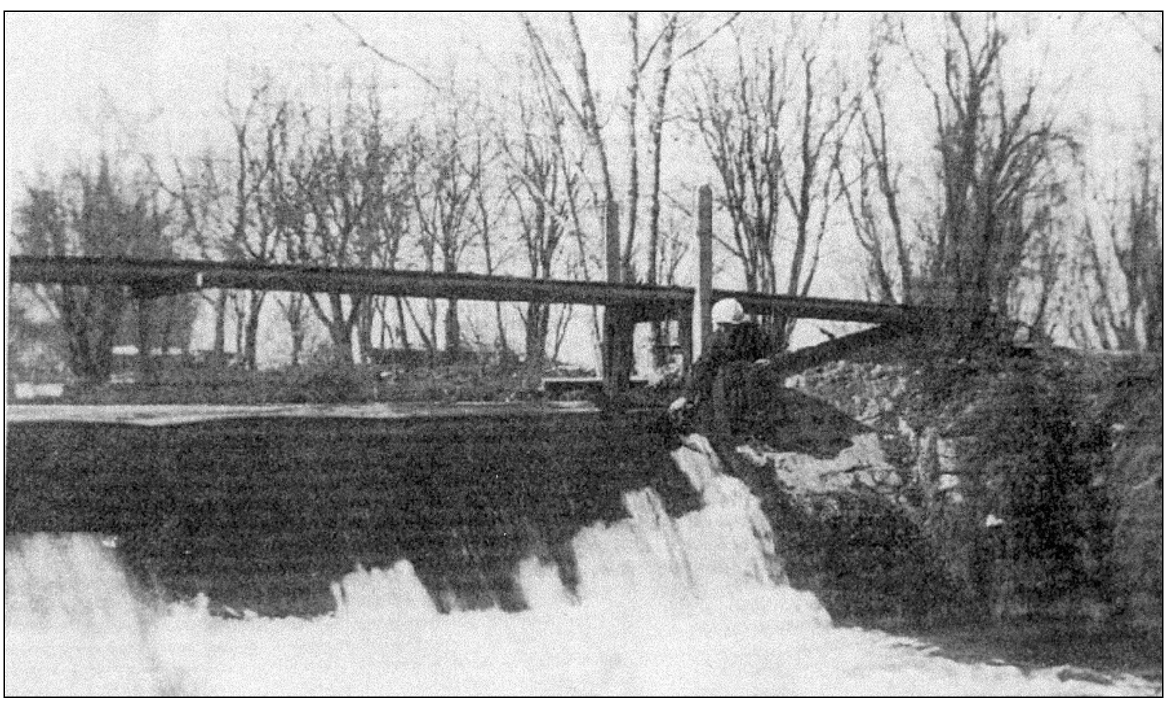
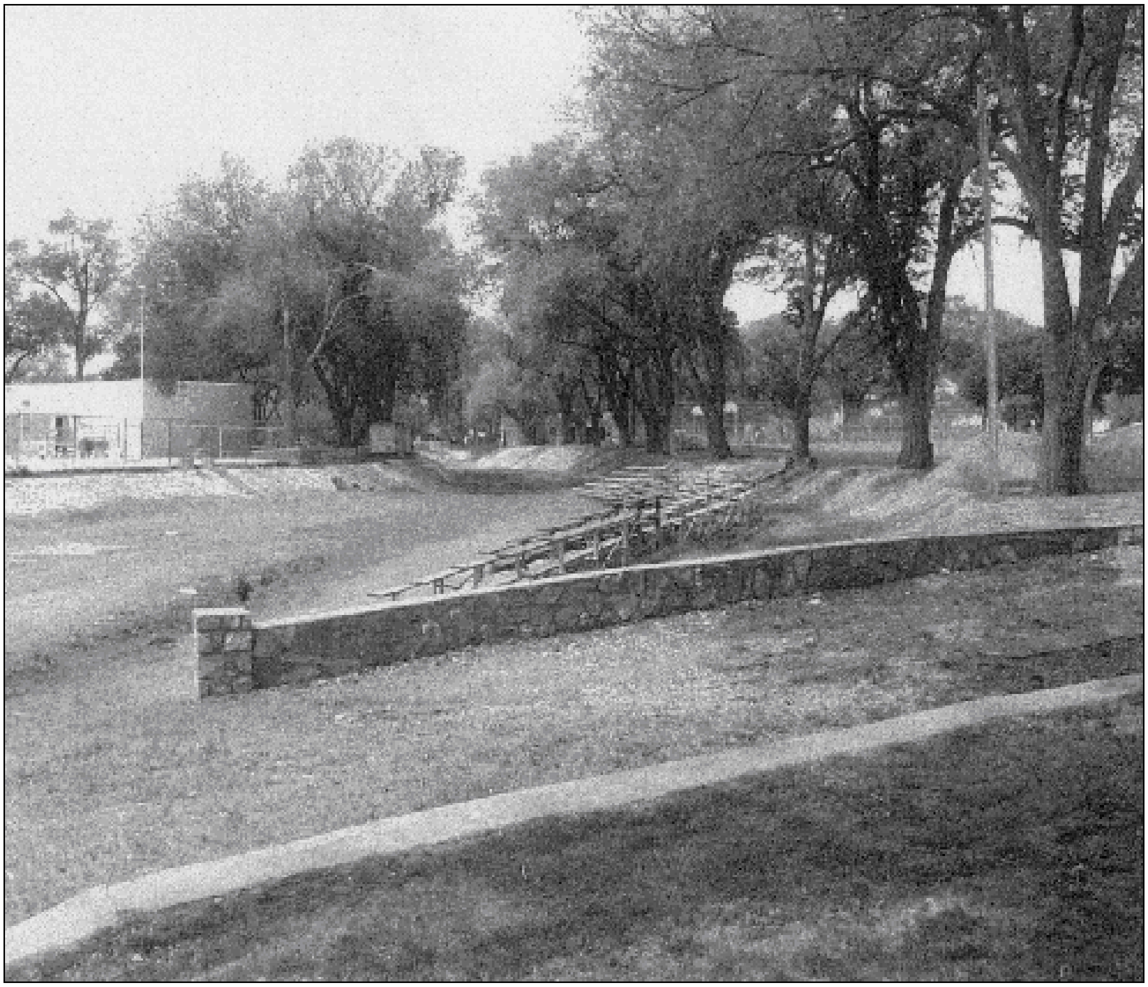


Figure 3. Photo of Spring River



Hondo Groundwater Basin

Description of the Basin. The Hondo Groundwater Basin encompasses 1101 square miles and is the second smallest basin at six percent of the planning area (Plate 1).[8 above] The basin was first declared in 1953. It has been expanded three times since then, with the last expansion taking place in 1993. This basin is located in the west-central section of the planning area. It includes the northeastern corner of Otero County and a portion of the southeastern corner of Lincoln County. This basin lies entirely within the planning area.[2 above] It includes the Hondo and Ruidoso Rivers, Eagle Creek and Rio Bonito. All of these systems are tributaries of the Pecos River draining from west to east, with the lower reaches running through the Roswell Groundwater Basin. This basin is located in the hill and mountain country and includes the Arizona and New Mexico Mountains and Pecos-Canadian Plains and Valley Major Land Resource Areas. The landscape includes rugged hills and mountains with narrow river valleys. The vegetation ranges from grasses and shrubs in the lower elevations, through the piñon-juniper woodlands to the conifer forests of ponderosa pine, Douglas-fir and spruce in the higher elevations. Some of the highest elevations are alpine in nature and do not have the conifer forests. Most of the farmland is found in the narrow river valleys, although some mountain meadows are farmed in the higher elevations. Elevations range from 4400 feet at the far eastern edge of the basin to nearly 12,000 feet on the summit of Sierra Blanca.[20]

The climate in the basin ranges from mild in the valleys to cool in the high mountains. The summer temperatures in the lower valley near Picacho range from 58° F to 88° F. Winter temperatures in this area range from 23° F to 55° F. The summer temperatures around Ruidoso range from 47° F to 80° F. Winter temperatures range from 16° F to 49° F. The growing season in the valleys is approximately 179 days while the growing season in the higher elevations is around 102 days. The average precipitation ranges from 14 inches in the valleys to 30 inches in the mountains. At the higher elevations, one-third to one-half of the annual precipitation falls as snow from November through April. The lower elevations receive some snowfall, but it is usually less than one-third of the total annual precipitation. The area is subject to torrential rains that can cause floodflows in the lower areas and drainage ways. Precipitation records from selected stations in the Hondo Basin are shown in Appendix D.[3 above]

The soil types in the basin include the following. The valleys are filled with deep alluvial deposits of loamy soils. These loam soils range in texture from sandy loam to clay loam. The mountain meadows contain loams and clays. The steeper slopes are comprised of shallow soils with occasional rock outcrops and bluffs occurring on the upper slopes. Most of the forest soils are rich in humus and very fertile. These soils produce grasslands with a variety of shrubs in the lower elevations. Riparian

[20] *Natural Resource Conservation Service Technical Guide - Capitan Field Office.*

vegetation occupies the undisturbed stream banks in the bottom areas. Piñon-juniper, with grass and shrub understory occupy the soils in the middle zone of the basin, while conifer stands occupy the soils at higher elevations. Where the conifer stands are open and in the meadows, grasses and forbs cover the loamy soils. These areas are used for forage production, farming, wildlife habitat, recreation and timber production, while they also provide aesthetic and watershed benefits. Mineral resources are limited to sand, gravel, caliche, rock and small amounts of gold and silver.

Wildlife populations in the basin include elk, deer, bear, lion and the introduced Barbary sheep. Turkey, quail and dove are also found in these areas, as well as grouse and pigeons in the higher elevations. Ducks and geese winter or stop in the basin during their migration. Other birds, rodents, reptiles and predator species occupy the area as well. The streams of the Rio Bonito and the Hondo and Ruidoso Rivers provide cool-water fisheries and where accessible, popular recreational areas. Additionally, the basin includes a few lakes, mostly man-made, which provide cool-water fisheries and recreational opportunities.

Both surface water and groundwater are used in the basin. The surface water is diverted from the Hondo River and its tributaries, the Rio Bonito, the Ruidoso River and Eagle Creek. This water is used to sustain and further develop irrigated farmland, urbanized areas, livestock, recreation sites and fisheries. Water supplies for livestock and wildlife in the area are met by impoundments constructed on small drainages. Additionally, some of the springs have been developed to support various uses. Groundwater supplies are appropriated from several geological formations. The main water-bearing formations are the alluvium and the deeper formations of San Andres, Glorieta and Yeso.[21] Wells developed in these formations yield one to 3500 gpm. Irrigation wells were first developed to supplement the surface water diverted from streams. Wells were later developed as a primary source of irrigation water. Wells developed in other formations for domestic and livestock water yield between one to 125 gpm. Some of the water used in the urban and community water systems is pumped from wells. The quality of water drawn from these wells varies. Well water in the eastern portion of the basin is of poor quality due to salinity and high mineral content. Well water in the western portion of the Hondo Basin is of very good quality. Most of the surface waters are high quality, but contain some dissolved minerals. Sediment contamination can effect surface water during periods of flooding.

Due to the recreation and tourism industry in the basin, a large transient population occurs during certain times of the year. Between November and February, tourists come to the basin to ski at Ski Apache. In the summer months, the cool temperatures and horse racing at Ruidoso Downs are major attractions. The permanent population of the basin is approximately 10,500 with major concentrations in Ruidoso

[21] Mourant, W.A., 1963, Water Resources and Geology of the Rio Hondo Drainage Basin Chaves, Lincoln, and Otero Counties: New Mexico Office of the State Engineer Technical Report 28.

(7500) and Capitan (2500).[4 above] The balance of the permanent population resides in small communities throughout the river valleys.

Initially the basin's economy relied heavily on agriculture and forestry. Over time, agriculture has remained a viable contributor to the economic base of the area; however, the timber industry's role has decreased. Currently, the major contributors to the economy of the basin are recreation and tourism.

Land ownership in the basin is divided as follows (see Plate 7 and Table 1): 33 percent of the land is privately owned, two percent is owned by the state of New Mexico, 34 percent of the land is federally owned and controlled by the Forest Service (30 percent) and the BLM (four percent), 29 percent is occupied by the Mescalero Apache Indian Reservation and the remaining one percent is owned and/or controlled by a variety of entities. The largest portion of land in the basin, 90 percent, is devoted to livestock grazing (see Plate 6). Five percent is used for farming. Four percent is used for urban and recreational uses. One percent is used for wildlife habitat. Figures 4 and 5 show photos of Benson Canyon located south of Cloudcroft along the Peñasco River taken in 1928 and 1995 respectively. Note the increased tree coverage in Figure 5.

Historical Overview. Evidence exists that the Native Americans used surface water in the Hondo Basin for limited irrigation and domestic purposes prior to the arrival of European settlers. Records are unclear as to the first major efforts to use surface waters in the basin. However, it has been noted that the community of Missouri Bottom, located on the lower reaches of the Hondo River near Roswell, was abandoned in 1872 because water users on the upper watershed had depleted the flow of the river. This notation suggests that irrigation systems within the basin were developed prior to 1872. In 1908 the following community ditches were reported to be in operation. Diversions from the Hondo River served the following ditches: Picacho, Buckguyes, Chene, J&P Analla, P. Chaves Springs and the J. Gonzales. Diversions from the Ruidoso River served the following ditches: P. Chaves, A. Chaves No. 2, Ice Storm, F. Hilburn, South Chosas (lower), Q. Sanchez, North Chosas, South Chosas Upper, Leopoldo Gonzales, A. Chaves No. 1, Barragan, Barragan and West, L. Gallegos, P. Gonzales, A. Sanchez, F. Silve, Mirabel and Norman, J. M. Sanchez, F. Sanchez South, S. Sanchez North, Hewitt, Maxwell Community, Bracken Community, Pope and Allison, Avint, North Hale, South Hale, F. Herrera North and Wingfield. Additionally, in 1934 the Rio Bonito served the following ditches: Lutz, Cruz de Jara, La Providencia, Lincoln Community and the Las Chosas. Presently, in the reaches of the Ruidoso River, between Ruidoso and its confluence with the Rio Bonito, there are 29 diversion dams serving approximately 179 landowners and 1264 acres of irrigated land. In the reaches of the Rio Bonito, between Fort Stanton and its confluence with the Ruidoso River, there are 13 points of diversion serving 40 landowners and 1030 acres of irrigated land. In the reaches of the Hondo River, from its headwaters to the confluence of the Ruidoso River and Rio Bonito at the McKnight Ranch, there are five points of diversion serving 16 landowners and 672 acres of irrigated land.[22]

Water resources in the basin were first commercially developed by the Southern Pacific Railroad Company in 1906. The railroad initially acquired water rights to the Rio Bonito, but later obtained additional water rights from Eagle Creek. After experiencing water shortages during low-flow periods, the railroad began construction of the Bonito Dam in 1934 in an effort to secure a permanent supply of water. The Rio Bonito water rights and Bonito Dam were later sold to the City of Alamogordo when the railroad converted to diesel engines and ultimately abandoned the mountain railway. The Villages of Ruidoso and Capitan developed the Eagle Creek Water Supply Association and in 1954 purchased the Eagle Creek water rights and existing pipelines from the Southern Pacific Railroad Company.[23]

The Village of Ruidoso was incorporated in 1946 and began developing a municipal water system shortly thereafter. The Village of Capitan was also incorporated around that time and also developed a water system. Additionally, several other community water systems have been developed in the basin and presently serve the smaller unincorporated communities, as well as some rural areas.

In recent years the Mescalero Apaches have developed some of their water rights for recreational purposes. They have constructed a dam on Carrizo Creek that provides water for the Inn of the Mountain Gods recreational and tourism development.

[22] *Records of Diversions, Landowners and Acres Served – Lincoln County – Provided by the Natural Resource Conservation Service – Capitan Field Office.*
[23] Author Unknown, 1995, Water Plan for the Village of Ruidoso.

Figure 4. Historic Photo of Benson Canyon Looking West, 1928

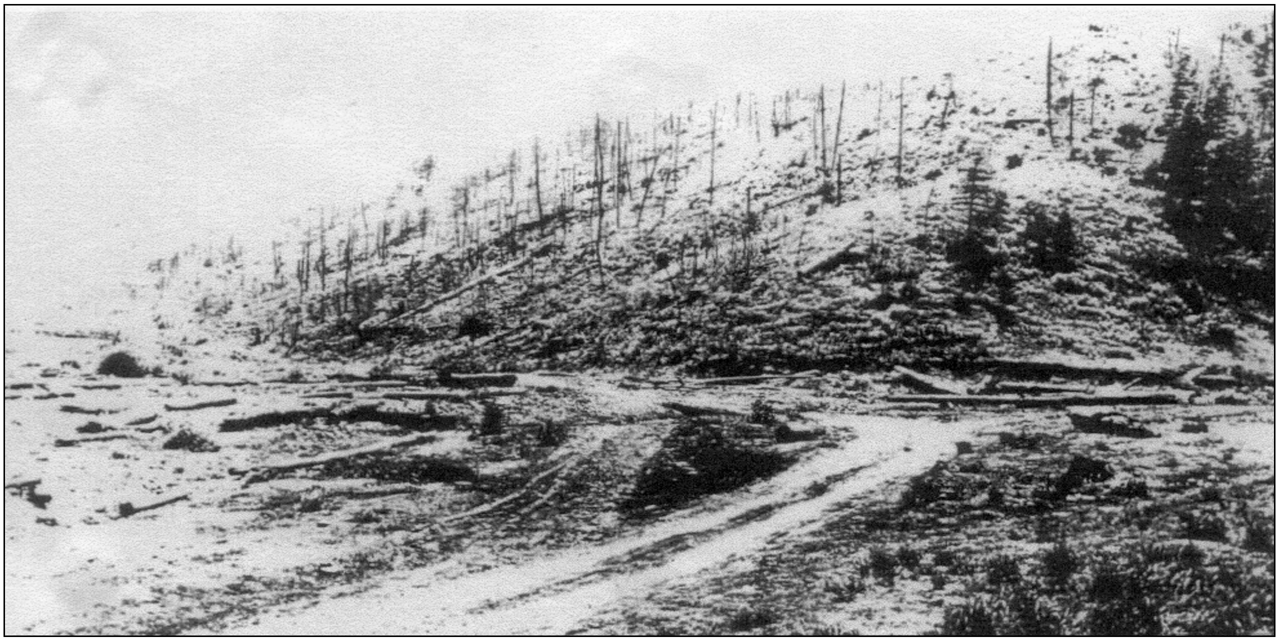
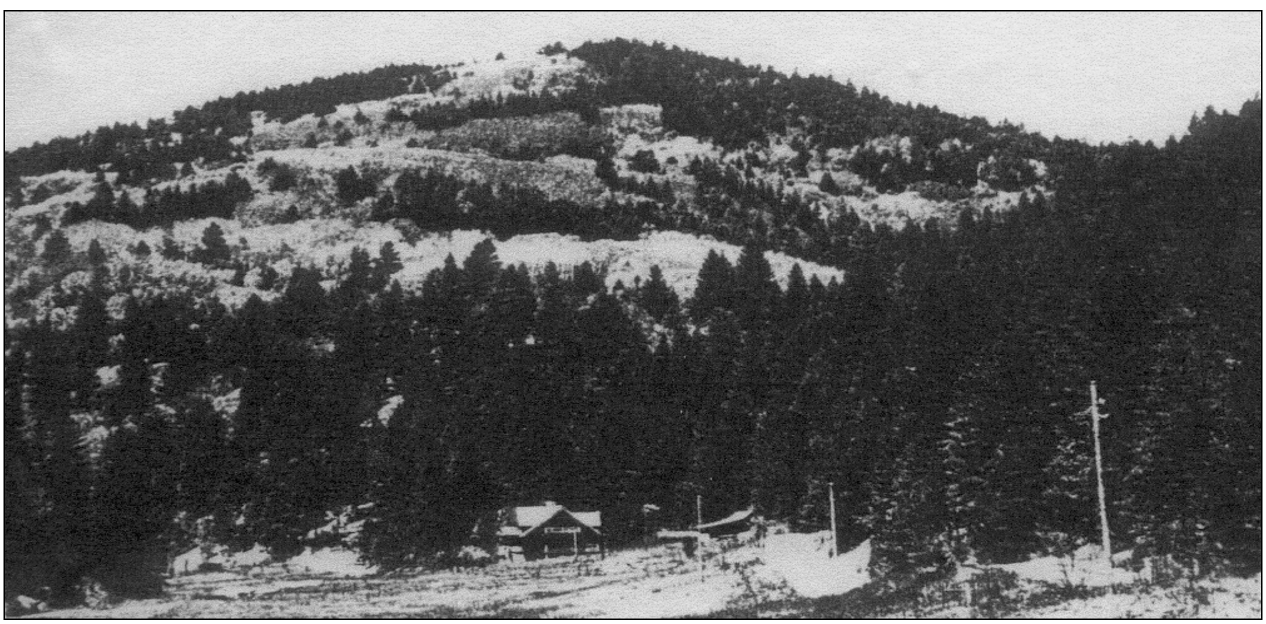


Figure 5. Modern Photo of Benson Canyon Looking West, 1995



Peñasco Groundwater Basin

Description of the Basin. The Peñasco Groundwater Basin consists of 903 square miles and is the smallest declared basin at five percent of the planning area.[8 above] The basin was declared in 1953 and has been expanded twice with the last expansion taking place in 1993. The basin is located in the west central part of the planning area and borders the south end of the Hondo Groundwater Basin. It includes a portion of the northeastern corner of Otero County and part of the southwestern corner of Chaves County. This basin lies entirely within the planning area.[2 above] It includes the upper watershed of the Peñasco River and its tributaries and a small part of the upper watershed of the Felix River's drainage. These are tributaries of the Pecos River that drain from west to east and have lower reaches that pass through the Roswell Groundwater Basin. This basin is located in hill and mountain country and includes both the Arizona and New Mexico Mountains and the Pecos-Canadian Plains and Valley Major Land Resource Areas. The landscape includes rugged hills with narrow river valleys. The vegetation ranges from the grasses and shrubs of the lower elevations, through the piñon-juniper woodlands, to the conifer forests of ponderosa pine, Douglas fir and spruce in the higher elevations. Most of the farmland is located in the narrow river valleys and is irrigated by stream diversions. Elevations range from 4300 feet at the eastern edge where the Peñasco River exits the basin, to 9700 feet in the mountains south of Cloudcroft.[24]

The climate in the basin ranges from mild in the lower valleys to cool in the high mountains. The summer temperatures in the eastern portion of the basin range from 45° F to 93° F. Winter temperatures range from 27° F to 58° F. The summer temperatures at Cloudcroft range from 36° F to 75° F. Winter temperatures range from 15° F to 45° F. The growing season in the valleys is approximately 180 days, while the growing season in the higher elevations is around 120 days. The average annual precipitation ranges from 14 inches in the valleys to 30 inches in the mountains. At the higher elevations one-third to one-half of the annual precipitation falls as snow during the period from November through April. The lower elevations usually receive less than one-third of their annual precipitation as snowfall. The area is subject to torrential rains that can cause flooding in the low areas and drainage ways. Precipitation records from selected stations in the Peñasco Basin are shown in Appendix D.[3 above]

The soil types found in the basin are rich and diversified. Deep loamy soils of alluvial deposit are found in most of the river valleys. The soils on the uplands and ridges are loams and shallow loams. These loams range from sandy loams to clay loams. Rock outcrops and sometimes bluffs occur on the ridges in the basin. The forest soils are high in humus. The lower elevations support grass and shrub vegetative communities. Riparian vegetation occupies the undisturbed stream banks in the bottom

[24] *Natural Resource Conservation Service Technical Guide - Artesia and Alamogordo Field Offices.*

areas. Piñon-juniper, with a grass and shrub understory, occupy the soils in the middle zone of the area while conifer forests occupy the soils of the higher elevations. Forbs cover the loam soils in the open conifer stands and in the meadows grasses. These areas are used for forage production, farming, wildlife habitat, recreation and timber production, while they also provide aesthetic and watershed benefits. Mineral resources are limited to sand and gravel, caliche, rock and a small amount of gold and silver.

Wildlife populations include elk, deer, bear, lion and the introduced species of Barbary sheep. Turkey, quail and dove are also found in this area with grouse and pigeons found in the higher elevations. Some ducks and geese winter in the basin while others stop here during migration. Other birds, rodents, reptiles and predator species are also found in the basin. The Peñasco River and its tributaries, such as Aqua Chiquita, provide cool-water fisheries and, where accessible, are popular recreation areas. Several reservoirs in the basin that are supplied by springs or other permanent water supplies have been developed as fisheries for commercial recreation.

The basin relies on both surface water and groundwater. The surface water is diverted from the Peñasco River and its tributaries. This water is used for a variety of purposes including farm irrigation, livestock use and recreation development. Impoundments have been constructed on small drainages to supply water for livestock and wildlife. Additionally, some of the larger springs have been developed to support various uses. Groundwater supplies are appropriated from several geological formations with the main water-bearing formations being the alluvium and the deeper formations of San Andres, Glorieta and Yeso. Wells developed in these formations yield from one to 3500 gpm. Irrigation wells were first developed to supplement the surface waters diverted from the streams during periods of low flow. Some wells were later developed for primary sources of irrigation water. Wells developed in other formations yield between one and 125 gpm and are usually water sources for domestic and livestock purposes. Water for the urban and community water systems is derived from groundwater aquifers. Groundwater in this basin ranges from very high to poor quality with high concentrations of salinity and sulfur. Surface water is generally of good quality, although it may contain high levels of some minerals.

The basin is similar to the Hondo Groundwater Basin in its resource base. The basin has developed a recreation and tourism industry that attracts a large transient population. As many as 4500 people may visit the basin during certain times of the year. The permanent population of the basin is approximately 1650. The only incorporated population centers in the basin are Cloudcroft, with a population of 750 and Mayhill, with a population near 100.[4 above] The balance of the permanent population resides in small communities throughout the river valleys.

Initially the economy of the basin was strongly tied to both agriculture and forestry. Although agriculture continues to be a viable contributor to the present economy, the timber industry's role has lessened over the years. Presently the major portion of the economic base is derived from recreation and tourism.

Land ownership in the basin is divided as follows (see Plate 7 and Table 1): 17 percent of the land is privately owned, five percent is owned by the State of New Mexico, 58 percent is federally owned and controlled by the Forest Service (54 percent) and the BLM (four percent), 19 percent is occupied by the Mescalero Apache Indian Reservation. The remaining land area is owned and/or controlled by a variety of entities. The largest portion of land in the basin, 90 percent, is used for livestock grazing (see Plate 6). One percent is used for farming. Urban areas and recreational sites occupy one percent. Five percent is devoted to wildlife habitat and the remainder serves a variety of miscellaneous uses.

Historical Overview. Native Americans occupied the area prior to the settlers' arrival in the mid-1800s. Development of farmland and diversion systems continued until the 1950s when the basin was declared and the use of water was regulated. There are presently 34 diversions on the Peñasco River serving 52 landowners. Six diversions have been constructed on the Aqua Chiquita to provide water for ten landowners. One diversion exists on the Blue Creek serving two landowners, and one diversion has also been constructed on Steven's Draw to serve one landowner. Groundwater has been developed from wells and springs to supplement the surface water. Some areas within the basin use groundwater as their primary source of water.[25]

Commercial development of water in the Peñasco Basin, as in the Hondo, started with the formation of the railroad company that was developed to serve the growing timber industry in the basin.[26] The railroad industry did not develop large water supplies in the basin, but did use water from the rivers and springs where available. The timber industry developed some water resources for use in processing timber. Recently the recreation industry has developed water resources for use in winter sports areas.

The Village of Cloudcroft developed its first water system in the early 1950s to provide water for permanent residents and the large transient population that visits the area. This system relies on wells and springs for its water supply. Several community water-supply systems have been developed to serve the unincorporated communities and rural areas in the basin.

[25] *Records furnished by the Natural Resource Conservation Service - Artesia Field Office.*
[26] Summers, W.K., 1976, Ground-Water Resources of the Upper James Canyon Basin, Otero County, New Mexico.

Carlsbad Groundwater Basin

Description of the Basin. The Carlsbad Groundwater Basin is located in the southern 11 percent of the planning area and encompasses 2347 square miles, 1870 square miles of which are within the planning area (Plate 1).[8 above] The basin was declared in 1947. Since that time there have been six expansions of the basin's boundaries, with the last expansion occurring in 1993.[2 above] It is located in the southern region of Eddy County. This basin extends into Lea County, which lies outside the planning area. The basin extends south of Carlsbad to the state line and west to the Guadalupe Mountains.[2 above] The Pecos River enters the basin in the northwest corner and exits the basin near the south-central region. The major drainage systems in the basin originate along the western edge in the Guadalupe Mountains. All drainage flows to the Pecos River. The basin is dominated by the Southern Desertic Basins, Plains and Mountains Major Land Resource Area, but does include some of the Pecos-Canadian Plains and Valleys Major Land Resource Area. The landscape ranges from nearly level in the river valleys and plains areas, to canyons and very rugged, rocky mountains in the Pecos-Canadian Plains and Valleys area located in the western part of the basin. The terrain east of the Pecos River ranges from flat to rolling with sand hummocks and sharp breaks along arroyos. The vegetation consists of open grass stands of medium to short grass in the plains areas to some piñon-juniper woodlands occupying the higher elevations. The largest area supports desert shrubs, succulents and grass stands. The large swales have stands of sacaton and tabosa grass.[27]

The farmlands in the basin are concentrated along the Pecos River from Carlsbad to south of Malaga. Farmland is also found along the Black River and its tributaries. Elevations range from 2870 feet, where the Pecos River exits New Mexico, to 7366 feet in the Guadalupe Mountains in the western part of the basin.

A desert climate dominates the basin. The summer temperatures around Carlsbad and Loving range from an average low of 67° F to an average high of 96° F. Winter temperatures range from an average low of 29° F to an average high of 59° F. The temperatures in the mountains will typically be ten to 15° F cooler, on average, than the lower elevations. The growing season is approximately 210 days in the farm areas and 180 to 190 days in the mountains. The basin's precipitation ranges from an annual average of 12 inches in the lower elevations to an average of 14 inches in the mountains. Most of the precipitation comes as summer rains and can result in intense, short-duration storms that cause large amounts of runoff and potential flooding. The basin receives some snowfall; however, this is usually less than one-fourth of the total annual precipitation. Precipitation records from selected stations in the Carlsbad Basin are shown in Appendix D.[3 above]

[27] *Natural Resource Conservation Service Technical Guide - Carlsbad Field Office.*

The soil types found in the basin are varied but usually display the characteristics of a desert climate. The soils range from deep loams, deep sands and clays, to very shallow, poor-quality soils and areas of bare rock and cliffs. The soils that are being farmed consist of loams, sandy loams and some clays. Farmlands overlie shallow soils in some areas. Most of the soils are slightly to strongly saline. The sandy soils are found in the eastern portion of the basin, while large areas of gypsum soils are found in the southern areas. Rock cliffs and large areas of shallow soils and bare rock occur in the foothills and mountains in the western portion of the basin. The vegetation on these soils ranges from open grass stands, grasses, shrubs, desert succulent mixtures and some piñon-juniper woodlands. Mixed stands of trees and riparian vegetation can be found along the Black, Delaware and Pecos Rivers, and around springs and playas in the basin. These areas are used for forage production, farming, wildlife habitat, recreation, while they also provide aesthetics and watershed benefits. The mineral resources in the basin include gas and oil, potash, caliche, sand and gravel and rock.

Wildlife populations include mule deer, javalina, lion and Barbary sheep. A few antelope have been reintroduced in the eastern edge of the basin and feral hogs have been noted along the Delaware River. Ducks, geese, quail and dove are plentiful in the basin and there is a small population of turkeys along Black River and in the higher elevations. Other birds, rodents, reptiles and predator species are also found in the basin. The Pecos, Black and Delaware Rivers, along with several impoundments, provide warm-water fisheries as well as being popular recreational areas. Several species of plants, animals and fish listed as endangered or threatened also reside in the basin.

The basin uses both surface water and groundwater. The Carlsbad Irrigation District (CID) diverts surface water from the Pecos River. Water has been diverted from the Pecos River at three diversion points below the City of Carlsbad. Surface water is also diverted from the Black River, Dark Canyon, Rocky Arroyo and the Delaware River. Surface waters are used for irrigation, recreation and livestock purposes. Surface water captured by playa lakes and impoundments provides a source of water for livestock and wildlife in the basin. Four major springs, as well as many smaller springs, provide water for irrigation, livestock, wildlife and recreation purposes.

Groundwater supplies are derived from several geological formations including the Delaware Mountain Group, the Carlsbad and Capitan Limestones, the Castile, the Rustler and Dockum Formations and alluvium and terrace deposits. The two major aquifers that yield large supplies of water are the Capitan and Carlsbad Limestone Reef Aquifer (Capitan Reef) and the shallow-water aquifer found in the alluvium and terrace deposits.[28] Irrigation wells have been developed in the farming areas from Carlsbad

[28] Bjorklund, L.J. and Motts, W.S., 1959, Geology and Water Resources of the Carlsbad, Eddy County, New Mexico: U.S. Geological Survey Open-File Report 59-9.

south to Malaga and along the Black and Delaware Rivers. Wells developed for irrigation purposes will yield between 400 and 4000 gpm.

The City of Carlsbad, Village of Loving and five other community water systems derive their water supplies from the two major aquifers mentioned previously. Domestic, livestock and commercial wells have been developed in other aquifers throughout the basin and yield from less than one to 1000 gpm. Both surface water and groundwater supplies have a wide-range of quality. The major constituents influencing the quality of water in the basin are salts and sulfur.

The basin has the second largest population in the planning area. Settlement first occurred around Carlsbad, then called Eddy, near 1880. Although population within the basin has increased since 1880, at times the area experienced declines in population levels. Carlsbad has remained the primary population center with a population of 24,952. Located ten miles southeast of Carlsbad, Loving contains 1243 residents. Other areas of population include Happy Valley, La Huerta, Otis, Malaga and White City.[4 above]

The major economic base of the basin is the development of mineral resources. Potash has been in production for many years and gas and oil production enjoyed a large increase in the late 1970s and early 1980s. Production of these resources, however, is declining due to resource supply and current prices. The mining of salt also contributes to the local economy. The national and state parks, as well as other recreational developments in the basin, maintain a large tourism and recreation economic base in the area. Agriculture and manufacturing contribute to the economy. In recent years the development of the Waste Isolation Pilot Project (WIPP) for storage of nuclear waste has played a large part in the economy of the area.

Land ownership within the basin is divided as follows (see Plate 7 and Table 1): 17 percent of the land is privately owned, 17 percent is owned by the State of New Mexico, 56 percent is classified as public domain land and under the control of the BLM, three percent is federally owned and under the control of the Forest Service, four percent of the land is occupied by national and state parks and the remaining three percent is owned and/or controlled by a variety of entities. The largest portion of land in the basin, 80 percent, is devoted to grazing domestic livestock (see Plate 6). Four percent of the land in the basin is dedicated to recreational uses. Three percent is devoted to irrigated agriculture. One percent is used by cities, villages and developed areas. The remaining 12 percent is occupied by mineral extraction sites, roads, water bodies and various other uses.

Historical Overview. Surface waters in the basin were first used as a source by Native Americans. The presence of Mescalero Apache Indians prevented settlement of the area until the mid-1800s. The Pecos Valley Land and Ditch Company was the first to attempt farming and irrigating in the basin on a large scale in 1887. The founding members of the company include Charles B. Eddy, his brother John Eddy, Joseph Stevens, Elmer Williams and Arthur Mermod. Between 1890 and 1894 the Pecos Valley Land and Ditch Company constructed two storage reservoirs, a large flume and several miles of canal. It is documented that the irrigation system experienced several setbacks when the dams were severely damaged or washed out by floods in the Pecos River. Disgruntled farmers abandoned farming efforts when they did not consistently receive adequate water supplies from the company. In 1895, after falling into receivership, the company was taken over by landholders under the direction of Francis Tracy. In 1904 the project was again severely damaged by floods. In 1905 the BOR authorized the Carlsbad Project and began restoration efforts that would create a project that was resistant to the flood-prone conditions of the Pecos River. In 1922 laws were passed that gave irrigation districts broader authority and the ability to assess levies. In 1932 the governing entity of the Carlsbad Project organized as the CID and entered into a contract with the United States Government to construct Alamogordo (now Sumner) Dam and Reservoir.[6 above]

The CID has experienced water shortages throughout its entire history and has been involved with water litigation for many years. The New Mexico State Engineer is presently adjudicating waters in the Carlsbad Groundwater Basin. Other small areas of farming have been developed in the basin where surface water is available, such as in Dark Canyon, Rocky Arroyo and along the Delaware and Black Rivers. The groundwater resources in the basin were first developed for livestock and domestic purposes. Irrigation use of groundwater was developed to supplement the unreliable surface-water supply from the CID. Some of these wells were developed in the late 1890s and early 1900s. The wells were pumped when adequate water could not be received at the proper time from the irrigation district. Water from most of the supplemental wells has a high concentration of salts; hence, farmers prefer the higher quality river water. Farmland that lies outside the CID boundaries relies on groundwater for its water supply. Most of this development lies west of the CID. Three large springs supply water for irrigated land on the middle section of Black River. These springs flow as much as 15 cubic feet per second (cfs) and provide very high-quality water.[29]

The community of Eddy was founded in 1888. The name of this community was later changed to Carlsbad. In 1930 the Village of Carlsbad drilled a well and initiated a municipal water system. Today Carlsbad draws water from three main aquifers, the Capitan Reef, which is the City's main water source, the shallow-water aquifer and the Ogallala Aquifer. The Ogallala Aquifer lies outside the Carlsbad Groundwater Basin and outside the planning area. The Ogallala is the only aquifer from which water is imported into the planning area. The City of Carlsbad also owns surface-water rights

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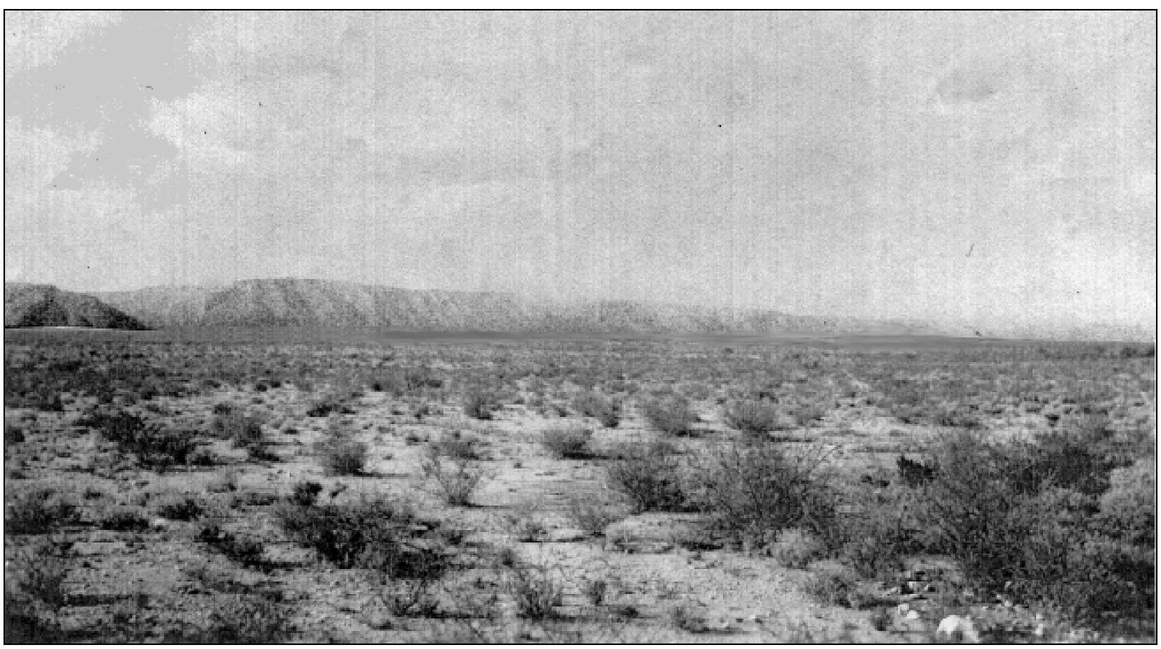
[29] Hendrickson, G.E., and Jones, R.S., 1952, Geology and Ground-Water Resources of Eddy County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining & Technology Groundwater Report 3.

which they have used to develop recreation areas along the Pecos River.[30] The Village of Loving, along with the Otis Water Users Community water system, has developed water systems that are supplied by water from the shallow-water aquifer. Happy Valley, White City and La Huerta Community water systems draw their water supply from the Capitan Reef. The Carlsbad Caverns National Park has developed Rattlesnake Spring as their source of water for the many tourists that visit the area.

Water resources in the basin support commercial activities, such as the mining and processing of potash ore and salts and oil well drilling and recovery operations. Additionally, the WIPP plant requires a large supply of good water, provided from the Ogallala Aquifer, for their daily operations. Figures 6 and 7 show historic (1935) and modern (1993) views of the Black River Valley in Eddy County.[31,32] Note the increase in density of desert scrub.

Figure 6. Historic Photo Across Black River Valley Showing Reef Scarp Between Slaughter and Rattlesnake Canyons



[30] Leedshill – Herkenhoff, 1995, City of Carlsbad 40 - Year Water Plan: Leedshill – Herkenhoff Project No. 94017.13.
[31] *Figure 6, Photo Courtesy of Roger Ford, NRCS.*
[32] *Figure 7, Photo Courtesy of Bill See.*

Figure 7. Modern Photo Taken at Approximately the Same Location as Figure 6

Capitan Groundwater Basin

Description of the Basin. The Capitan Groundwater Basin is located in the southeastern three percent of the Pecos River Basin planning area (Plate 1). The basin was initially declared in 1965 and the boundaries have not changed since that time.

The entire basin is 1550 square miles, though only about one-fourth (435 square miles) resides within the planning area.[8 above] The basin includes the east-central section of Eddy County and some parts of Lea County. The basin begins approximately one mile northeast of Lake Avalon and five miles east of Carlsbad and extends east to the Eddy County boundary line.[2 above]

The basin is the only one that does not contain a major drainage to the Pecos River. There is no perennial surface water in this basin. This basin is hydraulically connected to portions of the planning area through the Capitan Reef. Groundwater pumpage in this basin effects groundwater supplies in the Carlsbad Groundwater Basin. Some recharge to the Pecos River may occur from the aquifers within this basin. Storm runoff throughout the basin travels to playa lakes and/or the Pecos River via small drainage systems. This basin is entirely in the Southern Desertic Basins, Plains and Mountains Major Land Resource Area and is dominated by desert characteristics. The landscape ranges from nearly level to gently rolling and hummocky sand dunes. The vegetation consists of open grass stands of medium to short grasses, mixed grasses and shrub stands and areas that are entirely occupied by mesquite and/or shinnery oak. The playa lakes usually support stands of shrubs or trees. No farmland has been developed in the portion of the basin that is located within the Pecos River Basin planning area. Elevations in the basin range from 3182 feet in the southwest corner to 3773 feet in the northeast corner.[33]

Summer temperatures in the basin range from an average low of 67° F to an average high of 96° F. Winter temperatures range from an average high of 27° F to 56° F. The growing season is approximately 205 days long and annual precipitation averages 12 inches. Most of the precipitation in the basin comes as rainfall during the summer and fall. Some rains can result in intense, short-duration storms that produce flood conditions. The basin receives only a small amount of snow that contributes less than 15 percent to annual precipitation levels. Precipitation within the basin is not recorded because the area does not include an incorporated community. However, precipitation attributes of the basin are very similar to those of the Carlsbad Basin.

The soil types found in the basin are transitional between desert and plains. The soils range from deep loams, deep sands and clays, to shallow rocky soils and gypsum. The soils in the western portion of the basin are mostly shallow and gypsum soils, while the eastern section of the basin contains sandy loams, sand hummocks and deep sands. Most of the shallow and gypsum soils support stands of short to medium grasses and mixed stands of grasses and shrubs. The deeper soils support stands of mid-level grass and shrubs. The sand hummocks and deep sands are usually occupied by stands of mesquite and shinnery oak mixed with mid-to-tall grasses. Some stands of mesquite and shinnery oak support limited vegetation. These areas are used for forage production, wildlife habitat and recreation while providing aesthetic and watershed benefits. The mineral resources in the basin include gas and oil, potash, caliche and sand and gravel.

Wildlife populations in the basin include mule deer and some antelope. The area also supports quail and dove and some prairie chickens. Other birds, rodents, reptiles and predator species are found throughout the basin as well. The sand dune lizard and prairie chicken are threatened species found in the Capitan Basin.

Development of surface water in the basin has been limited. Several impoundments have been constructed in the basin to catch surface water for livestock and wildlife. Water captured by playa lakes is also used for these purposes. The major aquifer in the basin is the Permian Capitan Formation, though groundwater is also derived from the Castile, Rustler and Dockum Formations. No springs are known to

[33] *Natural Resource Conservation Service Technical Guide - Carlsbad Field Office.*

exist in the basin. Water quality in the basin is poor and yields are typically less than 100 gpm. Wells have been developed in the basin for livestock and domestic uses and for commercial uses in the gas and oil and potash industries.[28 above]

The basin is the most sparsely populated area in the planning area. No incorporated villages, cities or populated areas exist in the portion of the basin that lies in Eddy County. Although no official count exists, current population in the basin is estimated to be less than 100 people.

The economic base of the basin is tied to trade centers in the surrounding groundwater basins. The primary components of the basin's economy are the gas and oil, potash and livestock industries.

Land ownership in the basin is divided as follows (see Plate 7 and Table 1): three percent of the land is privately owned, 24 percent is owned by the State of New Mexico, 72 percent is classified as public domain land and under the control of the BLM, and the remaining one percent of the land is owned and/or controlled by a variety of entities. The largest portion of the land in the basin, 95 percent, is devoted to grazing domestic livestock (Plate 6). Three percent of the land is occupied by roads, potash mine and gas and oil development sites. The remaining two percent is occupied by wildlife enclosures, landfill and a variety of miscellaneous uses.

Historical Overview. The basin has few available records documenting the development of water. As ranches were established in the area, landowners developed wells to provide water for livestock and domestic purposes. Most of the groundwater in the basin has a high mineral concentration, usually salts, which make it impractical for human consumption. The potash industries in the basin developed wells to provide water for mining and processing of potash ore. As the development of gas and oil resources increased in the area, such industries either acquired water from existing wells in the area or drilled new wells to aid in their operations. The limited supplies and poor quality of water within the basin restricted the development of water resources in the area. Presently there appears to be very little prospect of further development of water resources in the area.

Socioeconomic Overview

The socioeconomic overview presents a summary of economic conditions, mostly in terms of employment, in each county in the planning area. The overview is presented for counties instead of by declared groundwater basin because most economic data is collected by county. Recent trends in agriculture and the value of water are also discussed.

Chaves County

The Chaves County cities include Roswell, Dexter, Hagerman and Lake Arthur. A list of major employers in the City of Roswell is shown in Table 2.[34]

Table 2. Major Employers in Roswell

Name	Service	Employees
Roswell Independent School District	Education	1181
Nova Bus of America	Manufacturing	700
Eastern New Mexico Medical Center	Medical Care	679
City of Roswell	City Services	586
Eastern NM University-Roswell	Education	340
Leprino Foods, Inc.	Food Products	330
New Mexico Military Institute	Education	292
Wal-Mart	Retail Services	281
Furr's Supermarkets	Retail Services	215
Chaves County	County Services	190

Information made available through the New Mexico Department of Labor allows calculation of the percentage change of economic activity by industry for Chaves County. The number of jobs listed by industry and the percentage change is shown for 1980 and 1997 in Table 3.[35]

Chaves County experienced a decrease of 4.72 percent in farm employment between 1980 and 1997. The county experienced a larger decrease in farm employment in the mid-1980s. From 1984 (1506 jobs) to 1985 (1298 jobs) the number of jobs dropped by 14 percent. The number of jobs did not climb to the 1984 level again until the year 1991 (1505 jobs).

Although the manufacturing industry shows less than a one-percent increase over the 17-year period, the number of jobs in that industry fluctuated widely from 1980 to 1997. Between 1980 (2738 jobs) and 1990 (3647 jobs) manufacturing experienced a 33 percent increase in the number of jobs held. However, by 1992 the number of jobs had dropped to 2350, a decrease of 36 percent.

[34] Roswell Chamber of Commerce, November 2000.

[35] New Mexico Department of Labor, June 2000, ES-202 and Current Employment Statistics Program:. Regional Economic Information System, Bureau of Economic Analysis.

Table 3. Annual Averages of Wage and Salary Employment by Industry for Chaves County (Number of Jobs)

Industry	1980	1997	% Change
Agricultural	1673	1594	-4.72
Manufacturing	2738	2743	0.18
Mining	625	609	-2.56
Construction	896	994	10.94
Trans. & Public Utilities	881	812	-7.83
Wholesale & Retail Trade	4294	5040	17.37
Finance, Insurance & Real Estate	851	800	-5.99
Services & Miscellaneous[1]	2737	4526	65.36
Government	3733	5285	41.58

[1]The services series beginning in January 1988 is not strictly comparable with prior data because of the results of a special employer survey.
Note: Industry classification is according to the 1972 Standard Industrial Classification (SIC) Manual for the years 1980 to 1987 inclusive and the 1987 SIC Manual for the years 1988 and 1989. Data may not be strictly comparable. Data reflects number of jobs, by place of work.

Table 3 indicates a slight decrease in the number of mining jobs available in Chaves County. The annual averages present a variable picture. Between 1980 (625 jobs) and 1982 (1099 jobs) the county experienced a 76 percent increase in the number of mining jobs. After 1982, the level of jobs in the mining industry fell (603 jobs in 1986) and rose (717 jobs in 1990) before reaching a level of 609 in 1997.

The number of construction jobs in Chaves County experienced a dramatic increase in 1982. Between 1980 (896 jobs) and 1982 (1378 jobs) the number of construction jobs has increased by 84 percent. Following 1982, the number of jobs in this industry fell, then increased several times before reaching a level of 994 in 1997.

The number of available jobs in the finance, insurance and real estate industries experienced a 34 percent increase between 1980 (851 jobs) and 1984 (1140 jobs). Following 1984 the level of jobs in this industry remained steady for the next five years before dropping to 860 in 1990, a decrease of 17 percent.

The industries with the greatest increase in economic activity from 1980 to 1997 in Chaves County include wholesale and retail trade (17.37 percent), services and miscellaneous (65.36 percent) and government (41.58 percent).

De Baca County

Sources at the Fort Sumner Chamber of Commerce state that employment in the area stems mainly from schools, hospitals, nursing homes, city and county services and a number of small businesses.

Table 4 provides information made available by the New Mexico Department of Labor and allows the percentage change of economic activity to be determined for various industries in De Baca County.[35 above]

Table 4. Annual Averages of Wage and Salary Employment by Industry for De Baca County (Number of Jobs)

Industry	1980	1997	% Change
Agricultural	299	330	10.37
Manufacturing	*	15	--
Mining	*	0	--
Construction	46	28	-39.13
Trans. & Public Utilities	61	19	-68.85
Wholesale & Retail Trade	122	107	-12.30
Finance, Insurance & Real Estate	11	25	127.27
Services & Miscellaneous	98	85	-13.27
Government[1]	200	263	31.50

[1]The services series beginning in January 1988 is not strictly comparable with prior data because of the results of a special employer survey.
* Disclosure – Included in Services and Miscellaneous
Note: Industry classification is according to the 1972 Standard Industrial Classification (SIC) Manual for the years 1980 to 1987 inclusive and the 1987 SIC Manual for the years 1988 and 1989. Data may not be strictly comparable. Data reflects number of jobs, by place of work.

Farm employment is the largest category in De Baca County and increased 10.37 percent from 1980 to 1997. Closer examination of the annual data shows that the county also experienced a decrease in farm employment over the given period of time. Between 1983 (302) and 1989 (255) there was a 16 percent decrease in farm employment in De Baca County. Following 1989, farm jobs steadily increased until reaching 330 in 1997.

Although a comparison of the number of jobs in the manufacturing industry between 1980 and 1997 is not available, information between 1993 (22 jobs) and 1997 (15 jobs) indicates a 32 percent decrease in the industry.

Table 4 indicates a 13.27 percent decrease in the number of jobs in the Services and miscellaneous industries. However, at the annual averages show that the industry experienced a 35 percent increase between 1982 (93 jobs) and 1985 (126 jobs). Following 1985, the industry encountered a steady decline until 1991 when the level of jobs reached 84. After 1991, the number of jobs rose and fell several times before reaching a level of 85 in 1997.

As indicated in Table 4, the major increases in economic activity for De Baca County took place in the finance, insurance and real estate (127.27 percent) and government (31.50 percent) industries.

Eddy County

The cities included in the planning area that lie within the boundaries of Eddy County include Artesia, Carlsbad, Hope and Loving. Detailed information regarding economic activity in the Cities of Hope and Loving is limited; however, a listing of major employers in the cities of Artesia and Carlsbad is contained in Tables 5[36] and 6.[37] Hope and Loving are both economically dependent on agriculture.

Table 5. Major Employers In Artesia

Name	Service	Employees
Navajo Refining Company	Gasoline, Fuel Asphalt, LP Gas	430
Artesia Public Schools	Education	377
Yates Petroleum Corporation	Oil and Gas Production	350
City of Artesia	City Services	151
U.S. Treasury Dept. Law Enforcement Bureau of Prison/Indian Affairs	Training Academy	100
Artesia General Hospital	Medical Care	100

Table 6. Major Employers in Carlsbad

Name	Service	Employees
Westinghouse	Energy	764
Carlsbad Municipal Schools	Education	752
IMC-Kalium	Potash	571
Columbia Medical Center	Healthcare	496

Information made available through the New Mexico Department of Labor allows the percentage change of economic activity by industry to be determined for Eddy County. Below the number of jobs listed by industry is shown for 1980 and 1997. This information is followed by the percentage change for each industry.

Annual data for Eddy County indicates slight increases and decreases in farm employment from year-to-year. However, the overall trend has been a decline of 12.47 percent in the number of jobs in the agricultural industry, as shown in Table 7.[35]
above

[36] Artesia Chamber of Commerce, November 2000.
[37] Carlsbad Department of Development, November 2000.

Table 7. Annual Averages of Wage and Salary Employment by Industry for Eddy County (Number of Jobs)

Industry	1980	1997	% Change
Agricultural	954	835	-12.47
Manufacturing	1047	976	-6.78
Mining	4111	2945	-28.36
Construction	1291	1004	-22.23
Trans. & Public Utilities	1166	1707	46.40
Wholesale & Retail Trade	3341	4102	22.78
Finance, Insurance & Real Estate	570	687	20.53
Services & Miscellaneous	2836	4804	69.39
Government[1]	2297	3407	48.32

[1]The services series beginning in January 1988 is not strictly comparable with prior data because of the results of a special employer survey.
Note: Industry classification is according to the 1972 Standard Industrial Classification (SIC) Manual for the years 1980 to 1987 inclusive and the 1987 SIC Manual for the years 1988 and 1989. Data may not be strictly comparable. Data reflects number of jobs, by place of work.

Table 7 indicates only a 6.78 percent decrease in the number of jobs in the manufacturing industry between 1980 and 1997. However, there were times during this 17-year period where the decrease in the number of jobs was more significant. From 1981 (1121 jobs) to 1988 (627 jobs) the decrease in the number of manufacturing jobs reached 44 percent. Following 1988, the number of jobs rose slowly to 921 in 1994. After 1994 the number of jobs dipped again before rising to 976 in 1997.

Table 7 also shows that the number of jobs in the construction industry decreased by 22.23 percent between 1980 and 1997. However, a closer look at the annual averages for this time period indicates wide swings in the number of jobs. Between 1981 (1397 jobs) and 1989 (761 jobs) the number of jobs decreased by 45 percent. Following 1989, the number of construction jobs rose to 959 by 1991, a 26-percent increase. After 1991, the level of jobs rose and fell several times before reaching 1004 in 1997.

As indicated below the major increases in economic activity for Eddy County took place in the transportation and public utilities (46.40 percent), services and miscellaneous (69.39 percent) and government (48.32 percent) industries. Although less significant, the wholesale and retail trade (22.78 percent) and finance, insurance and real estate (20.53 percent) industries also experienced increases in economic activity.

Lincoln County

The cities included in the planning area that lie within the boundaries of Lincoln County include Capitan and Ruidoso. Detailed information regarding economic activity in Capitan is limited; however, a list of major employers in the City of Ruidoso is in Table 8.[38]

Table 8. Major Employers in Ruidoso

Name	Service	Employees
Ruidoso Municipal Schools	Education	300-400
Lincoln County Medical Center	Medical Services	200-300
Ruidoso Care Center	Heath Care	100-200
Village of Ruidoso	Village Services	100-200
Cattle Baron Restaurants	Food Service	50-100

Information made available through the New Mexico Department of Labor allows the percentage change of economic activity by industry to be determined, as well as the percentage change in the number of jobs held between 1980 and 1997 for Lincoln County.

Table 9 shows a decrease in farm employment of 4.02 percent for Lincoln County.[35 above] However, there were times between 1980 and 1997 when the decreases in the number of jobs exceeded this level. For example, between 1983 (528 jobs) and 1986 (450 jobs) the decrease in farm employment reached 15 percent. The number of jobs in Lincoln County also experienced times of increase throughout the 17-year period. For instance, between 1990 (440) and 1996 (508) the county underwent a 15 percent increase in the number of agricultural jobs.

Table 9 shows more than a 100 percent increase in the number of manufacturing jobs. However, over the 17-year period Lincoln County did experience decreases in the number of jobs in the manufacturing industry. During 1983 (143 jobs) and 1988 (29 jobs) the number of jobs held in the manufacturing industry decreased by 80 percent. Following 1988 the number of jobs climbed to 217 in 1993 before declining slightly to 212 in 1997.

[38] Ruidoso Village Hall.

Table 9. Annual Averages on Wage and Salary Employment by Industry for Lincoln County (Number of Jobs)

Industry	1980	1997	% Change
Agricultural	523	502	-4.02
Manufacturing	103	212	105.83
Mining	28	*	*
Construction	417	444	6.47
Trans. & Public Utilities	179	235	31.28
Wholesale & Retail Trade	849	1594	87.75
Finance, Insurance & Real Estate	302	413	36.75
Services & Miscellaneous	912	1567	71.82
Government[1]	1011	1314	29.97

[1]The services series beginning in January 1988 is not strictly comparable with prior data because of the results of a special employer survey.
* Disclosure – Included in Services and Miscellaneous
Note: Industry classification is according to the 1972 Standard Industrial Classification (SIC) Manual for the years 1980 to 1987 inclusive and the 1987 SIC Manual for the years 1988 and 1989. Data may not be strictly comparable. Data reflects number of jobs, by place of work.

As indicated by Table 9 the number of jobs in the construction industry rose only 6.47 percent between 1980 and 1997. A closer look at the annual averages shows dramatic increases and decreases in the level of jobs. From 1980 (417) to 1984 (639 jobs) the number of industry jobs rose 53 percent. Between 1984 and 1988 (193 jobs) the industry underwent a 70 percent decrease in the number of jobs. While from 1991 (208 jobs) to 1997 (444 jobs) the industry encountered an increase of 113 percent.

The number of jobs in the Finance, Insurance & Real Estate Industry increased steadily from 1980 (302 jobs) to 1984 (488 jobs), a growth of 62 percent. Between 1984 and 1990 (210 jobs) the number of jobs in the industry declined by 57 percent. Following 1990 the number of jobs grew to 413 in 1997 marking a 97 percent increase over the seven-year period.

As shown below the major increases in economic activity in Lincoln County occurred in the Wholesale and Retail Trade (87.75 percent) and Services and Miscellaneous (71.82 percent) Industries. Smaller increases also took place in the Transportation and Public Utilities (31.28 percent), Finance, Insurance and Real Estate (36.75 percent) and Government (29.97 percent) Industries.

Otero County

Cloudcroft lies within the boundaries of Otero County, New Mexico.

Information made available through the New Mexico Department of Labor allows the percentage increase and decrease of economic activity by industry to be determined, as well as the percentage change in the number of jobs held between 1980 and 1997 for Otero County (Table 10).[35 above]

Table 10. Annual Averages of Wage and Salary Employment by Industry for Otero County (Number of Jobs)

Industry	1980	1997	% Change
Agricultural	512	548	7.03
Manufacturing	991	935	-5.65
Mining	*	*	*
Construction	585	869	48.55
Trans. & Public Utilities	603	857	42.12
Wholesale & Retail Trade	2843	3340	17.48
Finance, Insurance & Real Estate	439	661	50.57
Services & Miscellaneous[1]	2965	4022	35.65
Government	4548	6361	39.86

[1]The services series beginning in January 1988 is not strictly comparable with prior data because of the results of a special employer survey.
* Disclosure – Included in Services and Miscellaneous
Note: Industry classification is according to the 1972 Standard Industrial Classification (SIC) Manual for the years 1980 to 1987 inclusive and the 1987 SIC Manual for the years 1988 and 1989. Data may not be strictly comparable. Data reflects number of jobs, by place of work.

Table 10 lists an overall increase of 7.03 percent in farm employment for Otero County. However, between 1980 (512 jobs) and 1993 (615 jobs) the county experienced a 20 percent increase in farm employment. Following 1993, employment slowly declined before reaching 548 jobs in 1997.

Table 10 indicates only a 5.65 percent decrease in the number of manufacturing jobs between 1980 and 1997. However, different sections of the 17-year period indicate larger decreases. For example, between 1991 (1499 jobs) and 1993 (685 jobs) the industry experienced a decrease of 54 percent. In the following year the number of jobs increased dramatically to 961, an increase of 40 percent, before falling to 935 in 1997.

Table 10 indicates an overall increase of 42.12 percent in the number of jobs in the transportation and public utilities industry in Otero County. Closer examination of the annual averages indicates periods of both increases and decreases in the number of jobs in the industry. Between 1984 (742 jobs) and 1987 (482 jobs) the industry experienced a decrease 35 percent in the number of jobs. From 1990 (471 jobs) to 1991 (799 jobs) the industry underwent an increase of 70 percent in the number of jobs held.

With the exception of the manufacturing and mining industries, all industries shown below experienced an increase in economic activity between 1980 and 1997. The smallest increase, 17.48 percent, took place in the wholesale and retail trade industry. While the largest increase in economic activity in, 50.57 percent, took place in the finance, insurance and real estate industry.

Table 11 summarizes the percentage change in the levels of jobs in the five New Mexico counties included in the Lower Pecos Regional planning area.[39] Similar data is also included for the state of New Mexico and the United States. A picture of mixed growth and contraction of sectors is evident.

Table 11. Percentage Change of Non-Agricultural Employment by Industry in the United States, New Mexico and Selected Counties from 1980 to 1997

Industry	United States (%)	New Mexico (%)	Chaves County (%)	De Baca County (%)	Eddy County (%)	Lincoln County (%)	Otero County (%)
Agricultural	--	--	-4.72	10.37	-12.47	-4.02	7.03
Manufacturing	-7.94	34.30	0.18	--	-6.78	105.83	-5.65
Mining	-41.97	-46.60	-2.56	--	-28.36	*	*
Construction	30.95	33.02	10.94	-39.13	-22.23	6.47	48.55
Transportation & Public Utilities	24.52	13.07	-7.83	-68.85	46.40	31.28	42.12
Wholesale & Retail Trade	40.89	62.38	17.37	-12.30	22.78	87.75	17.48
Finance, Insurance & Real Estate	37.77	48.82	-5.99	127.27	20.53	36.75	50.57
Services & Misc.	101.45	112.96	65.36	-13.27	69.39	71.82	35.65
Government	20.42	41.60	41.58	31.50	48.32	29.97	39.86

* Disclosure – Included in Services and Miscellaneous
Note: Data beginning in 1996 may note strictly comparable with prior years due to the re-designation of establishments owned by Native American tribes into Local Government. Data reflects number of jobs, by place of work.

Trends in Agriculture

Agriculture is a major industry in the Pecos Valley and is the largest water-using sector. Agriculture in the Lower Pecos mirrors a national declining trend in employment, though the decline does not necessarily imply less production by the agricultural sector. The agricultural industry has undergone a shift in the last 20 years with the growth of the dairy industry. In 1980, dairy in the Pecos Valley and New Mexico was a minor agricultural product. By the year 2000, New Mexico ranked as the 10th largest dairy state in the U.S. Approximately half of all the dairy production growth in New Mexico has occurred in the Pecos Valley. The dairy industry has

[39] U.S. Department of Labor, Bureau of Labor Statistics (US data) Current Employment Statistics Program (New Mexico data).

become the dominant agricultural component in the Lower Pecos accounting for 50 percent of all agricultural receipts. Table 12 indicates the change in dairy cattle numbers and cash receipts relative to non-milk agricultural commodities from 1980 to 1999. [40,41,42]

Table 12. Growth of Dairy in the Pecos Valley (dollars in thousands)

Year	Number of Dairy Cows	Cash Receipts % of total		Total Farm Receipts
		Milk	Non-milk	
1980	3500	$8390	$213,666	$222,056
		4%	96%	100%
1999	91,000	$222,861	$225,252	$448,113
		50%	50%	100%
Annual Growth Rate	16.3%	16.4%	0.3%	3.5%

A sustained annual growth rate of 16.4 percent in cash receipts is a dynamic industry significantly contributing to the Pecos Valley economy.

Other agricultural commodities have had mixed results in terms of economic growth. Table 13 indicates the distribution of cash receipts between crops and non-dairy livestock.[40 above, 41 above, 42 above]

Table 13. Non-Dairy Agricultural Receipts in the Pecos Valley, 1980 - 1999 (dollars in thousands)

County	1980			1990			2000		
	Crop	Livestock	Total	Crop	Livestock	Total	Crop	Livestock	Total
De Baca	$1673	$13,406	$15,867	$2425	$18,187	$20,612	$4366	$14,656	$19,022
	*			45%	36%	30%	80%	-19%	-8%
Chaves	$25,335	$107,566	$132,901	$51,450	$51,932	$103,382	$43,631	$68,564	$112,195
	*			103%	-52%	-22%	-15%	32%	9%
Eddy	$17,109	$41,322	$58,431	$28,959	$45,464	$74,423	$30,563	$22,299	$52,862
	*			69%	10%	27%	6%	-51%	-29%
Total	$44,117	$162,294	$207,199	$82,834	$115,583	$198,417	$78,560	$105,519	$184,079
	*			88%	-29%	-4%	-5%	-9%	-7%

*Percent change in ten years

[40] U.S. Department of Agriculture, 1980, New Mexico Agricultural Statistics: New Mexico Agricultural Statistics Service.
[41] U.S. Department of Agriculture, 1990, New Mexico Agricultural Statistics: New Mexico Agricultural Statistics Service.
[42] U.S. Department of Agriculture, 1999, New Mexico Agricultural Statistics: New Mexico Agricultural Statistics Service.

Though crop receipts increased during the eighties, in general, most agricultural products have declined in the valley. The increase in dairy, however, has had a significant impact on one major crop—alfalfa. The Pecos Valley has long been known as an alfalfa production region with high-quality alfalfa. The quality of alfalfa in the Pecos Valley and the dry mild climate are major factors in the dairy industry's growth. High production dairy cattle (New Mexico ranks at the top of the U.S. in milk production per cow) require 8 – 9 tons of alfalfa per year. Table 14 indicates acreage of alfalfa yield, production and cash receipts for the crop.[40 above, 41 above, 42 above]

Table 14. Alfalfa Acreage, Yield, Production and Receipt from 1980 to 1999

Year	Acreage (acres)	Yield (ton/acre)	Production (tons)	Price ($/ton)	Receipts
1980	76,000	5.4	409,630	$80	$ 32,770,400
1990	87,500	4.7	412,080	$111	$ 45,740,880
*	15.1%	-12.6%	0.6%		39.6%
1999	88,544	6.8	600,700	$ 125	$ 75,087,500
*	1.2%	44.1%	45.8%		64.2%

* percentage change

As opposed to other crops, alfalfa has excellent economic returns, which has resulted in increased acreage. In 1980, alfalfa accounted for 40 percent of total irrigated acreage in the Pecos Valley. By 1999, the crop accounted for 63 percent. Despite the 46-percent increase in production, alfalfa in the Pecos Valley has not kept up with the dairy industry. For a nine-ton consumption per cow, the 93,000 dairy cows in the valley consume 837,000 tons of alfalfa. The Pecos Valley has become a net importer of alfalfa.

The future of agriculture in the Pecos Valley depends on the direction of the dairy industry. There is no indication that the dairy sector is slowing down. Since 1995, dairy production has increased 30.4 percent. New Mexico has excellent conditions for dairy production. One factor necessary for continued expansion is increased local cheese and dry milk capacity at processing plants. However, there are ultimate limits on this growth. One major limiting factor is the marketing of dairy products. New Mexico's dairy production long ago exceeded its consumption of fluid and solid dairy products. The sale of processed milk products for export is complicated by U.S. federal dairy programs and is subject to federal budget considerations. Another consideration is water pollution concerns of large-scale dairy dry lot production. Dairy production itself is not limited by water availability. Dairy cattle use approximately 0.35 AFY. For 79,000 head, this amounts to 28,000 AF.

Economic Value of Water

Agriculture is the dominant user of water in the Pecos Valley and thus determines the economic value. If industry and cities cannot obtain water through market purchases to provide for growth in consumption, then the value of water in these sectors would increase dramatically. However, as long as a city can procure the water it needs from agriculture, the value of water has as its equilibrium, the value in agricultural use.

In the absence of a robust water market, the regional value of water must be estimated from various data sources. Using cost and return data from the New Mexico Cooperative Extension, it is possible to construct an economic value of water in agriculture. For this analysis, the value of water is the residual return after all other costs are paid. For example, a crop may have $1000 total return per acre and $900 of non-water expenses. This leaves a $100 residual value that can be attributed to the availability of water. If the crop uses three AF, then the value of water is $33 per AF.

An important factor in the value of water is the role of fixed costs. A farmer has extensive capital investment in farm equipment, irrigation systems, land and other improvements. If the farmer were to lease his water for a short period, he would essentially idle the other capital associated with farming. He certainly would not lease his water unless he got a return to the water and the idled capital. On a longer time frame, say a lease of 20 years or permanent sale of water, the farmer would sell farm equipment, even sell the land and thus not require a payment for these factors of production. The long run value of water to the present owner is less than the short-run value. For that reason, the spot-market in water is more costly per AF than a long-term contract or sale.

Table 15 indicates the short run residual income that can be attributed to water use for agriculture in the Pecos Valley.[43] The New Mexico Cooperative Extension Cost and Return Budgets are used for a range of different groundwater and surface-water farms in the region.

A reasonable range would be $100 to $120 per AF. Care must be used in the interpretation of these values; these are short run values only. That is, an increase or decrease in one year of water supply would have about $110 benefit or cost to the economy per AF.

[43] Libbin, J.D., Hawkes, J.M. and Duffy, J.W. 2000, 1999 Projected Crop Cost and Return Estimates: New Mexico Cooperative Extension Service.

