Jemez y Sangre Regional Water Plan

Volume 1: Report

Prepared for:

Jemez y Sangre Water Planning Council

March 2003

Prepared by:

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Acronyms and Abbreviations

afy	acre-feet per year
ASR	aquifer storage and recovery
ft msl	feet above mean sea level
BBER	Bureau of Business and Economic Research
BMP	best management practice
$CaCO_3$	calcium carbonate
CDM	Camp Dresser & McKee Inc.
cfs	cubic feet per second
CIR	consumptive irrigation requirement
CPI	Consulting Professionals, Inc.
CMA	critical management area
CWA	Clean Water Act
DBS&A	Daniel B. Stephens & Associates, Inc.
DEM	digital elevation model
DO	dissolved oxygen
EC	electrical conductivity
EDU	El Dorado Utilities
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ET	evapotranspiration

ft^2/d	square feet per day
FWS	free water surface
gpcd	gallons per capita per day
gpm	gallons per minute
in/yr	inches per year
ISC	Interstate Stream Commission
JySWPC	Jemez y Sangre Water Planning Council
LANL	Los Alamos National Laboratory
MCL	maximum contaminant level
mgd	million gallons per day
mg/L	milligrams per liter
MODFLOW	modular three-dimensional finite-difference ground-water flow model
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
NEPA	National Environmental Policy Act
NH_3	un-ionized ammonia
NH_4^+	ammonium ion
NMED	New Mexico Environment Department
NMDWB	New Mexico Drinking Water Bureau
NMSA	New Mexico Statutes Annotated
NMWQCC	New Mexico Water Quality Control Commission
NOAA	National Oceanic an Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System

OSE	Office of the State Engineer (New Mexico)
PCE	tetracholoroethene (derived from percholorethylene)
PDSI	Palmer Drought Severity Index
PDO	Pacific Decadal Oscillation
PET	potential evapotranspiration
PVID	Pojoaque Valley Irrigation District
SCID	Santa Cruz Irrigation District
SDWR	Secondary Drinking Water Regulations
SFMWB	Santa Fe Municipal Water Board
SJC	San Juan-Chama
TDS	total dissolved solids
TMDL	total maximum daily load
TSS	total suspended solids
UNM	University of New Mexico
URGWOM	Upper Rio Grande Water Operations Model
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WATERS	Water Administration Technical Engineering Resource System (OSE database)
WCC	Woodward-Clyde Consultants
WWTP	wastewater treatment plant

Glossary

Acre-foot of water	The amount of water that would cover an acre to a depth of one foot or about 325,829 gallons.
Adjudication	A legal proceeding in which a court determines the validity, priority, and amount of a water right.
Aquifer	A geologic formation that is saturated with water and sufficiently permeable to yield a usable quantity of water to wells or springs.
Anion	A negatively charged ion.
Beneficial use	New Mexico's Constitution recognizes beneficial use as the basis, the measure, and the limit of the right to use water (N.M. Const. art. XVI, §3). Beneficial use means application of water to a lawful purpose that is useful to the appropriator and at the same time is a use consistent with the general public interest. Storage of water in a reservoir for future use is also recognized as a beneficial use, despite the fact that "stored water" is necessarily not being diverted.
Black water	Domestic wastewater that has come in contact with human or animal waste and may contain fecal coliforms or other pathogens; typically water from toilets and kitchen sinks.

Brownfields	Areas of land, typically former locations of industrial and commercial activity, that are abandoned, vacant, or underutilized; where contamination is real or perceived, and where the possible existence of contamination is a deterrent for redevelopment.
Appropriation	The right to use water for a beneficial use.
Cation	A positively charged ion.
Consumptive use	Water that is evaporated or transpired and is lost from the water system.
Consumptive irrigation requirement	The quantity of irrigation water expressed as a depth or volume, exclusive of effective precipitation, that is consumptively used by plants or is evaporated from the soil surface in a specific period of time. Does not include incidental depletions or water requirements for leaching, frost protection, wind erosion protection, or plant cooling (these requirements are accounted for in the on-farm efficiency values. The CIR may be determined by subtracting effective rainfall from consumptive use (Wilson and Lucero, 1997).
Declared groundwater basin	An area with reasonably ascertainable boundaries that has been designated by the State Engineer to prevent impairment of existing water rights. Once a basin has been declared, applicants must apply to the State Engineer to appropriate groundwater from the basin.
Depletion	The net reduction in surface-water flow between two specified points in the flow system.

Dissolved oxygen	A percentage that indicates the degree of water oxygenation, which reflects the general health of a watercourse with regard to supporting aquatic organisms. The larger the DO percent, the more likely that a healthy fishery can be supported.
Diversion	The amount of water removed from a stream or aquifer for human use (e.g., irrigation or drinking water).
Domestic wells	Domestic water rights are also known as “72-12-1" water rights after the section of the water code that requires the State Engineer to approve all applications for a well to supply a household for domestic uses. A regulation adopted by the State Engineer allows domestic well users to use up to 3 acre-feet per year.
Evapotranspiration	The combined processes of simple evaporation and plant transpiration by which water is converted to vapor and lost to the system.
Forfeiture	If a water right is not used for a four-year period and for one additional year after notification, the right is forfeited. Water rights not used prior to 1965 do not require a one-year period of non-use after notification.
Greywater	Domestic wastewater that has not come in contact with human or animal wastes and does not contain pathogens; typically water from showers and washing machines.

Hydraulic conductivity	A rate of proportionality describing the rate at which water can move through a permeable medium. The density and kinematic viscosity of the water must be considered in determining hydraulic conductivity (Fetter, 1988, p. 571).
Hydrology	The science of the occurrence, circulation, distribution, and properties of the waters of the earth and their reaction with the environment.
Impairment	The diminishing quantity or quality of the water supply of an existing user by a new use or change in an existing use.
Instream Flow	Water in a stream or river for fish, wildlife, recreation, watershed or other purposes.
Interstate Compact	An agreement between two or more states that has been approved by the U.S. Congress and allocates the water in the rivers and streams flowing through those states.
Ion	An isolated electron, positron, atom, or molecule that has lost or gained one or more electrons and thus acquired a net electric charge.
Mining Water	The practice of withdrawing groundwater resources at a rate greater than replenishment of the system by recharge.
Native Water	Water that naturally originates in the stream or river. San Juan/Chama Project water, which is pumped from the Colorado River basin into the Chama River basin, is not native water to the Rio Grande.
Outflow from sub-basin	Groundwater discharge across sub-basin boundaries.

Phreatophyte	A plant with a deep root system that obtains water from the groundwater or from the capillary fringe above the water table.
Porosity	The ratio of void space in a rock to the bulk volume of that rock, expressed as a percent.
Prior appropriation	The doctrine of prior appropriation has these essential principles: (1) the first user (appropriator) in time has the right to take and use water; and (2) that right continues as a priority use against subsequent users as long as the appropriator puts the water to beneficial use.
Priority date	The date indicating when the water right was first exercised or applied for. The priority date determines the seniority of the water right. Senior water rights holders are entitled to receive their full water right before junior water rights holders receive any water.
Recharge	Recharge is water that is added to groundwater storage from infiltration of rain, snow, or stream flow.
Return flow	Return flow generally refers to water that is returned to the hydrologic system. For example, water that flows off an irrigated field and back into the stream or ditch is considered return flow.
Riparian	Refers to the habitat and lifeforms along streams, lakes and wetlands.

San Juan/Chama Project Water	San Juan/Chama Project water refers to water transported from the Colorado River basin into the Rio Grande basin for use by several cities, counties, and tribes through leases or repayment contracts with the Bureau of Reclamation to use San Juan/Chama water. The San Juan-Chama water is a portion of New Mexico's allocation of the Colorado River.
Senior water right	A water right with a priority date older than a junior water right.
Specific yield	The quantity of water that a unit volume of aquifer will yield by gravity after it is saturated, expressed as either a ratio or a percentage of the aquifer volume; specific yield is a measure of the water available to wells.
State Engineer	The New Mexico statutes give authority over water to the State Engineer, who is appointed by the Governor.
Stream loss or gain	The amount of water that either flows into a stream from springs or seeps from an aquifer (gain to stream), or that seeps out of the stream and recharges the aquifer (loss from stream).
Surface-water inflow	The amount of water that annually enters an area as surface runoff.
Total maximum daily load	Described as a watershed or basin-wide budget for pollutant influx to a watercourse.

Transfer	The State Engineer must approve applications for the new use of water or the sale, change of use or location, or lease of a water right; this procedure is generally referred to as a water rights transfer.
Transmissivity	The rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media (Fetter, 1988, p. 578).
Water budget	A systematic summary of the terms (inflow, outflow, and storage) of the storage equation as it is applied to the computation of soil-moisture changes, groundwater changes, etc.; a water budget provides an evaluation of the hydrologic balance of an area.
Water hardness	Traditionally reported in terms of an equivalent concentration of calcium carbonate ($CaCO_3$), with 0-60 mg/L of $CaCO_3$ termed soft, 61-120 mg/L of $CaCO_3$ termed moderately hard, 121-180 mg/L of $CaCO_3$ termed hard, and more than 180 mg/L of $CaCO_3$ termed very hard.

Acknowledgements

The Jemez y Sangre Water Planning Council would like to thank the New Mexico Interstate Stream Commission, Bureau of Reclamation, City of Santa Fe, and Los Alamos National Laboratory for financial support provided for the preparation of this regional water plan. Without the generosity of member organizations, which allowed staff to contribute countless hours attending subcommittee and Council meetings and reviewing and preparing materials for public meetings, the plan would not be what it is today.

The Council would also like to thank Mike Hamman, director of the City of Santa Fe Water Division, who conceived of and initiated the planning process. The first Chair of the Council, Estevan Lopez, of Santa Fe County, helped bring member organizations together and work through the initial stages of water planning. Bob Vocke of Los Alamos National Laboratory played an active role as Chair of the Council in guiding the planning effort, assisted by Elmer Salazar who helped to keep Council meetings on track and timely. Los Alamos National Laboratory also provided technical assistance early in the planning effort to compile water supply and quality data into a database.

Subcommittee chairs who kept the process on track and resolved differing opinions include Moises Gonzales, Chair of the Population Subcommittee; Conci Bokum, Chair of the Public Welfare/Public Involvement Subcommittee; Amy Lewis, Chair of the Technical Subcommittee; Peter Chestnut, Chair of the Legal Subcommittee; Ernest Mirabal, Chair of the Pueblo Subcommittee; and Paul Aamodt, Chair of the Alternatives Subcommittee.

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Executive Summary

The population in the Jemez y Sangre Water Planning Region, which includes Española, Los Alamos, Santa Fe and surrounding areas, has reached the point where the demand for water may exceed available supply during years of average precipitation. During drought years the demand does exceed the supply, particularly for systems that rely on surface water. The cumulative pressure of domestic wells and high-capacity public wells is causing water tables throughout the region to decline. Meanwhile, expectations for obtaining municipal water supplies from river diversions have been compromised by drought. Santa Fe, the largest city and primary job center of the region, has imposed increasingly strict water conservation measures on its citizens. Concurrently, population growth in other parts of the southwestern United States has increased the pressure on limited supplies and raised concerns that water in the Jemez y Sangre region could be exported unless the region's future supply and demand is defined through regional water planning.

These issues helped motivate stakeholders to participate in regional water planning for the Jemez y Sangre region. The droughts that occurred in 2000 and 2002, during the Jemez y Sangre planning process, provided a new sense of urgency in the effort to better understand the balance between supply and demand for water. These droughts also helped to highlight the importance of answering questions such as: How can the region find or save enough water to meet the expected population growth in the next century? How much can conservation or growth management contribute toward reducing demand? How would the agricultural community be impacted if water is transferred to municipal use? Addressing these questions is the focus of the Jemez y Sangre Regional Water Plan.

The Purpose of Regional Water Planning

Regional water planning in New Mexico began with a 1987 federal court ruling that New Mexico could not prohibit the out-of-state transfer of its groundwater unless it actively and effectively planned for its water future. With legislative authority, the New Mexico Interstate Stream Commission established 16 planning regions and charged each with writing a regional water plan.

The Jemez y Sangre Water Planning Region is one of the most diverse in New Mexico, covering all or parts of 3 counties, 2 incorporated municipalities, all or part of 8 Pueblos, a multitude of historic and traditional villages, and some of the fastest growing areas of the state. The Jemez y Sangre Water Planning Council (JySWPC), formed in 1998, consists of representatives from 24 diverse entities, including all the local governments, several state and federal government agencies, water and soil conservation districts, acéquia associations, and interested environmental, business, and technical groups. Representatives of the Pueblos within the region participate as observers.

The central waterbody in the region is the Rio Grande, which enters the region at Embudo, collects runoff from the Sangre de Cristo and Jemez mountain ranges, and exits the region at Cochiti Lake. The Rio Chama enters the region from the northwest, bringing with it central New Mexico's share of water from the San Juan-Chama Project, which captures part of New Mexico's share of the Colorado River. Approximately midway between Embudo and Cochiti Lake is the Otowi Gage. This gage represents a boundary that helps establish New Mexico's Rio Grande water delivery obligations to Texas, as defined by the Rio Grande Compact.

Population growth amplifies the demand for water. The City of Santa Fe and areas of Santa Fe County near the city are among the fastest growing areas in the state. These areas are expected to experience most of the region's growth during the planning period, which extends to 2060.

The purpose of the Jemez y Sangre Regional Water Plan is to assess the available supply of clean, usable surface water and groundwater, to determine the present and future demand for water, and to identify methods for meeting the projected demand through conservation, management, and/or acquisition of water or water rights. The plan has been deliberated over, reviewed, and completed through a process of public participation and technical evaluation. After submission to and acceptance by the Interstate Stream Commission, it will be distributed to public and private water managers so that they can consider and implement the various alternatives as appropriate.

Public Welfare: The Guiding Philosophy

In addition to considering technical issues, the JySWPC was responsible for understanding how water planning relates to the public welfare of the region. Through its membership and a series of public meetings, the Council members gathered input about what constitutes public welfare in the region and ultimately drafted a public welfare statement to represent the philosophy that guides the plan. This statement, the full text of which is provided on the following page, celebrates the rural and wildlands character of north-central New Mexico. It declares that sustainable use of water is a desired goal, cites economic sustainability as an important objective, and calls for preservation of water quality. It insists on water planning in the context of respect for water rights and property rights, especially the senior rights of the Pueblos and acequias. It calls for open, collaborative decision-making in the process.

Technical Approach: Determining Available Supply and Projected Demand

The most critical aspect of water planning is to understand the current availability and present uses of water, and how usage might change over time in conjunction with increased population and economic activity. This plan details the amounts of water used by various sectors, and quantifies water use by diversion type, such as surface water, groundwater, and domestic wells.

The region was divided into ten sub-basins for the purpose of evaluating the hydrogeology and population data. Through the consolidation of technical and demographic data, the Jemez y Sangre WPC developed water budgets for each of the sub-basins in the region, summarized current and projected uses, and compared projected demands to the amount of water available. Finally, to summarize possible alternatives for addressing the projected supply/demand gap, the sub-basins were grouped into five subregions, as shown in Figure ES-1:

- Northern Subregion (Velarde, Santa Clara, and Santa Cruz Sub-Basins)
- Aamodt Subregion (Tesuque and Pojoaque-Nambe Sub-Basins)
- Santa Fe Subregion (Santa Fe, Caja del Rio, and North Galisteo Sub-Basins)
- Los Alamos Sub-Basin
- South Galisteo Sub-Basin

PUBLIC WELFARE STATEMENT FOR JEMEZ Y SANGRE REGION

Water is the element that interconnects all people and their environment in the Jemez y Sangre region, and the region to the larger environment that is the earth. Every person living in the region expects enough water for basic needs, and every person has the responsibility to protect water resources and use their share wisely. Using the best possible information, water planning and decision making should balance diverse needs and reflect the values of the region.

Rural and Wildlands Character

Residents of the Jemez y Sangre region place great value and importance on the preservation of the rural character of the region. Urban and rural residents alike appreciate and wish to maintain the historic, agriculture-based communities, rural vistas, wildlife habitat and attributes of natural landscapes including rivers, streams and trees.

Water Sustainability

Residents understand that the history of the region reflects water scarcity and cycles of drought. It is a high priority of residents of the region to serve current and future human needs without long-term depletion of the available water supply, while maintaining acceptable water quality and healthy interdependent ecological systems. Sustainability requires a combination of efforts, including encouraging conservation and efficiency by all sectors at every scale, discouraging activities that deplete or degrade the water supply, planning for population growth and land use, seeking new water sources that do not impair other regional values, and improving the use of existing water supplies.

Economic Sustainability

Each sub-region has unique economic needs and conditions that depend on the availability of water. It is important to have quality jobs and a healthy economy in order to maintain a good quality of life in the long term.

Water Quality

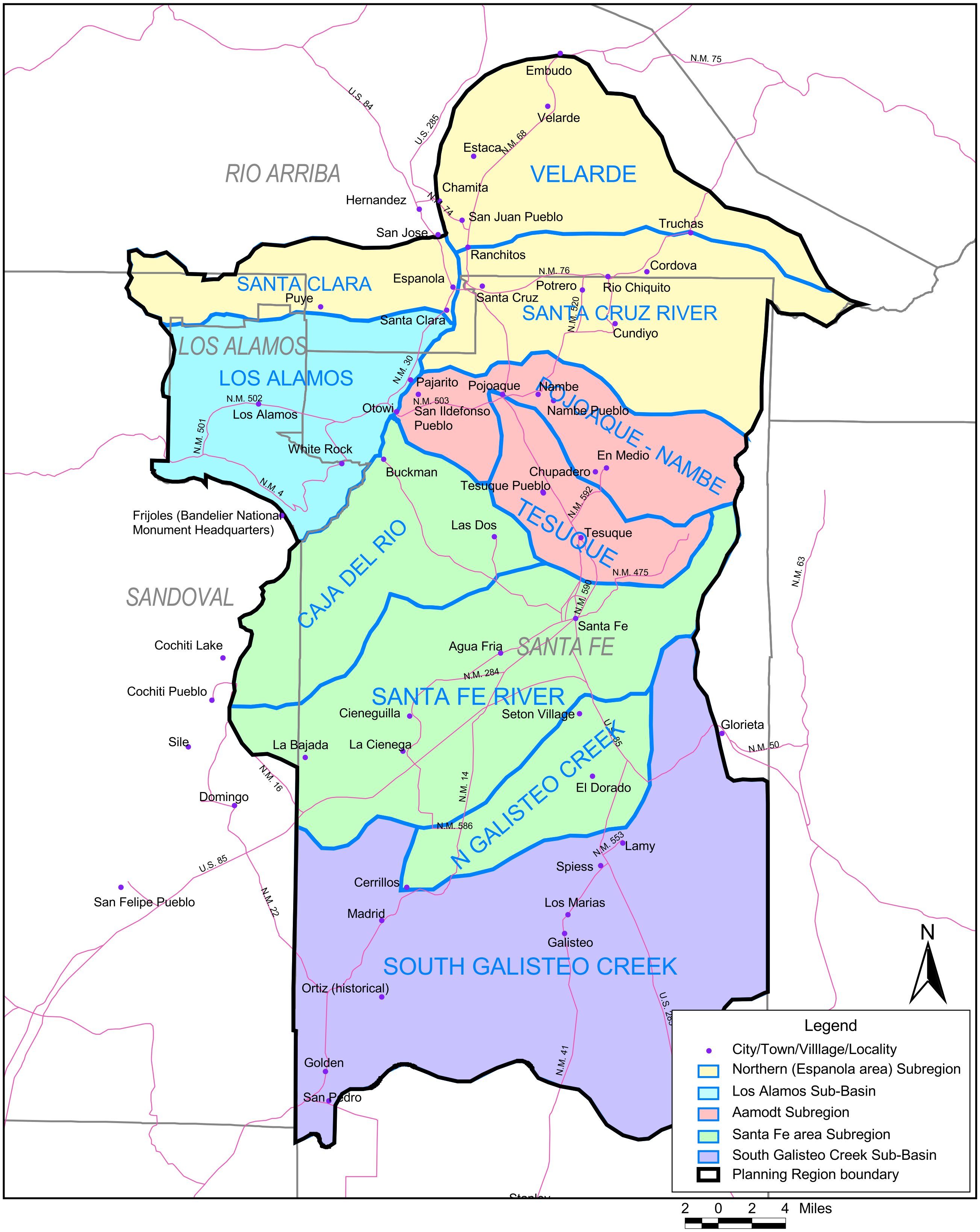
Water quality is a significant consideration in the region's water supply. In many sub-basins, the available groundwater has been compromised by contamination, either human caused or natural. Wastewater treatment and reuse of treated water should be expanded throughout the region. The available water should be protected from potential contamination from the impacts of human activities or natural events.

Rights and Responsibilities

Water planning must be carried out in a context of respect for water rights and property rights. Like all rights, the right to use water, especially in an arid region, is married to the responsibility to use water efficiently and wisely. The Jemez y Sangre region respects the senior water rights of the pueblos in the region and recognizes pueblos' tribal sovereignty.

Decision Making

In this demographically and geographically diverse region, it is necessary for all governmental and private entities to work together to achieve the goal of a balanced and sustainable water future. Fostering healthy, vibrant communities requires a commitment to open, inclusive dialogue and decision making.



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JEMEZ Y SANGRE REGIONAL WATER PLAN

Jemez y Sangre Subregions

ES-1

Water planning and management is affected by numerous municipal, state, tribal, and federal laws that protect water quality and control the transfer, use, and quantity of diversions. Accordingly, the legal issues that affect the management of water resources in the region were considered in the evaluation of supply, demand, and alternatives for meeting that demand.

Measuring Supply: Water Resources and How They Are Used

A major task in the development of the Jemez y Sangre Regional Water Plan was the quantification of water resources in the region: where water comes from, how it travels through streams and rivers, and how it percolates into the ground. To develop these estimates, the JySWPC contracted with Duke Engineering & Services to conduct a water supply study, the findings of which were incorporated into the regional water plan.

Surface Water

The region's surface supply comes from two main sources: (1) the Rio Grande and Rio Chama, which flow into the region from the north and (2) tributary streams derived from melting snow from the higher peaks that flank the region on the east and west. Most regional surface water is used for agriculture, although the City of Santa Fe receives about 40 percent of its water supply from snowmelt and other precipitation that is captured in dams in the Santa Fe River watershed above the City. A significant amount of the surface water in the region evaporates directly into the atmosphere or indirectly through transpiration from vegetation.

Two efforts are underway, one led by the City of Santa Fe and Santa Fe County, and the other by the City of Española, to construct diversion structures on the Rio Grande. These structures would allow the lead entities to directly capture their respective shares of water from the San Juan-Chama Project. Other entities in the region with rights to San Juan-Chama Project water are Los Alamos County, the Pojoaque Valley Irrigation District, and San Juan Pueblo.

Groundwater

Groundwater provides most of the water used by municipalities, unincorporated subdivisions, private homes, and many businesses in the region, and also provides a small amount of the water used for irrigated agriculture. The City of Santa Fe, Española, and Los Alamos County all operate well fields, as do smaller or unincorporated communities such as Eldorado, south of Santa Fe. Significant pumping has caused water tables to decline in some aquifers. In some cases this has resulted in dry wells, dry springs, and other supply problems.

Groundwater occurs throughout the region in a number of distinct geologic formations. Some formations are thick aquifers with substantial storage, while others are thin and yield only small amounts of water because of specific geologic conditions.

Water Usage in the Region

In the Jemez y Sangre Water Planning Region, 70 percent of the water is used for agriculture and 30 percent is used for municipal, domestic, and industrial purposes. Surface water provides 98.8 percent of the supply for irrigation diversions, with the remainder coming from groundwater. Groundwater provides about 80 percent of the municipal, domestic, and industrial uses; the remaining 20 percent is diverted from surface water (Santa Fe River for the City of Santa Fe). Domestic wells produce about 35 percent of the groundwater diversion for municipal and domestic uses.

Most irrigation occurs in the Velarde, Santa Cruz, and Pojoaque-Nambe Sub-Basins, with lesser amounts in the Santa Clara, Tesuque, Santa Fe River, and South Galisteo Sub-Basins.

Measuring Demand: Demographics

As population increases in the region, the demand for water will increase. Population growth is a function of the rates of births, deaths, in-migration, and out-migration. For a projection of what the population would be in the future based on recent demographic trends, the JySWPC turned to the University of New Mexico's Bureau of Business and Economic Research, which projected a "most-likely" population and a "low" growth projection for the region. A deliberate effort was made not to constrain the projections by making assumptions about water or land availability or possible policy changes that would change the projection, as it is important for decision makers to understand what would happen if constraints are not imposed. Actions to constrain population were the focus of an alternative studied later in the planning process.

Although the population of the Jemez y Sangre region nearly doubled from 1970 to 2000, population growth is projected to slow in the first half of this century because of an increasing median age and a declining fertility rate. Based on the most-likely projection, the population of region is projected to increase from about 160,000 in 2000 to about 360,000 by 2060. The projected net in-migration for Los Alamos and Rio Arriba Counties is negative, whereas the projection for Santa Fe shows a positive net in-migration, accounting for 40 to 60 percent of growth in the sub-basins within Santa Fe County. While the Santa Fe Sub-Basin accounts for more than half of the population in the region in the year 2000, its relative percentage will shrink by 2060.

Summing it Up: Present and Future Water Demand and Uses

Demand projections provided in this plan focus on municipal, industrial, commercial, and domestic use. In terms of the amount of irrigated acreage, the regional trend in agriculture in the region is downward. Therefore, an increase in the number of agricultural acres was not projected and the amount of water used by irrigation was assumed to remain constant. In general, water diverted for agricultural uses is not measured (metered) or monitored. Combined with a lack of adjudication, this results in uncertainty about the how much wet water is actually being used for irrigation, the amount of acreage in production, and the amount and priority dates of water rights.

Future nonagricultural water demand was estimated based on the projected population multiplied by the average per capita usage, assumed to be 0.15 acre-feet per person per year (approximately 134 gallons per day) for each sub-basin except the Santa Fe Sub-Basin. For Santa Fe, a multiplier of 0.183 acre-foot per year (approximately 163 gpcd) was used for populations supplied by the municipal system and approximately 0.10 acre-foot was used for those served by domestic wells. Using these calculations, the nonagricultural demand for water in 2060 is projected to be 31,500 acre-feet per year greater than the current demand. Based on projected growth, demand would be most concentrated in the Santa Fe, North Galisteo, Tesuque, Santa Cruz, and Nambe-Pojoaque Sub-Basins.

General Findings: The Heart of the Matter

The availability of water in the Jemez y Sangre region is critical for the future quality of life, social stability, and economic health of regional residents. This plan takes a longer view than the usual 40-year planning horizon utilized by the New Mexico Office of the State Engineer by projecting supply and demand to the year 2060. This plan focuses attention on both (1) the problems related to meeting current demands with existing supplies and (2) addressing the projected gap between supply and demand. The JySWPC offers the following general findings in support of the recommendations put forth in this plan.

Findings Related to the Vulnerability of Water Supply

- The amount of water diverted from groundwater in some areas is much greater than the recharge rate, resulting in water level declines.

- Surface water, which comprises 74 percent of the water supply to the region, is vulnerable to drought, watershed health degradation, and secondary effects following catastrophic fires.

- In most years water supplies are insufficient to entirely fulfill all existing surface water rights in the region. Therefore, communities that are planning to utilize surface water to meet demands will be vulnerable most years without a contingency plan.

- Water supplies are vulnerable to water quality degradation resulting from catastrophic fire, septic tanks, or other contaminant sources.

- Evaluation of sustainability and development potential of groundwater resources within the region would benefit from a better understanding of the hydrogeology and a regional numerical groundwater and surface water model that is acceptable to all parties.

- Determination of seniority and quantity of water rights is not possible in the absence of adjudications. Until adjudications are complete, innovative solutions that require quantification of water rights for analysis and implementation cannot be pursued.

- Domestic wells divert an estimated 7,700 acre-feet from the region (based on a per capita demand rate) supplying 35 percent of the water supply for municipal/domestic needs in the region. In some areas, domestic wells are affecting surface water supplies and senior water rights holders.

Findings Related to the Projected Gap Between Supply and Demand

- Under current trends, the population in the region is projected to potentially increase from 160,000 in 2000 to 360,000 people in 2060.

- Population growth of an additional 200,000 people would increase residential and commercial water demand by 31,500 acre-feet per year at current per capita water demand rates. This represents an average gap, with more severe shortfalls expected in drought years.

- The available San Juan-Chama water with return flow credits cannot meet the entire projected increase for the region, even if the maximum contracted firm yield is available. In the most optimistic assessment, existing San Juan-Chama contracts would meet only 40 percent of the projected gap; therefore, additional alternatives must be pursued.

- Meeting the remaining increased municipal/industrial water demand with agricultural water rights may have negative public welfare implications if the transactions do not take the needs of the region's communities into consideration.

- The quantity of water rights that may be for sale from agriculture is not known. However, to meet 50 percent of the projected gap of 31,500 acre-feet per year in 2060, approximately 60 percent of the agricultural land within the region, or 10 percent of the agricultural land within the Middle Rio Grande Conservancy District, would have to be retired. A greater percent of land likely would need to be retired or their water rights leased to account for the vulnerability during drought periods.

- The projected gap between supply and demand cannot be entirely eliminated through conservation.

- Reduction of the projected increase in demand of 31,500 in 2060 by 50 percent could be achieved by eliminating all outdoor watering with potable water by all residents. Such severe conservation measures may be detrimental to public welfare of the region. A reduction in the projected increase in demand of 25 percent could be achieved with less severe compromises to the quality of life.

- The projected gap between supply and demand cannot be entirely eliminated through growth management.

- Growth management, if successfully implemented, could reduce the projected increase in demand of 31,500 acre-feet by 2060 by as much as 50 percent, but this may only shift the growth from one area to another if not implemented consistently throughout the region. Growth management may have negative public welfare effects and is difficult to implement.

Evaluating Alternatives: Informed Collaboration

In February 2001, the Alternatives Subcommittee of the JySWPC, composed of Council members and over 20 citizens from Velarde, Española, Tesuque, Galisteo, Santa Fe, and Los Alamos, developed a system of evaluating and ranking alternatives that were suggested by the public to protect and restore water resources, improve efficiency, protect against drought, and fill the gap between supply and projected demand. The committee organized an innovative workshop, called a charrette, that brought together experts in hydrology, law, economics, engineering, land use planning, agriculture, and other disciplines to begin evaluating the feasibility of the alternatives with regard to a variety of aspects. The committee evaluated and identified alternatives aimed at closing the actual supply/demand gap and those aimed at stabilizing and preserving existing water supplies.

Tough Decisions: Closing the Supply/Demand Gap

A Council subcommittee developed four scenarios that could be used to close the supply/demand gap. These scenarios were aimed at focusing attention on key policy questions that will have to be addressed by government leaders in order to fulfill the future demand for water. This focus on the broad policy directions led to an informed debate and deliberation by the JySWPC. All identified scenarios assumed that the contracted San Juan-Chama water with return flow credits would be utilized, but focused on one or more additional approaches to close the gap. The four scenarios are:

- Emphasizing water conservation to reduce projected demands
- Emphasizing growth management to reduce projected demands
- Emphasizing acquisition of agricultural water rights
- Emphasizing a combination of the above three scenarios along with leasing of Jicarilla Apache San Juan-Chama water

Following public meetings during which these scenarios were presented to people throughout the entire region, options were developed at the subregion level to reflect more specific conditions. The analysis of these options clearly demonstrated that the water supply/demand gap cannot be met entirely with San Juan-Chama water or through conservation or growth management. A combination of alternatives must be pursued, all of which have public welfare implications. Decision makers are called upon to strike the appropriate balance between the tough decisions that face the region.

Rather than dictating how local water supply problems should be addressed, the JySWPC developed option charts for each of the subregions so that decision makers could develop scenarios to suit their own particular conditions and priorities. These option charts, outline the available alternatives and indicate the degree to which each alternative can be used to meet the projected gap. However, the options charts provide only a simplistic representation of the available alternatives and do not depict the complexities and interconnections among alternatives.

Subregion scenarios were developed to illustrate a combination of alternatives that could be used to meet the projected demand gap under both average and drought conditions during each decade of the planning period. Two known drought cycles were used to build the scenarios for each of the subregions. In addition, the subregion scenarios all rely on the population projections and water supply estimates developed as part of the planning process. All scenarios include projections showing that less surface water, including include San Juan-Chama Project water, would be available during a drought. This should be kept in mind as some potential approaches to closing the supply/demand gap, which include purchasing (surface) water rights from agricultural interests for municipal domestic and industrial uses, will be vulnerable to drought.

Recommendations: Roadmap for the Future

The JySWPC adopted the following recommendations for the implementation of the Jemez y Sangre Regional Water Plan. The first two recommendations, which are unnumbered, have overarching impacts on the implementation of the remaining numbered recommendations. The numbered recommendations are grouped into five categories. Recommendations under Categories I, II, and III describe actions that address management, protection, and restoration of water supplies, none of which will result in new wet water rights. Recommendations under Categories IV and V describe actions that will address the projected water supply/demand gap.

The implementation of recommendations under Categories I through III will depend on appropriate staffing or funding from regulatory and natural resource management agencies and/or local governmental entities. The Jemez y Sangre Regional Water Plan does not specifically detail how communities should close the projected gap between supply and demand as discussed under Categories IV and V; instead, it provides options that communities can implement to close this gap. Communities with a projected gap that cannot be closed with a moderate level of conservation and/or the use of San Juan-Chama Project water will have to use measures that may impact public welfare of the region. These impacts may include:

- Impacts to quality-of-life, if more severe conservation measures are implemented
- Private property rights, if growth management measures are pursued
- Degradation of the rural character of the region, if water rights are transferred from agriculture to urban use

To minimize public welfare impacts to communities, municipalities with the greatest projected demands should consider developing partnerships with agricultural communities. These partnerships could be used to foster transactions that minimize negative impacts to the region. An example of this type of partnership/transaction is the funding of conservation measures (e.g., lining of irrigation ditches or leveling of fields) that would reduce agricultural demands and transfer “saved” water to urban uses. Careful study of irrigation systems and the current fate of “lost” water would be required to determine the efficacy of such a plan. Adjudication of water rights would be desirable before such a plan is implemented to determine the value and risk or vulnerability of the water rights transaction. Other partnerships/transactions may involve the transfer of agricultural water only during times of drought or working with communities that no longer have agrarian-based economies.

The Category I through V recommendations were developed from white papers that were presented at the planning charrette. These white papers detail the technical, legal, and estimated costs of the various alternatives and discuss how these alternatives might be implemented. The JySWPC has indicated which recommendations it intends to pursue as a council. Entities within the region need to first set their own priorities and then pursue appropriate recommendations alone or in combination with partners. Each community or water utility should conduct a feasibility study to prioritize planned water projects and to weigh the cost benefits and other implications of various alternatives.

Many of the recommendations presented below are either underway or under consideration, as evidenced by the results of the water system survey conducted by the JySWPC. For example, demand reduction may already be occurring due to land use ordinances implemented by Santa Fe and Rio Arriba Counties, or through conservation efforts by the City of Santa Fe.

Recommendation: Create Advisory Boards

Water advisory boards should be established for areas with specific mutual interests. These boards would serve as a foundation for pursuing the implementation of the recommended alternatives under Categories I through V. The JySWPC will serve as an interim committee to help move this process forward and will act as an advocate for recommendations. As indicated below, workshops will be held to develop strategic plans and to develop funding approaches for implementation of some of the regional alternatives. Most alternatives will need to be pursued by individual communities or through partnerships. Actions such as reducing the use of septic tanks and domestic wells by providing regional services may best be implemented through a water advisory board or other mechanism.

Recommendation: Adjudicate Water Rights

Adjudication of water rights, presently underway by New Mexico Office of the State Engineer (OSE), should be expedited to better define the water rights in the region, including those rights not presently being put to use. Quantification of water rights and determination of priority dates impact many of the recommendations discussed below. For instance, the development of drought contingency plans, discussed in Recommendation 20, is impacted by the priority dates of water rights held or leased by communities. If water banking is part of the drought contingency plan, the vulnerability of the leased water during a drought must be understood. The transfer or lease of water rights, subject to Recommendation 24, is impacted by the determination of whether or not the right has been put to beneficial use. While the lack of adjudication does not prevent such a transfer, it does result in uncertainty in determining the relative value and vulnerability of the water right during drought periods. In addition, adjudication of the water rights above the Otowi Gage would help New Mexico determine if water rights based on the 1929 condition of the Rio Grande Compact are being used.

Category I: Recommended Actions to Protect Existing Supplies

1. *Restore watersheds*. Pursue restoration of piñon-juniper, ponderosa pine, and higher elevation vegetative zones (e.g., mixed conifer) to reduce risk of catastrophic fire and severe erosion and subsequent filling of reservoirs with sediment and debris. Watershed restoration may also improve overall ecosystem health, reduce runoff during high intensity storms, prolong duration of flow in ephemeral and intermittent streams, increase annual yield of surface flows, establish healthy riparian areas, and improve water quality.

