The City's Water and the Living River

December 14, 2016

Introduction

In 2016 the Governing Body addressed a number of questions relating to the City's water resources. While these kinds of questions are not unusual, and many are routine, the Governing Body has recognized that changing conditions require heightened scrutiny of how City water is used, as the threats posed by climate change challenge existing policies and practices and call for innovation and community engagement to reach viable solutions. It is now generally understood that the City must adapt to the likelihood that water will be a diminishing resource as weather patterns change.[1] While the City has local water resources, like the Santa Fe River and Buckman and City well-fields, it also obtains a significant proportion of its water from Colorado via the federal Bureau of Reclamation (BOR) San Juan – Chama Project (SJCP)[2]. As a result, changing climate conditions in Colorado and upstream along the Rio Grande will also affect our water supply. Projected changes to the SJCP water supply include a decrease in flows by one-quarter overall, decreased flows in summer and increased flows in spring, reductions in Heron Reservoir storage, increased evaporation and a reduced availability of full allocations to SJCP contractors.[3] In fact, those changes are already occurring. As an example, in 2016 the City received only 95% of its SJCP water right of up to 5,230 acre feet/year (AFY) due to an overall reduction in available water, and in 2015, the City received only 93% of its SJCP allocation. Now more than ever, it is critical for the City to focus on understanding how water supply and demand may change in conjunction with climate changes and which adaptation options are most viable.

This summary report has been prepared at the request of the Governing Body as one step on the continuing path toward that goal. The request was precipitated by an incident earlier this year when a City facility was vandalized, diverting River water from its intended course. While staff anticipates supplementing this report over time to add new information and update stale material, the competition between the acequias and the living river for inflowing Santa Fe River water can be viewed as a precursor of the kinds of challenges the City will likely increasingly face in the future.

Whatever the challenges that climate change poses to the City, the primary goal of the Water Division remains unchanged: to ensure that the City's water resources are managed and protected in an efficient and responsible manner to provide the community with clean, reliable and safe drinking water.

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[1] "Over the past 50 years across most of the Southwest, there has been less late-winter precipitation falling as snow, earlier snowmelt, and earlier arrival of most of the year's streamflow. Streamflow totals in the Sacramento-San Joaquin, the Colorado, the Rio Grande, and in the Great Basin were 5% to 37% lower between 2001 and 2010 than the 20th century average flows. Projections of further reduction of late-winter and spring snowpack and subsequent reductions in runoff and soil moisture pose increased risks to the water supplies needed to maintain the Southwest's cities, agriculture, and ecosystems." Ch. 20: Southwest. *Climate Change Impacts in the United States: The Third National Climate Assessment.* See Appendix A.

[2] The SJCP diverts water from the Navajo River in Colorado, which flows from Colorado into New Mexico, then back into Colorado to join the San Juan River, a tributary of the Colorado River. Diverted water is carried through tunnels under the Continental Divide to Heron Reservoir, which is located on a small tributary of the Rio Chama. The Rio Chama flows into the Rio Grande. The City's SJCP water is delivered via the Rio Grande to the Buckman Direct Diversion (BDD) facility, a project developed jointly with Santa Fe County and Las Campanas.

[3] P. ES-17 of the Executive Summary, *Santa Fe Basin Study: Adaptations to Projected Changes in Water Supply and Demand, August 2015*, prepared for the BOR, the City of Santa Fe and Santa Fe County, attached as Appendix B.

Background

The City has multiple sources of water, including SJCP water delivered to the BDD facility via the Rio Grande, Santa Fe River water, which is stored in two reservoirs east of the City, McClure and Nichols Reservoirs (the Reservoirs), water from the Buckman well-field, a cluster of 13 active wells located northwest of the City in proximity to the Rio Grande, and from the City well-field, another cluster of 7 active wells located in proximity to the Santa Fe River within the City.

Source	*Water Rights/AFY*	*Source of Right*
Santa Fe River	5,040	License No. 1677 for 3,500 AFY with a 1925 priority date; and Declaration No. 01278 for 1,540 AFY with apre-1907 priority date
SJCP	5,230	Contract No. 05-WC-40-540; October 19, 2006
Buckman Well Field	10,000	Permit No. RG-20516
City Well Field	4,865	Permit No. RG-1113 et al.

Copies of License No. 1677 and Declaration No. 01278 are attached as Appendices C and D respectively.

License No. 1677 also grants the City the right to store up to 3,500 AF of Santa Fe River water in the Reservoirs.

The City can also store "relinquishment credit water" in the Reservoirs when the Rio Grande Compact[4] (the Compact) would otherwise limit the City's right to store Santa Fe River water. Relinquishment credits are administered by the State Engineer and accrue when more Rio Grande water is delivered to Texas than the Compact requires. Currently the City has a balance of 7,207 AF in relinquishment credits.

Because relinquishment credit water is Santa Fe River water, which is the least expensive to treat and deliver to City water customers, there are advantages for the City in releasing its SJCP water into the Rio Grande in exchange for relinquishment credits.

Generally, the City uses proportionately more SJCP and Santa Fe River water than well-field water in order to "rest" its wells for use in drier years when SJCP and Santa Fe River water are not as readily available. In part this is because surface water is a more renewable resource than groundwater and in part because the City must offset groundwater pumped from many of its wells.

To understand offsets, it is important to recognize that surface water and groundwater are hydrologically connected. Snowmelt and rainfall feed New Mexico's rivers. The rivers in turn slowly replenish groundwater. Thus, pumping groundwater over time depletes surface water.

[4] The 1938 Rio Grande Compact is an agreement by Colorado, New Mexico and Texas apportioning the waters of the Rio Grande above Fort Quitman, Texas, among the three states. It establishes annual water delivery obligations, depletion entitlements for Colorado and New Mexico, and provides for debits and credits to be carried over from year to year until extinguished. A copy of the Compact is attached as Appendix E.

New Mexico law requires the City to offset the depletion of surface water by "retiring"[5] an equivalent amount of surface water rights in the stream systems depleted by the pumping. Thus the City must acquire surface water rights from the Rio Grande, La Cienaga, Nambe, Pojoaque and Tesuque stream systems in order to "retire" them when it uses groundwater. When the City requires developers of projects in the City to purchase and transfer water rights to the City for new development, the water rights are intended to offset pumping from the Buckman well-field and Northwest wells that will result from increased demand occasioned by the new development. Offsets are described in more detail in Appendix F, attached.

In 2015 the City's Water Division produced and delivered a total of 8,167 AF of water, including 8,062 AF to City water customers and 105 AF to the Santa Fe County Water Utility.

The foregoing is addressed in more detail in the 2015 Annual Water Report prepared by the City of Santa Fe Water Division. A copy of that report is attached as Appendix G.

The City also sells reclaimed wastewater from the City's treatment plant to contractors for uses such as irrigation for golf courses and recreational fields, dust control, and livestock watering. The remainder flows into the lower Santa Fe River to support the riparian ecosystem and local agriculture in the areas of La Cienaga and La Bajada. The City and Santa Fe County, together with BOR, have undertaken a feasibility study to identify the highest value use of reclaimed water from the City's and County's wastewater treatment plants. The results of that study will be presented in the coming year.

[5] "Retiring" surface water rights means that the surface water may no longer be diverted – typically, for irrigation – but must be allowed to flow, augmenting the stream to counterbalance the loss over time occasioned by groundwater pumping.

Legal Parameters – the Regulation of Water in New Mexico

Under the Constitution and by statute...

Under the New Mexico Constitution, "Beneficial use shall be the basis, the measure and the limit of the right to the use of water."[6]

Ultimately, "[a]ll natural waters flowing in streams and watercourses, whether such be perennial, or torrential, within the limits of the state of New Mexico, belong to the public and are subject to appropriation for beneficial use."[7] A "watercourse" includes any river, creek, arroyo, canyon, draw or wash, or other channel having definite banks and bed with visible evidence of the occasional flow of water.[8]

And "...owners of any works for the storage, diversion or carriage of water who may make application to store or carry water in excess of their needs for irrigation or other beneficial use, shall be required, as trustee of such right, to deliver such surplus at reasonable and uniform rates to parties entitled to use the same under like conditions and circumstances."[9]

Although the term "beneficial use" is not defined in either the Constitution or applicable statutes, New Mexico courts have established certain requirements for a beneficial use. The first of these is "maximum utilization": "Our entire state has only enough water to supply its most urgent needs. Water conservation and preservation is of utmost importance. Its utilization for maximum benefits is second to none, not only for progress, but for survival."[10]

The concept of beneficial use of water requires actual use for some purpose that is socially accepted as beneficial.[11] Thus "actual use", as opposed to a speculative use[12], is another fundamental principle of beneficial use. An intended future use is not sufficient to establish beneficial use if the water is not put to actual use within a reasonable period of time[13] as determined by the Office of the State Engineer.

However, a non-consumptive use can be a "beneficial use".[14] For example, the use by the Albuquerque-Bernalillo County Water Utility Authority of Rio Grande water to "carry" SJCP water to its water treatment plant, then return an equal quantity of water to the Rio Grande is a non-consumptive use that

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[6] Const. Art. 16, § 3

[7] N.M. Stat. Ann. § 72-1-1 (West)

[8] *Ibid.*

[9] N.M. Stat. Ann. § 72-1-1 (West)

[10] *Jicarilla Apache Tribe v. U.S.*, 657 F.2d 1126 (1981), citing *Kaiser Steel v. W.S. Ranch Co.*, 81 N.M. 414, 467 P.2d 986 (1970)

[11] *Montgomery v. N.M. State Engineer*, 2005, 1137 N.M. 21, 114 P.3d 339, cert. granted 137 N.M. 767, 115 P.3d 230, affirmed in part, reversed in part, 141 N.M. 21, 150 P.3d 971.

[12] *Ibid., Jicarilla Apache Tribe*, 1134. "It is important to observe that no matter how early a person's priority of appropriation may be, he is not entitled to receive more water than is necessary for his actual use. An excessive diversion of water, through waste, cannot be regarded as a diversion to beneficial use within the meaning of the Constitution..."; and, "In sum, it is essential that there shall have been a beneficial use which is more than speculative." In *Jicarilla*, the City of Albuquerque that the storage of "excess" SJCP water, i.e., water to which it was entitled, but which was intended to accommodate future growth, in Elephant Butte Reservoir for recreational purposes was a beneficial use.

[13] *Ibid., Montgomery*

[14] *Carangelo v. Albuquerque-Bernalillo County Water Utility Authority*, 320 p.3d 492, 2014-NMCA-032 (2013)

is nevertheless beneficial.[15] It is not important that "[m]ost, if not all, appropriations of water in New Mexico are for consumptive use."[16]

The court has described a non-consumptive beneficial use as "...no more than a type of water use where either there is no diversion from a source body, or where there is no diminishment of the source."[17]

"Artificial surface waters, as distinguished from natural surface waters, are...defined...as waters whose appearance or accumulation is due to escape, seepage, loss, waste, drainage or percolation from constructed works, either directly or indirectly, and which depend for their continuance upon the acts of man. Such artificial waters are primarily private and subject to beneficial use by the owner or developer thereof; provided, that when such waters pass unused beyond the domain of the owner or developer and are deposited in a natural stream or watercourse and have not been applied to beneficial use by said owner or developer for a period of four years from the first appearance thereof, they shall be subject to appropriation and use; provided, that no appropriator can acquire a right, excepting by contract, grant, dedication or condemnation, as against the owner or developer compelling him to continue such water supply."[18]

As we will see, "bypass water" is water that passes "unused beyond the [City's] domain" and becomes public water, subject to appropriation.

By contract...

The City's use of its water is also regulated by contracts like the Compact and its contract with BOR for SJCP water and with Santa Fe County for the construction and operation of the BDD facility to treat the SJCP water.

By court order...

And, there are other limitations on the City's use of its water, including the rights of the Acequia Madre Community Ditch Association (Acequia Madre) and the Acequia Cerro Gordo Community Ditch Association (Acequia Cerro Gordo) to take water from the Santa Fe River before the City takes its water. These priority rights are embodied in the 1990 Order of the First Judicial District Court in *Anaya, et al. v. Public Service Company of New Mexico, et al.*, No 43,347[19] which provides that "PNM's releases of water to the acequias shall occur during the months of April through October at such times and at such rates as may be requested by the acequias; provided, however, that PNM shall not be required to release water in quantities greater than would otherwise be available to the acequias from stream flow, assuming no impoundment or diversion by [the City]..." The July 5, 1990 Order was amended by the court on February 10, 2015 on the Acequia Madre's Motion (the Order). The Order establishes the quantities of water to be delivered to the Acequias Madre and Cerro Gordo. The parties have also

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[15] *Ibid., Carangelo*, 504

[16] *Ibid.*

[17] *Ibid.*

[18] NMSA 1978 § 72-5-27; see also *Hagerman Irrigation Co. v. McMurry*, 16 N.M. 172; 1 Wiel, *Water Rights in the Western States* ss 30, 31, 32 (3d Ed. 1911); 1 *Waters and Water Rights*, s 53.2 (Clark, ed. 1967); *Turley v. Furman*, 16 N.M. 253; *State ex rel. Reynolds v. Luna Irr. Co.*, 1969-NMSC-111, 80 N.M. 515, 458 P.2d 590.

[19] The Order applies to the City as the successor to PNM's interest in the water utility.

agreed to a Stipulated Operating Agreement implementing the Order. Copies of the Order and the Stipulated Operating Agreement, as amended are attached as Appendices H and I respectively.

In addition to the Acequias Madre and Cerro Gordo, two other acequias have rights in Santa Fe River water, although their rights have not been established as having priority over the City's rights. These are the Acequia Llano and the Acequia Muralla.

The maximum potential water obligations of the City to all four acequias, including with the farm delivery rate (FDR) and the project delivery rate (PDR), are set out on a table attached as Appendix J. The FDR and the PDR address respectively the additional amounts of water required to deliver the water at the acequia's headgate and at the point of delivery for each of the irrigated properties served by the acequia.

By ordinance and resolution...

Finally, the City itself regulates the use of its water through the adoption of resolutions and ordinances. As examples, Santa Fe City Code (SFCC) Sections 25-11 and 25-12 address respectively water conservation and development water budgets.

And in February 2012, the City adopted SFCC Section 25-13, the "Santa Fe River Target Flow Ordinance," most often referred to as the "Living River Ordinance (the Ordinance), and Resolution No. 2012-28, establishing administrative procedures for the Ordinance (the Administrative Procedures). Copies of the Ordinance and the Administrative Procedures are attached as Appendices K and L respectively.

Some History – the Acequias, the Living River, and the Law

The Ordinance

The purpose of the Ordinance is "...to formalize the city's commitment to provide for a target flow within the Santa Fe River in order to enhance and further the objective of restoring the Santa Fe River as a living river by committing to use up to...1,000...AFY...of the city's water supply, depending upon hydrologic conditions in the Santa Fe River watershed. ..."[20]

A public process[21] identified the following four community objectives for the 1,000 AFY "living river" flows, which were incorporated in the Administrative Procedures[22]:

1. Create an ecologically healthy vegetative corridor;
2. Benefit the entire community with flows (e.g., equity);
3. Nurture a beautiful, natural urban greenspace with water in an arid environment; and
4. Provide an educational resource for schools and community stewardship.

These concepts have informed a number of developments along the Santa Fe River since they were first articulated, including "...a range of initiatives to make substantial improvements along the Santa Fe River and within the River's broader watershed. These improvements have included forest management practices in the upper watershed; riparian rehabilitation projects along the entire river corridor; a variety of erosion control and storm water management project; construction of significant new reaches of the Santa Fe River Trail; and enhancements within the City's parklands along the river's banks. Consistent with these efforts to protect the City's water supply, improve the drainage and hydrologic functions of the river system, support greenery, shade and wildlife habitat, and to beautify the corridor with aesthetic enhancements, the City also seeks to increase water flows in the River below the City's reservoirs."[23]

The City's Santa Fe River projects are shown on a map attached as Appendix M. They extend the length of the River from Canyon Road east of Patrick Smith Park to Siler Road and represent an investment of approximately $15,000,000 over 16 years, with most having commenced after the adoption of the Ordinance.