Table 15. The Short Run Value of Water (One Year or Less) in Pecos Valley Agriculture

Farm Location	Irrigation Type	Delivery	Water Use (AF/acre)	Water Delivery Costs ($/AF)	Net above Operating Expenses ($/acre)	Gross Value[1] ($/AF)	Net Value of Water ($/AF)
City of Roswell	Sprinkler	Ground	3.55	$37.56	$335.26	$132.00	$94.44
City of Roswell	Flood	Ground	3.49	$15.72	$453.58	$145.68	$129.96
City of Artesia	Flood	Ground	3.54	$9.12	$382.95	$ 117.30	$108.18
City of Artesia	Sprinkler	Ground	3.42	$14.76	$369.13	$122.69	$107.93
City of Carlsbad	Flood	Canal	2.88	$10.20	$252.78	$97.97	$87.77
De Baca County	Flood	Canal	2.70	$12.60	$305.67	$125.81	$113.21

[1] Gross value does include water delivery and application costs

The long run value of water in agriculture is indicated in Table 16.[43 above]

A reasonable range for water values in the long run would be between $30 and $50 per AF. This value is not the value of a water right that is a permit to use an acre-foot of water indefinitely. Perennial water-right values can be estimated from these results for a one-time purchase of a AF volume. Assuming a five-percent return on equivalent capital, a water right that has an annual value of $50 per year, has a capital value (present value) of

PV = $40/5% = $1000 per AF.

According to the short and long-term analysis, efforts to increase the supply of water in the Pecos Valley would have an annual benefit of $50 to $100 for every increase in AF of supply. The capital value of a perennial water right would have a present benefit of $1000 to $2000. A permanent supply would produce the lower range of values.

Table 16. The Long Run Value of Water (Permanent Sale) in Pecos Valley Agriculture

Farm Location	Irrigation Type	Delivery	Water Use (AF/acre)	Water Delivery Costs ($/AF)	Net above Operating Expenses ($/acre)	Gross Value ($/AF)	Net Value above Costs ($/AF)
City of Roswell	Sprinkler	Ground	3.55	$51.48	$47.89	$64.97	$13.49
City of Roswell	Flood	Ground	3.49	$26.64	$256.95	$100.26	$73.62
City of Artesia	Flood	Ground	3.54	$24.00	$125.84	$59.55	$35.55
City of Artesia	Sprinkler	Ground	3.42	$33.00	$122.58	$68.84	$35.84
City of Carlsbad	Flood	Canal	2.88	$16.80	$51.95	$34.84	$18.04
De Baca County	Flood	Canal	2.70	$21.00	$130.83	$69.46	$48.46

Water is the constraining resource for agricultural production in the Pecos Valley. An increase in permanent supply would increase acreage and the associated agricultural industries that provide inputs for farming such as seed and fertilizer distributors and retail sale of farm machinery and irrigation equipment. Wittlesey, Robison and Hamilton[44] have estimated the secondary economic benefits of an increased or decreased water supply. They use a secondary economic multiplier of approximately two for every dollar of agricultural production that is affected by water supply. Using this multiplier, a permanent increase of one acre-foot would have a contribution of $40 in primary economic activity and $80 in secondary activity for a total of $120 in economic activity. Accordingly, the Lower Pecos Valley Regional Water Plan utilizes $100/AF as the value of water for planning purposes.

Summary of Economic Trends

Water produces $50 to $100 of economic value per AF used in agriculture in the Pecos Basin. The future expansion of agriculture in the Pecos Valley depends on the dairy industry. One cannot predict whether this industry will continue to grow at the previous rapid pace. Though there were increases in agricultural employment in De Baca and Otero Counties, the two largest agricultural counties (Chaves and Eddy) have had modest declines in agricultural employment. Because agricultural is the largest water-using sector, these trends would indicate less future demand for agricultural water. Similarly, mining—a large water user—has followed a national declining trend. Conversely, urban jobs in services, retail, finance and government have increased in the planning area, mirroring the trends in jobs for the State of New Mexico and the U.S.

[44] Whittlesey, N.K., Robison, H. and Hamilton, J., 1993, Economic Effects of Irrigated Land Retirement in the Pecos River Basin: Report to the New Mexico Interstate Stream Commission and the New Mexico State Engineer Office.

economy as whole. These jobs themselves are not water consuming, but add to the water demand of the region by facilitating population and economic growth. Overall the economic picture would indicate that future water demand in the Lower Pecos would be driven by a pattern of changing uses, but not by a dramatic increase in the overall regional consumption of water. Projected use is discussed further in Section VIII.

Principles of Resource Management

Water-resource assessment emphasizes physical factors of the water resource, but the institutional factors are as important to the overall plan. Recent reviews[45,46,47] have found that successful water planning considers the physical and other factors together. In the Lower Pecos Valley, the following principles are applied in developing the Regional Water Plan.

<u>Attributes of the Resource</u>

The water resource (encompassing both groundwater and surface water) has variable availability that affects its suitability for use, and for non-use purposes such as instream flows. Planning is reliable for a predictably constant resource, but is problematic for a resource with unpredictable flash flows, or random intermittent dry periods.

The natural variability of flow established the pre-development environment of the river basins, and the environment was adapted to it. Basin development has altered the flow characteristics of the Lower Pecos Valley streams. Therefore the variability in trends is of interest to planners.

Aquifers and surface reservoirs have stored contents and an associated through-flow that flushes the contents in time. The stored resource is measured as a volume (AF). The flowing resource is measured as a rate, as volume per unit of time (AFY). The ratio of the volume to the flow rate indicates the residence-time of water in the stored volume. For example, Sumner Lake, when holding 50,000 AF with an inflow and outflow of 100,000 AFY, is flushed out every six months; that is its water-residence time. An aquifer, such as the Roswell artesian aquifer, holding in excess of ten million AF of operable storage with a recharge and discharge of 250,000 AFY, would be flushed out every 40 years, which is its water-residence time.

[45] Fort, D.D., 1998, Water in the West: The Challenge for the Next Century: Report of the Western Water Policy Review Advisory Commission.
[46] Mays, L.W., 1996, Water Resources Handbook: McGraw-Hill.
[47] Thompson, S.A., 1999, Water Use, Management, and Planning in the United States: Academic Press.

These attributes cause the type of resource to have different utility for different purposes. The near-uniformity of the availability and character of groundwater at a particular place makes it suitable for uniform requirements, such as municipal and industrial purposes and for stabilizing other uses during drought. The variability of mountain-tributary flows is suited to recreational and habitat-maintenance purposes, among others.

Variable availability can be made to better match the schedule of demands for water by intentionally storing and releasing the available water as needed, or by controlling the schedule of demand itself. Both approaches are practical and have been implemented in the Lower Pecos Valley. Surface reservoirs and aquifer wellfields store and release water as required. Drought programs, conservation and watermaster administration on adjudicated streams help to control demand during water shortages.

The water-resource assessment in this report (Section VI) outlines the Lower Pecos Valley total water resource in the broad categories of stored and flowing water resources.

Storage in the Groundwater System

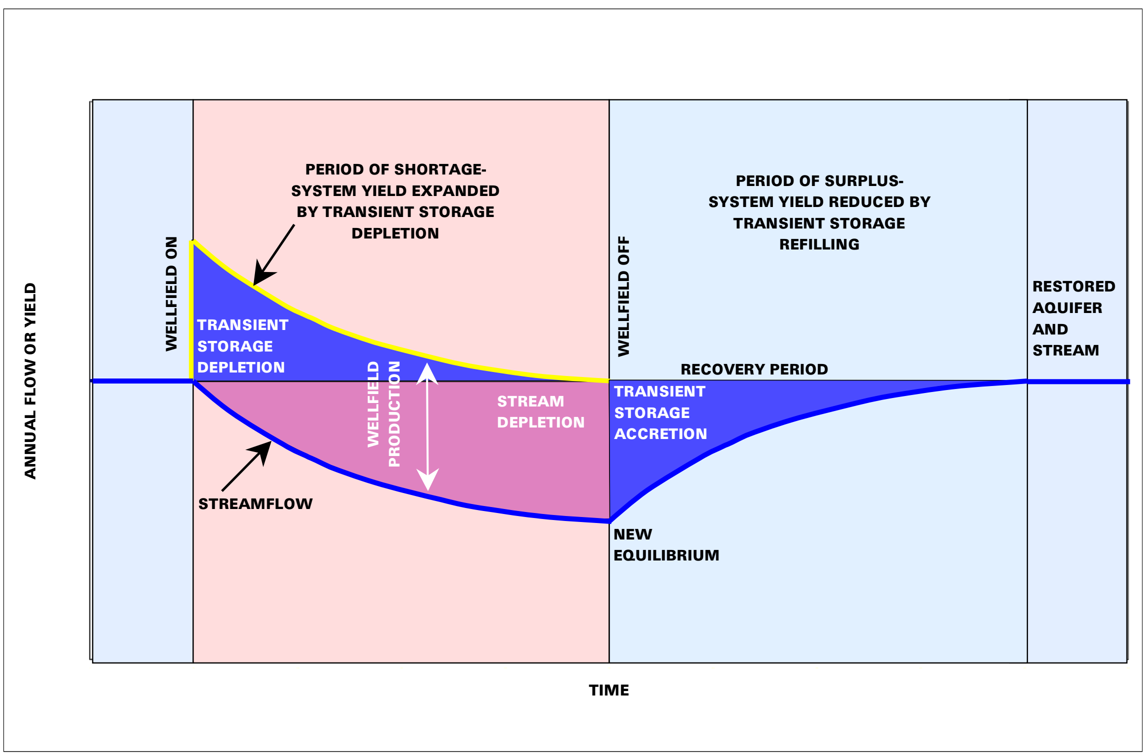
Before any wells were drilled into an aquifer such as the Roswell artesian aquifer, the natural movement of water into it (recharge) and the natural flow out of it to streams or springs and evaporation from high water tables and native vegetation (discharge), were in approximate balance.

Drawing-down an aquifer produces water from storage, analogously to drawing down a surface reservoir. Transitional storage is the volume of water that is produced and can be used during the transition to a new steady-flow condition in the aquifer. Water is also captured to the aquifer from surface sources. Over four million AF has been produced from Roswell Basin transitional storage in past decades and the aquifer is now approximately in balance. Over twenty million AF has been captured from Pecos River baseflow by groundwater pumping over the decades at rates of up to 250,000 AFY. The increased inflow to, or decreased outflow from, the aquifer is termed "capture" of surface water. The volume released from aquifer storage is added to the basin yield for the years storage is contributing.

Figure 8 shows the effects on streamflow of a wellfield that is placed into operation to increase basin yield during a period of shortage and then shut off during a subsequent period of adequate basin yield. While the wellfield is pumping, streamflow diminishes as an increasing proportion of water supplied to the wellfield comes from induced recharge, but net basin yield increases due to the yield from aquifer storage. If pumping continues long enough, equilibrium may be established and all water supplied to the wellfield will come from stream depletion. Once pumping stops, induced inflow from the stream will continue, interception of water that would otherwise discharge from aquifer to stream will continue, and water will accumulate in the aquifer to replace the transitional storage.

A simplified analytical calculation by BGW using the drain formula by Ferris and others[48] for leaky bed aquifer parameters from Barroll[49] indicates that, in the Roswell artesian aquifer, 50 percent of the water supplied to wells is derived from surface water after ten years of pumping. After 20 years of pumping, the amount increases to 75 percent and after 50 years, to 90 percent. If a wellfield were pumped for a single year then shut down, as proposed as part of managed aquifer operations in Section X, the volume produced from the aquifer in one year would be captured from the river in diminishing amounts, from five to one percent of the volume pumped, over a 20-year period. The behavior of the hydrologic system allows for groundwater pumping during a dry period and replenishment of aquifer storage during a subsequent wet period.

Figure 8. System Yield During Managed Wellfield Operation and Recovery



[48] Ferris, J.G., Knowles, D.B, Brown, R.H. and Stallman, R.W., 1963, Theory of Aquifer Tests: U.S. Geological Survey Water-Supply Paper 1536-E.

[49] Barroll, P., 1993, Groundwater Leakage Through the Roswell Basin Aquitard Results of a Subsurface Temperature Study in Southeastern New Mexico: New Mexico Office of the State Engineer, Hydrology Report 93-3.

Recharge and Discharge

Recharge is the amount of water added to the water table during a period of time. It is commonly derived from seepage of surface runoff. The term applies both to natural inflow (natural recharge) and to inflow that is induced by pumping (induced recharge) as described above. It is expressed as a volume (AF), or as a thickness (in inches) on the watershed area (thickness x area, implying a volume). However expressed, recharge varies at different places and times. Any determination of recharge is characteristic of a place and a time of study. It would be convenient to find that the Lower Pecos Valley has a certain recharge amount that applies throughout the basin and is constant through time, however, that level of management convenience is not possible.

Recharge is greatest where surface-water loading of the soil is greatest: at high elevations, at mountain fronts and where water is ponded naturally or artificially above unsaturated soils. Recharge is effective where the net result from a combination of water losses to the atmosphere and seepage to the soils is favorable to the water table. Where the balance favors loss to the atmosphere, a net discharge from the water able results. Net discharge is common where the water table approaches or intersects the land surface at low topography such as mainstem-river riparian zones or in waterlogged soil zones. Over 263,000 AFY of such loss has been identified in the Lower Pecos Valley.

Diversion, Consumption and Return Flow

Water accounting classifies water uses based on their net impact on the hydrologic system. Water use involves withdrawing or diverting an amount from the source of water, conveying water to the place of use, applying water to a process that suits the purpose of use and disposing of the surplus as return flow. The surplus often contains the suspended or dissolved residue of the process. The process of water use is often reduced to three steps: diversion, consumption and return flow. Consumption means loss of water in the process so that it does not return to the source system and is distinguished from "consumption" in the sense that we consume drinking water. Accounting for water in these categories provides a way to quantify water-use impacts on the source system. A large diversion with large return flow may have a small impact on the system.

The same three components are used to indicate the efficiency of a water operation. For example, diverting 100 AF consuming 60 AF and returning 40 AF might be said to be a 60-percent efficient system in terms of consumption as a percent of diversions. Maintaining the same consumption while diverting less and returning less would therefore raise efficiency, as defined in this way, but the net impact on the source system would remain a loss of 60 AF. For this reason, we do not consider conservation to increase the basin yield unless it reduces consumptive use. Managing diversions without altering net consumption affects the routing of water through the basin, but not the amount remaining for use. Consumptive use, in terms of a loss from the basin, is the more critical factor in resource assessment and is the focus of this report.

Conservation is most beneficial to a system that has a stored source to meet its diversion requirements. Reduced diversion requirements in that case can extend the service of the stored reservoir contents. CID and PVACD are in the category where reduced diversions would be beneficial to the stored resources even if consumptive use remained the same and the overall basin yield was unaffected. FSID has become more efficient, but lacks a storage facility to take advantage of the efficiency.

Substitution of Water Losses

Managed water operations have partially replaced unmanaged natural water cycles in the Lower Pecos Valley. Losses are associated with both managed and unmanaged flow. In describing the hydrologic effects of a new water-management operation, the new project's effects are quantified in terms of a projected water balance involving withdrawals, consumption and returns. A comprehensive assessment also considers the net effect of the project by inventorying the antecedent (or pre-project) flow into, losses from and discharges from the project site. Antecedent conditions projected into the future without the project being present are considered the baseline for evaluation. The project effect is evaluated as the difference in these components, with and without the managed water operation on the site. The baseline analysis often reveals that the baseline of natural depletions is a significant fraction of the proposed project depletions. Consumption by agriculture may simply replace part of the existing consumption by riparian vegetation. Only a fraction of absolute project depletions may be reflected as a loss from basin yield measured at downstream gages, due to substitution of project losses by the baseline losses. For example, removing exotic riparian vegetation does not produce a net gain if the baseline of natural vegetation will consume the same water. In some cases, such as riparian management projects, the management action can result in releasing baseline water for use downstream.

External Impacts

Water operations affect a variety of hydrologic matters of concern to basin residents. Water operations affect erosion and sedimentation, habitat, land subsidence, land use, economic activity, valued services from related resources and other matters. The administrative review for water permits (by the State Engineer and environmental agencies, among others) examines the external impacts on the public and specific parties that might otherwise escape attention. The Lower Pecos Valley Regional Water Plan recognizes the non-hydrologic effects and assumes that a comprehensive hydrologic analysis will provide the information needed for review by the administrative agencies.

Resource Economics

Water-resource use is driven by economic principles. Projects are selected based on the expected increased productive value of the water. The following economic principles come into play in the Lower Pecos Valley Regional Water Plan.

The compensatory principle asserts that a project should add enough value to pay its way, relative to existing alternative uses of the resources. No new project should devalue other water uses without being able to compensate them. This principle is the basis for transfers of water rights. A new use can have water if it compensates the stream of value expected by the owner of the old use and motivates him to be a willing seller. In that case, the seller can obtain more value from his water right by selling it than by using it for the former purpose.

The stored resource in the groundwater aquifer is analogous to ore in the ground. Water, or ore, in the ground generally is a resource only to the extent that it can be produced with value-added. Because the overall economy and the water-operations sector become more productive through time (with more efficient pumps, better designs and new know-how), the volume stored in the aquifer that can be produced increases with time. In the Lower Pecos Valley Regional Water Plan, we have found it likely that more can be done to take productive value from the flowing and the stored resource as time goes on.

Conservation is indicated by resource-use efficiency. Efficiency can be measured in terms of value generated per unit of resource depleted. By this measurement efficiency can be increased either by doing more with the same amount of water, or by doing the same with a lesser amount of water. The administrative permitting process pushes the analysis of a project toward a full accounting of external costs, so that a project does not fail to account for its full costs. Either over-conservation (that is, non-use) or under-conservation (waste) may impose unnecessary penalties on the Lower Pecos Valley's economy by precluding other uses.

The term "sustainable" has a broad range of meanings. In the Lower Pecos Valley Regional Water Plan, a sustainable project is one for which the effects are acceptable, in the administrative process and to the public, for as long as the effects are foreseeable. The dual nature (flowing and stored) of the water resource does not accommodate the single-minded objective of using only the renewable flowing component. The highly-variable flowing resource has not met past requirements in the Lower Pecos Valley, nor is it expected to meet future requirements, without calling upon its complement, the stored resource. The aquifers are an essential part of the

Pecos Valley Regional Water Plan. The longevity of the stored component in various uses and the operational drawdown and recovery of the stored component, are of interest in determining sustainability in the Lower Pecos Valley.

Administrative Role

The functions of water administration in New Mexico are served by the New Mexico Office of the State Engineer, the New Mexico Environment Department and the Federal permitting agencies (U.S. Environmental Protection Agency, U.S. Corps of Engineers and others under the National Environmental Policy Act). The administrative function is generally to protect the broad public interest in setting and maintaining standards for existing uses of the resource and to permit changes and new uses that comply with standards. The Regional Water Plan is designed to compile hydrologic information that may be pertinent to inform administrative review, but does not anticipate the result of any administrative process.

Legal factors that enter into water-resource planning are outlined in Section V.

Flexibility in Forecasts

The variability of surface-water supplies is not predictable with today's forecasting tools. The water-planning literature recognizes that demand for water also is both variable and unpredictable, change in demand is driven largely by population change, but population has proven very difficult to predict, especially on a local scale. The 1976 New Mexico Water Resources Assessment forecast major increases in New Mexico's water demand for uranium and coal mining in the San Juan Basin, other energy production, and power-plant cooling water. In striking contrast, demands now, only 24 years later, are focused on habitat protection, compact obligations and municipal growth. A recent post-audit of water-planning projections around the world showed that demand forecasts are systematically unreliable.[50] Growth of some sectors, such as mining and agriculture, are not predicted in the Lower Pecos Valley Regional Water Plan, whereas population projections are used as the basis for growth of demand.

In response to the unreliability of demand forecasts, water plans in the arid west have evolved toward frequent updates, rather than on fixed planning for longer-term horizons. Kansas updates its state water plan annually and advises that "a plan set in concrete is an obstacle to effective management, instead of a useful tool".[51] The Texas 1997 water plan is to be replaced after four years, in 2001, using regional plans. California updates every five years and Arizona revises its Active Management Area plans each decade. Colorado does not practice state water planning, but provides

[50] Barrow, C.J., 1998, River Basin Development Planning and Management: A Critical Review: World Development, Volume 26, No. 1, Elsevier Science Ltd.
[51] Kansas Water Office, 2000, The Kansas Water Plan Fiscal Year 2002.

continuous state administration of proposals developed by owners and managers of water-related projects. The PVWUO expects that the Lower Pecos Valley Regional Water Plan will be updated periodically, to retain its standing as a useful tool to effective management.

Flexibility is provided in the Lower Pecos Valley Regional Water Plan. New projects are evaluated at a conceptual, pre-feasibility study level. The evaluations can be readily updated if projects are proposed later with different variations. The plan is intended to be used for the benefit of future feasibility studies and for subsequent phases of water-management planning.

Compact Obligation to Texas

The Pecos River Compact states that "New Mexico shall not deplete by man's activities the flow of the Pecos River at the New Mexico-Texas state line below an amount which will give to Texas a quantity of water equivalent to that available to Texas under the 1947 condition."

Depletion by man's activities means to diminish streamflow as a result of beneficial consumptive use, but does not include diminution of flow by encroachment of salt cedars or by deterioration of the stream channel. A copy of the Compact is in Appendix E.

New Mexico's obligation to Texas is computed each year by summing the annual flood inflow (the flow at Pecos River below Sumner Dam gage plus the estimated flood inflows from Sumner Dam to Artesia, Artesia to Carlsbad, and Carlsbad to the state line) and adding depletions above Sumner Dam in excess of 1947 conditions (described below). The three-year average floodflow is computed using this year's and the previous two year's values, then is plugged into a formula to compute the 1947 condition at the New Mexico-Texas state line:

$$\text{1947 Condition} = 0.0489892 \times (\text{Three-year Average Floodflow})^{1.42318}$$

The index inflow-index outflow equation was approved June 11, 1984 by the U.S. Supreme Court in the Texas vs. New Mexico Pecos River Compact Litigation, No. 65 Original.[52] A plot of the formula is shown in Figure 9. If floodflow is over 1.1 million AFY, then New Mexico's obligation is larger than the floodflow. As floodflow increases, New Mexico is obligated to deliver an increasing proportion of Pecos River flow. The computed 1947 condition is then subtracted from the three-year running average of annual Pecos River flow at Red Bluff. The result, called the departure, is positive if New Mexico has over-delivered and negative if the State has

[52] Written communication, J. Longworth, New Mexico Interstate Stream Commission to P. Balleau, Balleau Groundwater, Inc., February 9, 2001.

under-delivered. New Mexico receives credits for depletions due to McMillan Dike, salvaged water, unappropriated floodwaters, losses of Texas water stored in New Mexico, and beneficial consumptive use of Delaware River water by Texas. These values are added to the credit to give the final calculated departure.

Flood inflows are computed in three reaches, Sumner Dam to Artesia, Artesia to Carlsbad, and Carlsbad to the state line. The flood inflows in the first two reaches are computed by taking the difference in computed or gaged inflows and outflows, including major irrigation diversions, return flow, springflow, riverbed losses, baseflow and reservoir evaporation. Flood inflows from Carlsbad to the state line are computed using the hydrograph scalping technique. During and immediately after a storm of 0.05 inches or more per day, the volume of the increase in Pecos River flow above baseflow is computed from gaging records at Dark Canyon, Carlsbad and Red Bluff. The difference between the volumes at each pair of adjacent gages is the floodflow. The flood inflow from the Delaware River near Red Bluff is computed and added to Pecos River floodflow.

Depletions above Sumner Dam include irrigation consumption, evaporation in Santa Rosa and Sumner Reservoirs and transfers of water above Sumner Dam. The depletions are subtracted from the estimated respective 1947 depletions and added to inflow below Sumner Dam.

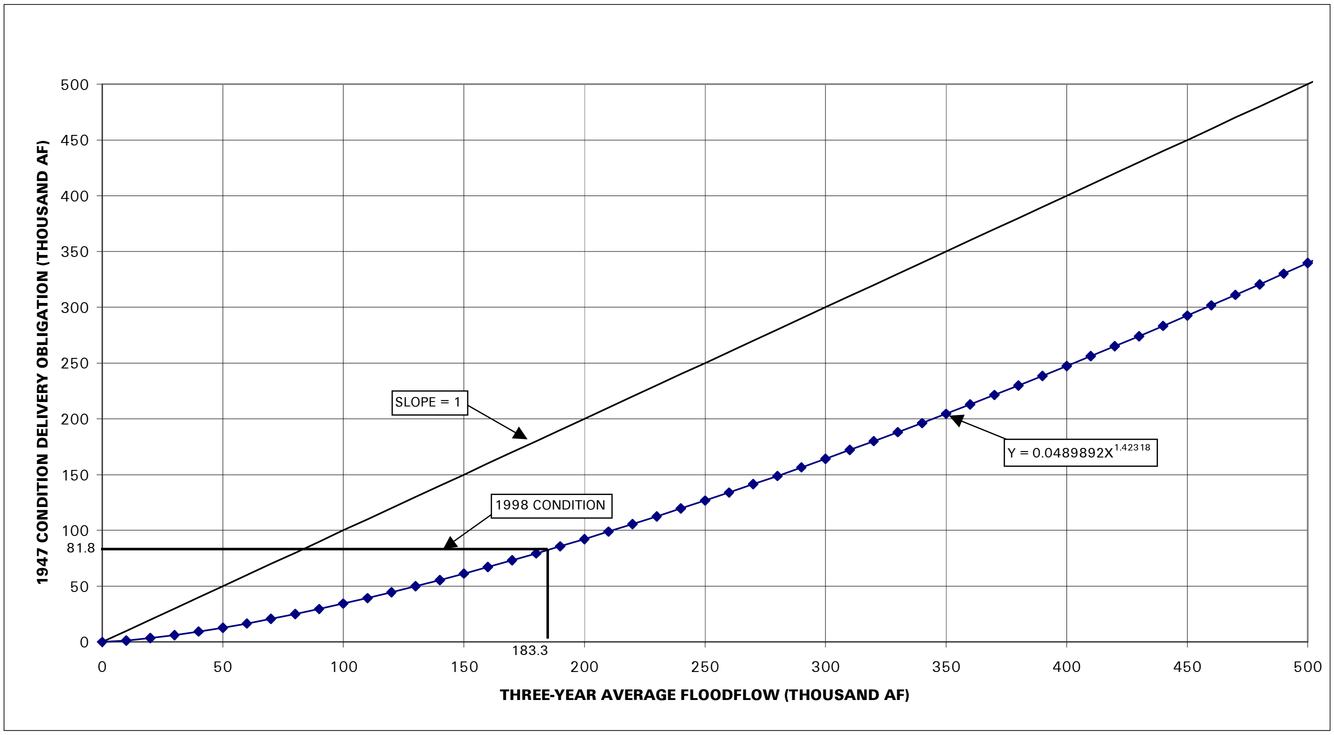
Salvage is defined in the Compact as that quantity of water that can be recovered and made available for beneficial use that was heretofore non-beneficially consumed. Any water salvaged from projects undertaken by the U.S. or by joint efforts of New Mexico and Texas is apportioned between the states as follows: 43 percent to Texas and 57 percent to New Mexico. New Mexico may keep and consume any water salvaged by New Mexico or may deliver the water to Texas for a credit.

Table 1 from the OSE Pecos Accounting Spreadsheet is in Appendix F. The table shows the final computation of flood inflows, depletions above Sumner Dam, and credits for the year 1998.

Increased depletions are addressed in Compact accounting for irrigators above Sumner Dam, Pecos River Pumpers, FSID and CID. Increased depletions by other water users are not specifically accounted for. However, a fraction of increased depletions will reduce flow at Red Bluff and will impact the State's ability to make deliveries.

Table 17 shows the sensitivity of change in output relative to change in input of the accounting workbook to various parameters. The OSE Pecos accounting spreadsheet was used to perform the analysis.[53] An increase in each input component except salvage produces an increase in obligation. The obligation increase is small partly because the increase in the input component is averaged over three years.

Figure 9. New Mexico Delivery Obligation Under Pecos River Compact



[53] Electronic communication, J. Longworth, New Mexico Interstate Stream Commission, to P. Balleau, Balleau Groundwater, Inc., February 6, 2001.

Table 17. Change in Baseline (80.5 Thousand AF) Delivery Obligation Resulting from Change in Input to Compact Accounting Workbook (thousands of AF except where noted)

Input Component	1998 Amount	Modified Amount[1]	Change in Amount	Modified Obligation	Change in Obligation[2,3]
Unmanaged					
Inflow below Alamogordo Dam	191.1	210.21	19.1	84.5	4.0
Flood Inflow, Alamogordo Dam to Artesia	6.1	6.7	0.6	80.6	0.1
Flood Inflow, Artesia to Carlsbad	4.7	5.2	0.5	80.6	0.1
Flood Inflow, Carlsbad to State Line	1.4	1.5	0.1	80.5	0.0
Managed					
River Pumping	4.3	4.8	0.5	80.6	0.1
FSID Diversion	42.4	46.6	4.2	80.8	0.3
CID Diversion	95.9	105.5	9.6	82.5	2.0
Salvage[4]	0.0	10.0	10.0	70.5	-10.0
Santa Rosa Reservoir Evaporation	26.1	28.7	2.6	81.1	0.6
Lake Avalon Evaporation	5.0	5.5	0.5	80.6	0.1
Irrigation above Alamogordo Dam	11558.0[5]	12713.8[5]	1155.8[5]	80.8	0.3

[1]Increased by ten percent, except salvage
[2]1998 Obligation was 80.5 TAF, including 1.3 TAF of credits to New Mexico
[3](+) is increase in obligation, (-) is decrease in obligation
[4]Assumes New Mexico undertakes salvage project
[5]Acres

SECTION V: LEGAL ISSUES

Introduction

The discussion of legal issues pertains to the statutes, laws and regulations covering water use and water rights in the middle and Lower Pecos Valley in New Mexico. The discussion is a general explanation of water laws relevant to the region. Specific applications of the water laws will be addressed in the discussion of the alternative water-supply options.

General Review of New Mexico Water Law

The Doctrine of Prior Appropriation governs the use of water in New Mexico. The Doctrine is followed in most of the western states where much of the country is arid and demand often exceeds the available supply of water. The New Mexico Constitution declares that water belongs to the public. Individuals are permitted appropriation for beneficial use. Beneficial use of the water is the basis, the limit and the measure of the water right and the priority of appropriation shall give the superior right.

The OSE is statutorily charged with the general supervision of the waters of the State and their appropriation, distribution and measurement. The OSE issues all permits for water use. The office is further empowered to adopt regulations and codes to implement and enforce provisions of the laws. Water users in the Lower Pecos River water planning region are subject to all state water laws, rules and regulations of the OSE as well as to decisions of state and federal courts that have established precedents for water use and administration.

Provisions for Water Use in the Lower Pecos River

Inasmuch as the OSE and courts have found both surface water and groundwaters of the Pecos Stream System to be fully appropriated, no new appropriations can be made for either surface or groundwater. An application to change a point of diversion or location of well, place and/or purpose of use, except in districts established under Federal Reclamation Law, must follow the required OSE procedures. As a general rule, an application to transfer the purpose of use is limited to the depletion value of the original use (i.e., that part of the diversion which is lost to the basin). This limitation ensures that other downstream users are not impaired. Any unused water dedicated or decreed to existing water rights becomes part of the available supply for other existing water rights users. New types, purposes or place of use, however, can be made by the transfer of existing rights in accordance with the Statutes and Rules and Regulations of the OSE. This procedure requires filing of necessary applications, publication of the proposed change in place and/or purpose of use and possible protest and hearing. All actions of the OSE may be appealed to the District Court.

An exception to the above requirement for a new appropriation exists when groundwater is to be appropriated for domestic or stock use. Permits for such rights are issued by the OSE without the requirement for publication and hearing and are limited by administrative policy not to exceed three AF per annum (AFY).

Special Districts and other Organizations Involved with Water Use

Located within the Lower Pecos River Watershed River System are various water districts having legal control over the use of water in that district. Such districts include the FSID, PVACD and CID. Soil and Water Conservation Districts, Planning and Zoning Commissions, Municipalities, and others also have control or input over how the water may be used. All are subject to specific New Mexico Statutes and court decrees concerning their organization and operation.

The FSID is authorized under S73-9 of New Mexico Statutes. The PVACD was organized under S73-1 through 73-1-27 of the Statutes to conserve the groundwater of the Roswell Groundwater Basin and is authorized to take whatever steps are necessary in this regard. The Carlsbad Irrigation Project was authorized under the United States Reclamation Laws and the CID was formed and operates under special legislation concerning irrigation districts working within federal reclamation projects.[54]

Also located within the planning area are several drainage districts organized under New Mexico Statutes. These drainage districts include the Roswell Drainage District, the East Grand Plains Drainage District, the Dexter Greenfield Drainage District, the Lake Arthur Drainage District and the Carlsbad Drainage District. Some of these districts are not in operation at this time, but may be reactivated dependent upon further necessity for drainage in the area.

Administration of Water Law in the Pecos Valley

Diversions of underground waters in the Roswell Artesian Basin in Chaves and Eddy Counties are metered under a Partial Final Judgment and Decree entered January 10, 1966 under Chaves County Cause Nos. 20294 and 22600 Consolidated. The Decree provides for the appointment of a watermaster to serve under the direction of the OSE for the administration and enforcement of the Decree. PVACD pays for costs of the Watermaster Office.

[54] New Mexico Statutes 73-10 and 73-11.

The OSE formally recognized the Pecos Valley Surface Water District in July 1, 1952. The boundaries of the District were subsequently modified in 1956, 1959 and 1963. The District now includes the Pecos River and many of the tributaries from south of Santa Rosa to Avalon Dam near Carlsbad. A watermaster appointed by the OSE administers the surface waters of the District in conformance with permits and licenses issued by the State Engineer and adjudication's of the courts. The operation of the District is financed by assessment of the water users in the District based upon their diversions.

The Pecos River Watermaster and the Roswell Basin Watermaster are primarily concerned with the annual quantities of water diverted within their respective districts and the operation and maintenance of measuring devices utilized for the distribution of such waters. The Roswell OSE administers changes in ownership of water rights and applications for transfer of diversion, relocation of wells and change of use. Each individual application is processed in accordance with the applicable statutes, rules and regulations and policies of the OSE pertaining to specific areas within the Pecos Stream System or groundwater basin.

The Lower Pecos River watershed extends into the Mescalero Apache Indian Reservation where the headwaters of the Rio Bonito, Eagle Creek, Rio Ruidoso, Rio Felix and the Rio Peñasco watersheds are located. The Mescalero Apache Government, in accordance with rights that have been or will be adjudicated in State adjudication proceedings, regulates use of water within the Reservation boundaries.

The various municipalities, community water systems and counties within the stream system have jurisdiction over the use of water from their water systems and may impose restrictions under zoning laws, subdivision acts and other regulations. Federal Governmental Agencies administering provisions of the Federal Endangered Species Act may have additional requirements. Municipalities, the Corps of Engineers and the BOR operate dams and reservoirs on the stream system or the CID under permits or licenses issued by the State Engineer or Decrees of the Court.

Interstate Administration

The Pecos River Compact was entered into between the states of New Mexico and Texas in December of 1947 and ratified by the United States Congress in January of 1948. The Compact governs the apportionment of waters of the Pecos River Stream System between the two states. All use of water in the Pecos Stream System in New Mexico is subject to the State's administration of the Compact provisions and subject to decisions by the Pecos River Compact Commission. The ISC is composed of one representative each from New Mexico (appointed by the governor) and Texas and one non-voting representative from the federal government.

In 1988, the U.S. Supreme Court ruled in Texas v. New Mexico and further defined provisions of the Compact. The U.S. Supreme Court appointed a rivermaster for the purpose of performing the duties set forth by the Court in its Amended Decree of March 28, 1988. The rivermaster has the power and authority to determine the annual quantities of water to be appropriated to each state under the Compact. Generally, under the Compact, any "new" water developed within the state by state or local planning and funds belongs to the state of New Mexico and any new water salvage by the United States or by joint undertaking of Texas and New Mexico is apportioned 43 percent to Texas and 57 percent to New Mexico. Unappropriated floodwater in New Mexico is divided equally between the states. A copy of the Compact is attached as Appendix E and summary Table 1 of the rivermaster's account for 1998 is in Appendix F.

Litigation

A Federal Decree known as the "Hope Community Ditch Decree" was filed May 8, 1933, wherein the majority of surface-water users from the headwaters of the Pecos River above Pecos, New Mexico to Avalon Dam near Carlsbad were decreed various rights. The adjudication of all water rights, both surface and underground, in the Pecos River Stream System in New Mexico commenced after Chaves County Cause Nos. 20294 and 22600 Consolidated (the Lewis Suit) was expanded to include the entire Pecos Stream System. This Cause, originally entered as an adjudication of the water rights in the Roswell Groundwater Basin with a Partial Final Decree issued in December of 1967, was expanded in 1974 to include the Hondo Basin and again in 1976 to include all other rights in the stream system. Surface rights below Carlsbad, New Mexico were adjudicated in the Black River and Livingston Decrees. Plate 8 shows the status of adjudications in the planning area. A summary of completed and ongoing adjudications is provided in Appendix G and a summary of hydrographic surveys is provided in Appendix H.

SECTION VI: WATER RESOURCE ASSESSMENT

Surface Water

Drainage Basins

The planning area consists of 16,800 square miles of the lower portion of the Pecos River drainage basin, in New Mexico (Plate 1). The Pecos River extends from northern New Mexico to its confluence with the Rio Grande in southwest Texas. Within the Pecos River drainage basin there are many sub-watersheds or smaller drainage basins (Plate 2). The most significant of these sub-watersheds, Arroyo del Macho and Rio Hondo, drain from the western mountains eastward into the mainstream of the Pecos River. A few of the tributary drainage basins have perennial flow but none maintains a surface flow for its entire length. The basin contains 14,013 miles of watercourses, of which 642 miles are perennial according to the USGS.[55]

For management and planning purposes, these drainage basins have been designated by Federal agencies as hydrologic units with assigned numbers for identification purposes. This information is provided on Plate 2 and Table 18.[56]

Table 18. U.S. Geological Survey Hydrologic Units in the Planning Area

Hydrologic Unit #	Hydrologic Unit Name	Area in Planning Region (Mi^2)	Perennial River Miles	Intermittent River Miles	Canal Miles	Intermittent and Perennial Water Body Area (Acres)
	Eight Basins near Planning area Boundary	30	0	6	0	24
13060003	Upper Pecos	3561	105	1744	35	4787
13060004	Taiban	187		131		412
13060005	Arroyo Del Macho	1872	1	1701	5	875
13060006	Gallo Arroyo	713		539		25
13060007	Upper Pecos-Long Arroyo	2661	117	1324	121	6816
13060008	Rio Hondo	1674	205	1669	56	479
13060009	Rio Felix	991	22	1150	13	214
13060010	Rio Peñasco	1066	83	1416	34	278
13060011	Upper Pecos-Black	3865	118	3486	131	8109
13070001	Lower Pecos-Red Bluff Reservoir	144		71		390
13070002	Delaware	43	9	34	4	0
Totals		16,807	662	13,272	400	22,409

[55] U.S. Geological Survey, December 8, 2000, http://nhd.usgs.gov/.
[56] U.S. Geological Survey, April 19, 2001, http://water.usgs.gov/.

Surface-Water Yields

Surface water is diverted for use from the Pecos River and its tributaries within the planning area. Surface water that originates in the upper reaches of the Pecos River and enters the planning area as river flow is stored in reservoirs for later release from storage. Surface water in the tributaries is diverted for irrigation or stored in reservoirs. Surface water is also consumed by unmanaged riparian vegetation. Perennial streams, gaging stations and major reservoirs are shown on Plate 9. Gaging station records are summarized in Tables 19 and 20.

The surface-water supply in the planning area is variable. The area has experienced drought during periods of low precipitation. High levels of runoff and flooding are seen during periods of high precipitation. About 130,000 AFY enters the planning area below Sumner Dam and about 75,000 AFY leaves as Pecos River flow to Texas. Tributary yield including surface-water runoff and baseflow contributions from groundwater is generated within the basin and has averaged 491,000 AFY since 1947.

Precipitation

Average annual precipitation varies throughout the planning area. Plate 10 shows average annual precipitation contours in the planning area. Appendix D contains historical precipitation data for the planning area. The precipitation data shows the generally dry period of the 1950s and the wet period of the 1980s affecting the entire planning area. The lower desert region in the south and central area receives an average of ten to 12-inches per year. Annual precipitation in the plains region located in the north and east averages 12 to 14 inches. The mountainous regions to the west receive an average over 16-inches annually. The Sacramento Mountains at the peak reach 30-inches annually. Appendix I contains values of land area between precipitation and elevation contours.

The area is subject to extended periods of drought and to years of high precipitation. For example, during l941 some sites in the planning area received precipitation levels four times the average. Variations in annual precipitation levels cause variable surface yields from the numerous watersheds within the planning area. Approximately 70 percent of the annual precipitation occurs during the summer months, usually in the form of high-intensity, short-duration storms. These storms usually cover only a portion of the planning area and create runoff in a few of the sub-watersheds.

Streamflow Data

A network of gaging stations is maintained on the mainstem of the Pecos River from Sumner Dam to the Texas-New Mexico border. Additional gaging stations are maintained on major tributaries of the Pecos River. Gaging stations are shown on Plate 9 and summarized in Tables 19 and 20. Table 19 provides average flow information for the Pecos River.[57] Table 20 provides average flow data for gaged tributaries.[57 above] Some partial-record stations are read monthly or following periods of heavy flow. Records for some stations start in the early 1900s and provide a long history of the river. Other stations were established recently. Appendix J contains a summary of all active and inactive gages in the planning area. Table 19 also shows the gaining and losing reaches along the Pecos River. Losing reaches typically include one or more irrigation diversions that reduce mainstem flow. Mainstem flow in gaining reaches is usually supplemented by agricultural return flow, tributary flow or groundwater inflow.

Figures 10, 11 and 12 display the hydrograph data for the Pecos River below Sumner Dam, near Acme, and near Artesia.[58] The flattening of duration curves at the Sumner Dam and Acme stations at 1000 cfs reflects deliveries at that flow to the CID. The flattening of the duration curve at 100 cfs below Sumner Dam reflects deliveries at that flow to FSID.[59] Figures 10 and 12 show that the Pecos River was almost never dry below Sumner and near Artesia before Sumner Dam was completed in 1937 (a value of 0.1 cfs or less on the hydrograph indicates zero flow). Appendices K and L contain hydrographs and duration curves for other gaged points on the Pecos River and gaged tributaries in the planning area, respectively. Average annual inflow since 1947 on the Pecos River into the planning area (gaged below Sumner Dam) is 130,000 AF. Outflow at Red Bluff is 75,000 AFY. In the decade of the 1990s the values have been 145,000 AFY of inflow and 75,000 AFY of outflow.

Tributary Inflow

Tributaries in the planning area convey rainfall and snowmelt to the Pecos River mainstem. The flow that reaches the river is that precipitation which has not been consumed by evaporation and plant and crop evapotranspiration along the tributary. The USGS has computed the average annual runoff in tributaries throughout the United States including New Mexico.[60] Based on the USGS data, tributary inflow is 107,000 AFY to the upper reach of the Pecos River in the planning area (Sumner Dam to Acme), 193,000 AFY in the middle reach (Acme to Brantley Dam) and 49,000 AFY in the

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[57] Ortiz, D., Lange, K. and Beal, L., 2000, Water Resources Data New Mexico Water Year 1999: U.S. Geological Survey Water-Data Report NM-99-1.
[58] U.S. Geological Survey, December 5, 2000, http://nm.water.usgs.gov/.
[59] Personal communication, B. Rao, OSE, to C. Cook, BGW, December 8, 2000.
[60] Gerbert, W.A. Graczyk, D.J. and Krug, W.R., 1987, Average Runoff in the United States, 1951-80: U.S. Geological Survey Hydrologic Investigations Atlas HA-710.

lower reach (Brantley Dam to Red Bluff). The total surface tributary inflow to the Pecos River in the planning area is 349,000 AFY. Ungaged recharge to groundwater aquifers contributes an additional quantity averaging 142,000 AFY of inflow, for a planning region total of 491,000 AFY.

Irrigation Consumptive Use

The consumptive irrigation requirements (CIR) for irrigated areas in the planning area are shown in Plate 11 and Table 21.[61] Irrigated areas are indicated on Plate 12. Table 22 shows estimates of irrigated area in each of the six declared basins. Appendix M shows a breakdown of the components of irrigation water demand. The various irrigation duties of water set out by court decrees (see Section V) are 2.5 AFY per acre from the Sumner Lake of the mouth of Salt Creek north of Roswell, 3.0 AFY per acre from the mouth of Salt Creek to the Texas state line and 3.75 to 4.00 AFY per acre for individual rights in the Pecos River reach below Carlsbad. In 1999, a total of 169,496 AF of surface water was diverted for irrigation within the Pecos Valley Surface Water District.[62]

The area of irrigated agriculture in the planning area is 128,440 acres (Plate 12, Table 22)[63]. The watermasters' report about 50,000 acres of surface-water irrigation and 114,000 acres of groundwater irrigation in recent years.[62 above, 64] Based on 128,000 irrigated areas and on average CIR of 2.5 AFY/acre, irrigation consumptive use averages 321,000 AFY. This consumptive use is supplied by diversions from both groundwater and surface-water resources.

Evaporation

Evaporation occurs on open-water surfaces. The high temperatures and hot, dry winds that prevail during the late spring and early summer months at lower elevations result in high rates of evaporation. Table 22 shows the total open-water area in each groundwater basin, including streams, ponds, playas and reservoirs. Assuming an average net evaporation of 60 inches per year, the total open-water evaporation from the planning area is 70,200 AFY. Tables 23 and 24 provide average monthly pond and reservoir evaporation amounts for each county that has recorded such information.[65] Plate 13 shows the net lake evaporation contours in the planning area based on BGW digital USGS gross lake evaporation minus NRCS PRISM data.[66, 67]

[61] Wilson, B.C. and Lucero, A.A., 1997, Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1995: New Mexico Office of the State Engineer, Technical Report 49.
[62] Turner, R.C., 1999, Watermaster Report: Pecos Valley Surface Water District.
[63] U.S. Geological Survey, 2000, National Land Cover Database, http://mapping.usgs.gov/.
[64] Torres, R.L., 1999, Roswell Basin Watermaster 34th Annual Report.
[65] Wilson, B.C., 1992, Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1990: New Mexico Office of the State Engineer, Technical Report 47.
[66] U.S. Soil Conservation Service, 1972, Gross Annual Lake Evaporation, New Mexico.

Table 19. Average Annual Flow in the Pecos River and Major Tributaries at Selected Gaging Stations

Gaging Station	Period of Record	Average Annual Flow (AF)	Gaining or Losing Reach[1]
Puerto de Luna	1980 – 1999	168,600	
Below Sumner Dam	1937 – 1999	145,400	Losing
Near Acme	1938 – 1999	130,600	Losing
Near Lake Arthur	1938 – 1999	162,600	Gaining
Near Artesia	1937 – 1999	170,000	Gaining
Kaiser Channel	1950 – 1999	120,500	Losing
Below Brantley Dam	1972 – 1999	111,600	Losing
At Dam Site 3	1939 – 1999	119,400	Gaining
Below Avalon Dam	1951 – 1999	26,140	Losing
Below Dark Canyon Draw	1970 – 1999	43,600	Gaining
Near Malaga	1938 – 1999	107,000	Gaining
At Pierce Canyon Cross	1938 – 1999	92,220	Losing
At Red Bluff	1938 – 1999	111,000	Gaining

[1] Indicates whether on average, the reach gains or diminishes in flow. Gains may include baseflow, tributary inflow and return flow. Losses may include seepage to groundwater, surface diversions, evaporation and consumption by riparian vegetation.

Table 20. Average Annual Flow in Selected Gaged Tributaries and Canals

Gaging Station	Period of Record	Average Annual Flow (AF)
Fort Sumner Main Canal	1939 - 1999	37,370
Rio Ruidoso at Hollywood	1982 - 1999	19,250
Eagle Creek Below S. Fork - Alto	1970 - 1999	1990
Rio Hondo at Diamond A Ranch	1940 - 1999	18,080
Rio Hondo Below Diamond A Dam	1964 - 1999	11,110
Rio Hondo at Roswell[1]	1981 - 1996	13,680
Rio Peñasco at Dayton	1951 - 1999	3420
Fourmile Draw Near Lakewood	1952 – 1999	2490
South Seven Rivers Near Lakewood[2]	1964 - 1996	2880
Rocky Arroyo at Highway Bridge	1964 - 1999	4380
Carlsbad Main Canal at Head	1939 - 1999	77,600
Dark Canyon Draw at Carlsbad	1973 - 1999	3400
Black River Above Malaga	1948 - 1999	9570
Delaware River Near Red Bluff	1938 - 1999	8160

[1]Discontinued Station
[2]No Data April 1997 – May 1999

[67] National Resource Conservation Service, 2001, Average Annual Precipitation 1961 – 1990: http://www.ftw.nrcs.usda.gov/prism/prism.html.

Table 21. Consumptive Irrigation Requirement (Feet Per Year)

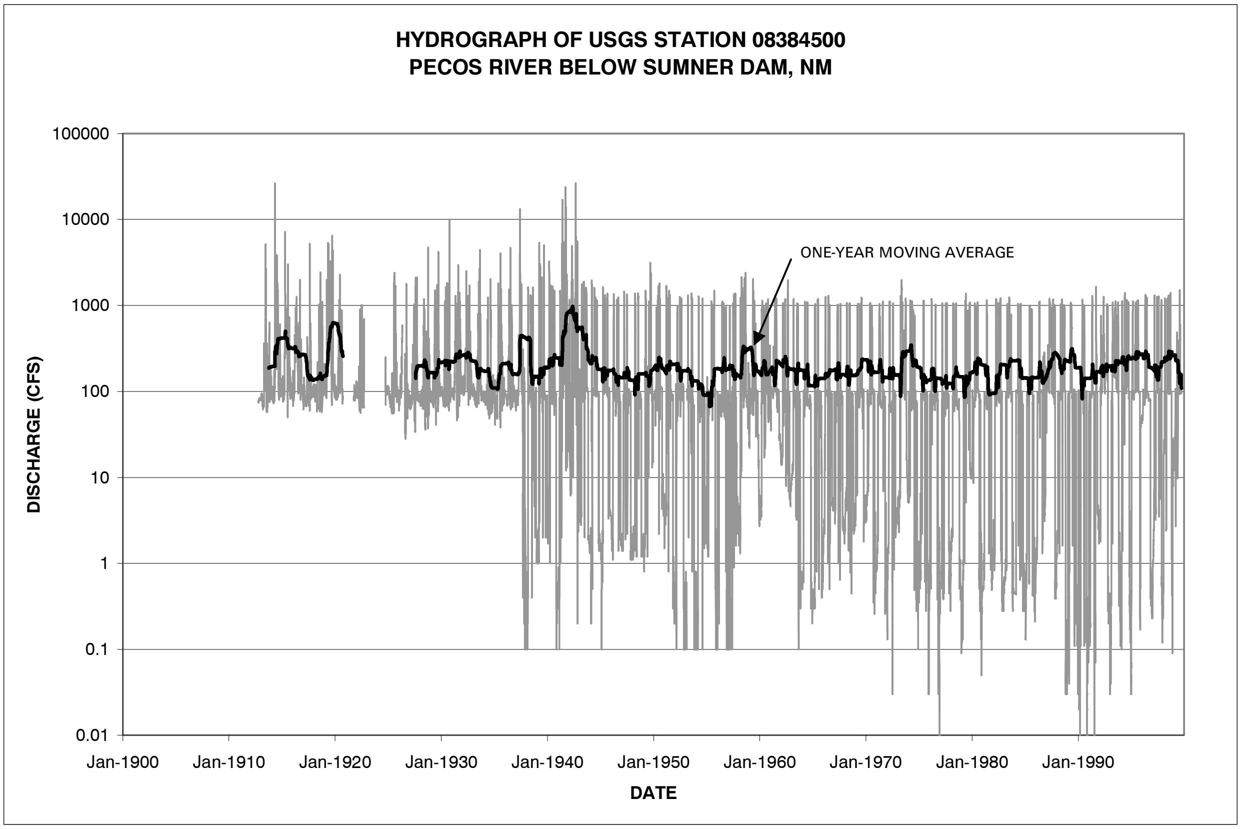
County/Location	Surface Water	Groundwater		
	Flood	Flood	Drip	Sprinkler
Chaves				
Rio Hondo	1.862			1.849
Rio Peñasco	2.391	2.391		
Roswell Basin North			2.325	2.418
Roswell Basin North (part)	2.072	2.072		
Scattered	2.874	2.874		
De Baca				
Fort Sumner Irr. Dist.	2.322			
Outside Fort Sumner Irr. Dist.		2.276		1.329
Scattered				2.749
Eddy				
Black River	3.037	3.037		
Carlsbad Basin Scattered	2.929	2.929		
Carlsbad Irr. Dist.	2.974	2.974		
Rio Peñasco	2.675	2.675		
Roswell Basin South		1.669	2.164	2.106
Lincoln				
Rio Hondo and Tributaries	2.435	2.435	2.502	
Scattered	2.488	2.488		
Otero				
Rio Peñasco	1.358			

Table 22. Vegetation and Open Water Summary by OSE Underground Water Basin

OSE Underground Water Basin	Managed Forest (Acres)	Open Water Including Playas and Reservoirs (Acres)	Irrigated Vegetation (Acres)	Unmanaged Vegetation[1]
Fort Sumner	110	1520	12,390	17,200
Roswell	150,630	4390	88,780	40,430
Hondo	323,830	160	7510	900
Peñasco	324,920	10	1610	0
Carlsbad	17,590	6860	18,140	11,270
Capitan	0	1100	10	700
Total	817,080	14,040	128,440	70,500

[1]Vegetated area in places with shallow water table outside of managed use areas for lands with less than 16 inches of precipitation and outside of managed forests.

Figure 10. Hydrograph and Duration Curve for Pecos River Below Sumner Dam



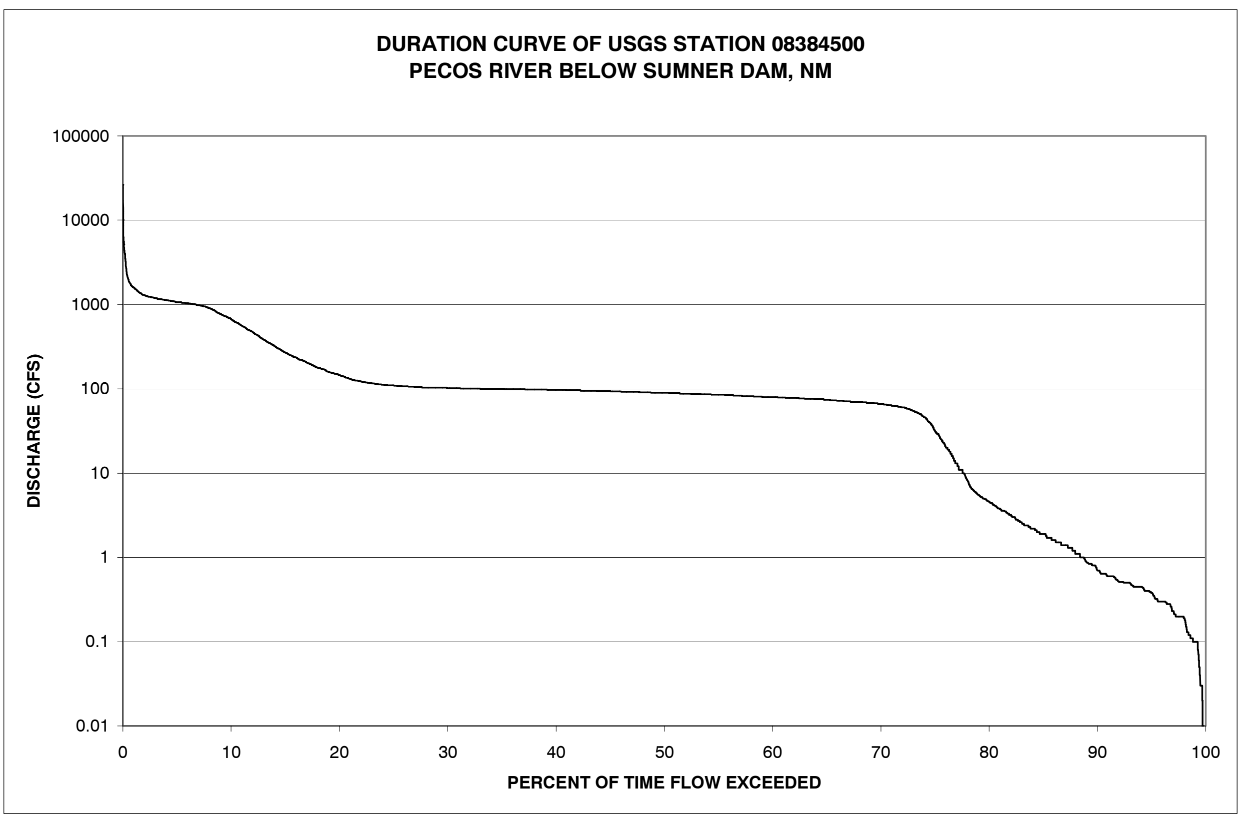
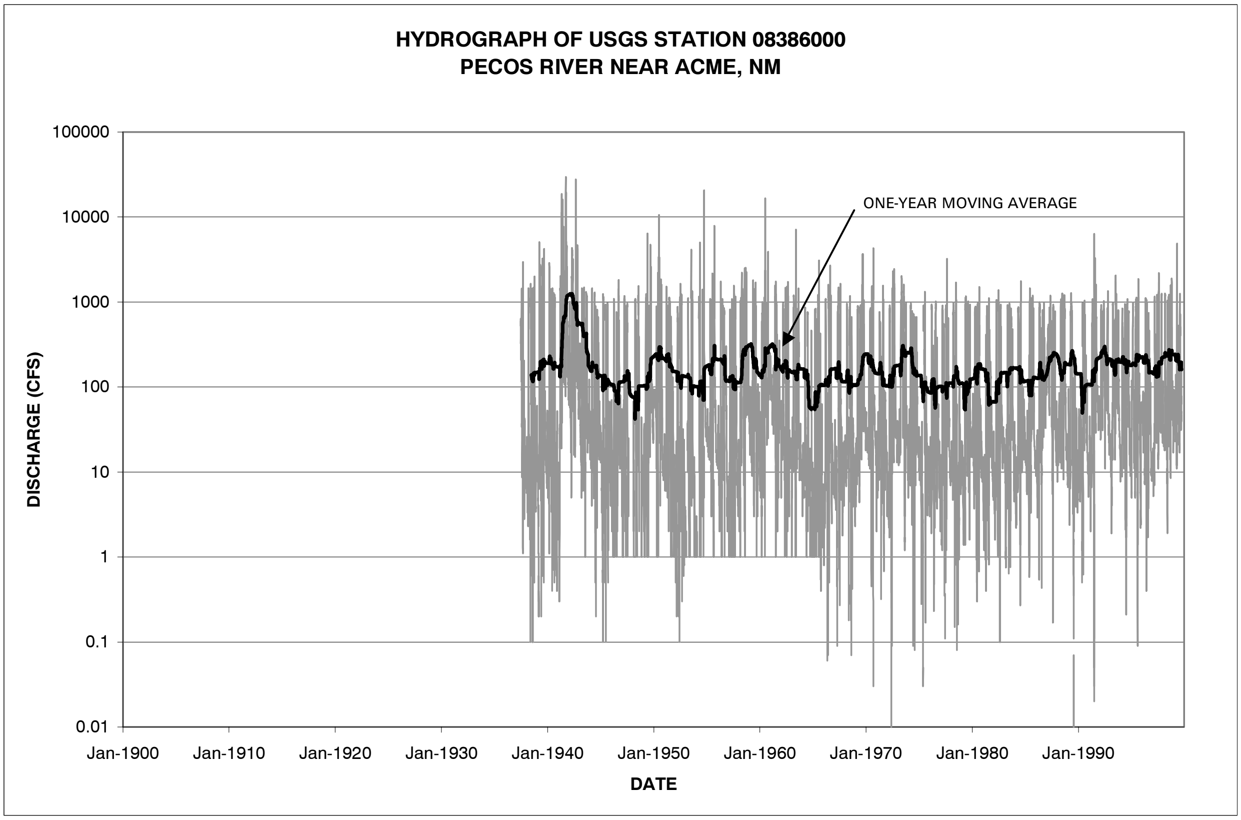


Figure 11. Hydrograph and Duration Curve for Pecos River Near Acme



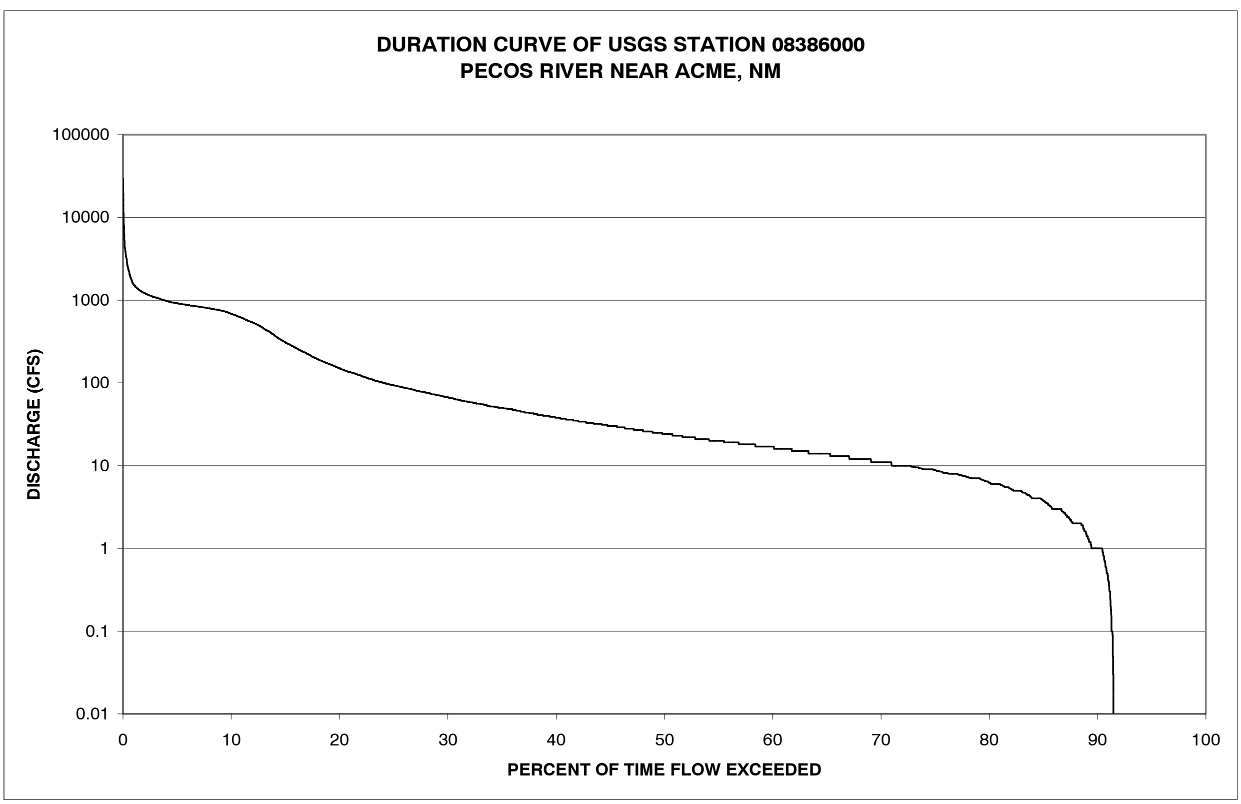
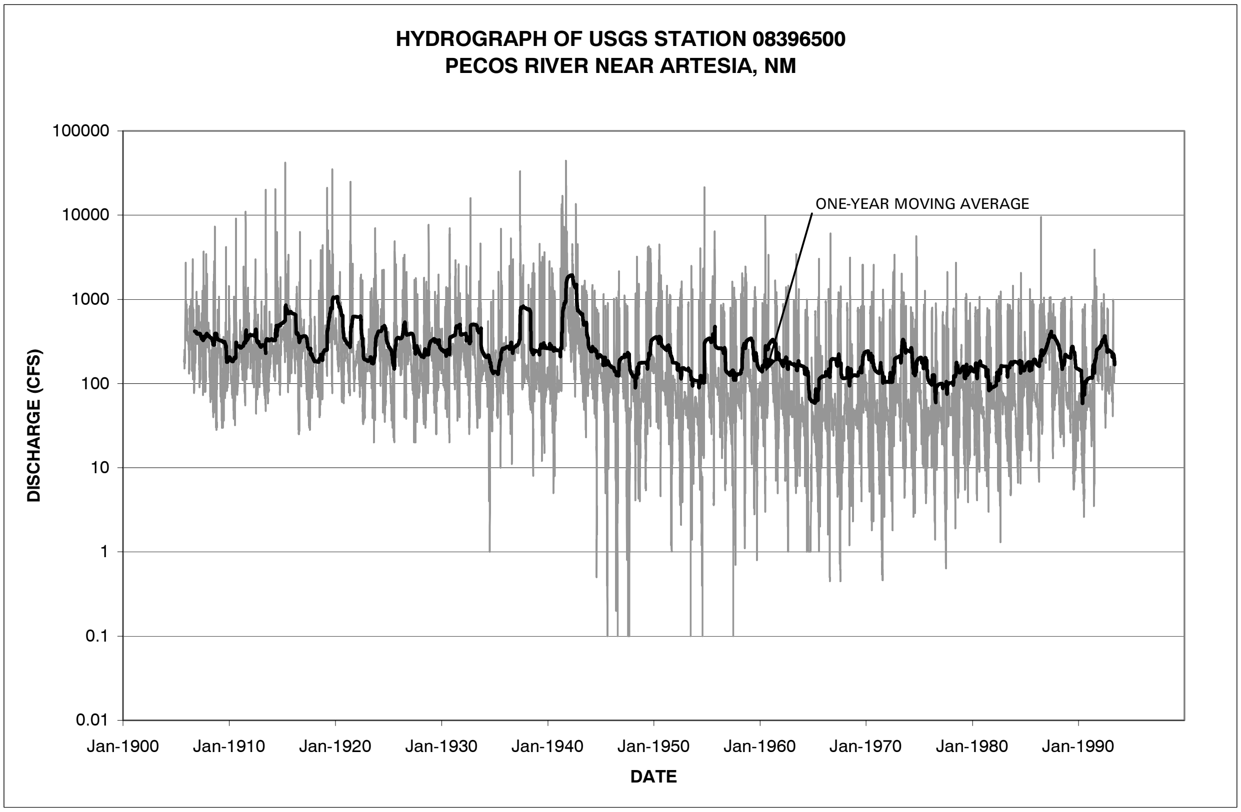


Figure 12. Hydrograph and Duration Curve for Pecos River Near Artesia



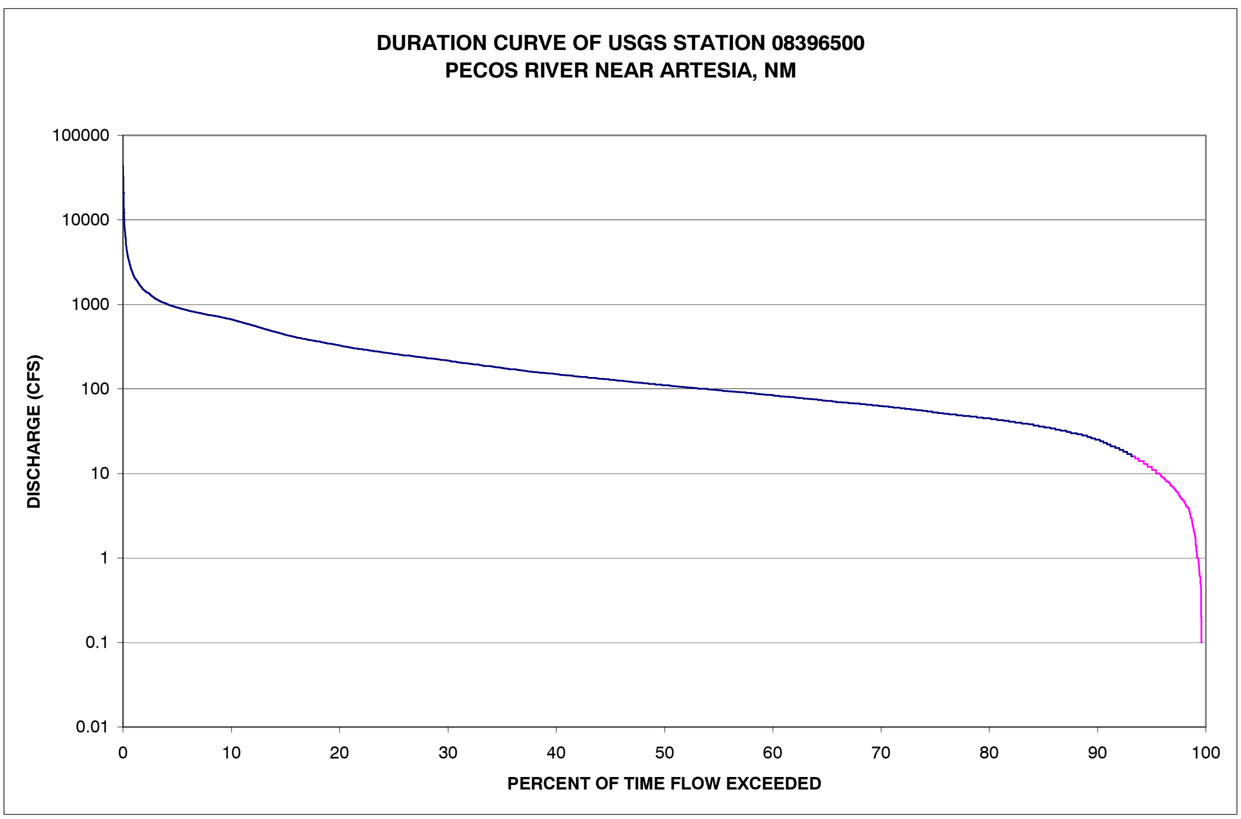


Table 23. Annual Evaporation by County

	(AF)					Total
	Chaves	De Baca	Eddy	Lincoln	Otero	
Stock Pond Evaporation	2121	428	756	555	406	4226
Reservoir Evaporation	808	6616	8781	214	0	16,419

Table 24. Average Monthly Class A Land-Pan Evaporation

Month	Site and Period of Record (inches)		
	Alamogordo (Sumner) Dam 1939 - 1962	Bitter Lake Wildlife Refuge 1951 - 1962	Lake Avalon 1951 - 1962
January	3.73	2.7	4.2
February	4.91	4.27	5.76
March	8.46	7.2	9.23
April	10.71	9.94	11.71
May	13.32	12.36	14.05
June	14.86	13.67	14.62
July	13.95	12.3	13.1
August	12.42	11.2	12.4
September	10.55	9.01	9.72
October	7.4	5.83	7.0
November	4.78	3.43	4.51
December	3.81	2.68	3.83
Annual Total	108.9	94.59	110.13

Storage Reservoirs

Within the planning area there are two operational storage reservoirs on the mainstream of the Pecos River: Brantley and Avalon Lakes (Plate 9). Eleven smaller reservoirs are located on the Pecos River and its tributaries. Two other reservoirs located north of the planning area on the Pecos River at Fort Sumner and at Santa Rosa are an integral part of the storage and delivery system for surface water in the area. Each of these facilities is described in the following sections and is summarized in Tables 25 and 26.[68,69] Water stored in reservoirs is subject to evaporation. Tables 25 and 26 show the estimated annual evaporation for man-made reservoirs and lakes at average storage levels. Annual evaporation losses from all reservoirs and lakes within

[68] National Resource Conservation Service, 2000, Basin Area Reservoir Summary.
[69] U.S. Army Corps of Engineers, 2000, National Inventory of Dams.

the planning area (excluding Santa Rosa and Sumner Reservoirs) total 18,624 AFY, which is slightly higher than the value in Table 23 (16,419 AFY) due to different periods of record.