   Some watershed projects are presently underway in various areas of the Jemez y Sangre region. To help initiate additional projects, the JySWPC will convene a workshop to develop strategies for creating partnerships and seeking funding for this alternative.

2. *Manage storm water to enhance recharge*. Develop municipal or county procedures and/or projects that capture storm water to enhance aquifer recharge and minimize erosion. Much of the moisture in the region results from high intensity rainfall events. Under historical natural conditions, this moisture was released slowly through runoff or recharge. However, with the increasing surface area of roads, parking lots, and roofs, precipitation moves into storm drainage systems much more quickly. Actions that reduce runoff velocity will enhance recharge to aquifers and reduce erosion in acéquias and streams.

   Municipalities should conduct a thorough review of drainage in urban areas to identify recharge areas for supply wells and feasible locations for detention ponds, infiltration basins, or instream measures to enhance recharge that are consistent with the Rio Grande Compact. The City of Santa Fe, El Vadito de los Cerrillos, and the State Land Office have storm water management ordinances, and Los Alamos County is proposing such an ordinance. The JySWPC will develop a subcommittee to work on strategies for educating appropriate authorities about methods for enhancing storm water management.

3. *Conduct pilot cloud seeding project*. Form partnerships and explore funding mechanisms for pilot cloud seeding projects. Although the effectiveness of a cloud seeding project would need to be demonstrated, and associated water rights may be impossible to establish due to difficulty in proving ownership of water, cloud seeding holds promise for increasing snowpack and surface supplies for existing water rights holders and enhancing stream flow for health of ecosystems. Ideal localities for cloud seeding include areas where watershed elevation is above 9,000 feet. The JySWPC will convene a workshop to develop partnerships, seek funding for one or several pilot cloud seeding projects, and work with ongoing state initiatives.

4. *Pursue sustainable management of water resources through better understanding of hydrogeology*. Establish a regional technical advisory group to guide aquifer study and management activities. The JySWPC has identified a need for a regional model that will facilitate better understanding and management of regional water resources (and support the development of Critical Management Areas [CMAs]). Decision makers within the region need a regional model that incorporates hydrologic boundaries of aquifer systems and is capable of simulating actual hydrologic processes. Part of developing a hydrologic model is to determine if sufficient data exist to support the development of a new model or the modification of existing models.

   Working together, decision makers within the region will be better positioned to secure funding from entities such as the Water Trust Board for hydrologic studies needed to provide information about decisions critical to the region's water resources. Most importantly, if a model is developed through a consensus process, stakeholders will have greater confidence in the model results and its utility as a planning tool.

5. *Evaluate establishing critical management areas to protect groundwater resources*. Establish CMAs to limit groundwater production in areas where senior water rights and stream and spring flow are threatened. The entities that wish to pursue this option should work with the OSE to define areas appropriate for consideration. For example, candidates for CMA designation might include areas where water supplies are diminishing or senior water rights are affected. Entities interested in CMAs should also

work with the OSE to develop appropriate best management practices such as the stringent regulation of domestic wells. JySWPC will host a workshop to further discuss the development of CMAs.

6. *Develop conjunctive use strategies*. Explore the potential of combining surface and groundwater rights to maximize renewable supplies when available, and to preserve aquifers for periods of drought. Water resource management could be enhanced if water purveyors have the flexibility to alternate between the use of surface water and groundwater depending on availability of the supplies. During wet periods, water purveyors should rely on surface water and rest the aquifer. This will help reduce vulnerability during periods of drought. To conjunctively manage water rights, permission of the OSE must be obtained, and modeling will be needed to support an OSE application. A regional model that has the buy-in of neighboring water users who are likely to protest such an application would provide an essential foundation for proceeding with this alternative. The City of Santa Fe, Eldorado, El Vadito de los Cerrillos, Cuatro Villa Mutual Domestic Water Users, and Santa Fe County currently have or have proposed conjunctive use strategies.

7. *Appropriate flood flows*. Pursue appropriation of flood flows on the Rio Grande or its tributaries during years when Elephant Butte is spilling. New Mexico cannot accrue a debt under the Rio Grande compact during years when the Elephant Butte Reservoir spills. Thus, diversions of surface water could be increased during these years, provided that senior water right users and the environment are not harmed. Although only 6 of the last 60 years have been spill years, the potential to use excess flow during spill years through existing water diversion facilities or to store the water for future use could help the region reduce its dependence on groundwater. Santa Fe County has already submitted an application to appropriate excess flows. However, environmental groups, such as Rio Grande Restoration, have protested a similar application by the City of Albuquerque and have indicated that they would protest additional applications. The application will need to be supported by technical analyses to address issues of potential impairment and determine if such an appropriation would be detrimental to the health of the Rio Grande. Should the application be successful, local governmental entities could

develop contracts or joint powers agreements to establish allocations for appropriated water and a plan for diverting and storing it when it becomes available. The recommendation for conjunctive use and for aquifer storage and recovery should be pursued in conjunction with this strategy to allow for effective use of flood flows.

8. *Remove trace constituents to protect human health*. Consider requiring local or regional water supply systems in areas where trace constituents (arsenic, uranium, nitrate, fluoride, etc.) exceed water quality standards. In areas where water quality is naturally poor or degraded due to septic tanks, regional water systems are the most effective method to provide safe, potable supply. The northern portion of the Jemez y Sangre Water Planning Region is a good candidate for such systems due to widespread instances of poor quality water in the valley between Española and Pojoaque. Water planners in all sectors need more data on groundwater contamination, including concentrations, sources, trends, and depth. This information will help them to prioritize areas that would best be served by water systems rather than domestic wells. Cañoncito at Apache Canyon, the City of Santa Fe, El Vadito de los Cerrillos, and Santa Fe County are proposing upgrades to treatment facilities.

9. *Address septic tank water quality degradation*. Monitor and reduce contamination from septic tanks through the most applicable method. A better understanding of water quality deterioration from septic tanks is necessary, particularly in areas with fractured granite or basalt, areas where the depth to groundwater is shallow, or areas with other conditions that reduce natural denitrification processes. Once the problem is better characterized, contamination could be addressed through either extending service to homes from local or regional wastewater treatment plants or establishing regular maintenance plans to provide routine pumping and inspection of septic tanks, as appropriate.

10. *Cleanup of contaminated groundwater and surface water*. Support increased funding to the New Mexico Environment Department (NMED) to pursue investigation and remediation of "orphaned" groundwater contamination sites for which no responsible party has been identified. Support increased funding for NMED to address

contamination of surface water, including acéquias, which are particularly vulnerable to contamination.

11. *Continue funding programs to protect surface water and groundwater*. Support ongoing monitoring and regulation by the NMED and Pueblos for various programs that serve to protect the surface water and groundwater in the region.

12. *Support restoration of stream reaches to their designated uses*. The U.S. Environmental Protection Agency and NMED should aggressively pursue protection of stream reaches to meet total maximum daily load standards to prevent further environmental degradation.

Category II: Recommended Actions to Improve System Efficiency

13. *Require wastewater reuse*. Encourage new subdivisions (particularly those relying on imported water) that will be served by a new or existing wastewater treatment system to plan for wastewater reuse, either through the use of greywater or treated effluent, which can be used for return flow credits, watering turf, or other nonpotable uses. The use of septic tanks for wastewater disposal degrades water quality and reduces options for wastewater reuse. The OSE has convened a committee to develop guidelines for building water efficient homes, including the reuse of greywater and black water. JySWPC will continue to work with this committee to educate the public and decision makers about methods of wastewater reuse, including greywater reuse. Wastewater is currently being used by the City of Santa Fe, Hyde Park Water Users Association, Las Campanas, and Los Alamos County, and is under consideration by many other communities.

14. *Encourage rainwater collection*. Encourage rainwater catchment to supplement outdoor watering and reduce dependence on potable water. Residents and businesses should be encouraged or required by ordinance to harvest roof water, to the extent practical, before this water enters municipal or natural drainage networks. Landowners would build and maintain roof water harvesting tanks or ponds according to local government

requirements. The OSE committee for building water efficient homes, of which the JySWPC is a participant, is developing guidelines for encouraging rainwater collection and storm water harvesting.

15. *Line ditches*. Consider lining ditches or utilizing piping, where appropriate, to extend supplies to all users. The effectiveness of a ditch-lining project is site specific and may have undesired effects such as loss of riparian habitat or bosque. Ditch lining may help farms located at the end of a ditch to receive their full supply by reducing water loss from infiltration. Acéquia del Cano and the Cuatro Villa Mutual Domestic Water Users Association have ongoing projects to line ditches and the Lower Cerro Gordo Ditch Association has proposed a ditch-lining project.

16. *Remove sediment in Santa Cruz Reservoir and investigate Nambe Reservoir*. Remove sediment in Santa Cruz reservoir to increase reservoir capacity by 1,800 acre-feet and enhance operation of the system. The U.S. Bureau of Reclamation should investigate the potential for increasing storage capacity in Nambe Reservoir by removing sediment.

17. *Repair leaks in water systems*. Conduct water audit and replace old and leaking water lines to reduce system demands. The average water loss in a municipal or mutual domestic system may exceed 10 percent. While this lost water may help recharge wells that produced the water, the recharge is not immediate and the loss reduces water system performance. Repairing leaks will help water purveyors meet daily demands, particularly where infrastructure is strained in terms of meeting peak demands. Community and municipal systems need to better understand the losses that occur through leaks by conducting water audits and developing plans and budgets to replace leaking pipes.

18. *Consider aquifer storage and recovery of excess water*. Consider aquifer storage and recovery as a viable method of managing excess water, when and if such water is made available through treated effluent or capture of flood flows from the Rio Grande (in years when Elephant Butte has spilled). Further study is required to determine if aquifer storage and recovery would be a viable beneficial method to store excess water.

Considering the water supplies available to date, the direct use of excess surface water, which will result in reduced groundwater pumping, is likely the optimal approach.

19. *Pursue increased storage capacity in Abiquiu Reservoir*. Pursue increased storage capacity by securing the 17,000 acre-feet of storage easements in Abiquiu Reservoir that are within the authorized amount. If a greater amount of storage capacity is desired (to hold flood flows or other water rights), the region would need to seek authorization from Congress. However, storage amounts above the 200,000 acre-feet (the total authorized storage amount of the reservoir once the 17,000 acre-feet is secured) would inundate homes and roads and may have negative ecological and aesthetic consequences. Increased storage capacity is especially desirable in the short term to increase the pool of water available, as the need for additional storage will be lessenedwhen the City and County of Santa Fe begin diverting water directly from the Rio Grande rather than through the Buckman well field. Increased storage could also be used to appropriate flood flows, as described in Recommendation 7.

Category III: Recommended Actions to Address Drought

20. *Develop drought contingency plans*. Develop or maintain drought contingency plans, including measures such as emergency conservation ordinances and/or provisions for temporary leasing from other sources. Drought management can be undertaken at a regional level through cooperative agreements or locally by individual counties, municipalities, community water systems, acéquias, irrigation districts, or Pueblos within the region. Drought planning that addresses both local and regional mitigation efforts will be most effective.

    The following actions would be required to develop and implement a regional drought plan:

    - Convene a meeting of water users/stakeholders to develop a regional drought plan or small-scale drought plans.

- Conduct technical analyses to evaluate the correlation between historical data and drought triggers and to define appropriate triggers.

- Conduct an analysis of drought severity and vulnerability of water supplies.

- Evaluate vulnerability of water rights to priority calls that may be made during a drought.

- Evaluate and adopt mitigation measures through a series of meetings that develops consensus on appropriate measures.

Communities that rely on surface water supply should also consider the need for contingency alternate supplies in case of catastrophic fire or for routine firefighting. The City of Santa Fe, El Vadito de los Cerrillos Mutual Domestic Water Users, La Vista Home Owners Association, and Santa Fe County have emergency water conservation ordinances for drought management. Acéquias, irrigation districts, and Pueblos have systems in place for sharing water during drought periods that have worked for hundreds of years. Communities that plan to shift their supply to surface water must develop drought contingency plans to be prepared for drought periods. Communities that rely on groundwater may also need to develop drought contingency plans to accommodate increasing demands during drought periods, particularly if the water supply system is struggling to meet demands in an average year.

Category IV: Recommended Actions to Reduce Projected Demand

21. *Pursue water conservation*. Pursue water conservation through a variety of measures. Municipalities that want to reduce demand through conservation need to:

- Know their customers' use habits.

- Elevate water conservation consciousness by establishing incentive rates.

- Provide ongoing education and outreach to all customer groups on how to save potable water through appropriate landscaping and use of nonpotable water for irrigation.

- Encourage the installation of conservation fixtures (efficient toilets, showerheads, sprinklers, evapotranspiration controllers, low-flow washing machines, recirculating hot water systems, drip irrigation, etc.) through rebates or other incentive programs.

- Encourage energy-saving fixtures and habits to reduce the amount of water used at power plants, which impacts water demand in other regions.

- Establish efficiency in new developments through regulations.

Conservation is most critical in the Santa Fe, Caja del Rio, North Galisteo, and South Galisteo Sub-Basins, which have very uncertain future water supplies for meeting projected demand. The communities of Santa Fe, Eldorado, Cerrillos, Madrid, Galisteo, Sunrise Springs and Santa Fe County have adopted water conservation ordinances. All communities in the region should adopt similar ordinances to discourage the waste of water.

22. *Pursue growth management to reduce demand*. Governmental entities that wish to pursue this option should conduct an educational and consensus-building program to formulate an approach. The approach should be perceived as egalitarian in the way it affects people and groups and should be integrated with other community goals. While growth management should not be considered only as a last resort, if the projected water supply/demand gap is not closed through conservation efforts or increasing the water supply (including San Juan-Chama Project water), growth management will be the final option for closing the gap.

    Demand reduction through growth management may be essential in the South Galisteo Sub-Basin, where the outlook for future water supplies is bleak. Growth management may also be necessary as part of the water plan for North Galisteo, Santa Fe, and Caja del Rio Sub-Basins, where the ability to increase the water supply is uncertain. Growth management is currently utilized by the City of Española, City of Santa Fe, Madrid Water Cooperative, Rancho Galisteo, Santa Fe County, and Cuatro Villa Domestic Water Users Association.

Category V: Recommended Actions to Increase Water Supply

23. *Utilize San Juan-Chama Project water as appropriate*. The City and County of Santa Fe presently divert San Juan-Chama Project water through the Buckman well field; however, the City's ability to divert San Juan-Chama water through this method is limited by the aquifer capacity. Los Alamos County has nearly completed a feasibility study for developing San Juan-Chama Project water. A direct diversion of San Juan-Chama water, combined with the flexibility to utilize the well field during periods when river flow is low, will enhance resource management.

    To the extent that other San Juan-Chama water may be available for purchase or lease (from Los Alamos, the Jicarilla Apache, San Juan Pueblo, etc.), the City and County of Santa Fe should pursue agreements to use such water, even for a short period (20 years), to offset past pumping of the Buckman well field. This will be essential, particularly if the City is unable to increase the San Juan-Chama water in storage over the next few years. The City of Española should also pursue diversion of its San Juan-Chama water, combined with a conjunctive use strategy that will allow for use of groundwater during times of drought. Diverters of San Juan-Chama water may have an opportunity to develop strategies for delivering water that will benefit other needs, such as those of the silvery minnow, without compromising their contracted amount or compact obligations (i.e., releasing contracted amount during periods of low flow).

24. *Transfer water rights through consensus process*. Pursue transfer of water rights from agriculture to urban use through partnerships/transactions that take into account community concerns. Inventory the processes that allow for consensus-based transactions in other areas of New Mexico or in other states where areas of origin have been protected. Develop mechanisms and pursue options for developing area of origin

protections that are appropriate for this region. Consideration of practical minimum flow requirements must be included in any transaction to evaluate impairment to the acéquias. The JySWPC will convene a subcommittee to seek funding to develop the inventory of successful models for consensus-based transactions. The JySWPC will work with parties interested in pursing consensus-based transactions. The City of Santa Fe, Santa Fe County, and Las Campanas have transferred water rights in the past and propose to transfer additional water rights in the future. The State Land Office and Sunlit Hills of Santa Fe may also consider transferring water rights in the future.

25. *Limited use of domestic wells*. Continue to allow developments to be based on individual domestic wells in areas where senior water rights are not impaired, spring flows and stream flows are not impacted to the detriment of the Rio Grande Compact, and environment and water quality are suitable. Areas in the Velarde Sub-Basin near the Rio Grande may meet these criteria. However, if well usage causes New Mexico to exceed the 1929 condition on the Rio Grande above the Otowi Gage, new domestic wells may be in conflict with the Rio Grande Compact. All domestic wells are subject to a priority call and individuals should be aware of the risk involved in providing a supply based on a very junior water right. CMAs that restrict domestic wells should be developed in areas where new domestic wells are a problem. County and municipal governments have authority to limit drilling of domestic wells where water service connections are available or through lot size restrictions. Currently, the City of Santa Fe, Santa Fe County, El Vadito de los Cerrillos, La Vista Home Owners Association, and the Madrid Water Cooperative restrict the drilling of domestic wells within their service boundaries.

The Bottom Line: Conclusions

Many of the recommendations under Categories I, II, and III involve actions that are regional in nature or best suited to partnerships among interested parties. Establishment of a funded water advisory board or other entity will assist with the task of implementation of these recommendations. Because many government entities are focused on addressing immediate emergencies, long-term goals such as better groundwater management and watershed restoration may end up on the "back burner" without assistance from a water advisory board or similar entity.

The recommendations under Categories IV and V for reducing the projected gap between supply and demand involve balancing the public welfare implications that each alternative presents. Decision makers must balance the desire for economic development based on growth against the hardships resulting from extreme conservation measures or the potential changes in the character of the region that may accompany the transfer of water rights from agriculture to urban uses. Some stakeholders will argue that economic development can occur without growth and others will claim that a significant portion of the agricultural water rights are not being used anyway, and that the regional character is already changing due to the low profitability of farming. These issues are complex and will take a great deal of work to resolve. The goal of the JySWPC is to play an active role in education and interaction with the public as communities work to address their water supply problems.

1. Introduction

This document is the regional water plan for the Jemez y Sangre Water Planning Region (Figure 1), prepared under the auspices of the Jemez y Sangre Water Planning Council (JySWPC or Council). Water rights holders and other stakeholders from the northern two-thirds of Santa Fe County, all of Los Alamos County and the southeastern part of Rio Arriba County formed this Council. Altogether, 24 stakeholder organizations signed a cooperative agreement committing to participate in the development of a regional water plan.

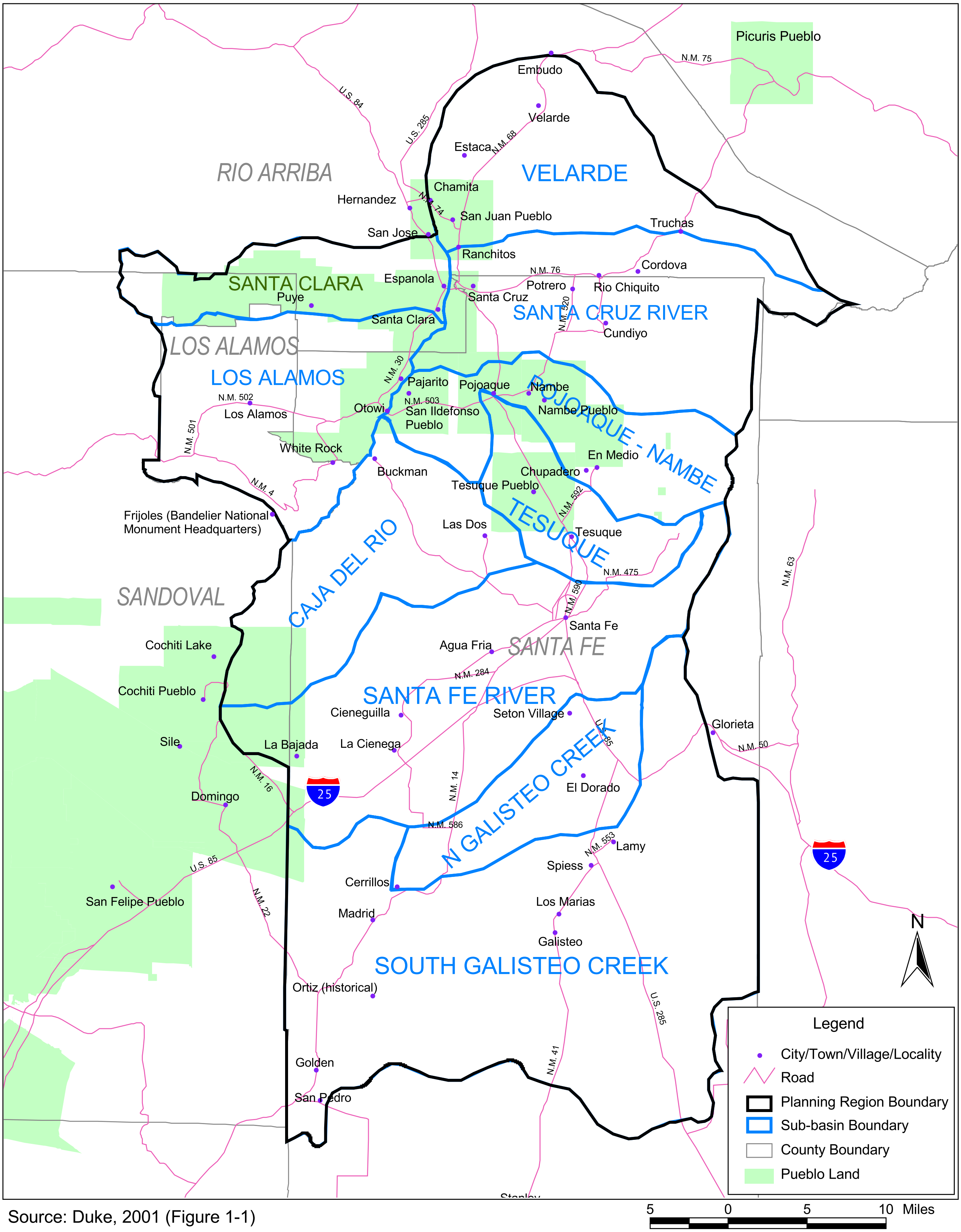
1.1 Purpose of Regional Water Planning

Regional water planning in New Mexico is the direct result of a 1987 federal court ruling that found New Mexico's prohibition against the out-of-state transfer of New Mexico groundwater to be unconstitutional. This ruling made it clear that New Mexico must actively plan for its water future. Regional water plans are used to budget water and thus help ensure the continuity of the water supply. In essence, regional water planning means understanding existing and potential water resource limitations and opportunities. It also means understanding the tradeoffs involved with different alternatives for meeting future water needs.

There are 16 water planning regions in New Mexico, established by the Interstate Stream Commission (ISC). Each region can write its own water plan for the ISC to accept and integrate into a statewide water plan. Public participation is important in the development of regional water plans to ensure local acceptance and to increase the plan's effectiveness in contributing to state decision-making concerning issues related to public welfare and conservation. Also, because regional water planning may be used as legal evidence of need and feasibility of supplying a need from specific sources, regional water plans should be "reliable, specific, technically sound, and based on generally acceptable hydrologic and engineering principles" (ISC, 1994).

Regional water plans assess water resources through:

- Determining the quantity and quality of water resources.



Source: Duke, 2001 (Figure 1-1)

JEMEZ Y SANGRE REGIONAL WATER PLAN

Jemez y Sangre Water Planning Region and Sub-Basins

Figure 1

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- Projecting population and other water resource demands under a range of conditions.

- Determining alternative approaches to meet projected demands through managing and conserving water supplies available to the region in accordance with existing rights, water supplies, interstate agreements, and court decrees.

1.1.1 Issues Specific to the Jemez y Sangre Water Planning Region

Major water resource challenges specific to the Jemez y Sangre Water Planning Region include:

- *Projected growth with little "new water" available to meet projected demands:* The only "unused" water in the region is San Juan-Chama (SJC) Project water held by the City of Española and Los Alamos County and return flow credits on the City of Santa Fe's SJC water.

- *Vulnerability of SJC water:* The "firm yield" of the SJC project water is not as firm as originally thought, particularly after the record low flows in 2002, potential claims by the Navajo Nation, and the August 2002 ruling by U.S. District Judge James A. Parker that the U.S. Bureau of Reclamation should release SJC water for the endangered silvery minnow.

- *Impact of domestic wells on senior water rights:* Because the Office of the State Engineer (OSE) does not restrict the use of domestic wells and because other water rights are difficult to obtain, much of the growth in the region is sustained by domestic wells. These wells impact both aquifer water levels and streamflow.

- *Unpredictable surface water supply:* The City of Santa Fe and the acéquias depend, at least in part, on surface water to meet the water demand, yet this supply is unpredictable in our semiarid region.

- *Ongoing water rights adjudication and litigation impedes water planning:* The lack of completed adjudications means that water rights are unquantified. It is difficult and possibly misleading to plan for use of a resource when that resource may not be available for use. Unquantified early priority Pueblo water rights also lend a degree of uncertainty regarding the amount of water available to other entities in the region.

- *Effects of Rio Grande Compact on water management:* The Rio Grande Compact (Compact) must be considered in nearly all water resource management decisions because it requires that 1929 conditions on the Rio Grande are maintained. The use of the Otowi Gage as a measuring station for Compact water has, thus far, restricted the transfer of water rights from the north to the south of the gage. The amount of water held in storage in Santa Fe Canyon reservoirs is also impacted by the Compact.

- *Jurisdictional issues*: These pose a problem for water resource management because the region includes significant parts of three counties, two cities, and eight pueblos as well as numerous villages, mutual domestic water associations, and acéquias. State and federal governments also have jurisdiction in certain circumstances. Actions taken by these various entities are often inconsistent, as in the conflict between the 100-year "life time" of the aquifer specified in the Santa Fe County Code and Compact obligations that require that the aquifer continue to discharge to the Rio Grande.

- *Water quality problems:* Quality issues such as groundwater contamination exist throughout the region, impacting the availability and cost of water.

- *Other unresolved issues.* Resource planning is more difficult because of ongoing unresolved issues. For instance, studies have not yet been completed to determine how to manage water resources to maintain riparian corridors and meet Endangered Species Act (ESA) obligations.

1.1.2 Purpose of the Jemez y Sangre Regional Water Plan

The purpose of the Jemez y Sangre Regional Water Plan is to assess the future water needs of the region and determine the feasibility of supplying or reducing these needs over the next 60 years, given the uncertainties described above. The planning process considers the public welfare and conservation issues of all stakeholders through a public participation process. The objectives of this plan are to define the available water supply (renewable and stored), determine the water demand (present and future), and develop alternatives for meeting demand. While working to meet these objectives, historical rights and uses must be respected and public welfare issues of regional importance such as quality of life and preservation of the environment must be addressed. Because the JySWPC does not have authority to implement many of the actions that will be required to address future water supply challenges, this plan outlines options to aid decision makers as they move forward on implementation. The plan provides recommendations about actions for which the JySWPC has reached consensus and, when opinions are divided, characterizes the diverse viewpoints held by Council members and participants.

1.2 Jemez y Sangre Water Planning Council

The JySWPC was created through a series of meetings, primarily with water diverters within the region. The meeting participants defined the region, named the planning entity the Jemez y Sangre Water Planning Council, and drafted language for a cooperative agreement. This cooperative agreement established the JySWPC as a legal entity. Both the cooperative agreement and the organization's bylaws are provided in Appendix A.

Official members of the JySWPC who signed the cooperative agreement are:

- Acéquia Madre de Santa Fe
- Amigos Bravos
- Bureau of Indian Affairs
- Bureau of Reclamation
- Los Alamos National Laboratory/ Department of Energy
- New Mexico Rural Water Association
- North Central New Mexico Economic Development District
- Pojoaque Valley Irrigation District

- City of Española
- City of Santa Fe
- Eldorado Area Water & Sanitation District
- Garcia Ditch
- Las Acéquia de la Cañada Ancha
- Las Acéquias de Chupadero
- League of Women Voters
- Los Alamos County Public Utilities
- Rio Arriba County
- Rio Grande Restoration
- Santa Fe Area Home Builders Association
- Santa Fe County
- Santa Fe Land Use Resource Center
- State Land Office
- Santa Fe Pojoaque Soil and Water Conservation District
- 1000 Friends of New Mexico

Six of the eight Pueblos in the region have attended the meetings and stated that, for the present, they prefer to participate as observers. Santo Domingo and Pojoaque Pueblos have not attended the meetings, but the City of Santa Fe has met with each Pueblo individually to explain the purpose of regional planning and to invite their participation in the process. Pueblo representatives have indicated that they realize considerable benefits can be gained from regional water planning efforts, but are concerned that many past regional water planning efforts have resulted in attempts to achieve a de facto quantification of the Pueblos' water rights. The Pueblos view this, whether it is done implicitly or explicitly, as an attempt to limit their tribal water rights. Thus, the Pueblos have chosen to participate as observers in the planning process. This means the Pueblos send representatives to planning meetings, and these representatives make comments and ask questions on behalf of their respective Pueblos as necessary. However, by such participation the Pueblos do not acknowledge that they are bound by any decisions made by the JySWPC.

The Pueblos in the region include:

- Pueblo de Cochiti (portions)
- Pueblo of Pojoaque
- Pueblo of San Juan
- Pueblo of Santa Domingo (portions)
- Pueblo of Nambe
- Pueblo of San Ildefonso
- Pueblo of Santa Clara
- Pueblo of Tesuque

1.3 Previous Water Planning in the Region

A variety of studies have been completed that support this water plan, including two key documents:

- The *Water Supply Study Jemez y Sangre Water Planning Region, New Mexico* was prepared by Duke Engineering & Services (Duke) in 2001 specifically for the JySWPC. It compiles water resource information in the Jemez y Sangre Water Planning Region and provides water budgets to support the planning effort. The water supply and water budget data provided in this plan was taken from the Duke report.

- The *Population Projections for the Jemez y Sangre Water Planning Region,* prepared for the JySWPC by the Bureau of Business and Economic Research (BBER) in 2000, provides demographic information for the region and projects future population based on a low estimate and an exponential projection. The document also projects growth using an economic model and discusses the impact of restricting the movement of agricultural water. Population and demographic information included in this plan is primarily from this source.

A number of other water supply and water planning studies have included all or part of the Jemez y Sangre Water Planning Region. Studies funded thus far by the ISC have focused primarily on the Santa Fe area and are, therefore, not comprehensive for the entire planning region. Even so, several of these studies provide important information related to the regional water planning effort.

The *Long-Range Planning Study for the Santa Fe Area - Phase I Report* (Harza et al., 1988) is an excellent report on possible management strategies for the Santa Fe Metropolitan Area. The report discusses alternatives for balancing the three sources of water for the Santa Fe area: (1) the Santa Fe River, (2) groundwater, and (3) imported water. Harza clearly explains the concept of "safe yield" and how values play a role in quantifying safe yield for each community. The alternatives for optimal utilization of the resources and the discussion of issues, although focused on the Santa Fe metropolitan area, apply to region as a whole.

The *Long-Range Planning Study for the Santa Fe Area - Phase II Report* (Harza et al., 1989) was prepared to evaluate the technical and financial feasibility of a regional water system for the Santa Fe Area and to identify a workable administrative framework for its implementation. The study indicated that regionalizing water service would be advantageous as a cost-of-service basis for the region, but major changes in current administrative functions would be needed to move forward with the plan.

The *South Santa Fe County Water Resource Assessment* (BBC, 1992) is another important piece of the regional water planning effort. The public participation component of this assessment revealed little interest in regionalizing water supply in the area, a conclusion that conflicts with the recommendations of the Harza studies.

In addition, several extensive water resource investigations reports do cover a large portion of the region. Santa Fe County has based land development on water availability since 1980 and, along with the Santa Fe Municipal Water Board (SFMWB), commissioned studies to quantify and characterize the water resources in Santa Fe County. The most recent study is the *Water Resource Inventory for Santa Fe County* (DBS&A, 1994), which addressed most of the technical data needs outlined by the regional water planning template for the area within Santa Fe County.

Several hydrogeologic investigations have been undertaken recently in the Jemez y Sangre Water Planning Region. The City of Santa Fe is currently involved in collecting hydrologic data that will assist in numerical modeling and future water planning, and has performed technical studies that will enhance our understanding of the hydrologic system (DBS&A and Watershed West, 2002). Los Alamos National Laboratory (LANL), in cooperation with numerous stakeholders, has developed a numerical model of the Española Basin. LANL has conducted extensive investigations on the hydrogeologic characteristics of the Pajarito Plateau. The U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Bureau of Reclamation, has developed the Upper Rio Grande Water Operations Model (URGWOM), a surface water management model of the Rio Grande. The City of Española has coordinated an effort to conduct wastewater planning for the Española-Pojoaque area.

LANL began developing a basin-scale model of the Española Basin in 1999 in support of two projects: the Groundwater Protection Program (an applied program focused on the real and potential impacts of LANL operations on the environment) and the Rio Grande Coupled Models Project (a basic-research initiative focused on regional hydrology). The basin model was designed to be flexible, so that iterations between data gathering and model improvements can be used to test conceptual models of flow and transport both on the Pajarito Plateau, where data is fairly dense, and in the larger basin, where data is more sparse. Continued funding for model development is expected from both the Groundwater Protection Program and basic-research initiatives at LANL.

The boundaries of the LANL model extend to the hydrologic and structural limits of the basin. The advantage of modeling the aquifer at this scale is that the model includes all likely areas of recharge and estimates of the total flux through the basin can be achieved through analysis of rainfall and streamflow data. Because the LANL model uses finite-element methodology, the entire basin can be simulated (at a coarse resolution) and areas of interest, such as municipal well fields, can be simulated at a very fine resolution. Finite-element methodology also allows geologic detail to be incorporated into the model; this is difficult with finite-difference codes (e.g., MODFLOW), particularly if the structure of the aquifer units is oblique to the model grid.

One area of research at LANL has been coupling models at various scales, which allows the total water budget implicit in the basin-scale model to be appropriately communicated to smaller-scale, local models. The importance of accurate model coupling was demonstrated in a recent study of capture zones on the Pajarito Plateau, where the influence of a well field outside the local-scale model boundaries proved to be much more important than was previously thought.

The underlying foundation of the LANL model is a three-dimensional geologic model of the basin. The model includes not only the Santa Fe Group, the largest aquifer unit in the basin, but also the volcanic rocks of the Pajarito Plateau and the Precambrian and Paleozoic/Mesozoic rocks of the eastern basin. Understanding the relation between geologic units and hydrostratigraphy has been a major focus of research at LANL.

Several aspects of current model development at LANL are of interest for the Jemez y Sangre region. First, the modeling effort is examining the impact of heat flow on groundwater flow in the basin. This may help to explain some aspects of hydraulic gradients and trace element geochemistry present in the central portion of the basin. Second, the relationship between declining water levels and the potential for increasing concentrations of naturally occurring contaminants such as arsenic, uranium, and unacceptably high levels of chloride and sodium is being examined. Third, time-lapse, high-precision gravity measurements are being conducted throughout the basin in an attempt to directly measure changes in storage. This information will help constrain the model's ability to predict the impact of drought conditions on recharge/discharge relationships.

Additional water planning documents that apply to the region are listed in the bibliography provided in Appendix B.

1.4 Contents and Organization of this Water Plan

The Jemez y Sangre Regional Water Plan was prepared in accordance with guidelines published by the ISC (ISC, 1994). Section 1 provides background information about the planning region and the JySWPC. Supporting information regarding the JySWPC is contained in Appendix A; Appendix B provides a comprehensive water resources bibliography for the region. Section 2 details public involvement in the planning process and the strategy chosen to maximize public involvement. Additional information on the public involvement process, including meeting minutes, newsletters, and public information flyers and fact sheets, is included in Appendix C. Section 3 provides background information related to the planning area including a general description, climate, demographics, and land ownership and use, as well as a summary of the physical characteristics of the sub-basins within the region.

Section 4 presents legal issues that affect water use and planning in the region, including those related to federal, state, and local laws and regulations. Water quality standards and water rights are addressed in this section along with a discussion of ongoing legal issues and local conflicts. Appendix D provides detailed descriptions of the laws and legal issues related to the Jemez y Sangre Regional Water Plan.

Section 5 assesses surface water and groundwater resources for the planning region, providing an analysis of these resources for each of the ten sub-basins in the region and an overview water quality issues for the region. This section also summarizes regional water supply, taking into account legal limitations and issues that might affect supply. Section 6 discusses historical and existing demographics and water use information needed to prepare a water budget and to project future water demand over a 60-year planning horizon. A summary of past and current water conservation measures is also provided. Appendix E provides population data and projections for the regions and various sub-basins.

Sections 7 and 8 address various alternatives for meeting future water demand. Section 7 summarizes the alternatives, including the process used to define and select them, and provides an implementation schedule and summary of projects under consideration. This section also presents various scenarios for five different subregions and describes how demand might be met under each scenario. Section 8 provides recommendations concerning alternatives and their implementation. Detailed analyses of the various alternatives are provided in the white papers included in Appendix F. Appendix G provides the results of a survey of water systems undertaken to determine if and where recommended alternatives are already being implemented in the region.