"Bypass Water" Means...

As noted above, the City has rights to 5,040 AFY of Santa Fe River water under Permit No. 1677 and Declaration 01278, with 1,540 AFY with a pre-1907 priority date and 3,500 SFY with a 1925 priority date. An associated storage right establishes maximum limits for storage in each of McClure and Nichols Reservoirs, with a combined storage limit of 3,500 AFY.

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[20] SFCC § 25-13.3

[21] The process is documented in "Bypass Flows in the Santa Fe River, Public Facilitation & Community Outreach, Reports, Notes and Related Documents, 2.23.11", prepared by Toby Herzlich & Company and Natural Systems International, both of Santa Fe, New Mexico (the Public Process Report). The Public Process Report is attached as Appendix N.

[22] Administrative Procedures, Article IV, Section 4.1.1

[23] Administrative Procedures, Article I, par. 2

Only the Acequias Madre and Cerro Gordo have established rights superior to the City's rights. Nevertheless, the City typically delivers water consistent with their existing rights to the Acequias Llano and Muralla, although neither has established that their rights predate the City's.

The Order provides that the City "...shall not be required to release water in quantities greater than would otherwise be available to the acequias from stream flow, assuming no impoundment or diversion by [the City]..."

The Ordinance provides for the City's Water Division to "...operate the city's system of reservoirs to ensure that a bypass target flow of up to one thousand (1,000) AFY of river water flows into the Santa Fe River below Nichols Reservoir..."[24]

According to the Ordinance, "Bypass flow means, generally, water that flows past a diversion or storage facility. In the administrative procedures, it refers to water that the city chooses not to store in the municipal reservoirs and thus allows to flow to the Santa Fe River below Nichols Reservoir[25] provided that the rate at which the bypass flow is passed through the outlet works of Nichols Reservoir dam is always equal or less than the stream inflow at the 'above McClure' gage."[26]

Thus, deliveries both to the acequias and for the living river are drawn from the amount of water that flows in any given period into McClure. The deliveries do not come from the City's stored water.

The Challenge of Bypass Flows

Because inflow is limited based on snowmelt and rainfall, and declines during the very period when the acequias and the living river need water most, during late spring and early summer, before the monsoon rains come, the acequias and the living river are often competing for the same limited resource. When snowpack is below normal levels or melts early, or the monsoon rains don't come, or come rarely or late, it exacerbates the problem.

In this context, it can be extremely difficult to meet the needs of the City's water customers and its obligations to the Acequias Madre and Cerro Gordo, accommodate the demand of the Acequias Llano and Muralla, and meet living river bypass flow requirements.
In addition, there are two fundamental conflicts embedded in the Ordinance and the Administrative Procedures.

1. *Whether the living river bypass flow is in addition to the City's obligation to the Acequias Madre and Cerro Gordo, and the rights of the Acequias Llano and Muralla, or whether they are inclusive.*

The Ordinance provides that "...the water for the target hydrograph shall not include water released for any other purpose at the time of release, provided that nothing in this section shall require the release of bypass water if the release might jeopardize the city's water right under License 1677 and Declaration 01728."[27]

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[24] SFCC § 25-13.5

[25] Because living river water passes "unused beyond the [City's] domain," it becomes public water, subject to appropriation – unlike water delivered to the acequias for irrigation, a consumptive beneficial use.

[26] SFCC § 25-13.4

[27] SFCC § 25-13.5

As noted above, the License limits the use of the City's 1925 water to "domestic, municipal and related purposes" and the Declaration limits the uses of its 1880 water to "municipal uses".

But since bypass flows are "water the City chooses not to store in the municipal reservoirs and...allows to flow into the Santa Fe River below Nichols...,"[28] the nature of its use is no longer relevant because once it is released into the River, it is no longer the City's water. As noted above, it is public water and subject to appropriation by others.

As a result, the release of bypass water of itself does not jeopardize the City's water right under the License and Declaration. And since bypass water is, by definition, limited to inflow, it does not raise the question it might raise if it permitted the release of stored water. In the latter case, the release of stored water would be inconsistent with the License and the Declaration.

Clearly, the living river bypass flow is in addition to the City's acequia obligations.

2. *Whether there is an obligation to provide living river bypass flows during the irrigation season.*

The Administrative Procedures define "upper river" as "the reach in the river for which target flows are maintained year-round to support all aspects of a healthy riverine and riparian ecosystem; at a minimum as far as Two Mile Pond and ideally, as far as the head-gate for the Acequia Madre."[29] The upper river includes the Preserve.

This implies that bypass flows should be directed through the Restoration Channel to the Preserve all year.

However, the substantive provisions of the Administrative Procedures addressing the target hydrograph and target bypass flows provide only for "Low Flows for the Upper River" of 0.3 cubic feet per second (cfs) during the colder season from mid-October to mid-March, increasing to 0.6 cfs from mid-March to early May and from mid-September to mid-October.[30] Data show that these flow targets were met or exceeded in 2016.[31]

There is no similar provision establishing specific flows to the upper River for the period from early May to mid-September.

The Public Process Report provides additional insight into the intentions behind the first of the four purposes identified in that report and incorporated in the Administrative Procedures, to "create an ecologically healthy vegetative corridor." It expands the concept as follows:

a. With the limited amount of water available, strive to support the maximum amount of riparian plantings and wildlife habitat along the river.

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[28] SFCC § 25-13.4

[29] Administrative Procedures, Article III, 29.

[30] Administrative Procedures, Article IV, Section 4.2.1. Note that these are "aspirational" goals.

[31] See Appendix O for available data.

b. Create a constantly-wet section of river in the upper watershed by providing a year-round trickle of flows. This section will serve as a river refuge to seed downstream reaches with river life.[32]

At the time, there was substantial seepage flow into the upper river from the Reservoirs upstream. Subsequently, over a period of a few years, the Reservoirs were repaired. During the years when the repairs were underway, significantly more water flowed into the River below Nichols dam. Together, these resulted in a "year-round trickle of flows" that sustained the upper River. It appears that during that time, beaver ponds developed on the Preserve and the riparian habitat expanded. But once the repairs were completed, and the Reservoirs were refilled, those flows declined significantly. In addition, as a result of the repairs, seepage was reduced. The 2016 irrigation season was the first after this unusual "wet period" and with a hydrograph that provided for 740 AFY of bypass flows, created competition for the released bypass flow water.

Managing Bypass Flows

The City's obligation to the Acequias Madre and Cerro Gordo, established under the Order, is the first to be met with bypass flows. Together, they are entitled to take 93.48 AFY (PDR) during the irrigation season. In addition, bypass flows are directed to the Acequias Llano and Muralla[33]. Together they have water rights in the River allowing delivery of 63.05 AFY (FDR) during the irrigation season. In fact, because of inefficiencies, it appears that the four acequias take significantly more bypass water than the allotted 156.53 AFY.[34]

The Administrative Procedures also call for a Spring Pulse timed, and in a magnitude "...to provide necessary flows through the downtown for the Fishing Derby and River Festival and for the blessing of the river in the village of Agua Fria around the day of San Ysidro, patron of the crops. ..."[35] The "Summer Flows" and "Summer Pulse" called for in the Administrative Procedures, consumed 484 AF in the period between May 13 and September 3, 2016, including 240 AF to support the Fishing Derby. For this target year (April 15, 2016 through April 14, 2017) living river flows through December 6, 2016 have totaled 558 AF out of the target year's hydrograph.

The Canyon Preserve

On the same day that the Governing Body adopted the Ordinance and the Administrative Procedures, February 29, 2012, the City issued a building permit (TNC BP 2043) to The Nature Conservancy (TNC) for "River restoration, including excavation, fill, rip rap, culvert, control gate, vegetation planting & seeding" (the TNC Project) for continued use as a "private open space preserve" on 525 acres it owns in the foothills adjacent to the Santa Fe National Forest. The TNC Project included opening a channel (the Restoration Channel) between the existing path of the River (the "Bypass Channel) and the "historic River" to direct Bypass Flows via a diversion structure (the Headgate) and culvert into the Santa Fe Canyon Preserve (the Preserve) and the "original route" of the Santa Fe River. Although it is not possible

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[32] Public Process Report, "Management of 1000 AFY in the Santa Fe River: Report of Recommendations Feb. 2, 2011", p. 3

[33] These acequias have rights in the Santa Fe River, but have not litigated over them and the City's delivery to them of bypass water is not intended as an acknowledgment that those rights have priority over the City's. Only an adjudication of the Santa Fe River Basin rights will establish applicable priorities.

[34] See attached Appendix Q for estimated deliveries of water to the acequias. Note that flows are not metered and that all numbers are estimated based on releases from Nichols.

[35] Administrative Procedures, Article IV, Section 4.2.1

to know exactly where the "original" River flowed, where it flowed in 1952 is shown on the 1952 USGS map attached as Appendix P as a fine blue line entering Two Mile Reservoir on the northeast end and exiting on the southwest end (the Historic River). The Bypass Channel is shown overlaid on the map in dark blue, exiting Nichols on the northwest corner and roughly paralleling the Historic River to a point of intersection below what is now known as Two Mile Pond.[36]

Part of the Preserve has been identified as wetlands on the U.S. Fish and Wildlife Service (USF&W) National Wetlands Inventory. A USF&W map showing the area is attached as Appendix R.

The identified wetlands are "artificial surface waters...dependent for their continuance upon the acts of man." As such, the City cannot be compelled to continue to supply to the Preserve with water.

Earlier this year, sandbags placed by the City to direct bypass flows into the Bypass Channel for delivery to the Acequias Madre and Cerro Gordo were moved so as to redirect flow into the Restoration Channel. As noted above, this incident of vandalism led to a search for solutions to the competition for "bypass flows" and precipitated this report.

[36] Two Mile Pond was created when Two Mile Dam was breached and Two Mile Reservoir drained after being deemed unsafe due primarily to excessive rodent and tree root holes on the downstream slope. A paper documenting the dam, entitled "Historic American Engineering Record, Two Mile Reservoir, Santa Fe, New Mexico" (HAER No. NM-5) is attached as Appendix S and includes a useful history of the development of the Santa Fe water system.

Possible Solutions

Water Division staff has developed a number of options for the Governing Body to consider to address the inefficiencies, conflicts, and limitations in water resources identified in this report. A summary table showing these options follows.

Available Options – River Flow Below Nichols Dam

	Option	Estimated Cost	Pros	Cons	Comments
1	Directly pipe water to Acequias Madre (Upper), Cerro Gordo and Muralla; regulate delivery of water to Acequia Llano via meter	$ 910,000	Would allow staff to account more accurately for the City's water obligations to the acequias. To include possible automation of meters and communication with Canyon Road Water Treatment Plant (CRWTP).	A section of the Santa Fe River Bypass Channel approximately 1,500' long will revert over time to its natural vegetative state.	The project would require a permit from the Army Corps of Engineers, and likely NEPA analysis, which would extend the time needed to complete by 6 months to a year
			Would prevent overdelivery of water to the acequias, leaving 25± AFY for living river releases or for sale to City customers at a value of $50,000 /year.		
2	Direct all Living River water flow through TNC restoration channel and Two-Mile Pond, with acequia deliveries through the Bypass Channel.	$ 185,000	Would support wetland area and riparian species around Two-Mile Pond in the area listed on the U.S. Fish & Wildlife Service Wetlands Inventory.	Would reduce River flow in lower reaches, due to increased evaporation and seepage (the Bypass Channel is designed to move water quickly to the point of delivery, minimizing these kinds of losses.) Evaporative and seepage losses can be more accurately determined with additional study.	Assumes a redesigned diversion structure at intersection of Bypass Channel and The Nature Conservancy (TNC) restoration channel to regulate the flow.

				The reduction of River flows in the lower reaches would have a negative impact on the City's investment in downstream improvements intended to take advantage of increased flows.	A map showing the locations and estimated $15M in costs of City improvements along the River's course is included in this report.
3	Direct all Living River target flows, acequia deliveries and storm flow through the TNC restoration channel and Two-Mile Pond.	$ 2,000,000 – $ 2,500,000	Would support wetland area and riparian species around Two-Mile Pond in the area listed on the U.S. Fish & Wildlife Service Wetlands Inventory	Would reduce River flow in lower reaches, due to increased evaporation and seepage.	Project would include reconstruction of a redesigned bridge along Cerro Gordo Road, related stormwater drainage improvements and the relocation of the Acequia Cerro Gordo's headgate
				The reduction of River flows in the lower reaches would have a negative impact on the City's investment in downstream improvements.	Restoration of the historic River channel may require construction of a footbridge to connect the Dale Ball trails and TNC Preserve
				A section of the Santa Fe River Bypass Channel approximately 1,500 ' long will revert over time to its natural vegetative state.	

	a. Retain Two-Mile Pond	$ 750,000 – $ 1,000,000	Open space below Two-Mile Pond could provide additional parking and vehicle turnaround for trail connection between Dale Ball trails and TNC Preserve	Increases City's liability if a flood event triggered the need to spill water from Nichols Reservoir	Infrastructure improvements would be required to provide adequate stormwater drainage, especially with the existing low-water crossing at Cerro Gordo Road
				May present challenges in assuring that flows entering Two Mile Pond exist within 96 hours in compliance with state law	Outlet structure at Two Mile Pond would need to be redesigned to be compliant with 96-hour requirement of state law
				May increase flood risk in City	Additional flood control structures may be needed for FEMA 100 year floodplain compliance
	b. Drain Two-Mile Pond	$ 2,500,000	May decrease flood risk in City		Infrastructure improvements would be required to provide adequate stormwater drainage and bridge along Cerro Gordo Road spanning restored River channel
4	City sells raw (untreated) water to TNC for restoration channel and Two-Mile Pond riparian area		City would be fairly compensated for its water in compliance with applicable law.	TNC may not be able to sustain costs of water, even at a reduced rate. (At the current Tier 1 rate of $ 6.06/1000 gal., cost to TNC of 75 AFY would be $150,000	A rate would need to be established to accurately reflect the cost of raw water and flow-through.

			Would support wetland area and riparian species around Two-Mile Pond in the area listed on the U.S. Fish & Wildlife Service Wetlands Inventory		Construction of a redesigned diversion structure at the intersection of the Bypass Channel and the restoration channel would likely be required to facilitate (at a cost of $100,000±.)
			Living River flows would be directed through the Bypass Channel, increasing the likelihood that they will extend to the River's lower reaches		
			Increased flows to the lower reaches of the River would support City investment in downstream improvements		

5	Status quo – winter seepage target flows continue to be directed to the TNC Reserve via the Restoration Channel and spring and summer pulse flows at rates provided for in Administrative Procedures continue to be directed to TNC Preserve via the Restoration Channel	$ 185,000	Construction of a redesigned diversion structure at the intersection of the Bypass Channel and the restoration channel would facilitate deliveries and improve recordkeeping.		Target low flows for the upper River (TNC Preserve): 0.3 cfs from mid-October to mid-March, increasing to 0.6 cfs from mid-March to early May and mid-September to mid-October. Although the definition of "Upper River" provides that "target flows are maintained year round", flows between early May and mid-September are not quantified.
6	Defer action pending the outcome of increased monitoring to better understand the complex hydrology/water budget between Nichols Dam, Two-Mile Pond, the Bypass Channel and the acequia headgates; maintain status quo in the interim	$ 35,000	This data would permit better-informed decision-making when considering the foregoing options	Accommodating the competing demands of the acequias and living river flows within legal constraints during the upcoming season, which is predicted to be dry is likely to be difficult and create tension in the community	The City has released an RFP for hydrogeologic services, which includes this monitoring; with fast-tracking, the study could be complete by the end of August 2017.