Table 25. Reservoirs Along the Pecos River Mainstem in the Planning Area

Reservoir	Year Built	Average Storage (AF)	Maximum Storage (AF)	Surface Area at Average Storage (Acres)	Evaporation at Average Storage (AFY)	Designated Uses
Santa Rosa Lake	1979	53,300	717,000	2457	10,237	Flood control, irrigation, recreation and other
Sumner Lake	1937	46,100	237,820	2930	13,185	Flood control and irrigation
Brantley Lake	1988	17,300	966,300	1611	8592	Flood control, irrigation and recreation
Lake Avalon	1907	2510	70,000	770	4170	Irrigation, water supply and other
Upper Tansill Lake	1895	550	617	99	561	Recreation
Lower Tansill Lake	1970	252	252	40	227	-
Six-Mile Dam	1905	0	100	--	--	Recreation
Totals		120,012	1,992,089		36,972	

Table 26. Off-Channel and Tributary Reservoirs in the Planning Area

Reservoir	Year Built	Average Storage (AF)	Maximum Storage (AF)	Surface Area at Average Storage (Acres)	Evaporation at Average Storage (AFY)	Designated Uses
Alto Lake Dam	1965	240	452	17	21	Water supply
Bonito Dam	1930	1247	2500	44	55	Water supply, recreation
Grindstone Canyon Dam	1987	1520	1700	38	47	Water supply, recreation
Silver Lake	1962	130	149	-	-	Flood control
Willow Lake	1940	2990	-	-	-	Irrigation, recreation
Lake Van	-	-	-	-	-	Recreation
Bitter Lakes	-	-	943	-	4951	Wildlife
Two Rivers	1963	0	168,000	0	0	Flood, sediment
Totals		6127	173,744		5074	

Santa Rosa Dam and Lake. The United States Army Corps of Engineers constructed Santa Rosa Dam and Lake in 1979. The dam is located 55 miles upstream from Sumner Dam and about seven miles north of Santa Rosa, in Guadalupe County. The dam consists of rolled earth and rockfill and is approximately 1900 feet long with a maximum height of 210 feet. It has an uncontrolled spillway 1050 feet wide and an outlet works consisting of a 10-foot diameter, concrete lined tunnel, with a maximum discharge of 5760 cfs. Santa Rosa Lake has a total storage capacity of 449,000 AF allotted as follows: conservation irrigation storage (200,000 AF), flood control (176,000 AF), and sediment space (82,000 AF). This reservoir is used for flood control, storage of irrigation waters, recreation and provides benefits for fish and wildlife. Even though the dam and lake are located outside the planning area they are an integral part of this Regional Water Plan.

Sumner Dam and Lake. Sumner Dam and Lake were constructed by the Bureau of Reclamation in 1937. Major modifications to the structure were completed in 1956. This structure and lake are located on the Pecos River approximately 21 miles upstream from Fort Sumner, in De Baca County. The dam consists of rolled earth and rockfill and is approximately 3000 feet long with a maximum height of 164 feet. There is a 500-foot wide emergency spillway on the left abutment. The outlet works have a capacity of 1740 cfs. The original capacity of the lake was 165,500 AF with 157,000 AF allotted to storage and 8500 AF dedicated to sediment storage and flood control. Presently the lake devotes 20,000 AF to irrigation storage and 145,000 AF to sediment storage and flood control. The reservoir is used for flood control, storage of irrigation waters, recreation and benefits for fish and wildlife.

Brantley Dam and Lake. Brantley Dam and Lake was constructed by the Bureau of Reclamation in 1988. The structure is located on the Pecos River 13 miles upstream from the City of Carlsbad, in Eddy County. The dam consists of a main concrete structure 730 feet long and 143.5 feet high. The east wing of the dam is 12,059 feet long with a maximum height of 150 feet. The west wing of the dam is 8720 feet long with a maximum height of 120 feet. The east and west wings are constructed of rolled earth and rockfill. The main outlet works consists of two four-foot square conduits controlled by hydraulic slide gates. There is also a low-flow outlet works designed to carry 20 cfs. The spillway is part of the concrete section of the dam and has a maximum capacity of 357,000 cfs. The capacity of Brantley Lake, 348,544 AF, is divided in the following manner: conservation (irrigation) storage (40,000 AF); flood control (189,700 AF); sediment space (116,300 AF); and recreation and fish and wildlife habitat (4000 AF). This dam was constructed primarily to replace McMillan Dam. The reservoir is used for flood control, storage of irrigation water, recreation and benefits for fish and wildlife.

Avalon Dam and Lake. The Pecos Irrigation and Improvement Company first constructed Avalon Dam, located six miles north of Carlsbad, in 1893. Following extensive damage to the structure caused by several floods, the Bureau of Reclamation rebuilt the dam between 1906 and 1907. Further construction and improvements to the dam were completed in 1938. Avalon Dam is an earth and rockfill structure 1360 feet long and 53 feet high. Appurtenant works include three spillways and an outlet works. The original capacity of the reservoir was 7600 AF, however, sediment deposits have reduced the capacity to 4200 AF. The reservoir is used mainly to regulate irrigation diversions, though some space is reserved for water storage, flood control and recreation. Additionally, the facility provides benefits for fish and wildlife.

Upper Tansill Dam and Carlsbad Lake. A group of private individuals constructed Tansill Dam in 1891. The structure is located in the City of Carlsbad. The dam, consisting of concrete, was originally designed to impound 600 AF of water for electricity generating purposes. The dam is approximately 15 feet high and is designed to allow the flow of the river to pass over the top of the structure. The lake is currently maintained by the City of Carlsbad. The primary uses of the facility are recreation and benefits for fish and wildlife.

Lower Tansill Dam and Lake. Lower Tansill Dam was constructed in and by the City of Carlsbad in 1971. The dam is situated downstream of Upper Tansill Dam. The 10-foot high concrete structure was intended to impound 252 AF of water. The dam is designed to allow the river to flow over the top of the structure. The reservoir provides recreational opportunities as well as benefits for fish and wildlife.

Six-Mile Dam. Private businesses constructed Six-Mile Dam in 1894. The dam is located on the Pecos River approximately six miles southeast of Carlsbad. The 15-foot high concrete structure was originally constructed as a diversion dam for irrigation water. It is used to hold waters released by the CID for three farms on the eastern side of the Pecos River. The reservoir is maintained by the City of Carlsbad and Eddy County as a recreational area. The reservoir also provides benefits for fish and wildlife.

Bonito Dam and Lake. The El Paso and Rock Island Railroad Companies constructed Bonito Dam and Lake in 1931 in an effort to secure necessary water supplies. The facility is located on Bonito Creek, ten miles northwest of Ruidoso, in Lincoln County. The original dam, consisting of a rubble and masonry structure, was raised 23 feet and capped with two feet of concrete in 1985. The outlet works consists of a control structure that places the water into a gravity flow pipeline that provides water to Nogal, Carrizozo, Alamogordo and Holloman Air Force Base. In an effort to extend its life, the dam was raised five feet and an emergency spillway was constructed on its western end. The lake has a capacity of 1091 AF devoted entirely to municipal storage uses. The lake is used as a recreational area and also provides benefits for fish and wildlife.

Alto Dam and Lake. Alto Dam and Lake was constructed in 1964 by the Eagle Creek Inter-Community Water Supply Association, Inc. This reservoir is located three miles north of Ruidoso, in the community of Alto. The dam consists of an earth and rockfill structure approximately 600 feet long and 48 feet high. The reservoir's entire capacity, 320 AF, is designated as storage for municipal water supplies serving the Villages of Ruidoso and Capitan. The reservoir also provides some recreational opportunities and benefits for fish and wildlife.

Grindstone Dam and Lake. The Village of Ruidoso constructed Grindstone Canyon Dam in 1988. The dam and lake are located about one mile south of Ruidoso. The dam is a dry rolled, compacted, concrete structure approximately 1500 feet long and 125 feet high. The outlet works consist of a filter and processing system used to treat and transport water into the municipal water system in Ruidoso. Although the capacity of the lake, 1500 AF, is devoted primarily to storing municipal water supplies, it does offer some limited recreational opportunities and benefits for fish and wildlife in the area.

Mescalero Dam and Lake. Mescalero Dam and Lake is located about six miles southwest of the Village of Ruidoso, on the Mescalero Apache Indian Reservation in Lincoln County. The structure consists of earth and rockfill. Although limited information exists on the main purposes of the reservoir, it seems to share the common uses of water storage and recreation, as well as providing benefits for fish and wildlife.

Silver Springs Dam and Lake. Silver Springs Dam and Lake are located on the Mescalero Apache Indian Reservation about 13 miles northeast of Cloudcroft, in Otero County. The structure consists of earth and rockfill. Although limited information exists on the main purposes of the reservoir, it seems to support recreation activities and provide benefits to fish and wildlife.

Two Rivers Reservoir. Two Rivers Reservoir was built as a flood- and sediment-control reservoir in 1963. The project consists of two earthfill dams that capture flow from the Rio Hondo and Rocky Arroyo into a common reservoir with a capacity of 168,000 AF. Benefits include flood control and sediment control.[70]

Lake Van. Lake Van is a natural lake located one mile east of Dexter, in Chaves County. Although the natural lake was initially sustained by springflow, it is currently maintained by pumped water. Lake Van is owned by the village of Dexter. The lake provides both recreational opportunities and benefits to fish and wildlife.

Willow Lake and Dam. Willow Lake and Dam were constructed in 1921. The dam is located approximately three miles south of Malaga, in Eddy County. The dam is an

[70] New Mexico Office of the State Engineer, 1967, Water Resources of New Mexico Occurrence, Development and Use.

earth and rockfill structure about 15 feet high. The reservoir's 2990 AF of capacity is primarily used to store irrigation water diverted from the Black River for the CID system. The lake also receives heavy use as a private recreational area and provides limited benefits to fish and wildlife.

Small Ponds, Lakes and Playas. Numerous small ponds, lakes and playas exist throughout the Pecos River Basin planning area. These impoundments vary in size and location and are used for livestock water supplies, the regulation and storage of irrigation water, recreation and to provide benefits for fish and wildlife in the area. Bitter Lake National Wildlife Refuge maintains several lakes and ponds. Some impoundments are fed by springs, others by pumped wells and still others by intermittent arroyos.

Major Irrigation Canals

A map of major surface water irrigated areas and canal systems in the planning area is shown in Plate 12. Plates 14 through 20 show close-in details of irrigated and other vegetated areas throughout the planning area. Four major canal systems and several minor systems divert surface waters from the Pecos River and its tributaries. The Watermaster of the Pecos Valley Surface Water District, (which includes most of the planning area) manages about 30 diversions.[71] A description of each major canal system follows. Other irrigation is supplemented by groundwater.

Fort Sumner Irrigation District. The FSID is located in the vicinity of Fort Sumner (Plate 17). The conveyance system begins with a diversion dam on the Pecos River approximately three and one-half miles northwest of Fort Sumner. The main canal is designed to carry 100 cfs of water. At approximately three miles below the diversion dam the upper canal begins. This canal receives about 20 cfs of water from the main canal via lift pumps. The system has rights to divert 100 cfs, or the entire flow of the Pecos River if it is less than 100 cfs as measured at the Puerto de Luna gaging station. Water releases are made from Sumner Dam to furnish flows to the FSID diversion dam. The conveyance system consists of approximately 25 miles of canals and laterals and provides water to approximately 6500 acres of irrigated land.[72] About 5770 acres are shown as irrigated on Plate 17.

Hagerman Irrigation Company. The Hagerman Irrigation Company was incorporated in 1886 and is located in the vicinity of Dexter in Chaves County (Plates 18 and 19). The conveyance system begins with diversion dams slightly over four miles east of Roswell, on the Hondo and Spring Rivers, not directly from the Pecos River. The canal consists of an earthen ditch designed to carry 50 to 100 cfs. The system was

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[71] Personal communication with R. Turner, Pecos Valley Surface Water District, to C. Cook, Balleau Groundwater, Inc., December 13, 2000.
[72] *Records Furnished by the Fort Sumner Irrigation District.*

designed to take advantage of the high water table in the area. Groundwater that rises to the surface is diverted to the main canal and used to supplement river water. The surface waters are further supplemented by artesian wells drilled in the early 1900s and from shallow wells drilled in the 1960s. The conveyance system consists of approximately 60 miles of canals and laterals and supplies water to 8600 acres of irrigated land. Over the years, 30 miles of laterals have been concrete lined to prevent leakage.[73] The layout and associated acreage, approximately 13,700 acres vegetated, is displayed on Plates 18 and 19.

Hope Community Ditch. The Hope Community Ditch system is located in the vicinity of Hope in Eddy County (Plates 16 and 19). The conveyance system begins with a diversion dam on the Peñasco River, approximately 17 miles west of Hope. The main canal consists of an earthen ditch designed to carry 135 cfs. The conveyance system consists of 47 miles of canals and laterals with various water control structures throughout the system. The system supplies irrigation water to 3200 acres of land. Problems of water shortage and water deliveries have plagued the Hope Community Ditch system for several years. During periods of low flows, the river bottom loses its natural protective lining and most available water escapes through the porous streambed, thus limiting deliveries to farms supplied by the system.[74] The region, with 725 acres under irrigation, is displayed on Plates 16 and 19.

Carlsbad Irrigation District. The CID is located between Avalon Dam and the Malaga area near Carlsbad (Plate 20). The conveyance system begins at Avalon Dam, which is approximately five miles north of Carlsbad. About three miles south of the dam, the canal splits into an east canal and a main canal. The east canal runs on the northeast side of the Pecos River. The main canal runs southeast across the Pecos River and ultimately provides water on the river's western side. The smaller east canal will carry approximately 50 cfs, while the main canal is designed to carry 400 cfs as it exits Avalon Dam. There are about 140 miles of canals and laterals in the CID system. Many of the laterals and a portion of the main canal have been concrete lined. The district also receives surface water from Black River, located west of Malaga, near the southern region of the canal system. The CID retains 176,500 AF of storage rights in the four main reservoirs on the Pecos River. Water is delivered to 25,055 acres of irrigated farmland throughout the district.[75] The district, with 15,100 irrigated acres including some recreational areas, is shown on Plate 20.

Other Irrigation Systems

Several smaller irrigation systems and acequias are maintained on the streams that have perennial flows, including the Rio Bonito, Ruidoso and Hondo in Lincoln

[73] *Records furnished by the Hagerman Irrigation Company.*
[74] Shanks, S.W., 1992, Hope Community Ditch Association History: unpublished.
[75] *Records Furnished by Carlsbad Irrigation District.*

County and the Aqua Chiquita, Peñasco and Felix Rivers in Otero and Chaves Counties. Some of these systems are organized under state law as community ditches. The various systems may serve from one to 25 landowners and may divert from five to 20 cfs from the streams. Some of these systems have been improved with more permanent diversions, concrete ditch linings and irrigation pipelines. Irrigated acreage in the Hondo Basin totals 8400 acres (Plates 14 and 15). Irrigated acreage on the Peñasco Basin totals 1800 acres (Plates 14 and 16). Irrigated areas along Felix River total 1100 acres (Plate 16).

Extensive areas of groundwater irrigation near the cities of Roswell and Artesia are organized under the PVACD. Approximately 69,000 irrigated acres are shown on Plates 18 and 19.

Other areas of groundwater and surface-water irrigation totaling about 12,800 acres are located outside of FSID and CID and elsewhere throughout the planning area.

Unmanaged Riparian Vegetation

The area of vegetated riparian and wetland throughout the planning area is shown on Plate 12. Table 22 shows the estimated vegetated area each of the six declared basin in the planning region.[63 above] Unmanaged loss areas were identified using Geographic Information System and image processing techniques. The New Mexico Geological Society LANDSAT data[76] shown on Plate 3 was automatically computer classified. Classes representing vegetation cover types were identified by correlation with the National Land Cover Database and by inspection of digital orthophotography[77] and National Wetland Inventory maps.[78] Land area with potential unmanaged loss was identified using 30 feet depth-to-water and ten-inch annual precipitation mapping. Places with historic managed use were identified using existing land cover data and by inspection of the LANDSAT image. The total vegetated area in places of potential unmanaged loss outside of managed use areas was then counted for Table 22.

The OSE has estimated that 185,000 AFY is non-beneficially consumed along the mainstem of the Pecos River.[70 above] Throughout the planning area, unmanaged riparian vegetation covers 70,500 acres. At an average consumptive use of 3 AFY/acre, unmanaged vegetation consumes 211,500 AFY. Open water evaporation from unmanaged (non-reservoir) sources totals 51,600 AFY, for a total unmanaged loss of 263,100 AFY.

[76] New Mexico Geological Society, 2000, LANDSAT Thematic Mapper5 Mosaic, Band 7, 4 and 2 Recorded in 1989, 1992 and 1993, distributed by Earth Data Analysis Center, University of New Mexico, Albuquerque, New Mexico.
[77] Microsoft, 2001, Terraserver, http://terraserver.homeadvisor.msn.com/.
[78] U.S. Fish & Wildlife Service, 2001, National Wetlands Inventory Center, http://www.nwi-fws.gov/.

One of the largest concentrated areas of unmanaged water loss is on McMillan Delta, located between Artesia and Brantley Lake (Figure 13). The delta is the former site of McMillan Reservoir, CID's terminal storage reservoir. The reservoir silted up and was breached in 1991 when it was replaced by Brantley Lake. The delta supports about 25,000 AFY, or ten percent of the total unmanaged consumptive use, including open water evaporation. Section X (Alternatives) contains a proposal to drain McMillan Delta to salvage a portion of the unmanaged losses.

Mountain Vegetation

Montane forest and riparian areas in the planning region total 817,080 acres as shown on Plate 12 and Table 22.[63 above] The forests are managed users of water although water is not generally diverted for that purpose. At the estimated rate of 22 inches per year, about 1.5 million AFY is consumed by the managed forested areas. This consumption is through all sources within the forested watershed, including trees, open meadows, open water, soil and other sources. It is from soil moisture before it contributes to runoff, therefore it is not part of the basin yield available for use downstream.

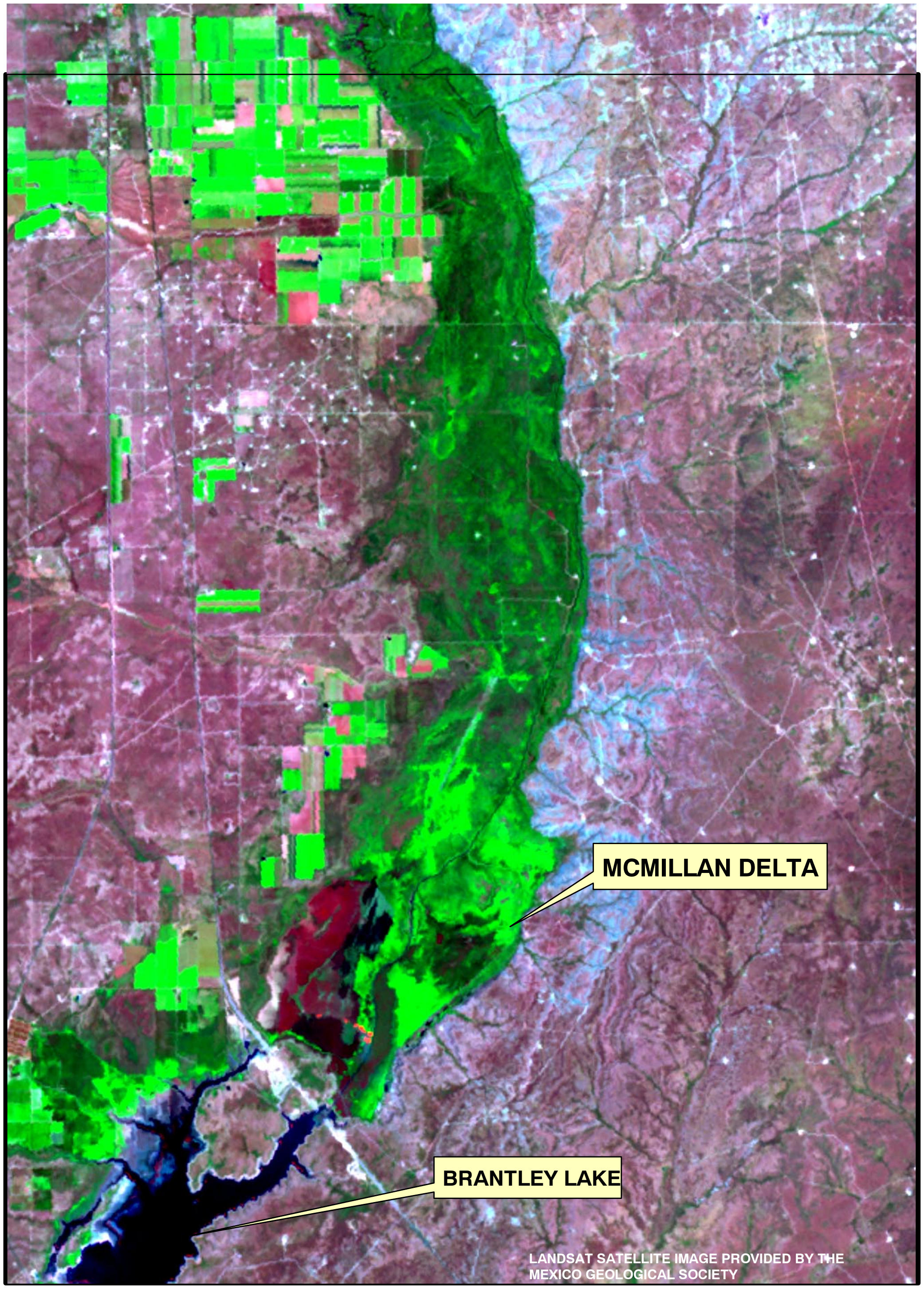
Water Imported to Region

Several thousand AF of water are imported to the Roswell, Carlsbad and Capitan Groundwater Basins. The water is pumped from the Lea County Groundwater Basin, under water rights held by entities outside the basin.

The City of Carlsbad owns 8800 AF of water rights in the Double Eagle wellfield. This is a developed water system that furnishes water to the City of Carlsbad, WIPP, Brantley State Park and to ranchers for domestic and livestock use. Water is also sold from this wellfield to oil and gas businesses for production.

Carlsbad also owns an additional 10,000 AF of water rights in Wellfield B near Tatum, an undeveloped wellfield held for future development. Two potash mines own a total of 11,115 AF of water rights in various wellfields in the Lea County Groundwater Basin. Some of these water rights are in production at this time. Others are held for future water needs by these mining operations. The Caprock Water System is a community water system that delivers water to Loco Hills and other communities and individuals in that area. Their water source is a developed wellfield in the Lea County Groundwater Basin.[30 above]

Figure 13. McMillan Delta



Groundwater

Geology and Soils Data

The geology of the planning region is displayed in Plate 21. The rocks that crop out in the planning area range in age from Precambrian to Recent. Appendix O contains a list and a figure of the stratigraphic units, along with their thickness, distribution and physical properties. Sedimentary rocks underlie most of the planning area. Igneous rocks found in stocks, sills, dikes and laccoliths of the Tertiary age crop out in many places in the planning area and are especially abundant in the western portion.[70 above]

The aquifers identified by the USGS[79,80,81,82] are displayed on Plate 22 with the area of each major and minor aquifer. Recharge and discharge areas are shown on Plate 23. Table 27 shows the estimates of stored groundwater up to 100-feet below the water table in each of the groundwater basins. Millions of AF are stored in each of the groundwater basins, totaling 88 million AF for the region. The present water table and the historic fluctuation in water levels at selected wells are shown on Plate 24. The large stored resource is planned for use by domestic and stock wells for the foreseeable future. It is available to other uses only if the associated depletion of interrelated streams is offset.

Yield from Aquifer Storage

Well yield from aquifer storage is water removed from the aquifer that causes drawdown of the water table or potentiometric head. The most heavily used aquifer in the planning area is the Roswell artesian aquifer (see Plate 22). Saleem and Jacob[83] estimate that the Roswell Basin has yielded approximately six million AF from aquifer storage. Net aquifer yield from storage in the Carlsbad Basin is near 3500 AFY. Net yield from aquifer storage in other groundwater basins in the planning area is negligible.

Replenishment of aquifer storage is water that refills the aquifer and causes the water table or potentiometric head to rise. Water to refill the aquifer necessarily flows

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[79] Robson, S.G. and Banta, E.R., 1995, Ground Water Atlas of the united States, Arizona, Colorado, New Mexico and Utah: U.S. Geological Survey Hydrologic Investigations Atlas 730-C, http/capp.water.usgs.gov/gwa/ch_c/index.html.

[80] Welder, G.E., 1983, Geohydrologic Framework of the Roswell Ground-Water Basin, Chaves and Eddy Counties, New Mexico: New Mexico Office of the State Engineer, Technical Report 42.

[81] Richey, S.F., Wells, J.G. and Stephens, K.T., 1985, Geohydrology of the Delaware Basin and Vicinity, Texas and New Mexico: U.S. Geological Survey Water Resources Investigations Report 84-4077.

[82] Green, G.N. and Jones, G.E., 1997, Digital Geologic Map of New Mexico: U.S. Geological Survey, Open-File Report 97-0052, in ARC/INFO format.

[83] Saleem, Z. A., and Jacob, C. E., 1971, Dynamic Programming Model and Quantitative Analysis, Roswell Basin, New Mexico: Water Resources Research Institute in cooperation with New Mexico Institute of Mining and Technology.

from other sources in the basin and is therefore counted as an outflow from the basin. Replenishment of aquifer storage was estimated by BGW based on the magnitude of water level recovery in the 1980s and 1990s. About 30 feet of recovery from 80 feet of drawdown has been seen in the last 20 years. The proportional recovery from six million AF is over two million AF.

Fort Sumner Groundwater Basin

Hydrogeology

The general stratigraphy of the Fort Sumner Groundwater Basin is shown in Figure 14[84]. The thickness, yield and quality of water for each formation are summarized in Table 28.[85]

In general, the highest yield and quality of water comes from the Santa Rosa Formation and the alluvium and terrace deposits. The potential yield of the San Andres Formation is generally unknown in the basin because the formation is too deep and the water quality too low to produce water economically. Water in the San Andres, Artesia and Chinle Formations is of poor quality due to the presence of soluble gypsum and other salts and water is produced at a very low rate.

Water Use

The primary use of groundwater in the Fort Sumner Groundwater Basin is farmland irrigation. Major irrigated areas lie east of Sumner Lake and southwest of Fort Sumner. Some irrigation also takes place south of Taiban. Fort Sumner's municipal water system, located in the center of the basin, relies on groundwater to supply the city and surrounding rural areas with water. Additionally, there are numerous domestic and livestock groundwater wells scattered throughout the basin. Irrigated vegetation is displayed on Plate 17.

Records taken from a 1996 annual report by the OSE indicate that groundwater rights in the Fort Sumner Basin total 45,063 AF. The report also states that 41,642 AF of water was pumped from groundwater aquifers in 1996.[86]

[84] National Resources Planning Board, 1942, Pecos River Joint Investigation: Reports of the Participating Agencies.
[85] Mourant, W.A. and Shomaker, J.W., 1970, Reconnaissance of Water Resources of De Baca County, New Mexico: Groundwater Report 10.
[86] New Mexico Office of the State Engineer, 1996 Annual Report of Water Use for the Pecos River Drainage.

Table 27. Estimates of Groundwater in the Planning Area

Basin	Aquifer	Area (acres)	Porosity	Reference	Stored volume to 100 feet below water table
Fort Sumner	High Plains aquifer	54,327	0.35	1	1,901,457
Fort Sumner	Roswell artesian aquifer	3576	0.05	2	17,880
Fort Sumner	Shallow alluvium	93,875	0.40	3	3,754,986
Fort Sumner	No principal aquifer / consolidated sediments	1,507,596	0.02	4	3,015,192
				Total	**12,566,097**
Roswell	Capitan Reef aquifer	13,068	0.05	5	65,340
Roswell	High Plains aquifer	31,754	0.35	1	1,111,381
Roswell	Roswell artesian aquifer	1,602,669	0.05	2	8,013,343
Roswell	Roswell shallow aquifer	502,796	0.2	6	10,055,916
Roswell	Shallow alluvium	453,930	0.40	3	18,157,204
Roswell	No principal aquifer / consolidated sediments	4,779,341	0.02	4	9,558,683
				Total	**59,527,964**
Hondo	No principal aquifer / consolidated sediments	662,801	0.02	4	1,325,601
Rio Peñasco	No principal aquifer / consolidated sediments	580,373	0.02	4	1,160,746
Carlsbad	Capitan Reef aquifer	300,144	0.05	5	1,500,720
Carlsbad	Pecos River Basin alluvial aquifer	103,061	0.35	7	3,607,147
Carlsbad	Roswell artesian aquifer	29,816	0.05	2	149,081
Carlsbad	Roswell shallow aquifer	5607	0.2	6	112,148
Carlsbad	Shallow alluvium	146,368	0.40	3	5,854,716
Carlsbad	No principal aquifer / consolidated sediments	671,142	0.02	4	1,342,285
				Total	**12,566,097**
Capitan	Capitan Reef aquifer	148,757	0.05	5	743,786
Capitan	Shallow alluvium	11,393	0.40	3	455,707
Capitan	No principal aquifer / consolidated sediments	135,805	0.02	4	271,610
				Total	**1,471,103**
				Grand Total	**88,617,608**

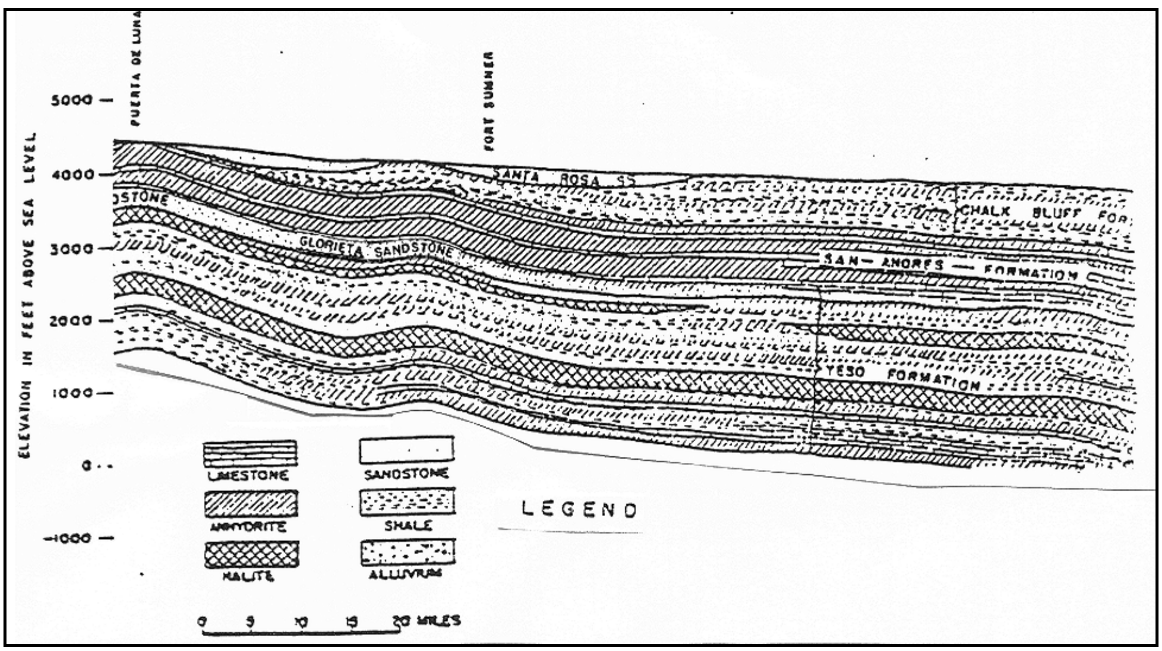
1. Summers, W. K., 1972, Geology and Regional Hydrology of the Pecos River Basin, p. 152 (Ogallala Formation)
2. Havenor, K. C., 1968, Structure, stratigraphy and hydrogeology of the northern Roswell Artesian Basin, NM Inst. Mining and Tech. Mineral Resources Circ. 93, 26 p. (Approx. average porosity of 291 samples of San Andres limestone)
3. W.K. Summers, 1972 Geology and Regional Hydrology of the Pecos River Basin, p. 152 (Surficial deposits overlying Ogallala Formation)
4. Freeze, D.A. and Cherry, J.A., 1979, Groundwater: Prentice Hall, (Consolidated sedimentary clastic rock)
5. Assume same as Roswell artesian aquifer
6. Assume same material and porosity as High Plains aquifer
7. Composed of alluvium and partially decomposed sedimentary rock. Average value of 0.35 assumed.

Table 28. Fort Sumner Groundwater Basin Hydrogeology

Geologic Unit	Thickness (ft)	Water Yield (gpm)	Water Quality
Alluvium and terraces	0 - 500	Up to 1300	Fair
Chinle Shale	0 - 1000	Small quantities	Fair
Santa Rosa Sandstone	0 - 380	15 - on occasion up to 1000	Good
Artesia Group	0 - 100	10 or less	Poor
San Andres Formation	0 - 1500	Unknown	Poor
Glorieta Sandstone	0 - 160	10-20	Poor

Comparisons of records of water levels taken from various wells pumping from the primary aquifers in the basin, annual records for average groundwater pumping and records of groundwater rights indicate that the water table has stabilized. However, additional data is needed to confirm this conclusion. If the water table of the basin remains stable, it can continue to sustain an annual yield between 40,000 and 45,000 AF.

Figure 14. Geologic Section Through Fort Sumner



The estimated sustainable annual yield of 45,000 AF will fluctuate with weather conditions. For example, extended periods of drought will cause the water table to decline, while extended wet periods will cause it to rise.

Historical Water Table Declines

The USGS has monitored water levels in selected wells in the basin for many years. A report published in 1995 compiles data for 175 wells used as a primary water source.[87] Between 1964 and 1990 (27 years) the highest and lowest water elevation levels were recorded for each of 175 wells. Of these wells, 94 experienced higher elevations of water in the early part of the 27-year period, while 85 show a higher elevation of water in the latter part of the period.

A hydrograph for one well in the basin shows that the static water level declined from 1974 to 1984. From 1984 to 1993, however, the static water level rose. Hydrographs for two other wells in the basin show strong declines in the water level until about 1985. From 1985 to 1990 the water level has been stable or has declined slightly. Selected well hydrographs are shown on Plate 24.

Aquifer Resource

Based on aquifer extent and an assumed specific yield ranging from two to 40 percent, about 13 million AF is the stored volume in the top 100 feet below the water table (Table 27). The stable water levels at the current pattern of use suggest most of the production is derived from the interrelated Pecos River.

Roswell Groundwater Basin

Hydrogeology

A geologic cross-section in the Roswell Groundwater Basin is shown in Figure 15.[79 above] A summary of the hydrogeology and water quality of the basin is shown in Table 29.[16 above]

The highest yield of good-quality water comes from the San Andres Formation, the Artesia Group and the alluvium and terrace deposits. The San Andres Formation contains water high in salt that is unpotable east of the Pecos River. The San Andres forms the main reservoir of the artesian aquifer and is overlain by the Artesia Group, which is the upper confining layer for the artesian aquifer.

The alluvium and terrace deposits form a belt 12 to 30 miles wide and 60 to 70 miles long west of the Pecos River. The depth-to-water ranges from zero to ten feet near the river to 100 feet on the western edge of the alluvium. Major and minor aquifers are shown on Plate 22.

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[87] Wilkins, D.W. and Garcia, B.M., 1995, Ground Water Hydrographs and 5 Year Ground-Water Level Changes, 1984-93 for Selected Areas in and adjacent to New Mexico: U.S. Geological Survey Open-File Report 95-434.

Water Use

The primary use of groundwater in the basin is irrigated farmland. The most heavily irrigated areas occur from Roswell south to the Seven Rivers area in Eddy County. In addition to agricultural uses, water withdrawn from both the artesian and shallow aquifer in this area support almost all uses including municipal and industrial. Other areas of concentrated use within the basin occur north of Roswell in the Macho Creek area. Irrigated areas are shown on Plates 15, 16, 18 and 19.

The 1999 annual water use report from the OSE and the Roswell Basin Watermaster indicate that approximately 343,694 AF of groundwater was pumped from the basin during 1996.[87 above]

Figure 15. Geologic Section Through Roswell

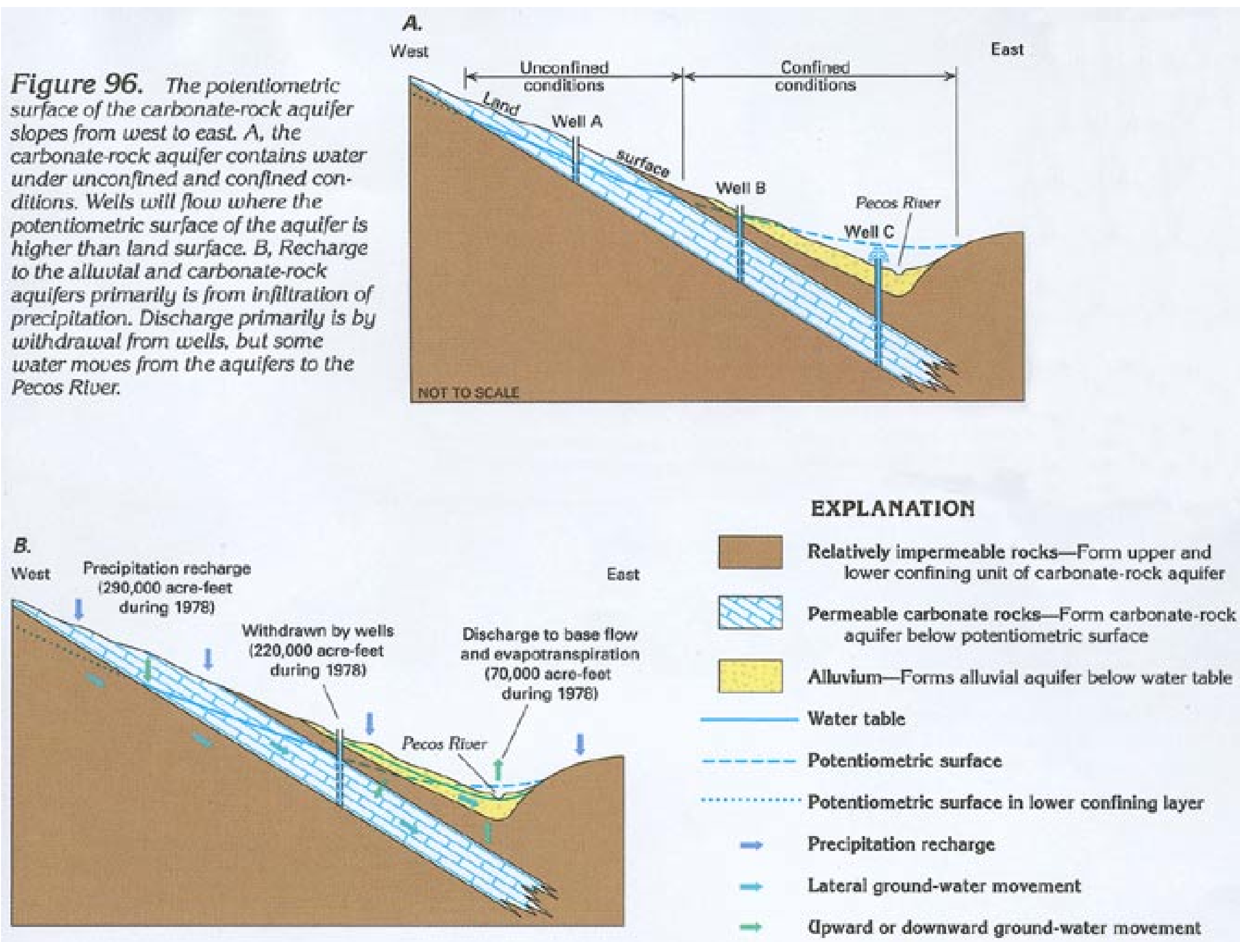


Table 29. Roswell Groundwater Basin Hydrogeology

Geologic Unit	Thickness (ft)	Water Yield (gpm)	Water Quality
Alluvium and terraces	Up to 350	2 – 3500	Poor – Good
Artesia Group	1,000+	5 – 2000	Good
San Andres Formation	1000 – 2000	8 – 5000	Poor – Good
Glorieta Sandstone	0 – 160	Up to 700	Good
Yeso Formation	1000 – 2000	1 –125	Poor – Fair

The highest period of use since well metering began in 1967 was from 1972 to 1976. Average use at that time was 406,451 AFY. It is worth noting that this period of high use coincides with the time when water table levels were rising.

With approximately 426,435 AF of active water rights and estimated pumpage only slightly less, it appears that the water supply in the basin can sustain an annual yield near 400,000 AFY from Roswell Basin aquifers under present conditions.

Historical Water Table Declines

During a period from 1938 to 1960, the water level in wells completed in the shallow and artesian aquifers declined from ten to 80 feet. In an effort to stabilize the water table, a number of actions were taken by the OSE, the PVACD and other entities. Water rights were adjudicated, wells were metered, conservation measures were taken and several thousand acres of irrigated farmland were retired. These actions resulted in a stabilized water table.[88] Records maintained by the USGS indicate the water table is currently rising. Part of the rise is related to the 1980s wet period.

The USGS monitors 303 wells in the shallow aquifer and 231 wells in the artesian aquifer within the basin. All of the 303 wells developed in the shallow aquifer derive their primary water supply from the alluvium deposits. From 1984 to 1989, 265 of these wells exhibited a rise in water level ranging from 0.01 to 34.47 feet. The remaining 38 wells experienced a decline in water level ranging from 0.06 to 14.97 feet.[87 above]

Hydrographs for selected wells in the basin (Plate 24) show a decline in the water level from 1940 to 1965. From 1965 to 1975 the water level stabilizes, then rises between 1975 and 1990.[64 above]

[88] Hudson, J.P. and Borton, R.L., 1974, Groundwater Levels in New Mexico, 1970, and Changes in Water Levels, 1966 – 1970: New Mexico Office of the State Engineer Technical Report 39.

The PVACD has maintained ten monitoring wells for many years. Records from the period between 1986 and 1996 indicate an average rise in the water level of at least one foot per year.

Aquifer Resource

Based on aquifer extent and an assumed specific yield ranging from two to 40 percent, about 60 million AF is the stored volume in the top 100 feet below the water table in the Roswell Basin (Table 27). The stable water levels at the current pattern of use suggests most of the wellfield production captures water seeping toward the interrelated Pecos River.

Hondo Groundwater Basin

Hydrogeology

Table 30 summarizes the hydrogeology and water quality in the Hondo Groundwater Basin.[21 above]

The San Andres Formation and alluvium deposits produce the highest yield of good-quality water in the basin. Water for these aquifers is used for domestic, municipal, livestock and irrigation purposes. The Glorieta Sandstone also produces water at a yield and quality suitable for irrigation in some areas. Most of the other formations in the basin generally yield water at a rate suitable only for domestic or livestock uses, except the Mancos Shale and Mesaverde Formations, whose waters are generally too poor for any use but livestock.[21 above]

Table 30. Hondo Groundwater Basin Hydrogeology

Geologic Unit	Thickness (ft)	Water Yield (gpm)	Water Quality
Alluvium	0 – 210	10 – 3500	Fair – Good
Cub Mountain Formation	0 – 500	5 – 50	Fair
Mesaverde Formation	0 – 540	5 – 20	Poor
Mancos Shale	0 – 400	6 – 75	Poor
Dakota Sandstone	0 – 130	5 – 125	Fair
Chinle Shale	0 – 180	5	Fair
Santa Rosa Sandstone	0 – 380	10	Fair
Artesia Group	0 – 450	10	Poor – Fair
San Andres Formation	0 – 1200	8 – 2000	Good
Glorieta Sandstone	0 – 160	2 –700	Good
Yeso Formation	1000 – 2000	1 – 125	Poor – Fair

Water Use

The agricultural sector in the Hondo Groundwater Basin relies on groundwater from wells to supplement surface-water flows. In some farming areas groundwater serves as the primary source of water for irrigation. The fastest growing use of groundwater is the development of wells for domestic use in and around the Villages of Capitan and Ruidoso. As new subdivisions are developed, the number of privately owned and operated groundwater wells increases, thus increasing the demand placed on groundwater resources in the basin. Irrigated areas are shown on Plates 14 and 15.

In 1996 the OSE reported 15,694 AF of groundwater rights in the basin. Included in these rights are supplemental groundwater rights. Due to their nature, supplemental rights create erratic use patterns, since they are only called upon when surface-water supplies are inadequate to meet users' needs.[86 above]

The OSE also reported 1996 groundwater pumping at 12,086 AF. This suggests full use of supplemental irrigation water rights, as well as full use of the majority of other recorded water rights.

Historical Water Table Declines

A report prepared by the USGS documents monitoring of 56 wells in the basin.[87 above] During the period 1985 through the winter of 1989-90, records indicate an increase in the water levels of 38 wells ranging from 0.02 to 9.40 feet. A decline in water levels ranging from 0.04 to 5.78 feet was observed for 18 of the wells.

The 56 wells in the basin were developed in seven different geologic formations. The majority of the wells were developed in alluvium deposits and display unstable water levels. Half of the wells in the alluvium show increased water levels, while the remaining half show a decrease. Hydrographs for selected wells are shown in Plate 24.

Aquifer Resource

Based on aquifer extent and an assumed specific yield of two percent, about 1.3 million AF is the stored volume in the top 100 feet below the water table (Table 27). The stable water levels at the current pattern of use suggests most of the production is derived from interrelated surface streams in the basin.

Peñasco Groundwater Basin

Hydrogeology

Figure 16 shows a geologic cross-section through the Peñasco Groundwater Basin.[84 above] Table 31 outlines the hydrogeology and water quality of the basin.[70 above]

Like the Hondo Groundwater Basin, the highest yield of good-quality water in the Peñasco Basin comes from the San Andres Formation and the alluvium deposits. The Glorieta Sandstone also yields water of sufficient quantity and quality for irrigation. Most other formations yield water in either insufficient quantity or insufficient quality to be used for anything but domestic or livestock purposes.

Water Use

The most intensive use of groundwater in the basin occurs along the river valleys where irrigated agriculture has been developed (Plates 14 and 16). Many of the wells in this area supplement surface waters. Extensive development of residential subdivisions has taken place in the basin. These developments rely primarily on individual wells that withdraw water from aquifers.

Figure 16. Geologic Section Through Hope

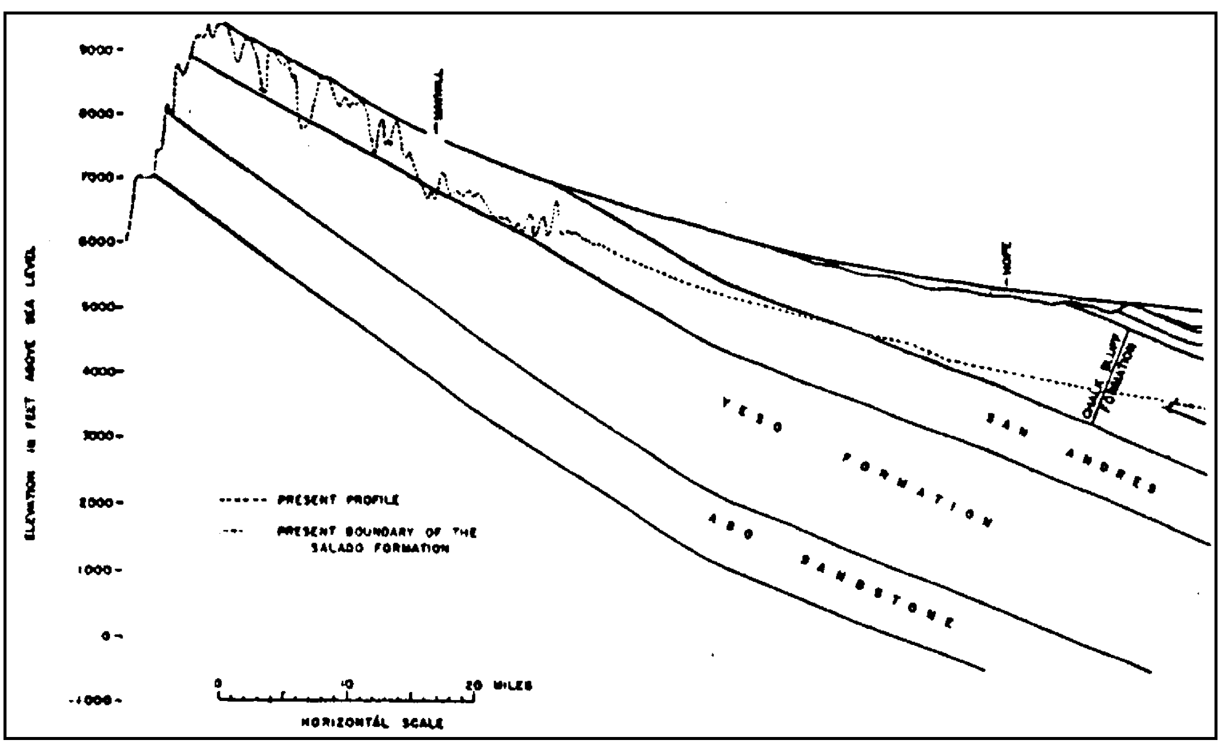


Table 31. Peñasco Groundwater Basin Hydrogeology

Geologic Unit	Thickness (ft)	Water Yield (gpm)	Water Quality
Alluvium	0 – 210	10 – 3500	Fair – Good
Cub Mountain Formation	0 – 500	5 – 50	Good
Mesaverde Formation	0 – 450	5 – 20	Poor – Fair
Mancos Shale	0 – 400	6 – 75	Poor
Dakota Sandstone	0 – 130	5 – 125	Fair
Chinle Shale	0 – 180	5	Fair
Santa Rosa Sandstone	0 – 380	10	Fair
Artesia Group	0 – 450	10	Poor – Good
San Andres Formation	0 – 1200	8 – 2000	Good
Glorieta Sandstone	0 – 160	2 – 700	Good
Yeso Formation	1000 – 2000	1 – 125	Poor

Records taken from a 1996 annual report by the OSE indicate the basin has 5416 AF of groundwater rights. In 1996 an estimated 5852 AF of water was pumped from the groundwater aquifers in the basin.[86 above]

Based on monitoring well records and pumping and water-rights data, water levels are rising in the basin in spite of groundwater pumping. Water-level data for the period 1990 through 1998 is needed to verify this observation. If additional data indicates that the water table has continued to rise, we may assume that groundwater can support a sustained yield in excess of the 5800 AF in this basin.

Historical Water Table Declines

Records for the last 35 years indicate that the water table has declined slightly in this basin. Water table levels fluctuate directly in response to weather patterns and agricultural use.[88 above]

A report prepared by the USGS documents monitoring of 32 wells in the basin.[87 above] Of these wells, 18 were developed in the Yeso Formation. The remaining 14 were developed in alluvium deposits. During the period from 1954 to 1989, water level extremes were detected in the 32 wells. In 25 of the wells, the high water level extremes occurred during the latter part of test period. The remaining seven wells experienced a low water level extreme during the latter part of the period. During the period from 1984 to 1989, 30 of the 32 wells experienced a rise in the water level of 0.01 to 81.40 feet. Two wells exhibited a decline in water level that ranged from 6.56 to 16.34 feet.

Aquifer Resource

Based on aquifer extent and an assumed specific yield of two percent, about 1.2 million AF is stored in the top 100 feet below the water table (Table 27). The stable water levels at the current pattern of use suggests most of the production is derived from interrelated surface streams in the basin.

Carlsbad Groundwater Basin

Hydrogeology

A geological cross-section through a portion of the Carlsbad Groundwater Basin is shown in Figure 17.[84 above] A summary of the hydrogeology and water quality is provided in Table 32.[29 above]

The highest yield of good-quality water comes from the Delaware Mountain Group, the Carlsbad and Capitan Limestones and the alluvium deposits. East of the City of Carlsbad, however, the quality of water in the Capitan and Carlsbad Limestones is poor. The Castile Formation crops out in a broad belt south and southeast of the Black River where it is an important source of water to many stock and domestic wells. The Rustler Formation produces water generally high in chloride and sulfate, but is an important source of water for the potash mines and small-scale irrigation near Carlsbad. Most other formations in the basin tend to produce water at a yield or quality too low for uses other than livestock or domestic.

A number of productive springs discharge groundwater in the basin. The Bell Canyon Formation of the Delaware Mountain Group produces water from springs at the base of the Guadalupe Mountains at a rate of up to 6700 gpm. Flows of 3500 gpm have been recorded at Carlsbad Springs issuing from the Carlsbad and Capitan Limestones. Several springs also discharge water from the Castile Formation near the base of the Guadalupe Mountains.[29 above]

Water Use

Major uses of water from the basin in the planning area occur in a band west of the Pecos River, approximately eight-miles wide, from La Huerta north of Carlsbad, to the Willow Lake area south of Malaga (Plate 20). Within the area large quantities of water are used for agriculture purposes. The City of Carlsbad obtains its water supply from the Capitan Limestone from wells located southwest of Carlsbad. The potash mines use water from the basin, as do the gas and oil industry. Scattered developments of water exist throughout the basin.

Figure 17. Geologic Section Through Carlsbad

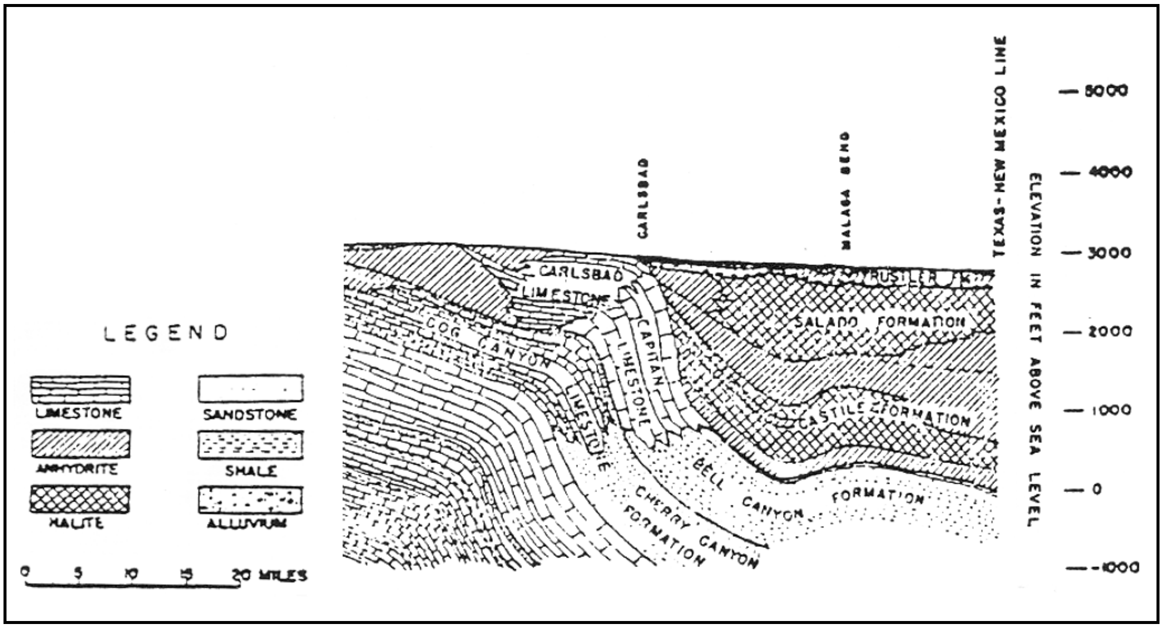


Table 32. Carlsbad Groundwater Basin Hydrogeology

Geologic Unit	Thickness (ft)	Water Yield (gpm)	Water Quality
Alluvium	0 – 500	2 – 3500	Poor – Good
Dockum Group	200 – 1000	1 – 750	Fair
Rustler Formation	200 – 500	10 – 300	Poor
Castile Formation	0 – 2500	5 – 50	Poor – Good
Carlsbad & Capitan Limestone	1000 – 1500	Up to 3500	Good
Delaware Mountain Group	0 – 1000	Up to 6500	Good
Bone Spring Formation	--	1 – 15	--

A 1996 annual report by the OSE reports that 93,497 AF of water rights are recorded or permitted in the basin. The same report lists 1996 groundwater pumpage at 23,494 AF. Therefore, pumpage for 1996 totaled approximately one-fourth the existing water rights in the basin.[86 above]

Based on the recent general rise in water levels throughout the basin described in the following section, it can be assumed that the groundwater aquifers can sustain an annual yield of at least 25,000 AF. Within the basin, 47,032 AF of the total 93,497 AF of water rights are listed as supplemental to surface-water rights. These supplemental water rights have not been used for several years. The groundwater aquifers may be able to sustain the entire 93,497 AF for short periods and recover without impairing groundwater supplies. Additional well data gathered from 1991 through 1997 should be compared to the 1996 through 1997 water-use levels in order to gain a more accurate picture of water use and its effect on groundwater resources in the basin.

Historical Water Table Declines

Water tables in the alluvial deposits south of Carlsbad decline as much as 40 feet during periods of heavy use. However, the water table recharges quickly from the river and other surface-water sources. From 1991 through 1995, three AF per acre or more of water was allocated to irrigators by the CID. During this time supplemental wells were not used and the water table rose as a result. The Capitan Reef aquifer has shown only a slight historical decline and tends to recover quickly when precipitation and runoff are adequate.[88 above]

A 1995 report by the USGS compiled data on 115 wells in the basin. Of these wells, 84 were developed in the alluvial deposits or shallow-water aquifer, while 31 wells were developed in six other formations in the Capitan Reef area.

During the winter periods of 1987-88 to 1993, a decline in water levels was observed for 45 of the wells developed in the alluvial deposits, while water levels rose in 35 wells and remained stable in four wells. The water table declined up to 8.51 feet and rose as much as 23.68 feet.

During the same period of time, 20 of the 31 wells developed in the Capitan Reef area experienced a decline, eight wells experienced an increase and three wells experienced no change in water level. Water level declined up to 5.51 feet and rose as much as 5.60 feet.

Hydrographs for six wells in the basin display water levels between 1984 and 1993. Three of the hydrographs are from wells developed in the alluvium deposits and show an inconsistent pattern in water level. One presents a fairly stable water level, one indicates a sharp rise beginning around 1978 and the third shows a decline followed by a rise in the water table. The other three hydrographs are from wells developed in the Capitan Reef Formation and indicate a stable long-term water level, though short-term fluctuations were quite high.[87 above] Hydrographs from selected wells in the basin are shown in Plate 24.

Aquifer Resource

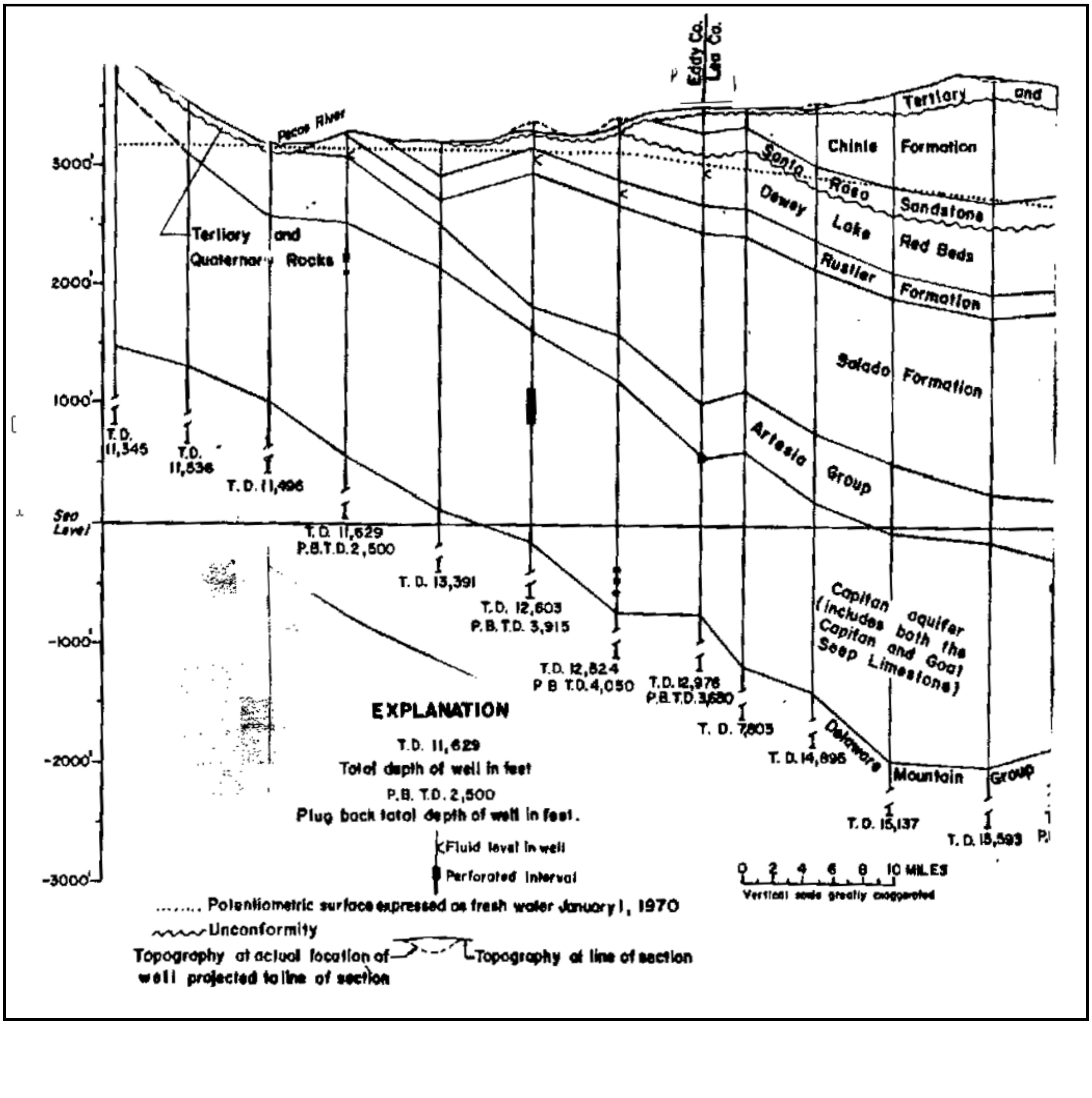
Based on aquifer extent and an assumed specific yield ranging from two to 40 percent, about 13 million AF is stored in the top 100 feet below the water table in the basin (Table 27). The stable water levels at the current pattern of use suggests most of the production is derived from the interrelated Pecos River.

Capitan Groundwater Basin

Hydrogeology

A geologic cross-section through part of the Capitan Groundwater Basin is shown in Figure 18.[84 above] Table 33 summarizes the hydrogeology and water quality in the basin.[29 above, 89]

Figure 18. Geologic Section Through Pecos River



[89] Haigler, L., 1962, Geological Notes on the Delaware Basin: New Mexico Bureau of Mines & Mineral Resources, New Mexico Institute of Mining & Technology Circular 63.

Table 33. Capitan Groundwater Basin Hydrogeology

Geologic Unit	Thickness (ft)	Water Yield (gpm)	Water Quality
Alluvium	0 - 350	2 - 3500	Poor - Good
Chinle Shale	0 - 1000	5	Poor - Good
Santa Rosa Sandstone	0 - 380	1 - 750	Fair - Good
Rustler Formation	0 - 500	10	Poor - Fair
Castile Formation	0 - 2500	5 - 10	Poor - Fair
Artesia Group	125 - 475	5 - 150	Poor - Good
Capitan Limestone	1000 - 2000	0 - 2500	Poor
Delaware Mountain Group	0 - 1000	Unknown	Very Poor
San Andres Formation	0 - 1500	0 - 2000	Poor
Yeso Formation	1000 - 2000	0 - 125	Poor – Fair

The highest yielding formations in this basin are the San Andres Formation, the Capitan Limestone and the alluvium deposits. Of these, only the alluvium produces good-quality water. Water in the San Andres and Capitan is poor and used for livestock, mining and oil and gas purposes. Most other formations produce water of variable quality that is used for livestock, domestic and oil and gas purposes.

Water Use

With no developed agriculture there are no concentrated areas of groundwater use in the basin. The largest quantities of water are dedicated to potash mining and the oil and gas industry. Domestic and livestock uses are scattered throughout the basin.

Historical Water Table Decline

Since water levels in the basin are directly linked to water-bearing formations in other groundwater basins, the water table will decline according to groundwater use in adjacent basins. This is especially true with the Capitan Reef Formation due to its high hydraulic conductivity. The water table in the basin declined as much as 35 feet when it was first developed, but has stabilized in recent years.[88 above]

Aquifer Resource

Based on aquifer extent and an assumed specific yield ranging from two to 40 percent, about 1.5 million AF is stored in the top 100 feet below the water table in the Capitan Groundwater Basin (Table 27).

Natural Variability in Water Supply

Hydrologic systems display considerable variability in the amount of precipitation, and therefore the associated amount of surface runoff. In the planning area, the major sources of water supply affected by natural variability are inflow to the Pecos River and annual precipitation and evaporation rates. Groundwater is relatively stable compared to surface water. In some aquifers with high transmissivity and strong recharge areas, such as the Capitan Aquifer in the Carlsbad Groundwater Basin, variations in precipitation have an almost immediate affect on the water level.

In the western United States, the natural variability in runoff promoted the creation of the priority system of water rights. In wet years, most or all rights are satisfied. In dry years, only the most senior rights are satisfied. Junior rights holders in the planning area have overcome this limitation to some degree by drilling supplemental wells to furnish water during dry years and by building reservoirs to capture peak storm flow for use during the growing season. The use of supplemental wells may infringe on senior rights if they influence a stream in a shallow aquifer closely related to the stream. Variability is managed by enforcing priority or by providing a leveling mechanism such as stored surface and ground resources to overcome variability within the limits of long-term average basin yield.

Figure 19 displays the reconstructed Drought Index for 300 years. The drought of the 1950s was significantly worse than any other drought in 300 years according to indexes developed from measurements and tree-ring data. Such a severe degree of drought is not expected to be repeated in the 40-year planning horizon.

Table 34 shows the statistics of representative precipitation stations and the Pecos River flow. The standard deviation of annual precipitation (shown at the end of Table 34) ranges from 23 to 43 percent of the annual averages. The standard deviation of Pecos River discharge near Artesia is almost 100 percent of the average value.

Table 35 shows the variable precipitation in Roswell and Pecos River runoff near Acme and Rio Ruidoso runoff at Hollywood in the driest and wettest one in five years, the median year and extreme years.[90] The Pecos River runoff in the driest one in five years is 74 percent of the median runoff and the wettest one in five years is 146 percent of the median. The driest one in five years of precipitation at Roswell is 71 percent of the median and the wettest one in five years is 139 percent of the median. Precipitation varies in location throughout the planning area, as well as in time.