2. Public Involvement

Public involvement is a key component of regional water planning. This section describes the public participation process used for the Jemez y Sangre Regional Water Plan and provides the public welfare statement that was developed as part of the process.

2.1 Documentation of Public Involvement in Planning Process

In 1997, the City of Santa Fe and Santa Fe County worked together to begin the process of developing a regional water plan. The City of Santa Fe dedicated a water resource planner on a half-time basis to create and coordinate the efforts of the JySWPC. The JySWPC was created through a series of meetings with primary water diverters within the region. Invited participants were limited to direct diverters of surface water or groundwater as well as representatives of several public interest organizations. Agencies, sovereign Pueblos, and groups or individuals that are directly affected by and/or that can directly influence the diversion of water were invited to participate. The intent was for JySWPC members to represent decision-making bodies that ultimately will be in a position to formally adopt the JyS Regional Water Plan. It was also felt that the JySWPC should include representatives from environmental/ public interest and business/development organizations to assure the concerns of these groups were addressed throughout the process. Individual citizens interested in JySWPC activities were allowed to attend meetings, but were not included as members of the Council.

Over 110 people were invited to participate in the water planning effort and creation of the Council. These included representatives from the following organizations:

- *Pueblos*: San Ildefonso, Tesuque, Nambe, Pojoaque, Santa Clara, San Juan, Cochiti, Santo Domingo, and Eight Northern Indian Pueblo Council
- *Counties:* Santa Fe, Los Alamos, Rio Arriba
- *Cities:* Santa Fe, Española, Los Alamos

- *Irrigation Districts/Acéquias:* New Mexico Acéquia Commission, New Mexico Acéquia Association, Acéquia de la Cienega, Acéquia Madre, Acéquia Cerro Gordo, Garcia Acéquia, Acéquia Muralla, La Bajada Community Ditch, Llano Ditch, Las Acéquia del Chupadero, New Mexico Farmers Marketing Association, Pojoaque Valley Irrigation District, Santa Cruz Irrigation District

- *Federal Government:* Bureau of Land Management, Fish & Wildlife Service, Bureau of Reclamation, USACE, Bureau of Indian Affairs, Natural Resource Conservation Service, Forest Service

- *State Government*: ISC, OSE, State Land Office, New Mexico Environment Department

- *Domestic Water Supply:* New Mexico Rural Water Users Association, Eldorado Water and Sanitation District, Galisteo Water Users Association, Agua Sana Water Users Association, Pojoaque Valley Water Users, Sunlit Hills Water System

- *Los Alamos National Laboratory / Department of Energy*

- *Advocacy Groups*: Rio Grande Restoration, Environmental Law Center, League of Women Voters, 1000 Friends of New Mexico, Water Dialogue, Amigos Bravos, Northern New Mexico Legal Services, Santa Fe Chamber of Commerce, North Central New Mexico Economic Development District, Rural Community Assistance Corporation, Santa Fe Area Home Builders Association, Santa Fe Land Use Resource Center, Santa Fe River Task Force

All organizations were personally contacted by City of Santa Fe staff and were invited to attend meetings through a combination of phone calls, face-to-face contacts or presentations, or letters. Staff from the City of Santa Fe met individually with each of the Pueblos on numerous occasions to explain the purpose of regional water planning and the City's interest in regional planning. Two presentations were made to the New Mexico Acéquia Association.

Beginning in February 1998, Merle Lefkoff, Toby Herzlich, and Nadine Tafoya facilitated four meetings that included the drafting of the cooperative agreement and naming of the JySWPC, as well as working with Santa Fe County and City staff to develop the planning process, edit correspondence, and meet individually with stakeholders. By August 1998, the JySWPC was formed through the signing of the Cooperative Agreement (Appendix A1). Council members are listed in Section 1.2.

Pueblo leaders chose to participate as observers in the process. A portion of the ISC funds were directed toward facilitating Pueblo involvement. Peter Chestnut was retained by the Northern Pueblos Tributary Water Rights Association to provide legal review and serve as a liaison with the Pueblos. Lee Wilson & Associates was retained to provide technical review of documents on behalf of the Pueblos. Representatives from the Northern Pueblos Tributary Water Rights Association stated that they could feel comfortable participating in the planning process if the JySWPC acknowledged the following:

- *No injury to Pueblo water rights*: The planning process will not limit Pueblo water right claims. It is understood that there are other processes that must occur before claims are finalized. Pueblos may not want to share information about future water needs.

- *Respect for senior water rights*: No decision made by the JySWPC has any effect, or will be binding, on a participating entity regarding water right issues.

- *Pueblo water rights do not arise under state law*: Federal law controls the extent of Native American water rights; state laws regarding prior appropriation, beneficial use, and forfeiture do not apply. The parties to the JySWPC recognize that participating Pueblos have tribal sovereignty.

2.1.1 Council Meetings

The JySWPC met monthly beginning in 1998. The water planning coordinator maintained an e-mail list of all members interested in JySWPC meetings and subcommittee meetings. Minutes of JySWPC meetings were mailed to approximately 200 individuals and newsletters were sent to approximately 1,200 individuals. LANL contributed staff time for assisting with mailings of minutes and newsletters, as well as providing technical assistance for development of a hydrologic database, as described in Section 5.

2.1.2 Subcommittee Meetings

Subcommittees met on an as-needed basis, often twice a week for short periods of time. Table 1 lists the subcommittees and chairs that were established to complete the water plan:

Table 1. Subcommittees and Chairs of the Jemez y Sangre Water Planning Council

Subcommittee	Chair	Period of Activity
Public Involvement/Public Welfare Subcommittee	Consuelo Bokum 1000 Friends of New Mexico	1998-2003
Population Subcommittee	Moises Gonzales Rio Arriba County Planner	1999-2000
Technical Subcommittee	Amy Lewis City of Santa Fe Water Resource Planner	1998-2001
Legal Subcommittee	Peter Chestnut Northern Pueblo Tributary Water Rights	1999-2002
Pueblo Subcommittee	Ernest Mirabal Nambe Pueblo	1998-2003
Alternatives Subcommittee	Paul Aamodt LANL and water rights holder in Nambe-Pojoaque	2001-2002
Executive Committee	Estevan Lopez, Santa Fe County Bob Vocke, LANL (co-chair) Elmer Salazar, LANL (co-chair)	1998-1999 2000-2003

Subcommittees were open to participation by the public. Subcommittees worked together to develop the scope of works and request for proposals issued to complete the work. Participants were on the selection committees and assisted in the review of work products. This process brought a degree of confidence that the report results were not biased or designed to one view point. The Alternatives Subcommittee included several citizens who attended the public meetings and volunteered to work on developing alternatives.

Subcommittee participants are listed in Appendix A3. Individuals who participated in a subcommittee do not necessarily sanction this plan or any part of it.

2.2 Strategy Chosen to Maximize Public Involvement

Public involvement during the planning process occurred at different levels, with the primary level of involvement occurring at JySWPC meetings. The next level of involvement was through public meetings held at key points in the planning process to inform the public and to obtain public input on the plan formulation. The third level of involving the general public was through communication and educational activities of the JySWPC such as newsletters, press releases, and press coverage of public meetings. These different levels of involvement are described in Sections 2.2.1 through 2.2.3.

The JySWPC established the Public Involvement/Public Welfare Subcommittee, chaired by Consuelo Bokum of 1000 Friends of New Mexico. The subcommittee was to:

- Plan for and supervise the process for public involvement
- Develop the foundation for the public welfare and community values sections of the regional plan

In 1999, the subcommittee contracted with Lucy Moore, Roberto Chene, and Rosemary Romero to provide design, facilitation, and summary services for public meetings, workshops, and Council meetings, as needed (Appendix A3). The subcommittee also contracted with Ed Moreno, a public relations expert, to help write news articles and prepare presentation materials for improved communication to the public and to ensure that the plan was easily accessible to the public.

2.2.1 Level I Involvement: Council Members

2.2.1.1 Dissemination of Information at Council Meetings

JySWPC meetings were held once a month and included a status report on subcommittee work. During periods when the JySWPC was awaiting the results of work from the contractors, presentations were given by JySWPC members or other officials to discuss important water issues. This helped Council members become informed about water issues and the concerns of other partners in the planning process. Appendix C1 contains a list of presentations on key water resource issues given at JySWPC meetings. Minutes of public meetings are provided in Appendix C2.

2.2.1.2 Workshops

Two significant workshops were held with the entire JySWPC. The first workshop was a week-long charrette, held in February 2002, designed to evaluate the alternatives developed by the alternative subcommittee. Experts from the southwestern United States were invited to prepare white papers on the various alternatives and to meet with JySWPC members to discuss the technical and legal implications of the alternatives. This format gave JySWPC members the opportunity to learn in detail about the value of the alternatives and ask questions of the experts. White papers were developed for each of the alternatives, as discussed in Section 7.

The second workshop was held in November 22, 2002 to discuss “area of origin” and the establishment of Critical Management Areas (CMAs). Elected officials were invited so that they could learn about regional water planning issues and help the Council address some of the more difficult ones. A summary of the workshop is provided in Appendix C2.

2.2.2 Level II Involvement: Public Meetings for Information and Feedback

2.2.2.1 Public Meetings

The JySWPC held its first series of public meetings in February 2001. Meetings were held in each of the ten sub-basins within the region to discuss the results of the water supply analysis. The JySWPC presented the sub-basin water budgets and the projected water demand based on population projections. Members of the public were asked to provide feedback about their values for the public welfare statement and to assist in developing alternatives to address the water supply problems. Meeting participants were given the opportunity to complete a survey form, which provided the JySWPC with specific feedback on public welfare values (Section 2.3).

A second set of public meetings was held in October 2002 to explain the results of the alternatives analysis and obtain feedback on the draft public welfare statement. A final meeting, to present the Jemez y Sangre Regional Water Plan to the public, is planned for the spring of 2003. Table 2 shows the dates and times of these public meetings. Summaries of the public meetings are provided in Appendix C2.

Table 2. Locations and Dates of Public Meetings

Location	Date
First Series of Public Meetings	
Velarde	February 1, 2001
Los Alamos	February 7, 2001
La Cienega	February 8, 2001
Española	February 13, 2001
Tesuque	February 15, 2001
El Dorado	February 19, 2001
Santa Fe-Sweeny	February 20, 2001
Santa Fe-Community College	February 21, 2001
Pojoaque	February 22, 2001
Cerrillos	February 27, 2001
Galisteo	March 8, 2001
Second Series of Public Meetings	
Santa Fe Sweeney Center	October 2, 2002
Cerrillos Fire Station	October 3, 2002
El Convento, Española	October 7, 2002
Final Public Meeting	
Santa Fe	May 2003 (anticipated)

2.2.2.2 Outreach to Specific Groups

Many people are uncomfortable attending large public meetings. For this reason, the JySWPC reached out to existing groups by presenting an overview of the regional water planning effort at various organizational meetings. Table 3 lists meetings attended by JySWPC members as part of this effort.

Table 3. Presentations About the Jemez y Sangre Water Planning Effort

Organization/Meeting	Presenter	Date
Northern Pueblo Tributary Water Rights Association	Amy Lewis, Mike Hamman	November 10, 1997
NM Acequia Commission	Amy Lewis	December 19, 1997
Santa Fe Land Use Resource Center Water and Growth Decisions Conference	Amy Lewis	May 16, 1998
Eight Northern Indian Pueblos	Amy Lewis	July 13, 1998
Nambe Pueblo Council Meeting	Amy Lewis, Mike Hamman	July 23, 1998
Northern Pueblos Tributary Water Rights Association	Amy Lewis, Mike Hamman	August 11, 1998
Tesuque Pueblo	Amy Lewis, Mike Hamman	August 25, 1998
City Council	Amy Lewis, Mike Hamman	August 26, 1998
Northern NM Acequia Workshop	Amy Lewis	November 20, 1998
Northern Tributary Water Rights Association	Amy Lewis, Mike Hamman	August 30, 1999
Judge Leslie Smith and Parties to the Aamodt Adjudication	Amy Lewis	September 27, 1999
League of Women Voters	Amy Lewis	January 13, 2000
Rio Arriba County Commissioners and Planning Department	Amy Lewis	February 9, 2000
Middle Rio Grande Water Planning Council	Amy Lewis	July 19, 2000
Old Santa Fe Association	Estevan Lopez, Amy Lewis	July 18, 2000
Santa Fe Board of Realtors	Amy Lewis	September 6, 2000
CLE Water Law Conference	Estevan Lopez, Amy Lewis, Peter Chestnut, Patricio Garcia	September 20, 2000
Regional Planning Authority	Amy Lewis	November 16, 2000
Santa Fe Geological Society	Amy Lewis	November 21, 2000
Santa Fe City Council	Amy Lewis	February 14, 2001
Decision Makers Conference	Amy Lewis	May 2001
City of Santa Fe Public Works/CIP & Land Use Committee	Amy Lewis	November 13, 2001
Regional Planning Authority	Amy Lewis	February 2002
Public Utilities Committee	Ed Moreno	September 4, 2002
Santa Fe Economic Development	Ed Moreno	September 10, 2002
Rio Arriba County Commission Meeting	Amy Lewis, Ed Moreno	September 26, 2002
Española City Council Meeting	Amy Lewis, Ed Moreno	October 1, 2002
Middle Rio Grande Planning Council	Lucy Moore, Ed Moreno	November 7, 2002
Board of Realtors	Conci Bokum	December 4, 2002

2.2.3 Level III Involvement: Public Education

2.2.3.1 Fact Sheets

The Public Involvement/Public Welfare Subcommittee developed a flyer that explained the purpose of regional water planning and distributed this flyer at public meetings, beginning early in the process. The flyer is provided in Appendix C3.

Fact sheets were also developed to help inform the public about key issues related to water planning. These fact sheets, which covered topics such as water law in New Mexico, public welfare, and a glossary of terms, are provided in Appendix C3.

2.2.3.2 Newsletters

The JySWPC contracted with an individual to prepare newsletters that were mailed to over 1,200 people interested in water resource issues. The first four newsletters were made possible through a grant from the Los Alamos Community Foundation. Copies of the newsletters are provided in Appendix C4.

2.2.3.3 Use of the Media

Press releases were sent to the two primary newspapers in the area and to organizational newsletters. Through these efforts, the planning process received excellent coverage. Copies of newspaper articles are provided in Appendix C4.

2.3 Public Welfare

A public welfare statement was developed by the JySWPC, in part from information collected from a survey form distributed during public meetings. The adopted public welfare statement is provided below. A fact sheet on public welfare was also developed (Appendix C3).

PUBLIC WELFARE STATEMENT FOR JEMEZ Y SANGRE REGION

Water is the element that interconnects all people and their environment in the Jemez y Sangre region, and the region to the larger environment that is the earth. Every person living in the region expects enough water for basic needs, and every person has the responsibility to protect water resources and use their share wisely. Using the best possible information, water planning and decision making should balance diverse needs and reflect the values of the region.

Rural and Wildlands Character

Residents of the Jemez y Sangre region place great value and importance on the preservation of the rural character of the region. Urban and rural residents alike appreciate and wish to maintain the historic, agriculture-based communities, rural vistas, wildlife habitat and attributes of natural landscapes including rivers, streams and trees.

Water Sustainability

Residents understand that the history of the region reflects water scarcity and cycles of drought. It is a high priority of residents of the region to serve current and future human needs without long-term depletion of the available water supply, while maintaining acceptable water quality and healthy interdependent ecological systems. Sustainability requires a combination of efforts, including encouraging conservation and efficiency by all sectors at every scale, discouraging activities that deplete or degrade the water supply, planning for population growth and land use, seeking new water sources that do not impair other regional values, and improving the use of existing water supplies.

Economic Sustainability

Each sub-region has unique economic needs and conditions that depend on the availability of water. It is important to have quality jobs and a healthy economy in order to maintain a good quality of life in the long term.

Water Quality

Water quality is a significant consideration in the region's water supply. In many sub-basins, the available groundwater has been compromised by contamination, either human caused or natural. Wastewater treatment and reuse of treated water should be expanded throughout the region. The available water should be protected from potential contamination from the impacts of human activities or natural events.

Rights and Responsibilities

Water planning must be carried out in a context of respect for water rights and property rights. Like all rights, the right to use water, especially in an arid region, is married to the responsibility to use water efficiently and wisely. The Jemez y Sangre region respects the senior water rights of the pueblos in the region and recognizes pueblos' tribal sovereignty.

Decision Making

In this demographically and geographically diverse region, it is necessary for all governmental and private entities to work together to achieve the goal of a balanced and sustainable water future. Fostering healthy, vibrant communities requires a commitment to open, inclusive dialogue and decision making.

3. Background Information

Much of the information provided in this section is summarized from Duke (2001) and BBER (2000 and 2002); additional information was obtained from State of New Mexico and U.S. government web sites (NMEDD, 2002; NMBGMR, 2002; NMEMNRD, 2002; National Park Service, 2002).

3.1 Description of Region

The Jemez y Sangre Water Planning Region, which covers approximately 1,892 square miles, includes most of Santa Fe County, all of Los Alamos County, and a small part of the southern half of Rio Arriba County. Two small portions of Sandoval County are also within the planning region boundaries; these areas were included in the hydrological assessment but have virtually no impact on the regional demographics. The region encompasses the drainage area of the Rio Grande from Embudo on the north to south of Galisteo, between the crest of the Sangre de Cristo Mountains on the east to the Jemez Mountains near Los Alamos (Figure 1).

The area covered by the Jemez y Sangre Water Planning Region is essentially equivalent to the Española and Galisteo structural basins proposed by Baltz (1978), which makes it appropriate for a water planning region from a hydrological point of view. The northern, southern, and eastern boundaries of the region correspond to the boundaries of other regional water plans (Chama, Taos, Pecos, Estancia). The southern two-thirds of the western boundary coincides with the Middle Rio Grande Planning Region.

The region has been divided into ten sub-basins based primarily on surface water flow divides, or in some cases, county lines (Figure 1). Moving in a generally north to south direction these sub-basins are:

- Velarde
- Santa Cruz
- Santa Clara
- Los Alamos

- Pojoaque-Nambe
- Tesuque
- Caja del Rio
- Santa Fe River
- North Galisteo Creek
- South Galisteo Creek

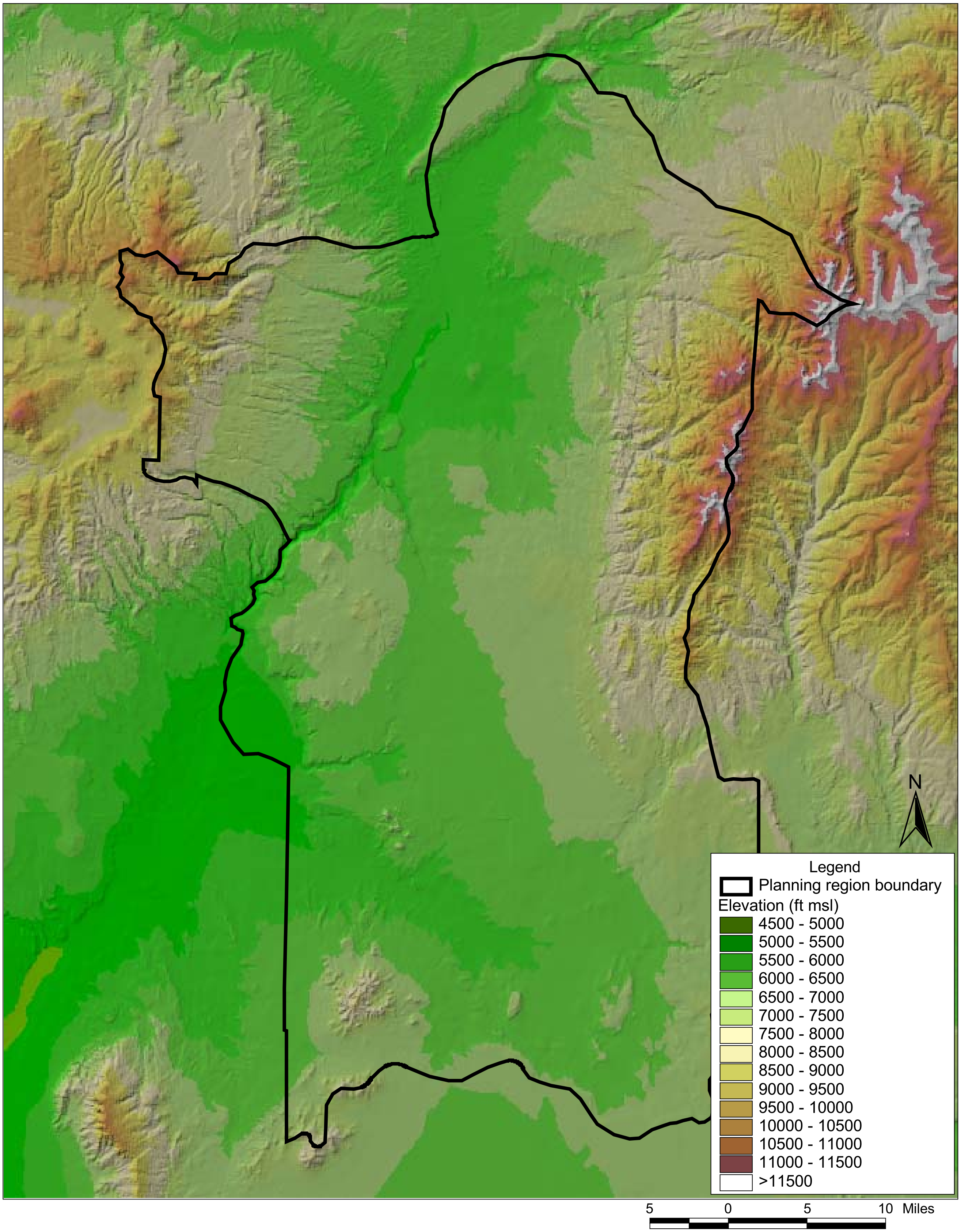
All of the sub-basins contain one or more tributaries of the Rio Grande and are thus hydrologically interrelated. As a result, understanding the relationships among the sub-basins is critical to regional water planning and management. Section 3.3 provides a more detailed discussion of the characteristics of each sub-basin.

3.1.1 Geography and Landscape

Most of the planning region falls within the Española Basin, a geologic structural feature; a small portion of the southern region lies within the northernmost part of the Albuquerque geologic basin. The Rio Grande, which flows through the region in a generally north-south direction, is the main hydrologic feature. It also defines the lowest topographic area of the region, the Rio Grande Valley, which is situated from 5,200 to upwards of 5,700 feet above mean sea level (ft msl) (Figure 2). To the east of the Rio Grande are the high peaks of the Sangre de Cristo Range, some of which exceed 12,500 ft msl. The Jemez Mountains, on the northwest boundary of the planning region, represent another topographic high point, with elevations in excess of 10,000 ft msl.

3.1.2 Climate

Climate in the Jemez y Sangre planning region varies from semiarid to alpine, depending primarily on elevation. Mean annual temperatures at weather stations in the planning region range from 47.9°F (Los Alamos) to 54.3°F (Cochiti Dam). Throughout the planning region, January is typically the coldest month and July the warmest, with mean annual minimum temperatures ranging from 32.2°F (Bandelier National Monument) to 39.9°F (Cochiti Dam), and



JEMEZ Y SANGRE REGIONAL WATER PLAN

Digital Elevation Model of the Planning Region

Figure 2

(S:\PROJECTS\9419\GIS\PROJECTS (PROJECT = jemezy-5-00_duke2.apr) (VIEW EXTENTS = TEMP) (VIEW NAME = V02 - D) (LAYOUT = Fig 02) mean maximum temperatures ranging from 59.8°F (Los Alamos) to 68.8°F (Española). More detail about regional climate and its influence on water supply is provided in Section 5.1.

3.1.3 Natural Resources

A substantial portion of the mountainous areas of the planning region fall under the jurisdiction of the U.S. Forest Service (Santa Fe National Forest). These areas are used primarily for recreational purposes and timber harvesting, and livestock grazing. They are also prime locations for wildfire. Of 20 communities identified in New Mexico as being vulnerable to wildfire, 3 are in the Jemez y Sangre Water Planning Region and several others are near the boundaries of the region. In addition to the potential loss of property associated with such fires comes the threat of degradation to the watershed through increased erosion and surface runoff.

Bandelier National Monument, which covers approximately 33,000 acres of land in the northwestern part of the planning region, receives approximately 300,000 visitors each year. In addition, 90,000 acres in the nearby Valles Caldera became a national preserve in 2000. The Santa Fe Ski Basin and nearby Hyde Memorial State Park are favorite recreational areas in the Sangre de Cristo Range. Hiking, backpacking, and fishing in the Jemez and Sangre de Cristo Mountains attract many tourists as well as local residents to these areas each year.

The planning region contains several economic mineral deposits, including pumice (Santa Fe and Rio Arriba Counties), mica (Rio Arriba County), sand and gravel (Santa Fe and Rio Arriba Counties), and gold (Ortiz Mountains, Santa Fe County).

3.1.4 Major Surface and Groundwater Resources

The Rio Grande, which drains south through the region from Embudo to Cochiti Reservoir, is the major surface water feature. The Rio Chama, which flows into the Rio Grande near the northwest boundary of the planning region, contributes a significant amount of water to the region. As mentioned, the planning region is divided into ten sub-basins defined primarily on the basis of watershed attributes, although some sub-basin boundaries coincide with county lines. The Santa Clara and Los Alamos Sub-Basins encompass the east slope of the Jemez

Mountains and tributaries in these sub-basins drain east to the Rio Grande. Tributaries in the remaining eight sub-basins drain west from the Sangre de Cristo Mountains (Figure 3), as described in more detail in Section 3.3. The quality of the surface water in the region is generally very good to excellent.

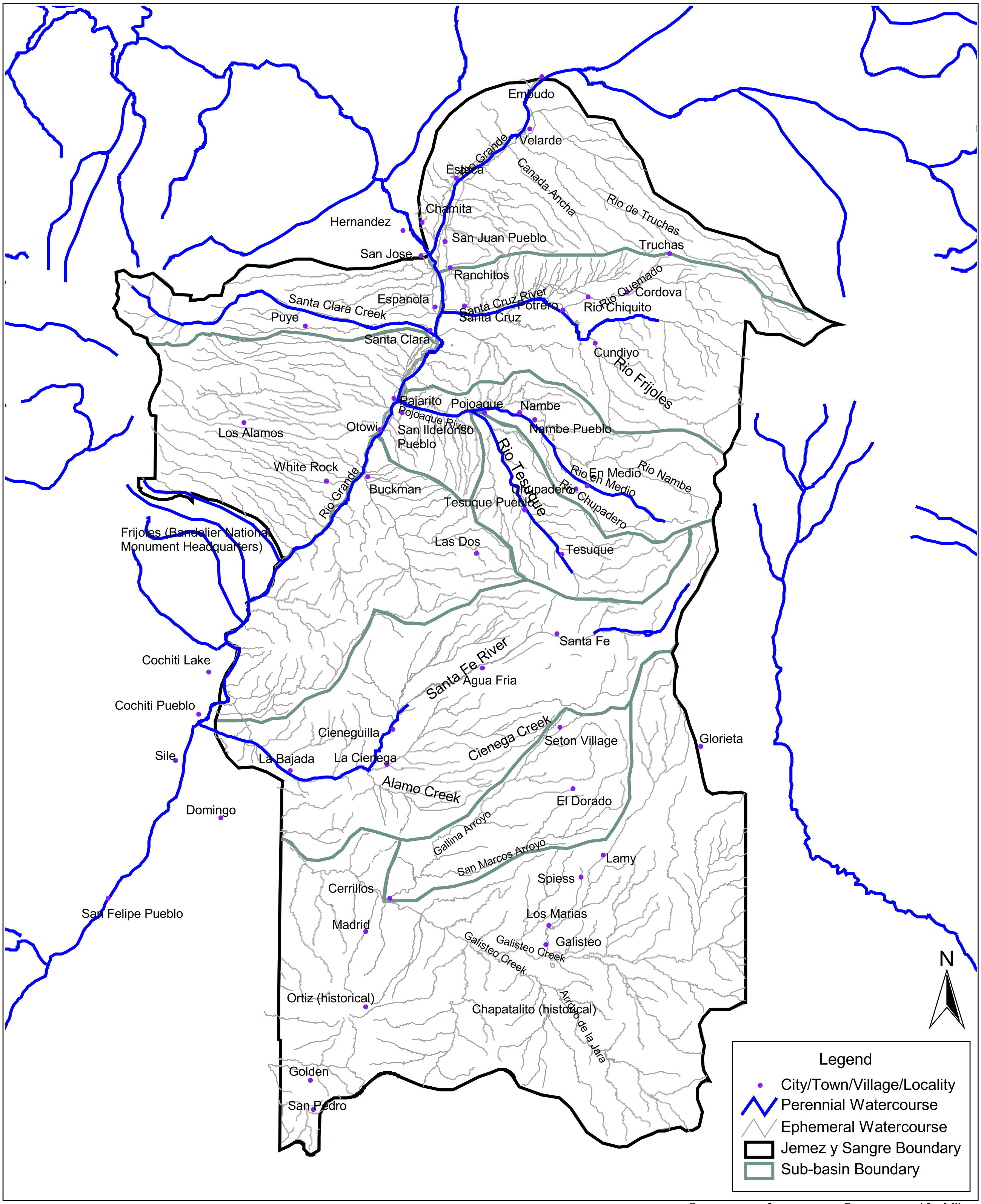
The Tertiary-age Santa Fe Group, which consists of the Tesuque, Ancha, and Puye Formations, is the primary aquifer in nine of the ten sub-basins (Figure 4). In the Rio Grande Valley, the Tesuque Formation has a thickness of more than 9,000 feet. A thin section of the Tesuque Formation supplies shallow wells in the North Galisteo Sub-Basin. The Galisteo Formation is the main water-bearing unit in the South Galisteo Creek Sub-Basin.

3.1.5 Demographics and Economy of the Region

Based on information provided by the BBER (2000), the population of the Jemez y Sangre Water Planning Region nearly doubled between 1970 and 1999. The current population is approximately 160,000, and is projected to reach approximately 360,000 by 2060. The three major employment centers are Santa Fe, Española, and Los Alamos.

Most of the population of the region resides in or near the City of Santa Fe. In 1999 the Santa Fe River Sub-Basin had approximately 86,000 people, or 54 percent of the region's population (Table 4). The Los Alamos and Santa Cruz Sub-Basins are currently the second and third most populous sub-basins, although projections indicate that both North Galisteo and Tesuque Sub-Basins will eventually overtake the slower-growing Los Alamos Sub-Basin. The Caja del Rio, South Galisteo, and Velarde Sub-Basins have the fewest residents and are expected to remain fairly small in population.

Historically (from 1970 to 1998), the population-to-job ratio for the planning region has been in the range of 1.8 to 2.4. Los Alamos and Santa Fe Counties rank first and second in per capita income among the 33 counties of New Mexico, with most employment stemming from the government and services sectors. Tourism is also a major industry for Santa Fe, which boasts several colleges as well as numerous museums, art galleries, and cultural attractions. The economy of Española, the second-largest municipality in the planning area, is based on the



Source: Duke, 2001 (Figure 3-1)

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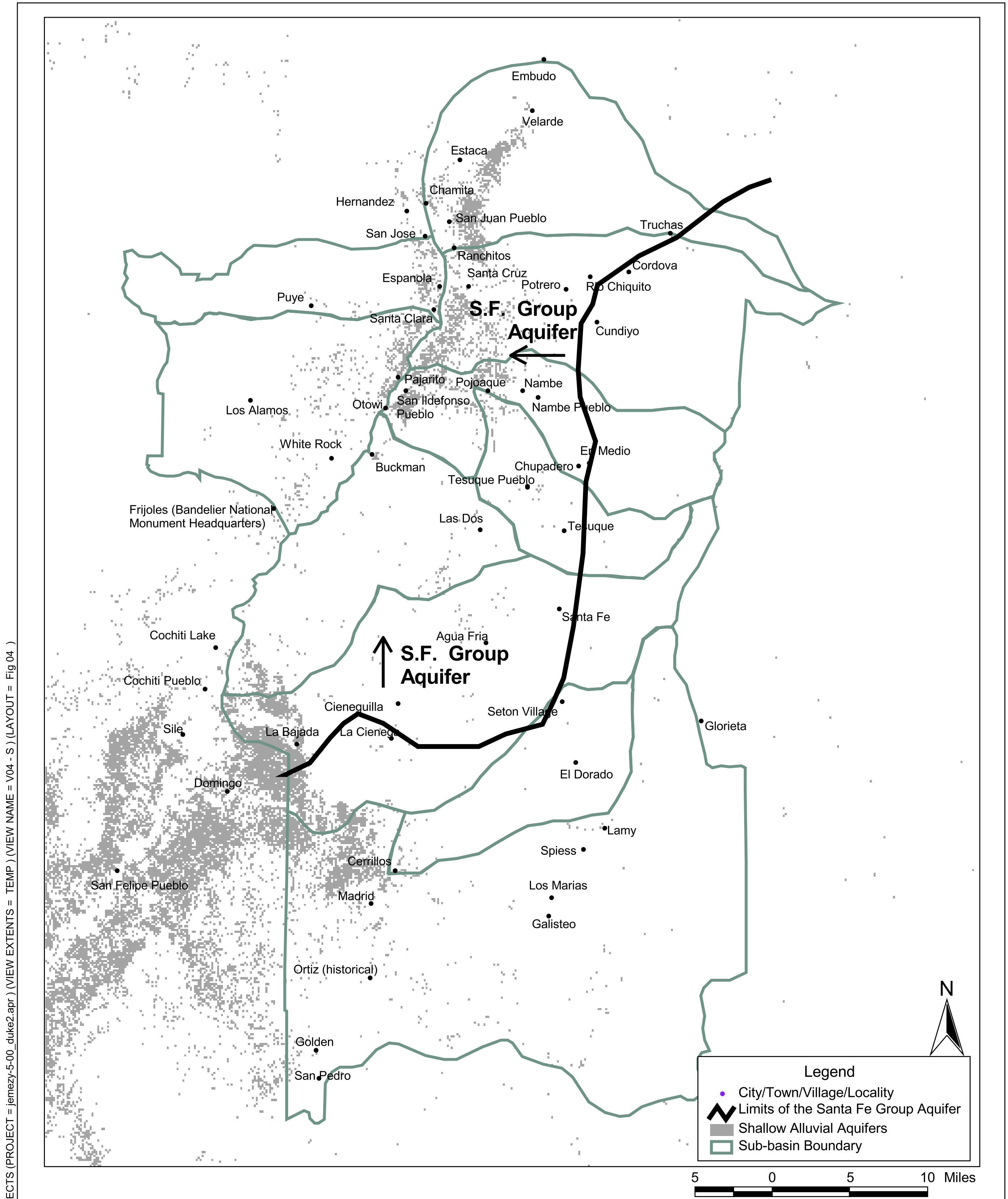
JEMEZ Y SANGRE REGIONAL WATER PLAN

Perennial and Ephemeral Watercourses

Figure 3



Source: Duke, 2001 (Figure 5-2)

JEMEZ Y SANGRE REGIONAL WATER PLAN

Southern and Eastern Extent of the Santa Fe Group and Distribution of Shallow Alluvial Aquifers

Figure 4

Table 4. Projected Population and Percentage Distribution in the Planning Region by Sub-Basin

Sub-Basin	July 1 Population Count							
	1990	2000	2010	2020	2030	2040	2050	2060
Velarde	3,671	4,974	5,637	6,313	6,861	7,311	7,729	8,130
Santa Cruz	18,094	20,768	23,713	27,435	31,104	34,788	38,847	43,383
Santa Clara	3,956	3,870	4,380	4,900	5,320	5,664	5,981	6,286
Los Alamos	18,609	19,758	20,509	21,422	22,105	22,573	22,862	23,137
Pojoaque-Nambe	4,794	6,280	7,559	9,580	11,988	14,799	18,229	22,383
Tesuque	3,268	4,859	6,898	9,306	13,818	17,263	23,026	30,422
Caja del Rio	262	554	693	912	1,185	1,518	1,942	2,476
Santa Fe River	71,961	87,709	104,092	118,824	132,404	14,3467	152,250	157,092
North Galisteo	5,834	11,072	13,837	18,208	23,658	30,326	38,785	49,449
South Galisteo	1,665	2,903	3,608	4,970	6,714	8,896	11,700	15,273
All sub-basins	132,115	162,486	190,926	221,870	255,157	286,605	321,171	358,031
Percentage Distribution								
Velarde	2.8	3.1	3.0	2.8	2.7	2.6	2.4	2.3
Santa Cruz	13.7	12.8	12.4	12.4	12.2	12.1	12.1	12.1
Santa Clara	3.0	2.4	2.3	2.2	2.1	2.0	1.9	1.8
Los Alamos	14.1	12.0	10.7	9.7	8.7	7.9	7.1	6.5
Pojoaque-Nambe	3.6	3.9	4.0	4.3	4.7	5.2	5.7	6.3
Tesuque	2.5	3.0	3.6	4.2	5.4	6.0	7.2	8.5
Caja del Rio	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7
Santa Fe River	54.5	54.0	54.5	53.6	51.9	50.1	47.4	43.9
North Galisteo	4.4	6.8	7.2	8.2	9.3	10.6	12.1	13.8
South Galisteo	1.3	1.8	1.9	2.2	2.6	3.1	3.6	4.3
All sub-basins	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Notes: The 1990 population figures in this table are for July 1, 1990.
Population projections represent “most-likely” scenario (BBER, 2000) with 2002 update.