7	Deliver up to 1,000 AFY of City water via the Restoration Channel to the River for aquifer recovery pursuant to an OSE permit under the Groundwater Storage and Recovery Act (NMSA 72-5A).	$10,000+ in application fees; annual fees of $500 and monitoring and reporting costs.	The City would not be foregoing its rights to use the water it delivers via the Restoration Channel, as it does now, since it would be able to pump an equivalent amount of groundwater.		The City would have to meet the statutory requirements and apply for a permit, as well as pay application fees and incur costs of managing the project, including monitoring and reporting costs.
			This would allow all inflow water to be utilized first to meet acequia obligations, with any remaining amounts to be attributed to Living River flows .		There may be infrastructure improvement costs associated with this option that have yet to be quantified.
					The study noted in Option 6 would provide information that would be useful in the application process.
					Albuquerque has a permit under this statute, which has not been commonly utilized. See attached Appendix T for an example of an aquifer storage and recovery project in Albuquerque.

Note: While TNC could pursue the purchase of Santa Fe River water rights, such rights are extremely limited and thus staff considers this impracticable as a way of enhancing flows

Conclusion

The City's "bypass flow" is not sufficient now to meet all the needs of the acequias and all the living river goals identified in the Ordinance and the Administrative Procedures, even when the full 1,000 AFY is available. As the City and the region become drier and rain and snow patterns change, we can expect this shortage to become more of a challenge.

Nevertheless, the City can make choices now and in the near future that will help, not just of policy, but by studying conditions as they exist in order to predict how they might change, and by investing in physical improvements to address those projected changes. Some of these efforts are already underway, including studies addressing the capture and use of stormwater and of wastewater.

It is possible – perhaps even likely – that eventually many current uses of the City's water will have to be relinquished in order to meet its first priority: providing clean, reliable and safe drinking water to City customers.

APPENDIX A

Climate Change Impacts in the United States

CHAPTER 20
SOUTHWEST

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On the Web: http://nca2014.globalchange.gov/report/regions/southwest

INFORMATION DRAWN FROM THIS CHAPTER IS INCLUDED IN THE HIGHLIGHTS REPORT AND IS IDENTIFIED BY THIS ICON

20 SOUTHWEST

Key Messages

1. **Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.**
2. **The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.**
3. **Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas.**
4. **Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides. Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland.**
5. **Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.**

The Southwest is the hottest and driest region in the United States, where the availability of water has defined its landscapes, history of human settlement, and modern economy. Climate changes pose challenges for an already parched region that is expected to get hotter and, in its southern half, significantly drier. Increased heat and changes to rain and snowpack will send ripple effects throughout the region's critical agriculture sector, affecting the lives and economies of 56 million people – a population that is expected to increase 68% by 2050, to 94 million.[1] Severe and sustained drought will stress water sources, already over-utilized in many areas, forcing increasing competition among farmers, energy producers, urban dwellers, and plant and animal life for the region's most precious resource.

The region's populous coastal cities face rising sea levels, extreme high tides, and storm surges, which pose particular risks to highways, bridges, power plants, and sewage treatment plants. Climate-related challenges also increase risks to critical port cities, which handle half of the nation's incoming shipping containers.

Agriculture, a mainstay of the regional and national economies, faces uncertainty and change. The Southwest produces more than half of the nation's high-value specialty crops, including certain vegetables, fruits, and nuts. The severity of future impacts will depend upon the complex interaction of pests, water supply, reduced chilling periods, and more rapid changes in the seasonal timing of crop development due to projected warming and extreme events.

Climate changes will increase stress on the region's rich diversity of plant and animal species. Widespread tree death

and fires, which already have caused billions of dollars in economic losses, are projected to increase, forcing wholesale changes to forest types, landscapes, and the communities that depend on them (see also Ch. 7: Forests).

Tourism and recreation, generated by the Southwest's winding canyons, snow-capped peaks, and Pacific Ocean beaches, provide a significant economic force that also faces climate change challenges. The recreational economy will be increasingly affected by reduced streamflow and a shorter snow season, influencing everything from the ski industry to lake and river recreation.

Observed and Projected Climate Change

The Southwest is already experiencing the impacts of climate change. The region has heated up markedly in recent decades, and the period since 1950 has been hotter than any comparably long period in at least 600 years (Ch. 2: Our Changing Climate, Key Message 3).[2,3,4] The decade 2001-2010 was the warmest in the 110-year instrumental record, with temperatures almost 2°F higher than historic averages, with fewer cold air outbreaks and more heat waves.[4] Compared to relatively uniform regional temperature increases, precipitation trends vary considerably across the region, with portions experiencing decreases and others experiencing increases (Ch. 2: Our Changing Climate, Key Message 5).[4] There is mounting evidence that the combination of human-caused temperature increases and recent drought has influenced widespread tree mortality,[6,7] increased fire occurrence and area burned,[8] and forest insect outbreaks (Ch. 7: Forests).[9] Human-caused temperature increases and drought have also caused earlier spring snowmelt and shifted runoff to earlier in the year.[10]

Regional annual average temperatures are projected to rise by 2.5°F to 5.5°F by 2041-2070 and by 5.5°F to 9.5°F by 2070-2099 with continued growth in global emissions (A2 emissions scenario), with the greatest increases in the summer and fall (Figure 20.1). If global emissions are substantially reduced (as in the B1 emissions scenario), projected temperature increases are 2.5°F to 4.5°F (2041-2070), and 3.5°F to 5.5°F (2070-2099). Summertime heat waves are projected to become longer and hotter, whereas the trend of decreasing wintertime cold air outbreaks is projected to continue (Ch. 2: Our Changing Climate, Key Message 7).[11,12] These changes will directly affect urban public health through increased risk of heat stress, and urban infrastructure through increased risk of disruptions to electric power generation.[13,14,15,16] Rising temperatures also have direct impacts on crop yields and productivity of key regional crops, such as fruit trees.

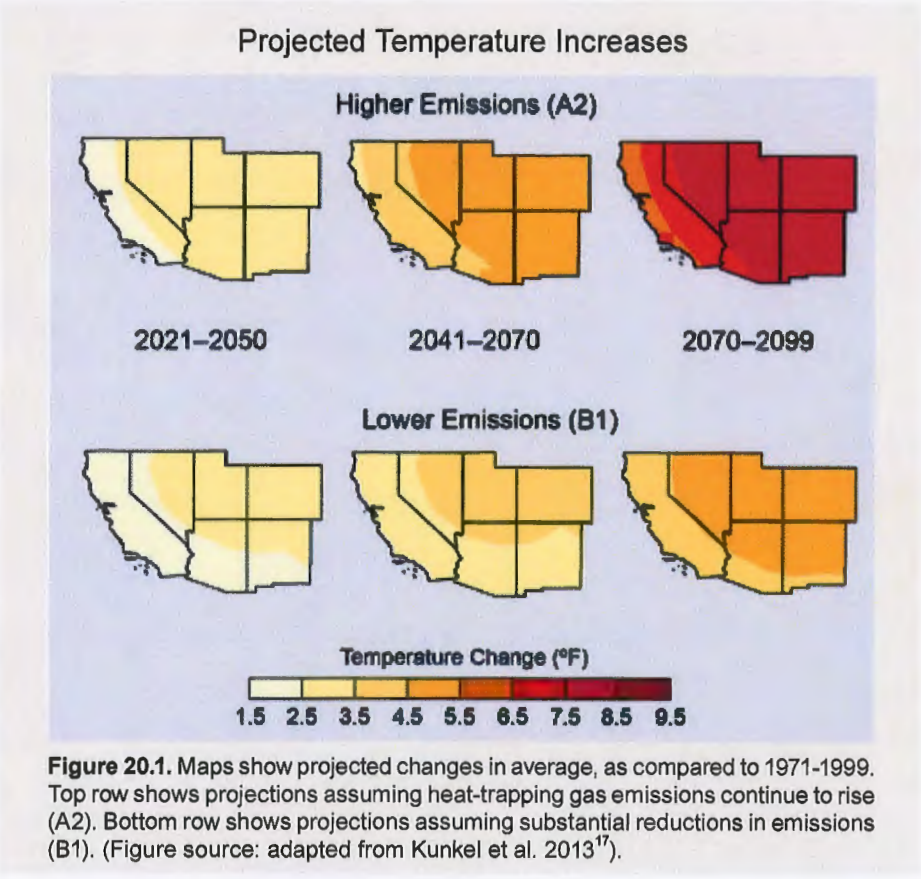

Figure 20.1. Maps show projected changes in average, as compared to 1971-1999. Top row shows projections assuming heat-trapping gas emissions continue to rise (A2). Bottom row shows projections assuming substantial reductions in emissions (B1). (Figure source: adapted from Kunkel et al. 2013[17]).

Projections of precipitation changes are less certain than those for temperature.[17,18] Under a continuation of current rising emissions trends (A2), reduced winter and spring precipitation is consistently projected for the southern part of the Southwest by 2100 as part of the general global precipitation reduction in subtropical areas. In the northern part of the region, projected winter and spring precipitation changes are smaller than natural variations. Summer and fall changes are also smaller than natural variations throughout the region (Ch. 2: Our Changing Climate, Key Message 5).[17] An increase in winter flood hazard risk in rivers is projected due to increases in flows of atmospheric moisture into California's coastal ranges and the Sierra Nevada (Ch. 3: Water).[19] These "atmospheric rivers" have contributed to the largest floods in California history[20] and can penetrate inland as far as Utah and New Mexico.

The Southwest is prone to drought. Southwest paleoclimate records show severe mega-droughts at least 50 years long.[21] Future droughts are projected to be substantially hotter, and for major river basins such as the Colorado River Basin, drought is projected to become more frequent, intense, and longer lasting than in the historical record.[18] These drought conditions present a huge challenge for regional management of water resources and natural hazards such as wildfire. In light of climate change and water resources treaties with Mexico, discussions will need to continue into the future to address demand pressures and vulnerabilities of groundwater and surface water systems that are shared along the border.

Vulnerabilities of Native Nations and Border Cities

The Southwest's 182 federally recognized tribes and communities in its U.S.-Mexico border region share particularly high vulnerabilities to climate changes such as high temperatures, drought, and severe storms. Tribes may face loss of traditional foods, medicines, and water supplies due to declining snowpack, increasing temperatures, and increasing drought (see also Ch 12: Indigenous Peoples).[22] Historic land settlements and high rates of poverty – more than double that of the general U.S. population[23] – constrain tribes' abilities to respond effectively to climate challenges.

Most of the Southwest border population is concentrated in eight pairs of fast-growing, adjacent cities on either side of the U.S.-Mexico border (like El Paso and Juárez) with shared problems. If the 24 U.S. counties along the entire border were aggregated as a 51st state, they would rank near the bottom in per capita income, employment rate, insurance coverage for children and adults, and high school completion.[24] Lack of financial resources and low tax bases for generating resources have resulted in a lack of roads and safe drinking water infrastructure, which makes it more daunting for tribes and border populations to address climate change issues. These economic pressures increase vulnerabilities to climate-related health and safety risks, such as air pollution, inadequate erosion and flood control, and insufficient safe drinking water.[25]

Key Message 1: Reduced Snowpack and Streamflows

Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.

Winter snowpack, which slowly melts and releases water in spring and summer, when both natural ecosystems and people have the greatest needs for water, is key to the Southwest's hydrology and water supplies. Over the past 50 years across most of the Southwest, there has been less late-winter precipitation falling as snow, earlier snowmelt, and earlier arrival of most of the year's streamflow.[26,27] Streamflow totals in the Sacramento-San Joaquin, the Colorado, the Rio Grande, and in the Great Basin were 5% to 37% lower between 2001 and 2010 than the 20th century average flows.[4] Projections of further reduction of late-winter and spring snowpack and subsequent reductions in runoff and soil moisture[28,29] pose increased risks to the water supplies needed to maintain the Southwest's cities, agriculture, and ecosystems.

Temperature-driven reductions in snowpack are compounded by dust and soot accumulation on the surface of snowpack. This layer of dust and soot, transported by winds from lowland regions, increases the amount of the sun's energy absorbed by the snow. This leads to earlier snowmelt and evaporation – both of which have negative implications for water supply, alpine vegetation, and forests.[30,31] The prospect of more lowland soil drying out from drought and human disturbances (like agriculture and development) makes regional dust a potent future risk to snow and water supplies.

In California, drinking water infrastructure needs are estimated at $4.6 billion annually over the next 10 years, even without considering the effects of climate change.[32] Climate change will increase the cost of maintaining and improving drinking

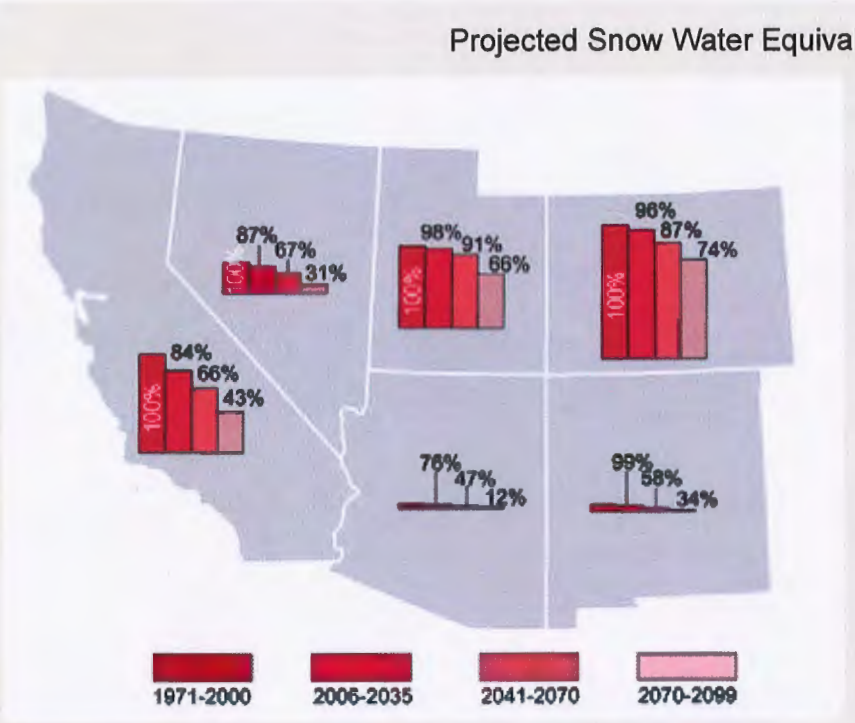

Figure 20.2. Snow water equivalent (SWE) refers to the amount of water held in a volume of snow, which depends on the density of the snow and other factors. Figure shows projected snow water equivalent for the Southwest, as a percentage of 1971-2000, assuming continued increases in global emissions (A2 scenario). The size of bars is in proportion to the amount of snow each state contributes to the regional total; thus, the bars for Arizona are much smaller than those for Colorado, which contributes the most to region-wide snowpack. Declines in peak SWE are strongly correlated with early timing of runoff and decreases in total runoff. For watersheds that depend on snowpack to provide the majority of the annual runoff, such as in the Sierra Nevada and in the Upper Colorado and Upper Rio Grande River Basins, lower SWE generally translates to reduced reservoir water storage. (Data from Scripps Institution of Oceanography).

water infrastructure, because expanded wastewater treatment and desalinating water for drinking are among the key strategies for supplementing water supplies.