The aquifer of the Roswell Basin has been used successfully to maintain relatively constant levels of use according to the basin watermaster. Well withdrawals

[90] U.S. Geological Survey, 2000, http://www.usgs.gov.

typically vary 15 percent from the average 349,000 AFY since watermaster administration began in 1967.[64 above]

Figure 19. Palmer Drought Index for the Lower Pecos Valley

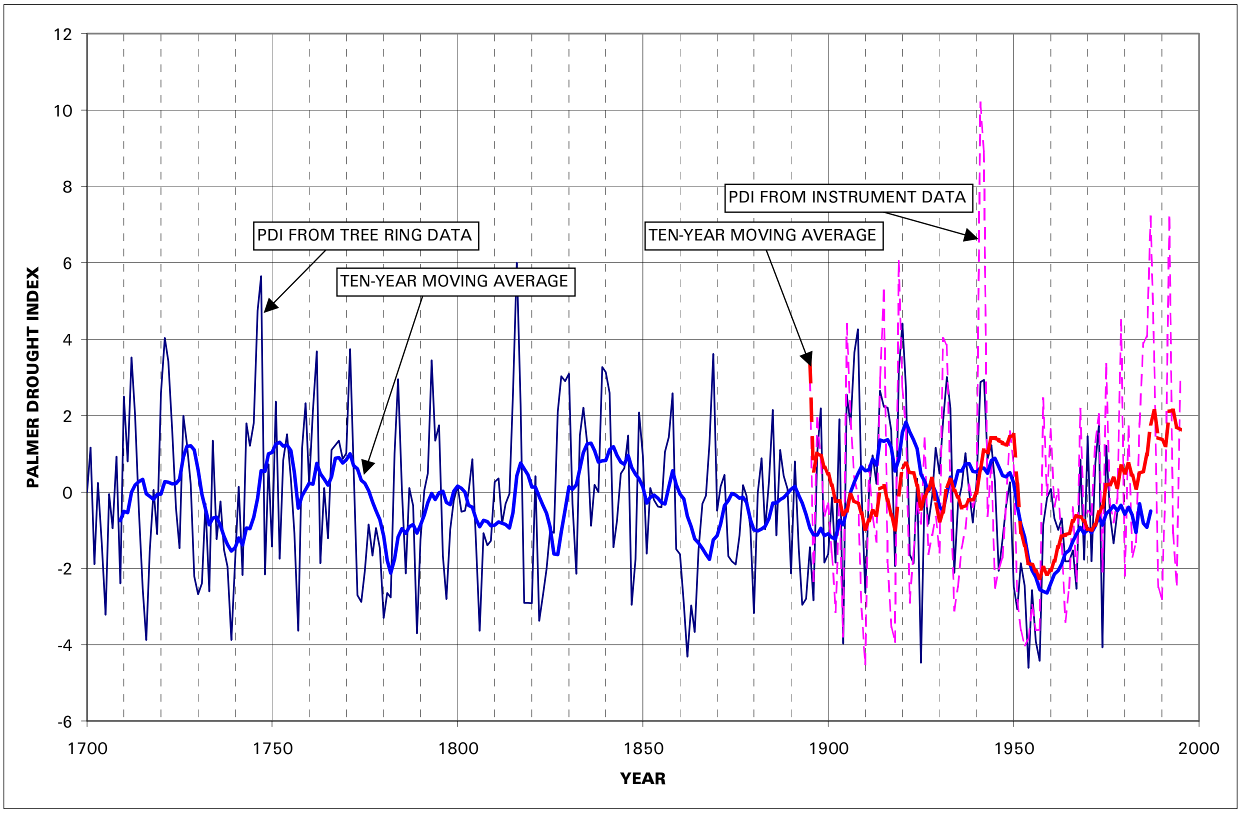


Table 34. Precipitation Records in the Planning Area

Year	Precipitation (in)					Discharge (thousands of AFY)
	Roswell	Cloudcroft	Carlsbad	Central Highlands	SE Plains	Pecos River near Artesia
1900	19.80					
1901	17.84		8.68			
1902	16.58		22.42			
1903	8.17	16.63	8.05			
1904	14.05	22.94	18.10			
1905	19.23	32.32	21.87			
1906	15.21	28.68	20.86			
1907	13.43	31.26	15.82			
1908	9.62	17.39	13.58			
1909	7.69	18.97	8.08			
1910	4.87	15.89	3.95			
1911	16.37	20.41	16.82			
1912	12.90	22.89	12.68			
1913	13.77	18.45	15.33			
1914	15.45	23.15	19.04			
1915	16.16	26.28	18.57			
1916	16.82	27.42	19.87			
1917	6.21	15.01	5.73			
1918	9.18	28.52	7.86			
1919	22.69	31.00	19.10			
1920	12.58	24.47	14.74			
1921	11.67	19.76	9.72			
1922	6.57	16.60	11.15			
1923	20.04	29.22	14.87			
1924	5.77	16.98	2.95			
1925	11.53	24.09	9.69			
1926	14.79	31.78	16.11			
1927	4.83	29.79	3.85			
1928	15.04	25.99	13.81			
1929	12.38	24.85	12.32			
1930	10.47	25.81	10.45			
1931	14.42	42.32	13.88	24.0	17.2	278.2
1932	18.83	35.54	18.13	20.5	19.5	363.1
1933	8.79	22.74	9.61	15.3	10.5	160.9
1934	6.96	17.15	6.79	9.5	7.8	100.2
1935	10.54	20.68	14.01	17.2	13.0	190.5
1936	11.82	27.50	11.99	17.5	11.8	201.4
1937	13.45	27.16	11.91	17.0	13.6	562.8

Table 34. Precipitation Records in the Planning Area (continued)

Year	Precipitation (in)					Discharge (thousands of AFY)
	Roswell	Cloudcroft	Carlsbad	Central Highlands	SE Plains	Pecos River near Artesia
1938	9.08	25.99	12.60	15.5	12.7	175.4
1939	12.81	24.56	7.89	17.7	13.2	189.7
1940	14.09	24.51	12.30	18.0	14.0	179.8
1941	32.92	48.10	33.94	31.0	35.3	1351.0
1942	14.77	31.89	17.50	20.3	17.0	511.7
1943	8.78	24.85	10.84	14.8	10.8	183.9
1944	11.35	25.54	14.86	15.8	14.0	155.8
1945	6.88	18.49	12.73	11.0	8.4	114.1
1946	11.62	20.15	11.72	16.8	13.5	146.0
1947	8.26		5.96	10.5	8.2	90.6
1948	9.30		10.73	13.3	10.6	127.7
1949	14.58	31.87	18.29	18.5	17.4	248.3
1950	17.02	21.00	12.72	13.5	12.5	191.5
1951	6.89	23.31	6.43	11.5	7.8	128.1
1952	8.64	22.68	5.06	14.0	8.5	106.6
1953	8.24	16.41	5.97	12.8	8.2	77.9
1954	10.18	19.83	10.18	13.8	11.7	239.7
1955	8.71	26.75	7.86	14.2	10.5	191.9
1956	4.35	16.48	4.40	8.6	6.5	96.4
1957	9.32	27.63	10.72	19.7	12.8	93.5
1958	13.06	37.80	20.96	22.0	19.2	244.8
1959	9.52	21.06	11.68	16.3	12.1	105.1
1960	13.57	23.05	16.56	16.0	18.5	224.6
1961	7.85	30.64	7.58	17.0	11.0	131.2
1962	11.81	28.47	13.06	15.6	13.1	123.5
1963	6.30	24.44	10.16	13.8	10.5	116.8
1964	6.98	21.33	3.95	12.2	6.8	44.1
1965	6.68	33.93	10.47	20.3	11.2	87.9
1966	9.68	24.53	13.83	13.7	13.5	141.0
1967	11.06	26.03	6.97	16.3	9.5	83.5
1968	15.84	27.09	15.30	16.0	15.5	91.2
1969	13.33	25.47	12.40	20.5	16.8	173.0
1970	8.63	11.00	8.09	11.7	9.8	100.0
1971	10.04	19.96	11.15	17.0	13.7	76.0
1972	16.24	32.65	18.74	21.5	18.8	148.5
1973	11.60	17.87	10.63	15.2	11.5	177.3
1974	18.65		23.11	19.5	19.3	143.7
1975	9.59		10.04	15.3	13.7	74.9
1976	11.55		11.26	14.9	12.4	71.9
1977	10.95		12.79	16.4	12.7	73.7
1978	18.25		23.33	21.8	19.7	106.9
1979	8.53		12.49	17.5	14.0	106.4

Table 34. Precipitation Records in the Planning Area (continued)

Year	Precipitation (in)					Discharge (thousands of AFY)
	Roswell	Cloudcroft	Carlsbad	Central Highlands	SE Plains	Pecos River near Artesia
1980	13.20	24.49	19.42	14.4	14.2	117.1
1981	24.33	29.17	15.32	17.0	17.8	65.6
1982	7.05	28.86	7.85	17.3	14.0	115.9
1983	10.03	29.23	10.67	17.8	11.0	131.4
1984	18.75	35.82	24.23	20.9	20.5	110.7
1985	14.54	35.96	12.56	22.0	17.1	132.5
1986	24.80	40.13	18.12	25.4	24.3	194.3
1987	16.20	22.62	15.68	19.4	16.0	227.3
1988	13.76	36.01	12.53	21.0	15.3	152.4
1989	6.08	26.71	5.99	13.4	10.0	107.5
1990	7.49	31.39	11.44	20.3	13.1	83.5
1991	21.06	39.24	23.66	23.0	20.2	193.8
1992	13.27	31.99	15.76	18.1	16.2	176.2
1993	10.35	33.91	8.01	17.1	11.2	154.3
1994	10.75	33.81	7.20	19.7	11.3	159.5
1995	8.45	25.17	7.45	14.3	11.1	168.3
1996		27.14		18.8	13.6	128.1
1997		31.46		23.7	20.9	160.1
1998		28.35				
1999		21.12				
Average	12.33	26.15	12.80	17.11	13.85	174.35
Std. Dev.	4.91	6.67	5.48	3.95	4.62	169.23

Table 35. Natural Variability in Rainfall and Streamflow

	Roswell		Pecos River Near Acme (08386000)		Rio Ruidoso at Hollywood (08387000)	
	Precip. (in)	Year	Mainstem Runoff (AF)	Year	Tributary Runoff (AF)	Year
Driest One in Five Years[1]	8.24	1953	79,658	1978	6750	1967
Median Year	11.60	1973	107,177	1996	11,947	1995
Wettest One in Five Years[2]	16.16	1915	156,534	1950	21,002	1973
Minimum	4.35	1956	40,984	1964	636	1953
Maximum	32.92	1941	876,432	1941	30,837	1985

[1] Twenty percent (one out of five) of measured years were dryer.
[2] Twenty percent (one out of five) of measured years were wetter.

Water Quality

Surface-Water Quality

The major water quality issue in the planning area is salinity. The surface waters of the Pecos River and its tributaries contain a number of naturally dissolved minerals that increase in concentration as the water moves downstream. The first major increase in salinity of the Pecos River is observed near Puerto de Luna. The last major influx of saline waters enters the Pecos River near Malaga Bend. As the river exits the state, water becomes saline enough to render it unusable for many purposes. Table 36 summarizes the water quality of the Pecos River at various stations.[91] Figure 20 shows the downstream trends of specific conductance in the Pecos River in 1955, 1970, 1980 and 1994. Water quality tends to degrade downstream as mineral concentrations (measured by specific conductance) increases. The increase is due partly to evapotranspiration of water by crops and phreatophytes, which removes only water and leaves dissolved minerals behind. The increase near Malaga Bend (above Red Bluff) is from highly mineralized springs discharging to the Pecos River. Over time water quality has fluctuated but does not show a general trend.

The New Mexico Water Quality Control Commission (NMWQCC) under authority of the New Mexico Water Quality Act of 1978, sets forth Water Quality Standards for Interstate and Intrastate Streams in New Mexico. The NMWQCC designates uses of certain stream reaches and the minimum water quality standards required to sustain existing uses.[92] The designated uses may include, depending on the reach, fisheries, livestock watering, wildlife habitat, irrigation, municipal water supply and others. Each of the designated uses has specific water-quality parameters that may not be exceeded by permitted discharges (usually municipal wastewater treatment facilities). The designated reaches of perennial streams in the planning area and their uses are shown in Plate 25. Surface-water quality is protected by establishing and maintaining controls on discharge of pollutants to surface waters. The New Mexico Environmental Department (NMED) is charged with the tasks of certifying discharge permits issued by the U.S. Environmental Protection Agency (EPA) under the National Pollutant Discharge Elimination System (NPDES), monitoring compliance of permit holders with standards set forth in the permit and conducting water-quality surveillance of the surface waters of the State. NPDES permitted discharges in the planning area are shown on Plate 25.

[91] Borland, J.P. and Ong, K., 1995, Water Resource Data New Mexico, Water Year 1994: U.S. Geological Survey Water-Data Report NM 94-1.
[92] New Mexico Water Quality Control Commission, 2000, State of New Mexico Standards for Interstate and Intrastate Surface Waters.

Groundwater Quality

The quality of groundwater in the planning area ranges from very high-quality water to water that is classified as brine and is unfit for most uses. Plate 26 displays the pattern of groundwater quality in the region and the general suitability for use. The mineral composition of the formation from which the water is drawn directly influences the mineralization of the water.

Sources of Contamination

Sources of pollution caused by man are small and localized within the planning area. Groundwater contamination from oil and gas activities has occurred in the Black River and Indian Basin areas. Streams have been contaminated with sewage effluent discharge from villages and towns and runoff from paved areas. Septic systems in rural subdivisions continue to be a concern, although no major instances of contamination have been reported.

Table 36. Pecos River Water Quality at Selected Locations

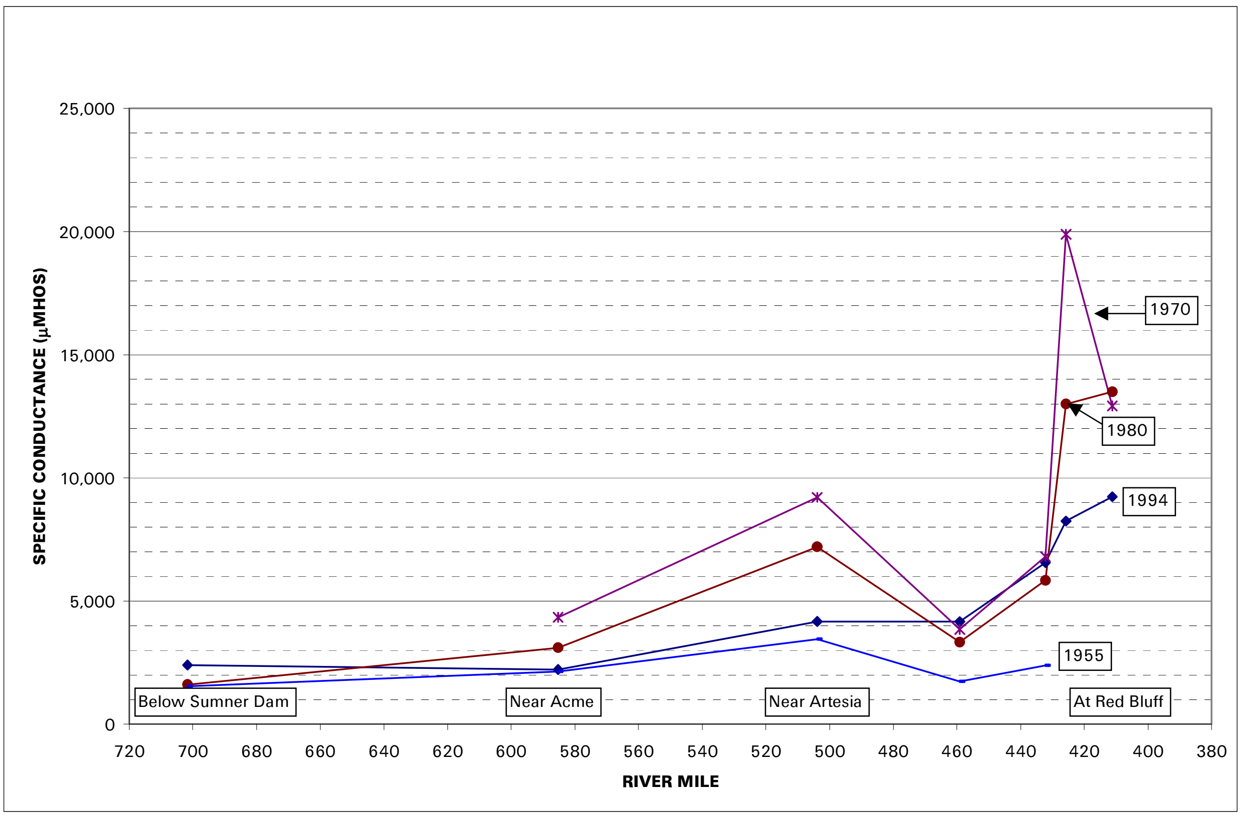
Year	TDS[1] (ppm) Conductance (micro μmhos) pH	Below Sumner Dam	Near Acme	Near Artesia	At Carlsbad	Near Malaga	At Pierce Can. Cross.	At Red Bluff
1955	TDS	986	1365	2208	1107	1530		
	Conductance	1540	2130	3450	1730	2390		
	pH	7.5	7.5	7.5	7.7	7.6		
1960	TDS	1133	1555	2246	1760	3245	4666	4890
	Conductance	1770	2430	3510	2750	5070	7290	7640
	pH	7.5	7.7	7.7	7.6	7.6		
1965	TDS	1178	1459	2156	1375	2539	5318	7488
	Conductance	1841	2279	3369	2148	3967	8310	11,700
	pH	7.6	7.6	7.5	7.5	7.6	7.5	7.4
1970	TDS		2778	5894	2464	4352	12730	8269
	Conductance		4340	9210	3850	6800	19,890	12,920
	pH		7.7	8	7.6	7.7	7.4	7.7
1975	TDS	1312	2457	4934	2374	3770	6323	8000
	Conductance	2050	3840	7710	3710	5890	9880	12,500
	pH		7.6	7.4	7.6	7.6	7.7	8.3
1980	TDS	1030	1984	4608	2131	3738	8320	8640
	Conductance	1610	3100	7200	3330	5840	13,000	13,500
	pH	8.2	8	8.2	8	8.2	8	8.3
1985	TDS	1408	2944	2848	2189	3712	6592	8832
	Conductance	2200	4600	4450	3420	5800	10,300	13,800
	pH	8	7.8	8.2	8.1	8.3	8.4	8.4
1994	TDS	1536	1421	2669	2662	4198	5280	5914
	Conductance	2400	2220	4170	4160	6560	8250	9240
	pH	8	8	8.1	8	7.8	8.1	8

[1] Total Dissolved Solids

The concentration of livestock in feeding operations and dairies can cause contamination from animal waste, either from percolation into groundwater or overland flows to surface water. The use of chemical fertilizers and pesticides in agricultural production, on home landscaping and by cities and other agencies can also cause contamination of surface water and groundwater.

The major contaminant of both surface water and groundwaters in the planning area is the natural mineralization of waters passing through or over soluble geological formations. Sediment from erosion is also a source of water-quality degradation in some areas.

Figure 20. Water-Quality Trends on the Pecos River



Although each of the above-mentioned potential sources of water contamination exists in the planning area, only isolated incidents of contamination have occurred. Plate 27 displays recorded sites of groundwater contamination. Administrative procedures have been instituted and financial assistance has been provided to assist with the control of most point sources of pollution and improved conditions can be noted in surface water because of these efforts.

Water-Quality Management Plans

The New Mexico Statewide Water Quality Management Plan (WQMP) was adopted on October 23, 1978 by the NMWQCC.[93]. The authority for the WQMP is the New Mexico Water Quality Act (NMSA 1978), which created the NMWQCC. The intent of the WQMP is to meet the requirement under Section 208 of the Federal Clean Water Act of 1977 that all states create and adopt water quality management plans. The WQMP addresses two issues, regional wastewater management and non-point-source (NPS) pollution. It does so by specifying work elements to provide plans and strategies to address significant aspects of each of the two major issues. The work elements for the Pecos Basin are summarized below.

The WQMP specifies that stream segments throughout the state first be classified as either water-quality limited or effluent-limited. A water-quality limited stream segment is one where the water quality does not to meet applicable standards and standards cannot be met by best available technology treatment of wastewater effluent. An effluent-limited stream segment is one where water quality does not meet standards, but which can be brought into compliance by implementing best available technology treatment of wastewater effluent. The classification of stream segments identifies those segments requiring setting of total maximum daily loads (TMDLs) of certain constituents. TMDLs are the sum of nutrient or contaminant loading from point-sources (such as wastewater treatment discharges), NPS and natural background. Water-quality limited stream segments require the setting of TMDLs. The WQMP specifies that TMDLs be set at a critical low-flow level equaling the 90 percent flow-duration level. This is the flow in a stream segment expected to occur at least 90 percent of the time.

To meet the TMDL, the WQMP specifies adoption of Best Management Practices (BMPs) to reduce NPS and establishment of point-source load allocations for wastewater discharges. BMPs apply to agriculture, silviculture, construction and other activities that may impact water quality, and are usually voluntary measures intended to reduce erosion, sedimentation and contamination by pollutants from fertilizers, pesticides, herbicides and septic tank effluent. Point-source loading by wastewater dischargers is under stricter regulation. The EPA has the responsibility for issuing and enforcing NPDES permits for wastewater discharge, usually based on technology conditions such as secondary treatment. The State has the responsibility of determining more stringent point-source load allocation in stream segments where technology-based permit conditions will cause violations of water quality standards.

[93] New Mexico Water Quality Control Commission, 1979, New Mexico Statewide Water Quality Management Plan.

The WQMP also addresses groundwater quality by specifying development of a statewide groundwater quality database and establishment of a groundwater monitoring system.

The WQMP specifies a provision for public participation and identifies management agencies to implement water quality management plans in each region.

NMED is updating the WQMP to reflect changes in federal statutes and eliminate irrelevant portions of the 1979 WQMP.[94] The revised plan will be based on elements of Title 40 of the Code of Federal Regulations (Environmental Protection), Part 130 (Water Quality Planning and Management). New elements not included in the 1979 WQMP include identification of implementation measures, development of programs to control dredge and fill material, and identification of the water-quality management plan to any applicable basin plans.

The NMWQCC releases a biennial report to the United States Congress describing water quality in the State, actual and potential pollution sources and the status of programs to control pollution. The year 2000 report lists stream reaches and lakes throughout the State for which the designated uses are not fully-supported or are threatened. The report lists the Pecos River reach from Black River to Tansill Dam as impacted by stream-bottom deposits and from the New Mexico-Texas border to Black River as impacted by metals, temperature, stream-bottom deposits and other pollutants. Tributaries of concern include the Rio Ruidoso from seeping Springs Lake to the Mescalero Apache Reservation, which is threatened by temperature, turbidity and stream-bottom deposits. The Rio Bonito from the confluence with the Rio Ruidoso to Angus Canyon and perennial reaches of the Rio Peñasco are also impacted by stream-bottom deposits.[95] The NMWQCC report also discusses specific groundwater quality concerns in the planning area. Leaking underground storage tanks have contaminated groundwater in industrialized areas such as Fort Sumner, Roswell, Artesia, Carlsbad, Ruidoso and Alto. Nitrate contamination from septic tanks is reported in Ruidoso, Hondo, Roswell, Dexter, Hagerman and Carlsbad. Contamination from solvents such as TCE (used as a degreaser and dry-cleaning solvent) has been reported in Roswell.[95 above]

Fort Sumner, Roswell, Artesia, Carlsbad and Cloudcroft have completed 40-year plans that address water resources and water quality management. Roswell, Artesia and Carlsbad have also completed water conservation plans. Ruidoso and Capitan are currently preparing water plans.

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94 Personal communication, G. Saums, New Mexico Environment Department to C. Cook, Balleau Groundwater, Inc., November 29, 2000.

95 New Mexico Water Quality Control Commission, 2000, Water Quality and Water Pollution Control in New Mexico – 2000 Biennial Report to U.S. Congress.

Many rural domestic water systems, as well as several incorporated villages throughout planning area, do not have long-range water plans that cover potential needs or quality control of water.

Agricultural producers have developed individual conservation plans on their farms and ranches. These plans have traditionally addressed erosion control and water conservation. These plans are being updated to address issues of fertilizer and pesticide management to avoid contamination of water supplies. Those agricultural operations that include confined animals should develop plans that address the problems of liquid and solid waste disposal and propose corrective actions to protect the quality of the water resource.

Municipal wastewater treatment plants (WWTP) discharge water of good quality with very low amounts of contaminants. Most of the discharge from these systems enters surface-water systems at some point. Several of the larger municipalities are implementing efforts to use effluent waters for irrigation of parks, golf courses and other public areas. The disposal of municipal sludge is becoming a problem in some localities and is addressed in NPDES permits dealing with water quality.

Lower Pecos Valley Regional Water Balance

Introduction

The regional water balance shows the components and magnitudes of water yield and consumption for the planning area. The relationships among the inflow and outflow components are depicted schematically in Figure 21. Inflow has four components, including Pecos River inflow, tributary inflow, release of reservoir storage, and well yield from aquifer storage. Outflow has five components, including Pecos River outflow, filling of reservoir storage, unmanaged evapotranspiration, managed consumptive use and replenishment of aquifer storage. For the purpose of the regional water balance, recharge to and subsequent discharge from the groundwater aquifers is considered to be tributary inflow.

The historic regional water balance for the Lower Pecos Valley planning area is shown in Figure 22. Figure 22a shows the components of inflow and Figure 22b shows the components of outflow. The period of 1900 to 1999 is shown, with each year's balance represented as a set of stacked bars accounting for inflow and outflow components. As the term "balance" implies, inflow must equal outflow each year, including any water removed from or added to surface (reservoir) or groundwater storage. The components of the balance and their averages since the Compact in 1947 and over the last ten years are shown in Table 37 and described below. The basin has yielded an average 706,000 AFY since 1947, but a larger amount of 754,000 AFY in the decade of the 1990s. Diagrams of Pecos River mainstem inflow and outflows during wet, dry and average years are attached in Appendix P. The values of inflow and outflow used to create Figure 22 are tabulated in Appendix Q.

Table 37. Average Water-Balance Amounts

Component	Average amount in the 1990s (AFY)	Average amount since Compact (AFY)
Inflow Components		
Inflow below Sumner Dam	145,000	130,000
Tributary Yield	608,000	491,000
Yield from Aquifer Storage	0	85,000
Sum of Inflow Components	754,000	706,000
Outflow Components		
Outflow at Red Bluff	-75,000	-75,000
Managed Consumptive Use	-340,000	-340,000
Unmanaged Evapotranspiration	-263,000	-263,000
Filling of Reservoir Storage	-1000	0
Replenishment of Aquifer Storage	-75,000	-28,000
Sum of Outflow Components	-754,000	-706,000

Description of Components

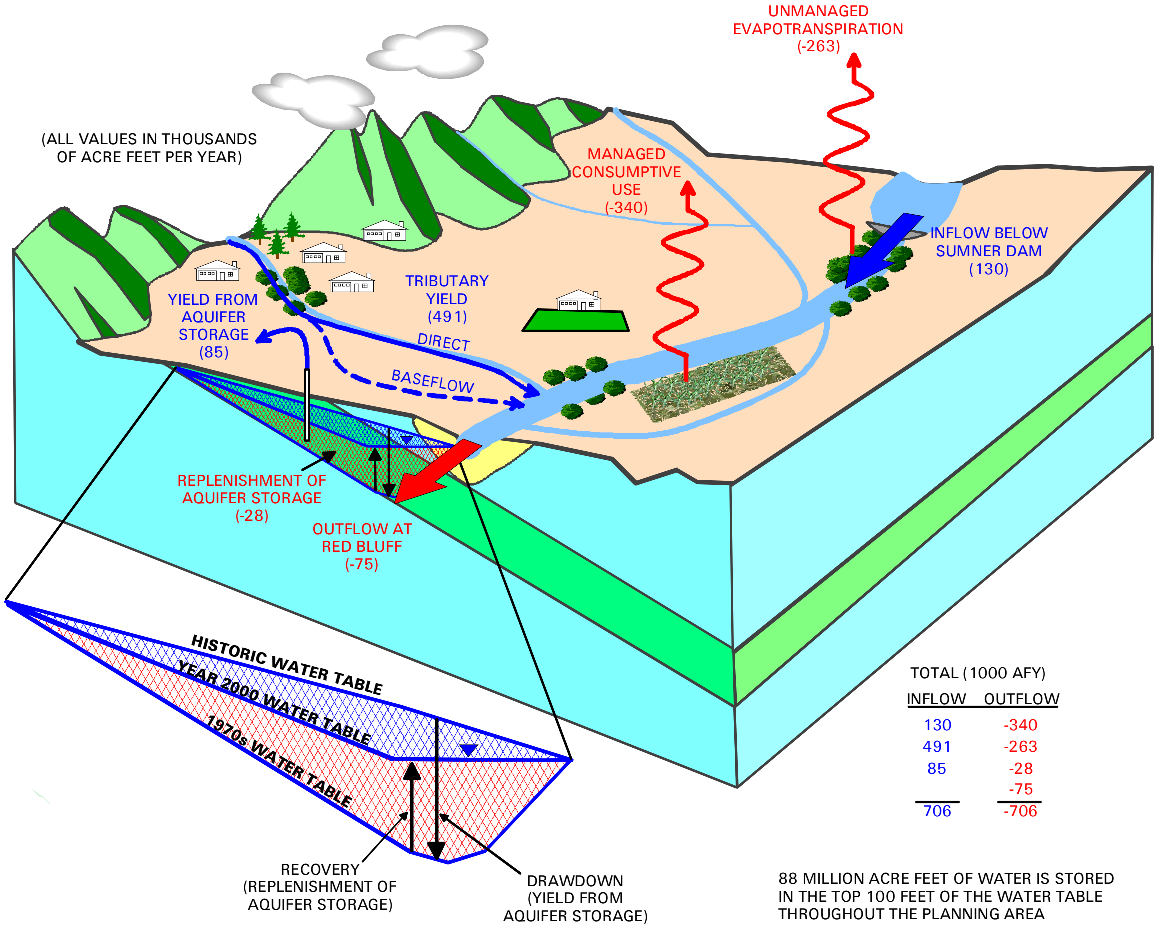
Pecos River inflow to the planning area is gaged below Sumner Dam. The values in Figure 22 are from gaging records for the years 1937 to 1999. Values prior to 1937 are from Appendix Table 8 of National Resources Planning Board.[96]

Surface water leaves the planning region at Red Bluff, Texas. Annual gaged flows at Red Bluff from 1938 to 1999 are shown in Figure 22. Values prior to 1938 are from the gage at Angeles, Texas,[96 above] which was located one-half mile below the mouth of the Delaware River.

Release from reservoir storage is counted as an inflow to the system, and filling of reservoir storage is counted as an outflow. Records of end-of-year storage in Avalon and Brantley Reservoirs[97] were used to compute the annual net change in storage. Records for Avalon were available for the years 1965 to 1999. The reservoirs, because of their cyclic operation, have little effect on the long-term average yield of the system.

[96] National Resources Planning Board, 1942, Regional Planning Part X – Pecos River Basin.
[97] Electronic communication, R. Gold, U.S. Geological Survey to C. Cook, Balleau Groundwater Inc, January 23, 2001.

Figure 21. Schematic of Water Budget Components in the Lower Pecos Valley



Well yield from aquifer storage totals six million AF in the years 1930 to 1970. The annual amount in Figure 22 comes from Saleem and Jacob.[83 above]

Replenishment of aquifer storage was estimated previously as two million AF, which is a rate of 75,000 AFY in 25 years.

Managed consumptive use includes consumption by irrigated agriculture and evaporation from reservoirs. The values in Figure 22 were computed previously in Section VI (Subsections "Irrigation Consumptive Use" and "Storage Reservoirs") as 321,100 and 18,600 AFY, a total of about 340,000 AFY. Consumption by irrigated agriculture includes areas along the mainstem and along tributaries. The growth of managed consumptive use from 1900 to 1939 is from estimates of the National Resources Planning Board.[96 above]

Unmanaged evapotranspiration includes consumption of water by phreatophytes and open-water evaporation (other than reservoirs). The annual amount of unmanaged evapotranspiration for 1940 to 1999 was computed previously in Section VI (Subsection "Unmanaged Riparian Vegetation") to be 263,100 AFY. The annual amount of unmanaged evapotranspiration prior to 1940 is a balancing term and is the difference of inflows and outflows for each year.

Tributary yield represents that fraction of precipitation (both snow and rain) that is not evaporated or transpired and reaches a watercourse or aquifer to be potentially diverted and put to beneficial use. The term includes both direct runoff and groundwater discharge as base flow to streams. The National Resources Planning Board estimated tributary and groundwater inflow for the years 1905 to 1939.[96 above] Their estimates are included in Figure 22 as tributary inflow for 1905 to 1939. From 1940 to 1999, tributary yield is the balancing term and is computed by subtracting inflow from outflow for each year.

The four inflow components and five outflow components are a serviceably complete water balance of the Lower Pecos Valley region for purposes of water planning.

<u>Historical Trends</u>

The history of water development in the planning area, described in detail for each basin in Section IV, is shown in terms of water balances in Figure 22. From 1900 to about 1940, irrigated agriculture (managed consumptive use) grew at a steady pace, supplied by surface water and a growing number of wells.

The gage "below Sumner Dam" reflects changes in rainfall patterns upstream and changes subsequent to the construction of Sumner Dam and pumping for irrigation of acreage north of Fort Sumner and east of Sumner Lake and the subsequent placement of that acreage in conservation status.

In that reach of the river from Sumner Dam to above Acme, surface flow has been influenced by pumpage from groundwater west of Fort Sumner, increases of woody vegetation on sandy soils, return flow from the FSID, salt cedar growth and later eradication of much of that growth, conveyance channel losses below the Fort Sumner Project and pumpage in the northern part of the Roswell Basin. Losses in this reach have averaged 14,800 AFY from 1938 to 1999.

Figure 22a. Lower Pecos Valley Water Budget Inflow

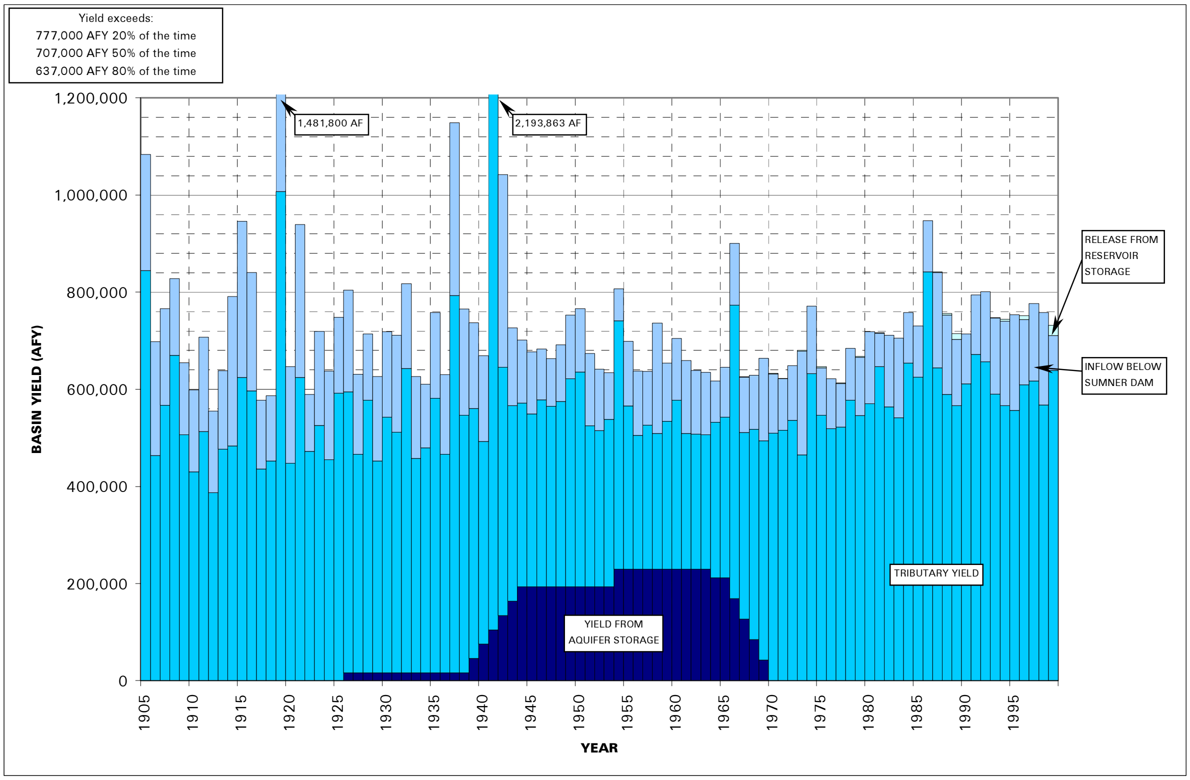


Figure 22b. Lower Pecos Valley Water Budget Outflow

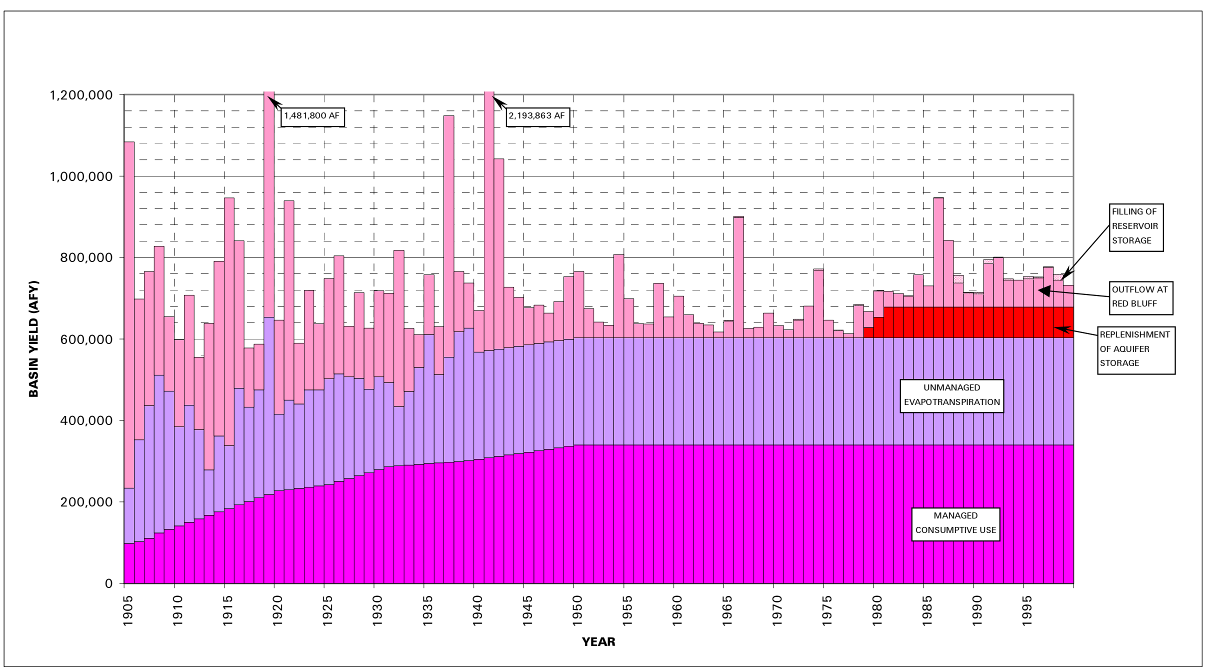
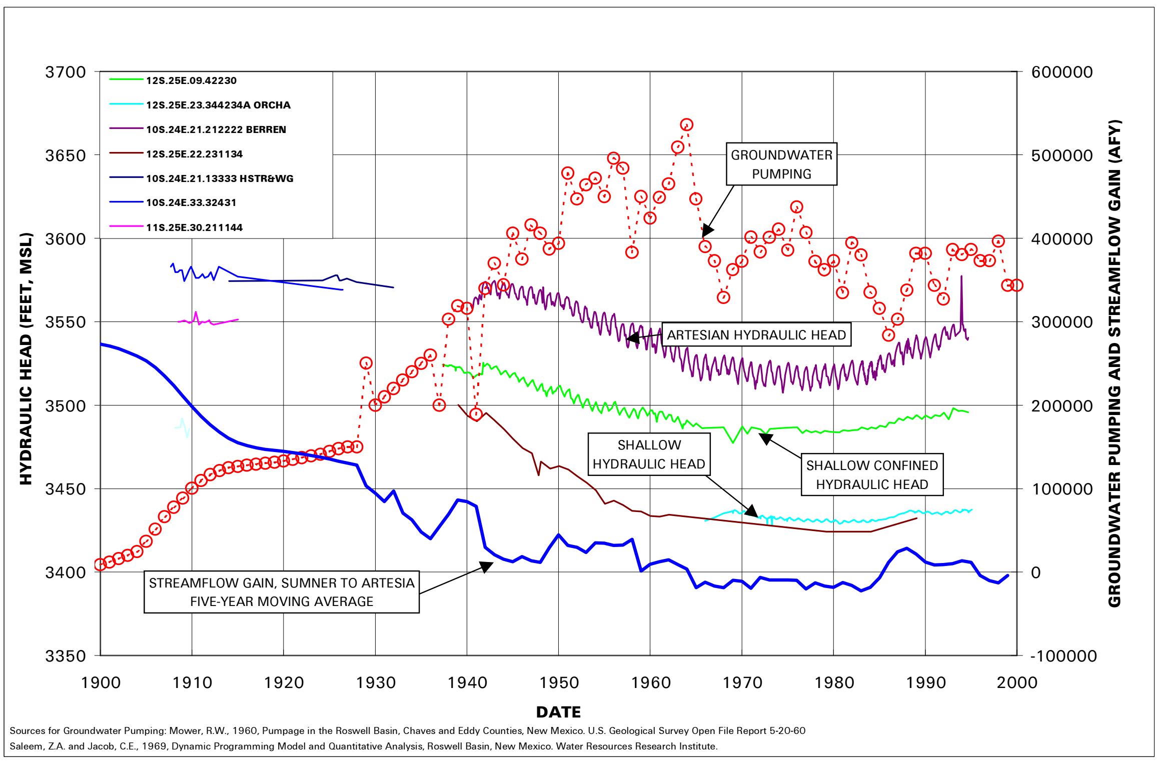


Figure 23 shows the growth trend of groundwater pumping in the Roswell Basin and the response in the aquifer and the streamflow gain from Fort Sumner to the Artesia gage. Streamflow gain from Acme to Artesia averaged 39,600 AFY from 1938 – 1999. The shallow and shallow confined hydraulic heads, in Figure 23, are from wells completed in the alluvial aquifer. Shallow confined wells occur where the artesian aquifer flows strongly upward into the alluvial aquifer and causes the wells to flow at the surface. The source of water for early wells was groundwater that originally issued from springs and flowed to the Pecos River. Increases in pumping led to decreases in springflow. Prior to the 20th Century, the springs in the Roswell Basin flowed at 150,000 AFY[16 above] but the major springs had gone dry by 1931. Figure 22 displays diminishing flow at Red Bluff and Figure 23 displays the record of diminishing streamflow gain in the Sumner to Artesia reach.

Figure 23. Well Hydrographs, Pumping History and Streamflow Depletion in the Roswell Basin



After World War II, irrigated agriculture increased. In the Roswell Basin, groundwater pumping increased from 300,000 AFY in 1940 to 500,000 in 1955 (Figure 23) and increased overall basin yield to that extent as in other basins. Some of this pumping was derived from aquifer storage (depicted by the dark blue bars in

Figure 22). The consequences of groundwater pumping were a reduction in both shallow and artesian aquifer levels and reduction of discharge to Pecos River streamflow. Streamflow gain from Sumner to Artesia is shown on Figure 23 as a five-year moving average. Other factors which affected streamflow in the Acme to Artesia reach include decreases in tributary inflow due to vegetation changes in the watershed, development of wells, phreatophyte growth and evapotranspiration and other water developments. Present increases in tributary inflow are due to decreased groundwater pumping, decreased surface divisions, conservation measures and increased rainfall. The original Pecos flow is estimated to have been 277,000 AFY in 1900; maximum depletion was near 300,000 AFY in the late 1960s, 70s and early 80s.

Figures 24 and 25 show the five-year moving averages of discharge at the upstream (Sumner Dam and Acme) and downstream (Artesia and Malaga) gaging stations. Streamflow in the upper gages show no long-term trends, except in the last two decades when discharges increase. Discharge at the downstream gages, in contrast, shows a distinct downward trend. The gage near Artesia shows a decrease from 300,000 AFY in 1920 to 100,000 AFY in 1980. The decrease in discharge is due to increased pumping and consumptive use of groundwater in the Roswell Basin, and to the spread of salt cedar along the reach.

Figure 26 shows the components of water that historically supplied pumping wells in the Roswell Basin from aquifer storage and surface-water depletion including interception of annual recharge to the aquifers. Through year 2000, about 29 million AF has been provided by wells in Roswell Basin and six million AF was depleted from aquifer storage. The remaining 23 million AF was derived from annual recharge to the groundwater aquifers that would have discharged as baseflow. The amount of pumping each year is equal to the sum of the blue bars (groundwater depletion) and the pink bars (intercepted annual recharge). The chart shows that after the springs went dry, wells began to pull water from storage. Further pumping in the decades following the 1930s led to increased depletion from storage and interception of annual recharge. Replacement of aquifer storage in recent decades is related to decreased pumpage and increased precipitation.

State Engineer and PVACD policies and metering of wells in the mid- to late 1960s led to a reduction in groundwater pumping (Figure 23). Aquifer declines slowed and, in the period 1965 to 1975, reached their lowest levels. For much of the 1970s, aquifer levels remained stable and there was no apparent net removal from aquifer storage. Wells have been supplied largely from annual recharge to the aquifers since the 1970s.

Figure 24. Five-Year Moving Average Annual Discharge at Upstream Pecos River Gaging Stations

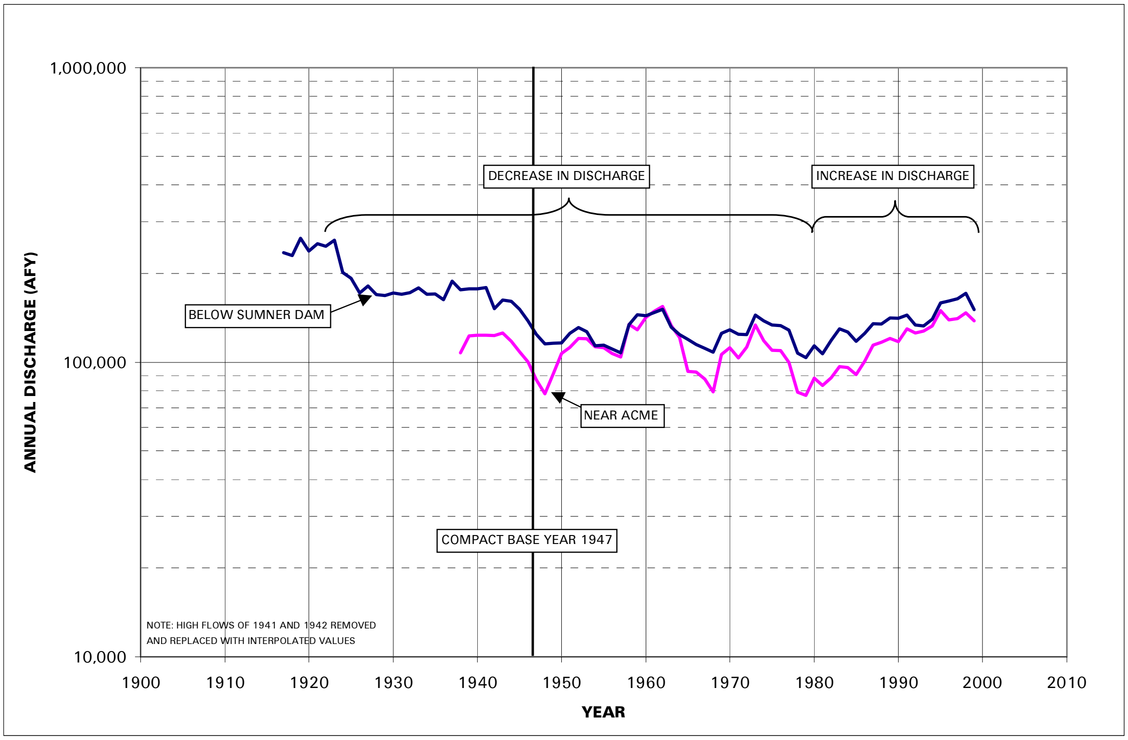


Figure 25. Five-Year Moving Average Annual Discharge at Downstream Pecos River Gaging Stations

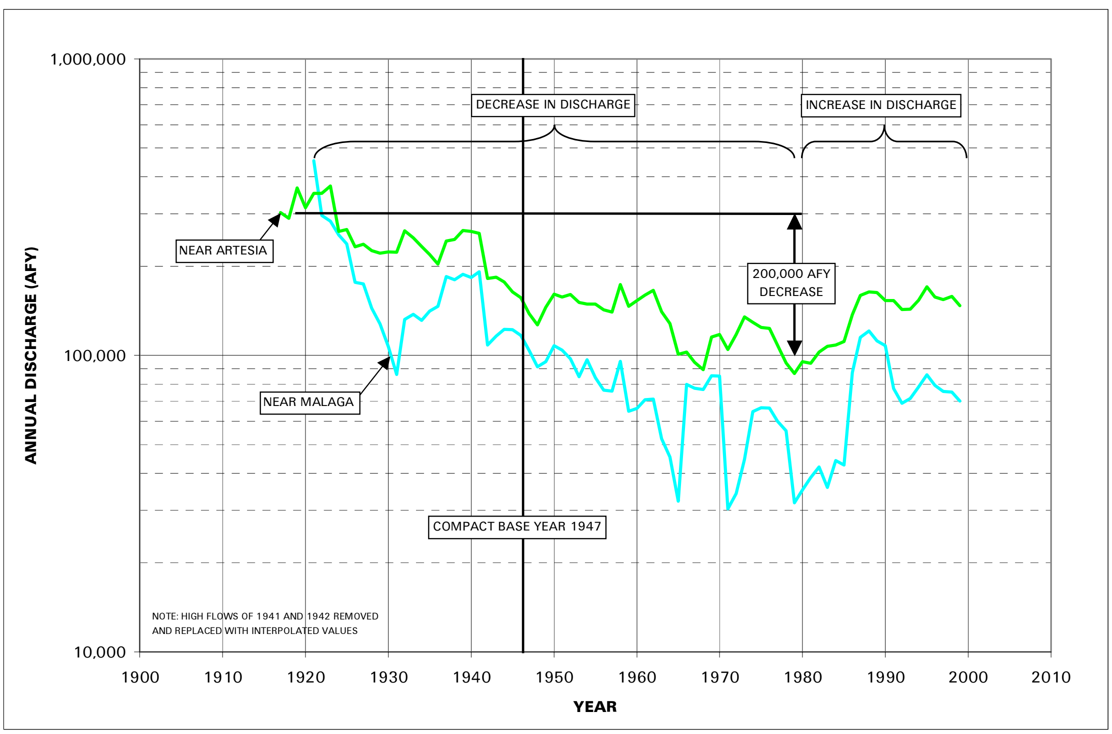
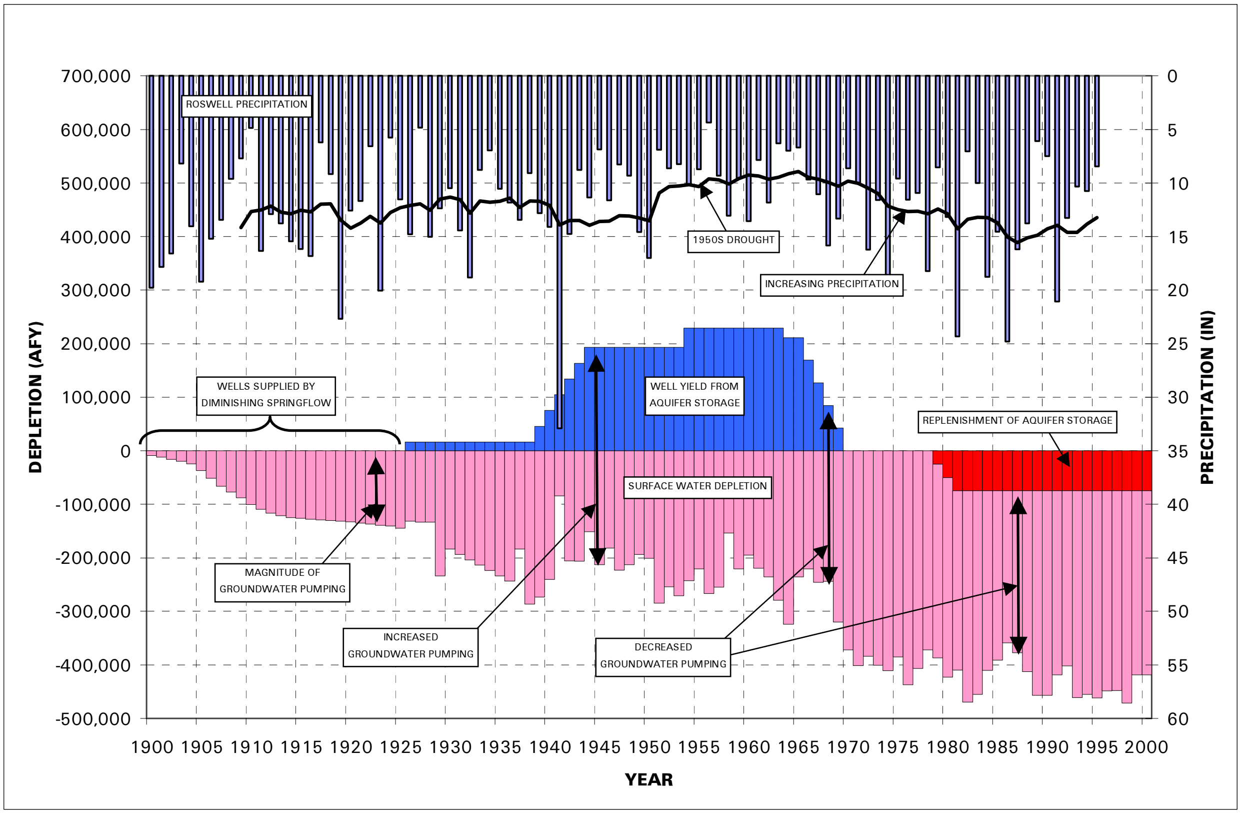


Figure 26. Precipitation and Sources of Pumping in the Roswell Basin



In the 1980s aquifer levels began to recover, indicating that water was moving into the space created by drawdown (Figure 23). The red bars in Figures 22b and 26 depict replenishment of aquifer storage. Water is removed from the overall basin yield in order to satisfy storage replenishment. The source of water for replenishment is larger groundwater inflow that might otherwise contribute to the baseflow of the Pecos River.

In the reach of the river between the Artesia gage and the Carlsbad gage the growth of phreatophytes since 1941, particularly salt cedar have contributed to reduced baseflow as have channel losses through the McMillan Delta. Discharge from the Roswell Basin, in the area of Major Johnson Springs and Boiling Springs (now covered by Brantley Reservoir) contributed to the baseflow in this reach.

In the reach of the river between the Carlsbad and Malaga gaging stations, additional decreases in streamflow have been caused by groundwater pumping for irrigation and industrial use. Pumpage in the La Huerta area and in Carlsbad reportedly caused reduction of flow from Carlsbad Springs. Phreatophyte growth in this reach has also contributed to reduced baseflow.

Figures 24 and 25 show a five-year moving average of discharge at the upstream gages (Sumner Dam and Acme) and downstream (Artesia and Malaga) gaging stations. The gage near Artesia decreases from 300,000 AFY in 1920 to 100,000 AFY in 1980.

Data are adequate to reconstruct the water account of 20th Century as a guide to water planning for the next 40 years. The basin has produced 707,000 AFY as a characteristic median flow since 1905, 706,000 AFY on average since the Compact year of 1947, and 754,000 AFY during the decade of the 1990s. These values include basin yield of 4.5 million AF from aquifer storage depletion in the period from 1930 to 1970. If the surface-water system were to be planned without a net yield from aquifer depletion then the median flow since 1905 would lead to an expectation of 660,000 AFY. The wettest year in five would be expected to yield 765,900 AF, and the driest year in five would be expected to yield 545,000 AF, based on flow since 1905. For years since the 1947 Compact, the average yield has been 621,000 AF, and in the decade of the 1990s, 754,000 AF.

Pre-development surface-water outflow to Texas has been estimated at 250,000 AFY.[70 above] Accordingly, unmanaged evapotranspiration in the planning area was near 400,000 AFY before development. Water used for 340,000 AFY of development for beneficial use has had the effect of diminished flows to Texas, salvage of unmanaged evapotranspiration, and a net gain from aquifer storage.

The best value for characterizing the surface-water yield of the basin for the purpose of planning is the long-term median of 660,000 AFY. The aquifer storage has been operated to level out the variability in surface yields by depleting and then accreting several million AF of aquifer storage volume.

The aquifer storage in the Roswell Basin is a critical component for leveling out future variations in surface water in wet and dry periods.

SECTION VII: PRESENT WATER USE

Introduction

This section quantifies present water use in each of the six groundwater basins in the planning area by type of use, including, irrigation and public water supply. Plate 1 shows the location of municipalities and Plate 12 shows irrigated areas in the planning area. The water rights and flood and drought contingency plans in each basin are discussed. Other uses of water are discussed for the planning areas as a whole, including domestic cooperatives, agriculture-related uses, commercial uses, domestic wells and recreational and biological uses. Compact deliveries are discussed as a constraint on consumptive uses within the planning area. Municipal, agricultural and domestic well return flow are quantified.

Diversions for agriculture and some municipalities are tracked by two State watermasters and a Federal watermaster. The Pecos Valley Surface Water District (PVSWD) was declared in 1952 and expanded to its present boundaries from south of Santa Rosa to the New Mexico-Texas state line. Annual diversions tracked by the PVSWD watermaster within the planning area are shown in Figure 27, along with the amount of irrigated acreage. The Roswell Artesian Basin was decreed in 1966 and a watermaster was appointed to administer water rights the same year. All groundwater pumping in the basin, including agricultural, municipal and industrial is metered and reported by the watermaster. Annual withdrawals from the Roswell Artesian Basin since 1967 are shown in Figure 28, as well as the amount of irrigated acreage.

Water usage in the planning is tracked by the OSE, various irrigation districts, municipalities and others. The numbers reported in this section are from a variety of identified sources.

Fort Sumner Groundwater Basin

Irrigation

Fort Sumner Irrigation District. The FSID is located in De Baca County in the vicinity of Fort Sumner, and was formed in 1919.[98] This irrigation project receives water from the Pecos River via a diversion and canal system. The District is allowed to divert up to 100 cfs for delivery to the 6500 acres of irrigated land. The main crops grown are alfalfa and irrigated pasture. Small grains and grain sorghums are also grown in the rotations.

[98] Houghton, W., 1994, Draft Water Plan for Agriculture: unpublished.

Most of the farmland in the FSID is flood irrigated through furrows, corrugations or borders. Practices such as land leveling and concrete ditch lining have been undertaken, and appurtenances such as pipelines and water control structures have been installed to improve system efficiency on the individual farms. The FSID diversion, depletion and return flow for 1995 is listed in Table 38.[61 above] FSID lands are shown in Plate 17.

Outside Fort Sumner Irrigation District. Groundwater has been developed for irrigation north of Fort Sumner on the east side of Sumner Lake and south of Fort Sumner on the west side of the Pecos River. Other small areas of irrigation have been developed in the tributaries of the Pecos River throughout De Baca County. In 1995, 3161 acres were reported irrigated with groundwater in these areas. The crops grown are alfalfa, small grains, sorghums and some pasture.

The area south of Fort Sumner on the west side of the Pecos River was first developed in the 1950s, with about 2200 acres being developed for irrigation. The area north of Fort Sumner and east of Sumner Lake was developed in 1965, with about 4100 acres being developed for irrigation. Since 1965 an area south of Taiban and other scattered tracts of irrigated lands have been developed in the basin.

Due to the low flow of wells (usually less than 1000 gpm) and the uneven terrain in the basin, most of the irrigated land has been developed under sprinkler systems. This has resulted in more efficient irrigation systems. Underground pipeline, meters and irrigation monitoring devices have been installed to improve the delivery system efficiency and to reduce pumping costs. Most of the sprinkler systems are of the pivot or side roll type.

The diversions, depletions and return flows for agriculture outside of the FSID within the Fort Sumner Groundwater Basin are shown in Table 38.[99, 10 above, 61 above]

Table 38. 1995 Water Use in the Fort Sumner Groundwater Basin

User	Acreage	Water Rights (AF)	Diversion (AF)	Depletion (AF)	Return Flow (AF)
Irrigation					
FSID	6500		44,663	18,196	26,467
Outside FSID	3161		13,240	10,580	2600
Public Water Supply					
Fort Sumner Water System		1100	472	287	185
Totals	9661	1100	58,375	29,063	29,252

[99] *Existing Municipal Water Use, Supplies and Storage facilities.*

Figure 27. Annual Surface-Water Diversions Within the Pecos Valley Surface Water District

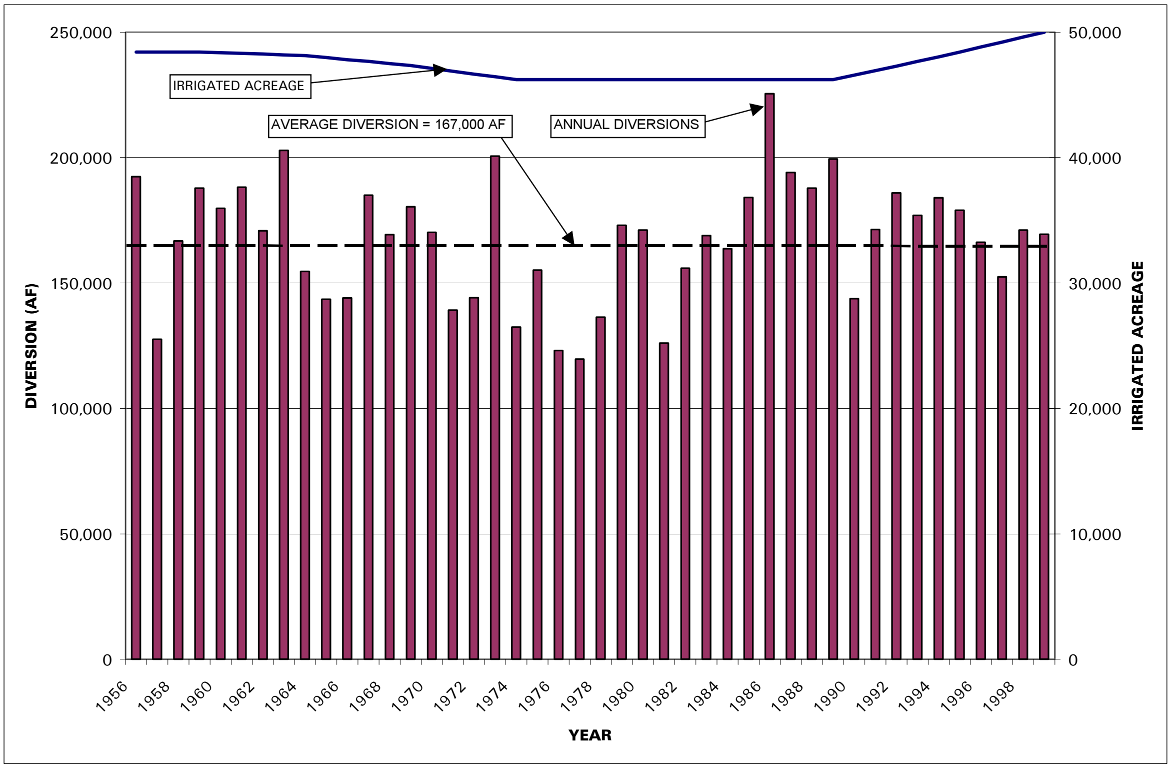
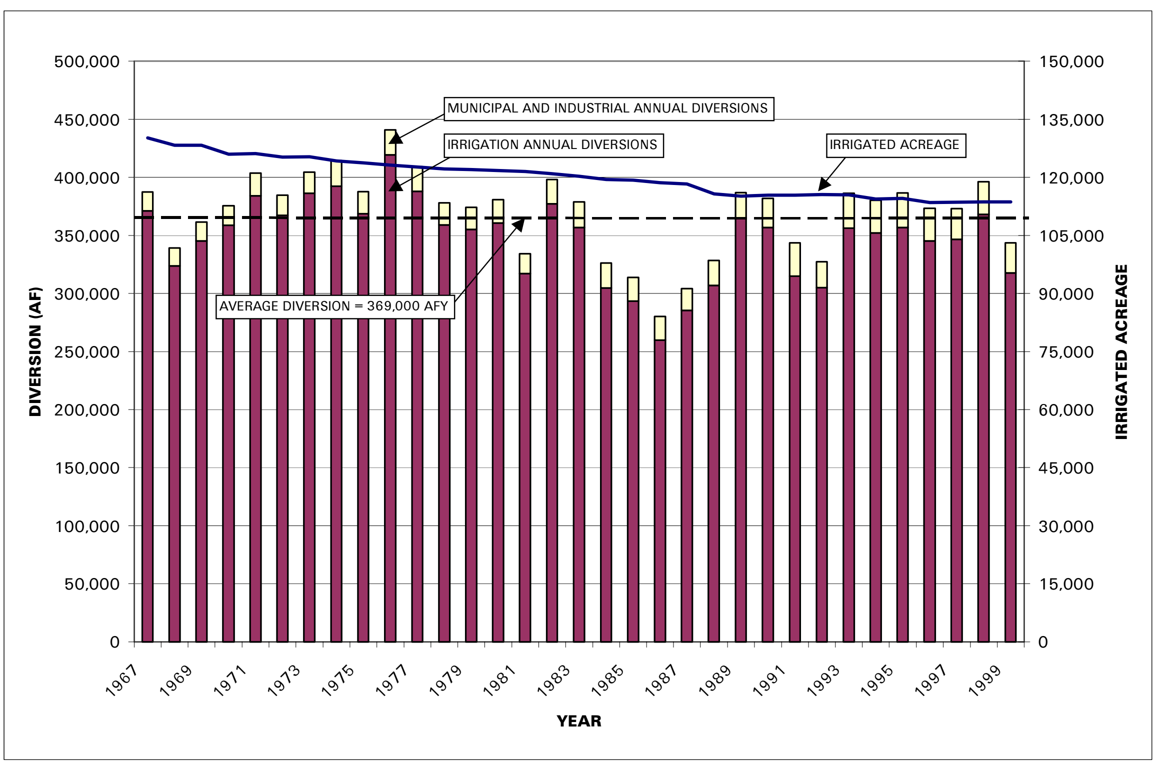


Figure 28. Annual Groundwater Diversions from the Roswell Artesian Basin



Public Water Supply

The Fort Sumner Water System. The Fort Sumner Water System was first established in 1916 and presently serves 685 water connections in the village. The system draws its water supply from two wells located five miles northeast of Fort Sumner, with plans under way to develop an additional well. Water is delivered to three storage tanks with a capacity of one million gallons (3 AF). Fort Sumner owns 1100 AF of groundwater rights, and plans to allocate 600 AF to commercial development and residential uses in the Village while reserving 500 AF for development of enterprises in an industrial park. At present, the Village of Fort Sumner does not make use of the effluent from wastewater treatment. This source of water could provide the Village with an additional 185 AFY for use on parks and other Village properties. Water is sold to the Valley Water Users Association from the Fort Sumner Water Supply, which supplies water to rural residents south and southeast of Fort Sumner. An overall development plan has been prepared for Fort Sumner and De Baca County. The plan describes the current municipal water system and the plans to improve and expand the system. It also gives pertinent data on water rights and water sources. Fort Sumner's diversions, depletions and return flows for 1995 are shown in Table 38.

Water Rights

A summary of water rights in the Fort Sumner Groundwater Basin is presented in Table 39.[86 above] The approximate 1996 water usage under each of these rights is also shown.

Approximately 14,740 acres of irrigated cropland with a total of 38,806 AF of groundwater rights have been declared and permitted in the Fort Sumner Basin, according to the hydrographic survey of 1976. An additional 121 AF of groundwater has been declared that is supplemental to surface water of the Fort Sumner Irrigation Project.

All surface-water irrigation for FSID is supplied by a canal from the Pecos River. The diversion cannot exceed 100 cfs, but actual allowable canal flow is determined by Pecos River flow at Puerta De Luna.

Approximately 60 percent of the Fort Sumner Groundwater Basin lies within the Lower Pecos River planning region and most of the population resides in that part. It is estimated that 75 percent of the domestic and livestock wells are located in that part as well. All water rights for other use categories recorded for the basin are located within the planning region.[86 above]

Emergency Contingency Plans

The following paragraphs discuss emergency contingency plans that have been or are being implemented for drought and flood conditions in the Fort Sumner Groundwater Basin.

Drought Considerations. De Baca County and the Village of Fort Sumner have written a comprehensive development plan for their area. Although the plan discusses the need for conservation of water and outlines several actions to assist with water conservation throughout the area needed actions in time of droughts are not included. De Baca County and Fort Sumner should consider preparing ordinances or plans that will address drought issues and coordinate with the State of New Mexico efforts in drought planning and actions.

Flood Considerations. Most of the populated areas in De Baca County are protected from flooding on the Pecos River by Sumner Dam. The major drainages to the Pecos River do not impact the populated areas, but can impact rural areas. Floodplain maps should be available for consideration when development occurs in the area.

Roswell Groundwater Basin

Irrigation

Water use in the Roswell Basin is dominated by agricultural usage, which is supplied by both surface water and groundwater sources. The City of Roswell is also a significant water user in this basin. A summary of water uses and water rights follows.

Roswell Area. The Roswell Groundwater Basin is the largest groundwater basin in the planning region. It covers parts of Chaves, Eddy, De Baca and Lincoln Counties. It includes all of the lands under the PVACD. The major irrigated area extends from north of Roswell to the Seven Rivers area in Eddy County. There are over 150,000 acres of irrigable land in the Roswell Basin; 108,355 acres were irrigated in 1995.

All groundwater uses for irrigation in the basin are metered. Due to the size and complexity of the Roswell Groundwater Basin, almost every type of irrigation system can be found in the area. Surface systems using furrows, corrugations and borders have been installed. Practices such as land leveling and ditch lining and installation of irrigation pipelines and surge irrigation are employed to improve efficiency. Several types of sprinkler irrigation systems have been installed. Side roll and pivot systems are the most popular, but solid-set sprinklers and drip irrigation systems are also used. The crops grown on most of the farms are cotton, alfalfa, corn, small grains, some vegetables and sorghums. Pecan orchard acreage has increased over the past 15 years.

Table 39. Summary Of Water Rights in the Fort Sumner Groundwater Basin

Category of Use	Water Rights		1996 Usage (AF)
	Groundwater (AF)	Surface Water (AF)	
Irrigation	38,806	100 cfs diversion right (Approx. 48,000 AF)	40,516
Supplemental Irrigation	121		6
Commercial	150		32.4
Recreation	153		3
Municipal and Municipal Type	1489		493.5
Domestic & Stock (873 wells)	2619		597
Cattle Feed Pens	15		0
Total	43,353	48,000	41,647.9

Diversions, depletions and return flows for irrigated agriculture in 1995 in the Roswell area are shown in Table 40.[61 above]

Hagerman Canal. The Hagerman Canal diverts water from the Hondo and Spring Rivers east of Roswell in Chaves County. The canal flows to an area south of Hagerman and provides water to 8600 acres of farmland. The water diverted from the rivers is supplemented by water pumped from wells and by water re-diverted from drainage systems. Irrigated land under the Hagerman Canal is shown in Plates 18 and 19.

Most of the farmland irrigated with water from the Hagerman Canal is flood irrigated through furrows, corrugations and borders. Most of the land has been leveled to an even or flat grade. Private wells are used to supplement the surface-water supply. Some of the ditches have been concrete lined or replaced with pipelines to improve delivery efficiency. The crops grown under this irrigation system are cotton, alfalfa, corn, small grains, sorghum and some vegetables. The 1995 water use for irrigated agriculture supplied by the Hagerman Canal is shown in Table 40.[61 above]

Pecos River Pumpers and Scattered Surface Use. The Pecos River Pumpers are located mainly in Chaves County along the Pecos River in the Dexter - Hagerman area. These are farms that were developed with water from the Pecos River. Instead of using diversions or dams to bring the water to the land, pumps have been placed to lift the water from the river and deliver it to the farms.

Table 40. 1995 Water Use in the Roswell Groundwater Basin

User	Acreage	Water Rights (AF)	Diversion (AF)	Depletion (AF)	Return Flow (AF)
Irrigation					
Roswell Area	108,355		359,440	258,289	101,151
Hagerman Canal	8600		16,876	8596	8280
Pecos River Pumpers and Scattered Surface-Water Users	250		1331	813	518
Upper Felix	1070		3871	2493	1378
Hope Irrigation Project	3200		13,138	6139	6994
Public Water Supply					
Roswell Municipal Water System		34,162	15,120	13,457	1663
Dexter Water System		195.3	1019	407	612
Hagerman Water System		648	778	389	389
Lake Arthur Comm. Water System		99.6	54	27	27
Artesia Mun. Water System		6687	4365	4365	0
Hope Comm. Water System		63	56	20	28
Total	121,475	41,855	416,048	294,995	121,040

All of the farms pumping water from the Pecos River were developed prior to the Compact of 1947. As flow in the river has declined due to the construction of dams, it has become increasingly difficult for the river pumpers to obtain adequate supplies of water to produce their crops. Wells were drilled in later years to supplement the surface supply. The 1400 acres of farmland under Pecos River pumpage once produced alfalfa, cotton, corn, small grains and forage crops. Much of this acreage has now been retired under the program of the ISC to increase surface flows to Texas to fulfill the terms of the Compact.

Due to the quality of the river water, the only practical means of applying it to the land is through flood irrigation. Borders and furrows are used to spread the water on the land. Irrigation pipelines and lined ditches have been installed to move the water from the river and to the fields. Most of the land has been leveled to improve application efficiency. The 1995 water use for Pecos River pumpers and other scattered surface water diverters is shown in Table 40.[61] above

Upper Felix. Irrigated lands of the Upper Felix lie in the Felix River Valley in Chaves County, New Mexico, about 50 miles west of the Pecos River. These irrigated lands receive water diverted from two points on the Felix River, from large springs along the river and from supplemental wells. There are 1070 acres developed for farming. The crops produced on these farms include orchards, alfalfa, forage crops and small grains. The farmland on the Upper Felix was developed prior to the area becoming part of the Roswell Groundwater Basin. Irrigated areas along the Felix River are shown in Plate 16.

Most of the farmed lands on the Felix are flood irrigated by furrows, corrugations or borders, though some are irrigated by sprinklers. Some tracts have been leveled to improve efficiency. Some landowners have installed irrigation pipelines and lined ditches to reduce water loss and improve delivery efficiency of the irrigation systems. A summary of water use for irrigation in the Upper Felix is listed in Table 40.[61 above]

Hope Irrigation Project. The Hope Irrigation Project or Hope Community Ditch, constructed in 1895, is located in the vicinity of Hope in Eddy County. The project receives water from the Peñasco River via a diversion and canal system. The diversion is 17 miles west of Hope in Chaves County. The canal system can carry 135 cfs when the water is available. Each lateral can carry 22 cfs to the farms. This system provides water to 3200 acres of land where alfalfa, small grains and forage crops are grown.[98 above] Irrigated land in the Hope Irrigation project are shown in Plates 16 and 19.

The Hope Irrigation Project, which suffers frequent water shortages during periods of low flow in the Peñasco River, has made many attempts to improve their system. A storage reservoir was constructed but would not hold water due to permeable soils. A retard dam was constructed and immediately filled with silt. It was cleaned out and silted full again. The system has been improved by the installation of a pipeline through Hope and several water control structures to provide water to the laterals. The on-farm systems have been improved with land leveling, ditch lining and structures for water control. A pipeline has been designed to carry the water past the section of river where water loss is the highest. A summary of 1995 water use in the Hope Irrigation Project is shown in Table 40.[61 above]

<u>Public Water Supply</u>

Public water suppliers in the Roswell Basin include the City of Roswell and a number of smaller community systems. A summary of several of these systems follows.