Sources: BBER, 2000 (Table 2-14)
BBER, 2002

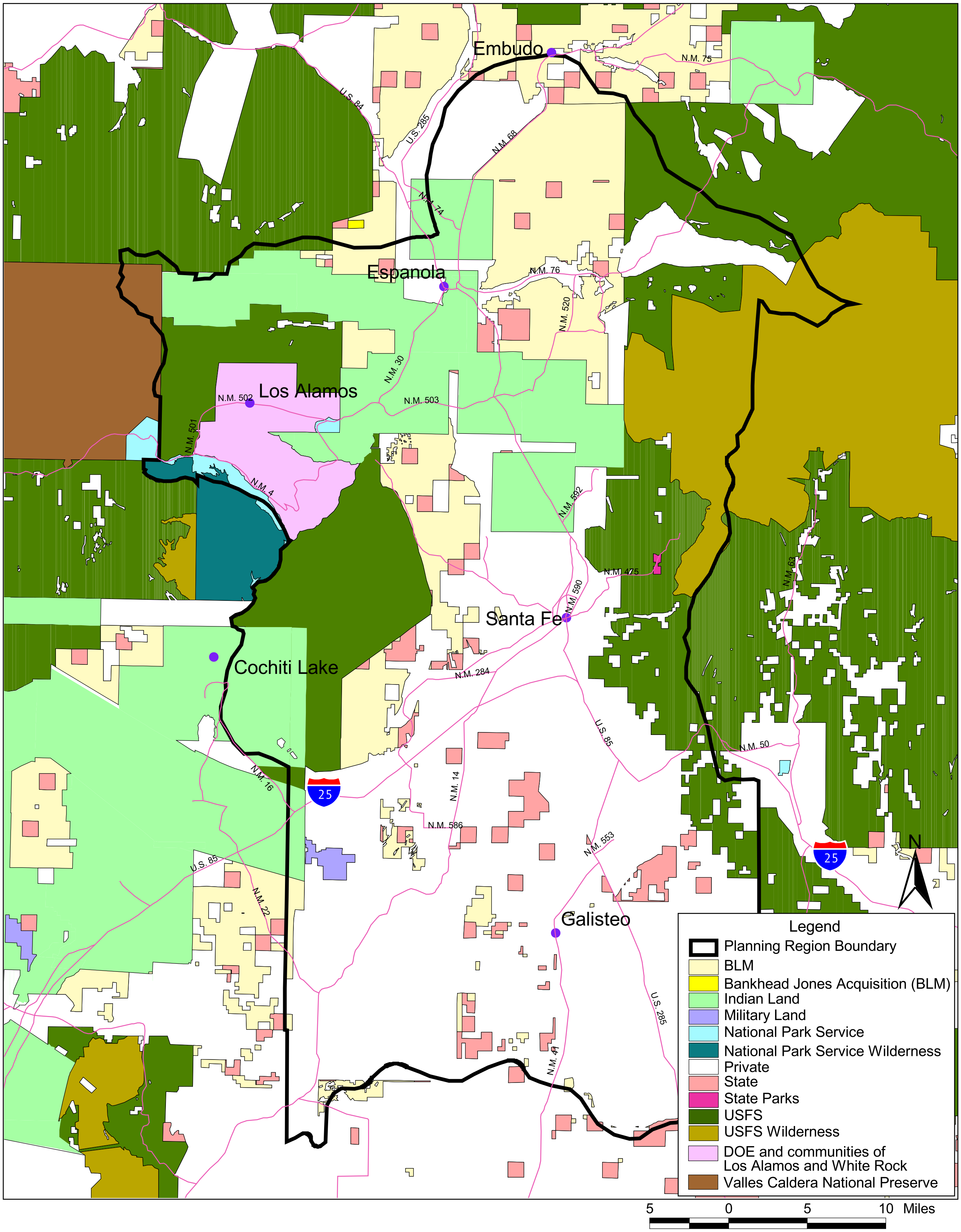
retail, services, and government sectors, with farming and recreational opportunities in the surrounding area. Nearby LANL employs nearly 14,000 people in the Los Alamos Sub-Basin and is the leading economic force in northern New Mexico. In Los Alamos County (all of which falls within the Los Alamos Sub-Basin), 50 to 60 percent of all jobs are with government agencies, while the remaining retail, services, and construction jobs are indirectly linked to the government sector (BBER, 2000).

The economy of much of the rest of the planning region depends on either the nearby municipalities (Santa Fe, Española, Los Alamos, and sometimes, Albuquerque), or on farming, ranching, and the government and services sectors. In the more northern parts of the region such as the Velarde Sub-Basin, government spending in the form of construction projects, transfer payments, and wages, is an important source of personal income (BBER, 2000). During 1997, the average annual net income per farm in Rio Arriba County was approximately $2,000.

3.1.6 Land Ownership and Land Use

The planning region contains a mix of public, private, and Pueblo lands, as well as some state-managed land, three major municipalities, and numerous smaller communities (Figure 5). A substantial portion of the mountainous areas of the planning region falls under the jurisdiction of the U.S. Forest Service (Santa Fe National Forest) and is used primarily for recreational purposes timber harvesting, and grazing. The U.S. Forest Service also has overall responsibility for the recently established Valles Caldera National Preserve, which is managed by the Valles Caldera Trust. The National Park Service manages nearly 33,000 acres of park and wilderness lands in Bandelier National Monument. Within Los Alamos County, the University of California manages LANL, which covers an additional 43 square miles (approximately 27,500 acres) of land.

Major cities and towns of the region include Santa Fe, Española, and Los Alamos, with numerous smaller towns and unincorporated developments throughout the planning region (see individual sub-basins discussions in Section 3.3). Much of the land in the Española Valley is in private ownership and used as small farms.



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JEMEZ Y SANGRE REGIONAL WATER PLAN

Land Ownership/Status

Figure 5

Six Pueblos (Pueblo of Nambe, Pueblo of Pojoaque, Pueblo of San Ildefonso, Pueblo of San Juan, Pueblo of Santa Clara, and Pueblo of Tesuque) are located in the northwestern and west-central portions of the planning region. Portions of two other Pueblos (Pueblo of Cochiti and Pueblo of Santo Domingo) are included in the southwestern border of the region. Altogether, approximately 167,700 acres within in the planning region are designated Pueblo lands.

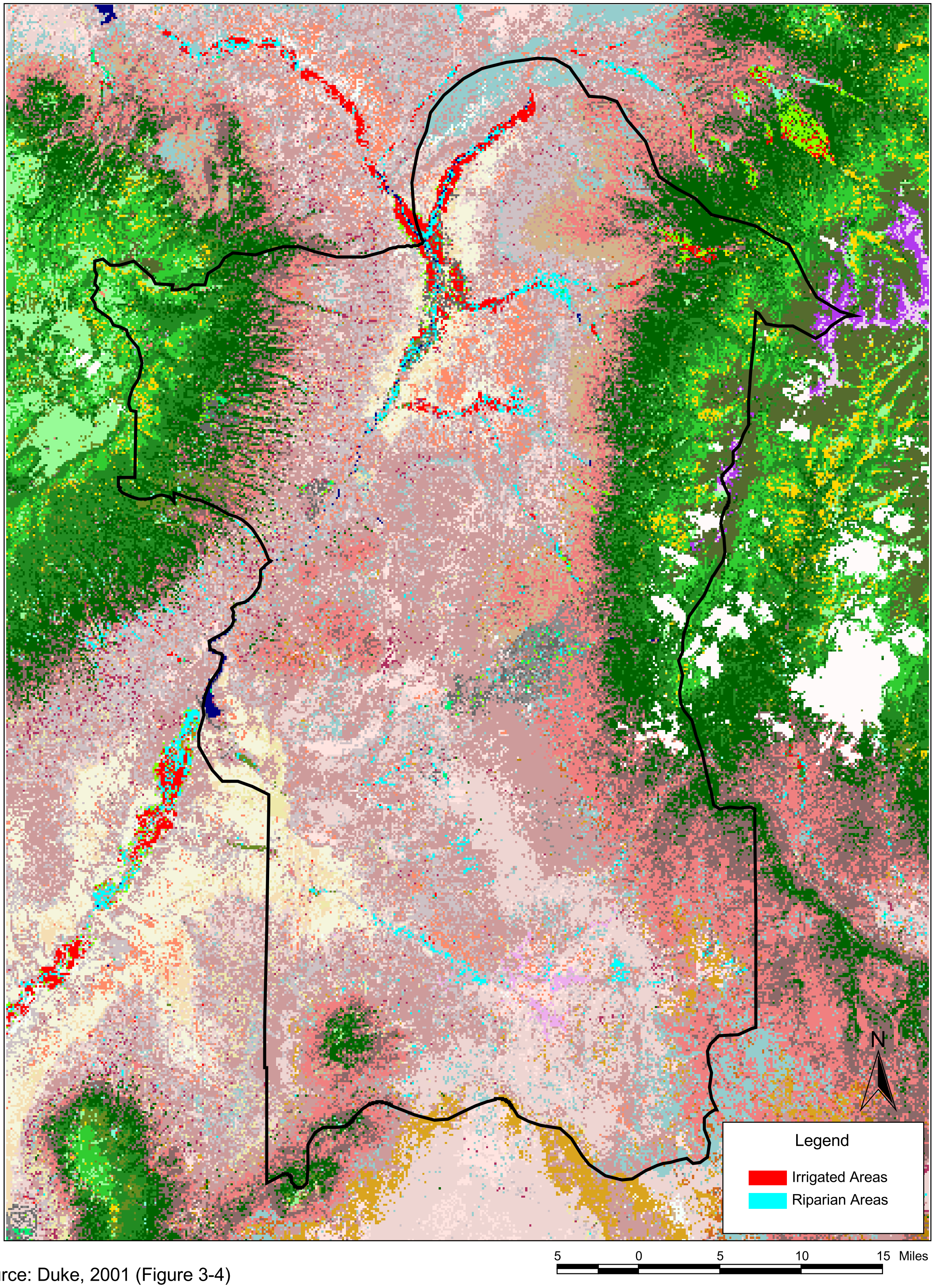
As shown in Figure 6, irrigated lands are found throughout the planning area, especially along major waterways and adjacent to the mountainous areas on the western and eastern edges of the region. Riparian areas are most common along the Rio Grande and its major tributaries in the northern part of the region, around Santa Fe in the central part of the region, and along Galisteo Creek in the southern part of the region.

3.2 Overview of Historical Water Use in the Region

Water use is reported by the OSE for each county in New Mexico every five years. The OSE tracks water use in New Mexico using the following categories:

- Public water supply and self-supplied domestic
- Irrigated agriculture
- Self-supplied livestock
- Self-supplied commercial
- Industrial
- Mining
- Power
- Reservoir evaporation

The majority of the water use in the planning region is for agricultural, public water supply, and self-supplied domestic uses. Irrigated agriculture is the largest use category in the planning region and is responsible for about 70 percent of diverted water. About 25 to 30 percent of the total water used in the planning region is for public water supplies. Domestic use in the region is estimated to be about 7,700 acre-feet per year, and the use of domestic wells is a growing



Source: Duke, 2001 (Figure 3-4)

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JEMEZ Y SANGRE REGIONAL WATER PLAN

Land Use/Land Cover in the Planning Region

Figure 6

sector. Self-supplied livestock, commercial, industrial, mining, and power use categories each make us less than 1 percent of the use in the region. Reservoir evaporation is most significant in the planning region within Santa Fe County, but is less still less than 2 percent of the water use in the County. Detailed information regarding water use in the planning region for each of these categories is provided in Section 6.

3.3 Summary of Sub-Basins' Characteristics

Table 5 provides a summary of the physical characteristics of each of the ten sub-basins in the Jemez y Sangre planning region, which are discussed in more detail below. Summary discussions of water quality and water budget information for the sub-basins are provided in Sections 5 and 6. Duke (2001) provides more detailed characterizations of each sub-basin.

3.3.1 Velarde Sub-Basin

The Velarde Sub-Basin, which covers an area of 167 square miles within the planning region, includes the communities of Alcalde, Estaca, Velarde, and small portions of Española and San Juan Pueblo (Figure 1). Extending from an altitude of 12,300 ft msl at its highest point to 5,572 ft msl at the Rio Grande, the Velarde Sub-Basin encompasses some 6,730 feet of elevation relief. The average elevation of the sub-basin is 6,847 ft msl. The Velarde Sub-Basin receives an average annual precipitation of 12.2 inches.

Most of the sub-basin drains the Sangre de Cristo Range in the vicinity of the Truchas Peaks. A small portion of the sub-basin west of the Rio Grande drains slopes on the east side of Black Mesa, but does not contribute measurable volumes to the local surface water supply. The main streams draining the mountain slope are Rio de Truchas and Cañada de Las Entrañas. Arroyos that drain lower elevations include Arroyo del Pueblo, Arroyo Ocote, Cañada Ancha, Arroyo del Palacio, Arroyo de Los Chavez, Arroyo de Ranchitos, and Arroyo de Los Borregos.

Table 5. Summary of Sub-Basin Physical Attributes

Sub-Basin	Drainage Area (square miles)	Minimum Elevation (ft msl)	Maximum Elevation (ft msl)	Elevation Relief (feet)	Mean Elevation (ft msl)	Main Channel Mean Elevation (ft msl)	Main Channel Slope (feet/mile)	Average Annual Precipitation [a] (inches)	Average Potential Evapo-transpiration [b] (inches/year)
Velarde	167	5,572	12,306	6,734	6,847	6,976	123	12.2	22.1
Santa Cruz	206	5,494	12,982	7,488	7,672	7,108	147	16.3	19.1
Santa Clara	84	5,523	11,525	6,002	7,501	7,316	176	18.3	21.2
Los Alamos	173	5,359	10,423	5,064	7,073	7,047	230	17.8	18.6
Pojoaque-Nambe	123	5,494	12,621	7,127	7,489	7,247	182	16.9	21.1
Tesuque	77	5,753	11,844	6,091	7,272	6,335	91	15.3	21.8
Caja del Rio	158	5,244	7,399	2,155	6,395	6,130	80	12.0	26.0
Santa Fe River	284	5,257	12,136	6,879	6,742	6,332	62	12.4	24.0
North Galisteo Creek	93	5,720	8,229	2,509	6,661	6,258	64	13.0	24.0
South Galisteo Creek	527	5,405	10,512	5,107	6,595	6,086	38	14.0	24.0

Source: Duke, 2001 (Table 3-1)

[a] Average annual precipitation based on spatial weighting of precipitation contours shown in Figure 7 over entire sub-basin.
[b] Average potential evapotranspiration (PET) based on spatial weighting of PET contours shown in Figure 10 over entire sub-basin.

ft msl = Feet above mean sea level

3.3.2 Santa Clara Sub-Basin

The Santa Clara Sub-Basin encompasses 84 square miles on the eastern slopes of the Jemez Mountains north of Los Alamos and southwest of Española. The sub-basin is bounded on the west by the crest of the Jemez Mountains, on the south by the Los Alamos Sub-Basin, on the east by the Rio Grande, and on the north by the drainage divide located north of Santa Clara Canyon (Figure 1). The majority of land in this sub-basin is within the Santa Clara Pueblo reservation boundary in Rio Arriba County.

Santa Clara Creek is the only perennial stream in this sub-basin, but it has several ephemeral tributaries along its reach. The headwaters of Santa Clara Creek are at an elevation of 11,525 ft msl and its discharge at the Rio Grande is at an elevation of 5,523 ft msl, for a total relief of about 6,000 feet. The Santa Clara sub-basin receives an average of 18.2 inches of precipitation annually, mainly from mountain snow and summer monsoon rains.

3.3.3 Santa Cruz Sub-Basin

The Santa Cruz Sub-Basin encompasses just over 200 square miles east of Española, bounded on the west by the Rio Grande, on the north by the Velarde Sub-Basin, on the east by the crest of the Sangre de Cristo Mountains, and on the south by the Pojoaque-Nambe Sub-Basin (Figure 1). Most of the Santa Cruz Sub-Basin is in extreme northeast Santa Fe County and southeast Rio Arriba County. The sub-basin drains the western flanks of the Sangre de Cristo range between Pecos Baldy on the south and Truchas Peaks on the north. The elevation ranges from 12,980 ft msl in the Sangre de Cristo range to 5,490 ft msl at the Rio Grande, a relief of 7,490 feet from east to west. The main stream draining the sub-basin is the Santa Cruz River and its principal tributaries are the Rio Quemado, Rio Medio, and Rio Frijoles. Other significant drainages within the lower elevation areas of the sub-basin flow only after major storm events and include Arroyo Seco, Arroyo Madrid, and Arroyo de la Mesilla.

3.3.4 Los Alamos Sub-Basin

The Los Alamos Sub-Basin, which encompasses Los Alamos County and small portions of Rio Arriba and Santa Fe counties, consists of the relatively high mountains and deeply cut plateaus of the Jemez Mountains. Portions of Santa Clara Pueblo and San Ildefonso Pueblo occupy the eastern part of the sub-basin with the Rio Grande forming the eastern boundary (Figure 1). Most sub-basin residents live in Los Alamos or White Rock. Landholdings are largely federal, including Los Alamos National Laboratory.

The watersheds within the sub-basin encompass a total area of approximately 173 square miles. The sub-basin extends from a high elevation of 10,423 ft msl in the Jemez Mountains to about 5,360 ft msl at the Rio Grande where the southernmost tributary (Rito de los Frijoles) joins the main stem river; thus the total elevation relief is about 5,060 feet. Rather than comprising a single, main watershed with a distinct outlet, the Los Alamos Sub-Basin is characterized by several canyons that drain southeastward to eastward and are directly tributary to the Rio Grande. They include Guaje Canyon, Los Alamos Canyon, Pajarito Canyon, Water Canyon, Ancho Canyon, and Canyon de los Frijoles. Several other smaller canyons are tributary to these major canyons. Almost all streams within this sub-basin are considered ephemeral or intermittent.

3.3.5 Pojoaque-Nambe Sub-Basin

The Pojoaque-Nambe Sub-Basin drains an area of 123 square miles in the northern portion of Santa Fe County. The elevation ranges from 12,621 ft msl at the peaks of the Sangre de Cristo Range to 5,494 ft msl at the Rio Grande, for a total relief of over 7,000 feet. The Nambe, Pojoaque, and San Ildefonso Pueblos are located within the sub-basin boundaries and occupy most of its land area, while the Santa Fe National Forest covers its eastern area (BBER, 2000). The closest long-term precipitation station to the sub-basin is Santa Fe. Average precipitation is 13.84 inches but has varied from 5.03 inches to 21.75 inches.

The main streams in the watershed are the Nambe River, the Rio En Medio, Chupadero and the Tesuque, all of which combine to form the Pojoaque River. The Nambe River is the principal stream in the watershed and has the only surface water reservoir in the watershed. The normal reservoir storage capacity is 2,023 acre-feet.

3.3.6 Tesuque Sub-Basin

The Tesuque Sub-Basin is located north of Santa Fe with headwaters in the Sangre de Cristo Range south of Lake Peak (Figure 1). The Tesuque Sub-Basin watershed encompasses 77 square miles and ranges from 11,850 ft msl on the east to 5,750 ft msl at the confluence of the Rio Tesuque and Pojoaque Creek, for a total relief of 6,100 feet across the sub-basin. Precipitation averages 15.3 inches per year, most of which results from winter snow, and brief but intense summer thunderstorms. Higher elevations receive significantly more precipitation than the lower areas along the Rio Tesuque.

The eastern portion of the sub-basin consists mostly of Santa Fe National Forest land, the central portion is Tesuque Pueblo land, and the northwestern area includes parts of the Nambe and Pojoaque Pueblos. Within the sub-basin, Tesuque and Little Tesuque Creeks flow generally west from the Sangre de Cristo Range, converging to form the north-northwest flowing Rio Tesuque. The Rio Tesuque eventually joins Pojoaque Creek to form the Pojoaque River, which in turn flows west to the Rio Grande.

3.3.7 Caja del Rio Sub-Basin

The Caja del Rio Sub-Basin is situated in the western part of Santa Fe County and includes a portion of San Ildefonso Pueblo (Figure 1). The Rio Grande forms the western boundary of the sub-basin. The Caja del Rio Sub-Basin, located between the combined Tesuque and Pojoaque-Nambe watershed on the north and the Santa Fe River Sub-Basin on the south, has a combined drainage area of about 158 square miles.

Elevations in this sub-basin vary from 7,400 ft msl at the highest point to about 5,150 ft msl feet at the Rio Grande near the sub-basin’s south boundary. The Caja del Rio Sub-Basin receives an annual average precipitation of 12 inches. The Caja del Rio Sub-Basin has several watercourses and arroyos that originate within it and are directly tributary to the Rio Grande.

Two additional drainages occurring in the northern half of the sub-basin are defined respectively by Thirty-one Draw and Arroyo Eighteen. Drainages in the southern half include Santa Cruz Arroyo, Arroyo Tetilla, and Arroyo Colorado, the latter two of which combine to form Canada de Cochiti, a tributary to the Rio Grande. The only available surface water records show some spring flows close to the Rio Grande.

3.3.8 Santa Fe River Sub-Basin

The Santa Fe River Sub-Basin, which drains the southern extent of the Sangre de Cristo Range and covers a total area of 284 square miles, contains the largest municipality within the region, the City of Santa Fe (Figure 1). The sub-basin has a total elevation relief of 6,900 feet, extending from 12,150 ft msl down to 5,250 ft msl at the Rio Grande. Average annual precipitation in the Santa Fe River Sub-Basin is 12.4 inches, with a minimum recorded precipitation of 5.03 inches and a maximum of 21.75 inches during the period 1868-1996.

The Santa Fe River is the most significant surface water resource within the sub-basin. Major tributaries to the Santa Fe River include Arroyo Hondo, Arroyo Calabasas, Cienega Creek, and Alamo Creek. The Santa Fe River is perennial from Santa Fe Lake at 11,700 ft msl to Nichols Reservoir and from the City wastewater treatment plant (southwest of Santa Fe) to Cochiti Lake. The natural outlet for the Santa Fe River is at the Rio Grande about 2 miles south of Cochiti Lake, but the river’s discharges are diverted northward to the lake about 3 miles upstream of the natural outlet.

3.3.9 North Galisteo Sub-Basin

The North Galisteo Creek Sub-Basin lies immediately south of the Santa Fe River Sub-Basin (Figure 1). The sub-basin has a drainage area of 93 square miles and an elevation relief of 2,510 feet, with land elevations ranging from 8,230 to 5,720 ft msl. The watershed receives an average annual precipitation of about 13 inches. The community of Cerrillos is located in the western tip of the sub-basin, while Eldorado, Eldorado at Santa Fe, Seton Village, Cañada de los Alamos, and San Sebastian are situated progressively to the east. Galisteo Creek does not actually flow within the sub-basin; however the drainages in the North Galisteo Creek Sub-Basin eventually empty into Galisteo Creek to the south. The main stream within this sub-basin is the southwest-trending Gallina Arroyo, formed by the merging of Cañada de las Minas and Cañada Ancha in the foothills near the southern extent of the Sangre de Cristo Range. San Marcus Arroyo joins Gallina Arroyo about two miles upstream of the watershed's outlet at Galisteo Creek.

3.3.10 South Galisteo Sub-Basin

The South Galisteo Creek watershed is the largest of the planning region's sub-basins, encompassing about 527 square miles. The Ortiz Mountains form part of the watershed's south boundary, while part of the eastern boundary of the defined sub-basin is formed by the eastern boundary of Santa Fe County and the entire western boundary of the sub-basin coincides with the border between Santa Fe and Sandoval Counties (Figure 1). The South Galisteo Creek Sub-Basin varies in elevation from 10,500 ft msl in the Sangre de Cristo Mountains to about 5,400 ft msl at the western Santa Fe County line. Lamy, Galisteo, Golden, and Madrid are the major communities in the sub-basin, which also contains an unpopulated portion of the Santa Domingo Pueblo land.

In upper portions of the watershed, Apache Canyon River and Galisteo Creek combine to drain about 32 square miles of the southern end of the Sangre de Cristo Mountains. For the initial 15 miles below the confluence of these two streams, Galisteo Creek flows toward the southwest. West of Galisteo, the creek flows west-northwest until it joins the Rio Grande about 5 miles west of the Santa Fe County/Sandoval County line. Tributaries to Galisteo Creek include Cañada Estacada, Arroyo de la Jara, Gavisco Arroyo, Cunningham Creek, and Arroyo Charro. Some geologic units in the sub-basin form an aquifer, but generally these are thin, entirely bounded laterally by low permeability rocks that receive little recharge. Thus, on a regional scale, they are not considered to be significant water-bearing units.

4. Overview of Water Law Applicable to Jemez y Sangre Water Planning Region

Water management is impacted by numerous municipal, state, tribal, and federal laws that control the transfer, use, and quantity of diversions and protect water quality. A report entitled *Overview of Water Law Applicable to this Region of New Mexico* is presented in Appendix D. This report, prepared by Kery, Belin, and Utton (2001a) under the direction of the JySWPC Legal Subcommittee chaired by Peter Chestnut, provides a comprehensive summary of applicable laws. Appendix D also contains a detailed discussion of key legal issues affecting the Jemez y Sangre region (Kery, Belin, and Utton, 2001b) and an analysis of legal issues pertaining to area of origin protections and critical management areas (Kery and Utton, 2002).

4.1 Overview of Water Law

The following summary of laws and legal agreements is taken from the *Overview of Water Law Applicable to this Region of New Mexico* (Appendix D1).

4.1.1 New Mexico Water Law

New Mexico water law covers the following issues:

- Prior appropriation and beneficial use
- Administration of water rights
- Appropriation and transfer of water rights and state permitted uses
- Other state agencies addressing water rights
- Water rights adjudication
- Local and regional water planning
- Water project financing

4.1.2 Pueblo Water Rights

Pueblo water rights are important in the Jemez y Sangre region, and are independent from state allocation law, regulation, and administration. Pueblos have aboriginal rights to water that date back to the Pueblos' existence as autonomous societies and the use of their lands and waters. These rights, which include historically irrigated acreage rights, seniority against all non-Pueblo users, and rights to water in temporary catchments and water for domestic and business use result from the application of very old principles of international law dating back four or five centuries. In addition, Pueblos have federally reserved water rights where lands outside Pueblo grants have been reserved for them by the United States.

4.1.3 Federal Law

In addition to federally reserved rights for Pueblos, federal law covers reserved water rights for land set aside for specific purposes (e.g., forest and park lands). In addition, several important federal acts (e.g., the ESA, National Environmental Policy Act [NEPA], Clean Water Act [CWA], etc.) affect the exercise of water rights and availability. Water availability issues related to the ESA and NEPA are discussed in more detail under Sections 4.2.4 and 4.2.5; more on the CWA is provided in Section 4.1.7.

4.1.4 San-Juan Chama Project

The SJC Project is a federal water project built in the 1960s to transport approximately 110,000 acre-feet per year (afy) of water from the San Juan River system to the Rio Grande via the Chama River. The purpose of the project was to make water to which New Mexico is entitled under the Colorado River compacts available for use in the Rio Grande Basin, where water has been in short supply. Several entities in the Jemez y Sangre planning region have contracts for SJC water, including the City and County of Santa Fe, Los Alamos County, City of Española, Pojoaque Valley Irrigation District (PVID), and the USACE.

Use of the SJC project water requires an OSE permit obtained through the same permitting process as for native river flows; however, SJC water is exempt from Rio Grande Compact delivery accounting.

4.1.5 City and County Regulation of Water Use

Both cities and counties have the authority to adopt ordinances conserving and regulating the use of water within their jurisdictions. For example, subdivision and other land use approvals are increasingly being conditioned upon an adequate availability of water. Also, county and municipal regulations may be important in the regulation of domestic wells, as the OSE has set a policy that allows counties or municipalities to implement their own restrictions on the issuance of domestic well permits within their jurisdictions. Furthermore, counties and municipalities may regulate water use by assuming responsibility for supplying water to their residents; such regulation may include the imposition of conservation measures or the exercise of eminent domain powers to establish or expand water utilities.

4.1.6 Interstate Compacts

New Mexico is a party to several compacts, including the Rio Grande Compact and the Colorado River compacts. The compacts obligate upstream states to deliver specified amounts of water to downstream states. In this way, compacts can place significant constraints on the water supply available for use, except for use by the Pueblos, which are specifically exempted from the Rio Grande Compact. The Rio Grande Compact is the most significant compact within the Jemez y Sangre planning region, however, the Upper Colorado River and the Colorado River compacts are relevant in that they control the SJC Project.

4.1.7 Water Quality Law

Federal, state, and tribal laws and regulations govern water quality within the Jemez y Sangre planning region. The most significant federal law is the CWA, a federal law that sets water quality standards for specific segments of surface waters, makes it unlawful for a person to discharge pollutants into surface waters without a permit, and allows for the designation of total maximum daily loads (TMDLs) for pollutants threatening the water quality of stream segments. Other federal laws that apply to water quality include the Safe Drinking Water Act and the Resource Conservation and Recovery Act. New Mexico has adopted its own surface water quality standards, as have a number of Pueblos within the planning region, including the Pueblos of Nambe, Pojoaque, San Juan, Santa Clara, and Tesuque.

4.2 Water Availability Issues

The following discussion is based primarily on a memorandum prepared by Kery, Belin, and Utton (2001a), under the direction of the JySWPC Legal Subcommittee, on water availability issues. A copy of this document is provided in Appendix D2.

4.2.1 Use and Regulation of Domestic Wells

The use and regulation of domestic wells is of critical importance in the consideration of water planning. Under the New Mexico Water Code, an applicant may receive a domestic well permit from the State Engineer without acquiring commensurate groundwater rights or retiring offsetting surface water rights. Because obtaining a domestic water right permit is essentially a ministerial process, it is viewed by many both as a loophole in the regulation of groundwater withdrawals and as an obstacle to the use of water supply as a growth management tool. Key issues related to domestic well use and regulation include:

- Appropriation and use of domestic water
- State Engineer prohibition of domestic wells
- Local government restrictions
- Transfer into community systems

Each of these issues is discussed at length in Appendix D.

4.2.2 Transfers Across the Otowi Gage

The State Engineer's administration of water right transfers in conformance with the Rio Grande Compact will affect the availability of water in the planning region. Under the Compact, which was agreed to by the States of New Mexico, Colorado and Texas in 1938, deliveries downstream are set under an inflow-outflow schedule. Deliveries to New Mexico from Colorado are calculated by upstream gages, and New Mexico's obligation to deliver water to the Rio Grande project at Elephant Butte Reservoir is determined by reference to the index supply at the Otowi Gage, located on the river on San Ildefonso Pueblo. Based on the quantity of flows measured at Otowi, the Compact establishes a delivery schedule of the amount of native flows that must be delivered to Texas at Elephant Butte Reservoir.

Because of the Otowi Gage's role in determining delivery amounts, the OSE has a long-standing administrative practice of not permitting a change in point of diversion from one side of the gage to the other, whether permanent or by lease. The Otowi Gage is located in the approximate middle of the Jemez y Sangre Planning Region and development of water resources has been, and is likely to continue to be, more significant below the gage than above, as reflected by a higher price for water rights in the middle valley than on the main stem in northern New Mexico. A critical question is how the administration of water right transfers within, to, or from the planning region could affect water availability.

4.2.3 Reuse of Return Flows

An important issue to municipalities, counties, and other entities that supply water and treat wastewater is the reuse of return flows to meet growing municipal demands. Such reuse will result in less water returning to the river system for use by other users and, consequently, raises questions of whether OSE approval is necessary and whether downstream users may oppose the reuse. Another type of reuse occurs when a water user seeks to increase diversions based upon the amount of return flows it makes to the river system. From a legal standpoint, a right to divert water provides its user with two types of water: the diversion portion, which equals the total amount withdrawn from the stream system, and the consumptive use portion, which is the portion that is consumed. Any amount left over that returns to the stream system by seepage, discharge, or even injection is a return flow. Where the OSE has already issued a permit to divert a specified quantity of water, the OSE's authority over return flows is limited unless the permit specifically addresses return flows.

4.2.4 National Environmental Policy Act Process

NEPA is a federal law that addresses process, not substance. It dictates the steps that must be taken to analyze environmental impacts of actions; it does not place limits on what actions may be taken. For planning purposes within the region, it is likely that any action that either receives significant federal funding or has federal agency involvement will have to be subject to review under NEPA. For example, it is virtually certain that any construction or development of SJC water from the Rio Grande to the City will be subject to a NEPA analysis. This is because the project will likely be constructed at least partially on federal or Indian land, will probably be at least partially federally funded, and will probably need various approvals from federal agencies.

4.2.5 Endangered Species Act Compliance

Two requirements of the ESA will most directly affect water management in this region. First, federal agencies, in consultation with the U.S. Fish and Wildlife Service, must ensure that their actions do not jeopardize the continued existence of endangered species or destroy or harm habitat that has been listed as “critical” for such species. The second is the ESA prohibition against the unlawful killing, harming, harassing, or taking of other detrimental action against a listed species unless an incidental take permit or statement has first been obtained from the Fish and Wildlife Service.

The Rio Grande silvery minnow is the only aquatic species on the federal endangered species list that exists in waters that might be affected by actions taken within the Jemez y Sangre Water Planning Region (Section 4.1.3). Other listed species such as the Southwestern willow flycatcher could be affected by water planning actions, but it is unlikely that large-scale water management or planning actions will significantly affect the existence of these species. Additional species that may be listed in the future could affect water management in this region, but such listing actions cannot be predicted at this time. The protection of the silvery minnow, an endangered species, has the potential to affect regional water planning and the allocation of water from the SJC Project (Section 4.2.4). In November 1999, several environmental groups collectively filed a lawsuit against the Bureau of Reclamation and the USACE regarding the endangered Rio Grande silvery minnow. A later Motion for Preliminary Injunction filed by these groups asked the District Court to direct the Bureau of Reclamation and the USACE to maintain a continuous flow of water in the Rio Grande from Cochiti Dam south for approximately 160 miles to the headwaters of Elephant Butte Reservoir. In August 2002, U.S. District Court Judge James A. Parker ruled that the Bureau of Reclamation must release water held in storage in Heron Reservoir (just north of the Jemez y Sangre planning region) to maintain minimum flows for the silvery minnow. Judge Parker's decision was stayed by the federal 10th Circuit Court of Appeals, therefore delaying implementation of the decision. Furthermore, rains in September and October 2002 alleviated the need to release the water, but releases of SJC water in the future for instream flow may reduce water available to cities and municipalities in the planning region.

5. Water Resources Assessment for the Planning Region

This section provides a description of the quantity and quality of water resources found within the Jemez y Sangre Water Planning Region. The information presented is drawn primarily from a detailed water supply study of the Jemez y Sangre planning region (Duke, 2001), which was conducted on behalf of the JySWPC. This section summarizes the more pertinent results of the 2001 water supply study and presents a concise assessment of water resources within the planning region. Most of the figures and tables presented in this section are derived directly from the Duke study (2001).

The major portion of the Jemez y Sangre Water Planning Region lies within the Española Geologic Basin, with a small part of the region extending into the northernmost portion of the Albuquerque Basin. As shown in Figure 1 (Section 1), the region has been divided into ten watersheds, or sub-basins: Velarde, Santa Cruz, Santa Clara, Los Alamos, Pojoaque-Nambe, Tesuque, Caja del Rio, Santa Fe River, North Galisteo Creek, and South Galisteo Creek.

The following subsections:

- Summarize the climate, surface water and groundwater supply, and water quality within the Jemez y Sangre Water Planning Region.
- Summarize water supply and quality within the planning region and each of the ten sub-basins.
- Summarize the water supply considering the legal constraints presented in Section 4.

Water budgets for each sub-basin, which include detailed data about inflow, outflow, and use, are presented in Section 6.

5.1 Weather and Climate

Precipitation (rainfall and snowfall) and evaporation are the primary controls on the entry and exit of water in the planning region. These are also important contributing processes to surface runoff and groundwater recharge. The Duke water supply study compiled data from 12 weather stations located within the planning region and maintained by the National Climatic Data Center, a branch of the National Oceanic and Atmospheric Administration (NOAA). Statistical analyses of temperature, precipitation, and snowpack were used to produce a general description of the region's climate.

5.1.1 Temperature

Table 6 lists the mean temperatures and the mean of annual maximum and minimum temperatures at each of the 12 weather stations. January is typically the coldest month of the year and July the warmest. At the Santa Fe weather station, near the center of the planning region, the average January maximum temperature is 42° F and the average minimum is 17° F. At the same station, the average July maximum temperature is 84° F and the minimum is 56 ° F.