Conservation efforts have proven to reduce water use, but are not projected to be sufficient if current trends for water supply and demand continue.[41] Large water utilities are currently attempting to understand how water supply and demand may change in conjunction with climate changes, and which adaptation options are most viable.[42,43]

THE SOUTHWEST'S RENEWABLE POTENTIAL TO PRODUCE ENERGY WITH LESS WATER

The Southwest's abundant geothermal, wind, and solar power-generation resources could help transform the region's electric generating system into one that uses substantially more renewable energy. This transformation has already started, driven in part by renewable energy portfolio standards adopted by five of six Southwest states, and renewable energy goals in Utah. California's law limits imports of baseload electricity generation from coal and oil and mandates reduction of heat-trapping greenhouse gas emissions to 1990 levels by 2020.[33]

As the regional climate becomes hotter and, in parts of the Southwest, drier, there will be less water available for the cooling of thermal power plants (Ch. 2: Our Changing Climate),[34] which use about 40% of the surface water withdrawn in the United States.[35] The projected warming of water in rivers and lakes will reduce the capacity of thermal power plants, especially during summer when electricity demand skyrockets.[36] Wind and solar photovoltaic installations could substantially reduce water withdrawals. A large increase in the portion of power generated by renewable energy sources may be feasible at reasonable costs,[37,38] and could substantially reduce water withdrawals (Ch. 10: Energy, Water, and Land).[39]

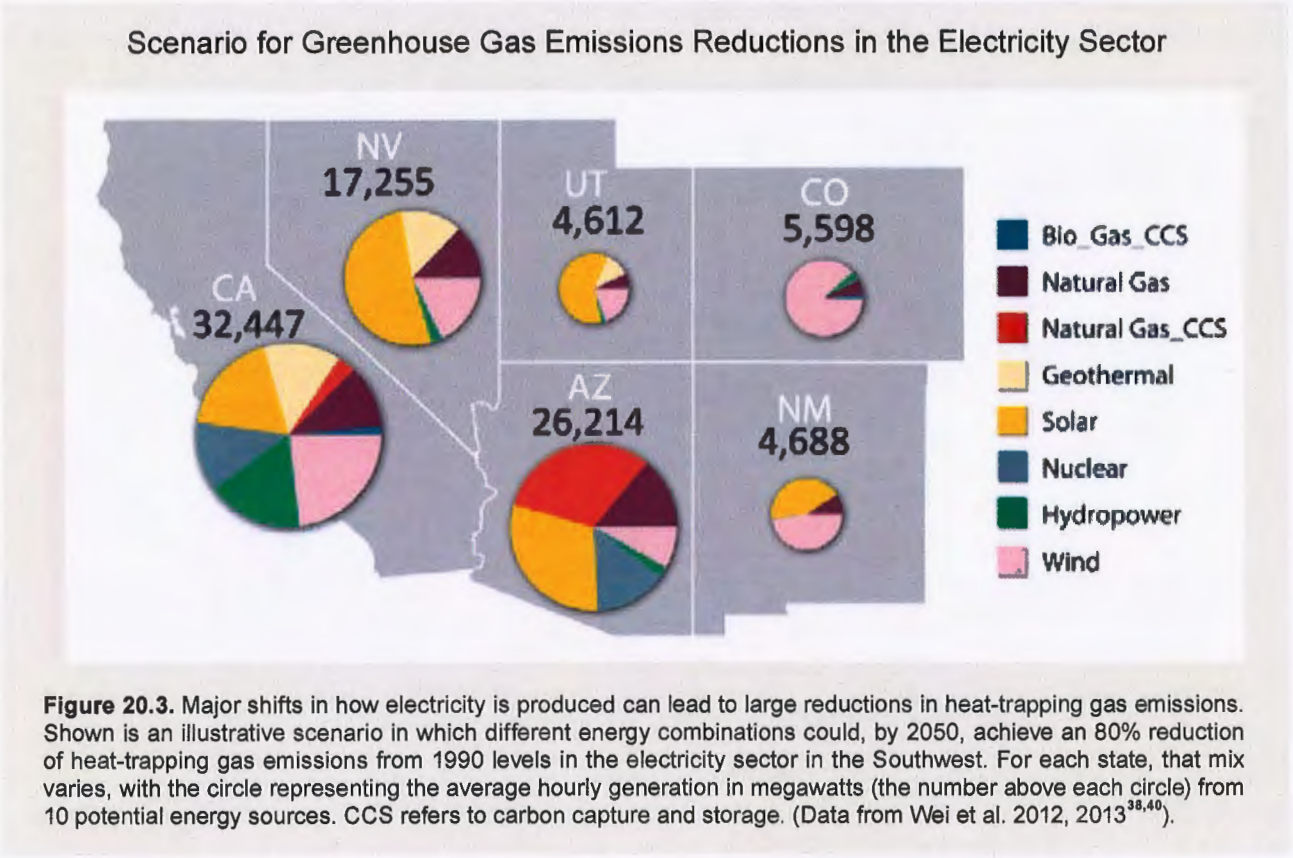

Figure 20.3. Major shifts in how electricity is produced can lead to large reductions in heat-trapping gas emissions. Shown is an illustrative scenario in which different energy combinations could, by 2050, achieve an 80% reduction of heat-trapping gas emissions from 1990 levels in the electricity sector in the Southwest. For each state, that mix varies, with the circle representing the average hourly generation in megawatts (the number above each circle) from 10 potential energy sources. CCS refers to carbon capture and storage. (Data from Wei et al. 2012, 2013[38,40]).

Key Message 2: Threats to Agriculture

The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.

Farmers are renowned for adapting to yearly changes in the weather, but climate change in the Southwest could happen faster and more extensively than farmers' ability to adapt. The region's pastures are rain-fed (non-irrigated) and highly susceptible to projected drought. Excluding Colorado, more than 92% of the region's cropland is irrigated, and agricultural uses account for 79% of all water withdrawals in the region.[44,45,46] A warmer, drier climate is projected to accelerate current trends of large transfers of irrigation water to urban areas,[47,48,49] which would affect local agriculturally dependent economies.

California produces about 95% of U.S. apricots, almonds, artichokes, figs, kiwis, raisins, olives, cling peaches, dried plums, persimmons, pistachios, olives, and walnuts, in addition to other high-value crops.[50] Drought and extreme weather affect the market value of fruits and vegetables more than other crops because they have high water content and because sales depend on good visual appearance.[51] The combination of a longer frost-free season, less frequent cold air outbreaks, and more frequent heat waves accelerates crop ripening and maturity, reduces yields of corn, tree fruit, and wine grapes, stresses livestock, and increases agricultural water consumption.[52,53] This combination of climate changes is projected to continue and intensify, possibly requiring a northward shift in crop production, displacing existing growers and affecting farming communities.[54,55]

Winter chill periods are projected to fall below the duration necessary for many California trees to bear nuts and fruits, which will result in lower yields.[56] Warm-season vegetable crops grown in Yolo County, one of California's biggest producers, may not be viable under hotter climate conditions.[54,57] Once temperatures increase beyond optimum growing thresholds, further increases in temperature, like those projected for the decades beyond 2050, can cause large decreases in crop yields and hurt the region's agricultural economy.

Longer Frost-Free Season Increases Stress on Crops

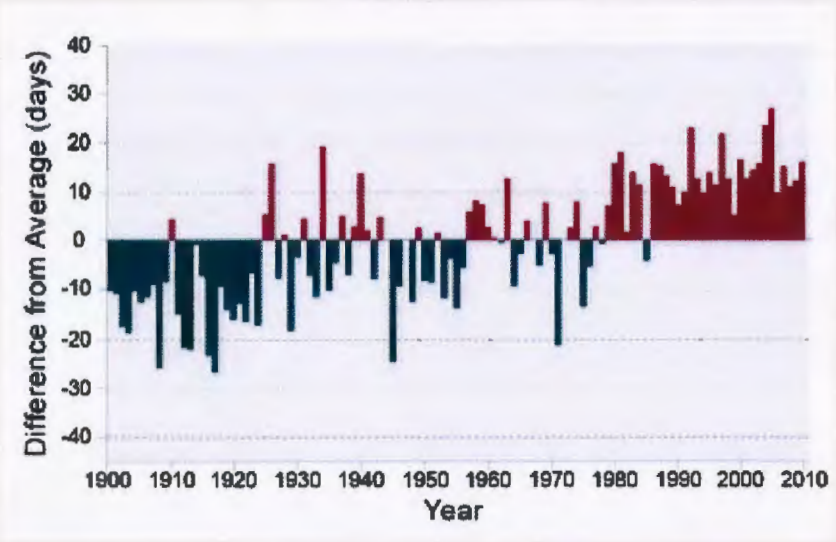

Figure 20.4. The frost-free season is defined as the period between the last occurrence of 32°F in spring and the first occurrence of 32°F in the subsequent fall. The chart shows significant increases in the number of consecutive frost-free days per year in the past three decades compared to the 1901-2010 average. Increased frost-free season length, especially in already hot and moisture-stressed regions like the Southwest, is projected to lead to further heat stress on plants and increased water demands for crops. Higher temperatures and more frost-free days during winter can lead to early bud burst or bloom of some perennial plants, resulting in frost damage when cold conditions occur in late spring (see Ch. 6: Agriculture); in addition, with higher winter temperatures, some agricultural pests can persist year-round, and new pests and diseases may become established.[47] (Figure source: Hoerling et al. 2013[4]).

Key Message 3: Increased Wildfire

Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas.

Fire naturally shapes southwestern landscapes. Indeed, many Southwest ecosystems depend on periodic wildfire to maintain healthy tree densities, enable seeds to germinate, and reduce pests.[58] Excessive wildfire destroys homes, exposes slopes to erosion and landslides, threatens public health, and causes economic damage.[59,60] The $1.2 billion in damages from the 2003 Grand Prix fire in southern California illustrates the high cost of wildfires.[60]

Beginning in the 1910s, the Federal Government developed a national policy of attempting to extinguish every fire, which allowed wood and other fuels to over-accumulate[61] and urban development to encroach on fire-prone areas. These changes have also contributed to increasing fire risk.

Increased warming due to climate change,[3] drought, insect infestations,[62] and accumulation of woody fuels and non-native grasses[63,64] make the Southwest vulnerable to increased wildfire. Climate outweighed other factors in determining burned area in the western U.S. from 1916 to 2003,[65] a finding confirmed by 3000-year long reconstructions of southwestern fire history.[66,67,68] Between 1970 and 2003, warmer and drier conditions increased burned area in western U.S. mid-elevation conifer forests by 650% (Ch. 7: Forests, Key Message 1).[8]

Drought and increased temperatures due to climate change have caused extensive tree death across the Southwest.[7,69] In addition, winter warming due to climate change has exacerbated bark beetle outbreaks by allowing more beetles, which normally die in cold weather, to survive and reproduce.[70] Wildfire and bark beetles killed trees across 20% of Arizona and New Mexico forests from 1984 to 2008.[62]

Numerous fire models project more wildfire as climate change continues.[64,71,72,73,74] Models project a doubling of burned area in the southern Rockies,[73] and up to a 74% increase in burned area in California,[74] with northern California potentially experiencing a doubling under a high emissions scenario toward the end of the century. Fire contributes to upslope shifting of vegetation, spread of invasive plants after extensive and intense fire, and conversion of forests to woodland or grassland.[63,75]

Historical and projected climate change makes two-fifths (40%) of the region vulnerable to these shifts of major vegetation types or biomes; notably threatened are the conifer forests of southern California and sky islands of Arizona.[71]

Prescribed burning, mechanical thinning, and retention of large trees can help some southwestern forest ecosystems adapt to climate change.[68,76] These adaptation measures also reduce emissions of the gases that cause climate change because long-term storage of carbon in large trees can outweigh short-term emissions from prescribed burning.[61,77]

Key Message 4: Sea Level Rise and Coastal Damage

Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides. Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland.

In the last 100 years, sea level has risen along the California coast by 6.7 to 7.9 inches.[78] In the last decade, high tides on top of this sea level rise have contributed to new damage to infrastructure, such as the inundation of Highway 101 near San Francisco and backup of seawater into the San Francisco Bay Area sewage systems.

Although sea level along the California coast has been relatively constant since 1980, both global and relative Southwest sea levels are expected to increase at accelerated rates.[78,79,80] During the next 30 years, the greatest impacts will be seen during high tides and storm events. Rising sea level will allow more wave energy to reach farther inland and extend high tide periods, worsening coastal erosion on bluffs and beaches and increasing flooding potential.[18,81,82,83,84]

The result will be impacts to the nation's largest ocean-based economy, which is estimated at $46 billion annually.[85,86] If adaptive action is not taken, coastal highways, bridges, and other transportation infrastructure (such as the San Francisco and Oakland airports) are at increased risk of flooding with a 16-inch rise in sea level in the next 50 years,[5] an amount consistent with the 1 to 4 feet of expected global increase in sea level (see Ch. 2: Our Changing Climate, Key Message 10). In Los Angeles, sea level rise poses a threat to groundwater supplies and estuaries,[82,87] by potentially contaminating groundwater with seawater, or increasing the costs to protect coastal freshwater aquifers.[88]

Projected increases in extreme coastal flooding as a result of sea level rise will increase human vulnerability to coastal flooding events. Currently, 260,000 people in California are at risk from what is considered a once-in-100-year flood.[82] With a sea level rise of about three feet (in the range of projections for this century – Ch. 2: Our Changing Climate, Key Message 10)[78,80] and at current population densities, 420,000 people would be at risk from the same kind of 100-year flood event,[85] based on existing exposure levels. Highly vulnerable populations

Coastal Risks Posed by Sea Level Rise and High Tides

Figure 20.5. King tides, which typically happen twice a year as a result of a gravitational alignment of the sun, moon, and Earth, provide a preview of the risks rising sea levels may present along California coasts in the future. While king tides are the extreme high tides today, with projected future sea level rise, this level of water and flooding will occur during regular monthly high tides. During storms and future king tides, more coastal flooding and damage will occur. The King Tide Photo Initiative encourages the public to visually document the impact of rising waters on the California coast, as exemplified during current king tide events. Photos show water levels along the Embarcadero in San Francisco, California during relatively normal tides (top), and during an extreme high tide or "king tide" (bottom). (Photo credit: Mark Johnsson).

– people less able to prepare, respond, or recover from natural disaster due to age, race, or income – make up approximately 18% of the at-risk population (Ch. 25: Coasts).[85,89]

The California state government, through its Ocean and Coastal Resources Adaptation Strategy, along with local governments, is using new sea level mapping and information about social vulnerability to undertake coastal adaptation planning. NOAA has created an interactive map showing areas that would be affected by sea level rise (http://www.csc.noaa.gov/slr/viewer/#).

Key Message 5: Heat Threats to Health

Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.

The Southwest has the highest percentage of its population living in cities of any U.S. region. Its urban population rate, 92.7%, is 12% greater than the national average.[90] Increasing metropolitan populations already pose challenges to providing adequate domestic water supplies, and the combination of increased population growth and projected increased risks to surface water supplies will add further challenges.[91,92] Tradeoffs are inevitable between conserving water to help meet the demands of an increasing population and providing adequate water for urban greenery to reduce increasing urban temperatures.