The Roswell Municipal Water System. The Roswell Municipal Water System was first established in the 1920s. Presently the system serves about 17,000 water connections and has access to 20 wells with 34,162 AF of groundwater rights. These wells have a capacity of 2.6 million gallons per day (8 AF per day). Most of the wells are located in or near the city limits of Roswell and provide water to the five storage facilities, with capacities ranging from 100,000 gallons to 7.5 million gallons. Water from this municipal system is used for domestic, industrial and commercial uses. The City of Roswell has completed a 40-year plan that outlines existing water uses, availability of water resources, projected demands and alternatives to meet those demands. A summary of 1995 water use is given in Table 40.[61 above]

The Dexter Water System. The Dexter Water System serves 435 residential and commercial water connections in the Village of Dexter in Chaves County. The system was constructed prior to 1914. The water supply is pumped from two wells to two storage tanks with a capacity of 305,000 gallons (0.9 AF). The Village presently owns 44.4 AF of groundwater rights and 150.9 AF of surface-water rights. The Village of Dexter also owns 187 AF of groundwater rights to maintain the recreational water in Lake Van. The Village does not make use of the effluent from the sewage plant, which returns to the river system. A summary of 1995 water use in given in Table 40.[100]

Hagerman. The Village of Hagerman first installed a water system in 1913. The system presently provides water to 460 residential and commercial water connections. The water supply is derived from two wells located near the Village and stored in two tanks with a capacity of 250,000 gallons (0.8 AF). The effluent from the WWTP returns to the river system. A summary of 1995 water use is given in Table 40.[61 above]

Lake Arthur. The Community Water System for Lake Arthur in Chaves County serves 154 water connections for residential and commercial use. The system has two wells with 99.6 AF of water rights that supply water to one tank. Lake Arthur does not have a municipal sewage treatment plant. Return flow from individual septic systems enters the groundwater system. A summary of 1995 water use is given in Table 40.[61 above]

Artesia. Artesia, in Eddy County, developed a municipal water system in 1903. Water is supplied from eight wells having rights totaling approximately 6687 AF, and stored in two large storage tanks with a capacity of 2.4 million gallons (7 AF). The system furnishes water to 4100 water connections for residential, commercial and industrial uses. The WWTP provides 750,000 gallons (2.3 AF) of effluent per day, that is used to irrigate parks, play areas and other City properties. A summary of 1995 water use is provided in Table 40.[61 above]

Hope. The Hope Community Water System was developed in 1954. Water is supplied by two wells and stored in three storage tanks with a capacity of 250,500 gallons (0.8 AF). Hope has 63 AF of water rights. Water is delivered to 73 water connections for residential and commercial uses. Hope does not have a WWTP. Some water returns to the aquifer from individual septic systems. A summary of 1995 water use is provided in Table 40.[101]

<u>Water Rights</u>

A summary of water rights in the Roswell Groundwater Basin is presented in Table 41.[86 above] Exercise of these rights in 1996 is also shown.

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[100] *Existing Municipal Water Use, Supplies and Storage facilities.*
[101] *Existing Municipal Water Use, Supplies and Storage facilities.*

Approximately 132,870 acres of irrigated land in the basin have declared or permitted water rights. Approximately 130,000 of these acres were adjudicated under Cause Nos. 20294 and No 22600 consolidated. Water rights under the Hope Decree for the remaining acreage were adjudicated. The places of use for surface-water rights are located in the vicinity of the Hagerman Canal System from the Hondo River east of Roswell to an area near Hagerman, New Mexico. The places of use for groundwater rights are located throughout the Roswell Groundwater Basin, but the heaviest concentration is located between Roswell and Artesia.[102]

Emergency Contingency Plans

The following paragraphs discuss emergency contingency plans that have been or are being implemented for drought and flood conditions in the Roswell Groundwater Basin.

Drought Considerations. The Roswell Basin hosts the largest population and the largest number of incorporated communities. Roswell, Artesia and Lake Arthur have developed comprehensive long-term water plans. Roswell and Artesia have developed water conservation plans. Although the long-term plans address conservation, they do not address drought considerations. The two water conservation plans contain proposed actions in case of water shortages which could apply to drought. Some of the communities have proposed ordinances to address water shortage and droughts. The rural areas rely on the New Mexico Drought Task Force and other local agencies for assistance during droughts. It is suggested that each incorporated community develop ordinances that will regulate water use during droughts and coordinate with the New Mexico Drought Task Force to monitor drought conditions.

Flood Considerations. Several flood-control projects have been planned and constructed to provide flood protection in the Roswell Basin. The Two Rivers Dam and the Zuber Draw project provide flood protection to Roswell and other communities in Chaves County. The Eagle-Tumbleweed and Cottonwood-Walnut projects will provide flood protection to Artesia and communities in the southern part of the basin. If feasible, flood-control reservoirs should be constructed in areas of exposed limestone to enhance groundwater recharge.

Chaves County has a flood commissioner and a workforce whose job it is to prevent flooding in the county and to assist with flood clean up. It is recommended that emergency flood plans and warning systems be developed for unprotected areas that are prone to flooding. Floodplain studies and maps should be used in approving development of the area.

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[102] Torres, R.L., 1996, Roswell Basin Watermaster 31st Annual Report.

Table 41. Summary of Water Rights in the Roswell Groundwater Basin

Category of Use	Water Source		1996 Usage (AF)
	Groundwater (AF)	Surface Water (AF)	
Irrigation	426,300	38,745	345,278
Supplemental Irrigation			
Commercial			4135
Recreation			
Municipal & Municipal Type	43,112		22,246
Domestic and Stock (5358 wells)	16,074		10,159
Cattle Feed Pens			138
Dairies			27,976
Total	485,486	38,745	409,932

Hondo Groundwater Basin

Like other basins in the planning area, water use in the Hondo Basin is highest in the agricultural sector. Table 42 lists 1995 water use by the major users in the basin.[103, 61 above] A summary of these uses follows.

Irrigation

Hondo Groundwater Basin. The Hondo Basin includes the tributaries of the Hondo River and the mainstem of the Hondo River to the Chaves County line. Use of both surface water and groundwater occurs in the narrow river valleys where agriculture has been developed. Fruit orchards, mainly apples, irrigated pasture and some hay and truck crops are produced on the 4573 acres of irrigated land. Irrigated lands are shown in Plates 14 and 15.

Most of the farms in this basin are flood irrigated through furrows, corrugations and borders, though some sprinkler and drip irrigation systems also exist. Land leveling, installation of irrigation pipelines and ditch lining have been implemented to improve water application efficiency. A summary of 1995 water use for agriculture in the Hondo Basin is provided in Table 42.[61 above]

[103] Author Unknown, 1995, Draft Water Plan for the Village of Ruidoso.

Public Water Supply

Three major public water suppliers and several domestic cooperatives utilize both surface water and groundwater sources to provide municipal and industrial water to users in the Hondo Basin. A summary of these suppliers follows.

Table 42. 1995 Water Use in the Hondo Groundwater Basin

User	Acreage	Water Rights (AF)	Diversion (AF)	Depletion (AF)	Return Flow (AF)
Irrigation	4573		28,107	10,599	16,131
Public Water Supply					
Ruidoso Water System			1119	382	1737
Ruidoso Downs Water System			260	47	213
Capitan Water System		252	164	73	91
Total	4573	252	29,650	11,101	18,172

Village of Ruidoso. The Ruidoso Water System was established in 1948 and presently serves 7161 water connections within the Village. This system uses both surface water and groundwater. Surface waters are diverted from the Ruidoso River and Eagle Creek and stored in Grindstone Reservoir and Alto Lake. Ruidoso also draws water from a wellfield in the Eagle Creek drainage and from wells within Ruidoso. The Village has access to seven permanent wells and two exploratory or temporary wells. Ruidoso's water rights consist of 483 AF from the Ruidoso Basin and 5160 AF in the North Fork (Eagle Creek). Ruidoso also holds a 70 percent interest in 459 AF of groundwater rights in the Eagle Creek Intercommunity Water Supply Association, and has an interest in 4600 AF of surface-water rights held by the Association.[104] A significant portion of water use in the Village is by seasonal tourists and part-time residents. Ruidoso uses the return of effluent to the stream system as a credit against the withdrawal of surface water. A summary of 1995 water use by the Ruidoso Water System is presented in Table 42.[105,103 above]

Village of Ruidoso Downs. The Ruidoso Downs water system draws water from three wells and stores it in two storage tanks with a capacity of 818,000 gallons (2.5 AF). Water is delivered to 775 connections for residential and commercial uses. Like other communities in the mountain area, Ruidoso Downs has a large transient population and annual consumption averages 25.2 million gallons (77 AF). Treated water from the WWTP is discharged to the Ruidoso River. A summary of 1995 water use is provided in Table 42.[106]

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[104] *Records Furnished by the Village of Ruidoso.*
[105] *Records Furnished by the Village of Ruidoso.*
[106] *Existing Municipal Water Use, Supplies and Storage facilities.*

Village of Capitan. The Village of Capitan developed a community water system in the 1930s. The water supply presently comes from one well, although the Village owns groundwater rights and surface-water rights from Eagle Creek. The water supply is pumped to four storage tanks with a capacity of one million gallons (3 AF) and is delivered to 654 water connections that supply residential and commercial users. Capitan has 220 AF of groundwater rights that may be increased by 23 AF if return-flow credits are applied. The Village also owns 32 AF of groundwater rights and has an interest in 2311 AF of surface-water rights held by the Eagle Creek Intercommunity Water Association. The treated water from the WWTP presently enters an arroyo and eventually becomes part of the Bonito Creek flow. A summary of 1995 water use is presented in Table 42.[61 above]

Water Rights

Water rights in the Hondo Groundwater Basin are summarized in Table 43.[86 above] The 1996 exercise of these rights is also shown. Approximately 5600 acres of land have water rights for irrigation purposes. Water rights in the Hondo Basin have been defined by a hydrographic survey and these rights are currently being adjudicated in Chaves County District Court, Cause Nos. 20294 and 22600 consolidated. The Special Master hearing the adjudication suit has ruled that farm delivery requirements for irrigation in each subsection of the Hondo Basin are as follows: 3.25 AFY/acre on the Rio Bonito, 3.2 AFY/acre on the Rio Ruidoso and 3.5 AFY/acre on the Rio Hondo. Irrigation surface-water rights are concentrated in the valley along the rivers. Most of the groundwater rights are located in these same areas with only scattered tracts of irrigated land lying outside the river valleys.[86 above]

Emergency Contingency Plans

The following paragraphs discuss emergency contingency plans that have been or are being implemented for drought and flood conditions in the Hondo Groundwater Basin.

Drought Considerations. The Hondo Basin is located in a mountain area and receives heavy use by a transient population, especially during the summer when streamflow is lowest. The Village of Ruidoso has experienced water shortages during droughts in the past and passed ordinances to control water use during these periods. The Villages of Capitan, Ruidoso Downs and Ruidoso have initiated the development of long-term comprehensive water plans. These plans should contain drought contingency programs. Ordinances should be passed by each community to control water use during periods of drought or water shortage. The counties as well as the incorporated communities should coordinate drought activities with the New Mexico Drought Task Force.

Flood Considerations. Flooding occurs in these mountain communities due to the numerous arroyos and streams that run through them. A few dams, such as Grindstone, Bonito and the Mescalero Indian Reservoir provide some protection. The river bottoms have been developed for agriculture and rural living and are subject to flooding. Emergency warning systems should be developed for this area and plans for protection and restoration should be developed.

Peñasco Groundwater Basin

Irrigated agriculture is the dominant water user in the Peñasco Groundwater Basin, diverting water primarily from streams. A summary of irrigation and other water uses in the basin follows.

Irrigation

Both surface water and groundwater are used in agriculture production along the Peñasco River, Blue Creek, Agua Chiquita and other tributaries in this watershed. Fruit orchards, irrigated pasture and some hay and vegetable crops are grown on the 2413 acres of irrigated land in the Peñasco Basin. Irrigated lands are shown in Plates 14 and 16.

Table 43. Summary of Water Rights in the Hondo Groundwater Basin

Category of Use	Water Source		1996 Usage (AF)
	Groundwater (AF)	Surface Water (AF)	
Irrigation	2664	16,289	2664[1]
Supplemental Irrigation	5674		5690
Commercial	62		55
Recreation	350		73
Municipal & Municipal Type	7629	6900	2076
Domestic and Stock (1884 wells)	5736		1429
Total	22,115	23,189	11,987

[1] Groundwater Only

Flood irrigation through furrows, corrugations and borders is the principal method of applying irrigation water to fields. Many of the irrigation systems have been improved by land leveling, ditch lining and installation of irrigation pipelines. A summary of irrigation use in 1995 is provided in Table 44.[61 above,107]

Public Water Supply

Water is supplied to municipal and industrial users by a few community and cooperative water supply systems. A summary of two of the larger systems follows.

Mayhill. The Mayhill water system in Otero County was constructed in the 1950s. This system withdraws water from one well, has one storage tank with a capacity of 16,000 gallons (0.05 AF) and supplies water to 50 connections. Mayhill has 270 AF of water-use declaration. Mayhill does not have a wastewater treatment system, but return flow to the aquifer may occur from individual septic systems. A summary of 1995 water usage is presented in Table 44.

Table 44. 1995 Water Use in the Peñasco Groundwater Basin

User	Acreage	Water Rights (AF)	Diversion (AF)	Depletion (AF)	Return Flow (AF)
Irrigation	2413		11,012	5261	5836
Public Water Supply					
Mayhill Water System		270	8	4	4
Cloudcroft Water System		850	124	96	28
Totals	2413	1120	11,144	5361	5868

Cloudcroft. The Village of Cloudcroft developed their first water system in the early 1950s to provide water for the permanent residents and the large transient population that visits the area. Cloudcroft is located in the Sacramento Mountains in Otero County. The municipal water system provides water to 900 connections. Only an estimated 250 of these are connections to being homes and businesses of permanent residents. The Village owns three wells, one of which is presently capped off. Water is also diverted from eight springs in the Pump House and James Canyon areas. Water from the springs and wells is delivered to a 200,000-gallon (0.6 AF) storage tank and three other storage tanks with a capacity of 750,000 gallons (2.3 AF) for treated water. Cloudcroft has 850 AF of water rights. The wastewater treatment system of Cloudcroft is one of two points where water is exported from the planning region. The treated water from the wastewater system discharges into an unnamed canyon that drains to the Tularosa Basin. Presently none of the water from this plant is reused. Cloudcroft completed a comprehensive study in 1995 that includes projections of water needs for

[107] Mevatec Corporation, 1995, Comprehensive Study of the Cloudcroft Infrastructure System: Prepared for the Village of Cloudcroft.

the next 20 years and recommendations for system improvements. A summary of 1995 usage is presented in Table 44.[61 above, 107 above]

Water Rights

A summary of water rights in the Peñasco Groundwater Basin is presented in Table 45.[86 above] The 1996 exercise of these rights is also shown. There are approximately 2413 acres of irrigated farmland in the Peñasco Groundwater Basin and 3200 acres of farmland in the Hope area. Agricultural lands irrigated with groundwater are assigned a duty of three AFY per acre, while those irrigated with surface water are given a duty of three to four AFY per acre. Rights are scattered along the river valleys where the streams and the alluvial fill aquifer provide adequate water.[86 above]

Emergency Contingency Plans

The following paragraphs discuss emergency contingency plans that have been or are being implemented for drought and flood conditions in the Peñasco Groundwater Basin.

Drought Considerations. Like the Hondo Basin, the Peñasco Basin is located in the mountain area and is subject to a large transient population. Cloudcroft has developed a comprehensive plan that addresses the facilities, supply and management of its water resources. The plan does not discuss conservation programs or drought contingency consideration. Mayhill is the only other incorporated community in the Peñasco Basin and does not have a plan for water resources. The incorporated communities should develop drought plans that are coordinated with the New Mexico Drought Task Force and the rural areas should work with the county and other agencies to coordinate drought considerations.

Flood Considerations. Cloudcroft contains the major population of this basin and is located at the summit or top of the watershed. The drainages that affect this community are small but can experience flooding. Most of the rural community is concentrated along arroyos and streams and is subject to potential flooding. Flood warning systems should be implemented in the area to provide needed protection.

Carlsbad Groundwater Basin

The Carlsbad Groundwater Basin study area is the largest user of surface water for irrigation of the declared basins in the planning area--almost 30,000 acres were under irrigation in 1995. The City of Carlsbad is also a significant user of groundwater. A summary of irrigation and other water uses in this basin follows.

Irrigation

Carlsbad Irrigation District. The CID serves 25,055 acres of irrigated land. Water for the project is diverted from the Pecos River at Avalon Dam and from the Black River. The crops grown on these lands are mainly cotton and alfalfa. Some silage corn and other forage crops, as well as small grains, are also used in the crop rotations. Pecan orchards are becoming of major importance in the district. Irrigated lands are shown on Plate 20.

Because of the availability of a large head of water, most of the irrigated land has been leveled into basin borders. The water is delivered through irrigation ditches, many of which have been concrete lined with turnouts and check gates installed. Some of the main canals and many of the laterals owned by CID have also been lined with concrete and rubble masonry to improve delivery efficiency. A summary of water use by CID in 1995 is given in Table 46.[61 above]

Outside Carlsbad Irrigation District. There are approximately 2942 acres of irrigated land in the Carlsbad Basin outside CID relying primarily on groundwater. Crops grown on this acreage are basically the same as those grown within CID.

Table 45. Summary of Water Rights in the Peñasco Groundwater Basin

Category of Use	Water Rights		
	Groundwater (AF)	Surface Water (AF)	1996 Usage (AF)
Irrigation	1782	19,362	4002
Supplemental Irrigation	2220		
Commercial	73		82
Recreation	255		255
Municipal & Municipal Type	1305		1120
Domestic and Stock (521 wells)	1563		391
Totals	7198	19,362	5850

Most of the irrigation wells close to the river or canals produce slightly to strongly saline water which can only be used for flood irrigation. The lands have been leveled to border basins, and pipelines and ditches have been installed to deliver water to fields. Many of the ditches have been concrete lined and outfitted with turnouts and check gates for better water control. Landowners were required to install meters on the wells to control water withdrawals, which are limited to 3 AF per irrigated acre. The water use for these irrigators in 1995 is shown in Table 46.[61 above]

Table 46. 1995 Water Use in the Carlsbad Groundwater Basin

User	Acreage	Water Rights (AF)	Diversion (AF)	Depletion (AF)	Return Flow (AF)
Irrigation					
Carlsbad Irrigation District	25,055		105,445	54,967	41,858
Outside Carlsbad Irrigation District	2942		10,528	6022	4527
Black River	1249		10,050	5323	4522
Delaware River	670				
Public Water Supply					
Carlsbad Water System		37,255	8955	5354	3601
Loving Water System		800	496	248	248
Totals	29,916	38,055	135,474	71,914	54,756

Black River. The Black River area is part of the Carlsbad Basin. The river heads in the Guadalupe Mountains southwest of White City and enters the Pecos River approximately two miles northeast of Malaga in Eddy County. Farming began here in the early 1900s near Rattlesnake and Blue Springs. Today, farms are scattered from an area south of Rattlesnake Springs to the Malaga area. These farms use both surface water and groundwater for irrigation purposes.[98 above] There were 1249 acres served with irrigation water in 1990 along the Black River.

The lands irrigated in the Black River area have been leveled into border basins. Irrigation ditches and pipelines have been installed to deliver water to fields. A few sprinkler systems are also in use. Some ditches have been improved with concrete lining, turnouts and checkgates. A summary of 1995 water use is presented in Table 46.[61 above]

Delaware River. The Delaware River heads in the Guadalupe Mountains in Texas. Only a small portion of this river passes through New Mexico, entering the state four miles west of Highway 285. Irrigation began on the Delaware in the 1940s with the construction of a diversion dam and canal. When the diversion was washed out in the 1960s, river and groundwater pumping were attempted unsuccessfully to provide irrigation water. Today, only one farm of 670 acres continues to irrigate.[98 above] Diversions, depletions and return flows on this farm are included in the amount for irrigation outside the CID in Table 46.[61 above]

<u>Public Water Supply</u>

Water for municipal and industrial use is supplied by a major municipal water system in Carlsbad and several small community and cooperative systems. A summary of water suppliers follows.

Carlsbad. The City of Carlsbad developed a municipal water system in the late 1920s. Presently, the system serves 9642 water connections. Carlsbad's primary water supply comes from nine wells developed southwest of the City in the Capitan Reef aquifer. Water is pumped to four storage tanks with a combined capacity of 12 million gallons (37 AF). Carlsbad has 9532.15 AF of water rights from the Carlsbad Basin-Capitan Reef aquifer. Water from this system is used for residential, commercial, light industry and recreation. The City of Carlsbad also owns 9693 AF of surface-water rights. Including 499 AF of diversion rights from the Pecos River, 600 AF for recreation use in Lake Carlsbad and 164 AF from CID. This water is used for irrigation of farmland, parks, golf courses and for recreational uses on lakes within the City. The City also owns 60 AF of shallow aquifer rights for irrigation. In 1972, Carlsbad acquired a wellfield in the edge of Lea County, northeast of the City, consisting of 18 developed wells with 18,288 AF of water rights. This is one point where water is presently imported into the planning region. The water from this system is used for municipal, commercial and industrial purposes with a small amount being used for domestic and livestock purposes. The WWTP for the City presently produces 3316 AF of return flow to the Pecos River. The City is required to return 1058 AF to the river, but is presently investigating ways to recycle the balance of the water. The City of Carlsbad has completed a 40-year water plan and a water conservation plan to guide water needs and development. A summary of 1995 water use is given in Table 46.[30 above]

Loving. The Village of Loving developed a water system in 1951. The system provides water to approximately 600 residential and commercial connections. Loving has four wells west of the Village with 800 AF of groundwater rights. The water is stored in three storage tanks with a capacity of 800,000 gallons (2.5 AF). A summary of 1995 water use is presented in Table 46.[61 above]

<u>Water Rights</u>

Water rights in the Carlsbad Groundwater Basin are summarized in Table 47.[86 above] The 1996 exercise of these rights is also shown.

The Carlsbad Basin has a total of approximately 36,000 acres of irrigated farmland; 9855 acres have permitted groundwater supplemental to surface water, 5822 acres have declared groundwater supplemental to surface water, 6392 acres have declared groundwater only and 13,931 acres have surface waters only. The basin is presently being adjudicated for surface water and groundwater. Groundwater use is for irrigation has a maximum duty of three AF per acre per annum. All groundwater rights used in agriculture are in private ownership. The ownership of surface-water rights under the CID is presently under question and will be determined by the Court. Some surface-water rights from Black River and other tributaries are under private ownership. The water rights involved with irrigated farming are located mainly along the Pecos and Black Rivers with small amounts on other tributaries. These and other water rights are listed in Table 47.[86 above]

Emergency Contingency Plans

The following paragraphs discuss emergency contingency plans that have been or are being implemented for drought and flood conditions in the Carlsbad Groundwater Basin.

Drought Considerations. The City of Carlsbad has developed a 40-year water management plan and a conservation plan. Carlsbad has also prepared ordinances to initiate some of the recommendations in these plans. Neither of these plans address drought as a separate issue. The Village of Loving is the only other incorporated community in this basin. Loving does not have a long-term water plan or a conservation plan. There is a large rural population scattered throughout the central part of the Carlsbad Basin that depends on community water systems. Very few of these systems have developed plans to protect their users against droughts. The incorporated communities, rural community systems and the counties should develop plans that address drought issues and should coordinate these plans and actions with each other as well as the New Mexico Drought Task Force.

Flood Considerations. One of the purposes for the construction of Brantley Dam was to provide flood protection to Carlsbad and property along the river. Avalon Dam also provides some flood protection from floodwater entering the river below Brantley Dam. Two other flood-control projects have been constructed in the Carlsbad Basin. The Hackberry Draw project provides flood protection to Happy Valley and Carlsbad and the Cass Draw project provides protection to rural areas south of Carlsbad. Carlsbad and the surrounding areas are still susceptible to floods from two major tributaries to the Pecos River below Brantley Dam.

The incorporated communities should work with Eddy County and the appropriate federal agencies to develop plans for flood warning systems, floodplain development and flood protection where possible.

Miscellaneous Uses Throughout Planning Area

Scattered throughout the planning area are a number of other water uses, including agriculture-related, commercial, domestic, livestock and recreational uses. Most of these uses are difficult to quantify within a single declared groundwater basin, so are presented here as general use within the planning area.

Table 47. Summary of Water Rights in the Carlsbad Groundwater Basin

Category of Use	Water Source		1996 Usage (AF)
	Groundwater (AF)	Surface Water (AF)	
Irrigation	19,178	176,000 Storage Rights CID	8404[1]
Supplemental Irrigation	47,032		235
Commercial	12,502		5949
Recreation	105		
Municipal & Municipal Type	10,117		8849
Domestic and Stock (1493 wells)	4542		1120
Total	93,476	176,000	24,557

[1] Groundwater Only

Domestic Cooperatives

There are many community or rural water co-ops (suppliers) in the Lower Pecos River planning region. These systems serve from one to 1070 customers. Some of these systems have their own water supply from wells, springs or surface flows, while others purchase their water supply from municipalities, villages or other water co-ops. A listing of systems that were not previously discussed and some of the pertinent information that is available for each is found in the Table 48.[108]

Agriculture Related Uses

Dairies. Small dairies were a part of the original development of agriculture throughout the planning region. Due to economic conditions and the availability of feed at the time, most of the small dairies had vanished by the late 1960s. Larger dairies, those with over 500 cows, began moving into the area in the mid 1970s. Most of the dairies found in the planning region today have herds ranging from 1500 to 6000 cows. They first occupied the area around Roswell and have since moved to farms from Roswell to south of Artesia. All of the large commercial dairies are presently located in the Roswell Basin. Dairies are required to secure water rights as a commercial business. These water rights transfer at a rate of two AF of commercial use for every three AF acquired from agricultural use. Water requirements for a dairy average approximately 100 gallons per day per cow. There are an estimated 79,000 commercial dairy cattle in the planning region. Water use by dairies in 1995 is estimated at 8850 AFY, not including irrigated acreage to raise feed for the cattle. Some dairy wastewater is used for irrigation.

[108] *Existing Municipal Water Use, Supplies and Storage Facilities.*

Table 48. Domestic Water Supply Cooperatives in the Planning Area

System	Water Rights (AF)	No. of Connections	Storage Capacity (gal)	Average Diversion (AFY)	Est. Pop.	City and Zip Code
Fort Sumner Groundwater Basin						
Fort Sumner Valley				103	565	Fort Sumner 88119
Roswell Groundwater Basin						
Artesia Rural Water Co-op	512.7			172	1700	
Atoka						
Back 40 Water System						Roswell 88201
Berrendo Water Users Co-op	1450.1			434	1350	Roswell 88201
Caprock Water Company						Artesia 88210
Cottonwood Improv. Assn.	343.2			94	1328	Artesia 88210
Cumberland Co-op Wtr. Users	231.4				500	
Greenfield Mut. Dom. Wtr. Consumers Association	80	96	150,000	23	228	Hagerman 88232
Morningside Water Co-op				22	200	Artesia 88210
Riverside Water Users Co-op	31.8				150	Artesia 88210
Sun Valley Sanit. Dist. Wtr.						
Sunset Manor Trailer Park						Roswell 88201
Valley View Estates Wtr. Sy.						
South Springs Acres	145.5			128	60	Roswell 88201
Fambrough Water Co-op	68.9				200	Roswell 88201
Hondo Groundwater Basin						
Aqua Fria Water System		74	14,000	17	200	Ruidoso Downs 88345
Alpine Vil. Sanit. Wtr. Sys.					48	Ruidoso 88345
Alto Village Water System	501.9	750			23	
Angus Water System		1	10,000	9.		Angus 88316
Camp Sierra Blanca Wtr. Sys.		1	200,000	13	80	Ft. Stanton 88323
Enchanted For. Water Co-op		69		7		
Fawn Ridge Prop Own Assn						
Ft. Stanton Hosp Wtr. Sys.				60	400	Capitan 88316
Sun Valley Sanit.					80	
Apple Blossom & White						
Angel Mesa					23	
Rancho Ruidoso Village				7	118	Ruidoso 88345
Ruidoso Water System		7161		1,328	5728	Ruidoso 88345
Shady Grove Trailer Park Wtr.						
Silver Cloud Wtr. Users Assoc.					130	
Silver Springs Mutual Domestic Water Consumers Assoc.						
Lincoln Mut. Domestic Water	29.5	53	30,000	13	65	Lincoln 88338
Circle B Water System						

Table 48. Domestic Water Supply Cooperatives in the Planning Area (continued)

System	Water Rights (AF)	No. of Connections	Storage Capacity (gal)	Average Diversion (AFY)	Est. Pop.	City and Zip Code
Peñasco Groundwater Basin						
Cedar Crk. Cabin Own. Assn.						
Chippeway Park Water Sys.						
Cloud Country Est. Wtr. Sys.					100	
Cloud Ctry. W. Wtr. Users		332		187	206	Artesia 88210
Cloudcroft Municipal Wtr. Sys.	850	900	950,000	215	650	Cloudcroft 88317
Mayhill Water System	270	50	16,000	8	150	Mayhill 88339
Ponderosa Pines					75	
Robinhood Park Water Assn.					325	
Twin Forks Ranch Inc Wtr.						
Weed					32	
Carlsbad Groundwater Basin						
Carls. Cvns. Pk. Wtr. Sys.		33	1,500,000	35	5000	Carlsbad 88220
Carls. Mun. Water Sys	37255	9642	12,000,000	8,502	27400	Carlsbad 88220
Happy Valley Water Co-op	117.5	240	100,000	109	800	Carlsbad 88220
Heath Trailer Park System						
Jewel Street Water Co-op						Carlsbad 88220
Loving Water System	800			228	1303	Loving 88256
Malaga Water System		150		109	640	Malaga 88263
Orchard Lane Trailer Pk. Wtr. Sys.						Carlsbad 88220
Otis Water Users Co-op	1134.3	1069	500,000	758	3286	Carlsbad 88220
West Winds Mobile Hm. Pk. Wtr. Sys.						

Cattle Feed Pens. In the planning area, there is one large feeding operation of 10,000 head of cattle or more, and eight small feeding operations of 500 head of cattle or less. These feeding operations are located in the Fort Sumner, Roswell and Carlsbad Basins. Concentrated cattle feeding operations have water rights similar to dairies in that water rights are rated as commercial. When agriculture water is transferred to feed lots, one-third is withheld due to a relatively small amount of return flow. Based on an estimated use of ten gallons per day per animal at full capacity of 500 head, the eight feeding operations would consume an estimated 44.8 AFY. The large feeding operation at full capacity would consume an estimated 112 AFY. Reported use in 1996 is 138AF.[86] above

Commercial Uses

Cheese Plants. As the number of dairies have increased in the planning region, the interest in locating processing plants in the area has also increased. A cheese plant moved to the area southeast of Roswell in 1988. This plant was expanded in 1995. There are presently prospects of locating other cheese plants near Fort Sumner and Artesia. The processing of cheese requires large quantities of fresh water. Wastewater is also a by-product of cheese production. This is low-quality water and is not usable for domestic purposes. Water rights for this type of processing plant are usually acquired from agriculture.

Oil and Gas Development. Exploration and development of oil and gas peaked in the mid-1980s and is presently steady or slightly declining. Water is used for several purposes in oil and gas fields during drilling and development. Fresh water is usually purchased from other sources such as municipalities, community water systems and individuals with agricultural or other water rights. Gas and oil production also produces poor-quality water from some wells that must be injected into deep formations containing brackish water.

Mining. The largest mining industry in the planning region is the potash mining operation located in Eddy County. Presently five mines operate east of Carlsbad. The potash mining industry uses water in mining of potash ore and processing it into a concentrate for shipment or into potassium fertilizer products. The potash mines also produce low-quality water that is not usable for other purposes. This water is usually pumped to playa lakebeds or ponds where it evaporates.

Other mining operations that occur throughout the region include sand and gravel operations, some building stone quarries and a few small hard-rock mining operations. These mining operations require water in some of their processes. In 1995 the estimated withdrawals of water for mining operations, including gas and oil, was 13,945 AF. This is water that was drawn from wells, springs and streams, but does not include water supplied by other water users; 4090 AF of this withdrawal was considered depleted from the water resources and the balance of 9800 AF was return flow.[61 above]

Other. The WIPP plant, the fabricating and construction businesses, the bus manufacturing business, several greenhouses and numerous commercial enterprises all use water in their daily activities. Most of the water used by these enterprises is supplied from the municipal or community water systems serving the area where they are located.

Domestic Wells

Water rights for domestic wells were developed on the premise of providing the water needed for a family to produce the food necessary to sustain them through the year. In early times the water needed to meet this criteria was estimated to be three AF, and almost all domestic wells to date have been granted three AF of water rights. Domestic wells were first developed in rural areas, usually on farms or ranches. As the population in the region has increased and people have sought to move from the crowding of the cities, subdivisions have been developed near the cities. Many of the subdivisions are developed on plans for each homeowner to install a domestic well. Since domestic well applications are seldom denied and they are not required to acquire water rights from other water users, these developments add to the fully appropriated water basin. Domestic wells are not metered. The OSE lists 8452 domestic wells in the planning region (Table 54).[109] At a permitted water right of three AF per well, approximately 25,356 AF of water rights are allocated to domestic wells. The OSE report estimated domestic withdrawal for 1995 at 7851 AF of water in the planning region.[61 above] The estimate displayed in Table 54 is based on 0.35 AFY of withdrawal per household and return flow of about ten percent of withdrawals. Net domestic well consumption is about 2600 AFY. Much of that is taken from aquifer storage, so that domestic wells are not a substantial factor in the annual water balance.

Domestic wells throughout the planning area are shown on Plate 28.

Livestock Ponds, Tanks and Wells

Livestock wells are permitted on the same basis as domestic wells, with a three AF water right. These permits are seldom turned down and there are no requirements for metering of the well. Livestock wells are usually developed in a locality where water is needed and concentrations of well development rarely occurs. In many instances water is pumped or flows by gravity through a pipeline to a location several miles from the well. Large open tanks are used to store livestock water. These tanks, while maintaining a reliable supply of water, have a high rate of evaporation loss unless covered with a solid top. Ponds developed for livestock water under a permit can store up to ten AF of water. Most of these ponds are developed on intermittent arroyos and are susceptible to high evaporation and seepage losses. Withdrawals for livestock were estimated at 4753 AF in 1995. Of this amount, 4543 AF was consumed and 210 AF were returned to the system.[61 above]

Recreational Uses

Although water users and project operators try to maintain recreational pools in the major reservoirs on the Pecos, minimum pools are required only in Brantley and Sumner Lakes. Brantley requires a minimum pool of 2000 AF[110] and Sumner requires a minimum pool of 2000 AF.[111] Of the reservoirs and lakes listed in Tables 25 and 26, only Lake Van and Upper and Lower Tansill Dams are maintained primarily for recreational purposes. Other lakes such as Santa Rosa, Bonito, Grindstone and Willow Lake all have secondary recreational benefits and receive heavy use for fishing, boating, water skiing and swimming. Lakes that are developed and maintained for recreational use as the primary purpose must have water rights allocated to recreation. The three major reservoirs, Lake Van and Upper and Lower Tansill Dams, all have water rights devoted to a permanent pool or recreational uses. The remainder of the lakes list recreation as a secondary benefit and are subject to complete drainage. The status of the lakes on the Mescalero Reservation is unknown at this time.

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[109] New Mexico Office of the State Engineer, 2001, WATERS Database.
[110] Corps of Engineers, 1989, Water Control Manual Brantley Dam and Reservoir.
[111] Corps of Engineers, 1993, Water Control Manual Sumner Dam and Lake Sumner.

The mountain areas in the western part of the planning region receive heavy use as recreation areas. Gambling, winter skiing, horse racing and other outdoor recreation opportunities have been developed as part of the economic base of the communities of Ruidoso, Ruidoso Downs, Cloudcroft and Capitan and the Mescalero Reservation. These activities are the basis for the development of large areas of summer homes and other lodging facilities to accommodate the transient population. Ruidoso reports that the transient population can exceed 45,000 on weekends of peak use. The development of wells for domestic use in the many subdivisions and the increased desire to keep water instream for recreational and aesthetic purposes has placed a burden on the water resources of the area. This use of water in the upper reaches of the watershed and the recharge areas of the groundwater aquifers has a direct affect on the entire water system for the planning region.

Pecos River Compact Deliveries

While deliveries of surface water to Texas under the Compact do not constitute a usage of water within the planning area, they represent a significant restriction on the amount of water that can be consumed within the planning area. Compact deliveries, obligations and departures from 1952 to 1983 are shown in Table 49.[112]

After many years of squabbling over rights to the waters of the Pecos River, in 1947 Texas and New Mexico agreed on the division of the river waters and the Compact was signed and ratified by both states. A copy of the Compact is provided in Appendix E. The language in the Compact did not limit its focus to just the surface-water flows but specified that man's activities would be restricted to limit the effects on the water supply at the state line.

A U.S. Supreme Court ruling in 1988 stated that New Mexico had allowed man's activity to reduce the flow of the river and ordered New Mexico to correct those mistakes. These court orders have required New Mexico to deliver an average of 80,670 AF of water to Texas since 1988. The yearly delivery is calculated through a complicated formula that considers river flows, floods, diversions and a number of other factors (see Section IV for a complete discussion of Compact accounting). A copy of the ISC procedures and spreadsheet used for Pecos River Compact accounting is in Appendix F.

[112] Murthy, V.R.K., Dean, Z.L., Kabir, N., and Whitenton, R.M., 1985, Computation of Departures of Stateline Flows of the Pecos River from the 1947 Condition During the 1950-83 Period: Texas Department of Water Resources.

New Mexico, through the ISC and the OSE, has acquired funds through the State Legislature to retire and lease water rights to meet water delivery demands (Plate 29). The OSE[113] reports the status of their program to provide Compact deliveries as follows:

"The Pecos River Compact allocates the water of the Pecos River between Texas and New Mexico. In its 1988 amended decree in Texas v. New Mexico, the U.S. Supreme Court found that New Mexico had underdelivered an average of 10,000 acre feet of water to Texas per year between 1950 and 1983. New Mexico agreed to pay $14 million in damages to Texas for historic underdeliveries in a negotiated settlement. Administration of the compact by the Supreme Court's river master requires that New Mexico make up any year-end net shortfall in current deliveries within nine months. New Mexico may accumulate credits. It may not accumulate underdeliveries.

In 1991, two consecutive years of annual shortfall had brought New Mexico's cumulative credit down to 11,100 acre-feet, and net shortfall seemed eminent. The N.M. Legislature directed the ISC to purchase and retire adequate water rights to meet compact obligations, and authorized severance tax bond funds for this purpose."[114]

The New Mexico Legislature, in response to the court order, directed the Commission to purchase and retire adequate water rights to increase flows of the Pecos River to meet compact obligations, and to avoid catastrophic economic consequences that may result from a water call in the Pecos River Basin and net shortfalls in deliveries to Texas. Also, the legislature authorized the sale of severance tax bonds to fund this purpose. Appropriations were made in alter years from the Irrigation Works Construction Fund.

Approximately $28 million was spent on the Pecos River water rights acquisition program between 1991 and 2000; $16.3 million on the purchase and retirement of 25,500 acre-feet of water rights, $11 million on leases of water to meet short-term delivery needs and $500,000 on administrative, professional and appraisal fees. Another $3 million is in an escrow account pending closing of a major water rights purchase.

Habitat Uses

Water in the planning region has not been designated for riparian use or instream flow on a permanent basis except for a 28 cfs release from Brantley Dam. Temporary instream flows have been used in studies of endangered species. Applications have been filed with the OSE for instream flows on some of the perennial streams. Riparian and instream flows occur in a natural state in conjunction with other uses. Waters that flow from springs and streams create riparian areas. During wet years riparian areas also develop in playa lakes. Drought conditions impact these areas.

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[113] New Mexico Office of the State Engineer, May 3, 2000, http://www.ose.state.nm.us.

[114] New Mexico Office of the State Engineer, 1999, 1997-1998 Annual Report, http://www.seo.state.nm.us/.

Table 49. Sumner Dam to New Mexico-Texas State Line Reach Summary of Annual Inflow-Outflow Computations in 1000 AF Units

Year	Three-Year Average Delivery at Red Bluff	Compact Obligation	Departure
1952	100.0	91.6	8.4
1953	53.1	60.7	-7.6
1954	104.5	98.7	5.8
1955	136.7	138.2	-1.5
1956	136.9	143.3	-6.4
1957	77.3	94.9	-17.6
1958	77.9	97.8	-19.9
1959	83.9	101.2	-17.3
1960	103.9	132.2	-28.3
1961	73.7	95.3	-21.6
1962	68.2	97.9	-29.7
1963	45.9	77.0	-31.1
1964	31.7	59.0	-27.3
1965	35.9	57.0	-21.1
1966	130.2	117.8	12.4
1967	134.4	133.9	0.5
1968	129.9	132.1	-2.2
1969	49.4	87.4	-38.0
1970	51.7	86.8	-35.1
1971	48.7	81.0	-32.3
1972	37.0	65.4	-28.4
1973	51.9	84.4	-32.5
1974	100.4	123.7	-23.3
1975	99.8	105.9	-6.1
1976	80.5	75.5	5.0
1977	26.8	38.0	-11.2
1978	46.1	56.0	-9.9
1979	54.8	66.7	-11.9
1980	75.6	87.2	-11.6
1981	55.6	62.4	-6.8
1982	52.2	63.3	-11.1
1983	37.7	58.2	-20.5
Averages	74.8	89.7	-14.9

The U.S. Fish and Wildlife Service establishes water requirements as part of endangered species recovery and habitat designation. The OSE reports the following status of meeting those new requirements: [115]

*"On August 5, 1991, the U.S. Fish and Wildlife Services issued a biological opinion finding that operation of the Pecos River reservoirs by the U.S. Bureau of Reclamation harmed the Pecos bluntnose shiner (*Notropis simus pecosensis*) which is federally protected as a threatened species under the Endangered Species Act (ESA). On January 13, 1992, U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service, the New Mexico Department of Game and Fish and the Carlsbad Irrigation District entered into a Memorandum of Understanding (MOU). The MOU provided that Reclamation would fund a five-year study by the Fish and Wildlife Service and the Department of Game and Fish to determine the biologic and hydrologic needs of the Pecos bluntnose shiner and to develop a water-budgeting hydrology model based on daily flows for the reach of the Pecos River from Santa Rosa Dam downstream to the headwaters of the Brantley Reservoir. The research under the MOU ended in 1996 and the MOU was extended in February of 1997 for a period of three years to complete the data analysis, interpretation of results and management recommendations. The Office of the State Engineer joined the extended MOU. The draft final reports were submitted to the ISC for review in July 1999.*

In November 1998, Reclamation took over operation of Sumner Dam in order to provide a minimum flow of 35 cfs at Acme gage north of Roswell, for protection of the bluntnose shiner. Reclamation projected that the minimum-flow regime would increase depletions on the Pecos by between 5,000 to 13,000 acre-feet per year. To implement the ISC's policy goals that ESA recovery activities take place within the framework of state law and that any new depletions be accompanied by water-rights offsets or compensation, the ISC and Reclamation entered into a lease agreement on November 13, 1998. The agreement provided that the ISC would lease water held in the Pecos Water Conservation Program to Reclamation to offset any depletions caused by the minimum-flow regime. To protect New Mexico's ability to meet its Pecos River Compact obligations, the lease further provided that Reclamation would make its best efforts to offset any new depletions with other valid New Mexico water rights. On April 23, 1999, the State Engineer approved two Bureau of Reclamation applications for temporary permits to transfer 2,600 acre feet of water from wells drilled in the Roswell aquifer as a partial offset to the 3,000-4,000 acre feet estimated to result from Reclamation's operations at Sumner Dam. The groundwater rights are associated with irrigation at Reclamation's Seven Rivers Ranch and Karr Farms. The lease and the permit established an important precedent for future ESA recovery activities."

Actual requirements for habitat maintenance and species recovery are unknown, but are planned to be provided as a new use within the system of water-rights transfers in the Lower Pecos Valley.

Summary of Water Rights and Uses

Table 50 summarizes the ground and surface-water rights by category in the planning area and the estimated 1995 and 1996 use. Differences between rights and diversions arise from different sources of the data and possible transfers among the

[115] New Mexico Office of the State Engineer, February 20, 2001, http://www.ose.state.nm.us.

categories. Table 51 shows 1990 water use in the planning area inventoried by the USGS by hydrologic unit.[116]

Agriculture remains the largest user of appropriated water in the planning region. Agriculture is also an important part of the economic base of the planning region. Agriculture draws its water supplies from both surface water and groundwater resources. The second largest uses are public water suppliers, which include the municipal water systems and the rural or co-op water systems. The public water systems supply water for residential, commercial and industrial uses. Other users such as WIPP and the mining, gas and oil and livestock industries also use water from these systems. Livestock and domestic uses rank third. Mining is the fourth largest water user. Water loss from lakes, streams, ponds and other unprotected water sources is very high due to evaporation, especially in the desert regions. Because the water resource is fully appropriated, new demands such as dairies, cheese plants, recreation, habitat maintenance and species recovery must be fulfilled by reducing use in other areas, or by salvaging unmanaged water losses.

Return-Flow Analysis

Return flow is the unused portion of a diversion that flows back to the groundwater or surface-water system. It is equal to the diversion minus the consumptive use. Transmission losses such as canal leakage, reservoir seepage, and pipe leakage are sources of return flow. In the Pecos River Basin, return flow eventually reaches the Pecos River. Figure 29 graphically depicts return flow from major diversions and other gains and losses in the planning area. Estimated return flow from public water supply and from agriculture in the planning area is shown in Tables 52 and 53, respectively.[61 above] Estimated return flow from domestic wells is shown in Table 54.

Table 50. Summary of Water Rights and Uses in the Planning Area Reported by OSE

Category of Use	Water Rights		Diversions	
	Groundwater (AF)	Surface Water (AF)	1995 (AF)	1996 (AF)
Irrigation	543,777	298,396	622,278	504,715
Commercial	12,787		5548	10,253
Recreation	863			331
Municipal & Municipal Type	63,652	6900	35,443	34,784
Domestic & Stock (10,129 wells)	30,795		12,604	13,696
Cattle feed pens	15			138
Dairies			8850	
Mines	6532		11,308	
Industrial	881		1,341	
Well Flooding	1155			
Total	660,457	305,296	697,372	563,917

[116] U.S. Geological Survey, November 12, 2000, http://www.usgs.gov.

Table 51. 1990 Water-Use Inventory in the Lower Pecos Valley Reported by USGS

Hydrologic Unit	Name	Withdrawal (AFY)		Total Withdrawal (AFY)	Consumptive Use (AFY)	Conveyance Use (AFY)
		Groundwater	Surface Water			
03	Upper Pecos	15,800	40,400	56,200	28,100	11,000
05	Arroyo Del Macho	22,400	3260	25,600	18,700	800
07	Upper Pecos-Long Arroyo	269,500	18,000	287,600	219,600	4500
08	Rio Hondo	67,590	27,100	94,900	60,800	7300
09	Rio Felix	29,300	3200	32,500	24,400	800
11	Lower Pecos-Black	72,000	70,900	142,900	78,100	15,800
Totals		476,590	162,600	639,700	429,700	40,200

Figure 29. Discharge, Major Surface Diversions and Return Flow Along the Pecos River Mainstem

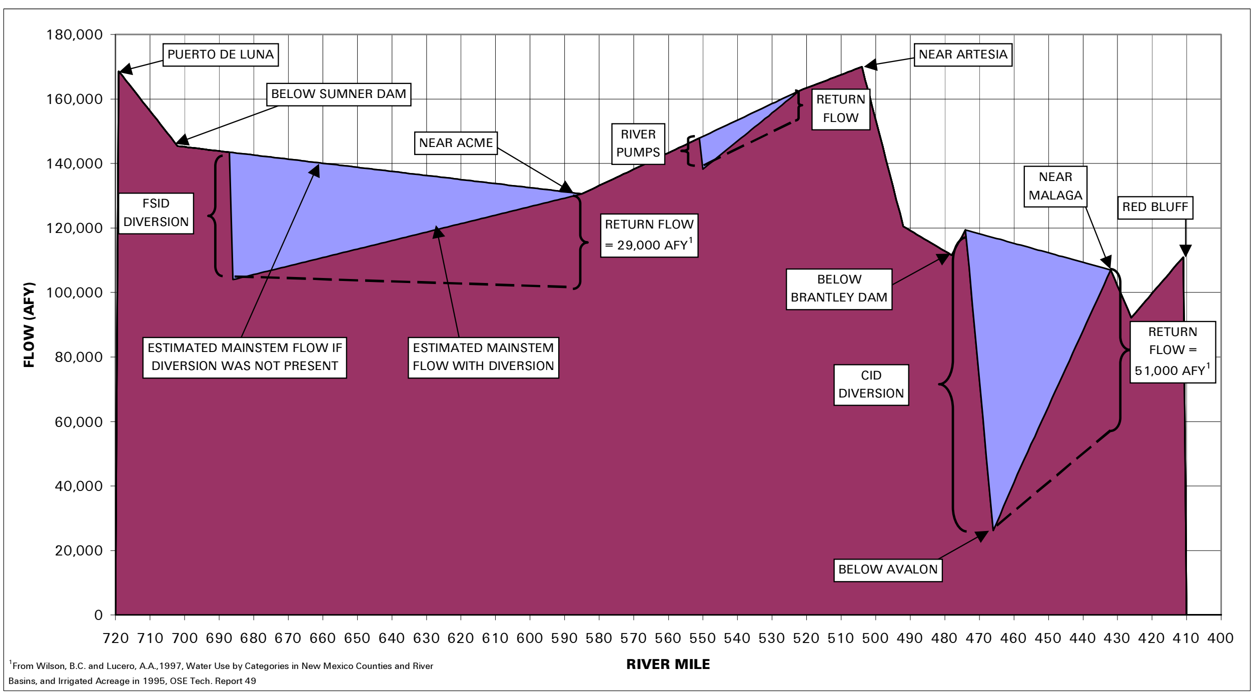


Table 52. Municipal Return Flow in 1995

Public Water Supplier	Withdrawals (AF)	Consumptive Use (AF)	Return Flow (AF)	Return Flow as % of Withdrawals
Fort Sumner Water System	369	236	133	36
Berrendo Water Users Association	1457	728	729	50
Roswell Municipal Water System	15,120	13,457	1663	11
Dexter Water System	1019	408	611	60
Hagerman Water System	778	389	389	50
Lake Arthur Community Water System	54	27	27	50
Artesia Domestic Water System	4365	4365	0	0
Hope Community Water System	56	28	28	50
Ruidoso Water System[1]	2119	382	1737	82
Ruidoso Downs Water System[1]	260	47	213	82
Capitan Water System	163	73	90	55
Mayhill Water System	8	4	4	50
Cloudcroft Water System	224	96	128	57
Carlsbad Water System	8955	5354	3601	40
Loving Water System	496	248	248	50
Totals	35,443	25,842	9601	27

[1] Very high return flow may be the result of groundwater inflow to sewage lines.

Table 53. Agricultural Return Flow in 1995

County	Total Withdrawals (AF)	Consumptive Use (AF)	Return Flow (AF)	Return Flow as % of Withdrawals
Chaves	293,738	195,900	97,838	33
De Baca	57,911	28,776	29,135	50
Eddy	237,368	150,719	86,649	37
Lincoln	31,410	13,679	17,731	56
Otero	1851	841	1010	55
Totals	622,278	389,915	232,363	37

Table 54. Return Flow from Domestic Wells in the Planning Area

Basin	Number of Domestic Wells[1]			Pumpage [2] (AFY)	Return Flow[3] (AFY)	Net Consumption (AFY)
	DTW>30 feet	DTW<30 feet	Total			
Fort Sumner	113	36	149	52.15	8.6	43.6
Roswell	3730	605	4335	1517.25	144.0	1373.3
Hondo	1462	428	1890	661.5	101.9	559.6
Peñasco	499	63	562	196.7	15.0	181.7
Carlsbad	1148	358	1506	527.1	85.2	441.9
Capitan	10	0	10	3.5	0.0	3.5
Totals	6962	1490	8452	2958.2	356.6	2603.6

[1] Data from OSE WATERS (2001).
[2] Assuming use of about 0.35 AFY per household.
[3] Return flow assumed to occur only at sites where depth-to-water <30 feet and to be 68% of withdrawal.

Return flow is generated from agricultural, municipal and industrial, domestic, and other water uses. Agricultural return flow comes from storage, conveyance and on-farm seepage and from tailwater. Return flow is collected by drains and either directed back to a surface stream or re-diverted for subsequent use. Some farms retain tailwater control as private water. Seepage not collected by drains either returns to a surface stream through the shallow groundwater system or supplies water to shallow wells.

Return flow from M&I use is often accomplished through a WWTP, though in smaller communities septic tanks are used to dispose of wastewater. Where a WWTP is used, used water is collected from household drains and toilets and routed to the plant through the sewage collection system. The water is treated to an acceptable standard and returned to a surface stream through a point-source outfall pipe. Return flow from M&I uses is quantified either by measuring effluent flow from the WWTP or by multiplying diversions by consumptive use factor between 0.45 and 0.55.[61 above]

Domestic return flow, the return flow from domestic wells, is through septic tanks and landscape irrigation seepage. Water used inside the house is disposed through drains or toilets and flows to the septic tanks. Some of the septic tank effluent evaporates on the surface or is taken up by plants. The rest percolates downward and is stored in the soil or returns to groundwater. The fraction of effluent returning to the groundwater system depends on climate conditions and the depth to the water table.

On average, municipal return flow is 27 percent of withdrawals and agricultural return flow is 37 percent of withdrawals, based on 1995 usage. Return flow is available for reuse after it reaches a surface water or groundwater body, and may be a primary source of supply for other users. Municipalities can be granted a return-flow credit, whereby diversion is expanded equal to the WWTP discharge. The municipality can adjust the amount of their diversion by the amount of water discharging from their treatment plant. The consumptive use portion of the permit cannot be exceeded. At Ruidoso, return-flow credits must be taken daily and require close monitoring of both diversions and return flows.

SECTION VIII: FUTURE WATER USE

Introduction

Future water demands are based in large part on studies conducted by the University of New Mexico's Bureau of Business and Economic Research and the New Mexico Water Resource Research Institute. This section identifies candidate sources of water for screening as alternatives in Section X. Section IX addresses, in accordance with the ISC Regional Water Planning Template,[117] current and ongoing water conservation efforts in each of the declared groundwater basins.

The region's projected water demand is planned to be met by means of the activities selected in report Section X. The amount of existing and projected increase in water requirements may be satisfied flexibly by a variety or a combination of actions. Future water requirements are projected in three categories: foreseeable increase, existing known shortfalls and uncertain changes. The foreseeable increases are those projected on Tables 55 and 56 based on population projections and including municipal, domestic and commercial growth.

The existing known shortfall is the Compact requirement for 10,000 additional AFY since 1988 relative to historic deliveries. As of 1997, about 16,600 AF of water rights have been retired through the ISC purchase program. Existing shortfall of supply is also based on requirements for environmental recovery, pending, water-right applications, on-going desertification of the basin and historical shortage for surface-water uses such as CID irrigation. A range of 10,000 – 50,000 AFY is recognized in the plan as a typical existing shortfall in water requirements.

The uncertain change in water requirements is for uses such as mining, agriculture, habitat maintenance and other sectors more sensitive to uncertain future conditions for selected products. These sectors may increase or decrease their water requirements. In either case, the actions presented in Section X would be applied to provide water or to re-distribute water to other uses.

Accordingly, the Lower Pecos Valley Regional Water Plan will focus on approaches to meet the foreseeable growth in water demand, but recognizes that the same approaches must be applied to satisfy existing shortfalls and future uncertainties. The amount of water available from the various actions and approaches is outlined in Section X and exceeds the amount of foreseeable increase in demand.

[117] New Mexico Interstate Stream Commission, 1994, Regional Water Planning Template.

Table 55. Estimated Present and Future Water Use by County and Type of Use

County/Use	Assumed Percentage Change[1]	Growth Rate (%/Year)	Water Use 1990[2] (AFY)	Projected Water Use 2035[2] (AFY)	Population 1990	Projected Population 2035	Per Capita Consumption (AFY)
Chaves County							
Domestic (self-supplied)	31	0.60	586	768			
Irrigated Agriculture	-4	-0.09	305,843	293,609			
Livestock (self-supplied)	5	0.11	3125	3281			
Commercial (self-supplied)	66	1.13	2802	4651			
Industrial (self-supplied)	71	1.19	157	269			
Mining (self-supplied)	25	0.50	149	186			
Municipal Use	52	0.93	13,557	20,594			
Dexter	54	0.96	336	518	898	1383	0.37
Hagerman	116	1.71	444	958	961	2074	0.46
Lake Arthur	50	0.90	45	68	336	503	0.14
Roswell	50	0.90	12,732	19,050	44,260	66,226	0.29
Totals for Chaves County			339,776	343,952	46,455	70,186	
De Baca County							
Domestic (self-supplied)	16	0.33	39	45			
Irrigated Agriculture	0	0.00	47,469	47,469			
Livestock (self-supplied)	6	0.13	409	433			
Commercial (self-supplied)	46	0.84	3	4			
Industrial (self-supplied)	50	0.00	0	0			
Mining (self-supplied)	5	0.11	10	11			
Municipal Use	9	0.19	221	240			
Ft. Sumner	9	0.19	221	240	1269	1381	0.17
Totals for De Baca County			48,372	48,442	1269	1381	
Eddy County							
Domestic (self-supplied)	34	0.65	161	216			
Irrigated Agriculture	5	0.11	224,029	235,231			
Livestock (self-supplied)	5	0.11	734	771			
Commercial (self-supplied)	67	1.14	238	398			
Industrial (self-supplied)	59	1.03	464	738			
Mining (self-supplied)	20	0.41	13,730	16,477			
Municipal Use	95	1.48	12,481	24,288			
Artesia	58	1.02	3436	5438	10,610	16,792	0.32
Carlsbad	112	1.67	8747	18,556	24,952	52,933	0.35
Hope	-69	-2.62	70	22	101	31	0.69
Loving	19	0.40	228	273	1243	1485	0.18
Totals for Eddy County			264,318	302,408	36,906	71,241	
Lincoln County							
Domestic (self-supplied)	14	0.29	265	302			
Irrigated Agriculture	0	0.00	26,409	26,409			
Livestock (self-supplied)	5	0.11	563	591			
Commercial (self-supplied)	84	1.35	822	1513			
Industrial (self-supplied)	84	1.35	57	106			

Table 55. Estimated Present and Future Water Use by County and Type of Use (continued)

County/Use	Assumed Percentage Change[1]	Growth Rate (%/Year)	Water Use 1990[2] (AFY)	Projected Water Use 2035[2] (AFY)	Population 1990	Projected Population 2035	Per Capita Consumption (AFY)
Mining (self-supplied)	0	0.00	35	35			
Municipal Use	125	1.80	1574	3535			
Capitan	148	2.02	168	417	842	2090	0.20
Ruidoso	113	1.68	1328	2828	4600	9794	0.29
Ruidoso Downs	274	2.93	77	289	920	3445	0.08
Totals for Lincoln County			31,298	36,025	6362	15,329	
Otero County							
Domestic (self-supplied)	25	0.50	800	1000			
Irrigated Agriculture	5	0.11	27,653	29,036			
Livestock (self-supplied)	5	0.11	322	338			
Commercial (self-supplied)	61	1.06	896	1442			
Industrial (self-supplied)	59	1.03	5	8			
Mining (self-supplied)	0	0.00	21	21			
Municipal Use	58	1.02	215	340			
Cloudcroft	58	1.02	215	340	636	1007	0.34
Mayhill			8	NA	127	NA	0.07
Totals for Otero County			30135	32,525	763	1007	
Planning Region							
Domestic (self-supplied)	26	0.51	1851	2331			
Irrigated Agriculture	0	0.00	631,403	631,754			
Livestock (self-supplied)	5	0.11	5153	5414			
Commercial (self-supplied)	68	1.16	4761	8008			
Industrial (self-supplied)	64	1.10	684	1121			
Mining (self-supplied)	20	0.40	13,945	16,729			
Municipal Use	75	1.24	28,048	48,997			
Totals for Planning Region			685,844	714,353			

[1] Based on percentage change in Tysseling, J.C. and McDonald, B., 1984, Projections of water availability in the AWR and Pecos River basins to the year 2005: New Mexico Water Resources Research Institute Report No. 186. Same percentage change is used to project increase in demand over the 45-year period (1990 to 2035) in this table.

[2] Water-use numbers are diversions. Consumptive use can be estimated by assuming 50%of the diversion is consumed and 50% is returned to groundwater or surface water.

Table 56. Projected Water Demand by Type of Use in the Planning Area

Category	Year 2000 (AFY[1])	Year 2040 (AFY[1])	Increase from 2000 to 2040 (AFY[1])
Agriculture	631,403	631,403	0
Domestic[2]	2958	3626	668
Livestock	5211	5442	231
Commercial	5475	8332	2857
Industrial	780	1211	431
Mining	14,559	14,559	0
Municipalities	32,728	53,936	21,208
Subtotal	693,114	718,509	25,395

[1] Amounts are diversions.
[2] Estimated from OSE domestic well records; values in Table 55 estimated based on population.

Projected Water Uses

Expected changes in water demands for each of the water use categories are discussed in the following subsections. The current and projected 2035 water uses for each category in each of the five counties within the planning region are presented in Table 55. Growth from year 2000 to 2040 is summarized in Table 56. Projections of water use by specific categories use data from WRRI.[118] Using the WRRI percentage of change water uses can be projected as shown in the data in Table 55. Actual future water use will depend on unpredictable factors such as technological advances, cultural values, climatic conditions and others. Table 55 shows the projected water demand to year 2035. Table 56 projects water demand five years later in 2040 to be 718,500 AFY, a growth of 25,400 AFY from year 2000. The projections are based on the growth rates for the planning area in Table 55 for all categories except mining, which is assumed to experience no long-term growth. The projected growth is stated in terms of diversions. Consumptive use growth would be about 12,000 AFY, assuming 50-percent consumptive use. While projections of water use based on expected growth are a useful tool for planning, actual future demand is constrained by available supply. An increase in a demand in one water use category is met not by an increase in the available supply, but usually by a transfer from and concomitant decrease in use from another water use category. However, strategies to increase the available water supply within the planning area are examined in this section and in Section X.

[118] Tysseling, J.C. and McDonald, B., 1984, Projections of Water Availability in the AWR and Pecos River Basins to the Year 2005: New Mexico Water Resources Research Institute WRRI Report No. 186.

Agriculture

The water resources of the Lower Pecos River Basin are considered fully appropriated under groundwater, surface water and Compact administration. This designation restricts the possibility of expanding agricultural use of the water resource. As demands for the limited water supply increase, agricultural management will shift to crops of higher value and lower consumptive use. Water use may also shift to lands with more productive soil. Population increases in the region will create a greater demand for water, which in turn will place pressure on agricultural water rights holders to sell or lease their water to support these new uses. Unknown impacts will be created by federal and state laws and programs such as the Endangered Species Act, the Clean Water Act, riparian enhancement and the wetlands programs. The Compact and pending court decrees will continue to impact the available water supply.

As water rights and water resources are transferred to meet these new demands, water available for agriculture production will decline and farmland will be idled. Among the five counties, slightly negative to slightly positive growth rates are projected in Table 55. Water use for irrigated farming is expected to maintain at about 630,000 AFY over the next 40 years. A two-percent growth in real value of productivity can be projected due to increased management efficiency using the available water resource. Agricultural water rights transferred to new purposes of use are required to compensate the full values of the former agricultural use.

Agriculture-Related Uses

In the early 1970s, a few large commercial dairies were located in the planning region. Today the region has the highest concentration of large dairies in the state. These dairies are located mainly in Chaves and Eddy Counties from Roswell to Artesia. It is predicted this growth will continue as the financial and environmental climate becomes less conducive to dairy operations in other localities. As dairies move into the region they acquire adequate water rights to meet the needs of their operations. Typically, these water rights are acquired from the agricultural water rights holders. The 1995 water use by dairies was estimated at 8850 AFY. Assuming dairies will increase by 25 percent through 2035, water use will increase by 2210 AFY. This number is part of irrigated agricultural in Tables 55 and 56.

As the number of dairies in the area increase and milk production increases, the potential for new processing facilities, such as cheese factories, milk processing plants ice cream and cottage cheese factories, will increase. Each of these industries will require water for some phase of the product processing or packaging. Again, these water rights must be acquired from other uses or supplied by public water systems from existing water rights.

Other agriculture-related enterprises such as livestock feed yards, poultry production operations and processing facilities have potential to grow in the region due to climate, population and economics. As these businesses move into the region, the water requirements will be fulfilled from existing water supplies.

Public Water Supply Systems

The Bureau of Business and Economic Research has prepared population projections for the counties and portions of counties that are located within the planning region. The projections are shown in Table 57 and Figure 30.[4 above] The projections show growth for most of the area, although the projected rate of growth slows over the next 40 years. The increases will depend upon the water resources of public water suppliers. Table 56 projects 21,208 AFY of increase to year 2040.

As the population increases, lands adjacent to municipalities will be developed for housing. Areas within commuting distance will experience subdivision of land into small units that provide more space such as five- and ten-acre tracts where livestock can be kept. Municipal and community water systems will expand to provide water where domestic water cannot be developed. Portions of this development will occur on the agricultural classes of land that have water rights. Some areas require the development of individual wells for each unit. As the value of land for home sites increases, existing land uses and water rights will be changed from other uses to meet the demands of an increasing population. Increased pressure will be placed on open lands for recreational uses, habitat protection for wildlife and for watershed protection and improvements.

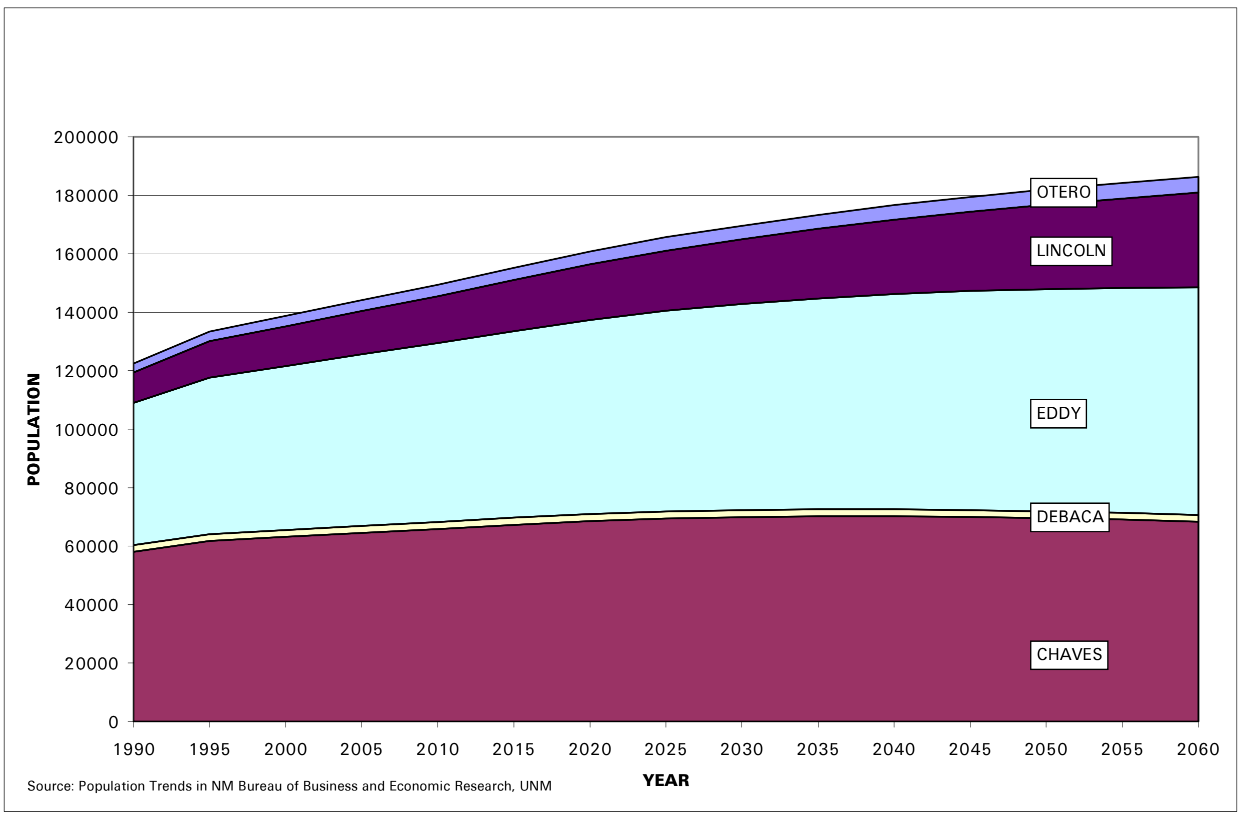
Commercial and Industrial Use

Commercial and industrial demands for water will continue to grow as population increases in the planning area. These new demands for water by commercial and industrial business may be met by acquisition of agricultural water rights. For the purposes of this water plan, the increase in water use for commercial and industrial uses is estimated to be 3290 AFY to year 2040.

Table 57. Projected Population by County in the Planning Area

Year	Chaves	De Baca	Eddy	Lincoln	Otero	Total
1990	58,033	2259	48,760	10,468	2980	122,500
1995	61,816	2308	53,529	12,478	3246	133377
2000	63,172	2338	56,082	13,653	3467	138712
2005	64,511	2370	58,746	14,865	3690	144182
2010	65,824	2396	61,216	16,139	3899	149474
2015	67,264	2422	63,908	17,507	4118	155219
2020	68,578	2439	66,473	18,982	4340	160812
2025	69,480	2439	68,708	20,497	4533	165657
2030	69,898	2423	70,519	22,061	4664	169565
2035	70,186	2403	72,241	23,735	4799	173364
2040	70,203	2373	73,719	25,415	4940	176650
2045	69,994	2336	74,985	27,110	5072	179497
2050	69,604	2294	76,075	28,824	5204	182001
2055	69,094	2249	77,044	30,576	5327	184290
2060	68,466	2200	77,886	32,362	5443	186357

Figure 30. Projected Population in the Lower Pecos Valley (1990 – 2060)



Domestic Wells

Table 54 shows domestic wells produced about 2958 AF in year 2000. The trend over the past several years in the planning region has been a migration of populations to a suburban or rural life style. Subdivisions have been developed in areas that are not served by public water systems. These home sites require development of domestic wells as a source of water. Permits for domestic wells granted by the OSE give the owner a three AFY water right and are seldom denied. Large subdivision developments might have as many as 100 to 600 domestic wells per section. Subdivision development will continue in the future and, depending on local hydrogeologic conditions, may place a strain on the available water supply for these subdivisions and adjacent water users. Well permit records for the three year period of 1995 through 1997 show that an average of 100 permits are granted per year. Based in 0.51 percent annual growth (Table 55), approximately 668 AFY of additional groundwater rights may be permitted in the next 40 years (Table 56).

Livestock Ponds, Tanks and Wells

Future development of additional livestock wells will be very limited. Most of the livestock industry (other than dairies) is established and new wells will be drilled only to replace existing wells that have failed or are in need of relocation. Additionally, because the permitted stocking rate in the planning area has been met, small growth in stock water (231 AFY) is expected within the 40-year planning period.

Recreational

Recreational demands for the limited water resource will continue to increase for fishing, boating, swimming and other water based activities, and for use in summer homes, vacation cabins, campsites and swimming pools. As with all new or increased water uses, the additional water will be transferred from existing water uses.