Table 6. Mean Annual Temperature and Mean Annual Extreme Temperatures

Station Number	Station Name	Mean Temperature (°F)		
		Annual	Annual Maximum	Annual Minimum
290041	Abiquiu Dam	50.0	64.3	35.6
290245	Alcalde	51.3	68.1	34.5
290743	Bandelier National Monument	50.1	68.0	32.2
291982	Cochiti Dam	54.3	68.6	39.9
292820	El Rito	48.5	63.2	33.8
293031	Española	51.7	68.8	34.6
294369	Jemez Springs	52.0	66.8	37.1
295084	Los Alamos	47.9	59.8	36.0
296676	Pecos Ranger Station	48.9	65.0	32.7
298072	Santa Fe	49.0	62.9	35.1
298085	Santa Fe 2	50.5	64.1	36.9
298518	Stanley 1 NNE	49.3	65.5	33.0

Source: Duke, 2001 (Table 2-4)

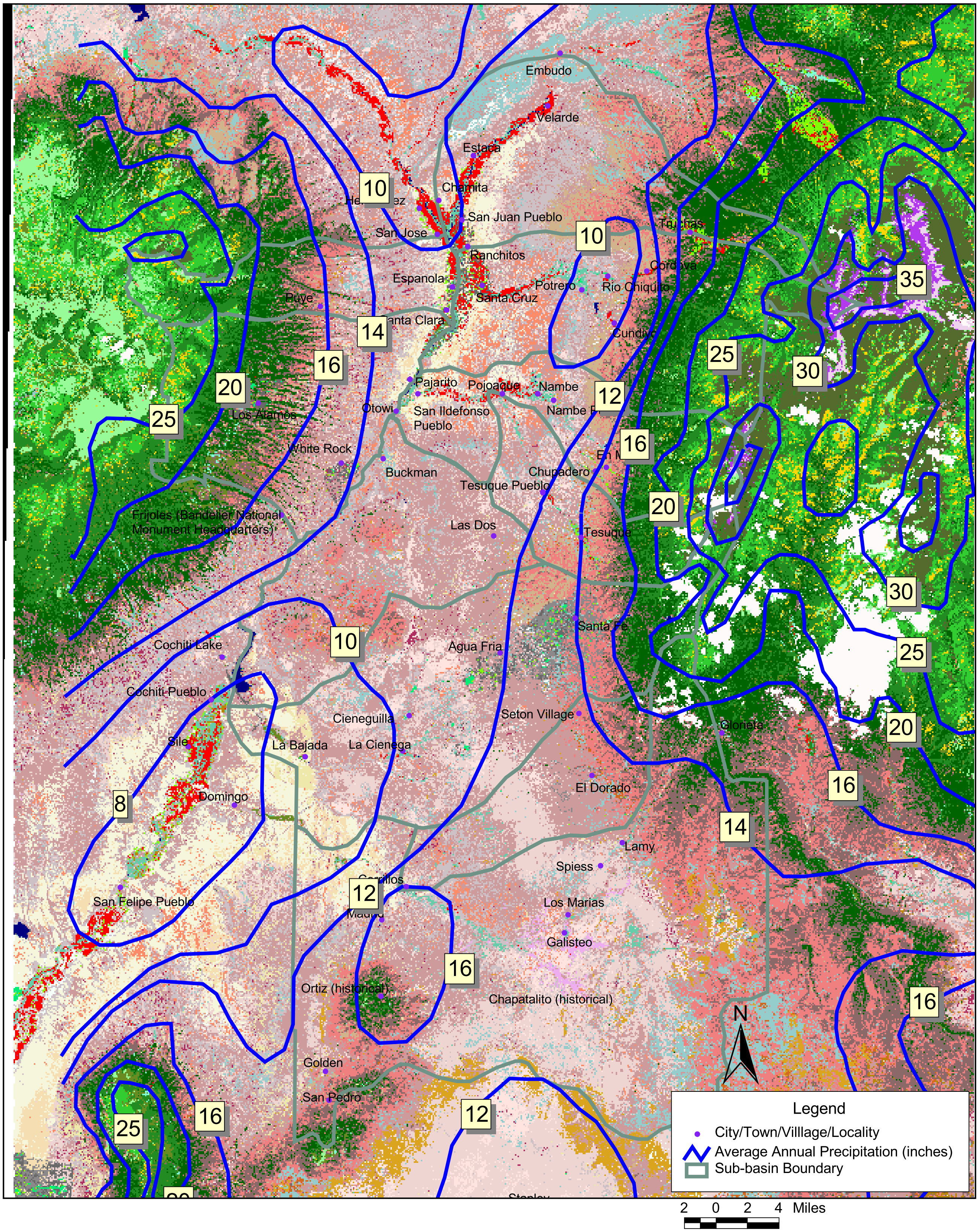
Mean annual temperatures vary throughout the planning region, generally decreasing as elevation increases. At Cochiti Lake near the southern part of the region (elevation 5,010 ft msl), the mean annual temperature is 54.3°F; El Rito near the northern extent of the region (6,870 ft msl) has a mean annual temperature of 48.5°F.

5.1.2 Precipitation

Figure 7 is a contour plot showing the distribution of average annual precipitation in the Jemez y Sangre planning region based on precipitation maps previously prepared by the SCS (1972) and Wasiolek (1995). This figure illustrates a large spatial variation in average annual precipitation over the planning region. Average annual precipitation in the mountain ranges on either side of the study area approaches 30 to 35 inches, whereas mean annual precipitation in the lowest elevations is about 8 inches. Table 7 lists mean annual average precipitation (combined rain and snow), along with the annual minimums and maximums for the recorded histories at 12 weather stations.

Monthly variation in precipitation was determined by calculating the average monthly precipitation over the 30-year period (1961 to 1990), and comparing it to monthly totals (Duke, 2001). A prominent peak in mean monthly precipitation usually occurs in August as a result of moisture that moves into the area from the Gulf of Mexico at this time of year (Tuan et al., 1969). The cumulative mean precipitation in the summer months of June, July, and August contributes more than 40 percent of the total annual precipitation.

As suggested by the statistical indicators in Table 7, annual precipitation is extremely variable within the planning region. For example, in the Santa Fe area (Santa Fe and Santa Fe 2 stations), the annual precipitation appears to fluctuate over a range of about 50 percent above and below the long-term average. Statistical analyses of historical data suggest that extended wet and dry periods tend to alternate with each other in cycles, with each cycle approximately 10 to 15 years in length (Duke, 2001). Figure 8 presents plots of the annual Palmer Drought Severity Index (PDSI) for the southern end of the planning region. PDSI values approaching –4 represent extreme drought conditions, while values approaching +4 represent extremely wet



Source: Duke, 2001 (Figure 5-23)

JEMEZ Y SANGRE REGIONAL WATER PLAN

Average Annual Precipitation for the Planning Region

Figure 7

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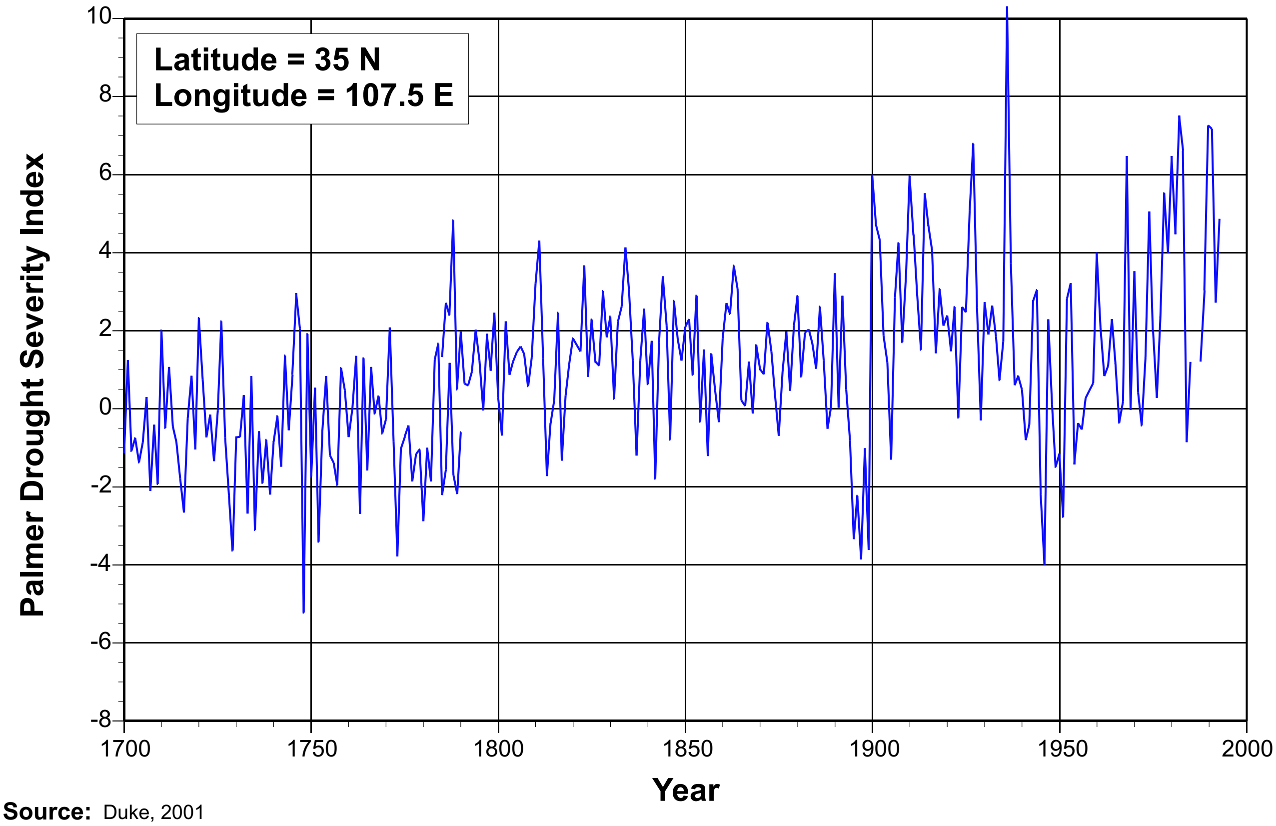
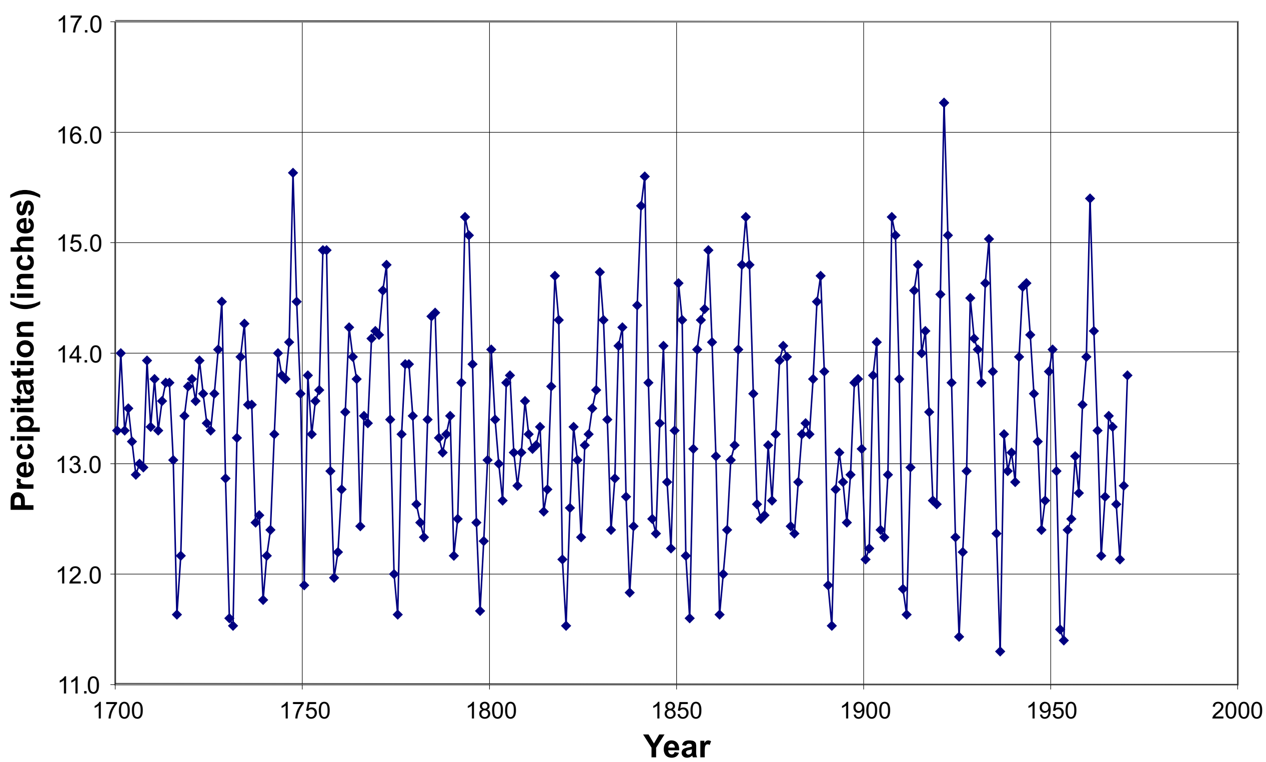


Source: Duke, 2001

Note: Paleoclimate Station 51
North-Central New Mexico



Note: Reconstructed precipitation data is a 3-year average

JEMEZ Y SANGRE REGIONAL WATER PLAN

Annual Palmer Drought Severity Index and Reconstructed Precipitation Data (from Tree Rings) at Arroyo Hondo

Figure 8

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conditions. Also shown in Figure 8 is the reconstructed precipitation at Arroyo Hondo based on tree ring data, illustrating several droughts including a drought in the 1950s. The variability in precipitation is an important factor in long-term planning, especially considering that the past 25 years has been perhaps the wettest period of the last 300 years.

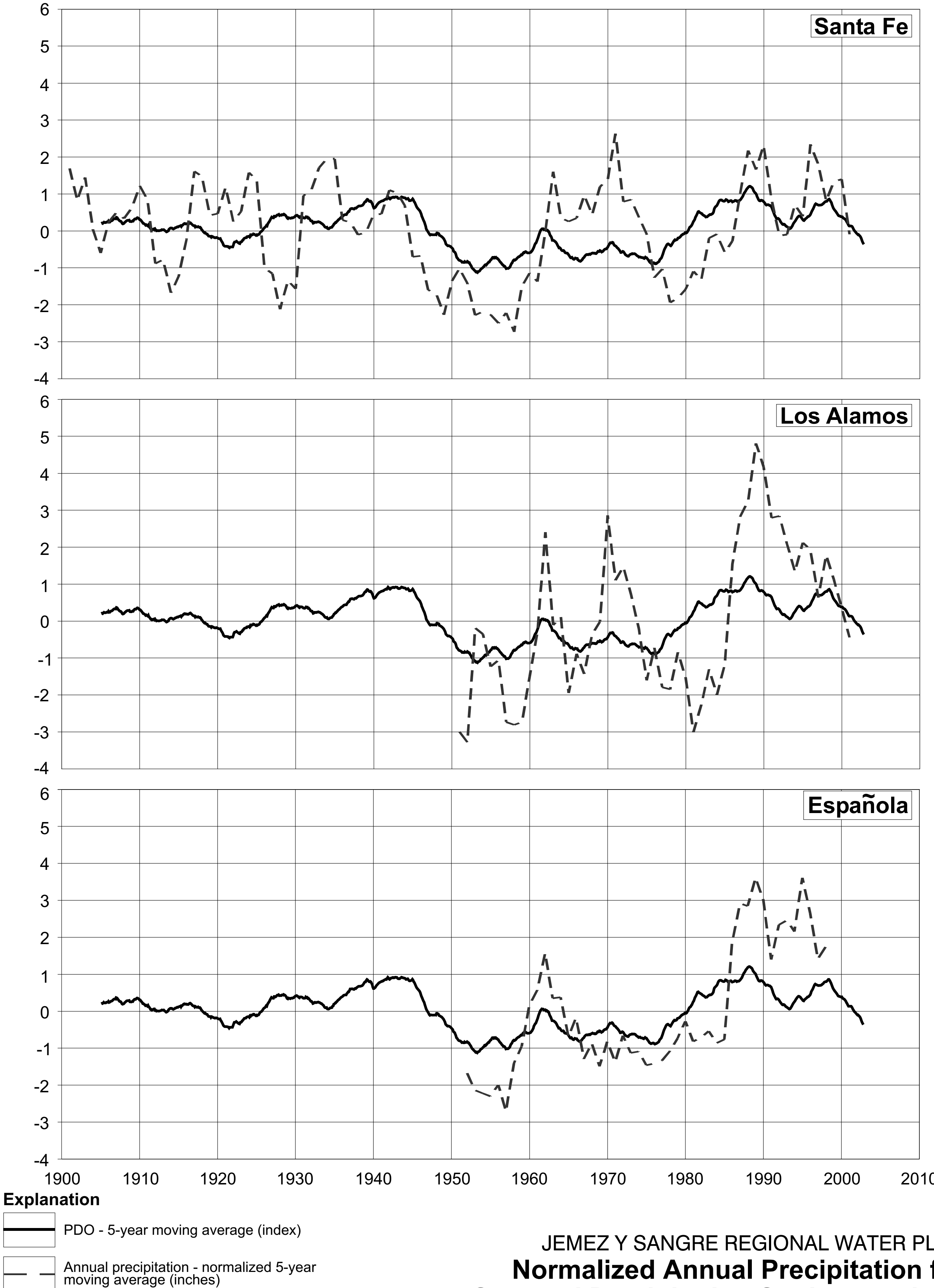
Table 7. Statistical Summary of Annual Precipitation at Selected Weather Stations

Station Number	Name	Years [a]	Annual Precipitation (inches) Mean	Median	Standard Deviation	Maximum	Minimum
290041	Abiquiu Dam	1957-1963	9.95	9.77	1.94	14.38	4.98
290245	Alcalde	1953-1996	9.89	9.28	3.05	16.16	2.66
290743	Bandelier National Monument	1931-1976	15.50	14.85	4.17	25.96	4.94
291982	Cochiti Dam	1975-1996	12.59	12.05	3.49	19.86	6.82
292820	El Rito	1931-1996	12.08	12.04	2.84	21.90	4.95
293031	Española	1938-1996	9.98	9.81	2.65	20.30	3.76
294369	Jemez Springs	1931-1996	17.44	16.54	4.39	28.72	6.17
295084	Los Alamos	1931-1996	18.40	18.34	4.46	30.34	6.80
296676	Pecos Ranger Station	1931-1996	16.17	16.46	3.67	25.34	9.23
298072 298085	Santa Fe Santa Fe 2	1868-1996	13.84	13.37	3.39	21.75	5.03
298085	Santa Fe 2	1972-1996	14.27	13.77	3.03	20.09	7.89
298518	Stanley 1 NNE	1954-1996	12.27	12.17	3.65	21.28	4.65

[a] Years of record used to determine statistical descriptors of annual precipitation.

Source: Duke, 2001 (Table 2-2)

The Pacific Decadal Oscillation (PDO) also has a strong influence on the weather patterns in New Mexico (Liles, 2000). The PDO is a long-term temperature fluctuation (20 to 30 years) of the Pacific Ocean, when temperatures in the western Pacific Ocean are warmer than average and temperatures in the eastern Pacific Ocean are cooler than average. Several independent studies find evidence for just two full PDO cycles in the past century: "cool" PDO regimes prevailed from 1890 through 1924 and again from 1947 through 1976, while "warm" PDO regimes dominated from 1925 through 1946 and from 1977 through (at least) the mid-1990s. Figure 9 illustrates the correlation between PDO and precipitation in the Jemez y Sangre region.



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JEMEZ Y SANGRE REGIONAL WATER PLAN

Normalized Annual Precipitation for Selected Precipitation Stations and the Pacific Decadal Oscillation (PDO) Index

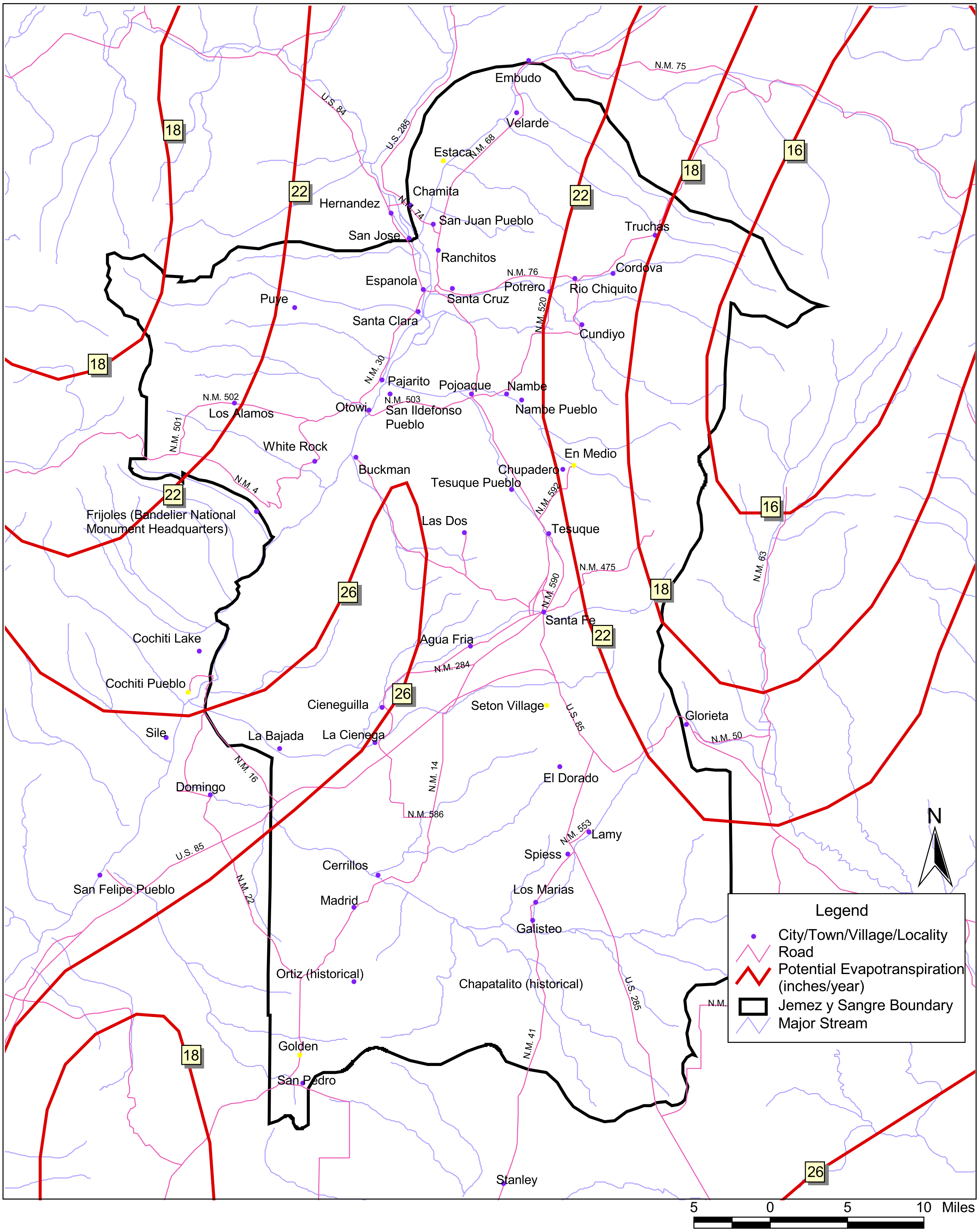
Figure 9

As shown in Figure 9, when the PDO is warm (positive) there is a strong trend of above-average precipitation in the region, and when the PDO is cool (negative), there tends to be below-average precipitation. During a negative or "cool" phase of the PDO, precipitation is about 91 percent of average in the Jemez y Sangre region. Streamflows during the negative periods are typically about 73 percent of the average streamflow. The positive PDO cycles tend to be wetter, averaging 110 percent of normal precipitation and 114 percent of average run-off (Liles, 2000).

5.1.3 Evaporation and Evapotranspiration

Both free water surface (FWS) evaporation and potential evapotranspiration (PET) rates were determined and presented in the Duke water supply study (2001). The FWS evaporation rate is meant to represent the rate of evaporation from an extensive free water surface, such as a lake. The potential evapotranspiration rate is intended to represent the amount of evaporation and evapotranspiration that would occur from areas of soil or vegetation if they were wet all the time. FWS rates were taken from an NOAA Technical Report (Farnsworth and Thompson, 1982) that discusses the distribution of evaporation rates over the entire state (Duke, 2001). PET rates were determined using a map of PET quantities prepared by Tuan et al. (1969) (Figure 10). Table 8 shows the estimated evapotranspiration rates for each of the sub-basins in the Jemez y Sangre region.

As shown in Duke (2001) and in Figure 10, both annual FWS evaporation and annual PET exceed precipitation throughout the study area, except at the highest elevations. Although the annual evaporation or evapotranspiration may exceed annual precipitation, precipitation for a given storm event may exceed the evaporation or evapotranspiration during the same time period, thus resulting in recharge. Evapotranspiration is used in Section 6 to calculate water budgets for each of the ten sub-basins within the planning region.



Source: Duke, 2001 (Figure 2-8)

JEMEZ Y SANGRE REGIONAL WATER PLAN

Average Potential Evapotranspiration Rate

Figure 10

Table 8. Estimated Evaporation and Evapotranspiration Associated with Surface Water, by Sub-Basin

Sub-Basin	Free Water Surface			Riparian Areas			Total ET Volume [c] (afy)
	Estimated Area [a] (acres)	Evaporation Rate (in/yr)	Evaporation Volume (afy)	Estimated Area [b] (acres)	PET Rate Average (in/yr)	ET Volume Riparian (afy)	
Velarde (including the Rio Grande)	195 [d]	45	731	1,000	22.1	1,842	2,580
Santa Cruz	132	45	495	2,000	19.1	3,183	3,680
Santa Clara	None	45	0	310	21.2	550	550
Los Alamos	106	45	398	1,027	18.6	1,592	1,990
Pojoaque-Nambe	120	45	450	1,365	21.1	2,400	2,850
Tesuque	80	45	300	540	21.8	980	1,280
Caja del Rio	None	45	0	92	26.0	200	200
Santa Fe River	80	45	300	440	24.0	880	1,180
North Galisteo Creek	None	45	0	65	24.0	130	130
South Galisteo Creek	125	45	469	1,050	24.0	2100	2,570

Source: Duke, 2001 (Table 3-11)
[a] FWS area estimated using 1992 Landsat image.
[b] Riparian area estimated using 1992 Landsat image.
[c] Total ET volume = FWS evaporation volume + riparian ET volume
[d] Rio Grande surface

in/yr = inches per year
afy = acre-feet per year
PET = Potential evapotranspiration
ET = Evapotranspiration
FWS = Free water surface

5.2 Surface Water Supply

Figure 3 (Section 3) shows the major watercourses and drainage patterns found in each of the sub-basins. Two of the sub-basins, Santa Clara and Los Alamos, originate on the east slope of the Jemez Mountains and drain eastward to the Rio Grande, while the remaining eight drain the west slope of the Sangre de Cristo Range on the east side of the Rio Grande. As delineated for this plan, the boundaries of the sub-basins are not everywhere coincident with actual drainage boundaries but may be aligned with county boundaries. Excluding areas omitted by these “artificial” boundaries, the total study area drainage encompasses 1,892 square miles.

Sub-basin attributes examined include drainage area, mean land elevation, land surface relief, main channel slope, mean annual precipitation, and mean annual PET. Table 4 (Section 3) lists some of the pertinent physical attributes of each of the sub-basins. Figure 2 (Section 3) is a composite digital elevation model (DEM) map for the entire planning region, which was built by combining numerous 15-minute maps.

5.2.1 Regional Surface Water Flow System

The major perennial waterway in the region is the Rio Grande. The average annual flow entering the planning region from the Rio Grande is nearly 600,000 afy. The average increase in river flow between the Embudo and near Otowi Bridge Gages appears to be greater than 400,000 afy. Most of this is attributable to inflow from the Rio Chama, which includes imported SJC Project water, with much lesser amounts contributed by surface outflows from sub-basins and groundwater discharge to the Rio Grande. The mean annual flow of the Rio Grande at the Near Otowi Bridge Gage is close to 1.1 million afy. This is probably close to the average amount of water that flows into Cochiti Lake because river gains and losses on the reach between Otowi and Cochiti Lake are probably minor in comparison to total flow in the river. As discussed in Section 4, use of this supply is limited by the provisions of the Rio Grande Compact.

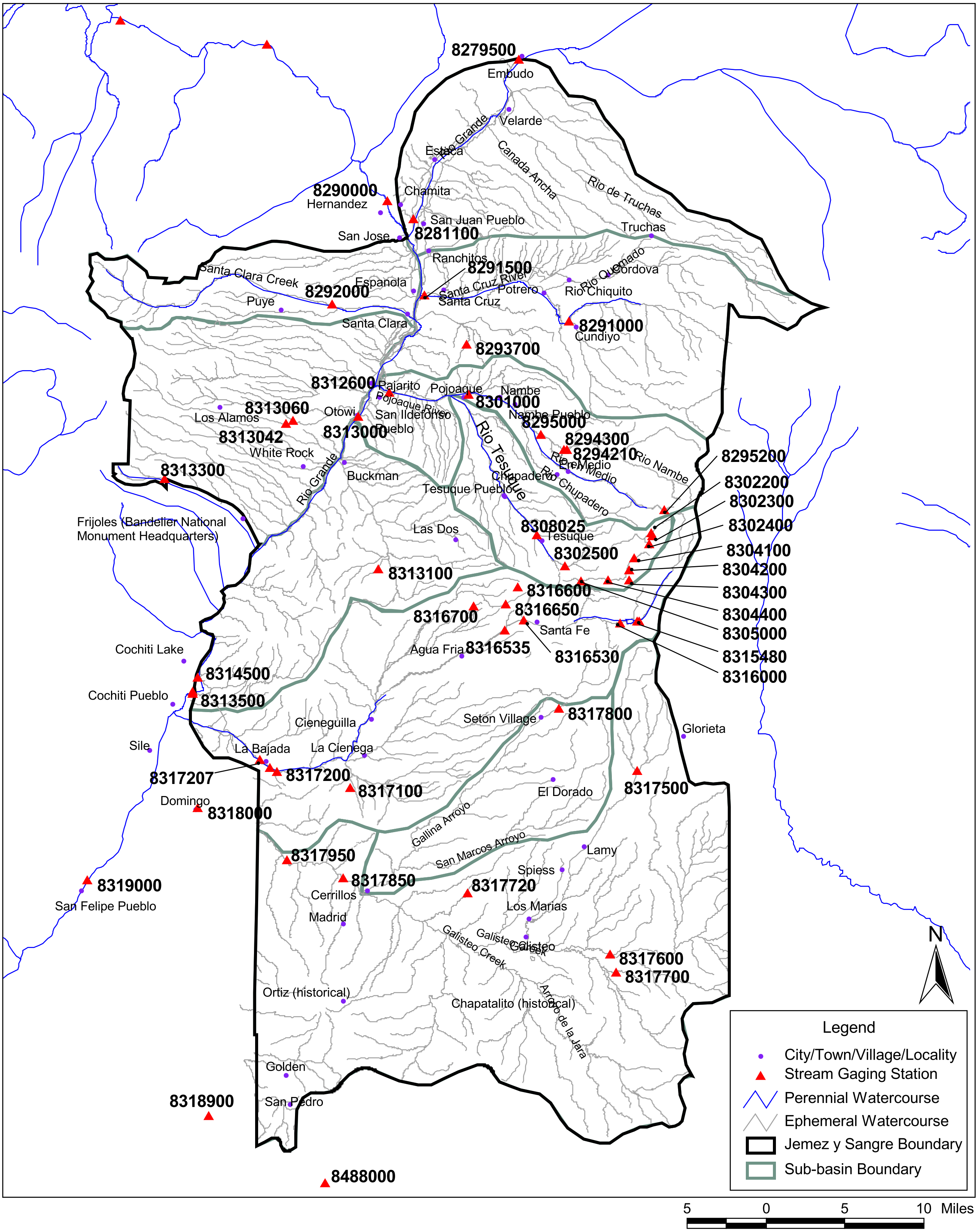
5.2.2 Streams and Rivers

Perennial and ephemeral streams in the planning region were identified using a combination of a USGS 1:500,000 surface-drainage map and, where available, daily streamflow records. These streams are shown on Figure 3. The two dominant waterways flowing into the region are the Rio Grande and the Rio Chama. Other prominent regional perennial streams that contribute directly or indirectly to the Rio Grande include the Santa Cruz River, Santa Clara Creek, Rio en Medio, Pojoaque Creek, Rio Tesuque, Pojoaque River, and the Santa Fe River.

The Duke water supply study (2001) identified 61 USGS stream gaging stations that were either within the planning region or monitored flows indicative of surface water processes occurring in the region. Figure 11 shows the locations of the sites and Table 9 lists those with records spanning 10 or more years. The Rio Chama stations are incorporated into the surface water analysis because processes on this river affect how SJC Project water is used in the planning region (see Section 5.3.3). Stations outside of the planning region are assigned to arbitrarily named regions that include the Rio Chama, Western Estancia, and Albuquerque basins.

Statistical analyses have been performed on the monitored streamflow from USGS gaging stations with 10 or more years of daily records; 26 of the 61 stations initially identified by Duke fall into this category (Duke, 2001). Table 9 presents statistical summaries for annual flow. Table 10 presents exceedance probabilities for annual flows, and Table 11 presents daily flows. The range in monitored flows at most of the stations is quite large.

Not every sub-basin in the Jemez y Sangre planning region has had flow monitored on its tributaries to the Rio Grande. Velarde Sub-Basin has not been monitored, and the Caja del Rio and North Galisteo Creek Sub-Basins are essentially ungaged, since only peak flows have been monitored on one watercourse in each sub-basin for limited periods of time. An estimate of the annual tributary inflow in ungaged areas was necessary to develop water budgets for all sub-basins. Duke elected to use the Reiland (1975) method to estimate the mean annual long-term streamflow from ungaged watersheds because of its simplicity and project time constraints. The Reiland method uses a simple runoff-versus-elevation relationship based on the principles that average annual precipitation typically increases with elevation whereas temperature and PET



Source: Duke, 2001 (Figure 3-4)

JEMEZ Y SANGRE REGIONAL WATER PLAN

USGS Stream Gaging Stations

Figure 11

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Table 9. Statistical Summary of Annual Flows at Gaging Stations

Station Number	Station Name	Period of Record	Annual Flow (cubic feet per second) [a]					
			Minimum	Maximum	Mean	Median	Standard Deviation	Coefficient of Variation
8279500	Rio Grande at Embudo	1912-1997	308.21	2,076.60	913.86	850.53	438.83	0.48
8281100	Rio Grande above San Juan Pueblo	1963-1986	292.35	1,644.70	808.85	807.38	388.93	0.48
8283500	Rio Chama at Park View	1930-1955	127.76	645.30	328.31	295.73	164.73	0.50
8284100	Rio Chama near La Puente	1955-1997	63.02	723.17	364.10	367.77	170.31	0.47
8285500	Rio Chama below El Vado Dam	1935-1997	147.76	823.44	421.52	396.02	181.92	0.43
8286500	Rio Chama above Abiquiu Reservoir	1961-1997	186.20	823.67	479.94	440.33	191.01	0.40
8287000	Rio Chama below Abiquiu Dam	1961-1997	199.52	872.48	506.73	490.69	178.25	0.35
8287500	Rio Chama near Abiquiu	1941-1967	178.92	1,060.70	397.33	375.31	197.75	0.50
8290000	Rio Chama near Chamita	1929-1997	159.72	1,209.90	543.54	528.41	252.44	0.46
8291000	Santa Cruz River near Cundiyo	1932-1997	8.93	75.17	31.70	27.81	16.70	0.53
8291500	Santa Cruz River at Riverside	1942-1951	1.81	19.66	9.69	8.32	7.65	0.79
8292000	Santa Clara Creek near Española	1984-1994	2.91	6.24	4.05	3.80	1.08	0.27
8294210	Rio Nambe below Nambe Falls Dam	1984-1997	7.01	25.75	15.83	15.97	5.31	0.34
8294300	Rio Nambe at Nambe Falls, Near Nambe	1963-1978	6.18	28.36	10.34	9.14	5.64	0.55
8295000	Rio Nambe near Nambe	1932-1951	3.22	28.50	10.77	9.68	6.65	0.62
8295200	Rio En Medio near Santa Fe	1963-1973	0.50	1.60	0.83	0.77	0.37	0.44
8302500	Tesuque Creek above Diversions Near Santa Fe	1936-1951	0.74	8.14	3.36	2.92	2.24	0.67
8313000	Rio Grande at Otowi Bridge	1918-1997	520.53	3,321.60	1,500.34	1,464.70	671.23	0.45
8314500	Rio Grande at Cochiti	1926-1970	454.96	3,298.40	1,301.79	1,221.65	676.36	0.52
8316000	Santa Fe River near Santa Fe	1913-1997	1.88	26.22	8.23	6.50	4.98	0.60
8317200	Santa Fe River aAbove Cochiti Lake	1970-1997	6.10	40.24	11.67	8.84	6.95	0.60
8317400	Rio Grande below Cochiti Dam	1970-1997	452.13	2,355.10	1,444.66	1,487.60	595.94	0.41
8317850	Galisteo Creek above Galisteo Reservoir	1970-1976	3.49	12.47	8.15	9.02	3.19	0.39
8317950	Galisteo Creek below Galisteo Dam	1970-1997	1.28	12.80	6.13	5.72	2.99	0.49
8318000	Galisteo Creek at Domingo	1941-1971	1.49	27.61	10.19	7.94	6.82	0.67
8319000	Rio Grande at San Felipe	1930-1997	502.65	3,401.70	1,418.86	1,344.40	674.24	0.48

Source: Duke, 2001 (Table 3-3).