Urban infrastructures are especially vulnerable because of their interdependencies; strains in one system can cause disruptions in another (Ch. 11: Urban, Key Message 2; Ch. 9: Human Health).[16,93] For example, an 11-minute power system disturbance in September 2011 cascaded into outages that left 1.5 million San Diego residents without power for 12 hours;[94] the outage disrupted pumps and water service, causing 1.9 million gallons of sewage to spill near beaches.[95] Extensive use of air conditioning to deal with high temperatures can quickly increase electricity demand and trigger cascading energy system failures, resulting in blackouts or brownouts.[14,15]

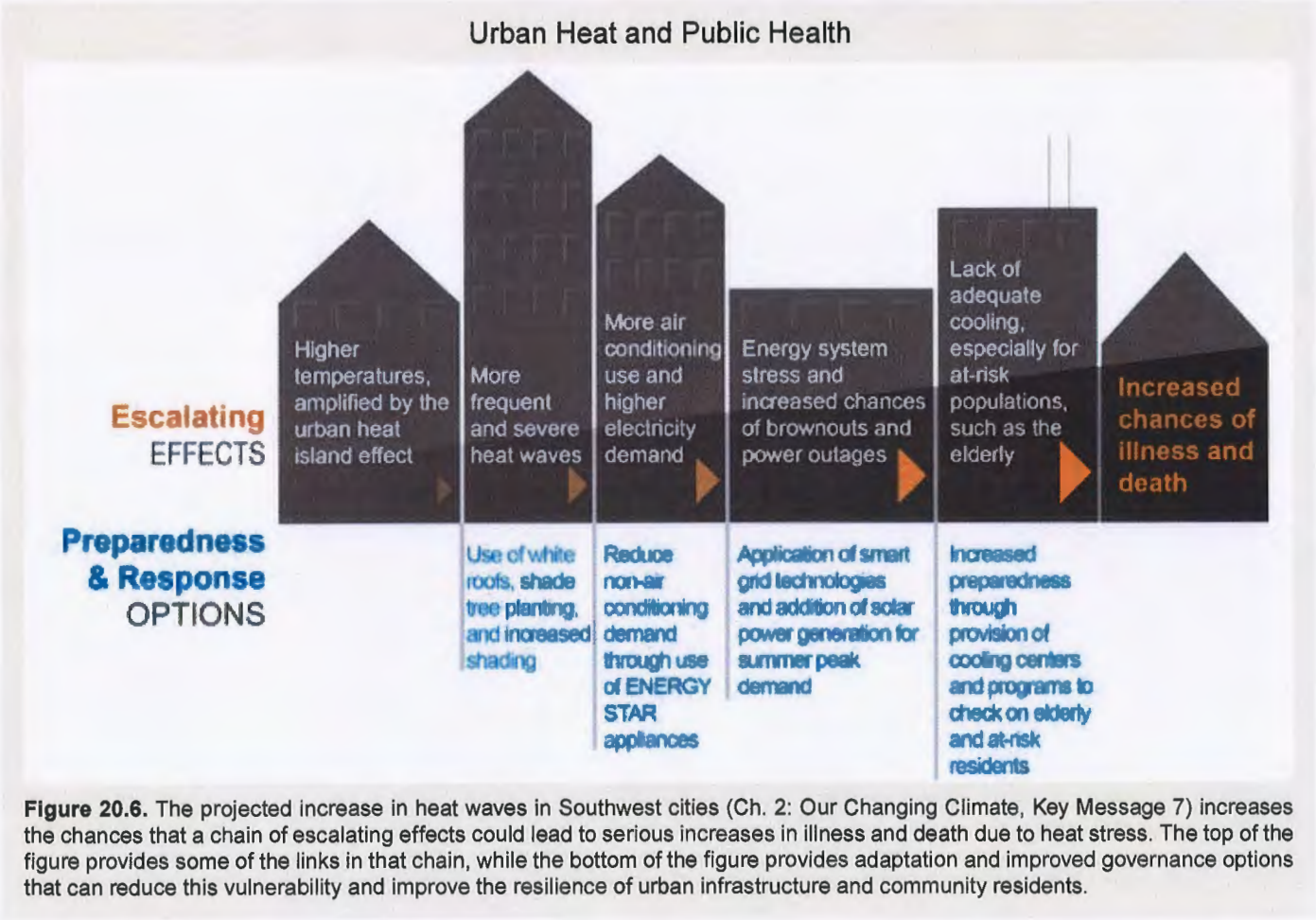

Figure 20.6. The projected increase in heat waves in Southwest cities (Ch. 2: Our Changing Climate, Key Message 7) increases the chances that a chain of escalating effects could lead to serious increases in illness and death due to heat stress. The top of the figure provides some of the links in that chain, while the bottom of the figure provides adaptation and improved governance options that can reduce this vulnerability and improve the resilience of urban infrastructure and community residents.

Heat stress, a recurrent health problem for urban residents, has been the leading weather-related cause of death in the United States since 1986, when record keeping began[96] – and the highest rates nationally are found in Arizona.[97] The effects of heat stress are greatest during heat waves lasting several days or more, and heat waves are projected to increase in frequency, duration, and intensity,[11,13,98] become more humid,[11] and cause a greater number of deaths.[99] Already, severe heat waves, such as the 2006 ten-day California event, have resulted in high mortality, especially among elderly populations.[100] In addition, evidence indicates a greater likelihood of impacts in less affluent neighborhoods, which typically lack shade trees and other greenery and have reduced access to air conditioning.[101]

Exposure to excessive heat can also aggravate existing human health conditions, like for those who suffer from respiratory or heart disease.[99] Increased temperatures can reduce air quality, because atmospheric chemical reactions proceed faster in warmer conditions. The outcome is that heat waves are often accompanied by increased ground-level ozone,[102] which can cause respiratory distress. Increased temperatures and longer warm seasons will also lead to shifts in the distribution of disease-transmitting mosquitoes (Ch. 9: Human Health, Key Message 1).[97]

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SUPPLEMENTAL MATERIAL

TRACEABLE ACCOUNTS

Process for Developing Key Messages

A central component of the assessment process was the Southwest Regional Climate assessment workshop that was held August 1-4, 2011, in Denver, CO with more than 80 participants in a series of scoping presentations and workshops. The workshop began the process leading to a foundational Technical Input Report (TIR) report.[103] The TIR consists of nearly 800 pages organized into 20 chapters that were assembled by 122 authors representing a wide range of inputs, including governmental agencies, non-governmental organizations, tribes, and other entities. The report findings were described in a town hall meeting at the American Geophysical Union's annual fall meeting in 2011, and feedback was collected and incorporated into the draft.

The chapter author team engaged in multiple technical discussions through more than 15 biweekly teleconferences that permitted a careful review of the foundational TIR[103] and of approximately 125 additional technical inputs provided by the public, as well as the other published literature and professional judgment. The chapter author team then met at the University of Southern California on March 27-28, 2012, for expert deliberation of draft key messages by the authors. Each key message was defended before the entire author team prior to the key message being selected for inclusion. These discussions were supported by targeted consultation with additional experts by the lead author of each message, and they were based on criteria that help define "key vulnerabilities, which include magnitude, timing, persistence and reversibility, likelihood and confidence, potential for adaptation, distribution, and importance of the vulnerable system."[104]

Key message #1 Traceable Account

Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.

Description of evidence base

The key message was chosen based on input from the extensive evidence documented in the Southwest Technical Input Report[103] and additional technical input reports received as part of the Federal Register Notice solicitation for public input, as well as stakeholder engagement leading up to drafting the chapter.

Key Message 5 in Chapter 2, Our Changing Climate, also provides evidence for declining precipitation across the United States, and a regional study[17] discusses regional trends and scenarios for the Southwest.

Over the past 50 years, there has been a reduction in the amount of snow measured on April 1 as a proportion of the precipitation falling in the corresponding water-year (October to September), which affects the timing of snowfed rivers. The implication of this finding is that the lower the proportion of April 1 snow water equivalent in the water-year-to-date precipitation, the more rapid the runoff, and the earlier the timing of center-of-mass of streamflow in snowfed rivers.[26,27] For the "recent decade" (2001 to 2010), snowpack evidence is from U.S. Department of Agriculture (USDA) Natural Resources Conservation Service snow course data, updated through 2010. One study[4] has analyzed streamflow amounts for the region's four major river basins, the Colorado, Sacramento-San Joaquin, Great Basin (Humboldt River, NV), and the Rio Grande; data are from the U.S. Department of the Interior – Bureau of Reclamation, California Department of Water Resources, U.S. Geological Survey, and the International Boundary and Water Commission (U.S. Section), respectively. These data are backed by a rigorous detection and attribution study.[10] Projected trends[18] make use of downscaled climate parameters for 16 global climate models (GCMs), and hydrologic projections for the Colorado River, Rio Grande, and Sacramento-San Joaquin River System.

Based on GCM projections, downscaled and run through the variable infiltration capacity (VIC) hydrological model,[105] there are projected reductions in spring snow accumulation and total annual runoff, leading to reduced surface water supply reliability for much of the Southwest, with greater impacts occurring during the second half of this century.[18,28]

Future flows in the four major Southwest rivers are projected to decline as a result of a combination of increased temperatures, increased evaporation, less snow, and less persistent snowpack. These changes have been projected to result in decreased surface water supplies, which will have impacts for allocation of water resources to major uses, such as urban drinking water, agriculture, and ecosystem flows.

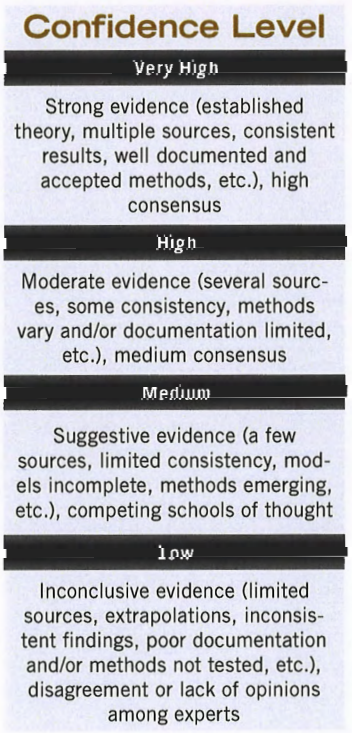
New information and remaining uncertainties

Different model simulations predict different levels of snow loss. These differences arise because of uncertainty in climate change warming and precipitation projections due to differences among GCMs, uncertainty in regional downscaling, uncertainty in hydrological modeling, differences in emissions, aerosols, and other forcings, and because differences in the hemispheric and regional-scale atmospheric circulation patterns produced by different GCMs produce different levels of snow loss in different model simulations.

In addition to the aforementioned uncertainties in regional climate and hydrology projections, projection of future surface water supply reliability includes at least the following additional uncertainties: 1) changes in water management, which depend on agency resources and leadership and cooperation of review boards and the public;[106] 2) management responses to non-stationarity;[107] 3) legal, economic, and institutional options for augmenting existing water supplies, adding underground water storage and recovery infrastructure, and fostering further water conservation (for example, Udall 2013[108]); 4) adjudication of unresolved water rights; and 5) local, state, regional, and national policies related to the balance of agricultural, ecosystem, and urban water use (for example, Reclamation 2011[43]).

Assessment of confidence based on evidence

There is **high** confidence in the continued trend of declining snowpack and streamflow in parts of the Southwest given the evidence base and remaining uncertainties.



For the impacts on water supply, there is **high** confidence that reduced surface water supply reliability will affect the region's cities, agriculture, and ecosystems.

Key message #2 Traceable Account

The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.

Description of evidence base

Increased competition for scarce water was presented in the first key message and in the foundational Technical Input Report (TIR).[103] U.S. temperatures, including those for the Southwest region, have increased and are expected to continue to rise (Ch. 2: Our Changing Climate, Key Message 3). Heat waves have become more frequent and intense and droughts are expected to become more intense in the Southwest (Ch. 2: Our Changing Climate, Key Message 7). The length of the frost-free season in the Southwest has been increasing, and frost-free season length is projected to increase (Ch. 2: Our Changing Climate, Key Message 4). A regional study[17] discusses the trends and scenarios in the Southwest for moisture, cold, heat, and their extremes.

There is abundant evidence of irrigation dependence and vulnerability of high-value specialty crops to extremes of moisture, cold, and heat, including, prominently, the 2009 National Climate Assessment[109] and the foundational TIR.[103] Southwest agricultural production statistics and irrigation dependence of that production is delineated in the USDA 2007 Census of Agriculture[45] and the USDA Farm and Ranch Irrigation Survey.[46]

Reduced Yields. Even under the most conservative emissions scenarios evaluated (the combination of SRES B1emissions scenario with statistically downscaled winter chill projections from the HADCM3 climate model), one study[56] projected that required winter chill periods will fall below the number of hours that are necessary for many of the nut- and fruit-bearing trees of California, and yields are projected to decline as a result. A second study[54] found that California wheat acreage and walnut acreage will decline due to increased temperatures. Drought and extreme weather may have more effect on the market value of fruits and vegetables, as opposed to other crops, because fruits and vegetables have high water content and because consumers expect good visual appearance and flavor.[51] Extreme daytime and nighttime temperatures have been shown to accelerate crop ripening and maturity, reduce yield of crops such as corn, fruit trees, and vineyards, cause livestock to be stressed, and increase water consumption in agriculture.[53]

Irrigation water transfers to urban. Warmer, drier future scenarios portend large transfers of irrigation water to urban areas even though agriculture will need additional water to meet crop demands, affecting local agriculturally-dependent economies.[55] In particular areas of the Southwest (most notably lower-central Arizona), a significant reduction in irrigated agriculture is already underway as land conversion occurs near urban centers.[48] Functioning water markets, which may require legal and institutional changes, can enable such transfers and reduce the social and economic impacts of water shortages to urban areas.[47] The economic impacts of climate change on Southwest fruit and nut growers are projected to be substantial and will result in a northward shift in production of these crops, displacing growers and affecting communities.

New information and remaining uncertainties

Competition for water is an uncertainty. The extent to which water transfers take place depends on whether complementary investments in conveyance or storage infrastructure are made. Currently, there are legal and institutional restrictions limiting water transfers across state and local jurisdictions. It is uncertain whether infrastructure investments will be made or whether institutional innovations facilitating transfers will develop. Institutional barriers will be greater if negative third-party effects of transfers are not adequately addressed. Research that would improve the information base to inform future water transfer debates includes: 1) estimates of third party impacts, 2) assessment of institutional mechanisms to reduce those impacts, 3) environmental impacts of water infrastructure projects, and 4) options and costs of mitigating those environmental impacts.

Extremes and phenology. A key uncertainty is the timing of extreme events during the phenological stage of the plant or the growth cycle of the animal. For example, plants are more sensitive to extreme high temperatures and drought during the pollination stage compared to vegetative growth stages.

Genetic improvement potential. Crop and livestock reduction studies by necessity depend on assumptions about adaptive actions by farmers and ranchers. However, agriculture has proven to be highly adaptive in the past. A particularly high uncertainty is the ability of conventional breeding and biotechnology to keep pace with the crop plant and animal genetic improvements needed for adaptation to climate-induced biotic and abiotic stresses.

Assessment of confidence based on evidence

Although evidence includes studies of observed climate and weather impacts on agriculture, projections of future changes using climate and crop yield models and econometric models show varying results depending on the choice of crop and assumptions regarding water availability. For example, projections of 2050 California crop yields show reductions in field crop yields, based on assumptions of a 21% decline in agricultural water use, shifts away from water-intensive crops to high-value specialty crops, and development of a more economical means of transferring water from northern to southern California.[47] Other studies, using projections of a dry, warmer future for California, and an assumption that water will flow from lower- to higher-valued uses (such as urban water use), generated a 15% decrease in irrigated acreage and a shift from lower- to higher-valued crops.[49]

Because net reductions in the costs of water shortages depend on multiple institutional responses, it is difficult as yet to locate a best estimate of water transfers between zero and the upper bound. Water scarcity may also be a function of tradeoffs between economic returns from agricultural production and returns for selling off property or selling water to urban areas (for example, Imperial Valley transfers to San Diego).

Given the evidence base and remaining uncertainties, confidence is **high** in this key message.

Key Message #3 Traceable Account

Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas.

Description of evidence base

Increased warming and drought are extensively described in the foundational Technical Input Report (TIR).[103] U.S. temperatures have increased and are expected to continue to rise (Ch. 2: Our Changing Climate, Key Message 3). There have been regional changes in droughts, and there are observed and projected changes in cold and heat waves and droughts (Ch. 2: Our Changing Climate, Key Message 7) for the nation. A study for the Southwest[17] discusses trends and scenarios in both cold waves and heat waves.