Riparian Uses/Instream Flow

As the interest in environmental issues increases, requests will also increase for environmental uses of water such as instream flows. These uses will require changes in present state laws and policies. In this regional plan, all such uses require the acquisition of water rights. Aquatic life that is listed as threatened or endangered will create demand for instream flow. With the bluntnose shiner and the Pecos pupfish listed as threatened and endangered, a minimum river flow of tens of cfs may be required to sustain these species. To meet this demand, water must be transferred from other uses. As additional species are listed the demand for water may increase. The

Regional Water Plan does not attempt to project future requirements, but provides that the water for species recovery and habitat designation be acquired from existing rights.

Vegetation Changes and Water Use

Vegetation changes in the planning region have a major impact on the water supply. Phreatophytes are a major user of water along the Pecos River and its tributaries. Today the stand of Pecos River riparian vegetation is near 70,000 acres. Unmanaged water losses from this vegetation exceed 210,000 AFY.

During the last 100 years, the Pecos watershed has undergone drastic vegetation changes due to man's activities. A study documenting vegetation changes has been completed by the Carrizozo Soil and Water Conservation District. The study compares photos taken around the turn of the century with recent photographs taken at the same locations in Lincoln County. The study concludes that there has been a drastic increase in woody vegetation. Deep-rooted plants (i.e., ponderosa pine, juniper, piñon and mesquite) have the ability to withdraw soil moisture from deeper levels than herbaceous plants. The ecological changes that have taken place in the past 100 years have had a definite effect on the water budget equation.

Upland vegetation has changed dramatically in the past century. Stands of woody vegetation have increased in coverage, plant size and density. Woody vegetation with deep root systems increases and herbaceous vegetation decreases. Woody species that have shown increases are mesquite, juniper, catclaw, sumac and mixed stands of desert shrub. In the mountain areas the conifer stands have gone from open stands of large trees to very dense stands of trees of mixed sizes. Where tree stands have been removed, thick stands of scrub oak now occupy that space. These changes have an effect on the available water supplies. Continued growth of woody stands and phreatophytic vegetation will further reduce the water available to other uses

Conclusion

Water demand is projected to grow by 25,400 AFY in the 40-year planning period. Growth is expected primarily in municipal use. Future agriculture and mining demands are uncertain and are assumed to be zero for planning purposes. The projected water demand is planned to be met by activities selected in Section X and evaluated in Section XI. The selected set of alternatives can meet foreseeable demand increases, existing known shortfalls and uncertain changes.

SECTION IX: WATER-MANAGEMENT CONSERVATION PROGRAMS

Introduction

Conservation issues in the Lower Pecos River planning region are being continuously researched as to cost and effectiveness. Conservation practices are a large part of the overall management program of both the surface water and groundwater resources in the region. Experience with existing programs and cost guide the evaluation of alternatives in Section X. For this reason, conservation practices and their future effect on water supplies and return flows are thoroughly addressed.

The OSE defines water conservation as "any action or technology that reduces the amount of water withdrawn from water-supply sources, reduces consumptive use, reduces the loss or waste of water, improves the efficiency of water use, increase recycling and reuse of water or prevents the pollution of water."[119]

Water conservation plans have been developed by the municipalities of Artesia, Carlsbad, and Roswell outlining the best practices to consider for implementation in these communities. Many of the individual farm conservation plans that have been developed contain items of water conservation and water management. Several federal agencies have addressed water conservation as a resource concern in resource plans and environmental assessments. Other water conservation measures include changes to existing works to improve efficiency, replacement of existing facilities to reduce losses and water banking to save water in times of surplus for later use in times of shortage.

Changes to Existing Works

The systems that deliver water to the various uses within the planning region are in place. Many of these systems have been in use for a long time. As water has become a critical issue and shortages have created unfavorable conditions, water users are looking for ways to improve water-use efficiency.

Agricultural users have lined ditches and installed pipelines to reduce evaporation and seepage losses. Fields have been laser leveled to improve field application efficiency. Irrigation efficiency has been improved through improved management techniques and by changing crops. Wells have been metered and adjudication of water rights continues in the region.

[119] Written Communication, B.C. Wilson, New Mexico Office of the State Engineer to Files, Regional Water Plans: Work Breakdown Structure for (a) Water Supply Assessment, (b) Water Demand Analysis and (c) Options for Balancing Supply and Demand: March 6, 1998.

Municipal water managers have continued to improve their water delivery systems. Several communities have developed procedures to recycle wastewater for the irrigation of parks and recreational areas. The use of rate structures has been evaluated as an incentive for municipal water users to conserve. Metering of all water use from municipal and community water systems will give a better accounting of the water being used.

Recycling of water is one of the most efficient methods of reducing water withdrawals. Several commercial and industrial businesses are changing their existing works to take advantage of this conservation practice.

Replacement of Existing Facilities

Replacement of existing facilities is very expensive and must be evaluated on an economic basis, or whether the benefits are worth the cost.

Where groundwater is used for irrigation, many of the flood irrigation systems are being replaced by sprinkler systems. In most cases this will improve irrigation system efficiency. Sprinkler systems are usually more economical to operate and can be managed to reduce water diversions. Consumptive use is less flexible.

Communities that have developed water conservation plans are considering retrofitting public facilities with water efficient devices and are encouraging homeowners to do the same. Irrigation systems for parks and recreational areas are being replaced with systems that provide more efficient water application.

Potash mines are replacing the old systems of ore processing and waste management with systems that allow more recycling of the water used to transport wastes. The mines are also implementing practices that conserve water in mining and processing operations.

The replacement of facilities in homes, farms and industrial areas is usually the owner's decision due to the high costs involved. If these practices become mandatory, the overall benefits to the region should be evaluated and programs made available to assist with the installation of new facilities.

Water Banking

At present, true water banking, the storing of excess water during periods of surplus for use in periods of shortage, is practiced in the surface reservoirs and the aquifers in the region. The PVACD has purchased water rights from 6875 acres of irrigated land and placed them in its water bank.[120] The practice of building credit for early water deliveries to Texas is a form of water banking. A more extensive water-banking program for the region could be beneficial and could assist in management of the water resource. A water-banking program would require very careful planning to avoid taking water from water-short areas, mixing surface water and groundwater supplies and overdrafting water-short supplies during droughts.

Another type of water banking that has been practiced in the planning area is the increased use of supplemental groundwater during the water-short years. During the drought of the 1950s, production of water from the Roswell artesian aquifer increased significantly and offset the surface-water supply shortage (see Water Balance in Section VI). The Roswell artesian aquifer is readily recharged from precipitation and induced surface-water infiltration. Carefully managed, the Roswell artesian and other aquifers can be used to increase supply during dry years and allowed to recover in wet years.

Vegetation Management

Vegetation management is a water-conservation tool that has been used extensively in the Lower Pecos Valley. Tables 58 and 59 summarize the existing condition of areas of vegetation types in the higher elevations, potential yields from management and the management authority over the lands.[121] Potential yield increases from mixed conifer woodlands and subalpine mixed conifers reflect the conclusion of Troendle[122] that only 25 percent of these lands could be managed for optimal water yield at any time. Water yield increase from piñon pine stands is based on a study by Baker[123] in which trees were killed with herbicides and left standing. Indications were that the yield increase ended when the dead trees were removed. Hibbert[124] reviewed a number of studies and determined that in areas receiving more than 18 inches of annual precipitation, replacing densely spaced, deep-rooted shrubs with shallow-rooted grasses can potentially increase streamflow. He noted, however, that little or no runoff increase can be expected by eradication of low-density brush and piñon-juniper woodlands. There are about 853,000 acres of land in the Lower Pecos Valley that receive more than 18 inches of rainfall. The vegetation type on these lands is given in Table 58. Timber harvesting on commercial forest lands can be a cost-effective means of increasing streamflow because sale of the timber generally covers the cost of removing

[120] New Mexico Water Resources Research Institute, Proceedings 34th Annual New Mexico Water Conference, The Relationship of Water Issues: Southeastern New Mexico as a Case Study: New Mexico State University Water Resources Research Institute Report No. 248.
[121] U.S. Geological Survey, December 1996, A GAP Analysis of New Mexico (CD).
[122] Troendle, C.A., 1983, The Potential for Water Yield Augmentation from Forest Management in the Rocky Mountain Region: Water Resources Bulletin Volume 19, Number 3, pp. 359-373.
[123] Baker, M.B. Jr., 1984, Changes in Streamflow in an Herbicide-Treated Piñon-Juniper Watershed in Arizona: Water Resources Research, Volume 20 No. 11, pp. 1639-1642.
[124] Hibbert, A.R., 1983, Water Yield Improvement by Vegetation Management on Western Rangelands: Water Resources Bulletin, Volume 19, Number 3, pp. 375-381.

it. Clear cutting mature, well-stocked ponderosa pine can produce up to three inches of water annually for a period of time.[125] Under multiple use management, however, the long-term increase would be about 0.5 inches per year.[126] Ponderosa pine is generally managed in New Mexico using seed-tree cutting or heavy thinning rather than clear cutting, which may reduce yield increases to less than 0.5 inches per year. Cutting mixed-conifer forests to maintain one-third of a working area in openings can produce up to 1.5 inches of water annually[127] through Toendle[122 above] concluded that only one-fourth to one-third of a larger area could be managed for optimal water yield at any one time. Clear-cutting aspen forests can result in short-term yields of up to five inches per year, though with an 80-year rotation the average yield increase is 0.33 inches.[128] The total potential yield from management of forests in Table 58 is about 19,000 AFY. However, management of lands for improved water yield is limited by land ownership. It is likely that only public, non-park land may be managed. Table 59 shows that only about half the lands above the 18-inch precipitation contour are public, non-park land. Therefore, the expected yield from watershed management is half of that calculated in Table 58, or about 10,000 AFY.

Past vegetation management efforts are discussed for each groundwater basin on the following subsections. Sections X and XI propose a watershed management pilot project to determine the potential salvage of water from further removal of woody vegetation.

Fort Sumner Groundwater Basin

<u>Agriculture</u>

Conservation practices are varied and many are site-specific or must be modified to adapt to specific conditions. In the Fort Sumner Basin both surface water and groundwater are used in agriculture production. Surface water is diverted from the Pecos River through a system of canals and ditches to the farms in the FSID.

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[125] Hibbert, A.R., 1981, Opportunities to Increase Water Yield in the Southwest by Vegetation Management: In Proceedings, "Interior West Watershed Management", Washington State University, April 8-10, 1980.

[126] Brown, H.E., Baker, M.B. Jr., Rogers, J.J., Clary, W.P., Kovner, J.L., Larson, F., Averery, C.C. and Campbell, R.E., 1974, Opportunities for Increasing Water Yields and Other Multiple-Use Values on Ponderosa Pine Forest Lands. U.S. Department of Agriculture, Forest Service Research Paper RM-129.

[127] Rich, L.R. and Thompson, J.R., 1974, Watershed Management in Arizona's Mixed Conifer Forests: U.S. Department of Agriculture, Forest Service Research Paper RM-130.

[128] Ffolliott, P.F. and Brooks, K.N., 1988, Opportunities for Enhancing Water Yield, Quality, and Distribution in the Mountain West: In Proceedings, "Future Forests of the Mountain West", U.S. Department of Agriculture General Technical Report INT-243.

Table 58. Potential Water-Yield Increases from Areas Receiving More than 18 Inches of Precipitation

Cover Type	Area Receiving 18 in. Precipitation (acres)	Principal Plants	Potential Water Yield Increase (in/yr)	Potential Water Yield Increase (AFY)	Comment (below)
Subalpine conifer forest	2,046	spruce, fir	0.39	66	1
Subalpine broadleaf forest	3,662	aspen	0.33	101	2
Rocky Mountain upper montane conifer forest	126,035	Douglas fir, white fir, spruce	0.39	4096	3
Rocky Mountain lower montane conifer forest	225,748	ponderosa pine	0.50	9406	4
Rocky Mountain /Great Basin closed conifer woodland	339,838	pinyon pine	0.17	4814	5
Rocky Mountain /Great Basin open conifer woodland (savanna)	68,917	juniper	0	0	6
Rocky Mountain montane scrub and interior chaparral	11,928	Gambel oak, mt. mahogany	0.47	469	7
Rocky Mountain montane deciduous Scrub	39,511	Scrub live oak	0	0	8
Plains-Mesa broadleaf sand-scrub	368	shinoak	0	0	8
Chihuahuan broadleaf evergreen desert scrub	948	creosote bush	0	0	8
Rocky Mountain subalpine and montane grassland	25,931	fescue, sedge	0	0	8
Short grass steppe	5,477	blue grama	0	0	8
Chihuahuan foothill-piedmont desert grassland	1,325	black grama	0	0	8
Rocky Mountain montane forested/shrub wetland	818	cottonwood, willow			9
Basin/playa	190	none	0	0	
Total	852,742			18,953	

1 Troendle[122 above] says that long-term water-yield increases of 2 cm (0.78 in.) to 6 cm (2.36 in.) are possible on lands optimized to increase water yield, but only about 25 percent of those lands can be maintained in that condition. The value shown is 0.25 x (0.78 + 2.36)/2 in/yr.
2 Ffolliott and Brooks[128 above] page 55.
3 This value was taken to be equal to the subalpine conifer forest value in comment 1, and is probably optimistic.
4 Hibbert[125 above] quotes Brown et al.[126 above] stating a long term yield increase of 0.5 inches/year can be obtained from mature, 100 ft^2 basal area/acre stands. Baker and Ffolliott (Baker, M.B. and Ffolliott, P.F., 2000, Contributions of Watershed Management Research to Ecosystem-Based Management in the Colorado River Basin: USDA Forest Service Proceedings RMRS-P-13, 2000) quote Schubert's (Schubert, G.H., 1974, Silviculture of Southwestern Ponderosa Pine: The Status of our Knowledge: USDA Forest Service, Research Paper RM-123) comment that 2/3 of ponderosa pine stands are too thinly stocked to get a yield increase.
5 Baker[123 above] found that herbiciding a pinyon/juniper site resulted in an average annual runoff increase of 0.17 inch, but that 60 percent of this increase was lost after the dead trees were removed. Baker's[123 above] site had shallow soils and more than 80 percent of all runoff was direct flow.
6 Baker and Ffolliot (Baker, M.B. and Ffolliott, P.F., 2000, Contributions of Watershed Management Research to Ecosystem-Based Management in the Colorado River Basin: USDA Forest Service Proceedings RMRS-P-13, 2000) said that the potential for increasing water yield in pinyon-juniper type is negligible on most sites.
7 Baker and Ffolliott (Baker, M.B. and Ffolliott, P.F., 2000, Contributions of Watershed Management Research to Ecosystem-Based Management in the Colorado River Basin: USDA Forest Service Proceedings RMRS-P-13, 2000) quote Hibbert's (Hibbert, A.R., 1979, Managing Vegetation to Increase Flow in the Colorado River Basin: USDA Forest Service, General Technical Report RM-66) comments that follow. There is good potential to increase water yields in chaparral stands that receive more than 20 inches of precipitation. 3.9 inches of increased runoff may occur where annual rainfall is 22 inches, but only 60 mm (2.36 in.) will reach downstream, and that only 1 of every 5 acres could be treated. Combining these values gives a total potential increase of 469 AFY, with the optimistic assumption that the entire cover type receives 22 inches of precipitation.
8 Hibbert[125 above] says oak woodlands have poor potential for increased yields unless the trees are in restricted-management riparian areas, and that other vegetation types, such as sagebrush and semidesert shrubs, are too dry for water-yield increase from vegetation manipulation. Yields from grasses are already maximum.
9 Though eliminating riparian species will increase water yield, current trends are to expand, not reduce, areas occupied by these species.

Table 59. Management Authority in Areas With Over 18 Inches of Precipitation

Organization	Area (acres)
Bureau of Land Management	2147
Indian Land	259,961
National Park Service	13,244
Private	117,416
State of New Mexico	1595
U.S. Forest Service	458,381
Total	852,744
Total public, non-park land	462,123

Irrigation systems in the District consist of ditches and graded borders or furrows. These systems have been improved with the installation of ditch and canal lining, irrigation pipeline, structures for water control and land leveling. Improvement of the irrigation systems and delivery canals began about 1948 and has continued to present. To date, approximately 95 percent of the ditches and canals have been concrete lined. Most of the construction today consists of repairs or replacement of ditch lining. Approximately 325,000 feet of concrete ditch lining has been installed. In 1970 these ditch lining projects cost an average of $6 per foot. Today, the cost is about $16 per foot. Using an average of $11 per foot for the 27-year period, an estimated $3,594,500 has been invested in ditch lining for water conservation.

The second part of these irrigation systems is the land to which the water is applied. There is approximately 6500 acres of land being farmed in the FSID. Slope originally ranged from one half to one percent and created irrigation grades that were too steep for efficient irrigation. These fields have been laser leveled to irrigation grades of 0.1 to 0.2 feet per 100 feet and all side slope has been removed. The cost of leveling has averaged $300 per acre, with a total cost of approximately $1,950,000 to level the 6500 acres.

The overall efficiency of these irrigation systems has increased an average of 65 percent, resulting in diversionary water savings of about 6800 AFY. With present technology and existing resources, the above-described systems are the most viable alternative for this area. To improve water conservation, the remaining five to ten percent of the ditches could be lined. At present prices of ditch construction, it will cost approximately $350,000 to line the remaining 20,000 feet of ditch. An additional $50,000 to $100,000 would be needed to complete the land leveling and field reorganization.

FSID and individual landowners presently spend a large percentage of funds available for conservation work on repairing or replacing older, deteriorating ditches. These projects are evaluated for feasibility of replacing the ditch lining with pipelines.

Due to the large flow of water the size of pipeline required is large and the pipe and installation are expensive. The use of pipelines would reduce evaporation and also provide a safety factor where these canals and ditches pass through town.

Practices that may improve the life of existing conservation measures should be evaluated for cost effectiveness and technical feasibility. These practices may include coating lined ditches with fiberglass or asphalt based materials, and using pipelines instead of ditches where feasible.

Changes in laws and policies that effect water rights and storage would conserve water by increasing the efficiency of water management. Present water delivery is based on a rotation system providing water to land owners approximately every three weeks. If FSID could store water and deliver only on a demand basis this would reduce water deliveries through the system and maintain unused water in Sumner Lake for other uses. If policy allowed, FSID could sell the conserved water or be paid for leaving the water in the reservoir. This would encourage conservation as well as provide funds to apply additional conservation work. With a reduced diversionary farm delivery requirement from the ditch lining and leveling, the 6800 AFY should be stored or otherwise credited to the FSID.

The return flow from the farmlands and irrigation systems to the river and other water sources is presently estimated at about 50 percent. Most of this return flow is from water flowing from fields after irrigation. Return flow to the river would be only slightly effected by the continued installation of conservation projects. Changes in management of the system, i.e., timing of deliveries may, have a slight effect on return flow to the river below the farms, but could also decrease the need for withdrawals from the river and the dam.

There are two areas in the Fort Sumner Basin where groundwater is used for agriculture production. One is located north of Fort Sumner and east of Sumner Dam. A second area is located south of Fort Sumner and west of the Pecos River.

Most of the irrigated land, approximately 3200 acres in the area north of Fort Sumner, was placed in the Conservation Reserve Program in the early 1990s and will remain in that program for another three to four years. The program requires all farming on that land to cease for a ten-year period. This provides the maximum conservation of the water that was being used for these farms since the water is no longer pumped from the aquifer. Assuming these farms were using two AF per acre, a water savings of 6400 AFY has been realized.

Three-fourths of the land still under cultivation use irrigation systems referred to as LEPA systems (low energy pressurized application). These are a type of pivot sprinkler system that places the water near the soil surface at a low pressure. Water loss due to evaporation is greatly reduced relative to flood and sprinkler irrigation. These systems operate at an overall application efficiency of around 95 percent.

The remaining one-fourth of the farmland irrigated by groundwater use different types of sprinkler systems for water application. These sprinkler systems operate at 60 to 70 percent application efficiency.

The overall installation cost of a pivot or LEPA sprinkler system is approximately $60,000 for a system that irrigates 160 acres. Approximately $1,200,000 has been invested in these irrigation conservation measures in the areas using groundwater in the Fort Sumner Basin. This has increased efficiency by an average of 30 percent and saved approximately 3120 AFY since installation. If the balance of groundwater irrigation systems is converted to LEPA systems, a water savings of about 780 AFY would be realized.

Other measures that may help conserve water are changes in crops, management of the systems and use of technology for irrigation scheduling.

Public Supplies

The Village of Fort Sumner has prepared a comprehensive development plan that includes planning for the use of the Village's water supply and for upgrading the water delivery and wastewater treatment systems. The plan does not include specific conservation measures. The Village has ample water rights for its present and projected future uses. Fort Sumner uses its water as a commodity that produces income through tourism. Therefore, the present rate structure encourages the use of but not conservation of water.

The Village is presently upgrading its delivery system by replacing pipes that leak or are too small to meet delivery demands. These improvements will increase system efficiency by about ten percent by reducing losses due to leaks and spillage. They will also improve delivery to meet demand. Approximately $700,000 is being invested in these improvements.

The Village is also in the process of upgrading their WWTP to meet new guidelines. Presently, the treated wastewater is discharged to the Pecos River. The new treatment plant will improve the quality of this return flow. Approximately $1 million is being invested in this effort.

Future beneficial use of treated wastewater from the plant for use on a private golf course or on nearby farms may improve conservation of the water and provide additional income to the Village. At present, the use of this water on city lands is prohibitive due to the distance of the treatment plant from parks.

The Village of Fort Sumner should consider developing a contingency plan that will address conservation measures during droughts and floods. If Fort Sumner experiences growth or other factors that have a long-term effect on the water supply, conservation measures such as use limitation, use scheduling, fee structuring and landscaping limitations may be needed.

The Valley Water Users Co-op is a subsidiary of the Fort Sumner water system that delivers water to users in the valley below Fort Sumner. Water use by members of the Co-op is limited to home use and a small amount of livestock watering. The fees charged for water through the Co-op are higher than Village fees to cover operation and maintenance costs of the system, which is 35 years old. The water used by the Co-op is sold to the Co-op by the Village and comes from the Village's water rights.

Conservation measures adopted by the Village of Fort Sumner would extend to users served by the Co-op.

Domestic Wells

Finding water of good quality for domestic and livestock use has been a problem in some locations in the Fort Sumner Basin. Landowners that have found good water usually develop pipeline systems to distribute the water throughout the land unit. Some landowners have joined together to develop delivery systems that serve more than one unit from a well that yields water of an acceptable quality.

Water users are installing covered storage tanks and smaller diameter drinking troughs to reduce evaporation on livestock watering systems. Domestic water use is controlled by the limited supply and expense of pumping the water.

Water conservation measures that may be considered in the future include limitations on landscaping, xeriscaping, and installation of water-efficient fixtures and storage of water in enclosed storage tanks. The effects of these conservation measures on return flow to the water system are small. Return flow of seepage from water impoundments would be reduced and any return flow from irrigating of landscaping around homes may be reduced. However, these reductions would be small and the overall effect on the water resource would be minimal.

Vegetation Management

Over the past 200 years, vegetation changes have occurred in the Fort Sumner Groundwater Basin that have effected both the water quantity and quality. Woody vegetation, which in most instances is a high water user, has increased in coverage and density while grass or herbaceous plant cover has been reduced.

Approximately 650,000 acres in this basin are now occupied with medium density mesquite stands. Completed studies indicate that 38 percent of the rainfall on a stand of mesquite is consumed, compared to 20 percent for grasses. In an area with an average annual rainfall of 12 inches, mesquite will use approximately 4.56 inches or 247,000 AFY over the infested area of this basin. Mesquite will use approximately 0.35 inches of moisture per day during peak growth and has the ability to take moisture from deep layers of a soil profile.

Both chemical and mechanical control methods have been used in this basin in the past. Presently most of the control is being done mechanically at a cost of $35 per acre on stands of medium density. At this cost, treating the acreage described above will cost $15,925,000. Maintaining the controlled area will cost $796,250 a year or a total of $23,887,500 over 30 years. Between 1500 and 2000 acres have been controlled each year for the past several years, mainly by mechanical treatment. The operation is relatively costly in terms of annualized cost per AF of water salvaged, but has other advantages.

Salt cedar along the Pecos River and some of the tributaries covers 7500 acres, which are considered high water yielding areas. Most of these areas historically had springs or surface flow. As salt cedar has invaded these areas, the frequency of surface-water flow has declined and, in some areas, has completely disappeared.

Estimates of water use by salt cedar range from three to seven AF per acre. Research indicates that salt cedar is opportunistic and will use the water available to it. Like mesquite it has deep roots that can take water from depths much greater than other plants. Using the lower use consumption estimate, 22,500 AF of water per year are being used from the 7500 acres. Removing salt cedar and lowering the water table could salvage about one AFY per acre or 7500 AFY over the infested area.

There has been very little effort in the past to control or remove salt cedar from these areas. Some mechanical and chemical control has been tried in the past on small, localized areas. Chemical control costs from $60 to $100 per acre and mechanical treatment can cost as much as $500 per acre. To eradicate 7500 acres of salt cedar at an average cost of $150 per acre would require an investment of $1,125,000. Maintaining this area would cost $56,250 annually. The total investment for ten years would be $1,687,500. The operation is relatively inexpensive in terms of annualized cost per AFY of salvage.

Another woody plant that is affecting the water supply in the Fort Sumner Basin is the elm tree, which is found mainly in the river valley. These trees occupy old homesteads and have spread to other areas especially along ditches and wet areas. Sumac, snakeweed and catclaws are also increasing in density and plant size. The total area occupied by these plant populations is estimated around 85,000 acres. Water use by these plants is slightly less than mesquite.

The control of these species would require a variety of methods. Hand cutting and stump treatment of elm, Russian olive and other species in close proximity to homes and cropland would be the preferred method. Mechanical and chemical treatment of sumac and catclaw would also provide adequate control. It is estimated that control of these species would cost approximately $35 to $100 per acre, due to the hand labor involved. At an average cost of $50 per acre, it will require an initial investment of $2,975,000 and a maintenance cost of $148,750 for a total of $4,462,500 over ten years.

All presently known methods (chemical, mechanical, and biological) of managing woody vegetation are suitable for use in the Fort Sumner area on a site-specific basis. Soils, topography, weather conditions and proximity to other land uses are key considerations in determining the method of control.

Return flows would not be effected since there is no direct diversion of service or groundwater. Existing flows from springs and streams have increased where vegetative management has occurred on watersheds. It can be assumed that the same phenomenon will occur in the Pecos River and its tributaries where vegetation is properly managed on a large scale throughout the basin.

A summary of the potential water savings in the Fort Sumner Basin is shown in Table 60.

Table 60. Summary of Water Savings Through Conservation in the Fort Sumner Groundwater Basin

Conservation Activity	Amount Installed	Amount Needed	Estimated Cost ($)	Potential Water Saved (AF)
Ditch Lining	325,600 ft.	20,000 ft	350,000	100
Land Leveling	6300 ac	200 ac	60,000	100
Sprinkler Systems	2400 ac	800 ac	300,000	780
Public Supply Systems	2 Systems	Repairs & Modification	1,700,000	28
Domestic & Stock Well	Unknown	Unknown	Unknown	57
Vegetation Management	Unknown	742,500 ac	18,850,000	93,000
Total			21,260,000	94,065

The change in basin yield due to these activities is small except for vegetation management, where the potential is large, but uncertain. The salvage from vegetation management in areas of low soil moisture has a potential that remains to be demonstrated and is too uncertain to be planned.

Roswell Groundwater Basin

Agricultural

The Roswell Groundwater Basin has the largest area of irrigated agriculture in the planning region. Approximately 90 percent of the 130,000 acres are irrigated with groundwater. The other ten percent is irrigated with water diverted from the Hondo, Felix and Peñasco Rivers or pumped from the Pecos River.

The traditional method of irrigating these farms was through ditches and pipelines to fields that were prepared with furrows, corrugations or borders. A conversion of the surface irrigation systems to sprinkler irrigation systems began about 20 years ago. Presently about 50 percent of the farmland in the Roswell Basin is using sprinkler irrigation.

In the early days of development in the Roswell Basin, land was brought into production without consideration of the available supply of water. Soon the water table began to drop, streamflow diminished and artesian well pressure declined. The PVACD was formed to govern water development and attempt to reverse the problems effecting the water supply. Through their efforts and those of the OSE, the water rights of the landowners in the basin were adjudicated. With a restricted water supply, producers turned to conservation practices to stretch the water supply to meet the crops' needs.

The earlier conservation practices included ditch and canal lining and land leveling. Low-pressure pipelines were installed as a part of the irrigation delivery systems as these materials became available. An estimated 1,815,000 feet of ditch lining and pipeline have been installed to improve water delivery and application efficiency. At an average cost of $3.50 per foot for materials and installation, total expenditures for these system improvements are estimated to be $6,352,500. Some of these ditches are being replaced with pipelines of improved quality. The ditches being served by surface water will remain in place due to the larger heads of water delivered through these systems.

The land being placed into cultivation in the early period of development in the basin was rough and had an uneven grade. To improve irrigation efficiency and crop production, the fields were first smoothed with heavy drags and were later leveled to specified grades. Side fall was removed when possible. Approximately $15 million has been invested in leveling 75,000 acres. Those fields that are irrigated by surface irrigation systems will continue to receive land leveling either to maintain an existing grade or to change the grade of the field. Much of the leveling being done today is precision leveling done with laser levels.

The pipelines, ditch lining and land leveling installed in the surface irrigation systems has improved the water delivery and field application efficiency on these farms from 35 to 60 percent. This efficiency increase has yielded an estimated water savings in terms of reduced farm-delivery requirement of one to three acre-inches per acre or 18,300 AFY. An undetermined portion of these savings is reduced return flow to the surface water and groundwater system.

With the metering of wells and stricter control on water use, landowners began to look for ways to increase efficiency, reduce water use and control tailwater. Sprinkler systems have provided the opportunity to meet these goals. The first sprinkler systems in the area were manually moved systems and a few side-roll systems. As the installation of sprinkler systems has increased, some of the fields that were served by lined ditches and had been leveled for surface irrigation have been reorganized for sprinkler irrigation. The side-roll sprinkler systems have cost an average of $300 per acre to install over the previous 20-year period (1996 costs are $450 per acre). Presently, approximately 40,000 acres are irrigated with this type of sprinkler system with an estimated investment of $12 million. The side-roll sprinkler systems operate at 65 to 75 percent on-farm application efficiency, an increase of ten to 15 percent over conventional surface irrigation systems. The increased efficiency has yielded on-farm net water savings of about two-acre inches per acre, or approximately 6600 AFY. Part of the water saved was former return flow to surface water or groundwater. Due to the adjudication of water rights by the OSE and PVACD some 12,000 acres of illegal irrigation was enjoined and subsequently PVACD purchased and retired another 6700 acres of water right all of which reduced overdraft in the basin.

In recent years, producers have been turning to the pivot sprinkler systems, either the conventional pressure system or the LEPA system. These systems are less labor intensive and more efficient than either the surface irrigation systems or the side-roll sprinkler systems. Pivot sprinkler systems now serve about 3500 acres in the Roswell Basin. These systems cost about $600 per acre to install with an estimated investment to date of $2,100,000. Operating efficiency of a pivot sprinkler system averages 85 percent. Conventional pivots operate at 75 to 80 percent and LEPA systems operate at 80 to 95 percent efficiency. It is estimated that these systems are currently saving about three to four inches of water per year over the irrigation systems they are replacing, an average of 875 AFY.

It is estimated that by the end of the 40-year planning horizon, approximately 30,000 acres will be served by pivot irrigation systems, 60,000 acres will be served by side-roll sprinkler irrigation systems and 20,000 acres will be served by surface and other types of irrigation systems. These upgrades or changes in irrigation systems will result in on-farm water savings of approximately 10,000 AFY, part of which is reduced return flow. This will require an investment of approximately $26,900,0000 at 1996 prices. This estimate includes the installation of miscellaneous systems such as drip, solid set and surge. These systems are not expected to dramatically increase in use.

All of the systems mentioned above are suitable for use in the Roswell Basin where water quality is good. As the mineral content of the water increases the suitability of sprinkler systems decreases and the need to install drip irrigation or surface irrigation becomes essential for economical crop production.

The improvement in the efficiency of the irrigation systems will cause a decrease in return flow to aquifers and stream systems. The return flow water is pumped for other uses or remains in the aquifer or stream. If the water is left in the aquifer it may increase flow to the river as the water table rises. Improvement or installation of drainage systems may be needed to prevent high water table from causing lands to be waterlogged.

Other measures that may help conserve water are changes in the types of crops grown, better or closer management of existing irrigation systems, use of technology for irrigation scheduling and the use of livestock manure as a mulch to reduce evaporation, increase organic matter, and improve soil moisture holding capacity.

Agricultural conservation generally reduces on-farm delivery requirements and incidental depletion (see Appendix M) without reducing consumptive irrigation requirement.

Public Supplies

The Roswell Basin is the most populated area in the planning region with two of the larger municipalities, four incorporated villages and 16 community water systems. There are several large industries that use water from public supplies or have developed their own water supply. Each of these water users has developed plans that meet their need for management and conservation of the water supply they control or use.

The Cities of Roswell and Artesia and the Village of Lake Arthur have developed 40-year water plans that detail their water supplies and their plans to develop and use them. Needed improvements to, and upgrades of water distribution systems are discussed. When these improvements are completed, water will be conserved through the prevention of leakage or spillage from breaks or from improper functioning of equipment.

Roswell and Artesia have also developed conservation plans that outline best management practices (BMP). When these practices are installed they will provide water savings. The ten listed BMPs that would be economical and feasible for the municipalities to install are:

1. Comprehensive and accurate water accounting
2. Utility and customer surveys
3. Conservation at public facilities
4. Substitution and recycling
5. Universal metering
6. Conservation rates
7. Prohibition of waste
8. Plumbing code
9. Landscape code
10. Education and outreach

Both cities incorporate recycling programs in managing their water resources. Artesia recycles an average of 850,000 gallons per day. This water is used to irrigate 188 acres of parks and recreation areas. Roswell uses recycled wastewater to irrigate farmland nine months of the year and discharges it to the Pecos River under agreements with the OSE the other three months. These recycling programs reduce pumpage from the aquifer by approximately 13,000 AFY.

Artesia has initiated a program that encourages installation of xeriscaping in new housing and commercial developments and when existing landscaping is being re-established. They have also installed a xeriscaping demonstration at the municipal building.

With the initiation of the ten BMPs listed above, Artesia and Roswell could reduce water consumption by as much as 15 percent of the present average annual use of 17,066 AF, for a water savings of 2550 AFY. Population in these municipalities is expected to increase and new water uses may equal or exceed the water saved.

The Village of Lake Arthur has addressed conservation issues and benefits in their 40-year plan. This community uses a fee structure that encourages water conservation. Their plan also calls for education programs to raise the level of awareness of the need to conserve water, for programs to encourage installation of more efficient plumbing fixtures and the use of xeriscaping, and for water scheduling of lawn and landscaping irrigation. These measures, plus improved metering, could result in water savings of ten to 15 percent, or from nine to 20 AFY.

The remaining Villages of Dexter, Hagerman and Hope do not have 40-year plans or conservation plans. These communities have adequate water supplies and use the sale of water as a major source of income for operating and maintaining the community. These communities as well as the other 11 community water systems should consider developing either 40-year plans or water conservation plans that would guide them in the management of their water resources.

Several industrial and commercial businesses operate within the boundaries of the Roswell Basin and use water in their operations. Navajo Refining is a gas and oil refining business that uses water in the processing of these products. They reduced water use from about 950 gpm in 1991 to 450 gpm in 1997 by installing a reverse osmosis process and a stripper system that cleans used water so that it can be recycled. This has provided water savings of about 800 AFY.

Gas and oil production is a major industry in this basin that uses water and produces water in their operation. Due to current laws and regulations, drilling operations require the use of high-quality water. The gas or oil well produces low quality water while being drilled and during the productive life of the well. This water must be collected and injected back into deep formations. The environmental feasibility of using this low-quality water for drilling operations (currently required to use high-quality) water should be studied. If impacts are found to be minimal, regulations should be modified to allow the use of low quality water for drilling.

The cheese production plant near Roswell uses approximately 530 AFY of water to process four million pounds of milk. This is presently the largest mozzarella cheese plant in the world. The manufacturing of cheese produces approximately 550 AFY of wastewater. This water is suitable for agriculture production and is presently used to irrigate 240 to 450 acres of farmland. As new technology becomes available that is cost effective, the effluent water may be recyclable. At present, the conservation practices listed under the agriculture section would be applicable to the wastewater used on the farms.

The dairy industry is one of the largest agriculture-related industries in the basin and uses large quantities of water to water livestock, clean the facilities and animals and other minor uses. Water use by this industry averages about 27,000 AFY., including water use to irrigate crops for feed. The dairy industry is expected to continue to grow throughout the next 40 years and water use is estimated to increase to 38,000 AFY. The wastewater from a dairy operation is usually placed in holding ponds and is either allowed to evaporate or is used for irrigation water on farmland. Conservation practices used for farming can be used to apply wastewater to the farms and help reduce water loss through evaporation. As technology improves, wastewater may be cleaned and recycled for certain uses in the dairy operation.

Other industries and commercial developments exist throughout the basin. Most of these use water supplied by the municipalities or by other water suppliers. Water conservation measures initiated by the water suppliers should apply to their users. As new industry or commercial interests present development plans they should be required to address water conservation needs and programs in their plan.

Return flows will be affected by any reduction in water use that is accomplished through conservation measures. The most significant reduction would occur where wastewater or other water sources are used for irrigation either on parks, lawns, and recreation areas or are used in crop production. Return flows from other uses are limited and average less than 25 percent of the water used.

Domestic Wells

Wells for domestic and livestock use have been developed throughout the basin. Many of these wells were developed prior to basin declaration when no restrictions were in place. Domestic and livestock wells developed today require a permit from the OSE and are restricted to three AF of use per year.

Water for domestic and livestock wells can be found at shallower depths in the central part of the Roswell Basin. These depths vary greatly. Water in the peripheral areas is found at much greater depths. Water in the eastern side of the basin is usually of poor quality. These conditions have led to the development of community water systems and the installation of extensive pipeline systems for livestock water.

Users are installing storage tanks outfitted with covers and smaller diameter drinking troughs to reduce evaporation on livestock watering systems. Surface water is caught in impoundments and is pumped to enclosed storage tanks to reduce evaporation and seepage losses.

Conservation practices that should be considered in the future include limiting the landscaping around homes, using xeriscaping, installing water efficient fixtures in the home and controlling spillage or excessive pumping from livestock wells.

Requiring metering of all wells may be a measure that would reduce water use. This would require additional funding for an agency to monitor the meters.

The effects of these conservation measures on return flow to the water system are relatively small. Return flow created by seepage from water impoundments would be reduced and any return flow from home use or irrigating of landscaping may also be reduced. These reductions would be offset by reduced pumping from the aquifers.

Vegetation Management

The Roswell Basin, with its wide range in elevation and topography has a variety of vegetation. Much of the area is showing symptoms of an imbalance in the plant communities that is effecting the quantity and quality of the water supply.

Approximately 300,000 acres of the basin are infested with medium density mesquite. Some of the infested areas are considered aquifer recharge areas. Another 300,000 acres contains stands of mixed density that effect springs and surface flow. Estimating that mesquite uses 38 percent of the moisture received from rainfall and snow, control of this woody vegetation could salvage some water to be released to streamflow and shallow-water recharge.

Both chemical and mechanical control methods have been successfully applied to this type of vegetation in this basin in the past. Presently most of the control is being done with the use of chemicals at a cost of approximately $20 per acre. Approximately 200,000 acres of mesquite have been controlled in the last 30 years. Much of this is in need of retreatment due to lack of maintenance. On average, it will cost approximately $35 per acre to control the mesquite. This will require an initial investment of $20,055,000 and annual maintenance cost of $2,002,750. The ten-year total cost would be $30,082,500.

Piñon-juniper stands that were once open grasslands with scattered stands of trees are now dense stands of trees with very little grass cover. This vegetation type has increased in density and occupies formerly open areas. Presently, piñon-juniper stands occupy approximately 350,000 acres in the Roswell Basin known to be aquifer recharge areas. This type of vegetation is found in higher rainfall areas. Piñon and juniper are evergreen trees and are larger than the mesquite. These factors relate to a higher water use and studies indicate that water could be salvaged if these trees were thinned to stands depicted in early records.

Most of the juniper control has been done mechanically or with prescribed burns. Some chemicals have also produced effective control of these plans. Prescribed burns cost an average of $15 per acre while mechanical control averages about $40 per acre. Chemical control has a wide cost range depending on the chemical used and conditions of the site. Control methods have been applied to approximately 20,000 acres of this type of vegetation with results indicating a positive affect on the water supply. At a cost of $40,000 per acre the initial investment would be about $8,400,000. Maintenance costs will average about $420,000 per year and the ten-year total investment would be $12,600,000.

The introduced species of salt cedar occupies approximately 75,000 acres of the valleys and river bottoms in the basin. Most of the areas occupied by this species had relatively high water tables or were areas of riparian and wetlands. As salt cedar has developed into mature stands in these areas, water tables have declined and surface water has disappeared. Water table decline and surface-flow reduction is also due to groundwater pumping.

Control of this species in critical areas could conserve as much as one AF per acre and may raise the water table. This water could improve flows in rivers and springs, improve riparian conditions and contribute to recharge of the aquifers.

Approximately 30,000 acres of salt cedar control has been done along the Pecos River, mainly by mechanical methods, at a cost of about $250 per acre. Recently, chemical control has been applied to several thousand acres with a high degree of success. This chemical control has been done at a cost of about $80 per acre. Using an average cost of $150 per acre for initial control, removing 75,000 acres of salt cedar will cost $11,250,000 and annual maintenance could cost $562,500. The total ten-year investment would be $16,875,000. Because the salvage of water from vegetation control is uncertain, the Regional Water Plan proposes to include water-table drainage to add to the savings.

Shinnery oak occupies the sandy soils east of the Pecos River. Studies show that as shinnery oak increases as grass cover decreases suggesting that the moisture is not available for the grasses. Soil erosion also dramatically increases in areas occupied by shinnery oak, negatively impacting water quality in runoff. Shinnery oak occupies approximately 100,000 acres of the Roswell Basin. An estimated 10,000 acres have been treated with chemicals at a cost of about $20 per acre. Chemical control appears to be the only suitable method of control of shinnery oak at this time.

There are a wide variety of other woody species in the Roswell Basin that affect water quantity and/or quality. These include tarbush, creosote, catclaw, sumac and desert succulents such as lechugilla, yucca and sotol. Introduced species such as the elm, tree of heaven, and tree of paradise have propagated in disturbed areas and in areas where adequate water exists. The area occupied by these species exceeds one million acres.

The control of these species would require a variety of methods. Prescribed burns have proven effective on most of the desert succulents at a cost of about $10 per acre. Chemicals such as tebuthirion are effective on creosote, tarbush and catclaw and cost around $35 per acre. Chemical control reduces stand density by 60 to 95 percent. Other chemicals are effective on sumac and on introduced species. Some hand cutting and grubbing may be necessary on stands near areas that are sensitive to chemicals. The cost of this type of control can range up to $100 per acre. The average cost of controlling these species is about $50 per acre.

All presently known methods (chemical, mechanical, and biological) of managing woody vegetation are suitable for use in the Roswell Basin on a site-specific basis. Soils, topography, weather conditions and proximity to other land uses are key considerations in determining the method of control.

Return flows will not be affected with vegetation management since direct diversion of surface or groundwater does not occur. Existing flows from springs and streams have increased where vegetative management has occurred on watersheds. This same result is expected to occur on a larger scale when vegetation is properly managed on a large scale throughout the basin.

A summary of the potential water savings in the Roswell Basin is presented in Table 61.

Table 61. Summary of Water Savings Through Conservation in the Roswell Groundwater Basin

Conservation Activity	Amount Installed	Amount Needed	Estimated Cost ($)	Potential Water Saved (AF)
Ditch Lining & Pipeline	1,815,000 ft		2,488,000	3333
Land Leveling	75,000 ac			
Sprinkler Systems	43,500 ac	20,000 ac	24,412,000	11,625
Public Supply Systems	24 systems	46,500 ac	Unknown	2660
Domestic & Stock Well	Unknown	Repair & Modification	Unknown	160
Commercial & Industrial	Unknown	Unknown	Unknown	40
Vegetation Management	251,000 ac	Unknown	30,800,000	180,000
Total			57,700,000	197,818

Saving water in terms of reducing diversion while maintaining consumptive use is helpful to the water-system operation but does not increase the net basin yield for growth. The salvage potential through vegetation management is unpredictable.

Hondo Groundwater Basin

Agricultural

Irrigated agriculture in the Hondo Groundwater Basin is located in the river valleys of the Ruidoso, Bonito and Hondo Rivers. Surface waters are diverted from the rivers by a variety of diversion structures and pumping systems to community ditch systems. Many of these community ditch systems were developed in the early periods of settlement and still serve the same land. Diversions constructed of rock and brush were used to divert water from the river to the ditches in the early days of development. Most of the diversions have been replaced by permanent structures.

These delivery systems will divert up to ten cfs when adequate flow is available. Approximately 70 percent of the community ditch systems use supplemental groundwater when adequate water supplies are not available from the rivers.

Presently, there are 37 diversions on the Ruidoso River that serve 254,900 feet of ditch system. Twenty-one diversions serve 165,000 feet of ditch system on the Bonito and 12 diversions serve 151,700 feet of ditch system on the Hondo.

Water loss from these ditch systems through seepage and spills varies widely depending on the soils they pass through, maintenance and terrain. The water loss, estimated to range between 20 to 50 percent, has caused problems of erosion and soil saturation. Landowners served by these ditches have tried a variety of methods to reduce water losses from the ditches and the associated problems caused by the water loss. To date, the most effective solution has been to replace the earthen ditches with pipelines. This practice was initiated about 30 years ago and today, 195,400 feet of pipeline has been installed in the ditch systems to reduce water loss. The pipelines have been installed in critical areas where losses were high and in areas that required a high degree of maintenance. Pipelines reduce water loss to less than five percent, an average of 15 percent less than losses from ditches.

The average cost of installing these pipelines for the last 20 years is $4 per foot. The total investment to date is $781,600. Estimating that it is feasible to replace two-thirds of the remaining 375,200 feet of ditch with pipeline, an investment of $1,550,000 would be required to complete this work. These projects would produce water savings of approximately 30 percent, part of which is reduction in return flow.

The farm irrigation systems are surface systems where the water is delivered to the fields through ditches and pipelines and applied through borders, furrows and corrugations. Approximately 90 percent of farmland in this basin has been leveled. Irrigation grades range from zero to one-half foot per 100 feet. Land leveling over the past 20 years has cost an average of $150 per acre. Leveling 90 percent of the 5600 acres of farmland in the Hondo Basin has required an investment of approximately $840,000. Most of the land leveling being done now is maintenance work. Some landowners are using laser leveling. The cost of this leveling averages about $45 per acre. Approximately $25,200 is spent annually on this effort.

With present technology, these improvements are the most feasible and produce water savings and reduced maintenance costs that make the projects cost effective. Some small sprinkler systems have been installed at the end of pipelines where adequate pressure can be produced. Installation of sprinklers throughout the systems would require additional energy costs.

The installation of conservation measures that reduce water loss will have a direct effect on the return flow. Most of the irrigated land is in close proximity to the steams and seepage from ditches and field runoff enter the rivers as return flow. Return flows to the aquifers would be effected to a lesser degree. These losses may be offset by reduced diversion from the rivers and reduced pumping from the aquifers.

Public Supplies

The Hondo Groundwater Basin is probably the fastest growing area in the planning region. The incorporated Villages of Capitan, Ruidoso and Ruidoso Downs support large transient populations that create intensive pressure on the water systems during certain times of the year. Fifteen community or co-op water systems are located throughout the basin that furnish water to communities and individuals that have otherwise been unable to find water of usable quality.

In recent years Capitan and Ruidoso have experienced shortages of water. To address this problem these communities have developed contingency plans and passed ordinances requiring conservation during water-short periods. These contingency plans and ordinances place certain restrictions on water uses such as landscape irrigation and vehicle washing. They also prohibit waste or runoff and establish rates and penalties that discourage overuse or waste of water. The Village of Capitan initiated the development of a 40-year plan in 1996 and the Village of Ruidoso Downs initiated the development of a 40-year plan in 1997. These plans will address needed actions to improve the operation of the water systems and address water conservation needs.

The location of water sources and water rights have created problems for these communities. The operation of delivery systems with many miles of pipeline has proven costly and inefficient. Seepage and spillage from breaks in pipelines have depleted the water supply by as much as 25 percent. As these villages complete their 40-year plans, apply the recommend conservation practices, and relocate or acquire water rights from sources that are more appropriately located, water losses may be reduced by about ten percent.

Surface water stored in Bonito Lake is under the control of the City of Alamogordo and Holloman Air Force Base. Bonito Lake is the only point where fresh water is exported from the planning region. The water from Bonito Lake is transported via pipeline to the communities of Nogal, Carrizozo and Alamogordo. The pipeline system is very old and in need of replacement. Estimates of water loss from this system reach as high as 50 percent due to large spills from breaks in the pipeline. The estimated cost of replacing the pipeline is approximately $2 million. Replacing the pipeline would decrease water loss to about ten percent. Another consideration would be the sale or trade of the Bonito Lake water rights to a user located closer to the lake. Replacement and maintenance cost of the pipeline would be reduced.

There is an increasing demand for water supplies for recreation, wildlife, and other such uses. In recent years the BLM purchased a large block of farmland and the appurtenant water rights. They plan to use the water rights and water to enhance the streamflow and improve the fishery in that reach of the Bonito River. The Mescalaro Apache maintain a lake near their recreation and resort area. This lake provides a source of water to the resort, but is also used for recreation. The ski areas use water during the winter months for maintaining ski runs. Recreation in these mountain communities will continue to increase and to place additional demands on water supplies.

Each community and municipal water system should consider developing 40-year plans as well as conservation/contingency plans to control waste and provide for the most efficient use of the water resource.

Water use and water conservation by community water systems has only small effects on the return flow to the surface water or groundwater systems. Return flow from the municipal water systems is generated through the wastewater systems. All three of these systems contribute direct return flow to the surface water. If recycling is a part of future conservation measures return flow could be reduced by as much as 50 percent.

Domestic Supplies

Wells for livestock water and home use have been developed throughout the basin. Groundwater in areas away from the river valleys is usually at a greater depth and yields a lower flow to wells. Extensive pipeline systems have been installed to deliver water to locations where water is needed for livestock and wildlife or to furnish homes. Many of these systems deliver water to large storage tanks and drinking troughs. Landowners are outfitting tanks with covers and using smaller drinking troughs to reduce water loss through evaporation. With the installation of these practices and proper floats, control valves and by-pass fixtures, water loss in these water systems has been reduced by 15 percent.

Many domestic wells have been developed in the valleys. These wells are used heavily for landscape irrigation when surface water is inadequate and dry conditions prevail. As new subdivisions are developed that require a domestic well for each parcel or lot, the demand on the available water resource will increase.

Practices that may help conserve water from domestic wells are (1) reduce landscape areas or change to a xeriscape; (2) meter domestic wells and enforce the three AFY permitted limit; (3) restrict new well development to less than three AFY or require the applicant to acquire water rights; and (4) install water-efficient fixtures in the homes. These practices could reduce home use of water resources by 15 to 20 percent.

Return flow to the surface water and groundwater sources from domestic uses originates mainly from the irrigation of landscaping around the home. The reduction of this water use would reduce return flow.

Vegetation Management

The Hondo Basin has a wide variety of vegetation types ranging from the semi-desert shrub and grassland at lower elevations to the conifer forests at high elevations. An increase in woody vegetation has occurred in all of the vegetative zones as documented by photographs. Woodlands that were once open stands of piñon-juniper, ponderosa pine, and firs with open meadows and good grass cover are now closed canopy, dense stands of trees with few meadows and very little grass cover.

Approximately 400,000 acres in this basin are occupied by piñon-juniper woodlands that range in stand density from sparse open stands to completely closed canopy of very dense stands. As these trees have increased in size and moved into new areas, springs and wetlands have dried up, grasses and forbs have disappeared and water pollution from erosion has increased. This type of woody vegetation is a heavy user of water and has a massive root system that can reach deeper water supplies. Approximately one-third to one-half of the piñon-juniper stands could be treated by chemical or mechanical treatment. The entire area could be managed by prescribed burn.

The U.S. Forest Service in conjunction with several other agencies and landowners have planned the Carrizo watershed demonstration project and are now applying the planned conservation work. With only a part of the planned practices applied on the 55,000-acre areas, wetlands are developing and springs that have not flowed water for over 50 years are now producing water. This demonstration area has already shown the ability to reclaim water resources. The demonstration should be continued to document net yield.

Treating 60 percent of the piñon-juniper occupied area would require applying chemical or mechanical treatment to approximately 240,000 acres. Records from the Carrizo demonstration show costs ranging from $15 per acre for grubbing with a bobcat to $80 per acre for dozing or pushing dense stands. Chemical treatment costs an average of $20 per acre. Using an average cost of $40 per acre treating the 240,000 acres would cost $9,600,000. Using prescribed burns to manage stand density of the remaining 40 percent of the area, or 260,000 acres, would cost approximately $20 per acre or $3,200,000. Water use would be reduced by approximately 13,333 AFY. Maintaining the area in an open stand condition will cost approximately $480,000 per year.

The second largest woody vegetation type in the Hondo Basin is the conifer forest. Approximately 150,000 acres are occupied by pine, fir and spruce species. Early photographs and documented records show most of the conifer forests to be open stands with grass under the trees and many open meadows throughout the area. These forest or woodland areas are now thick stands of mixed age trees where the grass cover has thinned or disappeared. Flow in the streams and springs has been reduced or has stopped due in part to the vegetation changes. Water quality has been affected by sediment from the increased erosion occurring in this area. Recognition that fire and forest management are necessary for sustained water yield from the watershed has encouraged agencies and landowners to better manage the vegetation on the watershed. The Forest Service is carrying out thinning projects using hand cutting and stacking. Fire is used to remove litter and under growth. Presently, efforts are being concentrated south and west of Ruidoso to reduce fire hazard. Approximately 5000 acres of forest has been thinned and/or harvested through commercial sales in recent years. These management practices cost about $195 per acre for a total investment of $975,000. Due to cost and reduced budgets, it is estimated that only 500 to 1000 acres per year will receive this type of treatment in future years.

The Mescalero Apache have carried out extensive forest management practices on that part of the Hondo Basin within the reservation. Although most of the work completed has been to restore forest health, increased flow from the springs and small streams has been noted.

At present, actual water yield information is not known. At a cost of $195 per acre, the initial cost for treating 150,000 acres would be $4,625,000, maintenance costs for ten years would average $731,250 and the total investment would be $21,937,500.

Approximately 100,000 acres in the Hondo Basin are covered with a variety of vegetation such as mesquite, cholla cactus, yucca, etc. Efforts to control these species have ranged from grubbing of cholla and mesquite to using prescribed burns to reduce top growth and slow the spread of new plants. Some chemical treatment has been used to reduce plant density or limit plant communities to specified areas. The cost of treating these areas will range from $5 per acre for prescribed burns to about $50 per acre for grubbing and stacking of cholla. It will cost an estimated $3,500,000 to treat this area using a combination of treatment practices.

Exotic species such as salt cedar, Russian olive and Siberian elm are increasing along the streams and in areas where shallow water tables are found. These species presently occupy less than 5000 acres in the Hondo Basin, but they are heavy water users. No concentrated or large-scale effort is being made to control these species or prevent their spread. Because these species exist only in scattered stands mixed with native riparian vegetation, control efforts will require hand treatment or individual plant treatment and will cost from $60 to $180 per acre, depending on the number of plants per acre.

Present conservation measures do not maintain existing conditions in the Hondo Basin, and the increase in water quantity used by vegetation will continue. This process will reduce water available for spring and streamflow, recharge to the aquifers, and other beneficial uses. If watershed health could be restored through the accelerated application of conservation measures, water could be salvaged for more beneficial uses. Return flows will not be effected with vegetation management since direct diversion of surface or groundwater does not occur. The proper management of this resource will improve conditions of the water supply from all sources.

A summary of the potential water savings in the Hondo Basin is presented in Table 62.

Table 62. Summary of Water Savings Through Conservation in the Hondo Groundwater Basin

Conservation Activity	Amount Installed	Amount Needed	Estimated Cost ($)	Potential Water Saved (AF)
Pipeline & Ditch Lining	195,400 ft	251,384 ft	1,550,000	5621
Land Leveling	5600 ac	Maintain	25,200	
Public Supply Systems	21 Systems	Repair & Modification	Unknown	250
Domestic & Stock	Unknown	Unknown	Unknown	214
Vegetation Management	105,000 ac	650,000 ac	14,351,000	69,923
Total			15,926,200	75,794

Savings that reduce diversionary requirements but not consumptive use are helpful to the specific water-operations management, but do not increase basin yield. Vegetation management is uncertain as to actual, rather than potential, savings.

Peñasco Groundwater Basin

Agriculture

The Peñasco Basin is similar to the Hondo Basin. Farmland is found mainly in the river valleys and supplied mainly by streams and springs and supplementally by groundwater. The major streams in this basin are the Peñasco River, the Aqua

Chiquita, Stevens Creek and Blue Creek. Presently, 42 diversions on these tributaries supply water to 186,000 feet of irrigation water delivery system. These diversions were first constructed of rock and brush or levees of earth removed from the channel and nearby areas. The diversions have been replaced with more permanent structures constructed of rock and wire, concrete or logs. The delivery systems are mainly earthen channels on a grade designed to carry a given flow of water. Water loss from these ditches ranges from 15 to 50 percent of the water diverted from the streams. In recent years, users of these delivery systems have been installing pipelines in the ditches in the areas where water loss is highest or in areas that require a high level of maintenance. Approximately 10,000 feet of pipeline has been installed in the various ditches. Due to the size of the flow in these ditches, pipes of a larger size are required. This high cost has made the selection of the installation areas more critical. Approximately $40,000 has been invested to date to improve the delivery systems and reduce water loss. The installation of pipelines reduces water loss in critical stretches of ditch to less than ten percent. The water supply for some of the delivery systems is not reliable and only certain areas have been improved. It is estimated that when pipeline is installed, the savings could be as much as 30 percent. Assuming that four AF of water is diverted for each acre farmed, 9652 AF would be diverted, provided the water supply is adequate. A 30-percent savings would equal about 2900 AF of water that could be used to meet other water rights or left in the streams. Part of the savings is in reduced return flow to the surface water and groundwater system. Assuming that 70 percent of the earthen ditches could be replaced with pipelines and would yield a substantial water serving, at present costs, it would require approximately $901,600 to install the 112,700 feet of pipeline. All of the farmland has been leveled to increase application efficiency. This has reduced the need to apply large amounts of water to meet the crop needs. Several of the on-farm irrigation systems have been improved with the installation of pipelines and outlets that provide better control of water.

The installation of conservation practices in delivery systems or on-farm irrigation systems will reduce return flow to surface-water systems and possibly groundwater aquifers.

The increase in new technology, such as sprinkler systems or drip irrigation may allow for greater savings in farm-delivery requirements. Economics will play a major roll in determining the installation and use of new irrigation methods.

Public Supplies

The Peñasco Basin has six municipal or community water systems that supply water to residential and commercial users. The Village of Cloudcroft is the largest incorporated area in the basin. Cloudcroft developed a 40-year comprehensive plan that addresses water development needs. Cloudcroft, like Villages in the Hondo Basin experiences a large transient population that places an extreme demand on the water system. Ordinances that restrict water use during periods of shortages help reduce waste. When the practices outlined in the 40-year plan are implemented, water losses could be reduced to less than ten percent of pumped water. The other incorporated Village is Mayhill. This water system serves about 50 customers and functions more like a community water system. The remaining four systems are community water systems. At present, none of these systems have 40-year plans or contingency plans to address shortages during drought or system failure. Some type of ordinance or plan could provide water savings and address issues of repair or expansion needs. The area of the Peñasco Basin is being rapidly developed for recreational purposes. Both summer homes and winter recreational activities are increasing and placing higher demands on the water supplies.

The WWTP of the Village of Cloudcroft is the second point where water is exported from the basin. The flow from the plant discharges into an arroyo that is part of the Tularosa planning region. Recycling the wastewater for landscape irrigation, washing cars, or return flow to the Peñasco River system may improve water supplies for limited uses. Return flow from public water supplies is small and water use or water conservation will have a minor affect. The use of these water supplies to irrigate landscaping or gardens will produce very limited return flow. Watering restrictions through ordinances would yield negligible affect on return flow.

Domestic Supplies

Wells for domestic and livestock use have been developed throughout the Peñasco Basin. The most concentrated area of domestic well development has been along the river valleys. These areas have been developed into home sites with individual wells, each with three AF of water rights. Wells developed away from the valleys are usually deep and produce only limited supplies of water. This has created a need to install extensive pipeline systems to deliver water to areas where none is available. Many homeowners have limited the landscaping around their homes and use storage facilities to enhance the available water supply. The facilities are being equipped with tops and control valves that reduce evaporation and spillage. Livestock water storage tanks are equipped in the same manner and smaller drinking troughs are being installed to reduce evaporation. These practices can reduce water use by ten to 15 percent.

Future considerations to control water development and provide needed conservation should include basin-wide ordinances or contingency plans to be implemented during droughts or other disastrous conditions.

Domestic water development has only a small impact on return flow. Most of the return flow through central WWTPs or septic tanks. Livestock water that is allowed to overflow from storage tanks or troughs or is pumped into earthen ponds probably generates very little return flow. The implementation of the practices discussed above would have a minor affect on return flow but would affect water supplies through reduced withdrawals.

Vegetation Management

The Peñasco Basin is similar to the Hondo Basin in topography, climatic conditions and vegetative types or zones. The eastern or lower side of the basin supports a desert type of vegetation, the middle area has open grasslands and dense stands of piñon-juniper woodlands and western or upper side has conifer forests. The entire basin has undergone major changes in plant communities during the past 50 to 100 years. These changes are well documented in photos and journals. Woodlands that were once open stands of piñon-juniper, ponderosa pine, fir, and aspen with open meadows and good grass cover are now closed-canopy, dense stands of trees with few meadows and very little grass cover.

Approximately 150,000 acres in this basin are covered with piñon-juniper woodlands that range in density from sparse open stands to completely closed canopy of very dense stands. As these trees have increased in size, density and the area they occupy, known springs and wet areas have dried up, grasses and forbs have disappeared and water pollution from erosion has increased. This type of woody vegetation is a heavy user of water and has massive root system that can reach deeper water supplies. Almost 100 percent of this woodland area is on recharge zones for aquifers that supply water for many other uses. Approximately 70 percent of the piñon-juniper stands could be treated by chemical or mechanical methods. The entire area should be managed with prescribed burns.

Agencies such as the Forest Service and BLM, groups such as the Mescalero Apache, and many individuals have recognized the problems caused by an increase in this species and have treated approximately 60,000 acres in the past 40 years. Approximately $1,200,000 has been spent to date treating these areas. To reduce the piñon-juniper stand be 60 percent or 90,000 acres at an average cost of $40 per acre would require an investment of $3,600,000. Once the initial control is completed, prescribed burns and chemicals could be used to maintain the stands in an open condition. This maintenance program would cost about $180,000 per year. Presently the Forest Service is planning about 5800 acres of piñon-juniper control by prescribed burns. Private individuals are applying about 2000 acres of control per year. The Forest Service allows about 1000 acres to be harvested for fuel wood each year, which helps to thin stands.

An estimated 272,000 acres of the Peñasco Basin are occupied by conifer forests consisting of ponderosa pine, fir, spruce and aspen. Early photographs and documented records show most of the conifer forests to be open stands with grass stands under the trees and many open meadows throughout the area. These forested areas are now thick stands of mixed-age trees where the grass cover has thinned or disappeared. Many of the trees are infested with mistletoe and disease, creating an unhealthy forest. Several areas that have burned by wildfire are now heavily infested with scrub oak brush. These vegetation changes have affected water flow in the streams and springs in the area. Erosion rates have increased due to decreased grass cover, affecting water quality by loading streams with sediment. Recognition that fire and forest management are necessary for sustained water yield from the watershed has increased efforts by agencies and landowners to better manage the vegetation on the watershed. The Forest Service sells timber as part of the forest management program. In the past ten years, 3000 acres of timber harvest has been completed. A timber harvest of 1500 acres was planned for 1998 and another 5000 acres will be harvested in future years. The Mescalero Apaches have been harvesting timber and thinning forest stands for several years. They have applied these management practices to approximately 25,000 acres. In the areas where timber harvesting has been implemented, grasses have returned and an increase in streamflow and water yield from springs has been noted. Applying good management practices that will reduce woody vegetation by 50 percent costs about $195 per acre for a total of $26,520,000. These costs could be partially offset by the sale of the timber resource. To maintain the forest in this condition will cost about $1,326,000 annually. The total ten-year investment would be $39,780,000.

Approximately 100,000 acres in the lower elevations of the Peñasco Basin are occupied with a variety of woody plants and desert succulents. Efforts to control these species have ranged from grubbing of cholla and mesquite to using prescribed burns to reduce top growth and control seedlings, thereby slowing the increase in plant density. Some chemical treatment has been used to reduce plant density or limit plant communities to specified areas. The cost of treating these areas ranges from $5 per acre for prescribed burns to about $50 per acre for grubbing and stacking of cholla. It will cost an estimated $3,500,000 to treat this area using a combination of treatment practices.

Exotic species that were introduced as ornamentals or for conservation uses are increasing along the streams and around springs and other wet areas. Salt cedar, Russian olive, Siberian elm and other non-native species use large amounts of water. At present, these species occupy less than 1000 acres in the Peñasco Basin and are not a major problem. If left unchecked, however, these species could crowd out the native species as they have done along the Pecos River and other tributaries. Since these species exist only in scattered stands or individual plants, control will have to be done by hand or with ground equipment. Hand cutting and clearing or hand treating each plant with chemicals will be required to prevent damage to other desirable plants. This type of treatment will cost from $60 to $180 per acre depending on density.

Native riparian vegetation in the Peñasco Basin is very similar to that found in the Hondo Basin. It is an essential part of the plant community and the ecosystem along rivers and other wet areas. Natural control of plant growth, such as fire, has until recently been removed from the management of these areas. Livestock grazing has also been eliminated or reduced. As a result, the density of the plant communities has increased.

Presently, with the exception of the work being done by the Mescalero Apaches, conservation measures are being applied at a rate that does not maintain existing conditions. At the present rate of application of conservation and management measures an increase in water quantities used by vegetation will continue. This process will reduce water available for spring and streamflow, recharge to the aquifer, and other beneficial uses. If watershed health could be restored through the accelerated application of conservation measures, water could be restored to the water regime in the basin.

Vegetation management does not have a direct effect on return flow since water is not diverted for plant irrigation. The proper management of this resource can increase streamflow and aquifer recharge.

A summary of the potential water savings in the Peñasco Basin is presented in Table 63.

Table 63. Summary of Water Savings Through Conservation in the Peñasco Groundwater Basin

Conservation Activity	Amount Installed	Amount Needed	Estimated Cost ($)	Potential Water Saved (AF)
Pipelines & Ditch Lining	10,000 ft	11,000 ft	$160,000	2900
Land Leveling	2413 ac	Maintain		
Public Supply Systems	8 Systems	Repair& Modification	Unknown	45
Domestic & Stock	Unknown	Unknown	Unknown	5
Vegetation Management	89,500 ac	492,500 ac	$60,930,000	61,006
Total			$61,090,000	63,956

Most of the water savings previously discussed are in the form of reduced diversions, rather than reduced consumptive use. The exception is vegetation management, where the net yield is uncertain and may be significantly less than the potential yield.

Carlsbad Groundwater Basin

Agriculture

The Carlsbad Basin has the second largest area of irrigated agriculture and is the largest user of surface water for irrigation in the planning area. Approximately 75 percent of the 36,000 acres of farmland are irrigated with surface water. The other 25 percent are irrigated from groundwater sources. Approximately 45 percent of the land irrigated by surface water also has access to supplemental groundwater.

The CID manages the delivery system that provides water to 92 percent of the farms that irrigate with surface waters. This system contains approximately 30 miles of main canal and 260 miles of lateral canals. The system also has storage in four major reservoirs on the Pecos River. Water loss from this system prior to the installation of conservation measures ranged between 40 and 50 percent per year or approximately 39,000 AF. The installation of conservation practices began with concrete lining of approximately ten miles of the main canal. During the 1970s the CID entered into a program with the BOR where two and one-half miles of the main canal were relined and approximately 85 percent or 221 miles of the laterals were lined. The completion of these projects has reduced water loss to about 23 percent or 17,940 AF when a three AF allotment is delivered. Most of the water savings is in reduced return flow. The installation of these conservation measures has required investment of approximately $9,950,000. The CID measures all water deliveries to the individual farms and uses computer modeling and records on a 24-hour basis to provide better management of the overall system and closer scheduling of water deliveries. Several miles of both open and underground drainage systems were installed in the early years of the irrigation project. Many of these drains are still functional and provide return flow to the river. Approximately 15 miles of open and underground drains were installed between 1910 and 1930. Several of these drains carry flows directly to the Pecos River or its tributaries. The CID works on or participates in other programs for water conservation within the project area such as salt cedar control. The construction of Brantley Dam to replace McMillan Dam was a major conservation measure that has saved water.

The installation of conservation systems on the farms is an ongoing program in the Carlsbad Basin. All 36,000 acres of farmland have been leveled into basin borders on flat grades. Large heads of water are used to flood each border quickly. This leveling has required an investment of $1,080,000. Many of the landowners maintain a program of laser leveling the land between crops to gain the most uniform water application possible. This costs approximately $50 per acre. Landowners have installed 1,087,653 feet of ditch lining and 109,761 feet of irrigation pipeline to conserve water and improve water application efficiency. These ditches are equipped with checkgates and turnouts. The installation of the pipelines has cost approximately $439,044. Lining irrigation ditches and installing the needed water control structures cost $14 per foot in

1996. Similar ditch lining projects completed in 1970 cost approximately $3.50 per foot. Using an average cost of $8.25 per foot an estimated $8,973,137 has been invested in these conservation measures. The overall irrigation system of leveled-basin borders and concrete lined ditches with turnouts and checkgates can reach system efficiencies of 80 to 90 percent. Water management efficiencies can reach 85 to 95 percent. These irrigation systems, prior to installation of conservation measures, averaged 50 percent on-farm efficiency or less.

Conservation projects that should be considered in the future are lining the remaining 20 miles of the CID main canal and the remaining 39 miles of laterals that deliver water to the farms. The projects will cost an estimated $9,398,400 and may increase system efficiency to 90 percent.

An estimated 40,847 feet of field ditches remain unlined at this time. Approximately 2500 feet of ditch are lined or are replaced with pipeline each year. To complete improvements to the remaining ditches will require an investment of $612,705. In addition to the lining of existing earthen ditches, approximately 15 percent of the presently lined ditches are deteriorating and need to be replaced. An additional investment of $2,447,219 would be required to replace these ditches. This conservation project would increase the efficiency of all of the irrigation systems to 85 to 95 percent. Most of the saved water would be in reduced return flow.

Future changes that may reduce water use or water loss are changes in crops that produce higher income but use less water or crops that are more tolerant to salty conditions and requiring less leaching. The installation of on-farm drain systems would increase return flows and reduce leaching requirements. As technology improves, irrigation water use could be reduced. Methods to reduce evaporation from the lakes and main canals could save large amounts of water since net lake evaporation rates are over 60 inches per year in this area.

Return flow from the irrigation systems would be reduced when the installation of the concrete lining and irrigation pipelines is complete.