[a] For stations with 10 or more years of record.

Table 10. Probability of Exceedance for Average Annual Flow at Gaging Stations

Station Number	Station Name	Period of Record	Percent of Time Flow Was Exceeded												
			99	98	90	80	70	60	50	40	30	20	10	5	1
			Average Annual Flow (cubic feet per second)												
8279500	Rio Grande at Embudo	1912-1997	283.6	297.2	385.0	473.6	589.6	737.3	872.1	989.5	1,109.4	1,268.8	1,493.8	1,759.4	2,245.0
8281100	Rio Grande above San Juan Pueblo	1963-1986	276.1	282.3	331.3	408.7	527.5	670.0	785.0	897.0	1,008.2	1,140.0	1,370.0	1,612.5	1,842.5
8283500	Rio Chama at Park View	1930-1955	113.3	116.7	143.3	175.0	207.0	242.0	283.3	350.0	418.8	497.5	591.3	685.0	785.0
8284100	Rio Chama near La Puente	1955-1997	56.7	63.4	157.5	183.8	237.3	302.0	350.0	427.0	490.0	542.5	595.0	670.0	782.0
8285500	Rio Chama below El Vado Dam	1935-1997	134.4	152.2	200.7	243.4	290.4	344.7	390.3	435.1	500.5	592.0	708.0	769.0	923.1
8286500	Rio Chama above Abiquiu Reservoir	1961-1997	168.0	186.0	230.3	274.0	346.0	396.8	446.3	508.8	576.3	661.4	764.3	839.0	1,047.8
8287000	Rio Chama below Abiquiu Dam	1961-1997	167.5	185.0	258.3	318.0	391.3	473.6	521.4	569.1	621.1	698.9	776.7	846.3	1,049.3
8287500	Rio Chama near Abiquiu	1941-1967	153.3	156.5	182.5	221.0	266.5	318.0	372.0	429.2	490.0	555.0	650.0	780.0	1,024.6
8290000	Rio Chama near Chamita	1929-1997	158.5	167.0	228.0	304.7	387.4	461.7	518.3	575.0	647.1	744.3	916.3	1,080.7	1,332.0
8291000	Santa Cruz River near Cundiyo	1932-1997	8.5	9.5	13.0	17.1	20.6	24.2	27.7	33.0	38.6	46.4	58.0	65.4	82.5
8291500	Santa Cruz River at Riverside	1942-1951	1.8	1.8	2.2	2.8	3.3	3.6	4.0	13.6	15.2	17.2	19.6	20.8	21.8
8292000	Santa Clara Creek near Española	1984-1994	2.3	2.4	2.7	3.1	3.3	3.6	3.8	4.0	4.7	5.3	6.2	6.7	7.0
8294210	Rio Nambe below Nambe Falls Dam	1984-1997	5.5	5.8	7.8	10.9	12.9	14.2	15.5	17.0	18.5	20.1	21.6	24.1	27.2
8294300	Rio Nambe at Nambe Falls, near Nambe	1963-1978	5.4	5.4	5.8	6.3	6.8	7.8	9.3	10.1	10.8	11.6	14.4	31.0	36.6
8295000	Rio Nambe near Nambe	1932-1951	3.2	3.3	3.9	5.7	6.7	8.4	9.8	10.8	11.8	13.9	23.2	29.0	36.2
8295200	Rio En Medio near Santa Fe	1963-1973	0.0	0.0	0.1	0.3	0.4	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.7
8302500	Tesuque Creek above Diversions near Santa Fe	1936-1951	0.1	0.3	1.4	1.8	2.1	2.4	2.7	3.1	3.6	4.5	7.9	8.6	9.2
8313000	Rio Grande at Otowi Bridge	1918-1997	479.8	499.5	652.2	831.1	1,039.4	1,286.7	1,497.8	1,669.6	1,841.3	2,108.0	2,424.0	2,828.0	3,510.0
8314500	Rio Grande at Cochiti	1926-1970	398.4	446.8	545.0	670.0	819.7	1,032.3	1,228.6	1,416.7	1,600.0	1,783.3	2,140.0	2,470.0	3,124.0
8316000	Santa Fe River near Santa Fe	1913-1997	2.2	2.4	3.4	4.3	4.9	5.7	6.8	8.1	9.7	11.7	16.8	20.2	25.6
8317200	Santa Fe River above Cochiti Lake	1970-1997	5.4	5.5	6.1	6.9	7.7	8.4	9.2	12.1	13.9	15.7	19.5	21.5	46.8
8317400	Rio Grande below Cochiti Dam	1970-1997	379.7	409.4	678.0	786.0	962.3	1,220.0	1,493.8	1,662.5	1,831.3	2,037.1	2,268.6	2,384.3	2,476.9
8317850	Galisteo Creek above Galisteo Reservoir	1970-1976	3.2	3.2	3.6	5.7	6.7	7.5	8.2	8.9	9.8	11.5	13.6	14.8	15.8
8317950	Galisteo Creek below Galisteo Dam	1970-1997	1.1	1.2	2.6	3.4	3.8	5.2	5.9	6.6	7.5	8.7	10.5	11.7	14.9
8318000	Galisteo Creek at Domingo	1941-1971	1.4	1.5	2.7	3.6	5.1	7.4	8.6	12.3	14.2	16.3	20.7	23.7	27.1
8319000	Rio Grande at San Felipe	1930-1997	476.8	493.5	625.6	774.4	957.9	1,149.1	1,331.8	1,516.7	1,702.8	1,888.9	2,278.0	2,479.0	3,965.0

Source: Duke, 2001 (Table 3-8)

Table 11. Statistical Summary of Daily Flows at Gaging Stations

Station Number	Station Name	Period of Record	Daily Flow (cubic feet per second) [a] Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
8279500	Rio Grande at Embudo	1912-1997	165.00	13,900.00	912.92	1,184.41	1.30
8281100	Rio Grande above San Juan Pueblo	1963-1986	95.00	7,850.00	796.60	924.84	1.16
8283500	Rio Chama at Park View	1930-1955	1.30	7,030.00	328.12	694.66	2.12
8284100	Rio Chama near La Puente	1955-1997	4.40	7,720.00	363.86	733.79	2.02
8285500	Rio Chama below El Vado Dam	1935-1997	0.00	6,010.00	423.57	623.54	1.47
8286500	Rio Chama above Abiquiu Reservoir	1961-1997	7.60	6,480.00	478.50	687.04	1.44
8287000	Rio Chama below Abiquiu Dam	1961-1997	8.80	2,780.00	506.53	555.06	1.10
8287500	Rio Chama near Abiquiu	1941-1967	1.00	5,330.00	397.11	549.50	1.38
8290000	Rio Chama near Chamita	1929-1997	0.00	8,760.00	543.26	743.30	1.37
8291000	Santa Cruz River Near Cundiyo	1932-1997	1.10	623.00	31.69	45.12	1.42
8291500	Santa Cruz R at Riverside	1942-1951	0.00	594.00	14.03	48.04	3.42
8292000	Santa Clara Creek near Española	1984-1994	0.00	29.00	4.01	2.78	0.69
8294210	Rio Nambe below Nambe Falls Dam	1984-1997	0.00	112.00	16.10	19.79	1.23
8294300	Rio Nambe at Nambe Falls, near Nambe	1963-1978	0.30	138.00	10.02	12.30	1.23
8295000	Rio Nambe near Nambe	1932-1951	0.10	152.00	10.57	15.00	1.42
8295200	Rio En Medio near Santa Fe	1963-1973	0.20	9.50	0.82	0.96	1.18
8302500	Tesuque Creek above Diversions Near Santa Fe	1936-1951	0.00	72.00	3.23	5.22	1.62
8313000	Rio Grande at Otowi Bridge	1918-1997	106.00	22,200.00	1,499.61	1,826.16	1.22
8314500	Rio Grande At Cochiti	1926-1970	1.00	22,400.00	1,300.16	1,737.22	1.34
8316000	Santa Fe River near Santa Fe	1913-1997	0.10	378.00	8.32	13.41	1.61
8317200	Santa Fe River above Cochiti Lake	1970-1997	0.00	1,000.00	11.51	30.23	2.63
8317400	Rio Grande below Cochiti Dam	1970-1997	0.51	8,290.00	1,443.92	1,478.49	1.02
8317850	Galisteo Creek above Galisteo Reservoir	1970-1976	0.01	873.00	8.79	40.85	4.65
8317950	Galisteo Creek below Galisteo Dam	1970-1997	0.00	1,170.00	6.32	35.42	5.60
8318000	Galisteo Creek at Domingo	1941-1971	0.00	4100.00	9.93	87.86	8.85
8319000	Rio Grande at San Felipe	1930-1997	34.00	21,300.00	1418.17	1,658.55	1.17

Source: Duke, 2001 (Table 3-5).

[a] For stations with 10 or more years of record.

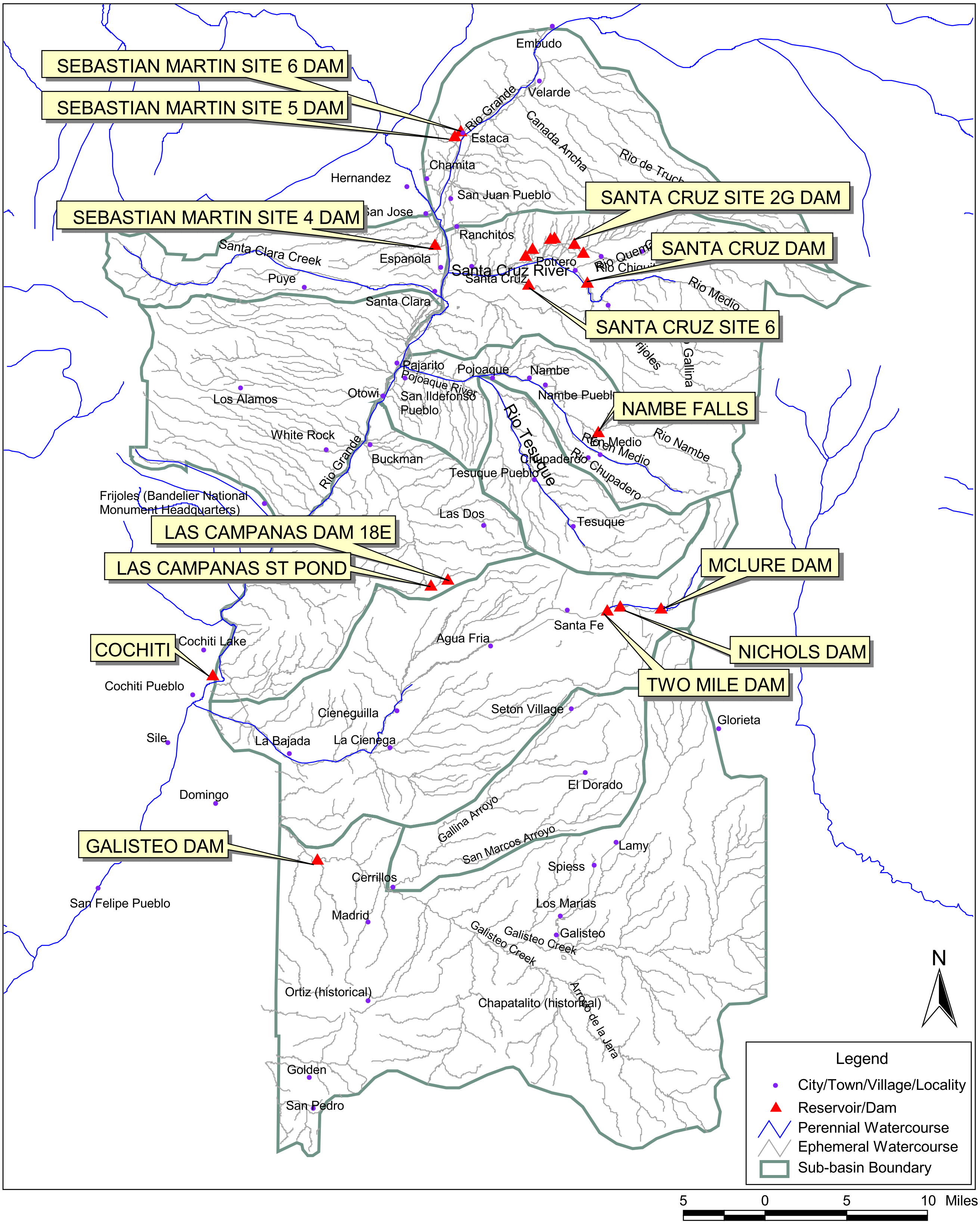
decrease. Because streamflow is generated where precipitation exceeds evapotranspiration, there is typically greater streamflow per unit area as elevation increases. Reiland (1975) applied his methodology specifically to the Pojoaque River watershed, and developed average streamflow values per unit land area for elevation intervals that occurred within the watershed.

5.2.3 Reservoirs and Lakes

Major dams and associated reservoirs in the planning region, which represent existing surface-water storage, are shown on Figure 12. Table 12 summarizes characteristics of dams and associated reservoirs, and also includes descriptions of dams and reservoirs that are either located a short distance outside the planning boundary or have some bearing on potential water supply of the region. Included in this latter category are surface-water storage entities that may influence SJC water diverted to the Rio Chama drainage. Two Mile Dam, which is listed in Table 12 and shown on Figure 12, was breached in 1994 due to dam instability. The capacity of the Two Mile Reservoir was transferred to McClure Dam once the height of the McClure Dam had been raised.

As Table 12 indicates, with the exception of Cochiti Reservoir on the main stem Rio Grande, the largest storage reservoirs in the planning region are Santa Cruz Lake on the Santa Cruz River, Nambe Falls Reservoir on the Rio Nambe, and McClure Reservoir on the Santa Fe River. Inflows and outflows from reservoirs vary seasonally and annually. Storage levels may drop considerably during particularly dry years (e.g., 1989 and 1996); however, reservoirs eventually recover once normal precipitation returns.

In addition to providing a storage benefit, reservoirs in the region may also provide flood control benefits. Reservoirs in the region generally fill when the snowpack melts in May and June. Historically, spring thaw was a time of flooding; today, the presence of reservoirs typically prevents flooding. However, if an extreme precipitation or snowmelt event occurs when reservoirs are already full, over-dam flooding could result. This would be of greatest concern at Nichols and McClure Reservoirs, which are located just above the City of Santa Fe.



Source: Duke, 2001 (Figure 3-5)

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JEMEZ Y SANGRE REGIONAL WATER PLAN

Reservoir and Dam Locations

Figure 12

Table 12. Major Dams and Reservoirs in and near the Planning Region
Page 1 of 4

Corps ID	Dam Name	Latitude	Longitude	Section	County	River	Owner Type	Use	Year Completed	Maximum Discharge (cfs)	Maximum Storage (ac-ft)	Normal Storage (ac-ft)	Surface Area (acre)	Drainage Area (mi^2)
NM00179	Kinsell Reservoir Dam	35.1383	-105.8883	T11N R10E S32	Santa Fe	Armijo Draw-Tr	P	I	1911	0		574		0
NM00241	Nichols Dam	35.7133	-105.8797	T17N R10E S21	Santa Fe	Santa Fe River	U	WS	1943	19,690	943	685	39	22
NM00242	Mcclure Dam	35.6950	-105.8333	T17N R10E S24	Santa Fe	Santa Fe River	U	WS	1926	16,100	3,770	2,700	77	17
NM00251	Santa Cruz Dam	35.9833	-105.9167	T20N R10E S27	Santa Fe	Santa Cruz River	P	I,R	1929	22,000	3,700		115	99
NM00561	Santa Cruz Watershed Site 6	35.9767	-105.9850	T20N R9E S9	Santa Fe	Santa Cruz River-Tr	P	D	1984	7,134	1,730	0	76	3
NM00547	Las Campanas Dam 18e	35.7167	-106.0583	T17N R8E S11	Santa Fe	Off Channel Reservoir	P	R	1992	840	58	31	4.9	0.92
NM00559	Las Campanas Effluent Storage Pond	35.7042	-106.0833	T17N R8E S15	Santa Fe		P	R		2	30		3	
NM00357	Two Mile Dam	35.6883	-105.8933	T17N R10E S10	Santa Fe	Santa Fe River-Os	U	S	1894	18,200	605	387	23	27
NM00412	Nambe Falls	35.8458	-105.9092		Santa Fe	Rio Nambe River	F	I,R, FW	1976	22,500	2883	2023	74	35
NM00002	Galisteo Dam	35.4617	-106.2083	T14N, R7E, S9	Santa Fe	Galisteo Creek	F	C,O	1970	90,000	152,600	0	1	596

Source: Duke, 2001 (Table 3-9)
ac-ft = Acre-feet
cfs = Cubic feet per second
mi^2 = Square miles

Owner Type:
F = Federal
S = State
L = Local government
U = Public utility
P = Private

Usage:
C = Floor control/storm water management
H = Hydroelectric
I = Irrigation
N = Navigation
WS = Water supply
R = Recreation
FW = Fish and wildlife pond
DI = Debris control
T = Tailings
O = Other

Table 12. Major Dams and Reservoirs in and near the Planning Region
Page 2 of 4

Corps ID	Dam Name	Latitude	Longitude	Section	County	River	Owner Type	Use	Year Completed	Maximum Discharge (cfs)	Maximum Storage (ac-ft)	Normal Storage (ac-ft)	Surface Area (acre)	Drainage Area (mi^2)
NM00264	Santa Cruz Site 6	35.9767	-105.9850		Santa Fe	Alamo Arroyo Tr-Santa Cruz	L	C,O	1984	7,134	1,352	628	0	3.1391
NM00173	Wp Johnson Erosion Ctrl	35.8850	-107.1567	T19N R3W S9	Sandoval	Jariado Arroyo	P	C	1945	616		124	34.7	17.89
NM00404	Cochiti	35.6250	-106.3333	T16N, R6W, S16	Sandoval	Rio Grande & Santa Fe	F	C,R, O,I	1975	136360	722000	50130	1200	14635
NM00127	El Vado Reservoir Dam	36.5933	-106.7333	T28N R2E S33	Rio Arriba	Rio Chama	P	I,R	1935	33500		219580		873
NM00262	Santa Cruz Site 4 Dam	36.0100	-105.9800	T21N R9E S34	Rio Arriba	Martinez Arroyo	P	C	1962	4898.6	322	0	29	2
NM00260	Santa Cruz Site 1 Dam	36.0083	-105.9167	T21N R10E S31	Rio Arriba	Cañada Ancha	P	C	1962	7298	963	0	43	8
NM00238	Santa Cruz Site 3a Dam	36.0200	-105.9533	T21N R9E S26	Rio Arriba	Santa Cruz River - Tributary	P	C	1972	6270	1610	0	60	2.2
NM00234	Sebastian Martin Site 6 Dam	36.1000	-106.0500	T22N R8E S26	Rio Arriba	Estaca Arroyo	P	C	1973	0	1022	0	45	2
NM00261	Santa Cruz Site 2g Dam	36.0133	-105.9367	T21N R9E S36	Rio Arriba	Arroyo De Los Encinos	P	C	1985	4730	1096	0	52.5	2
NM00263	Santa Cruz Site 5 Dam	36.0033	-105.9867	T21N R9E S33	Rio Arriba	Morada Arroyo	P	C	1962	3442	192	0	13	1
NM00237	Santa Cruz	36.0183	-105.9550	T21N R9E S26	Rio Arriba	Cañada De	P	C	1972	170	470	0	30	0.37

Source: Duke, 2001 (Table 3-9)
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O = Other

Table 12. Major Dams and Reservoirs in and near the Planning Region

Corps ID	Dam Name	Latitude	Longitude	Section	County	River	Owner Type	Use	Year Completed	Maximum Discharge (cfs)	Maximum Storage (ac-ft)	Normal Storage (ac-ft)	Surface Area (acre)	Drainage Area (mi^2)
	Site 3 Dam					Los Ramones								
NM00233	Sebastian Martin Site 5 Dam	36.1067	-106.0650	T22N R8E S26	Rio Arriba	Arroyo De Lopez	P	C	Unknown	1469	460	0	24	1
NM00441	Sebastian Martin Site 4 Dam	36.1033	-106.0700	T21N R8E S34	Rio Arriba	Arroyo De Borregos	P	C	1977	2713	691	0	36	1
NM00122	Heron	36.6661	-106.7100		Rio Arriba	Willow Creek	F	WS,I	1971	660	429646	401317	6148	193
NM00123	Heron Dike	36.6717	-106.7200		Rio Arriba	Willow Creek Tr	F	WS,I	1971		429646	401317	6148	193
NM10008	El Vado	36.5933	-106.7467		Rio Arriba	Rio Chama	F	I, R, WS	1935	17800	209330	186250	3360	492
NM00001	Abiquiu Dam	36.2400	-106.4300	T23N, R5E, S8	Rio Arriba	Rio Chama	F	C,I,WS,O	1963	25000	1369000	170000	3900	2146
NM00438	Sebastian Martin-Black Mesa Site 1	36.0817	-106.0817	T21N,R8E,S8	Rio Arriba	Trib To Rio Grande	L	C,O	1978	1927	280	110	0	0.5594
NM00439	Sebastian Martin-Black Mesa Site 2	36.0900	-106.0783		Rio Arriba	Arroyo Del Guique Tr-Rio Grand	L	C,O	1977	636	152	48	0	0.2094
NM00440	Sebastian Martin-Black Mesa Site 3	36.0967	-106.0733		Rio Arriba	San Rafael Tr-Rio Grande	L	C,O	1977	1190	151	76	0	0.3094

Source: Duke, 2001 (Table 3-9)
ac-ft = Acre-feet
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Table 12. Major Dams and Reservoirs in and near the Planning Region

Corps ID	Dam Name	Latitude	Longitude	Section	County	River	Owner Type	Use	Year Completed	Maximum Discharge (cfs)	Maximum Storage (ac-ft)	Normal Storage (ac-ft)	Surface Area (acre)	Drainage Area (mi^2)
NM00518	Sebastian Martin-Black Mesa Site 18	36.1383	-106.0683		Rio Arriba	Trib. To Rio Grande	L	C	1985	1666	235	67	0	0.95
NM83401	Los Alamos	35.8417	-106.3731		Los Alamos	Los Alamos Cr	F	WS	1943	600	49	41	3	5
NM00299	Doe Los Alamos Canyon Dam	35.8417	-106.3731		Los Alamos	Los Alamos Cr	F	WS	1938	600	49	41	3	5

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A draft Environmental Impact Statement (EIS), prepared in regard to City of Santa Fe drinking water projects, included an evaluation of the flood control storage in Nichols and McClure Reservoirs. The EIS, which considered an earlier Federal Emergency Management Agency study in evaluating flood potential below McClure and Nichols, concluded that the reservoirs do not provide sufficient flood control storage to provide protection from extreme runoff or flood events.

5.2.4 Irrigated Agriculture

Irrigated agriculture is an important component of the surface water system within the Jemez y Sangre region. Numerous acéquias within the region divert surface water to irrigate crops. Duke (2001) summarized irrigated acreage within the region (Table 13) and estimated irrigation diversions, depletions, and return flows (Table 14). The estimated irrigated acreage within the region was developed using several sources, including planning documents, LANDSAT imagery, and OSE data, as shown on Table 13.

The methods of Wilson and Lucero (1997) were used to apportion surface water diversions into depletions and return flows, as shown on Table 14. The diversion quantities shown in Table 14 represent an irrigation application rate, which was defined as consumptive irrigation requirement (CIR) divided by the product of the on-farm irrigation efficiency and off-farm conveyance efficiency. Most of the CIR values used were from Wilson and Lucero (1997), although the CIR values for the Pojoaque-Nambe and Tesuque Sub-Basins were taken from a court order issued under the Aamodt water rights adjudication case (U.S. District Court, 1994). Total depletions were calculated by multiplying the appropriate CIR by the irrigated acreage, and augmenting the resulting product by a fraction reflective of cumulative incidental losses. Return flows, which were assumed to go back to the natural drainage system, were determined by subtracting total depletions from irrigation diversions. In addition to surface-water computations, Table 14 lists analogous groundwater budget values associated with irrigation.

Table 13. Irrigated Acreage Estimates for the Planning Region

Sub-Basin	Irrigated Acreage by Information Source			
	Rio Arriba County Planning Office	1992-Landsat Image	Wilson and Lucero (1997)	Hydrographic Survey
Velarde				
Velarde Area	1815	3176	2870	NA
Rio de Truchas Area	3258	334	2925	2064.3 [a]
Velarde Total	*5073*	*3510*	*5795*	*2064.3*
Santa Cruz				4780 [a]
Rio Arriba County	1326	1010	4155	NA
Santa Fe County		910	5735	NA
Santa Cruz Total	*1326*	*1920*	*9888*	*4780*
Santa Clara	699	545	NA	NA
Los Alamos		0	0	0
Pojoaque-Nambe		957	2375 [c]	3538 [b,c]
Tesuque		170	0 [d]	0 [d]
Caja del Rio		0	0	0
Santa Fe River		306	965	485 [e]
North Galisteo Creek		0	0	0
South Galisteo Creek		88	0	0

[a] Hydrographic survey conducted during 1970.
[b] Hydrographic survey conducted during 1966.
[c] Includes Tesuque estimate
[d] Included in Pojoaque-Nambe estimate
[e] Hydrographic survey conducted during 1976.

Source: Duke, 2001 (Table 3-12)
NA = not available.

Table 14. Estimated Irrigation Diversions, Depletions, and Return Flows

Sub-Basin	Irrigated Land [a] (acres)		Consumptive Irrigation Requirement [a] (ft/yr)		On-Farm Irrigation Efficiency [a] (dimensionless)		Off-Farm Conveyance Efficiency [a] (dimensionless)		Total Diversion [b] (afy)		Incidental Depletion Fraction [a] (dimensionless)		Total Depletion [c] (afy)		Return Flow [d] (afy)	
	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water
Velarde																
Velarde and Vicinity	2,835	35	1.807	1.122	0.5	0.85	0.7	0	14,637	46	0.168	0	5,983	39	8,653	7
Rio de Truchas	2,925	0	1.126	0	0.4	0	0.7	0	11,763	0	0.113	0	3,666	0	8,097	0
Subtotal	5,760	35	2.933	1.122	0.9	0.85	1.4	0	26,400	46	0.281	0	9,649	39	16,750	7
Santa Cruz																
Rio Arriba County	4,155	0	0.894	0	0.55	0	0.7	0	9,648	0	0.179	0	4,379	0	5,269	0
Santa Fe County	5,735	0	0.675	0	0.55	0	0.7	0	10,055	0	0.179	0	4,564	0	5,491	0
Subtotal	9,890	0	1.569	0	1.1	0	1.4	0	19,703	0	0.358	0	8,943	0	10,760	0
Santa Clara	699 [e]	0	0.894	0	0.55	0	0.7	0	1,623	0	0.179	0	737	0	886	0
Los Alamos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pojoaque-Nambe	1,900 [f]	120	1.84 [f]	1.678	0.55	0.55	0.7529	0.7529	8,442	366	0.14	0.11	3,985	224	4,457	143
Tesuque	475 [h]	0	1.84 h	1.678	0.55	0.55	0.7529	0.7529	2,111	0	0.14	0.11	996	0	1,115	0
Caja del Rio	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santa Fe River																
Drip Irrigation	0	20	0	0.938	0	0.85	0	0	0	22	0	0	0	19	0	3
Flood Irrigation	815	130	1.14	1.14	0.5	0.5	0.7	0.7	2,655	296	0.179	0.15	1,095	170	1,559	126
Subtotal	815	150	1.14	2.078	0.5	1.35	0.7	0.7	2,655	318	0.179	0.15	1,095	189	1,559	129
North Galisteo Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Galisteo Creek	88 [j]	0	1.14	0	0.5	0	0.7	0	287	0	0.179	0	118	0	168	0

Source: Duke, 2001 (Table 3-13).
ft/yr = Feet per year afy = Acre-feet per year CIR = Consumptive irrigation requirement
[a] Unless noted otherwise, values taken from Wilson and Lucero (1997).
[b] Total diversion = (irrigated acreage x CIR)/[(on-farm irrigation efficiency) x (off-farm irrigation efficiency)].
[c] Total depletion = (irrigated acreage x CIR) x (1 + incidental depletion fraction).
[d] Return flow = total diversion – total depletion.
[e] Irrigated acreage in the Santa Clara sub-basin from estimate by the Rio Arriba County Planning Office.
[f] Irrigated acreage in the Pojoaque-Nambe Sub-Basin assumed equal to 80% of Wilson and Lucero (1997) estimate for combined area of Pojoaque-Nambe and Tesuque Sub-basins.
[g] Consumptive irrigation requirement in the Pojoaque-Nambe Sub-Basin based on an Order of the Court in the Aamodt adjudication case. (U.S. District Court, 1994).
[h] Irrigated acreage in the Tesuque sub-basin assumed equal to 20% of Wilson and Lucero (1997) estimate for combined area of Pojoaque-Nambe and Tesuque Sub-Basins.
[i] Irrigated acreage in South Galisteo Creek Sub-Basin estimated from 1992 Landsat image.

5.2.5 San Juan-Chama Project

The SJC Project, authorized as part of the Colorado River Storage Project, provides an average annual diversion of about 110,000 acre-feet of water from the upper tributaries of the San Juan River for use in the Rio Grande Basin of New Mexico. Some of this additional water is used for municipal, domestic, industrial, and agricultural purposes within the Jemez y Sangre planning region. The contracted quantities of SJC water within the planning region include:

- City and County of Santa Fe: 5,605 acre-feet
- County of Los Alamos: 1,200 acre-feet
- City of Española: 1,000 acre-feet
- PVID: 1,030 acre-feet
- San Juan Pueblo: 2,000 acre-feet

In addition, an annual allocation of SJC water is available to the USACE for its operation of Cochiti Reservoir. The intent is to compensate for evaporation losses and maintain a minimum surface area of 1,200 acres for the reservoir. The various entities that use SJC water contract for their respective supplies with the Bureau of Reclamation. Presently, not all contracting entities in the region are using their allocation of SJC water. SJC water is used by the City of Santa Fe to offset pumping from the Buckman well field and by the PVID to offset diversions from Pojoaque Creek. Additional analysis of the SJC Project is included Section 7, *Alternative Approaches and Scenarios to Close Supply/Demand Gap*, and in Appendix F.

5.3 Groundwater Supply

This section summarizes the groundwater supplies in the Jemez y Sangre Water Planning Region and the general characteristics of hydrogeologic units in the Española Basin, including both water-bearing aquifers and relatively impermeable units.

The evaluation of groundwater resources draws on diverse forms of data, with particular attention paid to the locations and characteristics of the numerous wells found in the region's hydrogeologic units. Types of wells included in the discussion range from monitoring wells maintained by the USGS to irrigation and municipal supply wells. Groundwater level hydrographs from many of the wells are presented as are pumping records from wells with recorded discharges. Accompanying figures portray the spatial distribution of aquifers, groundwater levels and associated hydraulic gradients, and distribution of groundwater withdrawals.

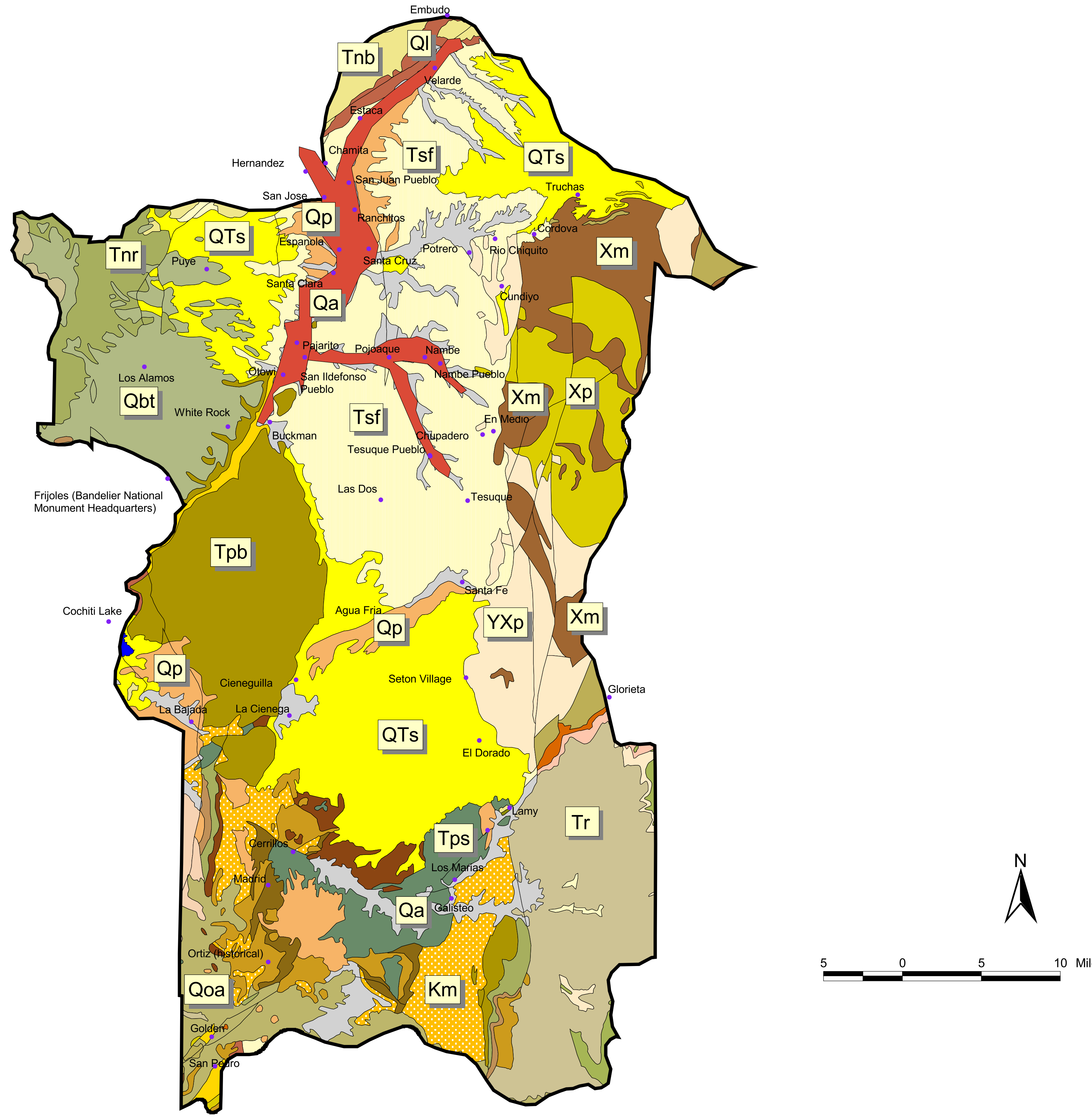
This section was compiled using information obtained primarily from the Duke study (2001). To develop an understanding of both regional and local geology, Duke relied on reports from the USGS, the New Mexico Bureau of Mines and Mineral Resources, and LANL. Information regarding the major aquifer systems in the planning region, as well as other less transmissive hydrogeologic units, was obtained from government agency and consulting reports that address groundwater flow conditions throughout the region. To develop conceptual models of groundwater flow and storage, Duke used the previously mentioned sources as well as several groundwater modeling studies (past and ongoing).

5.3.1 Regional Hydrogeology

The Jemez y Sangre Water Planning Region lies within the Española Basin (Kelley, 1977). This structural geologic basin is centered near the City of Española, on the confluence of the Rio Grande with its principal tributary, the Rio Chama. The basin encompasses the Española Valley, which is generally considered to comprise the lower-lying areas within the structural basin. The Sangre de Cristo Mountains form the eastern boundary of the basin, and the Jemez Mountains the western boundary.