Analyses of weather station data from the Southwest have detected changes from 1950 to 2005 that favor wildfire, and statistical analyses have attributed the changes to anthropogenic climate change. The changes include increased temperatures,[3] reduced snowpack,[27] earlier spring warmth,[30] and streamflow.[10] These climate changes have increased background tree mortality rates from 1955 to 2007 in old-growth conifer forests in California, Colorado, Utah, and the northwestern states[7] and caused extensive piñon pine mortality in Arizona, Colorado, New Mexico, and Utah between 1989 and 2003.[69]

Climate factors contributed to increases in wildfire in the previous century. In mid-elevation conifer forests of the western United States, increases in spring and summer temperatures, earlier snowmelt, and longer summers increased fire frequency by 400% and burned area by 650% from 1970 to 2003.[8] Multivariate analysis of wildfire across the western U.S. from 1916 to 2003

indicates that climate was the dominant factor controlling burned area, even during periods of human fire suppression.[65] Reconstruction of fires of the past 400 to 3000 years in the western U.S.[66] and in Yosemite and Sequoia National Parks in California[67,68] confirm that temperature and drought are the dominant factors explaining fire occurrence.

Four different fire models project increases in fire frequency across extensive areas of the Southwest in this century.[71,72,73,74] Multivariate statistical generalized additive models[64,72] project extensive increases across the Southwest, but the models project decreases when assuming that climate alters patterns of net primary productivity. Logistic regressions[74] project increases across most of California, except for some southern parts of the state, with average fire frequency increasing 37% to 74%. Linear regression models project up to a doubling of burned area in the southern Rockies by 2070 under emissions scenarios B1 or A2.[73] The MC1 dynamic global vegetation model projects increases in fire frequencies on 40% of the area of the Southwest from 2000 to 2100 and decreases on 50% of the areas for emissions scenarios B1 and A2.[71]

Excessive wildfire destroys homes, exposes slopes to erosion and landslides, and threatens public health, causing economic damage.[59,60] Further impacts to communities and various economies (local, state, and national) have been projected.[74]

New information and remaining uncertainties

Uncertainties in future projections derive from the inability of models to accurately simulate all past fire patterns, and from the different GCMs, emissions scenarios, and spatial resolutions used by different fire model projections. Fire projections depend highly on the spatial and temporal distributions of precipitation projections, which vary widely across GCMs. Although models generally project future increases in wildfire, uncertainty remains on the exact locations. Research groups continue to refine the fire models.

Assessment of confidence based on evidence

There is **high** confidence in this key message given the extensive evidence base and discussed uncertainties.

Key message #4 Traceable Account

Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides. Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland.

Description of evidence base

The key message and supporting text summarizes extensive evidence documented in the Technical Input Report.[103] Several studies document potential coastal flooding, erosion, and wind-driven wave damages in coastal areas of California due to sea level rise (for example, Bromirski et al. 2012; Heberger et al. 2011, and Revell et al. 2011[81,82]). Global sea level has risen, and further rise of 1 to 4 feet is projected by 2100 (Ch. 2: Our Changing Climate, Key Message 10).

All of the scientific approaches to detecting sea level rise come to the conclusion that a warming planet will result in higher sea levels. In addition, numerous recent studies[78,80] produce much higher sea level rise projections for the rest of this century as compared to the projections in the most recent report of the Intergovernmental Panel on Climate Change[83] for the rest of this century.

New information and remaining uncertainties

There is strong recent evidence from satellites such as GRACE[110] and from direct observations that glaciers and ice caps worldwide are losing mass relatively rapidly, contributing to the recent increase in the observed rate of sea level rise.

Major uncertainties are associated with sea level rise projections, such as the behavior of ice sheets with global warming and the actual level of global warming that the Earth will experience in the future.[78,80] Regional sea level rise projections are even more uncertain than the projections for global averages because local factors such as the steric component (changes in the volume of water with changes in temperature and salinity) of sea level rise at regional levels and the vertical movement of land have large uncertainties.[78] However, it is virtually certain that sea levels will go up with a warming planet as demonstrated in the paleoclimatic record, modeling, and from basic physical arguments.

Assessment of confidence based on evidence

Given the evidence, especially since the last IPCC report,[83] there is **very high** confidence the sea level will continue to rise and that this will entail major damage to coastal regions in the Southwest. There is also **very high** confidence that flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some areas of the California coast during storms and extreme high tides.

Key message #5 Traceable Account

Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.

Description of evidence base

There is excellent agreement regarding the urban heat island effect and exacerbation of heat island temperatures by increases in regional temperatures caused by climate change. There is

abundant evidence of urban heat island effect for some Southwest cities (for example, Sheridan et al.[98]), as well as several studies, some from outside the region, of the public health threats of urban heat to residents (for example, Ch. 9: Human Health, Ostro et al. 2009, 2001[99,100]). Evidence includes observed urban heat island studies and modeling of future climates, including some climate change modeling studies for individual urban areas (for example, Phoenix and Los Angeles). There is wide agreement in Southwest states that increasing temperatures combined with projected population growth will stress urban water supplies and require continued water conservation and investment in new water supply options. There is substantial agreement that disruption to urban electricity may cause cascading impacts, such as loss of water, and that projected diminished supplies will pose challenges for urban cooling (for example, the need for supplemental irrigation for vegetation-based cooling). However, there are no studies on urban power disruption induced by climate change.

With projected surface water losses, and increasing water demand due to increasing temperatures and population, water supply in Southwest cities will require greater conservation efforts and capital investment in new water supply sources.[92] Several southwestern states, including California, New Mexico, and Colorado have begun to study climate impacts to water resources, including impacts in urban areas.[91]

The interdependence of infrastructure systems is well established, especially the dependence of systems on electricity and communications and control infrastructures, and the potential cascading effects of breakdowns in infrastructure systems.[16] The concentration of infrastructures in urban areas adds to the vulnerability of urban populations to infrastructure breakdowns. This has been documented in descriptions for major power outages such as the Northeast power blackout of 2003, or the recent September 2011 San Diego blackout.[94]

A few references point to the role of urban power outages in threatening public health due to loss of air conditioning[14] and disruption to water supplies.[94]

New information and remaining uncertainties

Key uncertainties include the intensity and spatial extent of drought and heat waves. Uncertainty is also associated with quantification of the impact of temperature and water availability on energy generation, transmission, distribution, and consumption – all of which have an impact on possible disruptions to urban electricity. Major disruptions are contingent on a lack of operator response and/or adaptive actions such as installation of adequate electricity-generating capacity to serve the expected enhanced peak electricity demand. Thus a further uncertainty is the extent to which adaptation actions are taken.

Assessment of confidence based on evidence

The urban heat island effect is well demonstrated and hence projected climate-induced increases to heat will increase exposure to heat-related illness. Electricity disruptions are a key uncertain factor, and potential reductions in water supply not only may reduce hydropower generation, but also availability of water for cooling of thermal power plants.

Based on the substantial evidence and the remaining uncertainties, confidence in each aspect of the key message is **high**.

APPENDIX B

Santa Fe Basin Study

Adaptations to Projected Changes in Water Supply and Demand

Santa Fe Basin, New Mexico

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region
Albuquerque Area Office

City of Santa Fe
Water Division
Water Resources and
Conservation Section

Santa Fe County
Utilities Division

August 2015

Santa Fe Basin Study:

Adaptations to Projected Changes in Water Supply and Demand

Report partners

Bureau of Reclamation

City of Santa Fe

Santa Fe County

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August 2015

Acronyms and Abbreviations

AAO	Albuquerque Area Office
AF	acre-feet
AFY	acre-feet per year
amsl	above mean sea level
ASR	aquifer storage and recovery
BCSD	Bias Correction and Spatial Disaggregation
CIP	Capital Improvement Plan
City	City of Santa Fe
County	Santa Fe County
CMIP3	Coupled Model Inter-comparison Project Phase 3
DOI	United States Department of Interior
ET	evapotranspiration
GCM	General Circulation Models
GDD	growing degree days
GHG	greenhouse gas
gpcd	gallons per capita per day
HD(e)	Hybrid-Delta Ensemble Unit
IPCC	Intergovernmental Panel on Climate Change
MOA	Memorandum of Agreement
MRGCD	Middle Rio Grande Conservancy District
NMED	New Mexico Environment Department
O&M	operation and maintenance
OSE	New Mexico Office of the State Engineer
Reclamation	Bureau of Reclamation
RWRP	City of Santa Fe Reclaimed Wastewater Resource Plan
STELLA	Systems Thinking Experimental Learning Laboratory with Animation
SURFS	Stream Unit Response Function Solver
TSC	Technical Services Center
URGWOM	Upper Rio Grande Water Operations Model
URGSiM	Upper Rio Grande Simulation Model
VIC	Variable Infiltration Capacity
WCRP	World Climate Research Programme
WaterMAPS	Water Management and Planning Simulation
WaterSMART	Sustain and Manage America's Resources for Tomorrow

Executive Summary

Study Purpose

Climate change, in concert with human development and other changes, promises to alter many aspects of life in the Santa Fe basin, including the availability of water to the City of Santa Fe (City) and Santa Fe County (County), and the resources that depend on the Santa Fe watershed (Figure E-1). The health of forests, fish and wildlife, and other ecosystems as well as human development, food security, and quality of life are likely to be affected. This Basin Study has been undertaken by the City and County along with the United States Department of Interior (DOI) Bureau of Reclamation (Reclamation), to evaluate these projected changes and to develop potential strategies for adaptation that can be used for planning.

Figure E-1. Map of Santa Fe County.

WaterSMART: Authorization and Program

This Basin Study was performed under the U.S. Department of the Interior's WaterSMART (Sustain and Manage America's Resources for Tomorrow) Basin Study Program. The Federal SECURE Water Act of 2009 and Secretarial Order 3297 established the WaterSMART Program, which authorizes Federal water and science agencies to work with State and local water managers to pursue and protect sustainable water supplies and plan for future climate change by providing leadership and technical assistance on the efficient use of water. WaterSMART allows all bureaus of the Department to collaboratively work with States, Tribes, local governments, and non-governmental organizations to pursue a sustainable water supply for the Nation, and integrate water and energy policies to support the sustainable use of all natural resources.

Basin studies, one of WaterSMART's tools, are basin-wide efforts to evaluate and address the impacts of increased competition for limited water supplies, climate change, and other stressors, and to define options for meeting future water demands in river basins in the Western United States where imbalances in water supply and demand exist or are projected. This Basin Study is consistent with Reclamation's Basin Study Framework and Section 9503 of the SECURE Water Act (Subtitle F of Title IX of P.L. 111-11, the Omnibus Public Land Management Act of 2009).

Cost Share and Funding

The cost-share partners for this study are the City, County, and Reclamation, which performed the study in partnership under a Memorandum of Agreement (Reclamation et al., 2011 [MOA]). The Santa Fe Basin Study analyses, modeling, evaluations, and reporting have been developed through the combined efforts of the City and County working in consultation with Reclamation's Albuquerque Area Office (AAO), with technical support from Reclamation's Technical Service Center (TSC), Sandia National Laboratories, and CDM Smith, an engineering firm.

Scope and Objectives

The opportunities for adaptation to future water supply shortages identified through this Basin Study are based on a better understanding of the future effects of, and associated risks from, climate change and population growth on the City and County's combined water supply portfolio. Through the Santa Fe Basin Study, the study partners seek to improve the resilience of the Santa Fe watershed and the communities the watershed supports, as well as the municipal water systems for the City and County, in the face of projected changes in population, human development, and climate. This Basin Study consisted of the following actions:

- Identify the vulnerabilities of systems in the Santa Fe watershed to climate change. A preliminary assessment qualitatively evaluated climate-change impacts on water supply sources, ecosystems, quality of life, agriculture and local food production, landscapes, land use, and water demand. This assessment was based on input obtained during a March 6, 2012 workshop and from research conducted by the authors and is summarized in this report and presented in full in Appendix A.
- Assess Santa Fe's changing water supply and demand, including native surface-water supplies from the Santa Fe Watershed, the Upper Rio Grande, and the San Juan Basin (imported water of the San Juan-Chama Project), as well as groundwater supplies to the city and county's well fields. This portion of the study includes an assessment of the likely water supply and demand conditions in 2050 for the City and County's combined water supply. There is a small amount of agricultural land (as of 2005, OSE estimated 590 acres irrigated with surface water and 130 acres

irrigated with groundwater) in the Santa Fe Watershed. However, the quantitative analyses in this study focused on municipal supply, demand, and adaptation measures, since municipal use represents the largest portion of water use within the basin, and is the primary area of interest of Reclamation's study partners. This assessment included:

- Developing climate and hydrology projections for use in this Basin Study. This work by Reclamation and Sandia National Laboratories is described in Appendices B, C1, and C2.
- Developing an independent transient analysis of the projected changes over the course of the 21st century of the reliability of Reclamation's San Juan-Chama Project. This work by Reclamation and Sandia National Laboratories is presented in full in Appendix D.
- Updating the City's Water Management and Planning Simulation (WaterMAPS) model to include the County as a partnering entity and to enhance the model to include functionality to assess projected climate impacts. This work by CDM-Smith is discussed in detail in Appendix E.
- Using the updated WaterMAPS model, running simulations to determine the impacts to the City and County's combined water supply under future demand and projected climate conditions. These simulations by CDM-Smith are described in detail in Appendix F.

- Identify and analyze potential adaptation strategies for the combined City and County water supply. This portion of the study included:
  - Assessing the vulnerability and possible shortcomings of the current long-range water supply strategies.
  - Identifying management or infrastructure changes that might strengthen the entire basin, its component systems, and its inhabitants to provide more flexibility in the face of an uncertain future.
  - Combining these adaptation strategies into portfolios that would provide adequate water supply in the 2050s, considering projected population growth and climatic changes. Since it is likely that no single adaptation strategy will suffice to fill the gap between supply and demand, these combined portfolios helped the City and County select adaptive strategies that best meet the regional water supply needs. Appendix G describes the adaptation strategies and alternative climate mitigation portfolios evaluated.

Location and Description of the Study Area

This Basin study focuses on the Santa Fe River watershed, a sub-basin to the Rio Grande watershed. The Santa Fe watershed is in the high-elevation desert of northern New Mexico (Figure E-1). It spans the Sangre de Cristo Mountains on the east and the Rio Grande on the west. The City of Santa Fe is the main municipality in the watershed and within the northern portion of Santa Fe County

(Figure E-2). The Santa Fe Basin includes the City and the portion of the County that has the highest population density and the highest growth rate, as well as the part that has historically depended on the City of Santa Fe for its water supply.

For water-supply assessment purposes, the study area also encompasses:

- The upper Rio Grande watershed (upstream of Otowi stream gage)
- Tributaries within the San Juan River watershed, a portion of which are delivered to Santa Fe through Reclamation's San Juan-Chama Project
- Groundwater from the aquifers of the Santa Fe Group

Each of these sub-basins is a source of surface-water for the combined municipal water supply for the City and County. The first two sub-basins are within the Rio Grande basin; the third lies within the Upper Colorado River Basin (Figure E-2).

Santa Fe averages over 300 days of sunshine a year, with a temperate climate and four distinct seasons. The summer months in Santa Fe, from May to September, feature typically hot, sunny weather, with fairly low humidity and cooler evenings. Daily summer temperatures in Santa Fe peak at around 93°F during July and August. Thunderstorms typically occur in the early evening during this season. Rainfall in the Santa Fe area is spread throughout the year, although the highest frequency and intensity of rain occurs as part of the summer monsoons, which occur primarily during the months of July and August. The average annual precipitation in Santa Fe is about 14 inches.