Public Supplies

Presently the Carlsbad Groundwater Basin has the second largest population in the Lower Pecos River planning region. The incorporated areas are the City of Carlsbad and the Village of Loving. There are also nine community water systems in this basin that serves a large part of the population. The potash mines and gas and oil development businesses are heavy users of water and either use water from public supplies or have developed their own water supplies. Each of these water users has developed plans that meet their need for management and conservation of their water supply.

The City of Carlsbad has developed a 40-year water plan that details their water supply and their plans to develop and use that resource. Needed improvements to the water system are noted as well as the overall management of the system. When these improvements are implemented, water will be conserved by prevention of leakage and spillage, and by better overall management of the system.

The City of Carlsbad has also developed a water conservation plan that outlines BMP. The plan states that if three of ten BMPs (3, 4 and 6, see below) are implemented, water use may be reduced by ten percent over the next 20-year period. If all ten BMPs are implemented as discussed in the plan, water consumption may be reduced by 20 percent over the next 20-year period.

Carlsbad is presently evaluating recycling of wastewater to irrigate golf courses, parks and for possible agriculture use. Presently, the processed wastewater is discharged to the Pecos River. When recycling is implemented 2000 AFY could be available to irrigate parks, golf courses and other city property. This would reduce pumpage from the aquifer and surface-water diversions by 2000 AFY. With the initiation of the BMPs and the recycling program, a reduction of 3700 AFY of water withdrawals from groundwater and surface water could be achieved. An emergency ordinance has been drafted by the City to control water use during drought or other emergencies. The City of Carlsbad uses the sale of water to provide part of the City's operating revenue. A balance between the need for water conservation and the economic impact water conservation could have on the City's revenues should be evaluated before fully implementing these practices.

Although the Village of Loving has not developed a 40-year water plan or a conservation plan, water conservation is recognized in the management of their water resources. Wastewater from the treatment plant is used in agricultural production when possible. When not used for irrigation, the water is added to the Pecos River as return flow. The Village also sells water to the Malaga Water Users Association. This, combined with other sales, provides a source of income to the Village. Loving monitors their water supply closely and has temporarily stopped approving water connections outside the Village limits. Meters are strictly monitored to prevent water loss or unauthorized uses.

None of the water co-ops have developed 40-year water plans or water conservation plans in the basin, although several of them are experiencing water supply shortages or problems with water quality. Although several of the larger water co-ops develop short-term plans for improving the efficiency of their systems, long-term overall planning is needed to better address how to meet future water demands and conservation issues. Improved system efficiency and implemented conservation measures could reduce water diversions by as much as 15 percent.

Two potash mines use water resources from the Carlsbad Basin. International Minerals and Chemical Corporation (IMC) uses water that is pumped from the Capitan Reef near Carlsbad to the mine site east of Carlsbad. Mississippi Chemical Corporation has surface-water rights available with a diversion point from the Pecos River northeast of Loving. All of the mines recycle water when possible. Fresh water is used in potash processing and milling, and wastewater is used to move mine wastes to tailings ponds. By re-using water, the mines have reduced water usage by as much as 30 percent.

Gas and oil production is a major industry in this basin and water is used in drilling operations and production. This industry also produces large amounts of water from deep formations. Present laws and regulations require drilling and production operations to use water from upper formations that require a water right. Water produced from gas and oil wells must be returned to the deeper formations. The possibility of using the water produced from gas and oil wells in the drilling of other wells or in production operations should be studied. If no negative impacts are likely, the laws and regulations should be changed to allow the use of the produced water. This could provide conservation of the fresh water now being used to produce gas and oil and to drill wells. Produced water may, in the future, provide a source of water that can be used as a public water supply or for other uses.

Recreation is a major business in the Carlsbad Basin and is dependent on an adequate supply of water. The Carlsbad Caverns National Park has 500,000 to 700,000 visitors each year. The water supply for this transient population is pumped from Rattlesnake Springs and piped a distance of six miles. This system has been in place for many years and water loss from breaks in the system occur frequently. This system should be replaced to improve efficiency and reduce loss from system failure. White City, Inc. is a corporation-owned recreational enterprise that is dependent on tourism. This corporation has developed groundwater resources to provide water for their clientele and business operations. Wastewater is collected in evaporation ponds and leach fields and provides some return flow to groundwater.

The City of Carlsbad uses part of their surface-water supply to maintain lakes on the Pecos River within the city. These recreational areas are used heavily by tourists and residents and influence the economic stability of the community.

The BLM recently acquired part of Black River and all of the Delaware River in New Mexico. The BLM plans to maintain or develop these areas as recreational sites or as natural areas. The water will be used to maintain instream flow for fishing and wildlife habitat. The Forest Service maintains a recreational site at Sitting Bull Falls. Recreational uses of water resources should be well planned, and conservation measures that will reduce waste or use should be implemented. Phreatophytic vegetation along recreational waterways should be controlled to reduce use or water loss, and means to reduce evaporation should be considered. Return flow produced by the water uses discussed above may be reduced by the implementation of the suggested conservation measures.

Domestic Supplies

Wells for domestic and livestock water have been developed throughout the Carlsbad Basin. These wells are usually controlled by a well permit and are limited to three AFY. Domestic withdrawal is typically near 0.35 AFY per household and consumptive use is less. Many of these wells produce poor-quality water that is high in salts or contains sulfur.

Wells developed for domestic purposes in alluvial areas of the valley are usually shallower than wells that are developed in the limestone and sandstone formations. The wells developed east of the main irrigation canal and south of Black River are usually high in salt content while wells in the western part of the basin produce better-quality water. Many of the domestic and livestock wells produce small flows. These conditions have led to the development of community water systems and the installation of extensive pipeline systems for livestock water.

Water users are installing covered storage tanks and smaller diameter drinking troughs to reduce evaporation from watering systems. Surface water is caught in impoundments, but landowners are now storing the water in enclosed tanks. Agencies interested in wildlife management are installing artificial watersheds or other devices to catch rainwater and make it available to wildlife thereby lessening the amount of water pumped from groundwater resources to meet wildlife needs.

Conservation practices that should be considered in the future include limiting landscaping around homes or using xeriscaping where possible, installing water efficient fixtures in homes and controlling spillage or excessive pumping from livestock wells.

The effect of conservation measures on return flow to the water cycle will be small. Return flow of seepage from water impoundments would be reduced and any return flow from home use or irrigation of landscaping may be reduced. These reductions would be offset by reduced pumping from the aquifers.

Vegetation Management

The terrain of the Carlsbad Basin ranges from mountainous terrain on the west edge to desert valley at the lower elevations and plains in the east. A variety of vegetation occupies the basin. Because of factors such as fire control, management of grazing, weather changes and atmospheric conditions, plant size and density has increased and is affecting the health of the watersheds and negatively impacting water quantity and quality.

Approximately 130,000 acres of the Carlsbad Basin are covered with average density mesquite in aquifer recharge areas. Another 300,000 acres contain stands of mixed density that affect runoff and surface recharge of springs and small streamflows. Treating the mesquite at $35 per acre would cost $4,550,000 on those areas considered recharge zones, and $9,555,000 to control the remainder. With a five percent per year investment for maintenance the total cost for ten years would be $17,850,000.

Chemical control has been successfully applied to this type of vegetation in this basin. Presently most of the control work is being done with the use of chemicals at an average annual cost of approximately $20 per acre. An estimated 10,000 acres of mesquite have been controlled in the last 30 years. Much of this is needing retreatment due to a lack of maintenance of the treated areas.

Piñon-juniper stands occur on the western edge of the Carlsbad Basin. Most of this vegetation type occurs in the steep rugged area of the Guadalupe Mountains and is not feasible to treat mechanically. Piñon-juniper stands in this area have increased in density and continue to expand. Presently 60,000 acres in the basin occupied by these stands are considered recharge areas to the Capitan Reef and shallow aquifers. Both aquifers are a major source of water in the basin. The National Forest Service and National Park Service are developing plans to use natural fire and prescribed burns to reduce these stands and control the spread of this vegetation. Water could be salvaged to increase the flow of springs and rivers and recharge the aquifers.

The use of chemicals to reduce piñon-juniper stand density should be evaluated. Some of the chemicals presently available will control these species under certain conditions and may offer more permanent control than fire. Prescribed burns cost an average of $15 per acre and would require an investment of $900,000 to treat this area. Re-treatment would be required every five to seven years at a cost of $5 to $15 per acre. Chemical control costs an average of $40 per acre and would require an investment of $1,440,000, but would provide a ten to 20-year period before retreatment is required. Assuming a five percent maintenance cost per year for a ten-year period, it would cost $2,160,000 to complete this improvement.

Salt cedar has invaded approximately 35,000 acres in valleys and river bottoms in the Carlsbad Basin. Most of the area occupied by this species had relatively high water tables or were riparian and wetland areas. As salt cedar has developed into mature stands in these areas, the water table has declined and surface water has diminished.

Estimates of water use by salt cedar range from three to seven AF per year. These plants have root systems that, once established, can take water from greater depths than other plants in the area. They also exude salts that contaminate the soil surface and affect water quality. Control of this species within the Carlsbad Basin could conserve water, improve flows in rivers and springs, enhance riparian conditions, and contribute to recharge of the aquifers.

Approximately 5000 acres of salt cedar control has been completed along the Pecos River, mainly by mechanical methods. Mechanical control costs an average of $250 per acre and usually requires frequent re-treatment to remove seedlings. Recent work with chemical control has been done at a cost of about $150 per acre and would require an investment of $5,250,000. Adding a five-percent maintenance cost per year for ten years, control of the salt cedar would yield a total cost of $7,875,000.

The largest population of the Carlsbad Basin is occupied by a wide variety of desert vegetation. These include sumac, tarbush, creosote, catclaw and desert succulents such as lechugilla, yucca and sotol. In recent years these species have increased in stand density, area occupied, and size of the plants. This may have an impact on water quality and quantity. The area occupied by these species is estimated at 600,000 acres and includes critical aquifer recharge areas.

The control of these species would require a variety of treatment methods. Prescribed burns have proven effective on most of the succulents, at a cost of about $10 per acre. It should be noted that this is the only control method that, at present, will be considered in the National Parks and wilderness areas. Chemicals such as tebuthirion are effective on creosote, tarbush, and catclaw at costs up to $50 per acre. These methods will produce a control of 60 to 95 percent. Other chemicals are effective on sumac and other species that infest this area. Some hand cutting, grubbing and other methods may be necessary on stands that are near areas sensitive to chemicals. Costs of this type of control can range up to $100 per acre.

Shinnery oak occupies the sandy soils east of the Pecos River. Little is known about the effects of this species on water supplies. Studies show that as shinnery oak numbers increase, grass stand density and coverage decrease, indicating that the moisture is not available for the grasses. Soil erosion also dramatically increases on areas occupied by shinnery oak. This affects the quality of runoff that enters the rivers and arroyos. Shinnery oak occupies approximately 70,000 acres of the Carlsbad Basin. An estimated 10,000 acres have been treated with chemicals over the past 20 years at a cost of about $20 per acre. Chemical control appears to be the only suitable method of shinnery oak control at this time.

All presently known methods (chemical, mechanical, fire and biological) of managing woody vegetation are suitable for use in the basin on a site-specific basis. Soils, topography, weather conditions and proximity to other land uses are key considerations in determining the method of control.

Return flows will not be effected with vegetation management since direct diversion of surface or groundwater does not occur. Existing flows from springs and streams have increased where vegetation management has occurred on watersheds. This same results is expected to occur on a larger scale when vegetation is properly managed throughout the basin.

A summary of the potential water savings in the Carlsbad Basin is presented in Table 64.

Table 64. Summary of Water Savings Through Conservation in the Carlsbad Groundwater Basin

Conservation Activity	Amount Installed	Amount Needed	Estimated Cost ($)	Potential Water Save (AF)
Ditch Lining & Pipelines	1,366,902 ft	515,515 ft	12,458,324	56,250
Land Leveling	36,000 ac	Maintain		
Public Supply Systems	10 Systems	Repair & Modification	Unknown	1461
Commercial/Industrial	Unknown	Unknown	Unknown	1785
Domestic & Stock Wells	Unknown	Unknown	Unknown	12
Vegetation Management	33,500 ac	1,125,000 ac	34,500,000	86,000
Total			46,958,324	145,508

The potential water savings benefit the specific water operation, but do not affect overall basin supply unless consumptive use is also reduced. Vegetation management is uncertain as to actual yield rather than potential yield.

Capitan Groundwater Basin

Industrial Use

Gas and oil production is a major industry in this basin and water is used in drilling operations and production. This industry also produces large amounts of water from deep formations. Due to poor water quality and difficulty in locating adequate supplies of water from shallow aquifers, much of the water used in drilling is imported from other basins. Present laws and regulations require drilling and production operations to use high-quality water from upper formations. Low-quality water produced from gas and oil wells must be returned to deeper formations. The possibility of using low-quality water produced from gas and oil wells for drilling and production operations should be investigated. If no negative impacts are apparent, the laws and regulations should be changed to allow use of low-quality water. This could provide conservation of fresh water now being used to produce gas and oil. Produced water may, in the future, provide a source of water that can be used as a public water supply or for other uses. There is also potential for using this water source to meet Compact obligations. At present, it is not economically feasible to treat this water to acceptable standards.

The majority of the potash mines in the planning area are located in the Capitan Basin. These businesses use water in the mining and milling of potash used in fertilizer and other products. The milling process requires high-quality water to prevent contamination of the potash products. Due to the poor quality and inadequate supplies of water from the Capitan Basin, water is imported from the Carlsbad and Lea Groundwater Basins. Most of the mines reuse the water after processing potash to move the wastes to tailings ponds.

Conservation measures outlined here would have very little affect on return flow.

Domestic Supplies

Domestic and livestock water of good quality and adequate supply are difficult to find in this part of the Capitan Basin. When it is found, extensive pipeline systems are installed to deliver this water to areas where water is in short supply. The shortage of water and the expense of pumping and building pipelines make landowners aware of the need to practice good conservation. Storage facilities and drinking facilities that help reduce water loss by evaporation are always considered prior to installation.

Most of the homes in this basin have minimal landscaping requiring irrigation. To further conserve domestic water supplies, consideration should be given to installing fixtures that are considered water efficient.

Due to the short supply of water, most water users are very aware of the need for conservation and few changes are expected in this basin. No changes to return flows will occur from conservation of domestic water supplies.

Vegetation Management

The part of the Capitan Basin in the planning area is basically southern desert consisting of rolling hill terrain and low depressions. The vegetation is typically desert except along the eastern side of the basin where a transition to the plains occurs. This basin lies on the east side of the Pecos River and has few well-defined drainages. The vegetation conditions as noted for other basins are also prevalent in the Capitan Basin.

Over 65 percent of the Capitan Basin is occupied by mesquite. In some areas of sandy soils the only vegetation is mesquite which occupies the large sand dunes. The area between the dunes is usually bare and all topsoil is gone. Areas of mesquite that have been treated with chemical show a rapid return to more desirable vegetation and a shrinking of the dunes as the sandy soil is spread back out.

The density of the 175,000 acres of mesquite range from light, scattered stands to very heavy, thick stands that are hard to move through. Although these areas are not known to be major recharge areas, the area does contribute flow to the Pecos River. Several playa lakes are also found in this basin.

Chemical control has been successfully applied to this type of vegetation and presently, most of the control is being done with chemicals at an average cost of approximately $35 per acre. An estimated 5600 acres of mesquite control has been done in the basin during the past 30 years. Most of this area is in need of retreatment or maintenance by fire. To apply chemical control to the entire mesquite area would require an investment of approximately $4,287,000. Mechanical control could be used on the lighter, scattered stands at a cost of about $45 per acre. Estimating it will cost an additional five percent for maintenance, the total cost for ten years would be $6,431,250.

Shinnery oak is found along the eastern side of the Capitan Basin. It occurs in stands that are almost pure shinnery oak and in stands mixed with mesquite. Shinnery oak usually occurs in thick or heavy stands and competes heavily for moisture and nutrients. Little is known about the effects of this species on water supplies. Studies show that as shinnery oak stands increase, grass stands decrease, indicating that the shinnery is out-competing the grasses for moisture and nutrients. Soil erosion also dramatically increases on areas occupied by shinnery oak. This affects the quality of runoff entering arroyos and playas. Shinnery oak occupies approximately 80,000 acres of the basin. Chemical control is presently the only control method that is successful on shinnery oak. Cost estimates range between $20 and $35 per acre. Removal of 50 percent of the shinnery oak would require an investment of approximately $800,000. With maintenance cost for ten years estimated at five percent of the initial cost, the total ten-year cost would be $1,200,000.

Desert vegetation occupies the western part of this basin, similar to that found in the Carlsbad and Roswell Basins. Species included are sumac, tarbush, creosote, catclaw and desert succulents such as lechugilla, yucca and sotol. In recent years these species have increased in stand density, area occupied, and the size of the plants. This is having a major impact on water quantity and quality. The area occupied by these species is estimated at 100,000 acres.

The control of these species would require a variety of treatment methods. Prescribed burns have proven effective on most of succulents at a cost of about $10 per acre. Chemicals such as tebuthirion are effective on creosote, tarbush and catclaw at cost up to $50 per acre. These methods will control 60 to 95 percent of the vegetation. Other chemicals are effective on sumac and other plant species that infest this area. Hand cutting, grubbing and other methods may be necessary on stands that are near areas sensitive to chemicals. Costs of this type of control can range up to $100 per acre.

Salt cedar has infested the shallow water areas, playa lakes and earthen ponds and now occupy about 500 acres in the basin. Salt cedar can use up to seven AFY of water when it is available. These plants contaminate the soils with secreted salts and hindering establishment or growth of other plants. Chemicals have proven to be the most effective control of this plant. It will cost an average of $150 per acre to treat the salt cedar, or a total cost of about $75,000.

All presently known methods (chemical, mechanical, fire and biological) of managing woody vegetation are suitable for use in the basin on a site-specific basis. Soils, topography, weather conditions and proximity to other land uses are key considerations in determining the method of control.

Return flows will not be affected with vegetation management since direct diversion of surface or groundwater does not occur. Existing flows from springs and streams have increased where vegetation management has occurred on watersheds. This same result is expected to occur on a larger scale when vegetation is properly managed throughout the basin.

A summary of the potential water savings in the Capitan Basin is presented in Table 65.

Table 65. Summary of Water Savings Through Conservation in the Capitan Groundwater Basin

Conservation Activity	Amount Installed	Amount Needed	Estimated Cost ($)	Potential Water Saved (AF)
Commercial/Industrial	Unknown	Unknown	2,300,000	802
Domestic & Stock	Unknown	Unknown	Unknown	26
Vegetation Management	8400 ac	356,000 ac	7,180,000	18,166
Total			9,480,000	18,994

The savings is in diversionary requirements, except for vegetation management, which is uncertain as to the full potential savings.

Although the cumulative potential water saved among six declared basins, including the mountain forests, is several hundred thousand AFY, the amount considered reliable for planning purposes is much less as outlined in the subsequent evaluation of alternatives.

SECTION X: WATER PLAN ALTERNATIVES

Introduction

For many years there has been concern that the water supplies of the Pecos River Basin will become insufficient to satisfy all water demands and that water scarcity will constrain economic development. Substantial water law has resulted from attempts to define ownership and to adjudicate property-right limitations to the water resources of the basin. Yet, the water resources of the basin are certain to become more scarce and valuable as additional demands are made, demands that result from economic and human needs that compete for the limited available supplies.

In a fully appropriated basin such as the Pecos River Valley, few sources of additional water supply exist. Interbasin transfers of water can "create" new water, particularly when water is transferred from an undeveloped basin to one in which demand is high. Potential exists for transferring additional water from the Lea County and Salt Basins to the east and west of the planning area. An interbasin transfer from the Salt Basin has been proposed, but is not treated here.

Other proposals for "creating" new water include salvage of evapotranspiration by removing vegetation. A proposed alternative for future vegetation management is outlined. Evapotranspiration losses can be salvaged in McMillan Delta. Lowering the water table would eradicate salt cedars and recover an estimated 12,000 AFY.

With a large reservoir of poor-quality water underlying many areas of the Pecos River Valley, desalinization represents a prospective solution to water shortages.

Other potential future water sources include increased precipitation from cloud seeding, reduced evaporation by underground water storage and reduction of reservoir surface area, and agricultural and industrial water conservation. Details of these alternatives can be found in this section.

Table 56 (Section VIII) developed a growth of water requirements equal to 25,400 AFY by year 2040. Consumptive use of half that amount implies that new basin yield of 12,000 AFY is to be provided in the Regional Water Plan. In order to meet the estimated shortfall between supply and demand in 2040, 17 alternatives (plus a no-action alternative) are presented herein and discussed in terms of costs, expected water yield, feasibility, and impacts including Compact and environmental effects.

An alternative, in the context of this water planning document, is defined as a broad category of actions or group of actions that, if implemented, will reduce the predicted shortfall between supply and demand in the Lower Pecos Valley and will meet Compact requirements from the year 2000 to the year 2040. A key element in the identification and evaluation of the alternatives, however, is that each one shall meet, to the extent possible and while protecting existing priorities, the stated objectives of:

1. ensuring an adequate supply to meet existing water rights,

2. supporting projected growth of the general population in the planning region (and a concomitant growth in commercial, industrial and other activities) over the 40-year time period,

3. supporting growth in agriculture by two percent, whether measured by water or by economic growth,

4. meeting the Pecos River supply and Compact obligations,

5. maintaining or improving the environment for humans, plants, and animals, and

6. allocating all future available water for beneficial use in New Mexico.

The Planning Committee has spent considerable time attempting to identify the actions that are practical and technically feasible, as well as environmentally, politically, socially, and legally acceptable for the Lower Pecos planning region in order to meet the average shortfall. The experience with on-going basin water-management operations, conservation programs and costs detailed in Section IX, as well as the Principles of Resource Management outlined in Section IV, have been applied to identify planning alternatives. The alternatives considered in the Regional Water Plan are:

Alternative 1 – Enhanced Water Market
Alternative 2 – Managed Wellfield Operations
Alternative 3 – Agricultural Water Conservation
Alternative 4 – Moving Reservoir Storage
Alternative 5 – Municipal Water Conservation
Alternative 6 – Industrial Water Conservation
Alternative 7 – Riparian Vegetation Management
Alternative 8 – Watershed Management
Alternative 9 – Dewatering of McMillan Delta
Alternative 10 – Desalination
Alternative 11 – Construction of Interstate Pipeline
Alternative 12 – Cloud Seeding
Alternative 13 – Construction of Large Reservoirs
Alternative 14 – Aquifer Storage and Recovery
Alternative 15 – Reduce Reservoir Surface Area
Alternative 16 – Reducing Conveyance Losses in Pecos River

Alternative 17 – Import Water from Salt Basin

Evaluation Criteria

The 17 alternatives (plus no action) are discussed in this section based on several evaluation criteria:

Expected Water Yield
Costs
Feasibility (Technical, Legal and Political)
Impacts (Pecos River Compact, Environmental, Social and Economical)

Two of the alternatives, Agricultural Conservation (Alternative 3) and Municipal Conservation (Alternative 5), have several actions that are discussed and evaluated individually. In Section XI (Evaluation of Alternatives and Implementation) these criteria are assigned values (yes or no for feasibility and a relative weight for impacts) for each alternative. The selected alternative(s) should be continuously evaluated during implementation to verify yield, cost, feasibility and impacts. A description of the criteria follows.

Expected Water Yield

The water yield of an alternative is either a decrease in consumptive use (managed or unmanaged) or an increase in basin yield. A decrease in consumptive use creates an opportunity for redistribution of existing water supplies. The three components of water accounting are diversion, consumption and return flow. Many proposed alternatives, such as ditch lining and effluent reuse, reduce the water user's diversion requirement and reduce return flow. Consumptive use changes, a small percentage or in some cases not at all. A portion of the water saved by ditch lining is salvage from phreatophytes living on ditch leakage. The specific water operation sees a reduction in the delivery amount, but the supply and consumption in the basin has changed much less than the diversionary amount.

Two alternatives, Construction of an Interstate Pipeline (Alternative 11) and Cloud Seeding (Alternative 12), increase basin yield. Other alternatives that yield water do so by reducing consumptive use or by salvaging outflow from the basin. Moving Reservoir Storage and Covering Reservoirs reduces evaporative consumptive use. Riparian and Watershed Management reduce unmanaged evapotranspiration. Construction of Large Reservoirs or Aquifer Storage and Recovery to capture and store unappropriated floodflows reduces outflow from the basin.

Three of the proposed alternatives, Enhanced Water Market (Alternative 1), Managed Wellfield Operations (Alternative 2), and Riparian Vegetation Management (Alternative 7) require further discussion with respect to water yield.

The water market equates supply with demand by allowing efficient transfer of the resource. Demand shrinks by means of compensation by one use for another. Though the consumptive use of water traded in the market moves from one use to another, it is treated as a yield to the new project for the purposes of analysis. Under a water market, consumptive use is reduced in one economic sector (e.g. agriculture) and the gains are put to beneficial use in another economic sector (e.g. municipal use). The cost of the transfer is the cost of the water.

Under the riparian vegetation management alternative, consumptive use is reduced in unmanaged losses and the gains are beneficially used in an economic sector (e.g. agriculture). The cost of the benefit is the cost of managing the vegetation.

Managed wellfield operations also deserve special consideration. When a well is turned on, it removes storage from groundwater. When it is turned off, the storage is replenished (in the Roswell artesian aquifer over many decades) from other sources in the basin as induced recharge of surface water. If the aquifer fully recovers, the net yield over the decades is zero. However, for the purposes of analysis, the yield of the managed wellfield operations alternative will be that quantity of water that can be practically withdrawn above baseline pumping for one year. The payback period at induced rates of one to five percent per year is assumed to occur when the water is relatively more available than in the year(s) of aquifer operation.

<u>Costs</u>

The cost of each alternative takes into account capital and operation and maintenance (O&M) costs. Where possible, unit costs are multiplied by the number of appropriate units. The total capital and O&M costs are then annualized over the 40-year planning period at seven-percent interest. Where no capital or O&M costs are apparent, other types of costs are computed, such as the loss of consumer surplus (the value attached to loss of use).

Feasibility

Technical. Is technology reasonably available to implement the alternative? Are there other engineering or operational constraints that make the proposed alternative infeasible? Will the alternative yield the anticipated amount of water? The cost component is an important qualification in technical feasibility, as almost any project can be made technically feasible if enough money is spent. The low-cost technically feasible alternatives are preferred, but other factors come into play.

Legal. Is the alternative legal within state, local and federal law? Will there be harm to third parties that might cause litigation? An alternative may require legislation – either as a change in the law or local and state funding. Without such legislative action, the alternative cannot be implemented and is not feasible.

Political. Is the alternative acceptable to the public and to elected officials? Will there be strong opposition by particular interests that may prevent implementation of the alternative?

Impacts

Pecos River Compact. Will the alternative change the State's obligations or deliveries under the Compact? The Compact is a critical factor when planning any project in the Pecos Basin. Both obligations (what the State is required to deliver) and deliveries (what the State is able to deliver) must be considered. The Compact states that "New Mexico shall not deplete by man's activities the flow of the Pecos River at the New Mexico-Texas state line below an amount which will give to Texas a quantity of water equivalent to that available to Texas under the 1947 condition," as discussed in Section IV.

Environmental. What are the impacts of the alternative on streamflow, habitat, water quality and other environmental quality indicators?

Social and Economic. Will the alternative be perceived as fair? Does the project have enough benefit to compensate for its cost? Does it enhance the economic growth of region relative to other potential infrastructure projects?

Each of 17 alternatives plus the no-action alternative is described and evaluated in these terms. The no-action alternative is treated as the baseline, with no yield, not costs, no issues of feasibility and no impacts.

Cumulative Impacts

A cumulative impact is defined in 40CFR 1508.5-91 as:

"The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonable foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

The impacts of the baseline are discussed under Alternative 0 (No Action). Cumulative impacts of each of the 17 alternatives will be the baseline plus the incremental impacts discussed under each alternative.

Alternative 0 – No Change in Current Activities

Description

This section reviews the effect of taking no action to resolve the potential mismatch between the water supply and the water demand over the planning period. Alternative 0 is the baseline for assessing the effects of Alternatives 1 – 17. The no-action approach recognizes that there is a market for water rights. This circumstance may result in an economical and, ultimately, acceptable resolution of the water issues: it would allow the current and future water problems in the Lower Pecos River planning region to be solved by the open market and by the current administered law of appropriation.

Currently, the ISC is purchasing and retiring water rights. At the present time, the ISC is paying about $1,750 per acre foot of water delivered to the State line by retiring water rights. The economic impacts have been studied and quantified by others.[44 above] They evaluated, among other scenarios, the impacts of the leasing and purchasing of water rights and the associated land relative to the requirements of satisfying the Compact. They concluded that the cost to the region and State of buying up to 15,000 AF of water rights would be about $32,011,000 in direct costs and $26,577,000 in indirect costs for a total of $58,588,000. As a rough order of magnitude, one might expect a total cost for 28,000 AF (the expected shortfall in 2040) to be about $120 million, or an annualized unit cost of about $400 per AF.

Most senior water rights are held by individuals, irrigation districts, and municipalities. As communities continue to grow and attempt to attract new commercial, industrial and tourism activities in order to improve the economic base, the communities in the planning region will seek the least expensive way to satisfy their growing water needs. In the industrial sector, there will be an emphasis placed on more efficient water use, on reuse of water, and on pricing water to encourage conservation without penalizing the industries ability to compete on a national level. When the above measures are exhausted, the municipalities will buy water rights from agriculture, agriculture-related businesses or other water users that have senior water rights. This action results in the elimination of marginal farming operations and a reduction in agricultural activities in the planning area. Since one of the major economic activities in the area is agriculture at the present time, the effect will be to depress the economy in the short term, not only in agriculture itself but also in businesses that depend upon or support agriculture. The efforts of the municipalities to bring in other commercial and industrial activities, including tourism, will tend to offset the effect of the agricultural down turn in the longer term.

It could be expected that agricultural activities will continue to decline as more water rights are acquired by municipalities and as other less water-intensive enterprises are started up in the region. Junior water rights that could have been transferred to other agricultural enterprises will be retired when land is sold out of agriculture into other activities. The overall effect is that the economy switches from a mostly agricultural base to one based to a greater degree on other commercial and industrial activities. It may take many years or even decades before an improvement in the economic base occurs.

Insofar as the no-action alternative is the baseline for comparison to the 17 other alternatives, it has no issues of yield, cost, feasibility or impact.

Alternative 1a – Enhanced Water Market

Description

Alternative 1a is for action to enhance operation of the water-rights market by creating explicit administrative criteria and standard models by which all interested parties can evaluate the effect and costs of transferring water to new projects.

Water-rights markets have been shown to function well in allocating water to more economically productive uses in New Mexico. A water-rights market automatically equates demand to supply. A 1970 study suggested that small amounts of Pecos Basin water could "most efficiently be obtained from internal basin sources through water transfers."[129]

The Pecos River system is one of the more completely adjudicated rivers in New Mexico with active adjudications proceeding. Several sub-basins or sections of the river (Hondo and Roswell Basins) are essentially complete. Others sections are in

[129] d'Arge, R.C., 1970, Quantitative Water Resource Basin Planning, An Analysis of the Pecos River Basin, New Mexico: Water Resources Research Institute No. 8.

process. A description of completed and ongoing adjudications is provided in Appendix G. The status of hydrographic surveys is provided in Appendix H.

Another important element in a priority water market is a secondary market for leasing in which unused water from one water right holder can be leased to another water user. Monitoring and metering of the system becomes an important requirement to prevent impairment to other users.

Most water-market transfers do not move water from the agricultural to the non-agricultural sector. A study of applications to the OSE to change the place or purpose of use showed that 29 percent of transfers were from agriculture to non-agriculture, while 38 percent were from non-agriculture to non-agriculture. Another 26 percent of transfers were between agricultural water uses.[130]

There are series of steps that must occur to develop a functional market. The following points outline the basic steps necessary for a priority-based market:

1. Water users and water right holders must have knowledge and acceptance of the principals of a water market.

2. The OSE must facilitate water transfers – both leases and exchange of water rights – with minimum transactions and legal cost to ensure integrity of the system.

3. There must be explicit administrative criteria and specific models of effects.

4. Water brokers must understand the workings of the river system, New Mexico water law and administrative procedures.

5. There must be rapid and clear information exchange between the parties and administrators when a transaction takes place so that water can be transferred in a timely fashion.

6. Leasing rates must be readily available to water users, i.e. posted through an exchange medium.

As an illustrative example, purchasing acreage from CID may be feasible. The illustrative example is for action to purchase active consumptive use acres of water rights owned by members of the CID. The orderly purchase and retirement of the senior rights associated with the CID would require a comprehensive study for an

[130] Nunn, S.C., 1990, Transfers of New Mexico Water, A Survey of Changes in Place and/or Purpose of Use, 1975 to 1987: Proceedings 34th Annual New Mexico Water Conference, Water Resources Research Institute Report No. 248.

approximate ten-year period of acquisition. This would include the study of which laterals and ditches are required for the continued efficient operation of CID and the passing of various state and federal laws for the change of purpose, use, storage and the diversion of the water. At the end of the first ten-year period of acquisition, a second ten-year period could be implemented.

Currently, approximately 6000 acres are in the State Engineer's lease program and the CID remains able to operate efficiently. The study would have to determine if these acres would be the most likely to be sold in the initial phase of the program. Additional marginal cropland could be encouraged to be sold or leased. The sale of water rights is an accepted practice in New Mexico both legally and politically.

The purchase and retirement of these water rights would provide for future Compact deliveries, endangered species requirements, instream flow and municipal and industrial growth.

The cost for the acquisition of the initial water rights would be negotiated among the parties, but is estimated at a level above the current productive value discussed in Section IV. The custom and culture and Carlsbad would be affected as well as the local economic and tax base of south Eddy County.

The Reclamation Act envisioned farms of 160 acres. Water used on tracts of five acres or less should be preferred candidates for transfer. Procedures could be established for the remaining farms to obtain their water by installing river pumps and ditches from the river to the farms. State law and the political climate do not prohibit this process.

Expected Water Yield

A priority based water market does not create additional water supplies but it does adjust demand to available water. The demand-supply balances will hold no matter what future growth in the municipal sectors occurs or if there is a drought. Junior rights remain at risk unless using stored water sources. For the purposes of analysis, the yield of Alternative 1a is considered to be 12,000 AFY, but it may be more or less as interested parties intend.

Costs

It is expected that $450,000 will be required to set up the administrative criteria and models and $300,000/year will be required to operate. Annualized costs are $333,754 and the cost per AF of yield is $28.

Feasibility

Technical. With adequate administration, valid models, and follow-up monitoring of the system, a priority-based water market is feasible.

Legal. A water market is within the intent of New Mexico appropriative water law. Some legislation and/or changes in State Engineer policies may be required to facilitate transfers and exchange of water rights within the planning region.

Political. An Achilles heal for priority-based markets is the tendency for political interference. External pressures can disrupt a priority market.

Impacts

Pecos River Compact. Because a water-market trades consumptive use from one sector to another with no net change in basin consumption, this alternative will have no impact on Compact obligations. A water market may facilitate Compact deliveries by allowing the ISC to efficiently purchase and retire water rights or to lease water when a delivery shortfall is eminent.

Environmental. One feature of a water market is the capability to accommodate environmental issues and riparian habitat. The necessary step is to assign or purchase senior water rights for valuable native habitat and instream flow. This gives an accurate economic picture of the cost of maintaining such environmental concerns.

Social and Economic. A well-functioning water market will contribute to economic growth in the Pecos Valley. Farmers, industry and municipalities can make sound investment decisions based on water prices and resource availability. This alternative does not preclude the adoption of water supply alternatives reviewed in later sections. For example, Alternative 8 increases water supply through watershed management. The most economically productive allocation of this new water would be additional junior water rights. The increased water will shore up existing rights and will allow new economic activity. The water market will preserve traditional economic activity. Expensive water supply enhancement programs often end up costing more than the water is worth and cause bankruptcy and economic loss in the agricultural sector (the Central Arizona Project is an excellent example of this). The water market increases options for farmers and contributes to their economic well-being.

Alternative 1b – Enhanced Administrative Enforcement

Description

Enforcement of existing decrees, permits and contracts is an essential part of market administration. New Mexico water law provides that no new surface uses after 1907 and no new underground uses after declaration of an underground water basin shall be initiated without approval of an application by the OSE. In those areas where the water rights have been adjudicated, any use over and above that defined in the Court Decree is enjoined. The obligation for enforcement of New Mexico water laws is a statutory duty placed upon the OSE.

Of the total irrigation domestic and commercial water rights declared, permitted, licensed or adjudicated with the Lower Pecos Valley Regional Water Plan area there are an estimated 1600 equivalent irrigated acres or more exceeding the imposed limitations. This would relate to approximately 3200 AFY of consumptive use which might be made available to meet the demands of existing water right holders if the water laws were fully enforced.

Domestic uses are limited by permit to three AFY for the irrigation of not to exceed one acre of noncommercial garden or lawn. Declared domestic rights are also generally limited to three AFY.

More than 12,000 permits for domestic uses have been granted within the Ft. Sumner, Hondo, Peñasco, Roswell and Carlsbad Basins and an estimated additional 2000 domestic rights, either declared or undeclared, are in existence. Of this total it is estimated that five percent, or 700 domestic uses are exceeding the imposed limitations by irrigation of additional acreage or using the water for subdivision or other purposes. An estimated 3000 AF might be made available by strict application of the water law.

The OSE policy regarding the amount of water granted to domestic uses and revision of the domestic groundwater statutes may be required.

Expected Water Yield

The amount of water that could be made available from Alternative 1b would depend upon the results of the study and subsequent action to be taken and would not be available until such study is made. The study would be technically and legally feasible and it is believed such a study could be made by an independent consultant for $50,000 to $100,000. The study would have no political or adverse impacts but would lead to making more water available for use of existing water rights.

Costs

The costs of adequately enforcing the existing water laws in the planning region would be those required for additional personnel and use of geographic information systems currently being developed by the New Mexico Interstate Stream Commission and State Engineer. This information would provide data as to new acreage being irrigated and excess uses for domestic wells.

The costs involved could require an additional $100,000.00 per year or approximately $16.00 per acre foot for 6250 AFY of supply. Regardless of costs, the obligation for enforcement of New Mexico water laws is a statutory duty placed upon the Office of the State Engineer.

Feasibility

Technical. Enforcement of existing priorities is technically feasible.

Political. The enforcement of the water laws may have some adverse political impacts upon those affected; however, that should not be viewed as a deterrent to enforcing the water law.

Impacts

Pecos River Compact. This alternative would improve the States' ability to meet Compact deliveries, but would not change obligations.

Environmental. Little environmental/biological impacts should result from enforcement of state water laws.

Alternative 2 – Managed Wellfield Operations

Description

Water withdrawn from aquifer storage through wells increases the basin yield and, if managed properly, can be an effective measure to mitigate the effects of shortage. During the drought of the 1950s, groundwater pumping was used in this manner to maintain irrigated fields that had previously relied on surface diversions. The Roswell artesian aquifer is presently being replenished by streamflow and groundwater inflow (Figures 22 and 26). During a drought, transient storage depletion is used to temporarily increase basin yield. The depleted storage can be replenished during periods of surplus. The additional pumping proposed in this alternative is pumping above the current baseline of aquifer pumping.

A process by which existing agricultural wells are compensated for releasing water to the river or to other uses during times of shortage would benefit all users in the basin, including necessary Compact deliveries.

This alternative proposes to withdraw water from wells to meet short-term shortages. Such wells might be those located at the southern end of the Roswell Basin or within the Carlsbad Underground Water Basin to meet shortages under the Compact or within the CID. Extreme care must be taken to keep the points of diversion (wells) from becoming concentrated. Underground water is not like a lake. When a cone of depression is created in the water table, water moves slowly to fill it. In many areas of the artesian basin, salt water moves in when the hydrostatic level is lowered as in 1964.

Expected Water Yield

The expected water yield for this alternative is 10,000 AFY. The assumption is that aquifer storage normally used to support agriculture can be expanded to a higher level of peak historical wellfield production, and the increment above normal withdrawal rates could be directed to satisfy new purposes, including Compact obligations in some years.

The effect on the Pecos River from one year, or a few years, of pumping is estimated to be one to five percent of the pumped volume each future year over a 20-year period. The largest effect will occur within one year and diminish thereafter.

Costs

Annual costs for managing aquifer operation are $500,000. The cost per AF of yield is $50.

Feasibility

Technical. This alternative is technically feasible as demonstrated in past years. Numerous wells exist throughout the planning area that can be used to exercise managed wellfield operations. New wellfields could be provided by transfer of existing rights.

Legal. If existing water rights were used to make up the water in times of shortage, applications to change place of use would be required but should present no legal ramifications. If, however, the water to be pumped was in excess of the existing water right from that well it would be considered a new appropriation from the groundwater source and might require special legislation unless existing rights were transferred. Any new appropriation would be subject to protest and would present the possibility of impairment by depletion of existing supplies, and possible saline encroachment into the groundwater aquifer. It is possible that existing water rights which have been retired and banked by the PVACD and the ISC might be transferred for this purpose.

Political. The concept of using the San Andres Aquifer in particular as a source of water for the basin in times of drought and to allow it to refill in periods when there is excess rainfall would probably be acceptable to the general public and to most elected officials in the planning region. However, it may be perceived by some agriculture interest groups as a threat to their water supply; consequently, it will probably be necessary to explain and to demonstrate to those affected the hydrologic foundation on which this alternative is based. On the other hand, at the present time, other agriculture interest groups might welcome the concept in that problems are beginning to arise with regard to the water table being too high and threatening agricultural production. Apparently some work has been undertaken recently to refurbish the drainage systems in some agricultural areas because the water table is rising to within a few feet of crop roots.

Since the concept has been and can be helpful in meeting Compact obligations, the ISC would probably endorse the concept and encourage a more systematic, predictable approach to its implementation. This process may also create a more stable environment for the agriculture economy by reducing uncertainties related to the procurement of water to meet Compact obligation based on a hit-and-miss buy/lease effort.

The involvement on the part of the OSE and the approval by the OSE of the methodology and procedure will be crucial. Here again, a well-defined, systematic implementation strategy needs to be developed and based on pre-established criteria for initiating the process at any given time.

<u>Impacts</u>

Pecos River Compact. During periods of shortage, managed wellfield operations increase basin yield and improve the State's ability to meet Compact deliveries. Water derived from managed wellfield operations for Compact deliveries can be used to either directly meet Compact deliveries or to furnish water to a user that would otherwise have diverted surface water. During the aquifer recovery period (See Figure 8, Section IV), that induced recharge from the stream will reduce baseflow at low rates. A change in baseflow does not impact the State's ability to meet Compact obligations.

Environmental. The impact to the environment from this alternative is comparable to the impact of existing wellfields. Pumping of some wellfields may cause nearby springs to diminish in flow or dry temporarily. The degree of exercise of this alternative should consider such effects.

Social and Economic. No social issues are anticipated from implementing this offset option, but economic factors are of considerable concern. If, for example, individual well owners are allowed to exceed their pumping limits in order to supply water to the river, they would need to be compensated for the energy costs and the regular equipment operating and maintenance expenses. It may prove expedient to establish a list of well owners whose wells are appropriately located and who are willing to participate in a program of this type for just compensation. Where the State of New Mexico has already purchased water rights and if it owns the wells, it would pump water to meet Compact obligations as necessary and would be expected to conform to the established pumping strategy.

Alternative 3 – Agricultural Water Conservation

Description

Potential actions for improving conservation of irrigation water include the following. Most of the benefits are in minimization of on-farm requirements and return flow, rather than consumptive use. Reduced on-farm requirements make water available for re-distribution.

Laser Leveling for Agriculture. Releveling of irrigated land prevents water pooling in low spots, minimizes excess tailwater from sloped land and allows for even spreading of flood irrigation. Releveling may be required every five years to smooth out low spots created by plowing, irrigating, harvesting, etc.

Use of LEPA, Sprinklers and Drip Systems for Agriculture. LEPA(low energy pressurized application), sprinklers and drip systems increase on-farm efficiency by controlling the rate at which water is applied to the coil. The methods minimize tailwater, deep percolation growth of non-crop vegetation and evaporation of pooled water, but not crop consumptive use.

Lining Ditches with Concrete for Agriculture. Lining ditches (or replacing them with pipes) reduces leakage and improves project conveyance efficiency. In many cases, lining can prevent growth of non-crop vegetation along a ditch that non-beneficially consumes water.

New Mexico State University agricultural economists estimate irrigation cost amount to 30 percent or more of an average producer's production cost. Agricultural producers have an interest in increasing their efficiency of agricultural water use and have done so. In the planning region, more than 90 percent of all irrigated lands have a conservation plan developed and practices are being put in place and implemented.

The best management practices are outlined in each plan, taking into consideration site-specific parameters.

The fact that basin-wide efficiency is not altered by on-farm irrigation efficiency can be confusing. The consumptive irrigation requirement (CIR) is the only portion of a water right which may be sold or leased. The principle is that all other water diverted by agriculture is returned to the system and therefore not consumed. Accordingly, Alternative 3 is of value to each agricultural water manager, but does not add water to the basin as a whole unless consumptive use is reduced.

Metering and other conservation efforts allow the water user to apply the water precisely on the irrigated acreage to meet the needs of the crop with minimum waste. For example, in the Roswell Groundwater Basin prior to metering and conservation measures overuse of water and non-essential winter irrigation was prevalent and was either wasted onto adjacent lands or, in many cases, was allowed to run down bar ditches or into dry arroyos and intermittent stream beds. Evapotranspiration from the land and non-crop vegetation was considerable and readily observable and further increased non-beneficial vegetation. Such excess application and evapotranspiration of water is no longer observable. Further, the majority of water in the Roswell Basin is pumped from the deep artesian aquifer but return flow accrues to the shallow aquifer. Thus when excess water is applied from the artesian aquifer it raises the water table in the shallow aquifer and increases evapotranspiration from plants and the ground in areas where this would not normally occur. The reduction of pumpage from the artesian aquifer will eventually reach the river by increased flow in areas close to the river and thus redistribute or reroute some of the reduction to downstream users.

Another example of salvage could occur in the Ft. Sumner Irrigation District, where 7 to 10 AF is now diverted for each acre in the project. Much of the excess water returns to the Pecos below the project, however in this process, the return flows contribute to wetlands and high non-beneficial vegetation before it reaches the river. If the District could obtain storage rights and thus better utilize available supply, additional conservation measures could reduce the return flow and evapotranspiration.

The CID project efficiency may be improved under this alternative by abandoning use of Avalon Dam. The CID has proposed to deliver water directly to the Main Canal from Brantley Dam by use of a channel and dike to be constructed through the Avalon Reservoir. The currently reduced capacity, 4980 AF and excessive surface area of Avalon Reservoir, near 1000 acres, would be abandoned while salvaging nearly 5000 AFY from lake evaporation and associated vegetative losses. As a further upgrade of the conveyance system improvement, a pressured-pipe system to replace the main canal may be evaluated.

About four miles of dike and channel alignment would be required to replace Avalon Reservoir. At $500,000 per mile, the cost would be $2 million, annualized to $200,000 per year. The cost per acre foot of $40 per year would be highly feasible.

If the project were extended to include pressure-pipe conveyance from Brantley Dam through Southern Main Canal, about 32 miles of conduit would be needed at a cost of over $30 million. Salvage of conveyance losses would amount to 10,000 AFY. The salvage of 10,000 AFY + 5000 AFY at an annualized cost of $3 million remains attractive at a cost of $200 per AF.

Salvaged water would be retained in Brantley Reservoir due to reduced project delivery requirements for CID. The 5000 AFY to 15,000 AFY of additional storage would serve to reduce the shortage frequency at CID and to provide a surplus in years of better supply.

Direct diversion to the river rather than circuitous diversion through groundwater aquifers with high water tables and attendant evapotranspiration losses will unquestionably result in more water in the river.

The selling or leasing of "saved water" would be detrimental to the water supply of the region. Benefits of conservation are reduced labor costs, pumping costs or efficient application of water, all of which foster the purposes of conservation.

The following yields and costs are set forth for certain types of conservation measures that might yield water savings and are not intended as recommended projects, but only to arrive at estimates of quantities which might be saved and costs incurred.

Expected Water Yield

The recoverable losses include deep percolation past the root zone in a field, leakages from unlined ditches and runoff. These losses are often the targets for increasing efficiency at the farm level.

Most of these actions only reduce return flow from seepage or tailwater. The savings will be realized by individual farms or by projects, but basin-wide reduction on consumption will be small. The expected water yield for each of these actions follows.

Laser Leveling for Agriculture. An estimated 20,200 acres can be laser-leveled. At an estimated savings in incidental depletions of five percent, the expected yield to the basin is 2000 AFY.

Use of LEPA, Sprinklers and Drip Systems for Agriculture. Approximately 47,300 acres require irrigation system upgrades. The approximate consumptive use for these lands is 94,600 AFY. At individual savings of five percent, the yield for changing to LEPA sprinklers or drip is 4700 AFY.

Lining Ditches with Concrete for Agriculture. Most water lost from leaky ditches returns to the water table. Some water is used by vegetation along the ditch. An estimated 1000 AFY is used for vegetation along the 151 miles of ditches to be lined for planning purposes, ditch lining will only yield water that would otherwise be consumed by evapotranspiration, or 1000 AFY gain by the basin.

Costs

Changing to a more efficient irrigation system involves a large capital investment, and the new system requires new management skills. These systems are currently being put into place in other areas of New Mexico for reasons of reducing high groundwater pumping costs, extending the life of a well field and accommodating special soil conditions. They have not been put in place for the purpose of making more water for other uses. An agriculture water user usually looks at their management choices from an economic point of view. If they could sell or lease "saved water" and continue to raise their same crops, they would certainly realize economic benefits and at the same time foster the purposes of conservation. Costs for each action are as follows.

Laser Leveling for Agriculture. About 20,200 acres of additional agricultural land in the Fort Sumner and Roswell Basins can be laser leveled to improve water-use efficiency. At $300 per acre, the capital cost is $6 million. Leveling, and therefore additional costs, may recur every few years as determined by farmers. For the purposes of estimating cost, capital cost is assumed to recur every five years. The O&M costs are estimated at $600,000 per year. The annualized cost is $1.5 million per year and the cost per AF of yield is $739.

Use of LEPA, Sprinklers and Drip Systems for Agriculture. About 800 acres and 46,500 acres of land in the Fort Sumner and Roswell Basins, respectively, are available for application of improved watering systems. The total capital cost for implementing this approach is estimated to be $24.7 million. The cost for operation and maintenance of the sprinkler systems is assumed to be $1 million per year. The annualized cost is $2.8 million and the cost per AF of yield is $607.

Lining Ditches with Concrete for Agriculture. At a unit cost of $100,000 per mile, a total capital cost of $15.1 million is required to line an additional 151 miles of ditches within the planning area or replace them with pipes. One-half million dollars per year is estimated for maintenance and repair of new concrete ditches. The annualized cost is $1.6 million and the cost per AF is $1633.

None of these costs are justified by the effect on basin yield, even if justified in on-farm accounting terms.

Feasibility

Technical. These practices are technically feasible and adaptable to specific situations.

All the practices discussed are feasible and practical but expensive. When agriculture is limited to a specific duty of water, there is a propensity to make the highest and best use of the water. Not all fields can be leveled or sprinkler systems installed for various reasons, especially if development has taken place in the middle of a field and small fields are created.

All these practices reduce water loss from evaporation and transpiration and increase the efficiency of the operations with an incidental reduction in consumptive use. Water not needed or used is water saved.

Legal. Current irrigation practices in a particular area have already met the legal test of being "good irrigation practices." There should be no legal problem with the use of improved conservation practices provided that adjudicated consumptive limitations are not exceeded by such practices.

Political. Throughout the western U.S., there is public pressure from a rapidly growing urban population and special interest groups to have the government mandate new agricultural conservation technologies regardless of the impact on-farm operations, farm profitability or other things important to the agricultural community, and regardless of the small difference to other water uses.

Tax benefits are the most obvious means of encouragement. Since large capital outlays are required and the recovery is over a long and uncertain period, shorter tax recovery time should be provided.

Although New Mexico law exempts irrigation works and especially ditches from separate property taxes, as the irrigation system is considered part of the land, some assessors tax these systems separately contrary to the law. Sprinkler systems are the equivalent to a ditch – a modern means of conveying and distributing the water to the crop. Chaves County does not assess irrigation systems separately.

Since each water right is defined to a fraction of an AF and to a rigid area, there is no flexibility to use of the water. An example is growing native grass on twice the acreage using the same water and from the same point of diversion.

Impacts

Pecos River Compact. A reduction in consumptive agricultural use in the planning area will not change the State's Compact obligations. The actions proposed in this alternative have a small effect on consumptive use. They do not change Compact obligations but may help meet deliveries.

Environmental. Agricultural conservation reduces return flow and reduces the required diversion, and may help keep more direct runoff water in the river, and will keep more stored water unreleased by the reservoirs. The actions may reduce vegetation along ditches and near irrigated areas that provide habitat, but the difference is small.

Social and Economic. These practices are the responsibility of the land owner and require large capital expenditures. They cannot normally be fully justified by increased productivity or water savings by the individual; such water savings have great social benefit to the community and should be encouraged.

Alternative 4 – Moving Reservoir Storage

Description

This alternative proposes moving an additional 10,000 AF of storage from Brantley Lake to Santa Rosa Reservoir.

Water is stored in Lake Avalon and Brantley Lake and upstream for the CID. The two lower lakes are located near the area of the highest net lake evaporation in the planning area (about 73 in/yr; see Plate 13). Evaporative losses from the two lakes totaled 22,000 AF in 1998 when evaporative losses reached 91.5 inches.[131] Santa Rosa Reservoir, which lies north of the planning area, experiences about 51 in/yr average net evaporation. Moving storage upstream would reduce evaporative losses. Maximization of upstream storage has been authorized, and CID attempts to store water upstream as long as possible to satisfy their operational requirements.[132] Irrigation operations and endangered species concerns, however, require that some water be stored in Brantley and Avalon.

[131] Electronic communication, J. Longworth, New Mexico Interstate Stream Commission to C. Cook, Balleau Groundwater, Inc., February 6, 2001.
[132] Tetra Tech, Inc., 1999, Draft Pecos River Project Comprehensive Hydrology Research Report.

Expected Water Yield

Brantley Reservoir stored an average of 26,800 AF in 1998.[97 above] Based on 1998 storage data and evaporation rates, storing 10,000 AF in Santa Rosa instead of Brantley would reduce evaporation from Brantley 4500 AFY and increase evaporation from Santa Rosa 1000 AFY, for a net savings of about 3500 AFY.

Costs

The capital cost of reservoir construction is approximately $1000 per AF. The cost of storage each year is approximately the annualized capital cost. Under this alternative, the traded storage of 10,000 AF will incur no net costs. However, the 3500 AF that is saved will have to be stored and will incur a cost. Using the annualized capital cost assumption, the "capital" cost of storing 3500 AF is $3.5 million, or $0.26 million annualized. The cost per AF of water saved is $75.

Feasibility

Technical. Santa Rosa Reservoir has a capacity of 447,000 AF but has exceeded 100,000 AF of storage only a few months out of the last decade.[97 above] Sufficient capacity exists in the reservoir for increased storage. Deliveries are presently made to CID through Santa Rosa and Sumner Dams by releasing water at 1000 cfs. Deliveries under this alternative would potentially differ only in their timing. Presently, CID attempts to maximize upstream storage. All storage utilized on Avalon and Brantley is essential to CID operations and moving more storage upstream would adversely impact irrigation operations. Therefore, this alternative is not technically feasible from an operations standpoint.

Legal. The storage of water upstream in lieu of storage in downstream reservoirs should have little legal impact as long as it does not adversely affect Compact deliveries.

Political. It is just good politics to retain maximum storage for the operation of CID in the upper reservoirs. The endangered species, recreation on the lakes and less evaporation of a limited resource is beneficial for all interested parties and means more water for the farms and state line deliveries.

Impacts

Pecos River Compact. Evaporation from Brantley Lake is not included in the computation of New Mexico's Compact obligations. However, evaporation from Santa Rosa Lake is included. The increase in evaporation in Santa Rosa Lake under this alternative will increase New Mexico's obligation an estimated 200 AFY.[97 above] The water saved is more than enough to offset the increased obligation.

Environmental. The reduction of the volume in Brantley Lake would reduce the habitat available to introduced species of game fish and to native species of flora and fauna that have colonized the area in and around the lake. Some species would be displaced by the loss of habitat. There is no critical habitat supported by Brantley Lake nor any endangered species living in or around the lake. The timing and rate of flows from the upper reservoir are controlled by FWS to protect the bluntnose shiner. Adoption of the proposed alternative may affect the shiner by changing the timing or magnitude of flows.

Social and Economic. Retaining an additional 10,000 AF in the upper reservoirs during peak irrigation demand amounts to approximately one irrigation for the project. The movement of water from Fort Sumner to Brantley Lake during the irrigation season is severely limited by the "Recovery Plan" for the Pecos bluntnose shiner. Releases may not be for more than 14 days and then require a 14 day no-release period. Also, the fish require a seven week no-release period during the peak farming demand period (June through August). The economic loss to the farmers could be a 20-percent permanent loss in existing crops and an annual two to three ton loss per acre in hay production. The retention of additional water in Santa Rosa and Fort Sumner is not economically feasible for the community. CID should be encouraged to maintain its current program of maximizing storage in the upper reservoirs throughout the year.

Alternative 5 - Municipal Water Conservation

Description

Municipalities reduce pumping costs and make available more water for its citizens and businesses by conserving water. Wilson & Company completed a water conservation plan for the Cities of Roswell, Artesia and Carlsbad in 1993. This set of plans identified a series of BMPs that these cities could initiate to accomplish water-conservation goals. Increased use of accurate universal internal metering (for all facilities and customers), more accurate water accounting, leak and water-use audits, conservation at public facilities, changes in rate structures, prohibition of waterwater, and water reclamation were all identified as BMPs. Other BMPs listed plumbing code changes (low-flow fixtures), landscape code changes (xeriscape requirements, watering restrictions, etc.) and public education efforts. Alternative 5 discusses water conservation and recycling efforts to assist in extending municipal water supplies for the next forty years. The actions available to improve municipal water conservation include:

Time of Day/Day of Use. Time of day restrictions would limit outdoor watering to periods of low evaporation, such as mornings, evenings and non-windy days. Day-of-use restrictions specify the days of the week outdoor watering is allowed.

Low-Flow Fixtures, Audits and Leak Repair. Low-flow fixtures reduce demand by minimizing flow to toilets, showers and sinks. Audits of water consumption inform home owners , businesses and other entities how much water they use, where they use it and how they may reduce their use. Audits may also identify leaks. Leak repairs save water by preventing unintended water loss from pipes and fixtures.

Covering Reservoirs. Direct evaporation from reservoirs can be prevented by installing a cover. The City of Alamogordo covered a six-acre reservoir with plastic to prevent evaporation. Most municipalities currently store their produced water in closed reservoirs.

Wastewater Effluent Use for Agriculture, Parks, Etc. Diverting treated wastewater to city parks, crops, or golf courses replaces potable water (the city's treated water, groundwater, or surface diversion) with treated non-potable water. The practice reduces the diversion and treatment of drinking water.

Xeriscaping. Drought-tolerant plants that are accustomed to the dry New Mexico climate use less water than plants imported from moist climates. Replacing high water using plants and trees with drought-tolerant plants reduces water consumption if the plants are given only the water they need.

Water Rationing. Water rationing limits household use to a certain monthly volume and usually involves a penalty if the volume is exceeded.

Rate Structure Change. Municipalities that employ progressive rate structuring encourage conservation by charging a progressively higher rate for additional units of water use above a threshold.

Treated Wastewater Re-Injection. Treated wastewater can be re-injected into aquifers for long-term storage. Special injection wells are required and the chemistry of the wastewater and the groundwater and aquifer material must be compatible.

The following yields and costs are set forth for certain types of conservation measures that might yield water savings and are not intended as recommended projects, but only to arrive at estimates of quantities which might be saved and costs incurred.

Expected Water Yield

Time of Day/Day of Use. The present water use for municipalities is about 33,000 AFY (Table 56). An estimated 35 percent of single-family residential water use is for outdoor watering, or 11,500 AF. Time-of-use restrictions are estimated to save about seven percent, or 800 AF. The City of Alamogordo estimates their time-of-use restrictions save five percent.

Low-Flow Fixtures, Audits and Leak Repair. If 65 percent of the total municipal water consumption is for indoor use, then the indoor use is about 21,500 AF. If a rough estimate of four-percent savings for low-flow fixtures, audits and leak repair is made, a total savings of 860 AF may be realized.

Covering Reservoirs. An estimated annual loss of about 20,000 AF of water from reservoirs and stock ponds in the planning region is reported in Table 23. If an arbitrary assumption is made that about 25 percent of the area can be covered with floating plastic covers, then about 5000 AFY will be saved. It is important to note that the vast majority of reservoir area and all stock ponds are not used by municipalities as water sources. These reservoirs serve primarily as agricultural storage and recreational areas.

Wastewater Effluent Use for Agriculture, Parks, Etc. The WWTP design capacities for the Cities of Carlsbad, Artesia and Roswell were reported by John Waters to be 7, 1.5 and 10 million gallons per day (mgd), respectively. The total of about 19 mgd from the facilities is equivalent to about 21,000 AFY. Since the plants presumably do not run at design capacity, an arbitrary assumption is made that the water savings would about 15,000 AFY. Using wastewater for irrigation would reduce municipality's diversions, but would reduce return flow by the same amount, except in areas where a return flow to the river can be demonstrated (i.e. in parks along the river). Consumptive use would not change, so the yield for basin-wide planning purposes is zero.

Xeriscaping. The total outdoor water use for municipalities in the planning region was estimated to be 11,500 AF. If municipalities were to mandate xeriscaping, it is estimated that outdoor water use could be reduced by 50 percent, or about 5500 AFY.

Water Rationing. Total municipality water consumption within the planning area is 33,000 AF. A ten-percent reduction in water use would result in a savings of 3300 AF for planning purposes, it is assumed that the entire ten-percent reduction is made in outdoor watering.

Rate Structure Change. Various studies on the elasticity (a measure of how much demand changes for a product when the price changes) of water pricing show that when the price of water is increased by ten percent, water demand will fall by one to three percent in winter and two to five percent in summer. If one assumes that the effect is roughly linear, then a 20 percent increase in rates will result in an overall average (summer and winter) reduction of consumption of about four percent. Using 33,000 AF as the total water use by municipalities, the savings are about 1300 AFY. Only reductions in outdoor water use will yield actual savings on consumptive use. For planning purposes, it is assumed that the entire four-percent savings comes from reduced outdoor watering.

Treated Wastewater Re-Injection. As in the case of treated wastewater reuse for agriculture, parks, golf courses and similar irrigation applications, the total water savings for this option will also be about 15,000 AF, but only one of these two options can be used. Because wastewater injection does not reduce consumptive use, the net yield for planning purposes is zero.

<u>Costs</u>

Time of Day/Day of Use. This action will require enforcement. An estimated four workers at $50,000 per year are required for enforcement, giving an annualized cost of $200,000 per year. The cost per AF of yield is $244.

Low-Flow Fixtures, Audits and Leak Repair. The assumption is made that, on the average, a household would have to spend $100 to replace existing fixtures with low-flow units and $10 per year for maintenance. There are an estimated 48,000 dwelling units (single-family housing and apartments) in the planning area. The capital cost is $4.8 million, the annual O&M is $0.48 million and the total annualized cost is $840,000. The cost per AF of yield is over $1000.

Covering Reservoirs. Alamogordo has recently invested in a plastic cover and plastic liner for one reservoir with a surface area of about 250,000 square feet. The cost was $346,000. If one arbitrarily assumes that about one half of this is for the cover, then a cost of about, $0.70 per square foot is derived. An estimated 1000 acres of reservoirs and ponds would need to be covered to realize a water savings of 5000 AF, or a total of 44×10^6 square feet of surface area. The total capital cost would be about $31 million. If one assumes that the average life of the plastic cover is 20 years at which point it must be completely replaced, then another capital investment of $31 million must be made every 20 years. The annualized cost is 2.9 million and the cost per AF yield is $581.

Wastewater Effluent Use for Agriculture, Parks, Etc. The cost of upgrading the wastewater facilities in Carlsbad, Roswell and Artesia to meet standards suitable for irrigation is estimated at $200,000, $2 million and $6 million, respectively, for a total of about $8.2 million. To transport the water an estimated 60 miles of 12-inch PVC pipe are required. At an estimated cost of $105,000 per mile, including trenching, pipe, pipe laying, bedding and backfill, an additional cost of $6.3 million would be incurred. The total capital cost would therefore be about $14.5 million. An assumption of $0.5 million annually would be required to operate and maintain all three plants (above existing O&M costs) and the new distribution lines. The annualized cost is $1.6 million. No basin-wide yield is realized from this action.

Xeriscaping. There are about 36,000 single-family dwellings in the planning area. If at each house, $500 is spent to remove existing landscaping and replace it with xeriscaping, then the total capital cost to all of the homeowners will be about $18 million. Maintenance costs and the cost of water will be less than that for comparably sized, normal landscaping. The annualized cost is $1.35 million and the cost per AF of yield is $270.

Water Rationing. The cost of restricted use of the resource to the consumer (loss of consumer surplus) for rationing is $33 per household per year. An estimated 36,000 single-family homes exist in the planning area, giving an annualized cost of $1.2 million. Apartments would not be affected by rationing since individual apartments are rarely metered. The cost per AF of yield is $383.

Rate Structure Change. The cost of reduced use of the resource by the consumer (loss of consumer surplus) for rate structure change is $21 per household per year. If only single-family homes are affected (36,000 single-family homes), the annualized cost is $0.75 million and the cost per AF of yield is $627.

Treated Wastewater Re-Injection. The cost of treating wastewater to achieve a quality suitable for irrigation was estimated to be $8.2 million for the three major municipalities in the planning area (see Wastewater Effluent Reuse above). It is assumed that the same treatment standard is suitable for aquifer injection. In addition to that cost, the expense of drilling injection wells needs to be included. As above, if the amount of treated water available for re-injection is assumed to be a uniform 15,000 AFY, a pumping rate of about 9297 gpm will be necessary. Wells and a distribution system will be necessary. The total capital cost is about $28.5 million. Although the municipalities will not necessarily be required to recover the water from the aquifer themselves, someone will recover it, presumably using existing wells; consequently, another cost, in the form of operation and maintenance, will be invoked in this conservation option. The annual cost of pumping to raise 15,000 AFY 100 feet would be about $0.22 million. In addition there will be maintenance costs on the motors, pumps and wells. The annual cost for the latter is assumed to be such that the total O&M cost will be about $0.4 million. The annualized cost is therefore about $2.7 million per year. No net basin yield is realized from this action.

Feasibility

Technical. Covering reservoirs is technically infeasible because of high winds and recreational use. Wastewater reuse and injection are technically possible, but do not produce additional basin yield and are therefore impractical in basin-wide terms, even though reuse can help a particular water-right owner get the maximum consumptive use from his permit. All other measures described under this alternative are technically feasible.

Legal. Water rights allocated to municipal uses are based upon full depletion from the stream system or groundwater reservoir, thus conservation measures would not increase consumptive use of the existing rights and would not have adverse legal consequences.

Political. Water conservation can have a positive social and political impact on a community. Establishing water-conservation incentives are politically feasible because they have a direct effect on the public. The more expensive options, such as effluent reuse, should be considered at the state and federal government level. This is evident by the number of legislative grants and loans provided to municipalities for these types of projects over the past seven years.

Impacts

Pecos River Compact. The actions under this alternative that have no affect on consumptive use will not effect Compact deliveries. Those that reduce consumptive use may enhance the State's ability to meet Compact deliveries. None of the actions will change the State's Compact obligations.

Environmental. The actions proposed will have little or no environmental impact. Those actions that reduce return flow from WWTPs may reduce nutrient loading and improve instream water quality. Covering reservoirs may impact wildlife and fish by preventing gas (O_2 and CO_2) exchange at the water surface and restricting access to water. Excessive agricultural applications of effluent might cause groundwater contamination if not properly monitored. This type of discharge would require a state groundwater discharge permit. Currently both Carlsbad and Artesia have permits.

Social and Economic. The value of water conservation has a direct impact on a community. While there are some capital and maintenance costs in initiating a municipal water-conservation program can have a positive effect on the community. An adequate public outreach program must accompany the maintenance of such a program.

Alternative 6 - Industrial Water Conservation

Description

This alternative previews the potential water savings from industrial water conservation. Each segment of industry has a specific water requirement. Businesses strive to reduce costs, and water conservation methods can be one component. It is assumed that industry has this economic incentive to conserve water.

Mining and production of potassium chloride (fertilizer & chemical grade sale) is a major industry in the planning area. Processing ore to produce fertilizer and chemical grade salt requires a great amount of water in the order of 16,000 gpm or 25,810 AFY (estimated total for both IMC Kalium and Mississippi Potash, Inc.). Through the development and implementation of water conservation and recycling tailings brine water, mining companies utilize only 8900 gpm. Estimated year 2000 diversions by mines were 14,559 AFY (Table 56).

The water supply in the mining industry uses water from the Capitan Aquifer located near Carlsbad, New Mexico and Ogallala Aquifer located near Buckeye, New Mexico and from the Pecos River.

Expected Water Yield

Water use in the commercial, mining and industrial sectors is about 20,000 AFY. Conservation reduces demand by an estimated by 15 percent. Assuming half of the reduced demand is reduced consumptive use, the yield would be 1500 AFY.

Costs

Under this alternative, total capital costs are estimated at $1 million and O& M costs at $100,000. The annualized cost is $175,000 and the cost per AF of yield is $117.

Feasibility

Technical. The conservation measures considered under this alternative are to be added to the industrial process in the future only if such measures are technically feasible.

Legal. There appear to be two areas where incentives for conservation efforts may entice industry to implement or research innovative conservation programs. One incentive is to offer reduced rates for water purchases or a tax break when pumping is reduced. Another incentive is to define water conservation as beneficial use so reducing water consumption below the appropriated amount will not trigger any forfeiture or abandonment action.

Political. Water conservation can have a positive political and social impact. The local government should orchestrate monitoring all segments of the local economy. Local oversight, when possible, has an immediate effect and in most cases reflects the views of the public.

The local government should orchestrate monitoring industry. Local oversight of any program has an immediate effect and in most cases reflects the views of the public.

Impacts

Pecos River Compact. The alternative has no effect on Compact obligations, but may help Compact deliveries by reducing consumptive use.

Environmental. Environmental/biological impacts are minimized when conserving water.

Water-quality standards are in place for effluent process water.

Water conservation encourages reduced pumping of surface and/or groundwater, and reduces potentially polluting effluent. The alternative has negligible impact on the environment.

Social and Economic. The value of water conservation on a social level has a direct impact on a community as a whole. An industry that is dependent on water for processing or manufacturing has a stake in water conservation because the longer the water supply exists, the longer the business exists. In turn, employment is maintained, families benefit, taxes are collected and local service companies and retail businesses thrive.

Alternative 7 – Riparian Vegetation Management

Description

The action is to extend the existing program of mainstem Pecos River vegetative management.