Figure 13 illustrates the surface geology of the planning region, as presented in Green and Jones (1997). The Sangre de Cristo Mountains in the eastern part of the planning region are covered by Precambrian rocks, which are inferred to exist under the entire study area. The Precambrian rocks have relatively low permeability and storage capacity, but can transmit water though fractures to overlying younger sediments. Paleozoic rocks are found intermittently along the west flank of the Sangre de Cristo Mountains; however, most of the sediments lying within the Española Basin comprise the geologic unit known broadly as the Santa Fe Group. This

- Tr Chinle formation
- Jm Morrison formation
- Kd Dakota formation
- Km Mancos Shale; divided by Gallup Sandstone
- Kmv Mesaverde formation
- Pg Glorieta sandstone
- Psa San Andres formation
- Py Yeso formation
- QTs Upper Santa Fe Group
- Qa Alluvium; upper and middle Quarternary
- Qbt Bandelier Tuff; Jemez Mountains area only
- Ql Landslide deposits and colluvium
- Qoa Older alluvial deposits of upland plains and piedmont area
- Qp Piedmont alluvial deposits; upper and middle Tertiary
- Tnb Basalt and andesite, interbedded with Santa Fe and Gila Groups
- Tnr Silicic to intermediate volcanic rocks; Neogene
- Tos Espinaso formation
- Tpb Basalt and andesite flows; Pliocene
- Tps Paleogene sedimentary units
- Tsf Lower and middle Santa Fe Group
- Xm Lower Proterozoic metamorphic volcanic and volcanoclastic rocks
- Xp Lower Proterozoic plutonic rocks
- YXp Middle and lower Proterozoic plutonic rocks, undivided



Source: Duke, 2001 (Figure 5-1)

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JEMEZ Y SANGRE REGIONAL WATER PLAN

Regional Surface Geology

Figure 13

group consists primarily of the Tesuque, Puye, and Ancha Formations. A cross section illustrating the relationship of units within the Santa Fe aquifer system is presented in Figure 14.

Permian and Mesozoic rocks outcrop south of the Santa Fe River watershed, within the North Galisteo Creek and South Galisteo Creek Sub-Basins. Lower and middle Tertiary units, consisting of the Galisteo Formation and extrusive and intrusive rocks, are exposed in the southern part of the Jemez y Sangre planning area. The Galisteo Formation consists of sandstone, mudstone, and conglomerate (Kelley, 1978). Typically, the Galisteo and associated igneous units, along with the Permian and Mesozoic formations in the area, have low permeability and form a bedrock floor that controls the accumulation and movement of groundwater in overlying sediments (Spiegel and Baldwin, 1963).

The Tertiary Tesuque Formation of the Santa Fe Group consists of reddish-brown and pinkish-tan silty sand and gravel derived largely from the Sangre de Cristo Mountains (Spiegel and Baldwin, 1963). With a thickness of more than 9,000 feet near the Rio Grande (Kelley, 1978), the Tesuque is the principal groundwater-bearing unit in the planning region and is sometimes referred to as the Tesuque Formation aquifer. The Tesuque Formation consists of interbedded layers of gravel, sand, silt, and clay with some intercalated volcanic ash beds. Because of its stratification and the dipping of its sedimentary beds, the aquifer is considered anisotropic, with the primary hydraulic conductivity direction occurring along its bedding planes. Horizontal flow is faster than downward flow.

The Puye Formation of the Santa Fe Group is present on the western side of the Rio Grande (Griggs, 1964; Purtymun and Johanson, 1974) and is covered by Bandelier Tuff in the Jemez Mountains area. It consists of poorly sorted boulders, cobbles, and coarse sands (Spell et al., 1990). The thickness of the Puye formation varies from 60 feet near Otowi to more than 700 feet in Santa Clara Canyon (McAda and Wasiolek, 1988). The Puye Formation, which is generally underlain by the Tesuque Formation, also contains groundwater; however its occurrence is poorly characterized

The Ancha Formation of the Santa Fe Group occurs north of South Galisteo Creek, particularly within the North Galisteo Creek and Santa Fe River Sub-Basins. The Ancha is more permeable

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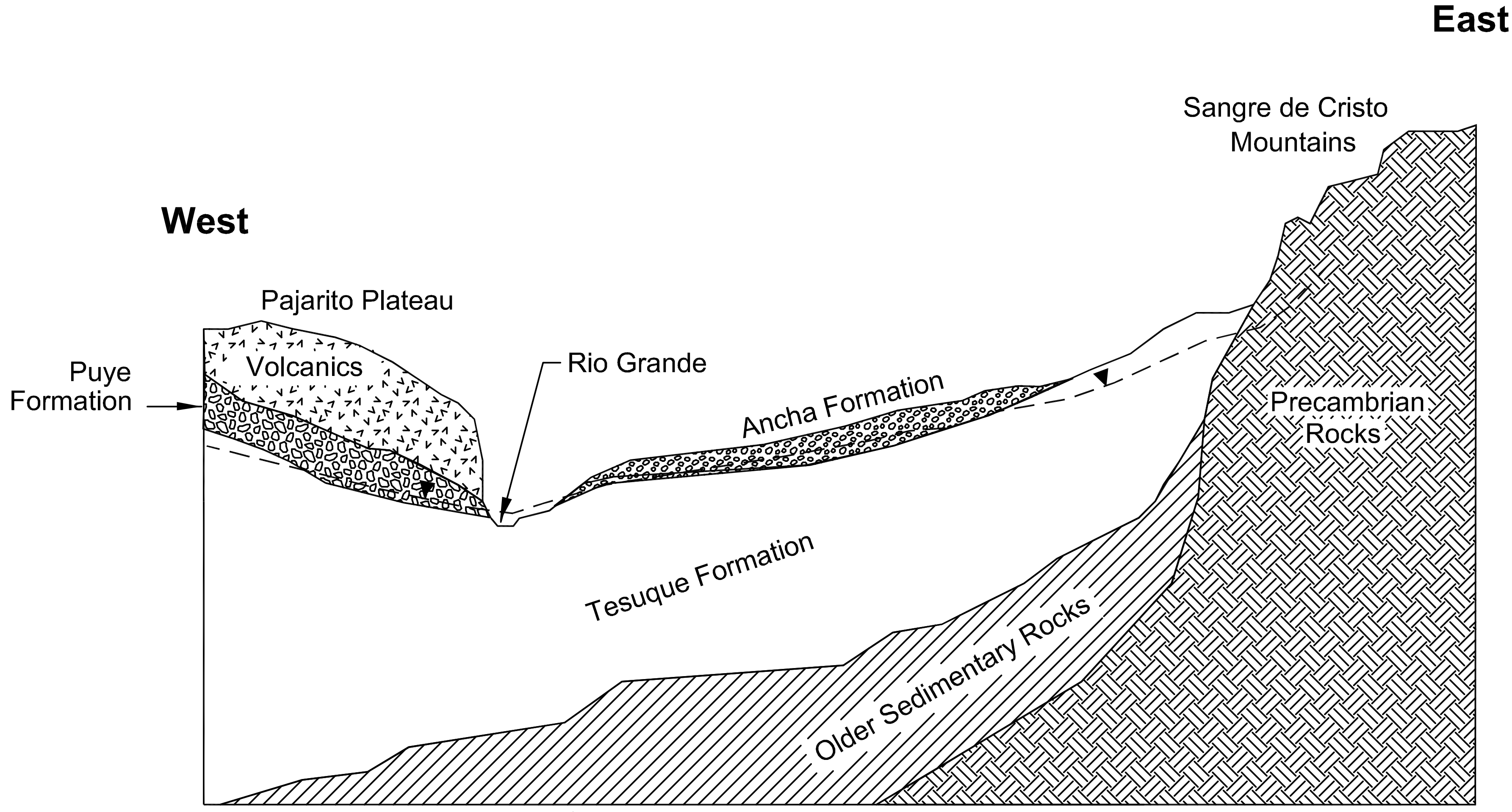


Source: DBS&A, 1994

Not to scale

JEMEZ Y SANGRE REGIONAL WATER PLAN

Schematic East-West Cross Section of the North Santa Fe County Aquifer System

Figure 14

than the Tesuque formation and is as thick as 300 feet in some areas. In most locales, the Ancha Formation is above the water table; however, when the formation is underlain by a low permeability unit it can accumulate water.

Shallow alluvial deposits, younger than the Santa Fe Group, lie beneath and adjacent to the Rio Grande and its main tributaries throughout the planning region. These deposits are better sorted and have a larger average grain size than the sediments comprising the Tesuque Formation. The shallow alluvial deposits vary from about two miles wide along the Rio Grande to less than a few hundred feet wide along the tributaries (see Figure 4, Section 3). The deposits are at least 55 feet thick along the Rio Grande (Galusha and Black, 1971) and less than 100 feet thick along the tributaries (Hearne, 1985).

5.3.2 Aquifer Characteristics

This section presents a brief discussion of the aquifer parameters hydraulic conductivity and transmissivity. Hydraulic conductivity is a comparative measure, used to describe how much water flows through an area of 1 square foot per day (ft^2/d). Typical values for hydraulic conductivities range from 0.0028 feet per day to 28 feet per day. Transmissivity is the product of hydraulic conductivity and the saturated thickness of the aquifer. Freeze and Cherry (1979) suggest that aquifers with a transmissivity greater than 13,824 ft^2/d are "good for water well exploitation"; however, aquifers with much lower transmissivity will produce water.

The Santa Fe Group, consisting of the Tesuque, Ancha, and Puye Formations, forms the principal aquifer system in all sub-basins in the planning region, except the South Galisteo Creek Sub-Basin where the Galisteo Formation comprises the main hydrogeologic unit. Summaries of the hydraulic characteristics of groundwater-bearing units in the Española Basin were developed using hydrogeology reports for areas within the planning region (e.g., Spiegel and Baldwin, 1963; Hearne, 1985; McAda and Wasiolek, 1988; DBS&A, 1994; Frenzel, 1995; U.S. District Court, 1997).

5.3.2.1 Hydraulic Conductivity and Transmissivity

Analysis of aquifer test data (DBS&A, 1994) indicates that the transmissivity of the Santa Fe Group aquifer system varies from 0.05 ft^2/d to 10,960 ft^2/d. Hydraulic conductivity is greater in the upper portion of the Santa Fe Group than in the lower portions of the group. Estimates of hydraulic conductivity for the upper portion (Ancha Formation) range from 3 feet per day to 21 feet per day. Transmissivity estimates range from 300 ft^2/d to 2,100 ft^2/d.

Hearne (1985) estimated that the hydraulic conductivity in the lower portion of the Santa Fe Group (Tesuque Formation) varies from 0.5 to 2 feet per day with a most likely value of 1 foot per day. This translates into transmissivities of 500 ft^2/d to 2,000 ft^2/d for the top 1,000 feet of the aquifer system. McAda and Wasiolek (1988) estimated the transmissivity to vary from 160 ft^2/d to 2,400 ft^2/d for the upper 800 feet of the Santa Fe Group. For very deep portions of the Santa Fe Group, transmissivities vary from 36 ft^2/d to 670 ft^2/d (McAda and Wasiolek, 1988).

Although the Ancha Formation is more permeable (higher conductivity), the Tesuque Group has substantially greater saturated thicknesses, which leads to higher transmissivities. Aquifer test data from the southern part of the planning region are too sparse to derive a hydraulic conductivity range for the Galisteo Formation. Spiegel and Baldwin (1963) reported that the conductivity of the Galisteo Formation is very low, which limits the availability of groundwater contained within it.

5.3.2.2 Groundwater Storage

Groundwater in the Santa Fe Group aquifer system is the major source of municipal and domestic supply in the planning region. Total groundwater storage in the planning region is estimated at 57.8 million acre-feet for the top 1,000 feet of the Santa Fe Group aquifer system, and 110 million acre-feet for the top 2,000 feet (Duke, 2001).

The Duke study (2001) developed estimates of groundwater in storage in the Santa Fe Group for each of the sub-basins. These estimates assumed that the aquifer system consists of a continuous, homogeneous porous medium. Although the aquifer is not homogeneous, the parameters adopted to represent a homogeneous system are believed to be generally representative of the Santa Fe Group as a whole. Storage estimates are presented in Table 15.

Groundwater levels and minimum and maximum saturated thicknesses listed for the Santa Fe Group in each sub-basin correspond to visual representations of this parameter shown in Figures 15 and16.

Table 15. Estimated Volume of Groundwater in Storage by Sub-Basin

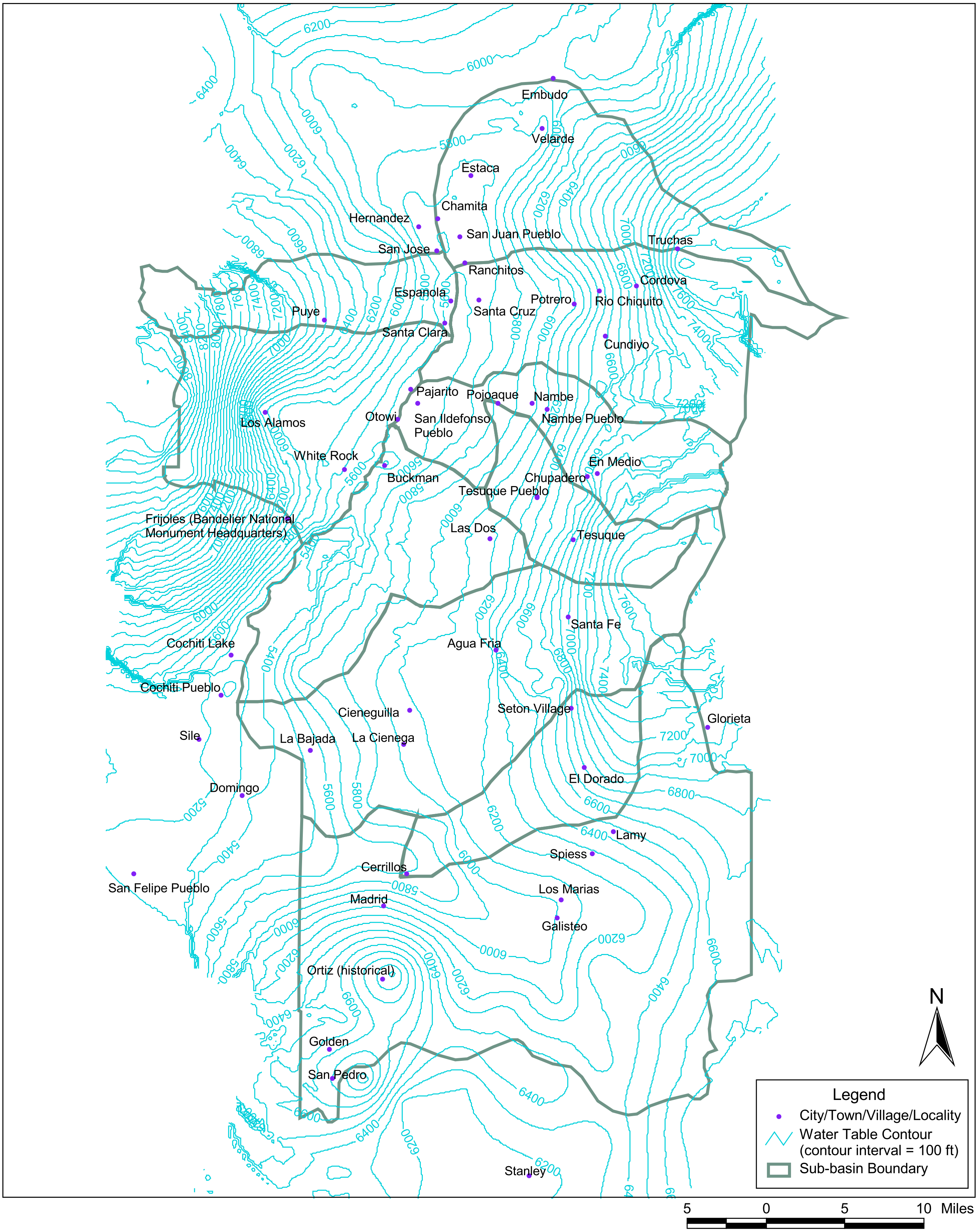
Sub-Basin	Area (acres)	Santa Fe Group Saturated Thickness [a] (feet)		Storage in Aquifer [b] (million acre-feet)	
		Maximum	Minimum	Top 1,000 feet	Top 2,000 feet
Velarde	97,100	9,527	0	9.57	18.86
Santa Clara	54,600	8,983	3094	5.46	10.92
Santa Cruz	59,300	6,474	0	5.43	10.30
Los Alamos	110,200	7,921	2,058	11.02	22.04
Pojoaque-Nambe	42,500	5,096	0	3.97	7.47
Tesuque	32,400	4,463	0	2.93	5.39
Caja del Rio	101,500	3,777	1,980	10.16	20.31
Santa Fe River	111,000	2,919	0	9.26	15.08
North Galisteo Creek		0	0	0	0
South Galisteo Creek		0	0	0	0
Total				57.80	110.37

Source: Duke, 2001 (Table 5-7)

[a] Santa Fe Group saturated thickness represents the difference between post-1990 groundwater (see Figure 5-8 in Duke, 2001) and the elevation of the base of the Santa Fe Group as provided by LANL.

[b] The planning region was divided into 1,000- by 1,000-meter cells, and the volume of groundwater storage in each cell was estimated by multiplying the cell area by the local saturated thickness and an assumed specific yield of 0.1.

Table 15 indicates that the Los Alamos and Caja del Rio Sub-Basins contain the highest quantities of stored groundwater. The Santa Fe River Sub-Basin has almost the same area as the Los Alamos Sub-Basin, but contains noticeably less stored water. This is largely because the saturated thicknesses of the Santa Fe Group in the Santa Fe River Sub-Basin are generally not as large as in the Los Alamos Sub-Basin (Figure 16). The Velarde Sub-Basin contains the third largest quantities of computed groundwater storage; the total saturated thickness of the Santa Fe Group in this sub-basin approaches 9,000 feet or more.



Source: Duke, 2001 (Figure 5-8)

JEMEZ Y SANGRE REGIONAL WATER PLAN

Groundwater Level Map (Post 1990)

Figure 15

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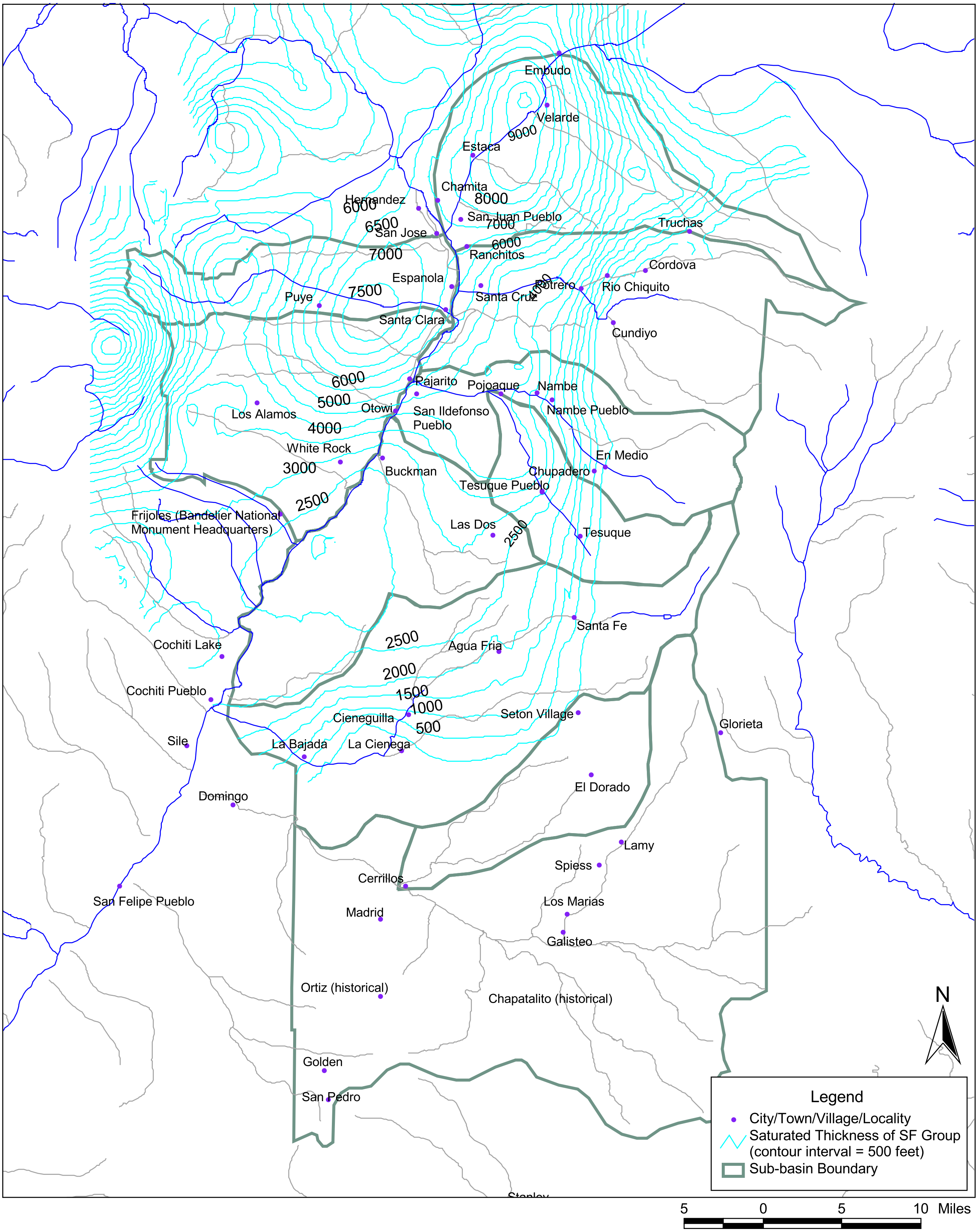

Source: Duke, 2001 (Figure 5-25)

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JEMEZ Y SANGRE REGIONAL WATER PLAN

Saturated Thickness of the Santa Fe Group

Figure 16

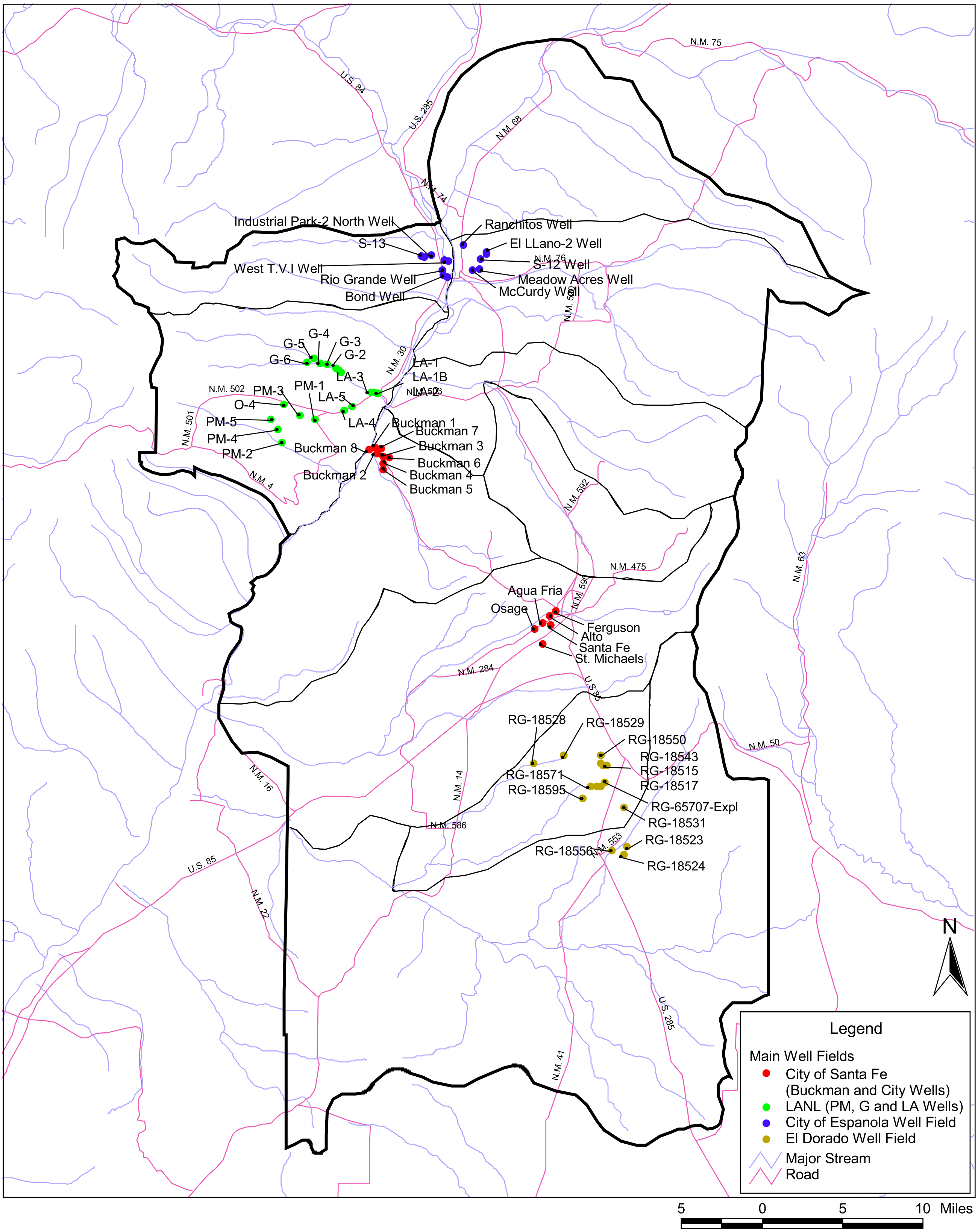
5.3.3 Well Fields

Groundwater withdrawals are used for municipal water supply in the City of Santa Fe (Buckman and City of Santa Fe well fields), Los Alamos (Los Alamos, Guaje, Pajarito Mesa, and Otowi well fields), the City of Española well field, and well fields for smaller communities such as Eldorado, south of Santa Fe (Figure 17). Table 16 lists the reported annual pumpages from these well fields and Figure 18 shows pumpages from the major well fields in the region.

The City of Santa Fe depends on both surface water and groundwater for its municipal water supply. The City diverts groundwater from both the Buckman well field and the City's well field centered on the western end of Santa Fe. The City began diverting water during 1950 from its local well field, the St. Michael's well was added to the supply system in 1961, and the Buckman well field was added in 1972. The average groundwater withdrawal from both well fields by the City of Santa Fe during the period 1950 to 1999 was 3,352 afy, and the average rate of pumping from 1990 through 1999 was 7,177 afy.

The Los Alamos well field began production in 1947, withdrawing 451 afy. This well field went out of service during 1993. The Guaje well field began production in 1950 and the Pajarito Mesa well field started operating in 1965; both are still active. The Otowi well field was added to the municipal supply system during 1993. Total pumping from all well fields in Los Alamos has varied from 451 afy in 1947 to 5,193 afy in 1976. The average total groundwater withdrawal for the period between 1947 and 1997 was 3,782 afy, and the average total pumpage for the period 1990 to 1997 was 4,418 afy. The City of Española well field began diverting groundwater in 1967. Annual pumping increased from 335 afy in 1967 to 1,336 afy in 1995. The average groundwater withdrawal rate for the period 1990 to 1997 was 1,170 afy.

Pumping from the Eldorado well field started in 1972 at a rate of 12 afy and increased to about 500 afy in 1999 (Shomaker and Associates, personal communication).



Source: Duke, 2001 (Figure 5-3)

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JEMEZ Y SANGRE REGIONAL WATER PLAN

Municipal Well Field Locations

Figure 17

Table 16. Annual Production of Major Well Fields
Page 1 of 2

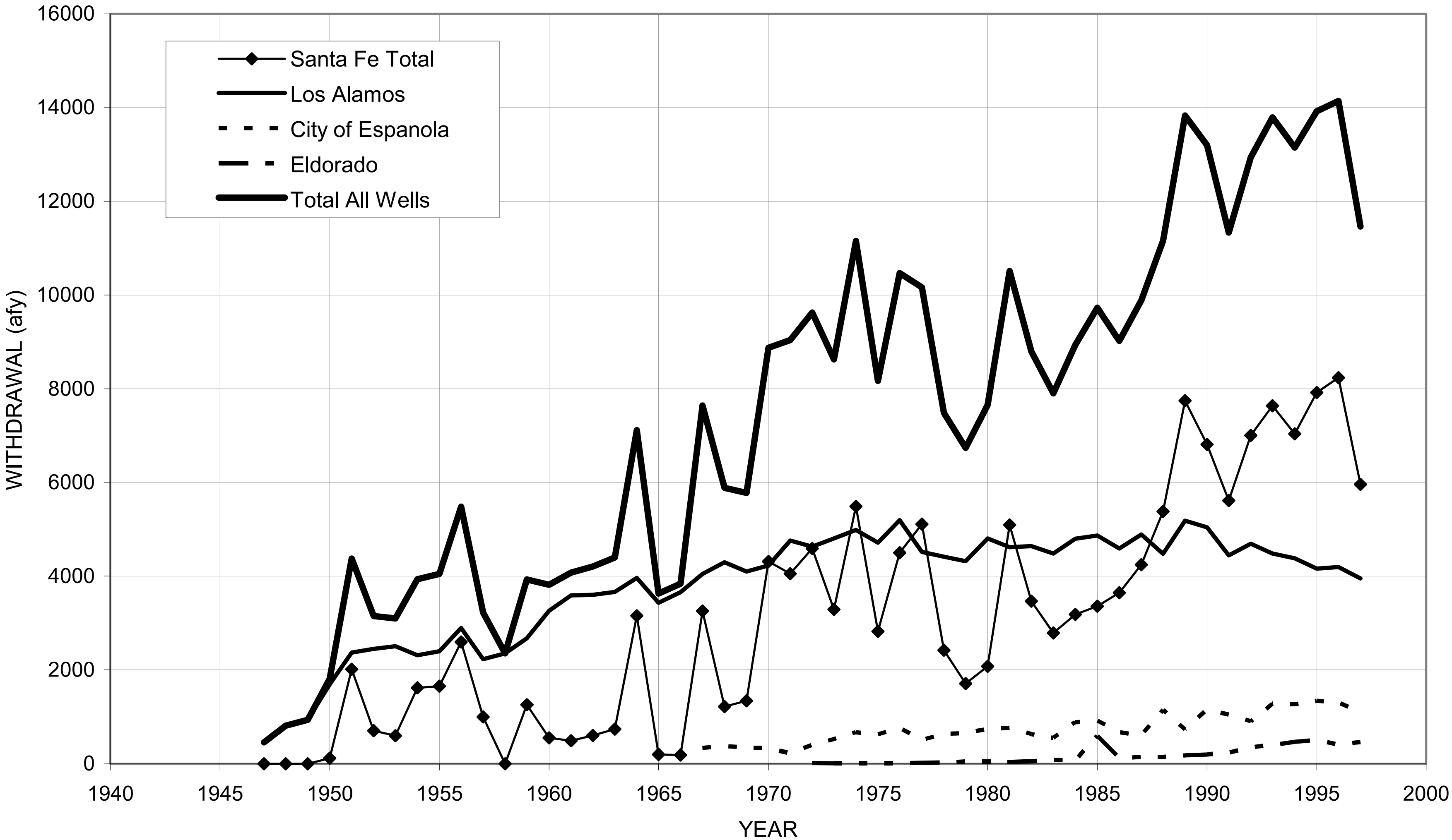
Year	Annual Production (acre-feet per year)					
	Santa Fe	Buckman	Los Alamos	Española	Eldorado	Total
1947	0	---	451	---	---	451
1948	0	---	810	---	---	810
1949	0	---	930	---	---	930
1950	121	---	1,688	---	---	1,809
1951	2,010	---	2,366	---	---	4,376
1952	699	---	2,449	---	---	3,148
1953	594	---	2,504	---	---	3,098
1954	1,618	---	2,314	---	---	3,932
1955	1,649	---	2,397	---	---	4,046
1956	2,594	---	2,891	---	---	5,485
1957	993	---	2,228	---	---	3,221
1958	0	---	2,354	---	---	2,354
1959	1,255	---	2,673	---	---	3,928
1960	550	---	3,262	---	---	3,812
1961	488	---	3,588	---	---	4,076
1962	601	---	3,603	---	---	4,204
1963	734	---	3,661	---	---	4,395
1964	3,154	---	3,962	---	---	7,116
1965	199	---	3,428	---	---	3,627
1966	185	---	3,655	---	---	3,840
1967	3,257	---	4,048	335	---	7,640
1968	1,213	---	4,297	374	---	5,884
1969	1,338	---	4,100	339	---	5,777
1970	4,315	---	4,229	328	---	8,872
1971	4,055	---	4,760	225	---	9,040
1972	3,739	849	4,628	393	15	9,625
1973	962	2,325	4,803	522	11	8,623
1974	2,202	3,288	4,984	664	11	11,149
1975	450	2,372	4,711	621	13	8,167
1976	1,801	2,700	5,193	758	14	10,465
1977	2,009	3,100	4,517	510	23	10,160
1978	810	1,609	4,413	627	26	7,485
1979	1,196	511	4,318	657	53	6,735
1980	1,565	507	4,803	733	46	7,654
1981	2,607	2,486	4,616	760	41	10,510

Source: Duke, 2001 (Table 5-1)   --- = No data available

Table 16. Annual Production of Major Well Fields
Page 2 of 2

Year	Annual Production (acre-feet per year)					
	Santa Fe	Buckman	Los Alamos	Española	Eldorado	Total
1982	2,192	1,274	4,640	630	57	8,793
1983	2,772	16	4,484	547	82	7,901
1984	2,868	312	4,800	881	74	8,935
1985	2,227	1,130	4,864	914	590	9,726
1986	2,095	1,548	4,591	667	118	9,020
1987	2,800	1,442	4,889	603	150	9,884
1988	2,909	2,470	4,478	1,149	148	11,154
1989	3,192	4,551	5,180	727	181	13,831
1990	2,984	3,824	5,039	1,153	197	13,198
1991	2,427	3,186	4,444	1,045	230	11,332
1992	2,248	4,752	4,689	897	349	12,935
1993	2,027	5,610	4,484	1,275	395	13,791
1994	2,054	4,982	4,379	1,264	466	13,145
1995	2,026	5,891	4,161	1,337	503	13,918
1996	2,578	5,656	4,195	1,302	406	14,138
1997	1,241	4,716	3,950	1,094	460	11,461
1998	2,271	5,216	4,011	---	519	---
1999	2,802	5279	4,265	---	502	---
2000	3,828	5.080	4,862	---	533	---
2001	2,755	4,744	4,697	---	540	---
2002	3,702	5,837	---	---	---	---

Modified from Duke, 2001 (Table 5-1) --- = No data available



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Groundwater Withdrawals from Major Well Fields in the Planning Region

Figure 18

5.4 Water Quality

To characterize the water quality in the region, Duke (2001) focused on 19 measures of inorganic water quality including pH, total dissolved solids (TDS), dissolved aluminum, arsenic, barium, chloride, cyanide, fluoride, iron, lead, manganese, nickel, nitrate as nitrogen, silver, strontium, sulfate, tritium, and uranium. These measures were selected primarily because the New Mexico Environment Department (NMED) and/or the U.S. Environmental Protection Agency (EPA) have established either water quality standards or water quality guidelines for their occurrence. NMED criteria consist of drinking water standards published by the New Mexico Water Quality Control Commission (NMWQCC, 2000a). EPA's standards comprise maximum contaminant levels (MCLs), secondary drinking water regulations (SDWRs), and action levels (U.S. EPA, 2000). In addition to these indications, Duke also considered dissolved oxygen, nutrients, phosphorus, and hardness as described below.

An additional indicator of inorganic water chemistry is the degree of water oxygenation, which is also referred to as a dissolved oxygen (DO) percentage. DO percentage reflects the general health of a watercourse with regard to supporting aquatic organisms, such as those found in vital fisheries; the larger the DO percent, the more likely that a healthy fishery can be supported.

Nutrients in the form of ammonia and total phosphorous are also used as indicators of water quality. As measured by the USGS, total dissolved ammonia includes the ammonium ion (NH_4^+) and un-ionized ammonia (NH_3). Ammonia can be very toxic to fish at high levels, although it is usually a minor component at the pH levels commonly observed in streams and groundwater (USGS, 1999).

Elevated concentrations of dissolved phosphorous, can lead to nuisance plant growth (USGS, 1999). Phosphorous is also a major contributor to stream and lake eutrophication.

Water hardness is traditionally reported in terms of an equivalent concentration of calcium carbonate ($CaCO_3$). In practical water analysis, the hardness is computed by multiplying the sum of milliequivalents per liter of calcium and magnesium by 50 (Hem, 1989). The resulting equivalent concentration of calcium carbonate, expressed in units of milligrams per liter (mg/L) of $CaCO_3$, is categorized as follows with respect to hardness:

- 0 to 60 mg/L of $CaCO_3$ Soft
- 61 to 120 mg/L of $CaCO_3$ Moderately hard
- 121 to 180 mg/L of $CaCO_3$ Hard
- More than 180 mg/L of $CaCO_3$ Very hard

5.4.1 Surface Water Quality

Duke (2001) found that the general quality of surface waters in the Jemez y Sangre planning region is very good to excellent. The concentration of TDS in surface waters is typically less than 250 mg/L, substantially below the standards listed in Table 17 and well below the 1,000 to 3,000 mg/L range that the ISC uses to classify "slightly saline" waters (Duke, 2001). Surface waters throughout the planning region typically comply with the other standards and guidelines listed in Table 17, although there are scattered cases of high concentrations of inorganic ions dissolved in surface water, mostly in locales that are affected by some form of wastewater discharge.