Problems, Needs, and Opportunities

The City and County water supply systems are interconnected, with the County system surrounding the City system to the north, south, and east of the City boundary and service area. The two water utilities also co-own one of the region's sources of supply (Figure E-2). The City and County water utilities have a diverse water supply portfolio, providing water to their customers with surface water from the three sub-basins and groundwater from two well fields. Because of this shared resource and infrastructure, cooperation between the City and County is essential for planning. The City and County are concerned about potential decreases in the availability and reliability of their joint surface water supply, as well as the quality of the water. The water utilities recognized the need for long-range planning efforts to identify future water supply deficiencies, identify strategies for meeting those shortfalls, and implement those strategies.

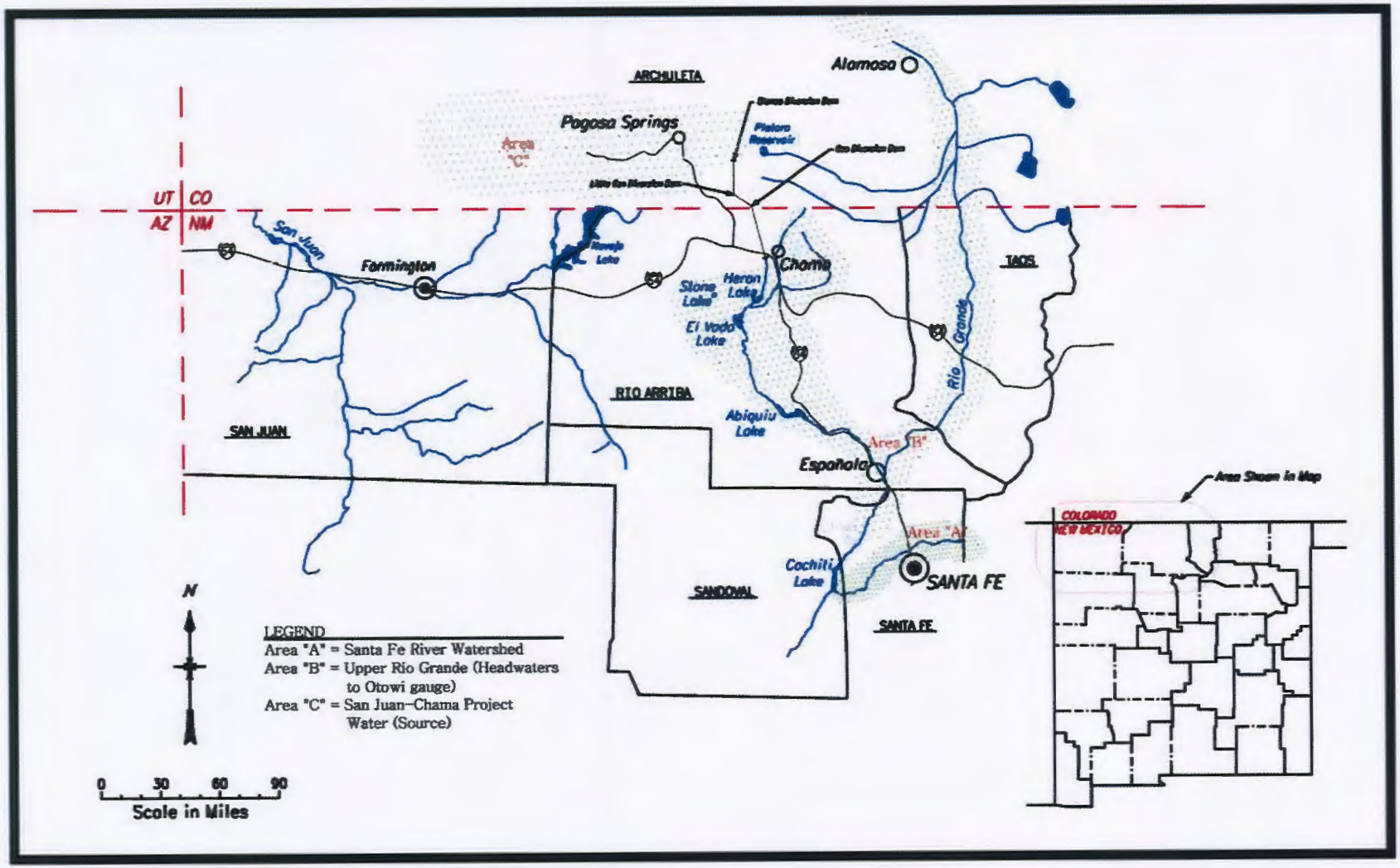

Figure ES-2. The Santa Fe watershed (shaded green) receives water supply from the Santa Fe sub-basin, the upper Rio Grande sub-basin (green stipple) and the San Juan-Chama River sub-basin (all green stipple).

The population continues to grow and the needs of the community continue to expand. Like many surface waters in the arid Southwest, however, supplies from the Santa Fe River, the Upper Rio Grande and the tributaries to the San Juan River are all limited, highly variable, and. dependent on seasonal snowpack and runoff conditions, They are also all vulnerable to climate-change-induced impacts. The groundwater is pumped from aquifers that are slow to recharge. In response to these conditions, the City and the County have been working for a more resilient, sustainable, diverse, and innovative water supply system for many years. To increase the sustainability of their water supply, the City and County water utilities have developed new surface-water sources. However, they also recognize that additional increases in supply and/or decreases in demand will be required to meet the challenges ahead. This Basin Study is the latest in a series of efforts to understand and strengthen water supply management in the Santa Fe area.

Characterization of Future Conditions

Future water supply conditions, water availability, and water demands were projected based on climate scenarios and population increases. The climate-projections used for this study were developed from The World Climate Research Programme (WCRP) Coupled Model Inter-comparison Project Phase 3 (CMIP3) (Meehl et al. 2007), and Reclamation's Bias-Corrected and Spatially Downscaled Surface Water Projections (Reclamation 2011[BCSD]).

Imported San Juan-Chama Project Reliability Analysis

To assess the reliability of Reclamation's San Juan-Chama Project. Reclamation and Sandia National Laboratories provided an independent, separate transient analysis of the projected changes over the course of the 21st century. The methods used for this analysis are described in Llewellyn, et. al. (2013) and results are more fully described in Appendix D. Projected changes to the water supply and project operations are:.

- Flows would decrease by one-quarter overall
- Flows would decrease in summer and increase in spring.
- Storage in Heron Reservoir would be reduced.
- Sufficient water for a full allocation to contractors will be available less frequently.

Even if sufficient water is available in tributaries to the San Juan River for diversions to the San Juan-Chama Project, shortages within the Colorado River Basin could lead to priority calls or shortage sharing agreements that would result in decreased supply to New Mexico under the Colorado River Compact. Such

shortages could result in decreases in Reclamation's authorization to divert water to the San Juan-Chama Project, even if sufficient water is available locally.

Santa Fe Municipal Supply Analysis (WaterMAPS)

As the 2050s are the period consistent with the study's 40-year planning cycle, the model generated five climate scenarios representing the range of variability expected in basin hydrology in the 2050s (Reclamation 2010).

Three of these five climate scenarios were deemed to represent the range of temperature and precipitation changes that are expected due to climate change: Warm-Wet, Hot-Dry, and Central Tendency groups. Therefore, these three scenarios were simulated by Sandia National Laboratories in the monthly-timestep operations model, Upper Rio Grande Simulation Model (URGSiM). Analysis is in Llewellyn et. al. 2013 and results are discussed in Appendix E. The output from these URGSiM simulations were used as input to Santa Fe's municipal supply operations model, Water Management and Planning Simulation (WaterMAPS), to generate the projections and alternatives evaluated in this Basin Study. A baseline scenario, referred to as "simulated historic" was used for comparison to climate-change impacted hydrologies. The simulated historic scenario combines current infrastructure and operations with synthetic, spatially distributed historic climate and inflows (Maurer et. al. 2002). The components of total demand, as modeled in WaterMAPS, are:

- **Population.** Population projections for the 2055 populations used for developing water demand are 125,019 and 44,673 persons for the City and County water service areas, respectively. The City's Long-Range Water Supply Plan completed in 2008 did not directly include the adjacent County population. The combined population leads to much greater demand without a commensurate increase in supply, so the gap between supply and demand reported in this study is not similar to previous City or County documents.

- **Per-capita water demand.** The current average annual per-capita water demand of 114 gallons per capita per day (gpcd) was derived from monthly water production data provided by the City and the City population data from 2002 to 2010. For the demand projections, the unit demand representing the annual average is assumed to be fixed at 114 gpcd (e.g., no conservation efforts assumed for future conditions). This average annual unit demand represents the baseline demand that is compared to the projected 2055 demands to identify the potential water supply gap. Demand values for reclaimed water used in this analysis were obtained from the City of Santa Fe Reclaimed Wastewater Resource Plan (Borchert, 2013), which outlines specific allocations for reclaimed water use. Demand for reclaimed water was based on the allocations and was not modified to account for climate change.

- **Seasonal variations.** In the water supply assessment portion of this study, projected changes to temperature and precipitation were input into a local dynamic systems water operations model (WaterMAPS) to assess potential changes to water supply. The simulated supply conditions were then compared with demand projections to evaluate deficits and needs in the future water supply for the Santa Fe area. Seasonal variability of demand and impacts on that variability due to climate change are also predicted as part of this study and included in the analysis. Other water demands include court ordered provision of water for irrigation systems (i.e., Acequia Madre, Acequia Cerro Gordo).

Water Supply and Demand

The analysis of water supply in the Santa Fe Basin uses the City's WaterMAPS model. WaterMAPS is a multi-criteria dynamic systems simulation model that was built on the Systems Thinking Experimental Learning Laboratory with Animation (STELLA) programming environment. STELLA, developed by Isee Systems, Inc. is a systems modeling industry standard. The results produced from WaterMAPS are used to evaluate how well the City and County will be able to meet future water supply objectives under the four climate scenarios.

The total present supply for the City and County is about 19,000 acre-feet per year (AFY), based on water rights, current water usage, administrative requirements, and current management targets. Although more water is currently available from groundwater sources, management targets for groundwater pumping are used in this analysis because these targets are considered to be sustainable and they add resilience to the overall water supply. The primary water supplies available are:

Surface Water Sources:

- **Rio Grande -** San Juan-Chama Project water and Rio Grande Native Water diverted through the Buckman Direct Diversion roughly 10 miles west of the City limits. The City's contract for San Juan-Chama Project Water is for 5,230 AFY. The County owns 1,325 AFY and plans to acquire an additional 590 AFY acre-feet/year (AFY) of native Rio Grande surface-water rights.
- **Santa Fe River Watershed -** The Santa Fe River originates in the Sangre de Cristo Mountains above downtown Santa Fe. The water from this watershed is stored in two reservoirs: McClure and Nichols, both owned and operated by the City, and treated at the Canyon Road Water Treatment Plant. The City has 5,040 AFY of water rights from the Santa Fe Watershed.

Groundwater Sources:

- **City Well Field (along the Santa Fe River)**: This supply includes the Osage, Northwest, St. Michael's wells, and "Other City wells" all located within the City limits (Agua Fria, Torreon, Alto, Ferguson, Santa Fe, and Hickox). The City has the right to produce roughly 4,865 AFY from this well field.
- **Buckman Well Field (near the Rio Grande)**: This source consists of 13 wells outside of the City limits and near the Rio Grande. Capacity 10,000 AFY, but management restrictions for sustainable yield limit pumping to 3,000 AFY.

Note: Under New Mexico water administration rules, use of groundwater results in depletion of rivers and the depletions must be offset (paid back to the river) by replenishing river flow. Offsets are part of the administrative requirements and are included in the water accounting in WaterMAPS.

The average annual per capita demand for the City of Santa Fe (114 gpcd) was used with future population for the City and the County to derive estimates of average future per-capita water demand. The effect of climate change on demand was estimated using the relationship between water use, temperature and precipitation from City data. The same relationship between water use, temperature and precipitation was applied to temperature and precipitation data for the climate change and simulated historic scenarios.

The gaps between water supply and demand under the climate change scenarios if no adaptation strategies are implemented are summarized in Table E-1. As can be seen on this table, a 2055 water supply gap of just over 5,000 AFY is projected to occur under simulated historic climate conditions (assuming climate similar to historic), due to population increases. However, the magnitude of the water supply gap is larger when we consider projected population growth under any of the three climate change scenarios.

Table E-1. Santa Fe Basin Projected Average 2055 Water Supply Gap

	Climate Change Scenario			
	Simulated Historic (no climate change)	Central Tendency	Warm Wet	Hot Dry
Total Demand - Average Annual (AFY)	21,643	22,925	22,646	23,299
Total Supply - Average Annual (AFY)	16,488	15,550	16,304	13,976
Water Supply Gap – Difference between Demand and Supply Average Annual (AFY)	**(5,155)**	**(7,375)**	**(6,342)**	**(9,323)**

The Hot-Dry scenario has the highest maximum annual deficit, about 14,000 AF while the Warm-Wet scenario has the lowest maximum annual deficit falling just below 9,000 AF.

System Reliability and Risk Assessment

This Basin Study is intended to assess adaptation strategies that may help reduce a projected gap between supply and demand for the City and County. This study has identified where vulnerabilities exist in the supply and has pinpointed adaption strategies and portfolios to address these system weaknesses to ensure a more resilient water supply to meet 40-year water demand projections.

On an annual basis, the predicted deficit ranges from 3,500 acre-feet (AF), the minimum projected deficit for the baseline scenario (i.e., considering population growth without climate change) to almost 14,000 AF, the maximum projected deficit for the Hot-Dry scenario. On a monthly basis, there is a 68 to 95 percent chance that there will be a water supply shortage in any given month in one of the scenarios by the year 2055, based on current supplies and management targets. Predicted deficits are more frequent and severe in the summer months (when demands and ecological needs are higher) than in the winter.

These deficits are expected to impact the Santa Fe area in the following ways:

- **Ability to Deliver Water:** All modeled scenarios, including the baseline as well as the three climate-change impacted scenarios, show an annual deficit ranging between 3,500 AF and 14,000 AF. Without adaptation actions, such shortages would severely impact the ability of the City and County to deliver enough water to meet demands.

- **Recreation:** Decreased flow in the Rio Grande during the summer months will likely impact water-based recreation.

- **Flow and Water Dependent Ecological Resiliency:** Decreased flow in the Rio Grande during the summer months will likely impact the habitat of aquatic and riparian species, including threatened and endangered species, and decrease the resilience of riverine and riparian ecosystems.

The potential impact to other key water resources categories identified in the SECURE Water Act, including hydroelectric power generation facilities, water quality issues (including salinity levels), and flood control management, were not directly evaluated in this study, although the impacts to these water-related components are discussed in Appendix A.

Consequences of Taking No Action

If no adaptation actions are taken to offset the growing gap between supply and demand in the Santa Fe Basin, deficits discussed above would severely impact the ability to deliver enough water to meet demands, leading to grave regional economic impacts. Additionally, water-based recreation and flow and water dependent ecological resiliency are likely to be impacted by decreased flow in the Rio Grande and the Santa Fe River, especially in summer months.

Adaptation Strategies

Developing Adapation Strategies

Representatives of the City and County identified adaptation strategies appropriate for the arid climate and landscape of the Santa Fe region that could meet future water demands (summarized in Table E-2).