The Pecos River Basin Water Salvage Project (Project) is a BOR-funded project authorized in 1964 and initiated in 1967. The project seeks to control salt cedar growth from the Sumner Dam area to the New Mexico-Texas state line. Originally, the project encompassed 53,950 acres. Since 1995, the project has been limited to 30,000 acres in New Mexico. Salt cedar was initially cleared using methods such as plowing, mowing, bulldozing, chaining and chemical control. Regrowth is prevented by root plowing. The success of the project has been difficult to assess.[133,134]

Expected Water Yield

An estimated 22,000 acres of high-density salt cedar remains along the Pecos River mainstem from Sumner Dam to Carlsbad. The potential for increased yield is about 22,000 AFY, but net yield from previous cleaning has not been found by careful monitoring and study. A more realistic sustained yield is the range of 0 to 10,000 AFY.

Costs

The cost of clearing riparian vegetation is estimated at $250 per acre initially and $10 per acre each year thereafter for maintenance. If 22,000 acres were cleared, a capital cost of $6.6 million and O&M cost of $0.22 million are estimated. The annualized cost is $0.7 million and the cost per AF of yield is $63 at the 10,000 AFY yield or larger at lesser yields.

Feasibility

Technical. It is technically feasible to utilize an integrated management approach. Mechanical, biological and chemical methods can manage salt cedar, elm and Russian olive vegetation.

Legal. Owners of private lands along the river have the authority to carry out a brush management program on their lands. Currently all federal land managing agencies have legislative authority to carry out vegetation management programs on lands they own or control.

Political. This project has political opposition, but has local support. Environmental groups including the Nature Conservancy, Ducks Unlimited and the Audubon Society have supported a 4000-acre riparian restoration demonstration project within this planning area.

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[133] Welder, G.E., 1988, Hydrologic Effects of Phreatophyte Control, Acme-Artesia Reach of the Pecos River, New Mexico, 1967-82: U.S. Geological Survey Water Resource Investigations Report 87-4148.
[134] Weeks, E.P, Weaver, H.L., Campbell, G.S. and Tanner, B.D., Water Use by Saltcedar and by Replacement Vegetation in the Pecos River Floodplain Between Acme and Artesia, New Mexico: U.S. Geological Survey Professional Paper 491-G.

Impacts

Pecos River Compact. If a water salvage project is undertaken in New Mexico by a Federal agency or jointly by New Mexico and Texas, 43 percent of the salvaged water must be delivered to Texas. However, if New Mexico undertakes the project, the salvaged water may be entirely consumed by this state.

Environmental. A watershed or riparian area can be considered as a system in equilibrium. Salt cedar, elm and Russian olives have disrupted the natural equilibrium. Steps toward restoring this system will be beneficial to wildlife, man and the environment.

Practices that reduce erosion or bank sloughing would have a positive impact on water quality. Some minor impact of temperature could occur in areas where vegetation is shading the water, but it would apply to a very small area. Mechanical control has the most negative impact on increasing sedimentation due to the initial disturbance. Chemical control has lower negative effects due to residual vegetation, which helps prevent wind erosion. Biological control has the least negative effect.

Removal of salt cedar elm and Russian olive could result in short duration of modification of terrestrial wildlife habitat. New Mexico State University is conducting an extensive study on a demonstration project east of Artesia. Data was collected before treatment of Salt Cedar, immediately after treatment and five year post-treatment. In a few years a better understanding of the impacts will be available.

Social and Economic. The local economy may be enhanced for a short term during the removal of introduced riparian vegetation salt cedar, elm and Russian olive. Monotypic stands of tamarisk are of limited or no value for recreation. A more bio-diverse ecosystem would have greater potential for recreation and wildlife.

Alternative 8 - Watershed Management

Description

Watershed management is the planned manipulation of one or more hydrologic factors of the drainage area so as to affect a desired change in or maintain a desired condition of the water resource. This alternative deals with the management of vegetation on the uplands of the watershed.

Expected Water Yield

As described in the subsection Vegetation Changes and Water Use in Section VIII, the expected water yield from watershed management is about 10,000 AFY.

Costs

An estimated 462,000 acres is potentially available for watershed management. At $55 per acre for initial treatment and $2 per acre for annual maintenance. The capital and O&M costs are $25 million and $0.9 million, respectively. The annualized cost is $2.8 million and the cost per AF of yield is $283 at the 10,000 AF yield rate, or higher cost at the lower rate.

Feasibility

Technical. The removal of vegetation by mechanical means or by fire is technically feasible.

Legal. Federal and state programs provide watershed planning and funding authority to several agencies. Some local agencies and organizations also have the legal authority to carry out watershed planning and application programs. Private property rights must be respected, and planning and application can be completed on private lands only with the permission of the private landowners. Legal affects in regard to the Endangered Species Act are not known.

Political. The Carrizozo watershed management project and the Mescalero timber stand improvement project have demonstrated a high degree of success in improving water recovery and water quality. A greater interest in these types of projects is developing. A strong educational program including opportunities for on-the-ground observations through tours and visual presentations are needed to educate the public and elected officials to gain support for good watershed management.

Impacts

Pecos River Compact. If a water salvage project is undertaken in New Mexico by a Federal agency or jointly by New Mexico and Texas, 43 percent of the salvaged water must be delivered to Texas. However, if New Mexico undertakes the project, the salvaged water may be entirely consumed in this state.

Environmental. This alternative has the potential for environmental impact. Large-scale removal of conifer forest can damage habitat. The increased surface runoff and exposure of soil to raindrop impact can cause erosion and silting of streams.

Social and Economic. Well-planned watershed management programs can improve economic conditions within the watershed by creating new jobs and possibly developing new industry or businesses. Wood resources and byproducts can be utilized to develop new products or sold as unprocessed wood. The application and maintenance work will offer opportunities for improvement of economic conditions.

Alternative 9 – Dewatering of McMillan Delta

Description

McMillan Delta, from Artesia to Brantley Lake, is the former site of McMillan Lake, an irrigation supply reservoir that silted up (Figure 13, Section VI). McMillan Dam was breached in 1991. Shallow groundwater in the delta hydraulically connected to the Pecos River supports about 12,000 acres of salt cedar that consume up to 24,000 AFY. As a consequence, losses along the mainstem are high in this reach (Figure 29). Additionally, the Kaiser channel's present location tens of feet above the natural streambed contributes to transmission losses. The BOR's McMillan Delta Project, authorized in 1958 but never constructed, sought to salvage 24,500 AFY. The project was to consist of a channel heading structure, a salvage channel, a levee, and a cleared floodway. In this alternative , construction of a series of drains or wells coupled with vegetation management would lower the water table and reduce the area of salt cedar infestation. Returning the river to its topographic low channel would reduce streambed leakage. The recovered water would be stored in downstream reservoirs for irrigation, municipal, or Compact delivery uses or exchanged for upstream uses. Tributary flow from the Rio Peñasco would be channelized.

A non-federal organization should undertake this project so that any salvage realized may be used by New Mexico. Flow through the reach should be measured for several years before any salvage project is initiated to obtain a baseline against which to measure salvage gains.

Hennighausen[135] suggested reactivating existing drains in high water table areas such as Fort Sumner, Roswell, Dexter, and others, and adding new drains in the Peñasco Delta, areas east of Roswell, and other areas. Measures such as these could salvage additional water.

There exists drainage systems in the artesian area. This water is private water and some has been sold and put to beneficial use, others have been neglected and the water lost to evaporation. The free water should be channeled to the river.

There are large undrained areas near the Pecos where water wicks to the surface and evaporates. It brings salts and alkali that kills off the wildlife and vegetation. Small plastic drain lines should be installed to take this water to the river.

[135] Hennighausen, F., 1990, Future Outlook for Water Use in the Pecos Stream System: Proceedings, 34th Annual New Mexico Water Conference, Water Resources Research Institute Report No. 248.

Expected Water Yield

Up to 12,000 AFY of water could be recovered from McMillan Delta.

Costs

Construction of canals and/or wells is expected to cost $1000 per acre foot produced and annual O&M costs are estimated at $10 per acre. The total capital and O&M costs at 12,000 acres of treatment are $12 million and $1 million respectively. The cost per AF of yield is $85.

Feasibility

Technical. The drains and wells proposed by this alternative would be similar to those used in many irrigated areas to prevent waterlogging. Wellfield pumping to drawdown the shallow water table is similar to construction or mine dewatering. The technical feasibility of these methods is well established.

Legal. The legal impacts of this alternative concern the methods employed for water salvaged from the McMillan Delta. Under the Compact, 43 percent of the water salvaged by projects undertaken by the federal government or jointly by the states of New Mexico and Texas, must be delivered to Texas. If New Mexico undertakes such a project the state is not obligated to deliver the salvage water to Texas and may consume all of it. The legal impacts of the Endangered Species Act is not known at this time.

Political. Little political opposition is expected. These are water conserving, environmental friendly, protective measures. The natural uncluttered riparian ecosystem is a much better environment than unfriendly salt cedars. However, getting political support for funding this dewatering of the McMillan Delta will be more difficult. The State must recognize its obligation to the Pecos River Compact as the court now interprets it.

The potential is there and it justifies serious study to get this water through to meet the Compact requirements. Politically, CID may have objections to allowing this water to be used to meet Compact requirements.

Impacts

Pecos River Compact. Forty-three percent of the water salvaged by projects undertaken by the Federal government or jointly by the states of New Mexico and Texas must be delivered to Texas. However, if New Mexico or any of its municipalities or other governmental entities (including irrigation districts) undertakes such a project, the state is not obligated to deliver the salvaged water to Texas and may consume all of it. Salvage of McMillan Delta losses would increase the yield of the basin by eliminating an unmanaged consumptive use. Some of the salvage water could be used by New Mexico, if necessary, to help meet Compact deliveries without increasing obligations.

Environmental. The riparian vegetation in the McMillan Delta is not currently classified as critical habitat, nor is it known to be home to any endangered species. The loss of riparian vegetation and wetlands, however, would cause habitat loss to some species of animals, particularly woodland species of birds. Reptiles and amphibians would benefit from salt cedar reduction and management.[136]

Social and Economic. Wasting this amount of water in this arid west that provides little benefit to neither fish nor fowl is social irresponsibility.

The court has decided that New Mexico has under delivered an average of 10,000 AF per year. If 12,000 AF can be salvaged by dewatering the McMillan Delta at a cost of $1,000 per AF with an annual maintenance cost of $10 per acre and the cost of leasing water is $300 per AFY, the project could be paid and operated for over a decade with four-year lease money. A serious study and evaluation is needed.

There exists drainage systems in the artesian area. This water is private water and some has been sold and put to beneficial use. Others have been neglected and the water lost to evaporation. This private water should be channeled to the river.

There are large undrained areas near the Pecos where water wicks to the surface and evaporates. It brings salts and alkali that kills off the wildlife and vegetation. Small plastic drain lines should be installed to take this water to the river.

Alternative 10 - Desalination

<u>Description</u>

The saline and brackish water reserves in the planning area are extensive. Total reserves of water containing more than 3000 milligrams per liter of dissolved solids are estimated to be on the order of hundreds of millions of AF. The construction of wells to extract the saline water and desalinization plants to treat it to drinking water standards would create a new source of water for the basin.

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[136] McDaniel, K.C. and Duncan, E. W., 2001, Saltcedar and Native Species in New Mexico.

Expected Water Yield

For evaluation purposes, and for comparison with other alternatives, a desalination plant using the reverse osmosis technique capable of producing 20 mgd (22,000 AFY) was assumed.

Costs

The capital cost of a plant to treat moderately saline water (3000 to 10,000 ppm total dissolved solids) and render it drinkable is estimated to be $17.6 million, based upon information obtained by personal communications with Livingston and Associates Engineering of Alamogordo and with the City of Alamogordo.

Operating and maintenance costs are a large part of the cost of desalination. A reasonable cost of $0.47 per 1000 gallons of water produced ($153 per AF) has been obtained from the sources mentioned above. This cost translates into an annual cost of $3.4 million for a 20 mgd plant. These costs do not include any expenditure for getting the treated water to an existing distribution system, nor does it include the cost of drilling wells, buying and installing pumps, electrical energy, or disposal of brine. The annualized cost of a desalinization plant is $4.7 million and the cost per AF of yield is $213.

Feasibility

Technical. Desalinization plants are in operation throughout the world. Their technical feasibility is well established.

Legal. At the federal level, the Water Desalination Act of 1996 provides for federal funding of research in desalination processes, and support for construction of plants has been provided within the United States. Most of this work deals with desalination of seawater.

At the state level, there would appear to be no need for new legislation for a few plants to be constructed, but presumably the withdrawal of water from underground basins for desalination purposes would require permits OSE. A permit to pump saline water from an aquifer in the southeast part of the planning area has already been issued, although its purpose was to prevent the saline water from entering the Pecos River.

As desalination of saline and brackish water becomes more economical and widespread throughout the state, it may be helpful for the OSE to appropriate these types of water resources in a way that will be more beneficial to the state as a whole and to the specific needs of the planning area. This action would probably require legislation and regulatory authority.

Production of underground saline water in the Lower Pecos Valley system may present unforeseen legal problems. Much of the saline groundwater is interrelated with the fresher groundwater and pumpage of the saline water could impair existing water rights by lowering the potentiometric surface in the fresh water portion of the aquifer. Pumping of saline water from the aquifer north and east of Roswell might help prevent further saline encroachment into the fresher aquifer to the west, but again might have some additional consequences as to the lowering of the potentiometric surface in the artesian aquifer.

Political. Since there is such a large amount of underground saline water available, it represents a regional resource that can be somewhat independent of external issues and constraints. Within the planning area, desalination is unlikely to have political problems when its cost becomes competitive with other water sources. In one sense, it represents "new water" that the region can depend upon and control more closely. However, there are environmental issues that may result in political activity.

<u>Impacts</u>

Pecos River Compact. Recovery and treatment of saline groundwater will not change the State’s Compact obligations. The supply of “new” water from heretofore unused aquifers will enhance the State’s ability to meet obligations. Continued groundwater pumping, however, may reduce streamflow reaching the stateline by inducing surface-water recharge to groundwater or depleting springflow.

Environmental. Unlike the possibilities available to coastal communities, which can return the concentrated brine to the ocean, the Pecos Valley area must either re-inject the water into another aquifer or must spread it out on the ground in pans to let the water evaporate and leave the solids behind. If the salt cannot be "mined" for its commercial value, then it might be necessary to confine it in landfills that will not let the solids seep into the ground. Salt flats already exist in the general area and may be suitable for brine disposal without impacting groundwater.

Full NEPA regulation will be needed, including an EIS.

Social and Economic. As noted above, some federal and state financial assistance for the construction of a moderately large plant is probably available. In the long-term desalination plants probably will have to be funded by the residents of the region for domestic and municipal use, and, in the case of the commercial, industrial, agriculture and mining sectors, by the businesses that plan to use the water. Since the cost of water produced by desalination does not, at this time, compete with that obtained from traditional sources, the added cost would have a negative impact on the cost of living in the planning area and might put some businesses that compete on a state-wide or national basis in a less competitive position relative to those located where water is plentiful.

A unique funding source is being used in Florida for desalination of water about ten percent less saline that ocean water. In this case, a private consortium is prepared to build the plant and sell the water to a local distribution company. Private enterprise is taking the risk and supplying the capital and O&M costs for the plant. This same approach may apply to the planning region. For the average citizen, the fact that the water comes from desalination would appear to pose no change in his or her life style or quality of life.

Alternative 11 – Construction of Interstate Pipeline

<u>Description</u>

The importation of water into eastern New Mexico (as well as West Texas) was the subject of a Bureau of Reclamation Study released in May 1968.[137] Several sources for the water were reviewed and evaluated, including the Columbia, Colorado, Missouri and Arkansas River Basins, some Canadian water systems, some Texas water basins, and the Lower Mississippi River. The conclusion made at that time was that the Lower Mississippi River was the only viable option, principally because the other basins did not anticipate having much excess water.

This section, which deals with the construction of an aqueduct from the Lower Mississippi River, has the potential for large quantities of water that could exceed the projected shortfall within our planning area at the year 2040 and beyond. Thus the projected shortfall could easily be met, as well as shortfalls for drought years. It is interesting to note that there may be times when excess water from the Mississippi would not be available because of drought conditions in that basin. On the other hand, the Mississippi is sometimes plagued with excess water that causes flooding and severe damage. This situation seems to indicate that large underground or deep surface-water reservoirs would be desirable to store and "even out" the water supply in the planning area that is, one would want to store the water at the end point of the delivery system (not necessarily in New Mexico) so that it can be used when water is not available from the Mississippi. This requirement would therefore tie into the large reservoir or aquifer storage and recovery alternatives. Both projects may be necessary to fully exploit both options. The conclusion in 1968 regarding water availability for export from the Mississippi has been summarized in the BOR report as follows[137 above] "There is no question but what water will be available in the Mississippi River for export during

[137] U.S. Department of the Interior, 1968, Progress Report on West Texas and Eastern New Mexico Import Project Investigations: Bureau of Reclamation, Region 5.

some periods of most years. However, the determination of the amounts and times when water can be exported will require exhaustive studies to establish future need in the (Mississippi) valley states."

Expected Water Yield

The above referenced BOR study was based on the assumption that 6,000,000 AF of water would be delivered per year to Bull Lake or possibly nearby Yellow Lake or both. This amount of water necessitated the diversion from the Mississippi of anywhere from 6,650,000 AFY to 7,100,000 AFY depending upon the route taken to get from the Mississippi to Bull Lake and the diversion point at the river. Bull and Yellow Lakes are depressions in the Texas high plains east of Roosevelt County, New Mexico. According to preliminary geologic investigation, the lakes would store of about 403,000 and 1,040,000 AF, respectively. Bull Lake is at an elevation of 3600 feet, and Yellow Lake at 3530 feet, and thus advantageous for many areas of the planning region. Roswell's elevation is 3612 feet and Carlsbad is at 3120 feet.

For comparison purposes with the other activities proposed for the other alternatives, the arbitrary assumption is made that the yield from an aqueduct from the Mississippi to the Lower Pecos would be about 300,000 AFY. This value is based, in part, on the fact that other areas, particularly Texas, would want larger quantities of water for their domestic, agricultural, and business enterprises as well. They would also share in the cost of the aqueduct.

Costs

The cited BOR report did not deal with costs of water delivered except in a qualitative way. Therefore, the capital cost estimate for this option is based upon cost data available from the Central Arizona Project. The capital cost of that project was $4 billion. The project delivers 1,505,000 AFY and is 336-miles long. For cost purposes, the length of the aqueduct from the Mississippi to Bull Lake is assumed to be 1000 miles, although the actual length depends upon the route and the point of diversion on the Mississippi. The BOR study showed the length for the aqueduct varying from 955 to 1300 miles for the different routes noted. Assuming the financial participation of Texas and a four to one ratio in the division of water between Texas and New Mexico, respectively, the estimated cost for New Mexico is $1 billion in capital and $1 million per year in O&M. These values translate to an annualized cost of $76 million and a cost per AF of yield of $253.

A comment in the BOR report regarding costs is worth noting, however. Regardless of the aqueduct route, the cost per acre-foot for delivering water from the lower Mississippi River system to irrigation in the study area appears certain to exceed substantially their ability to pay for such water." Also "economic benefits of irrigation to non-farm elements of the study area's economy are large and appear to be sufficient to warrant payment by those non-farm elements of costs of import water in excess of the irrigator's ability to pay."[137 above]

Feasibility

Technical. Several large-scale aqueduct/canal systems have been built in the U.S. and have operated very successfully and economically in spite of requiring numerous dams, reservoirs, pumping stations and energy recovery systems. Many areas of California and Arizona have prospered in many ways almost exclusively on the basis of the ability to get water by means of aqueduct systems. The proposed aqueduct from the Lower Mississippi to eastern New Mexico is technically feasible.

Legal. The undertaking of the construction of an interstate canal or aqueduct would require extensive state legislative actions, not only in view of costs, but also in view of the need for compacts to be worked out under federal supervision with other states. The most promising routes involve only Louisiana and Texas, and an agreement regarding cost sharing and other matters is likely to be reached. Since that portion of Texas that would benefit from such a canal appears to be projecting even larger water shortfalls than the Lower Pecos area, there is good incentive for the two states to cooperate to accomplish the task. From Louisiana's perspective, the incentive to enter into an agreement stems from the elimination or reduction of flooding in the Mississippi Valley below the diversion point. This factor would be difficult to quantify; therefore a financial contribution from Louisiana would probably be small. Furthermore, there would have to be assurance that no water could be diverted if shipping were endangered or that New Orleans, in particular, would be subject to further saline water encroachment. Action and legislation by the U.S. Congress would also be necessary for a project of this type since it crosses state lines. The project would probably be built by BOR and require at least a significant share of federal financing.

Political. The expenditure of state funds, even though they may be reimbursed over the next 20 to 40 years, for a project that will benefit only one portion of the state will likely create resistance on the political level. However, other portions of the state also have water problems that will require state help. The solution may be to develop a state-wide plan addressing all projected water shortage issues and thereby getting a more general consensus for solving the problem.

Impacts

Pecos River Compact. Importation of water by the State of New Mexico will not affect Compact obligations. Imported water can be used to meet the State's delivery obligations.

Environmental. There has been general opposition in the U.S. to undertaking large water projects because of the potential environmental impacts, many of which are related to building dams that affect the natural flow of water in rivers. However, this problem is mitigated to some extent by the fact that the needed dams lie only in the states which will benefit from the project. In Louisiana only three pumping stations would be required.

Other environmental issues concern the changes in salinity of the rivers. In some cases, the quality of the water in the river would be improved and that of the imported water would be adversely affected. In any case there may be adverse effects on fish and wildlife.

Social and Economic. The undertaking of an aqueduct project of the type discussed here would pose major economic challenges at both the state and federal levels. The financial commitments and uncertainties would be too large to be borne by the private sector. A combination of private and public funding may be possible. The more likely scenario would be to fund the project at the federal level at 75 percent, with the states providing cost sharing at the 25 percent level, and impose a cost on all users that would amortize the investment over a period of 20 to 40 years. The O&M costs would probably best be distributed such that each state, except perhaps Louisiana, maintains and operates that portion of the system that lies within its borders and share O&M costs incurred in Louisiana in accordance with the water distribution to each state. However, since considerably greater pumping costs would be incurred by Texas, some equitable compensation or cost sharing may be needed for this portion of the operating costs.

As indicated above, it seems unlikely that agriculture could survive in the Pecos Valley if it, alone, had to repay the cost of the project. However, since the loss of agriculture would have a major impact on the economic well-being of the region, some sharing of the increase in the price of water would be required by the general public.

Alternative 12 - Cloud Seeding

Description

The typical large cumulus clouds that form in the High Plains are (northwest Texas and southeast New Mexico) during the spring and summer have relatively few natural nuclei around which moisture in the air can nucleate and grow to form ice crystals or snowflakes high in the clouds which then melt and fall as rain. As a result, most of the cloud water is never converted to raindrops. Introducing silver iodide to the cloud provides additional nuclei so that more of the cloud moisture can be transformed into ice particles which grow to precipitation size and then melt and fall as raindrops. Silver iodide initiates the precipitation process earlier in a cloud, making it more efficient and producing precipitation sized particles, which can survive the fall through the dry sub cloud layer and reach the surface as meaningful rainfall.

Expected Water Yield

Since 1971, the Colorado River Municipal Water District has maintained a precipitation enhancement program for the purpose of creating additional rainfall runoff for storage in its reservoir system. The precipitation enhancement operations area includes the Gail, Lamesa, Big Spring, Colorado City, Roscoe, and Snyder areas of the South Plains. Comparing the seeded years with the unseeded years from 1971 to 1990, rainfall was 140 percent of normal during the seeded summer sessions. In the target area, rainfall totals ranged from 2.5 to 4 inches above normal during the seeded years.

An increase of from 2 percent to 15 percent in annual precipitation is estimated to occur as a result of cloud seeding.[138] Assuming that the average precipitation over the Lower Pecos planning region is about 12 inches, that the planning area is 13.6×10^6 acres, that, arbitrarily, the increase in precipitation from cloud seeding would be 8.5 percent, and that three percent of the precipitation becomes groundwater and surface water, then the increase in the water supply from this activity would be about 34,680 AFY.

Costs

The capital cost of cloud seeding is assumed to be of the order of $1 million, which would cover the cost of two aircraft and ancillary equipment. The O&M cost is estimated to be $0.05 per acre covered. This number is derived from the fact that the High Plains Underground Water Conservation District has experienced O&M costs at between $0.05 and $0.08 per acre covered, based upon the Texas/New Mexico project. The annualized cost is $0.8 million and the cost per AF of yield is $23.

Feasibility

Technical. Cloud seeding operations have been conducted for many years, but there remains some concern about the effectiveness of the process and the importance of the meteorological impacts.

Precipitation enhancement can cause thunderstorm systems to grow wider, last longer, pull in more moist air from the surface, and transform that moist air into moisture droplets. Research has shown that precipitation enhancement can cause extra cloud growth on each side of the thunderstorm, resulting in a longer life for the storm

[138] California Department of Water Resources, The California Water Plan Update: Bulletin 160-98, Vol. 2, November 1998.

system, which may cause more rain to fall over a larger area. However, the water yield of cloud seeding is highly uncertain, and is therefore considered technically infeasible.

Legal. No legislative authorization is needed since cloud seeding operations are already being carried out in New Mexico at the present time. It is to be noted that there are private companies that conduct these operations and that carry liability insurance for these activities.

This potential exists for lawsuits from those outside the cloud seeding area claiming that rainfall is being diverted, and for those within the cloud seeding area claiming damages for too much rain or for hail damage.

Political. Some institutional and political issues surround cloud seeding projects. The BOR, for example, is phasing out weather modification projects, in part because of institutional problems, and because the State of Colorado has opposed a demonstration programs. Principal problems arise from third parties who claim damage from flooding, high water conditions, and damage from hail. In the planning region some public information efforts would probably be desirable, as well as public involvement in the decision process.

<u>Impacts</u>

Pecos River Compact. All floodflows below Sumner Dam are subject to apportionment under the terms of the Compact. Weather modification that causes or increased floodflow may increase the State's delivery obligation to Texas.

Environmental. Some environmental concerns have been expressed in the past about weather modification and its impact on rainfall in other areas around the region being treated. The idea that increased rainfall reduces in rainfall downwind is a misconception. There are no indications of rainfall decreases downwind from any long-term cloud seeding projects. In fact, there is evidence that precipitation increases occur downwind of target seeding areas.

Another area of concern is the effect of silver iodide on health. The amounts used are very small. The typical concentration of silver iodide in rainfall or snow from a seeded cloud is less than 0.1 micrograms per liter (one part in 10,000,000,000 or a mere 1/250th of the acceptable level established by the U.S. Public Health Service). The silver concentration in rainwater from a seeded cloud is well below the acceptable concentration of 50 micrograms per liter as set by the U.S. Public Health Service. In fact, many regions have much higher concentrations of silver in the soil than are found in precipitation from seeded clouds. The concentration of iodide in iodized salt used on food is far above the concentration found in rainwater from a seeded cloud.

No significant environmental effects have been noted around operational projects during the past 30-40 years.

Social and Economic. According to Jim Jonish, a retired Economics Professor at Texas Tech University, private benefits include the potential for increased crop yields, improved grazing conditions for livestock, reduced irrigation costs, and improved water quality.

Some of the social benefits of precipitation enhancement are increased rainfall runoff into reservoirs used for drinking water supplies and recreational purposes, increased precipitation downwind of the target seeding area, a reduction in groundwater depletion from the local aquifer, higher humidity which results in lower evapotranspiration rates by growing vegetation, improved water quality and other secondary benefits, such as the multiplier effect on the region's economy.

An agro-economic study made in conjunction with the High Plains Experiment (HIPLEX) program from 1974 to 1980 assumed that a ten percent increase in rainfall could be obtained by precipitation enhancement during the growing season in the Big Spring-Snyder area of West Texas. In terms of crops and cattle, the regional economy would increase by $4 million and personal income by more than $2 million. In addition, more than a half million dollars would be saved in irrigation costs. Cotton yields were 64 percent above normal during seeded years (1971 to 1990) in this area.

A February 1997 paper by High Plains Water District Manager A. Wayne Wyatt and Assistant Manager Ken Carver states that the estimated increase in agricultural production resulting from one inch of precipitation on a timely basis on the four major crops grown within the High Plains Water District service area has a market value of approximately $81,055,865 with a regional economic impact of approximately $283,695,528.

Using a conservative estimate in calculating the value of increased production on a per acre basis for the four major crops grown in the region, the increase in cotton lint production would bring an additional income of $34.00 per acre; corn, $18.90 per acre; grain sorghum, $10.45 per acre; and wheat, $20.50 per acre.

Alternative 13 - Construction of Large Reservoirs

Description

The idea behind the suggestion of a new reservoir or series of reservoirs is that sufficient rainfall may occur within the Pecos River watershed such that the existing reservoirs would overflow. If about half of this water (because of the Compact) could be saved over periods of several years, a net gain could be realized. However, no spillage of water has occurred in recent times.

Expected Water Yield

Arbitrarily set at 250,000 AF, since this capacity would appear to offer a substantial hedge on growth at two percent for agriculture and growth at about 27 percent or so for population over the planning period of 40 years. The last major floodflow, however, was in 1941. Assuming 1941 was a 100-year event and the reservoir can only store 250,000 AF. The annual yield under this alternative is 250,000 AF/100 years = 2500 AFY. Surface evaporation will diminish the yield depending on the length of time water is left in storage.

Costs

Inquiries made to the BOR established that the Brantley Dam and Reservoir (with a capacity of 348,544 AF and constructed in 1988) had a capital cost of about $50 million; consequently, the capital cost of a new reservoir with a capacity of about 250,000 AF would likely be in the range of $50 million in today’s dollars, depending upon a large number of factors. The O&M cost is estimated at $0.1 million per year. The annualized cost is $3.8 million and the cost per AF of yield is $1,540.

Feasibility

Technical. The proposed alternative is not technically feasible. Few if any sites exist suitable for a large reservoir. The expected yield is highly uncertain. Because evaporation is high, stored floodwater from infrequent large storms would be lost before it could be used.

Legal. The water created in a new reservoir for the purpose of storing overflow would likely be considered as unappropriated floodwaters and thereby apportioned 50 percent to Texas and 50 percent to New Mexico under the Compact. Necessary permits for the storage and use of the water would have to be filed with the OSE under existing statutes.

Political. The construction of dams to create large reservoirs on rivers has, for some years, been politically sensitive from the standpoint of the general population throughout the United States. New dams or a dam on a river such as the Pecos would perhaps be of more concern on the part of the citizens of the area. However, off-stream dams and reservoirs designed to allow diversion of floodflow from the river for storage and return to the river at a later time would appear to be more acceptable and "saleable" from the public standpoint. Nevertheless, this particular offset option has marginal value with respect to the availability of excess water to fill it and the technical challenge of preventing loss of significant quantities of water from evaporation even if it is filled; consequently, elected officials may not perceive it as a very high priority option. During most seasons, the existing dams and reservoirs are capable of retaining most of the floodflow and it would require an unusual flood condition to provide the excess water for this option. This alternative is therefore considered politically marginal overall. Furthermore, since a significant fraction of the water so saved may have to be obligated to Texas (depending on the financing of the project), some politically sensitive interstate issues may arise also.

Impacts

Pecos River Compact. A new reservoir may be subject to approval by the Pecos River Commission. This could change the State's Compact obligations. Additional evaporation from the reservoir, when water is stored, will reduce the amount of water available to meet Compact deliveries.

Environmental. A new mainstem dam along the critical habitat reach of the bluntnose shiner (from Sumner Dam to Acme) could have negative consequences on the shiner's habitat. A new reservoir could provide new habitat for other species.

Social and Economic. A reservoir designed to store excess water in wet years or from large storms could be perceived to be regionally beneficial if the political issues could be resolved. The reservoir would have to be located well upstream so that most of the region could benefit from the stored water and so that evaporation losses could be minimized. It would theoretically benefit all sectors of the economy to some extent and agriculture in particular. Since this alternative involves surface storage, there would be land-use considerations to deal with. However, bodies of water that can be used for recreation are generally well received on the social level.

This type of project could also provide water for wildlife, both at the reservoir itself and downstream, and could therefore help resolve the endangered species issues on the Pecos. Depending on the quantity of water that can be collected and how reliable a source of water it might be, the project could be devoted entirely to meeting the endangered species water requirements.

At a cost of about $1,540 per AF of water saved, the construction of large reservoirs is economically marginal relative to some of the other options that have been identified to offset water shortages. The large-reservoir option would, furthermore, require extensive statistical analyses of precipitation and demand variability in order to determine how much water would actually be available on average and how long the water would have to be stored and how long it could be stored.

Alternative 14 – Aquifer Storage and Recovery

Description

A suitable underground geologic formation or zone within the planning area could be used to store excess water from high rainfall years for very long time periods. Wells would be used to inject and recovered the stored water.

Expected Water Yield

Similar to Alternative 13 (Construction of Large Reservoirs), the expected annual yield is 2500 AFY.

Costs

The cost is expected to be similar to the wastewater injection action of Alternative 5 (Municipal Conservation) or $2.7 million per year, annualized. The cost per AF of yield would be $1,095.

Feasibility

Technical. Aquifer storage and recovery is technically feasible.

Legal. Permits would have to be filed with the OSE under existing statutes. The groundwater storage would have to be conditioned on the basis that no existing rights would be impaired.

Political. To the extent that this option applies to the long-term storage of excess seasonal water or floodwater, no significant political resistance from the public or from elected officials would be expected, nor would opposition from special interest groups be anticipated insofar as this alternative applies to storage in geologic formations that are not hydrologically connected to the Roswell Underground Aquifer. To the extent that this option applies to the injection of treated wastewater, some general opposition might be expected even though the technology and safety have been demonstrated and proven. To overcome the latter, public education would be required.

Impacts

Pecos River Compact. The alternative will not affect Compact obligations. Storage of water that can be recovered may help meet Compact deliveries.

Environmental. No environmental impacts are expected under this alternative.

Social and Economic. The cost of this option, although lower than that for Alternative 13 (Construction of Large Surface Reservoirs), is still economically marginal. Also, the viability of the concept is closely tied to the statistical variability in the amount of excess flood or seasonal water available to inject into the underground geologic zone. However, the concept can potentially accommodate long-term storage since evaporation would not be a factor, although the storage time would depend on the transmissivity of the geologic structure that is receiving the water.

There would not appear to be any social problems associated with this option since the aquifer is underground and has no effect on land use.

Alternative 15 – Reduce Reservoir Surface Area

Description

The surface area of the existing lakes and reservoirs within the planning region can be reduced by ten percent by creating berms around shallow portions of the lakes to confine the water. From Tables 25 and 26, the total evaporation from reservoirs (including Bitter Lakes) in the planning area is 18,600 AFY. It follows that a reduction in evaporation of ten percent (1800 AF) would require a reduction of about ten percent in the surface area of the lakes.

An alternative method would be by using floating hydraulic suction dredges and floating pipelines to dredge excessive silt from the bottom of the existing reservoirs and use of the pumped slurry to fill shallow portions of the lakes to confine the reservoir area.

Expected Water Yield

The annual yield is 1800 AF for this alternative.

Costs

Approximately 300 miles of berms would need to be constructed. From personal communication with estimators at Mesa Verde Enterprises, a budgetary estimate of $55,000 per mile for a berm 15-feet high by 40-feet wide at the base and ten-feet wide at the top was obtained. The soil for the berm is presumed to be available within 300 feet and would be moved by bulldozers. The total capital cost would be about $16.5 million. O&M costs are estimated at $0.1 million per year. The annualized cost is $1.3 million and the cost per AF of yield is $743.

<u>Feasibility</u>

Technical. Though the proposed methods for reducing reservoir area are feasible, the change in the reservoir would reduce storage below design capacity and impact the reservoirs designated function. The alternative is therefore not technically feasible.

Legal. The proposed alternative would not present any significant legal problems.

<u>Impacts</u>

Pecos River Compact. No effects on Compact obligations are anticipated. Reduction in evaporation losses will increase the State's abilities to meet deliveries.

Environmental. Environmental impacts are minimal. The shoreline environment of reservoirs to be modified will be disrupted, but will re-establish once work is complete. Construction of berms may temporarily increase silt loading in reservoirs and downstream river reaches.

Alternative 16 – Reducing Conveyance Losses in Pecos River

<u>Description</u>

Certain reaches of the Pecos River are gaining reaches and others are losing reaches (see Figure 29). Some reaches of the river are gaining during some years and losing during others.

Potential causes of losses are:

1. Evaporative losses
2. Seepage
3. Transient bank and bed storage
4. Consumption by phreatophytes

The actual cause of the loss is uncertain.

An analysis of river reaches shows that the largest losing area is from Artesia to the Kaiser Channel near Lakewood where losses average 50,200 AFY (average losses since 1950). If the river were treated between Artesia and Lakewood, flows could be increased by a substantial amount. Fort Sumner to Acme is also of interest where environmental impacts might be less.

Expected Water Yield

The cause of the losses are unknown, therefore the yield is unknown.

Costs

The cost of solving the problem is unknown. If losses could be pinpointed to a small area, an inexpensive solution may be feasible.

Feasibility

Technical. The technology for sealing or reducing seepage exists but further study is needed to determine if it would be cost effective.

Legal. Several local, federal and state authorities have the authority to address this problem. The legal consequences of this alternative would be largely related to the environmental aspects.

Political. At some point, a political decision will have to be made to salvage this water. The loss of 50,000 AF of water annually in this arid west will have to be faced as population grows and greater pressure is put on the need of water for humans. There are apparently no known springs of equal size at elevations below the level of the river. How long will we tolerate this loss of water with no apparent benefit? This is a political question that will be made when the pressure for more water is great enough.

Impacts

Pecos River Compact. If a water salvage project is undertaken in New Mexico by a federal agency or jointly by New Mexico and Texas, 43 percent of the salvaged water must be delivered to Texas. However, if New Mexico undertakes the project, the salvaged water may be entirely consumed by this state.

Environmental. Environmental impacts are high under this alternative. Sealing the riverbed would destroy the streambed aquatic ecology in the treated reach. The loss of leakage from the river would dry up wetland and reduce riparian habitat. Vegetation in this reach consists of monotypic stands of salt cedar and is considered poor habitat. The loss of streambed leakage would probably prevent growth of native phreatophytes that rely on a shallow water table such as cottonwood, but the stream banks might support grasses and forbs.

Social and Economic. Humans and wildlife would benefit if the Pecos River losses were restored to create a more natural riparian condition with native trees and native grassland. The present lost water benefits no one. It would be nice if the Pecos were to become a clear stream instead of the historically muddy stream it was. We cannot and should not expect to fully restore the Pecos with its dangerous quicksand and vertical banks.

Whatever is done must be preceded by a competent study to determine where the water goes and how to salvage it. Sufficient riparian growth must be maintained since the Pecos is subject to severe and periodic flooding. If this water can be salvaged economically by the State of New Mexico, the obligation to the Compact would be solved and other water pressures would be relieved.

Alternative 17 - Import Water from Salt Basin

Description

Unappropriated water may exist in some water planning regions in New Mexico. If so, the region with the excess water (i.e. water for which there does not appear to be a foreseeable demand within the 40 year planning cycle) may wish to lease or sell that water to another region where a shortfall exist now or is expected to exist in the near future. One region where an excess amount of water appears to exist at the present time is in the Salt Underground Water Basin which is part of the planning region designated as the Tularosa, Great Salt and Sacramento River Basins.

The New Mexico portion of the Salt Basin, which is located in south central New Mexico, extends from the southern slopes of the Sacramento Mountains on the north (including the Sacramento River Valley) to the state line with Texas on the south, the crest of the Guadalupe Mountains on the east, and the crest of the Otero Mesa on the west. Within New Mexico, the Salt Basin covers about 1900 square miles and obtains its underground water from three major watersheds: the Sacramento River, Piñon Creek and Shiloh Draw. Elevations vary from just over 9000 feet in the Sacramento Mountains to about 4000 feet near the state line. The Salt Basin was declared a state-regulated hydrologic basin by the OSE on September 13, 2000, (19.27.61).

Studies by Mayer,[139] King and Harder,[140] Ashworth,[141] and John Shomaker & Associates[142] suggest that the amount of inflow into the Basin is in the range of 35,000 to

[139] Mayer, J.R., 1995, The Role of Fractures in Regional Groundwater Flow: Field Evidence and Model Results from the Basin-and-Range of Texas and New Mexico: Ph.D. Dissertation University of Texas at Austin.
[140] King, W.E. and Harder, V.E., 1985, Oil and Gas Potential of the Tularosa Basin – Otero Platform- Salt Basin Graben Area; New Mexico and Texas: New Mexico Bureau of Mines and Mineral Resources Circular 198.
[141] Ashworth, J.B., 1995, Ground-Water Resources of the Bone Spring-Victorio Peak Aquifer in the Dell Valley Area, Texas: Texas Water Development Board Report 344.

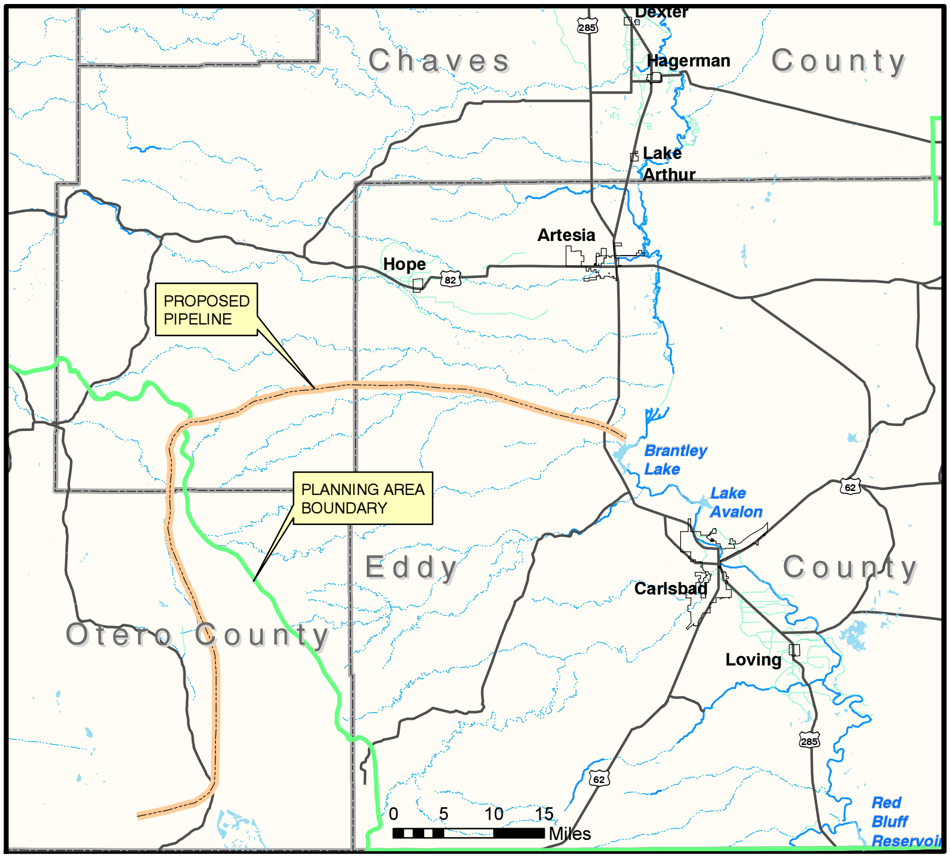
70,000 AFY. Current demands for water occur near the state line in New Mexico and just south of the state line near Dell City, Texas and are overwhelmingly comprised of irrigation for agriculture, with a relatively small amount needed for domestic wells and stock watering. The quality of the water is generally very good (< 1000 ppm TDS) in New Mexico, but becomes poor (3000 ppm to 6000 and higher) in the region around Dell City where extensive pumping of the underground water in done. Historically, water diversions from the underground water supply have been as high as about 20,000 AFY in New Mexico, but are much lower than this value at the present time. Diversions are currently about 90,000 AFY in Texas and appear to be sustainable at this level from the standpoint of the maintenance of a stable water table, although a significant increase in salinity of the water is occurring.

Expected Water Yield

For purposes of this alternative, it is assumed that 20,000 AFY is available from a willing supplier and can be pumped from the underground aquifer at a point in New Mexico about two miles north of the state line (at an elevation of about 4000 feet) and piped to Brantley Lake in the Pecos Valley (at an elevation of about 3270 feet) as depicted in Figure 31. The length of the pipeline has been estimated to be about 100 miles using a route that involves the fewest topographical barriers as possible and involving as small a rise in elevation to get across the crest of the Guadalupe Mountains as practical. The elevation of the discharge point is below that of the ground level at the source.

[142] John Shomaker & Associates, Inc., 2001, 40-Year Water Plan for the Tularosa and Salt Basins, Section 6; Tularosa, Salt, and Sacramento River Basins Regional Water Plan: South Central Mountain RC&D Council.

Figure 31. Proposed Pipeline from the Salt Basin



Costs

A capital cost of $129,227,000 has been estimated for the entire project including piping, pipe installation, wells, well pumps, rights-of-way, a small hydroelectric plant to recover some of the energy for pumping, and other items, and includes a contingency of 30 percent since the project is only conceptual in nature at this time. The cost of buying and/or leasing water rights is not included.

The recurring costs are estimated to be about $4,500,000 per year if the cost of electricity is assumed to be $0.10 per Kwhr to run pumps to cross the Guadalupe Mountains and no credit is taken for the sale or use of electricity from the hydroelectric plant. A gross assumption of a credit for the sale of electricity at $0.05 per Kwhr could potentially reduce the annual cost.

The above cost estimates result in a projected cost of water of $710 per acre foot or less annualized over a 40-year time period.

Feasibility

Technical. There are no technological barriers to the construction and operation of a pipeline of the type described. A pipe diameter of about 36 inches would appear to be sufficient to keep flow velocities at about 4 feet per second. Siphon systems involving larger pipe sizes are not uncommon in engineering projects.

Legal. A project of this type would not require any changes in local, state or federal law with regard to the construction of a pipeline. It would, of course, require the normal permits and would need to conform to current engineering and construction standards.

State statutes (72-14-43 and 72-14-44) already exists that would allow the ISC to appropriate, on behalf of the Tularosa, Great Salt, and Sacramento River Basins planning region, the unappropriated waters in the Salt Basin. However, this process has never before been attempted in New Mexico; consequently, there are no precedents to draw upon and a number of uncertainties exist. The Tularosa Basin Region is currently discussing the various issues concerning their rights and future control over the unappropriated water if the ISC were to follow the proposed process. There are also legal issues regarding the export of the water from one basin to another assuming that the ISC does appropriate the waters and the Tularosa Region is a willing seller and/or lessor of that water. There are also concerns on the part of the residents of the Salt Basin regarding their historical water rights in the light of the OSE declaration. Many of them have joined together to form the "Last Chance Water Company" in order to work with the OSE to get their water rights legally recognized and recorded. As of this writing, the members of the Company have indicated a willingness to sell or lease water for export to anyone in New Mexico or Texas.

Political. The diversion of additional underground water from the New Mexico side of the Basin for export to other regions within this state has interstate implications. Some discussions at the political level have been initiated regarding an equitable distribution of the available waters between the two states, but it appears as if 20,000 AFY can be exported without affecting the current demand within the Basin itself.

It is anticipated that Texas would be concerned as to the actual impact on the agricultural businesses located south of the state line of diverting 20,000 AFY of water from the New Mexico side of the Salt Basin. To further complicate the situation, the City of El Paso has already indicated an interest in buying water from the Salt Basin in New Mexico, and one corporation, which owns about 3000 acres of agricultural land in New Mexico, filed a Declaration of Owner of Underground Water Right for several purposes, including the change in use of the water to "transport for delivery to water utilities within El Paso County for retail/wholesale distribution within their service area" This proposed beneficial use was based on the diversion of 45,000 AFY, although not all of that amount was anticipated to come from wells in New Mexico. This aspect of the political issues relating to the Salt Underground Water Basin comes under the purview of State Statute 72-12B-1 which is entitled "Application For The Transportation and Use of Public Waters Outside of the State".

With regard to other political aspects of the pipeline project, it has been suggested that the exportation of the potable water from New Mexico to El Paso could be used to offset some of the Pecos River Compact deliveries without the need to construct a pipeline to Brantley Lake. Since the quality of the water on the Texas side is poor, the delivery of water to El Paso by Texas companies or municipalities from the Texas side would require the expenditure of considerable amounts of money for the construction of some type of desalting plant.

Impacts

Pecos River Compact. Whether or not the importation into the Lower Pecos River Basin of water from another water basin within New Mexico has an impact on the Pecos River Compact obligation is somewhat uncertain and may depend on the source of the funds used to construct the pipeline. The assumption is made here that there is no impact and that the waters so imported could be used to meet, among other beneficial uses, part of the required deliveries of water to Texas under the Compact.

Environmental. The environmental impact of the construction of a pipeline from the Salt Basin to the Lower Pecos River Basin is not considered significant. The pipeline would be buried underground, and, since the pipe is 36 inches in diameter, the amount of soil to be disturbed in installing the pipe is relatively small. The population density along the proposed route is extremely small. The water supplied to Brantley Lake will be of higher quality in terms of the total dissolved solids than that flowing into the lake from upstream. The environmental impact on the hydrology of the Salt Basin is expected to be a reduction of the amount of water that evaporates in the salt flats and playas located to the east and south of the Dell City irrigation area.

Social and Economic. The importation of water from the Salt Basin to the Lower Pecos River Basin can have social and economic benefits to both areas, to Otero and Lincoln Counties, and to the State of New Mexico. The benefits to the Pecos area lie in the acquisition of additional water to meet current and growing demands for water in all non-agricultural sectors of the economy, as well as help in meeting Pecos River Compact obligations.

The residents of the New Mexico side of the Salt Basin have expressed an interest in selling or leasing their water rights since the agricultural sector is depressed at the present time, although they appear to intend to continue the ranching aspect of their economy and will need sufficient water for that and domestic purposes. Economically they will benefit from the sale or lease of the water and will thereby be compensated for the prior agricultural value of the water.

If the Tularosa Basin region agrees to have the ISC appropriate the unappropriated waters of the Salt Basin (once the historical water rights of the residents have been equitably established and an understanding has been reached on the benefits to and control over the waters by the region), the two counties can (along with the residents) benefit financially from the sale or lease of water. The State of New Mexico can benefit from the importation project by reducing its need to lease water in the Pecos Valley Water Basin in order to meet Compact deliveries, by having a specific, well defined, and quantifiable need for the excess water in the Salt Basin in order to protect water from being acquired by interests outside of the State, and by helping to create a more stable and predictable agricultural economy in the Pecos Valley by eliminating some of the uncertainties in the priority call issue.

Summary of Alternatives

A tabulation of the costs and yields for each alternative and action is shown on Table 66. The alternatives are grouped by the sectors administrative, agriculture, municipal and industrial, land use and other projects. Feasibility is tabulated in Table 67, and impacts in Table 68. The three factors cost, feasibility and impacts are summarized in Table 69 for evaluation.

Table 66. Summary of Alternatives, Costs and Yields

Sector	Alt. No.	Action	Unit Costs		Number of Units	Type of Unit	Costs		Annualized Cost	Yield (AFY)	Cost per AF
			Capital	O&M			Capital	O&M			
Administrative	0	No change									
	1a	Enhanced water market					$450,000	$300,000	$333,754	12,000	$28
	1b	Enhanced administrative enforcement							$100,000	6250	$16
	2	Managed aquifer operations						$500,000	$500,000	10,000	$50
Agriculture	3	Agricultural conservation									
	3a	Laser leveling	300		20,200	acres	$6,060,000	$0	$1,477,978	2000	$739
	3b	LEPA/sprinkler/drip	522	21	47,300	acres	$24,690,600	$1,000,000	$2,852,021	4700	$607
	3c	Ditch lining/pipes	100,000		151	miles	$15,100,000	$500,000	$1,632,638	1000	$1,633
	4	Moving reservoir storage upstream	1000		3500	AFY	$3,500,000	0	$262,532	3500	$75
M&I	5	Municipal conservation									
	5a	Time of day/day of use					$0	$200,000	$200,000	800	$250
	5b	Low flow fixtures/audits/leaks	100	10	48,000	DU	$4,800,000	$480,000	$840,044	860	$977
	5c	Cover reservoirs	30,800		1000	acres	$30,800,000	$0	$2,907,302	5000	$581
	5d	Wastewater reuse	105,600		60	miles	$14,500,000	$500,000	$1,587,633	0	-
	5e	Xeriscaping	500	0	36,000	SFH	$18,000,000	$0	$1,350,164	5500	$245
	5f	Rationing		33	36,000	SFH	$0	$1,188,000	$1,188,000	3300	$360
	5g	Rate structure		21	36,000	SFH	$0	$752,760	$752,760	1300	$579
	5h	Wastewater injection					$28,500,000	$600,000	$2,737,760		
	6	Industrial conservation					$1,000,000	$100,000	$175,009	1500	$117
Land Use	7	Riparian vegetation management	250	10	22,000	acres	$5,500,000	$220,000	$632,550	10,000	$63
	8	Watershed management	55	2	462,000	acres	$25,410,000	$924,000	$2,829,982	10,000	$283
	9	Dewater McMillan Delta	1000	10	12,000	acres	$12,000,000	$120,000	$1,020,110	12,000	$85
Other Projects	10	Desalinization	800	153	22,000	AFY	$17,600,000	$3,366,000	$4,686,161	22,000	$213
	11	Construction of interstate pipeline					$1,000,000,000	$1,000,000	$76,009,139	300,000	$253
	12	Cloud seeding		0.05	13,600,000	acres	$1,500,000	$680,000	$792,514	34,680	$23
	13	Construct large reservoirs			250,000	AF	$50,000,000	$100,000	$3,850,457	2500	$1,540
	14	Aquifer storage and recovery					$28,500,000	$600,000	$2,737,760	2500	$1,095
	15	Reduce area of reservoirs	55,000		300	miles	$16,500,000	$100,000	$1,337,651	1800	$743
	16	Reduce conveyance losses									NA
	17	Import water from Salt Basin					129,227,000	4,500,000		20,000	$710

Table 67. Feasibility Analysis of Water-Supply Alternatives

Sector	Alt. No.	Action	Technical	Legal	Political	Result
Administrative	0	No change				
	1a	Enhanced water market	Yes	Yes	Yes	Yes
	1b	Enhanced administrative enforcement	Yes	Yes	Yes	Yes
	2	Managed aquifer operations	Yes	Yes	Yes	Yes
Agriculture	3	Agricultural conservation				
	3a	Laser leveling	Yes	Yes	Yes	Yes
	3b	LEPA/sprinkler/drip	Yes	Yes	Yes	Yes
	3c	Ditch lining/pipes	Yes	Yes	Yes	Yes
	4	Moving reservoir storage upstream	No	No	Yes	No
M&I	5	Municipal conservation				
	5a	Time of day/day of use	Yes	Yes	Yes	Yes
	5b	Low flow fixtures/audits/leaks	Yes	Yes	Yes	Yes
	5c	Cover reservoirs	No	No	No	No
	5d	Wastewater reuse	No	Yes	Yes	No
	5e	Xeriscaping	Yes	Yes	Yes	Yes
	5f	Rationing	Yes	Yes	No	No
	5g	Rate structure	Yes	Yes	Yes	Yes
	5h	Wastewater injection	No	Yes	No	No
	6	Industrial conservation	Yes	Yes	Yes	Yes
Land Use	7	Riparian vegetation management	Yes	Yes	Yes	Yes
	8	Watershed management	Yes	Yes	Yes	Yes
	9	Dewater McMillan Delta	Yes	Yes	Yes	Yes
Other Projects	10	Desalinization	Yes	Yes	Yes	Yes
	11	Construction of interstate pipeline	Yes	Yes	No	No
	12	Cloud seeding	No	Yes	Yes	No
	13	Construct large reservoirs	No	No	No	No
	14	Aquifer storage and recovery	Yes	Yes	Yes	Yes
	15	Reduce area of reservoirs	No	Yes	Yes	No
	16	Reduce conveyance losses	Yes	No	No	No
	17	Import water from Salt Basin	Yes	Yes	Yes	Yes

Table 68. Impact Analysis of Water-Supply Alternatives

Sector	Alt. No.	Action	Compact	Envir.	Soc/Econ	Total
Administrative	0	No change				
	1a	Enhanced water market	1	1	1	3
	1b	Enhanced administrative enforcement	1	1	3	5
	2	Managed aquifer operations	1	1	1	3
Agriculture	3	Agricultural conservation				
	3a	Laser leveling	1	2	1	4
	3b	LEPA/sprinkler/drip	1	1	1	3
	3c	Ditch lining/pipes	1	1	1	3
	4	Moving reservoir storage upstream	1	4	1	6
M&I	5	Municipal conservation				
	5a	Time of day/day of use	1	1	4	6
	5b	Low flow fixtures/audits/leaks	1	1	3	5
	5c	Cover reservoirs	1	5	3	9
	5d	Wastewater reuse	1	3	1	5
	5e	Xeriscaping	1	1	4	6
	5f	Rationing	1	1	5	7
	5g	Rate structure	1	1	4	6
	5h	Wastewater injection	1	3	1	5
	6	Industrial conservation	1	1	1	3
Land Use	7	Riparian vegetation management	2	3	1	6
	8	Watershed management	2	4	1	7
	9	Dewater McMillan Delta	2	2	1	5
Other Projects	10	Desalinization	2	2	1	5
	11	Construction of interstate pipeline	1	4	1	6
	12	Cloud seeding	3	2	1	6
	13	Construct large reservoirs	3	3	1	7
	14	Aquifer storage and recovery	1	2	1	4
	15	Reduce area of reservoirs	1	5	1	7
	16	Reduce conveyance losses	2	5	1	8
	17	Import water from Salt Basin	1	1	1	3

Table 69. Summary of Yield, Cost, Feasibility and Impacts for Water-Supply Alternatives

Sector	Alt. No.	Action	Yield	Cost Per AF	Feasibility	Impacts
Adminis-trative	0	No change	-	-	-	
	1a	Enhanced water market	12,000	$28	Yes	3
	1b	Enhanced administrative enforcement	6250	16	Yes	5
	2	Managed aquifer operations	10,000	$50	Yes	3
Agri-culture	3	Agricultural conservation				
	3a	Laser leveling	2000	$739	Yes	4
	3b	LEPA/sprinkler/drip	4700	$607	Yes	3
	3c	Ditch lining/pipes	1000	$1,633	Yes	3
	4	Moving reservoir storage upstream	3500	$75	No	6
M&I	5	Municipal conservation				
	5a	Time of day/day of use	800	$250	Yes	6
	5b	Low flow fixtures/audits/leaks	860	$977	Yes	5
	5c	Cover reservoirs	5000	$581	No	9
	5d	Wastewater reuse	0		No	5
	5e	Xeriscaping	5500	$245	Yes	7
	5f	Rationing	3300	$300	No	6
	5g	Rate structure	1300	$579	Yes	5
	5h	Wastewater injection	0		No	6
	6	Industrial conservation	1500	$117	Yes	3
Land Use	7	Riparian vegetation management	10,000	$63	Yes	6
	8	Watershed management	10,000	$283	Yes	7
	9	Dewater McMillan Delta	12,000	$85	Yes	5
Other Projects	10	Desalinization	22,000	$213	Yes	5
	11	Construction of interstate pipeline	300,000	$253	No	6
	12	Cloud seeding	34,680	$23	No	6
	13	Construct large reservoirs	2500	$1,540	No	7
	14	Aquifer storage and recovery	2500	$1,095	Yes	4
	15	Reduce area of reservoirs	1800	$743	No	7
	16	Reduce conveyance losses	0	NA	No	8
	17	Import water from Salt Basin	20,000	$710	Yes	3

SECTION XI: EVALUATION OF ALTERNATIVES AND IMPLEMENTATION

Evaluation

The evaluation of the alternatives in this plan is a public-policy process. This is so because there is no disinterested "scientific" measure on the desirability of an alternative. A positive impact of an alternative for one individual may be a negative impact for another. However, the evaluation process can be consistent and can result in an acceptable solution to a majority of individuals involved with the decision. This section reviews a normative procedure to evaluate and decide on an alternative that satisfies the goals of the Lower Pecos Valley Water Users. Each alternative is categorized as being feasible and having various impacts.

The Regional Water Planning Handbook[143] outlines three types of feasibility: technical, political, and financial. Legal feasibility is added. Feasibility is a yes/no characteristic. Financial feasibility depends on cost per AF.

The Regional Water Planning Handbook outlines five impacts: social, cultural, physical, hydrological and environmental.

Each alternative results in a mix of different types of impacts. To evaluate the alternatives the Lower Pecos Valley Water Users have ranked the desirability of projects according to their impacts (Table 68). The rankings indicate in general terms the preference of the PVWUO. Cost and yield are assessed with environmental, social/economic and compact impacts.

Overall Assessment and Summary

The yield, cost per acre-foot, feasibility, and impact assessment of all the alternatives are tabulated in Table 69 of Section X. The list is reduced to alternatives that are technically, politically and legally feasible in Table 70. Economic or financial feasibility is indicated for those alternatives with a cost per acre foot less than $100 indicated by the heavy demarcation line. The threshold of $100 is the value of water adopted in the Socioeconomic Overview (Section IV Background Information) as representing the agricultural value of water for all users in the basin.

[143] New Mexico Interstate Stream Commission, 1994, Regional Water Planning Handbook.

Table 70. Sorted Feasible Water-Supply Alternatives

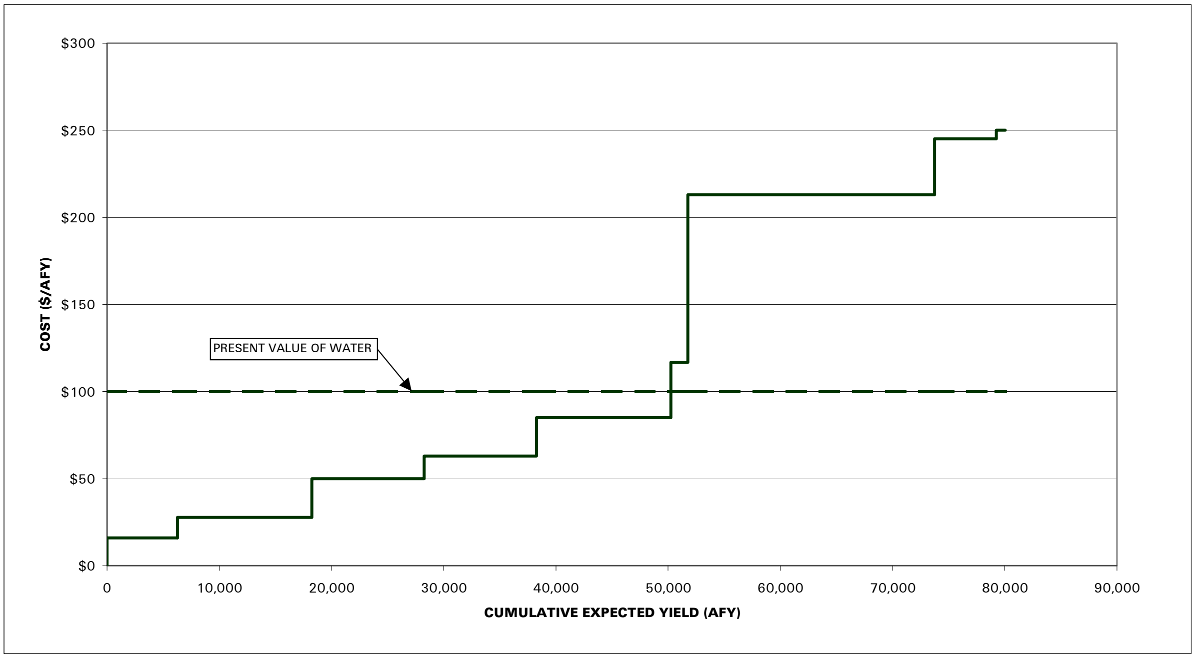
Alt. No.	Alternative/Action	Yield	Cost per AF	Feasibility	Impact Rating
1b	Enhanced administrative enforcement	6250[1]	$16	Yes	5
1a	Enhanced water market	12,000[1]	$28	Yes	8
2	Managed aquifer operations	10,000	$50	Yes	9
7	Riparian vegetation management	10,000	$63	Yes	6
9	Dewater McMillan Delta	12,000	$85	Yes	7
6	Industrial conservation	1500	$117	Yes	6
10	Desalinization	22,000	$213	Yes	6
5e	Xeriscaping	5500	$245	Yes	8
5a	Time of day/day of use	800	$250	Yes	9
8	Watershed management	10,000	$283	Yes	9
5g	Rate structure	1300	$579	Yes	5
3b	LEPA/sprinkler/drip	4700	$607	Yes	4
17	Import water from Salt Basin	20,000	$710	Yes	3
3a	Laser leveling	2000	$739	Yes	5
5b	Low flow fixtures/audits/leaks	860	$977	Yes	9
14	Aquifer storage and recovery	2500	$1095	Yes	6
3c	Ditch lining/pipes	1000	$1633	Yes	6

Note: Alternatives above the bold line are preferred for yield, cost, feasibility and impacts.
[1] Alternatives 1 and 1b do not increase physical yield but exchange equivalent demand.

Four alternatives – enhanced water market (including strengthened administrative enforcement), managed aquifer operations and riparian vegetation management, specifically dewatering McMillan Delta – are economically and otherwise feasible. The McMillan Delta dewatering project is considered a specific aspect of riparian vegetation management for evaluation purposes with the distinction that it includes dewatering and vegetation control. The amount of water produced by the four combined could exceed projected growth in demand. These alternatives are the leading candidates for implementation. Other alternatives may be acted on by parties who find them desirable.

Figure 32 illustrates the alternatives as a conservation-supply curve (the curve includes both water supply and demand reduction alternatives). The horizontal axis indicates the cumulative yield of water as costs of alternatives rise. The vertical axis presents the cost per acre-foot of additional water among the alternatives. Also indicated is the value of water ($100 per AF). From this graph, the economically justified alternatives would produce a total yield for new consumptive uses of 34,000 AF at reasonable cost and acceptable non-hydrologic effects.

Figure 32. Lower Pecos Valley Supply and Conservation Curve



Implementation Schedule

An important feature of the Regional Water Plan is the implementation schedule. Three activities are selected for implementation. The following steps are necessary for implementation:

1. Establish a program to develop administrative criteria for expediting water-right transfers in the Lower Pecos Valley. Appoint a committee of OSE Water Right Division personnel, watermasters, attorneys, PVWUO officials, hydrologists and water-right owners to report on procedures within one year. Develop and adopt in the administrative criteria a comprehensive hydrologic model of interrelated surface water and groundwater responses to transfers. Criteria are to include clear standards of evaluation of external effects of transfer applications, such that the parties can understand that hydrologic effects of a proposed water-use project are approvable by explicit standards.

2. Commission federal and state agencies, including the BOR and U.S. Fish and Wildlife Service, with CID and PVWUO to design a dewatering, water conveyance and habitat improvement plan for McMillan Delta under the existing authority of CID and BOR programs.

3. Develop a program of authorities and facilities for managed aquifer operations to respond to shortages in Pecos River flows for priority uses in New Mexico and Compact deliveries to Texas.

4. Seek state legislative approval and funding for selected watershed management pilot field tests in potential high-recharge areas of the basin. Design a test protocol. The objective is to check the uncertain potential to yield water as runoff or recharge. The schedule should allow adequate time to test the alternative, obtain funding and implement the program in an orderly fashion. Testing of the alternative on a limited scale is important because the consequences of any alternative are often poorly estimated beforehand.

The following is a suggested implementation schedule.

First Year:

1. Establish a program to develop administrative criteria for expediting water-right transfers in the Lower Pecos Valley.

2. Encourage agencies to work with the CID to design a McMillan Delta program. Design the pilot program as a limited scope implementation of the alternative. The pilot project would be initiated on a limited number of acres, for example 500 acres. This would have an approximate cost of $500,000 that would be obtained through legislation.

3. Develop a hydrologic model of interrelated surface water and groundwater responses to managed aquifer operations.

4. Seek legislative approval and funding for the pilot watershed management field tests and design a test protocol.

Second Year:

1. Conduct and monitor the baseline McMillan Delta program.

2. Managed aquifer operations would require legal review for compact compliance, design of option contracts to use farm wells to deliver water to the river, and initial sign up. Evaluate need for additional dedicated wellfield. A watermaster would monitor operations.

3. Conduct the pilot watershed management field tests.

Third Year:

1. Evaluate baseline McMillan measures.

2. Initiate aquifer management operations.

3. Continue watershed study.

Fourth Year:

1. Organize the necessary agencies and funding to implement the McMillan Delta plan.

2. Continue or revise monitoring measures for aquifer management.

3. Completely evaluate the pilot watershed program for feasibility and impacts. If positive, develop legislative and other funding sources.

Fifth Year:

Implement all above mentioned alternatives if supported by interested parties, plus watershed program if feasible. Capital projects, design, construction and operation must be phased in.

Sixth Year:

Submit legislative-funding proposals – revise annually as part of continual program.

SECTION XII: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The Lower Pecos Valley water supply has been 706,000 AFY since 1947 with an expected ± 40 percent variation in wet and dry years. Surface diversions and well withdrawals vary ± 15 percent of average in response to the supply variation. About 35 percent of the basin water supply (excluding water supplied by aquifer operations) is lost in unmanaged evapotranspiration from shallow water in river alluvium and about 15 percent is committed to Texas. The remaining 50 percent of the basin yield is consumed beneficially in the Lower Pecos Valley.

2. The expected median basin yield is 660,000 AFY. The wettest year in five would be expected to yield 765,900 AF, and the driest year in five would be expected to yield 545,000 AF, based on records since 1905.

3. The Lower Pecos Valley water-diversion demand is projected to grow in 40 years to be 25,400 AFY above a baseline of about 693,000 AFY in year 2000. The basin yield allocated to beneficial use in the basin must increase or be shifted about 12,000 AFY to accommodate the growth.

4. The Lower Pecos Valley region must undertake to enhance the administrative system of water-rights transfers. Transfers are expected to satisfy a large part of the growth in demand by retiring equivalent levels of former demand. Retirement of demand requires that the value of water in the former use be compensated by the higher value derived from the new use and that the transaction be free of administrative barriers.

5. The region must operate aquifer storage when necessary to serve demand at a relatively constant level during temporary periods of short supply. The region must recharge and restore the aquifer volume during periods of available supply.

6. A project to dewater and to convey Pecos River water efficiently through the low topography of the McMillan Delta has the prospect of producing 12,500 AFY for supplying up to half of the growth of demand, while enhancing the environment of the Delta.

7. Other riparian management, watershed management and existing conservation programs should be continually studied in an effort to improve the water supply of the region.

8. The operation and provisions of the Pecos River Compact are not necessarily being operated in the best interests of New Mexico and additional adjustments may be necessary.

Recommendations

1. Establish a program to develop administrative criteria for expediting water-right transfers in the Lower Pecos Valley.

2. Develop a program to produce water to the Pecos River from managed wellfield operations during shortage in New Mexico for Compact delivery to Texas.

3. Encourage the federal and state agencies, including the U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service, with Carlsbad Irrigation District and Pecos Valley Water Users Organization to design a dewatering conveyance and habitat improvement plan for McMillan Delta under the existing authority of the Carlsbad Irrigation District and U.S. Bureau of Reclamation programs.

4. Seek state legislative approval and funding for selected vegetative management pilot field tests in potential high-recharge areas of the basin. Seek legislative approval and funding for a study of the Lower Pecos River Watershed in the planning area to determine what changes have occurred in the recharge of the groundwater basins and subsequent discharge and direct flow to the stream system due to development and vegetative changes in the watershed, changes in patterns of rainfall and snowfall and occurrence of floodflows and other factors which may have caused losses to recharge of groundwater aquifers.

5. Seek approval and funding for an independent study to be made of the Pecos River Compact and operating manual to determine what changes could or should be made to benefit use of water in New Mexico. Such an independent study could be of assistance to current Compact Administrators.

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