The most abundant cation in regional surface waters is calcium, with sodium, magnesium, and iron occurring in lesser quantities. The predominant anions are bicarbonate and sulfate. Over most of the planning region, the surface water is characterized as calcium-bicarbonate, although calcium-magnesium-bicarbonate and sodium-bicarbonate types are occasionally observed (Duke, 2001). Most surface waters in the planning region are classified as moderately hard to hard because of their relatively high concentrations of calcium and magnesium.

Nutrients dissolved in surface waters occur in the planning region primarily as a result of agricultural land uses, although urbanization and wastewater discharges also contribute nutrients. The main stem Rio Grande receives dissolved nutrients from agricultural sources as far north as the San Luis Valley in southern Colorado and the Rio Chama above El Vado Reservoir. Noticeable nutrient source areas include irrigated areas near Española, one of the

Table 17. New Mexico Drinking Water Standards for Surface Water and EPA Drinking Water Standards

Constituent	New Mexico Surface Water Standard	EPA Drinking Water Standard
pH	6-9	6.5-8.5 [a]
Total Dissolved Solids (TDS)	---	500 mg/L [b]
Aluminum (Al)	---	0.05 mg/L [a]
Arsenic (As)	0.05 mg/L	0.05 mg/L [b], 0.005 mg/L [c]
Barium (Ba)	2.0 mg/L	2 mg/L [b]
Chloride (Cl)	---	250 [a]
Cyanide (CN)	0.2 mg/L	0.2 mg/L [b]
Fluoride (Fl)	---	2 [a]
Iron (Fe)	1.0 mg/L	0.3 mg/L [a]
Lead (Pb)	0.05 mg/L	0.015 mg/L [d]
Manganese (Mn)	---	0.05 [a]
Nickel (Ni)	0.1 mg/L	---
Nitrate as Nitrogen (NO_3 as N)	---	10 mg/L [b]
Selenium (Se)	0.05 mg/L	0.05 mg/L [b]
Silver (Ag)	---	0.1 [a]
Strontium (Sr)	8 pCi/L	---
Sulfate (SO_4)	---	250 mg/L [a]
Tritium (H_3)	20,000 pCi/L	---
Uranium (U)	5 mg/L	0.02 mg/L [c]

Source: Duke, 2001 (Table 4-1)

[a] EPA Secondary Drinking Water Regulation (SDWR) – a non-enforceable health goal which is set at a level at which no known or anticipated adverse effect on the health of persons occur and which allows an adequate margin of safety.

[b] EPA Maximum Contaminant Level (MCL) – the highest level of a contaminant that is allowed in drinking water. MCLs are enforceable.

[c] Proposed MCL.

[d] EPA Action Level (AL) – the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow. For lead it is the level which, if exceeded in over 10% of the homes tested, triggers treatment.

EPA = U.S. Environmental Protection Agency
--- = Not applicable
mg/L = Milligrams per liter
pCi/L = Picocuries per liter

more urbanized locales in the planning region, and the lower Santa Fe River downstream of the City of Santa Fe. Surface water in the Pojoaque Valley also occasionally contains elevated levels of nutrients, including ammonia.

A TMDL is a watershed or basin-wide budget for pollutant influx to a watercourse. A TMDL can also be established for a portion or a segment of a watershed. The NMWQCC is responsible for setting TMDLs in New Mexico. TMDLs are set for one or more constituents that have historically exceeded water quality standards. Since this program began, a variety of stream reaches within the planning region have been the subject of TMDL assessments. Table 18 lists the stream reaches within the planning region that are currently undergoing assessment, and provides a brief summary of the pollutants examined for each reach and the current TMDL status. Contaminants of concern being addressed by the TMDL program include turbidity, stream bottom deposits, pesticides, chlorine, pH, DO, and fecal coliform.

As Table 18 indicates, the Santa Fe River is the only watercourse in the planning region for which the NMWQCC has set TMDL-based limits. Specifically, for the reach of the river lying between the Santa Fe wastewater treatment plant (WWTP) and Cochiti Reservoir, loading limits have been established for chlorine and stream bottom deposits. Both DO and pH have been assessed on this reach, but have not been assigned TMDL-based limits. Also, although nitrate levels downstream of the WWTP were observed to be as high as 5.0 mg/L during the National Water Quality Assessment Program, no TMDL-based limits have been established for nitrate.

The TMDL study of the Santa Fe River identified a distinct link between chlorine in the river and effluent from the Santa Fe WWTP. A study by CDM (1998) provided evidence that the source of virtually all total residual chlorine in the river was the WWTP and that levels of this dissolved constituent decrease downstream of the WWTP. The Santa Fe WWTP has replaced its chlorination system with an ultraviolet disinfection system which will help it meet TMDL-based limits for chlorine.

Table 18. Total Maximum Daily Load Status of Streams in the Jemez y Sangre Water Planning Region
Page 1 of 4

Water Body Name, (Basin, Segment) Evaluated or Monitored Support Status, WBS Number	Affected Reach (miles)	Probable Sources of Pollutant	TMDL Due Date	NPDES Permits on the Reach	Uses not fully Supported	Specific Pollutant	Acute Public Health Concern
Pojoaque River from mouth on Rio Grande to Nambe Dam (Rio Grande, 2111), Evaluated Partially Supported, (URG1-10200)	14.4	Rangeland, removal of riparian vegetation, streambank modification/ destabilization	12/31/2017	• Pojoaque Terraces Mobile Home Park (NM0028436) • Pojoaque Valley Schools-Jacona Site (NM0029882)	MCWF, WWF	Stream bottom deposits	No
Tesuque Creek from the confluence with Little Tesuque Creek to the confluence of North and South Forks of Tesuque Creek (Rio Grande, 2118), Monitored Not supported, (URG0-10230)	6.7	Removal of riparian vegetation, streambank modification/ destabilization	12/31/2017	None	HQCWF	Turbidity	No
Little Tesuque Creek from Big Tesuque Creek to headwaters (Rio Grande, 2118), Monitored Not supported, (URG1 – 10230)	8.1	Recreation	12/31/2017	None	HQCWF	Turbidity	No
Little Tesuque Creek from Big Tesuque Creek to headwaters (Rio Grande, 2118), Monitored Not Supported., URG1 – 10230)	8.1	Natural, unknown	12/31/2017	None	HQCWF	Metals	No

Source: Duke, 2001 (Table 4-2); NMED web site, 2002
TMDL = Total maximum daily load
WBS = Water body segment
NPDES =National Pollutant Discharge Elimination System
WWTP =Wastewater treatment plant

HQCWF = High quality coldwater fishery
MCWF = Marginal coldwater fishery
WWF = Warmwater fishery
LW = Livestock watering

Table 18. Total Maximum Daily Load Status of Streams in the Jemez y Sangre Water Planning Region
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Water Body Name, (Basin, Segment) Evaluated or Monitored Support Status, WBS Number	Affected Reach (miles)	Probable Sources of Pollutant	TMDL Due Date	NPDES Permits on the Reach	Uses not fully Supported	Specific Pollutant	Acute Public Health Concern
Rio Frijoles from confluence with Rio Medio to Pecos Wilderness boundary (Rio Grande, 2112), Evaluated Partially Supported, (URG1 – 10240)	2.5	Unknown	12/31/2017	None	HQCWF	Unknown	No
Rio Chupadero from USFS boundary to headwaters (Rio Grande, 2118), Monitored Not Supported, (URG1 – 10240)	4.1	Road maintenance/ runoff, recreation, unknown	12/31/2017	None	HQCWF	Turbidity	No
Rio Chupadero from USFS boundary to headwaters (Rio Grande, 2118), Monitored Not Supported, (URG1 – 10240)	4.1	Road maintenance/ runoff, recreation, unknown	12/31/2017	None	HQCWF	Turbidity	No
Rito Canon de Frijoles from mouth on the Rio Grande headwaters (Rio Grande, 2118), Monitored Partially Supported, (MRG1 – 20100)	2.8	Land disposal	12/31/2017	None	HQCWF	Pesticide (DDT)	No
Santa Fe River from the Cochiti Pueblo to the Santa Fe WWTP (Rio Grande, 2110), Monitored Not Supported, (URG1 – 10300)	12.7	Municipal point sources	12/31/1999	Santa Fe WWTP (NM0022292)	MCWF, WWF, LW	Dissolved oxygen	No

Source: Duke, 2001 (Table 4-2); NMED web site, 2002
TMDL = Total maximum daily load
WBS = Water body segment
NPDES =National Pollutant Discharge Elimination System
WWTP =Wastewater treatment plant

HQCWF = High quality coldwater fishery
MCWF = Marginal coldwater fishery
WWF = Warmwater fishery
LW = Livestock watering

Table 18. Total Maximum Daily Load Status of Streams in the Jemez y Sangre Water Planning Region
Page 3 of 4

Water Body Name, (Basin, Segment) Evaluated or Monitored Support Status, WBS Number	Affected Reach (miles)	Probable Sources of Pollutant	TMDL Due Date	NPDES Permits on the Reach	Uses not fully Supported	Specific Pollutant	Acute Public Health Concern
Santa Fe River from the Cochiti Pueblo to the Santa Fe WWTP(Rio Grange, 2110), Monitored Not Supported, (URG1 – 10300)	12.7	Municipal point sources, rangeland, resource extraction	TMDL witten and WQCC approved	Santa Fe WWTP (NM0022292)	MCWF, WWF, LW	Chlorine	No
Santa Fe River from the Cochiti Pueblo to the Santa Fe WWTP (Rio Grande, 2110), Monitored (URG1 – 10300)	12.7	Municipal point sources, rangeland, resource extraction	TMDL written and WQCC approved	Santa Fe WWTP (NM0022292)	MCWF, WWF, LW	Stream bottom deposits	No
Santa Fe River from the Cochiti Pueblo to the Santa Fe WWTP (Rio Grande, 2110), Monitored Not Supported, (URG1 – 10300)	12.7	Municipal point sources, rangeland, resource extraction	12/31/1999	Santa Fe WWTP (NM0022292)	MCWF, WWF, LW	pH	No
Cienega Creek from the mouth on the Santa Fe to Cienega Village (Rio Grande, 2110), Monitored Partially Supported, (URG1 – 10310)	4.1	Rangeland, land disposal,unknown	12/31/2017	• Valle Vista Sewer Company (NM0028614) • Arroyo Hondo (Geohydrology Association) (NM0029823)	MCWF, WWF, IRR	Fecal coliform	No

Source: Duke, 2001 (Table 4-2); NMED web site, 2002
TMDL = Total maximum daily load
WBS = Water body segment
NPDES =National Pollutant Discharge Elimination System
WWTP =Wastewater treatment plant

HQCWF = High quality coldwater fishery
MCWF = Marginal coldwater fishery
WWF = Warmwater fishery
LW = Livestock watering

Table 18. Total Maximum Daily Load Status of Streams in the Jemez y Sangre Water Planning Region
Page 4 of 4

Water Body Name, (Basin, Segment) Evaluated or Monitored Support Status, WBS Number	Affected Reach (miles)	Probable Sources of Pollutant	TMDL Due Date	NPDES Permits on the Reach	Uses not fully Supported	Specific Pollutant	Acute Public Health Concern
Cienega Creek from the mouth on the Santa Fe to Cienega Village (Rio Grande, 2110), Monitored Partially Supported, (URG1 – 10310)	4.1	Rangeland, land disposal	12/31/2017	• Valle Vista Sewer Company (NM0028614) • Arroyo Hondo (Geohydrology Association) (NM0029823)	MCWF, WWF, IRR	Chlorine	No
Galisteo Creek, perennial portions (Rio Grande, unclassified), Evaluated Partially Supported	5.5	Rangeland, hydromodification, removal of riparian vegetation, streambank modification/ destabilization	12/31/2017	None	WWF	Stream bottom deposits	No

Source: Duke, 2001 (Table 4-2); NMED web site, 2002

TMDL = Total maximum daily load
WBS = Water body segment
NPDES =National Pollutant Discharge Elimination System
WWTP =Wastewater treatment plant

HQCWF = High quality coldwater fishery
MCWF = Marginal coldwater fishery
WWF = Warmwater fishery
LW = Livestock watering

The Santa Fe WWTP is not the only source for suspended solids on the Santa Fe River, but it is the only known point source. Currently, the plant is permitted to have effluent discharge containing 30 mg/L total suspended solids (TSS). The geometric mean of TSS measurements in WWTP effluent from data collected between July 1998 and June 1999 was 1.0 mg/L (Duke, 2001). From January 1995 to December 1995, the geometric mean load was 6.3 mg/L. For TMDL purposes, the waste load allocation for TSS in Santa Fe WWTP effluent is based on the WWTP's current permitted TSS concentration of 30 mg/L and the plant's design flow of 8.5 million gallons per day (mgd). Thus, on the basis of TSS information collected during the 1990s, it appears that the WWTP is meeting its allocation criteria.

Other potential point sources of surface water pollution in the planning region were identified through inspection of a list of permitted National Pollutant Discharge Elimination System (NPDES) sites. Duke (2001) lists the NPDES sites within the planning region.

The NMED has expressed concern that non-point sources of pollution in New Mexico may constitute one of the more serious water quality problems facing the state (NMWQCC, 2000b). Non-point pollution is diffuse in origin, the result of rain or snowmelt carrying pollutants from the land into streams, lake, and rivers. The principal contaminants contributed from this type of pollutant source are nutrients, sediments, toxic substances, organic matter, salts, metals, and petroleum and its byproducts. The NMED estimates that about 92 percent of known river water quality impairment in the state is due to non-point sources (NMWQCC, 2000b). The occurrence of significant agriculture activity and urbanization within the Jemez y Sangre planning region makes it likely that some surface water quality degradation is attributed to this type of source.

To study potential surface water contamination resulting from its operations, LANL conducted a study of plutonium and uranium in the sediments of the Northern Rio Grande Valley (Gallaher and Efurd, 2002). Samples of stream channel and reservoir bottom sediments were analyzed for plutonium and uranium isotopes. Isotopic fingerprinting techniques were used to help distinguish radioactivity from LANL from global fallout or natural sources. Of the seven major drainages crossing LANL, movement of LANL plutonium into the Rio Grande was traced only via Los Alamos Canyon. The LANL plutonium is identifiable intermittently along the 35-

kilometer reach of the Rio Grande to Cochiti Reservoir and can be traced primarily to pre-1960 discharges of liquid effluents upstream of the river. Levels of plutonium in the Rio Grande are usually more than 1,000 times lower than EPA cleanup levels (Gallaher and Efurd, 2002). None of the sediments from the Rio Grande showed identifiable LANL uranium, though historical monitoring records show a slight LANL impact.

5.4.2 Groundwater Quality

Groundwater in the planning region is generally of high quality. Except for several isolated locations where either natural or human processes have led to elevated levels of specific dissolved constituents, groundwater is suitable for domestic consumption. Table 19 lists the drinking water standards set by both the State of New Mexico and the EPA. The state criteria consist of drinking water standards published by the NMED Ground Water Quality Bureau. As with surface water standards, EPA's standards comprise MCLs, SDWRs, and action levels (U.S. EPA, 2000).

5.4.2.1 Nitrate

Nitrate is observed at relatively high concentrations at several locales in the planning region; Figure 19 illustrates locations where nitrate concentrations exceed the drinking water standard. Though this constituent occurs naturally within regional groundwater, nitrate background levels are generally very low in comparison to the drinking water standard of 10 mg/L as nitrogen (Table 19). Thus, elevated levels of nitrate are usually attributed to sources for such as fertilizer application, septic tank discharge, or surface water bodies that receive some form of effluent. Fluoride is another naturally occurring inorganic solute that sometimes occurs at elevated or problematic concentrations in groundwater.

5.4.2.2 Electrical Conductivity and Total Dissolved Solids

As part of an assessment of general groundwater quality in Santa Fe County, DBS&A (1994) developed mathematical relationships between measured TDS levels and corresponding measures of electrical conductivity (EC). In most cases, the resulting equations suggest that multiplying EC by a factor of about 0.6 to 0.7 will produce a viable estimate of TDS. Using this

Table 19. New Mexico Drinking Water Standards for Groundwater and EPA Drinking Water Standards

Constituent	New Mexico Surface Water Standard	EPA Drinking Water Standard
pH	6-9	6.5-8.5 [a]
Total Dissolved Solids (TDS)	1,000 mg/L	500 mg/L [b]
Aluminum (Al)	5 mg/L	0.05-0.2 mg/L [a]
Arsenic (As)	0.1 mg/L	0.05 mg/L [b], 0.005 mg/L [c]
Barium (Ba)	1.0 mg/L	2 mg/L [b]
Boron (B)	0.75 mg/L	---
Chloride (Cal)	250 mg/L	250 mg/L [a]
Cyanide (CN)	0.2 mg/L	0.2 mg/L [b]
Fluoride (Fl)	1.6 mg/L	2 mg/L [a]
Iron (Fe)	1.0 mg/L	0.3 mg/L [a]
Lead (Pb)	0.05 mg/L	0.015 mg/L [d]
Manganese (Mn)	0.2 mg/L	0.05 mg/L [a]
Nickel (Ni)	0.2 mg/L	---
Nitrate as Nitrogen (NO_3 as N)	10 mg/L	10 mg/L [b]
Selenium (Se)	0.05 mg/L	0.05 mg/L [b]
Silver (Ag)	0.05 mg/L	0.1 mg/L [b]
Strontium (Sr)	8 pCi/L	---
Sulfate (SO_4)	600 mg/L	250 mg/L [a]
Tritium (H_3)	20,000 pCi/L	---
Uranium (U)	5 mg/L	0.02 mg/L [c]

Source: Duke, 2001 (Table 6-1).

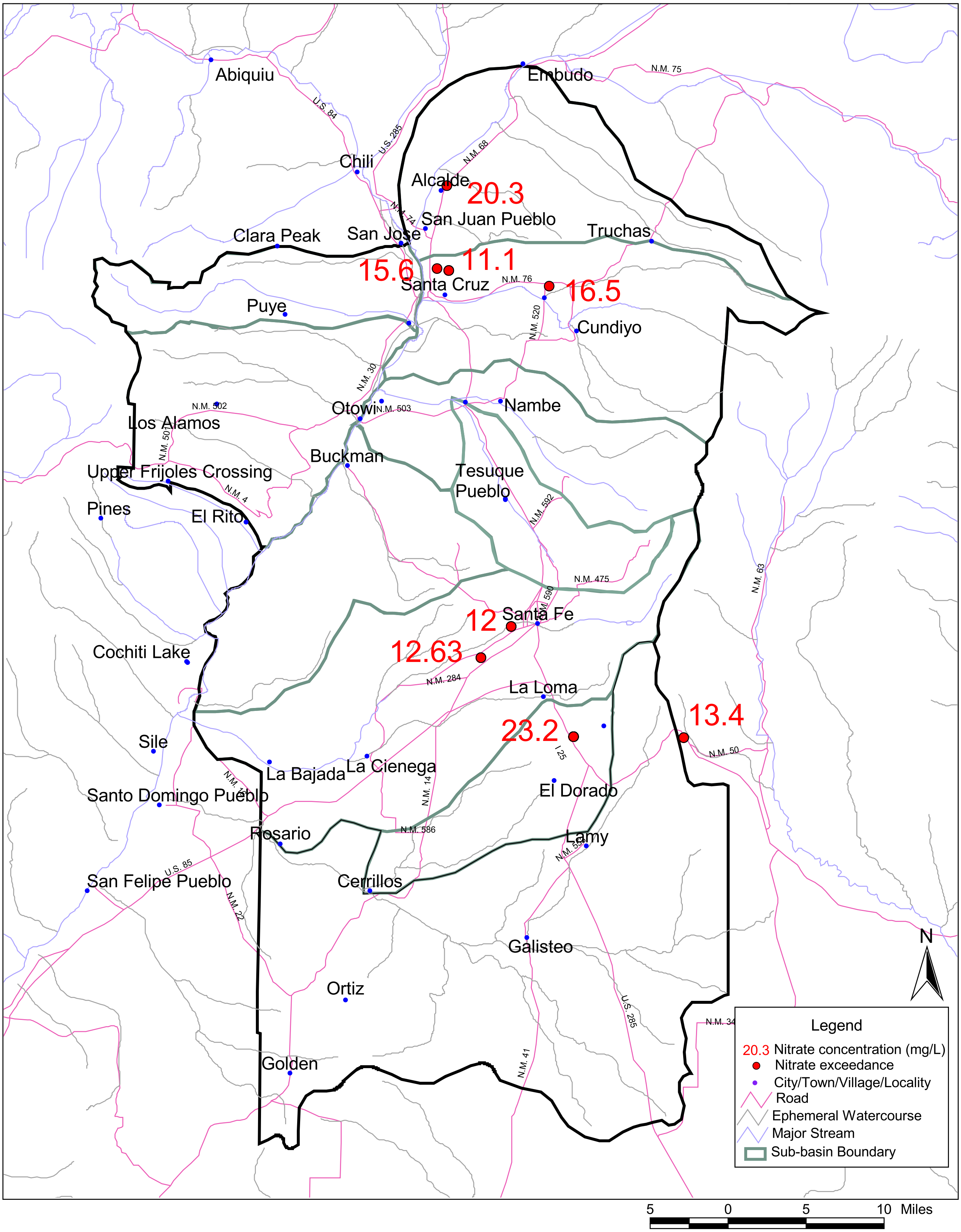
[a] EPA Secondary Drinking Water Regulation (SDWR) – a non-enforceable health goal which is set at a level at which no known or anticipated adverse effect on the health of persons occur and which allows an adequate margin of safety.

[b] EPA Maximum Contaminant Level (MCL) – the highest level of a contaminant that is allowed in drinking water. MCLs are enforceable.

[c] Proposed MCL.

[d] EPA Action Level (AL) – the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow. For lead it is the level which, if exceeded in over 10% of the homes tested, triggers treatment.

EPA = U.S. Environmental Protection Agency
mg/L = Milligrams per liter
pCi/L = Picocuries per liter
--- = Not applicable



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JEMEZ Y SANGRE REGIONAL WATER PLAN

Nitrate Exceedances

Figure 19

general rule, measurements of EC can be used to describe the spatial distribution of dissolved solids levels within the Santa Fe County portion of the planning region.

North of the town of Galisteo, particularly in areas where wells tap either the Tesuque Formation, the Ancha Formation, Precambrian rocks, or shallow alluvium adjacent to watercourses, EC levels in groundwater on the eastern side of the Rio Grande usually range from about 100 to 500 micromhos per centimeter (µmhos/cm). Thus, the TDS levels over most of this part of the planning region can be expected to be 350 mg/L or less. Isolated wells showing EC measurements in excess of 700 µmhos/cm are observed near the City of Santa Fe, in a shallow aquifer near Española, in the Buckman well field, near the community of Pojoaque, and just south of the southernmost extent of Santa Fe Group deposits within the planning region.

Most EC levels in the South Galisteo Creek Sub-Basin indicate that TDS levels in this southernmost portion of the planning region will exceed the New Mexico groundwater standard of 1,000 mg/L. Near the town of Galisteo, measured EC levels range from about 650 to 2,200 µmhos/cm. In this same sub-basin near the west boundary of the planning region, EC measurements generally range from 1,000 to 5,000 µmhos/cm.

Within the Los Alamos Sub-Basin west of the Rio Grande, measured TDS levels are generally less than 350 mg/L. Water supply wells that tap the so-called regional aquifer in the Pajarito Mesa, Guaje Canyon, and Otowi well fields typically yield groundwater with TDS concentrations of 150 to 500 mg/L. TDS concentrations exceeding 600 mg/L have been observed in some of the wells in the Los Alamos well field (Duke, 2001).

The Los Alamos well field, formerly used for water supply to the community of Los Alamos, is now owned by the San Ildefonso Pueblo. An area of relatively high TDS concentration, with values sometimes exceeding 1,000 mg/L, has been observed in wells near the Rio Grande between the historic townsites of Otowi and Pajarito, just north of where Guaje Canyon empties into the Rio Grande Valley. These relatively high concentrations of dissolved solids occur on the western side of San Ildefonso Pueblo, in conjunction with anomalous concentrations of nitrate and sulfate.

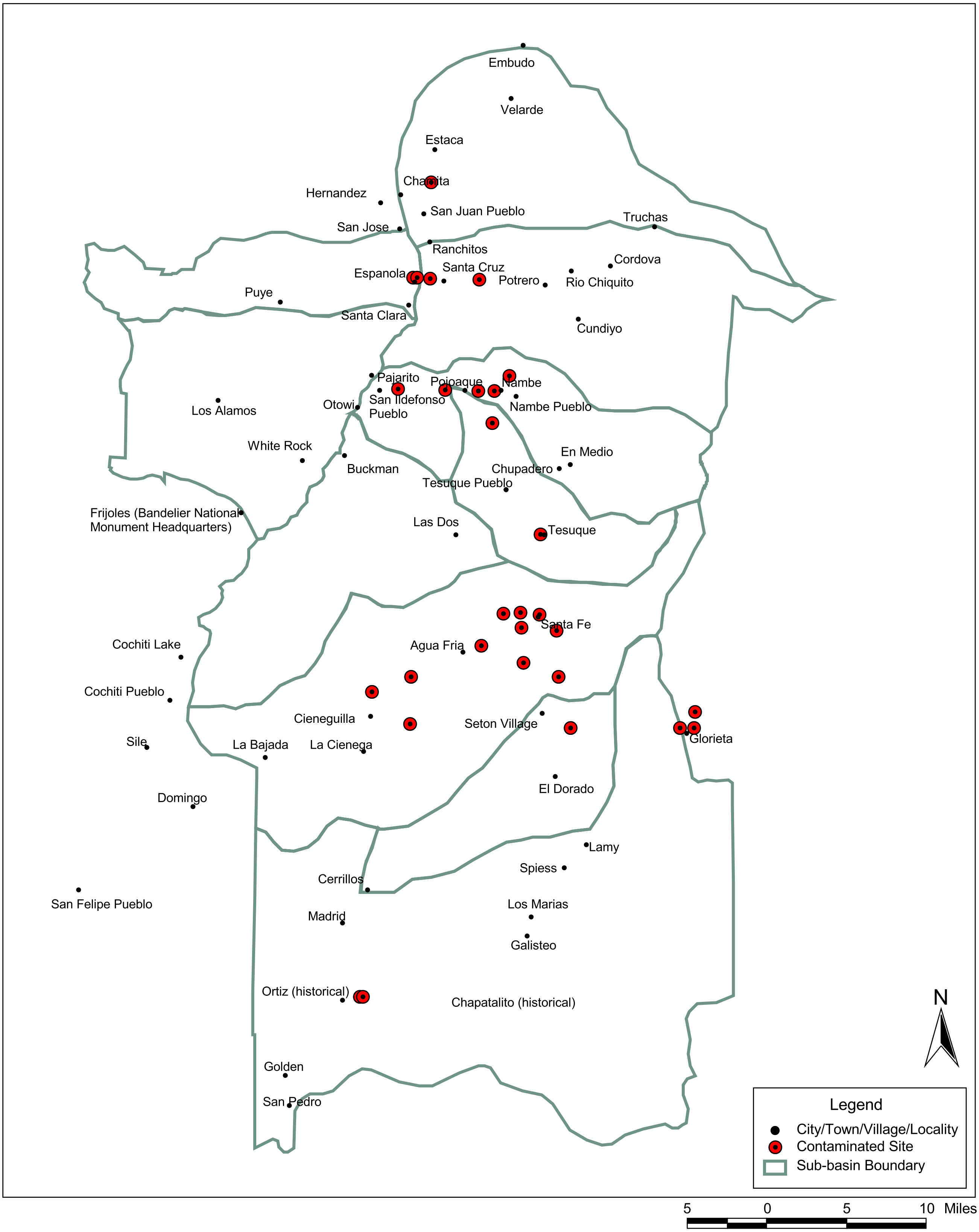
5.4.2.3 Known Groundwater Contamination

Duke catalogued known groundwater contamination sites, showing observed contaminants ranging from gasoline components to chlorinated solvents, pesticides, and radionuclides. Sources associated with the contaminants including leaking underground storage tanks, LANL, dry cleaning facilities, sewage treatment plants, and railroad and mining operations. Contamination has temporarily affected the use of some Española and City of Santa Fe supply wells and some domestic wells. Additionally, the presence of contaminated groundwater limits the suitability of some locations for future development.

Figure 20 shows the locations of known contamination sites, most of which occur near urbanized areas, such as the City of Santa Fe, Española, and the Pueblo of Pojoaque.

Two inorganic constituents that occur naturally in groundwater will likely be of concern to the Jemez y Sangre planning region because of changes to drinking water standards that will soon be enforced by the EPA. One of these constituents is arsenic, which currently is subject to an MCL of 0.05 mg/L. In January 2006, however, this MCL will be reduced to 10 micrograms per liter (µg/L) (0.010 mg/L), a level that is commonly exceeded in regional groundwater under natural conditions. The second constituent is uranium, for which the New Mexico drinking water standard is 5 mg/L. The EPA does not currently have a mass concentration standard for uranium in groundwater, but a new uranium MCL of 30 µg/L (0.03 mg/L) will take effect on December 8, 2003.

Most groundwater within the planning region meets the current arsenic MCL of 0.05 mg/L. All of the New Mexico Drinking Water Bureau (NMDWB) analyses for community water supply systems in the planning region, as taken from the Tier 1 database, show arsenic occurring at concentrations less than this value. However, out of 290 NMDWB samples included in the database, 22 have arsenic levels that are equal to or exceed the new MCL of 10 µg/L (0.01 mg/L). Thus it appears that some community systems may have to provide treatment for



Source: Duke, 2001 (Figure 6-9)

JEMEZ Y SANGRE REGIONAL WATER PLAN

Known Groundwater Contamination Sites in the Planning Region

Figure 20

(S:\PROJECTS\9419\GIS\PROJECTS (PROJECT = jemezy-5-00_duke2.apr) (VIEW EXTENTS = TEMP) (VIEW NAME = V20 - G) (LAYOUT = Fig 20) arsenic based on the new standard. Available data indicate that arsenic exceeds the new MCL of 10 µg/L in the Velarde, Santa Cruz, Los Alamos, Pojoaque-Nambe, Tesuque, Caja del Rio, and Santa Fe Sub-Basins. Additional testing may be required to fully evaluate the extent of elevated arsenic within the planning region. Further discussion of arsenic treatment is provided in Section 7 and Appendix F.

5.4.3 Summary of Water Quality by Sub-Basin

The following discussion summarizes the overall water quality for each of the ten sub-basins in the Jemez y Sangre planning region, beginning with Velarde Sub-Basin in the northern part of the region and moving generally southward (Figure 1). Information about general sub-basin characteristics is provided in Section 3, while Section 6 provides sub-basin water budgets (inflow and outflow). More detailed sub-basin characterizations can be found in Duke (2001).

- *Velarde Sub-Basin*: In general, water supplies meet applicable water quality standards, with the exception of the new arsenic standard. However, water quality concerns exist due to septic tank discharges. For example, there is an area of high nitrate in excess of drinking water standards in Alcalde.

- *Santa Clara Sub-Basin*: Water quality information for Santa Clara Creek is limited; however, it is likely similar to Rito de los Frijoles in Bandelier National Monument to the south. Both Rito de los Frijoles and Santa Clara Creek drain Tertiary volcanic tuff on the eastern flank of the Jemez Mountains, and both are subject to some recreational and cattle grazing land use. The Cerro Grande fire (May 2000) burned through the headwater area of Santa Clara Creek, affecting runoff and water quality.

- *Santa Cruz Sub-Basin*: Surface water quality is generally good; only iron and manganese were noted as having somewhat elevated concentrations when sampling was done in the late 1980s. The groundwater quality is generally very good except in the more congested areas, where septic tanks and drain fields have locally raised nitrate levels. Additionally, naturally occurring arsenic exceeds the new MCL in this sub-basin.

- *Los Alamos Sub-Basin*: The Los Alamos County public water supply meets drinking water quality standards, with the exception of the new arsenic standard. In addition to the public water supply, there are a few individual domestic water supply wells. Residual contamination associated with historical operations of LANL is a concern, and LANL is taking corrective action under its Environmental Restoration Project to address these concerns. LANL has an ongoing surveillance and monitoring program to assess the quality of surface water and groundwater. In addition, the public water supply is monitored to ensure it meets applicable water quality standards.

- *Pojoaque-Nambe Sub-Basin*: In general the quality of the groundwater is good, although local water quality problems include naturally occurring high levels of fluoride, uranium, and arsenic. Also, as in many other sub-basins, areas with higher population density have higher levels of nitrate associated with the use of septic tanks.

- *Tesuque Sub-Basin*: Surface water quality is very good overall with occasional elevated concentrations of iron, lead, and aluminum. The new arsenic standard is also exceeded in some locations. The source of these elevated concentrations is unknown, but might be natural weathering of the granitic core rock in the Sangre de Cristo Range, runoff (from roads, building sites, or the Santa Fe Ski area), or some combination of these. Groundwater is also of high quality in most of the Tesuque Sub-Basin with only a few localized areas having elevated nitrate levels due to agricultural fertilizers or concentrated septic leach fields. Except in local areas where nitrate levels are high, the calcium-bicarbonate groundwater meets drinking water standards and contains relatively low levels of total dissolved solids.

- *Caja del Rio Sub-Basin*: Assessment of water quality indicates localized impacts to surface waters associated with cattle use. Additionally, some wells in the Buckman well field experience elevated levels of natural radionuclides of concern and the new arsenic standard is exceeded in some locations.

- *Santa Fe River Sub-Basin*: The water quality is naturally very good, but the water is hard due to the concentrations of calcium and magnesium. The TDS concentration is generally less than 350 mg/L. Nitrate from an unknown source has been detected in many of the City wells at concentrations slightly above the 10 mg/L standard and the new arsenic standard is exceeded in some locations. Downstream of the City's wastewater treatment plant, nitrate concentration in the groundwater range from 4 to 6 mg/L. Within the City limits, leaking underground storage tanks have contaminated the groundwater in several locations. Chlorinated solvents have contaminated one City well and tetracholoroethene (PCE) from a dry cleaning operation has been detected beneath the railyard property. The railyard site is being developed as a Brownfields Superfund Site.

- *North Galisteo Creek Sub-Basin*: Water quality is generally very good, but the water is hard due to concentrations of naturally occurring calcium and magnesium. Given the few potential sources for contamination in this sub-basin, very few groundwater contamination problems exist. Nitrate occurs in wells along the mountain front in concentrations commonly ranging from 3 to 5 mg/L (as nitrogen). Pesticides have been detected in Cañoncito wells.

- *South Galisteo Sub-Basin*: Water quality is naturally quite variable. TDS can reach as high as 3,500 mg/L, much higher than the New Mexico drinking water standard of 1,000 mg/L. The cyanide heap leach operation in the Ortiz Mountains resulted in cyanide and metals contamination in groundwater and surface water near the mine. The pesticide Atrazine has been detected in wells in Lamy, the Girls Ranch, and Glorieta. A leaking underground storage tank has resulted in gasoline contamination of groundwater near Galisteo.

5.5 Summary of Water Supply Considering Legal Limitations

Water supplies in the Jemez y Sangre planning region are (or have the potential to be) affected by a number of legal limitations. Surface waters below the Velarde Sub-Basin and Otowi Gage are fully appropriated and are subject to Rio Grande Compact deliveries. As mentioned in Appendix D, the Rio Grande Compact specifies that New Mexico must make deliveries to Elephant Butte Reservoir based on an inflow-outflow gaging schedule premised on uses as of 1929. A junior water right that violates the Rio Grande Compact cannot be used. For example, if there is less than 400,000 acre-feet of usable water in Elephant Butte and Caballo Reservoirs, storage of water may not be increased in upstream reservoirs with post-1929 storage rights, such as Nichols and McClure Reservoirs near Santa Fe, unless other water sources are substituted. This limitation pertains only to post-1929 storage rights, but these comprise approximately 75 percent of the rights in these two reservoirs. Also, if New Mexico is in debit status under the Rio Grande Compact, Texas may demand releases from post-1929 reservoirs until Elephant Butte project storage is brought up to its regular annualized amount of 790,000 acre-feet. As mentioned in Section 4, however, SJC Project water is exempt from obligation under the Rio Grande Compact.

Pueblo water rights are exempted from the Rio Grande Compact. Because Pueblo water rights are the most senior rights in the planning region, they have the potential to limit more junior rights (Section 4.3). Existing uses and rights may also be affected by ongoing adjudications for the Rio Pojoaque system, Rio Santa Cruz and Rio de Truchas system, Rio Chama system, and Santa Fe River system (Section 4.2.5). Water supply and use may also be limited by ESA-mandated protection of two threatened and endangered species, the Rio Grande silvery minnow and the Southwestern willow flycatcher.

Local governments (cities and counties) have the authority to enforce ordinances to conserve and regulate the use of water within their jurisdictions, which may include restrictions on the issuance of domestic well permits (Section 4.6). Municipalities and counties may also exercise powers of eminent domain to establish or expand water utilities and, as part of this process, condemn existing water supplies, rights, or rights-of-way.