Table E-2. Adaptation Strategies for the Santa Fe Basin study area

Adaptation Strategy	Description	Infrastructure Components
Direct/Indirect Reclaimed Water Reuse	Use reclaimed water from the City wastewater treatment plant to meet contract obligations; remaining reclaimed water for potable reuse or return flow credits for pumping	New conveyance for reclaimed water from wastewater treatment plant to existing Buckman Regional Water Treatment Facility and distribution system or new conveyance to the Rio Grande for return flow credits
Water Conservation	Reduce water use on a per person per day basis	None
Direct Injection for Aquifer Storage and Recovery	Inject treated water into the aquifer in wet and normal years for use in dry years	Construction and operation of injection well(s); withdrawal using existing wells and distribution system
Infiltration for Aquifer Storage and Recovery in the Santa Fe River	Maintain flow in the Santa Fe River to induce infiltration into the aquifer for use in dry years	Withdrawal using existing wells and distribution system.
Additional Surface Water Rights	Additional surface water would be diverted at the Buckman Direct Diversion and treated at the Buckman Regional Water Treatment Facility.	Existing diversion, conveyance, treatment, and distribution systems

Formulating Adaptation Portfolios

These adaptation strategies were combined in different proportions to create adaptation portfolios (see Appendix G). These portfolios were modeled to evaluate which combination of adaptation strategies is most likely to meet the water supply needs of Santa Fe under projected conditions in the 2050s. Some of the evaluations performed using the local water operations model were to:

- Identify trends in water use, such as more pronounced spikes in use rates during drier and hotter summers, which could be preemptively addressed by increased conservation education.
- Identify likely water supply gaps (i.e., the difference between projected supply and projected demand) during the planning period (through 2055), under projected management, population, development, and climatic conditions.
- Evaluate a range of adaptation portfolios for addressing the projected supply gap in terms of cost, technical feasibility, public acceptance, permitting considerations, and the likely availability of funding assistance for individual alternatives.
- Evaluate the limits of individual adaptation strategies such as conservation or water rights acquisition to better understand potential limitations of existing practices in the future.

Evaluating and Comparing Adaptation Portfolios

The adaptation portfolios were evaluated to select the adaptation portfolio that best meets the needs of the Santa Fe Basin under projected population growth and climatic changes. (See Appendix G).

The initial step in evaluating the adaptation strategies and portfolios was to screen them against reliability criteria:

1. Average Buckman Well Field pumping does not exceed the management target by more than 500 AFY on average.

2. Total deficit does not exceed 2,000 AFY in any year in the simulations.

3. No more than 10 percent probability of deficits over 100 AFY (meaning that in 90% of the years, the deficit is less than 100 AFY)

Table E-3 summarizes the adaptation portfolios and the supply based on WaterMAPS simulations. Table E-4 provides the results of the reliability screening. Only those portfolios that provide a reliable water supply in 2055 were then evaluated against performance criteria. Portfolios 1 through 3 presented single adaptation strategies, and the results presented confirm that no single adaptation strategy will suffice to fill the gap between supply and demand. The solution for the Santa Fe Basin area must be a portfolio of adaptation strategies.

Findings

The five combination portfolios (Portfolios 4 through 8) that met the threshold of the reliability criteria were then evaluated using performance criteria. The performance criteria address multiple aspects of the water supply system and are both quantitative and qualitative. For each criterion, there is a corresponding performance measure that describes the metric that will be used to evaluate that criterion. All criteria are not of equal importance. Each criterion was assigned a weight to indicate its relative importance. The weights were developed on a consensus basis by the City, County, and Reclamation. The criteria, performance measures, and weights are shown in Table E-5.

The ranking process for the Santa Fe Basin Study was based on scoring each adaptation portfolio with respect to each of the performance criteria shown in Table E-5. The higher the score, the better the portfolio meets the criteria.

The ranking of the portfolios, based on the consensus scoring and the criteria weighting, is in Figure E-3. The ranking of the portfolios clearly shows that Portfolio 5, with an overall score of 3.8 out of 4.0, meets the performance criteria better than the other portfolios (Figure E-3). One common element of the three highest ranked portfolios is increased use of reclaimed water. This suggests that the City and County focus efforts to use reclaimed water from both the City

wastewater treatment plant and the County's Quill wastewater treatment plant. The three highest ranked portfolios also use the maximum number of adaptive strategies, demonstrating the value of a multi-faceted approach to meet future water demands in the Santa Fe region.

Table E-3. Santa Fe Basin Study Portfolios and Simulated Supply

	Simulated Supply from Adaptation Strategy (AFY)					
	Direct Reclaimed Water Reuse	Conservation	Direct Injection Aquifer Storage and Recovery	Infiltration Santa Fe River Aquifer Storage and Recovery	Additional Water Rights	**Portfolio Simulated Supply**
Portfolio 1: Conservation Only		4,005				**4,005**
Portfolio 2: Direct Reuse Only	4,024					**4,024**
Portfolio 3: Additional Water Rights Only					1,400	**1,400**
Portfolio 4: More Conservation & Water Rights (Reuse to Potable)	2,224	4,005	559	149	1,400	**8,337**
Portfolio 5: More Conservation & Water Rights (Reuse to Offsets)	2,224	4,005	559	149	1,400	**8,337**
Portfolio 6: More Infiltration ASR		3,003	0	2,841	1,400	**7,244**
Portfolio 7: More Direct Reuse (to Potable)	3,243	2,002		148	920	**6,313**
Portfolio 8: More Direct Reuse (to Return flow credits)	3,243	2,002		148	920	**6,313**

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Portfolio 8: More Direct Reuse (to Return flow credits)	3,243	2,002		148	920	**6,313**

Table E-4. Performance of Adaptation Portfolios Relative to Reliability Criteria

	Reliability Criteria		
	Avg Buckman Pumping in Excess of Target <500 AFY	**Maximum Annual Deficit <2000 AFY**	**Annual Deficit at 10% probability > 100 AFY**
Portfolio 1: Conservation Only	NO (Exceeds by 2,674 AFY)	YES (1,372 AFY)	NO (391 AFY)
Portfolio 2: Direct Reuse Only	NO (Exceeds by 2,225 AFY)	YES (1,159 AFY)	NO (378 AFY)
Portfolio 3: Additional Water Rights Only	NO (Exceeds by 4,451 AFY)	NO (3,978 AFY)	NO (2,363 AFY)
Portfolios 4 and 5:* More Conservation and Water Rights	YES (Does not exceed)	YES (57 AFY)	YES (0 AFY)
Portfolio 6: More ASR	YES (Exceeds by 291 AFY)	YES (553 AFY)	ALMOST (Keep) (161 AFY)
Portfolios 7 and 8:** More Direct Reuse	YES (Exceeds by 323 AFY)	YES (211 AFY)	YES (32 AFY)

*Portfolios 4 and 5 have the same water-supply reliability rating, so are grouped together in this table. The differences between them show up in terms of Performance Measures.
**Portfolio 8 is the same as Portfolio 7 except the treated water is returned to the Rio Grande for return flow credits.

Table E-5. Performance Criteria, Performance Measures, and Criteria Weight

Performance Criteria	Performance Measure	Criteria Weight
Cost Considerations		**15%**
Capital Cost	Qualitative: estimate	40%
O&M Cost	Qualitative: estimate	40%
Potential for Cost Share	Qualitative	20%
Reliability and Sustainability		**25%**
Drought Supply	Quantitative: assessment of annual deficit probability curves	50%
Groundwater Use	Quantitative: average and maximum pumping compared to management target	50%
Acceptance		**10%**
Regulatory Compliance Complexity	Qualitative	50%
Public Acceptance	Qualitative	50%
Environmental /Cultural		**30%**
SF River Flows	Quantitative: flow in Santa Fe River	50%
Wetland Preservation	Qualitative	50%
Technical Implementability		**20%**
Technology Viability	Qualitative	100%

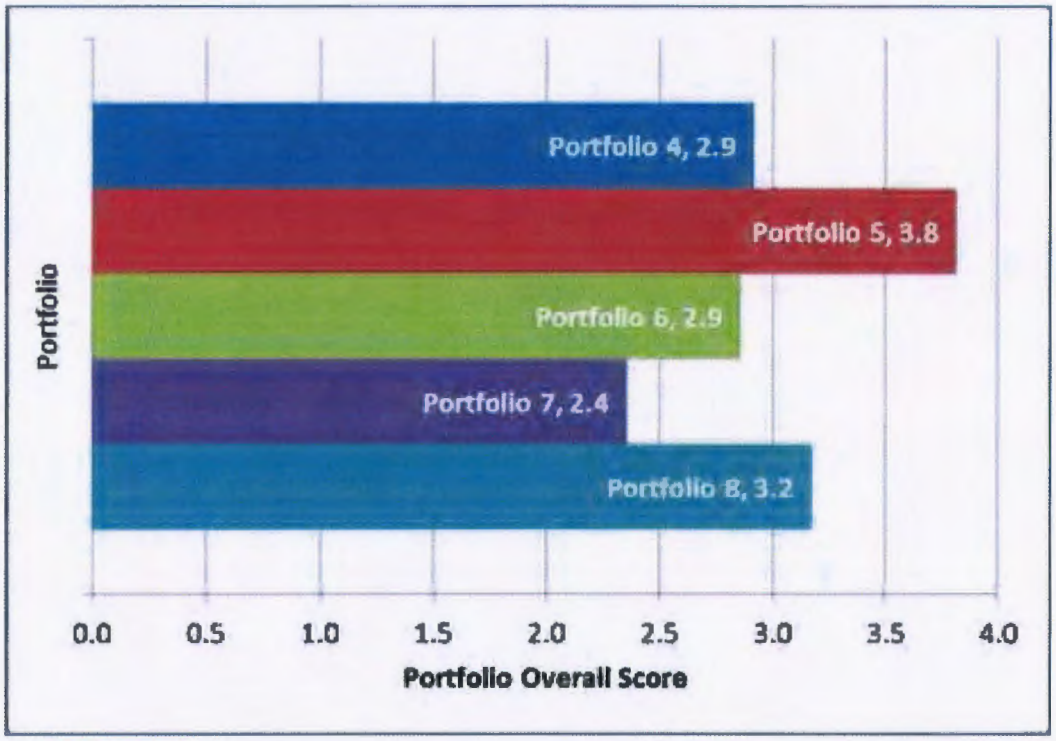


Figure E-3. Ranking of Santa Fe Portfolios.

Next Steps and Future Considerations

The highest ranked portfolio, Portfolio 5, includes over 2,200 AFY of direct water reuse, approximately 4,000 AFY of additional conservation, nearly 600 AFY of direct aquifer storage and recovery, nearly 150 AFY of indirect aquifer storage through infiltration below the Santa Fe River, and the acquisition of approximately 1,400 AFY of additional native Rio Grande water rights.

One of the primary adaption alternatives identified in this study is to "augment potable water supplies with reclaimed wastewater" as described in the report, Climate Change and the Santa Fe Basin: A Preliminary Assessment of Vulnerabilities and Adaptation Alternatives Bureau of Reclamation WaterSMART Program Initiative (February, 2013; Appendix A) and the City of Santa Fe Reclaimed Wastewater Resource Plan (RWRP) for the City (City of Santa Fe 2013) which identified potential alternatives to using reclaimed water as a supply source. City Council Resolution 2013-55 was enacted and approved and directs City Staff to pursue opportunities to evaluate and implement engineering and cost analysis of using reclaimed water alternatives to supplement water supplies. In June, 2014, the City and County were also awarded a grant through Reclamation's Title XVI Program to conduct a water reuse feasibility study. The water reuse feasibility study will evaluate alternatives for both potable and non-potable applications of reclaimed water to augment water supplies. The feasibility study will evaluate ways to cost-effectively use reclaimed wastewater in a more

efficient manner and will consider both potable and non-potable alternatives to meet water demand requirements while better balancing environmental conditions in the watershed.

Disclaimers

The Santa Fe Basin Study was funded jointly by Reclamation, the City of Santa Fe and Santa Fe County, and is a collaborative product of the study participants as identified in Section 1.4. Coordination and Participants of this report. The purpose of the study is to assess current and future water supply and demand in the Santa Fe Basin and other basins providing water to the City and County, and to identify a range of potential strategies to address any projected imbalances. The study is a technical assessment and does not provide recommendations or represent a statement of policy or position of Reclamation, DOI, or the funding partners. The study does not propose or address the feasibility of any specific project, program or plan. Nothing in the study is intended, nor shall the study be construed, to interpret, diminish, or modify the rights of any participant under applicable law. Nothing in the study represents a commitment for provision of Federal funds. All cost estimates included in this study are preliminary and intended only for comparative purposes.

While the best available information and consistent methodology was used in developing this Basin Study, projections into the future require many assumptions and result in inherent uncertainty. While this is necessary and appropriate for planning-level analyses, more detailed feasibility- and design-level studies would be needed when implementing some of the adaptation strategies identified. The purpose of this study is to provide a reasonable path forward based on the best information available. Some specific items to note are discussed below:

- Climate change impacts on groundwater supply were not explored for this Basin Study. The analysis accounted for likely reductions in groundwater supply through the use of management targets, which are significantly less than actual water rights.

- Water rights, management targets, and capacity constraints are changing annually and must be verified before using in future studies or planning projects.

- The predicted water supply gap is sensitive to population projections, which were not closely studied as part of this Basin Study. The future water service area for the County is not well known. Previous studies and input from the project team members were relied upon for this information.

APPENDIX C

393976

STATE OF NEW MEXICO)
)
OFFICE OF STATE ENGINEER)

LICENSE TO APPROPRIATE

License No. 1677 Refers to Files No. 1677, 01278 and RG-304

WHEREAS, on the 14th day of July 1926, after notice pursuant to statute the State Engineer did approve Application No. 1677, with a priority as of the date of filing Notice of Intention No. 1677, being the 11th day of September 1925, to appropriate 3500 acre feet of water per annum from the Santa Fe River, a tributary of the Rio Grande, for domestic, power, irrigation and municipal purposes in the City of Santa Fe and adjacent areas, and in conjunction with said appropriation to construct and use a storage dam and reservoir having a capacity of 2979.04 acre feet to be located on the Santa Fe River of the Rio Grande Stream System at the McClure (Granite Point) Dam Site within the Santiago Ramirez Grant, and

WHEREAS, on the 9th day of November 1942, after notice pursuant to statute, the State Engineer did approve Application No. 1677, to change the location of 669 acre feet of storage from McClure (Granite Point) Reservoir to a new storage dam and reservoir to be constructed on the Santa Fe River at the Nichols (Four Mile) Dam Site within the SE¼NE¼ Section 21, Township 17 North, Range 10 East, N.M. P.M., and

WHEREAS, on the 8th day of April 1943, after notice pursuant to statute the State Engineer did approve Application No. 1677, to change the location of an additional

107.4 acre feet of storage from McClure (Granite Point) Reservoir to Nichols (Four Mile) Reservoir, and

WHEREAS, on the 16th day of December 1946, after notice pursuant to statute, the State Engineer did approve Application No. 1677 to increase the storage rights under Permit No. 1677 from 2979.04 acre feet to 3500 acre feet, and

WHEREAS, on the 20th day of November 1950, Declaration of Ownership of Water Right, Numbered 01278 was filed claiming therein the right to appropriate 1540 acre feet of water per annum from the Santa Fe River for minicipal uses in the City of Santa Fe, New Mexico, said right was claimed to have been initiated on the 27th day of October, 1880, and

WHEREAS, on the 4th day of June 1958, after notice and hearing pursuant to statute the State Engineer issued "Memorandum Decision" approving Application No. RG-304 to drill a well in the City of Santa Fe for the purpose of appropriating a portion of the public water to which rights are claimed under Declaration No. 01278 and Permit No. 1677, provided that the maximum rate of production of water under Permit No. RG-304 shall not exceed 1,000 gallons per minute and provided that the total amount of water appropriated in any year under Declaration No. 01278 and Permits 1677 and RG-304 shall not exceed 5040 acre feet, and

WHEREAS, on the 10th day of August 1959, in Cause No. 29710, and on the 25th day of September 1959, in Cause No. 29700, the District Court of the First Judicial District setting within and for the County of Santa Fe, did enter judgments affirming the decision of the State Engineer

under Permit No. RG-304, and

WHEREAS, on the 29th day of December 1960, in Docket Case No. 6675 and on the 4th day of January 1961, in Docket Case No. 6703 the Supreme Court of the State of New Mexico affirmed the District Court decisions entered in Cause No. 29700 and in Cause No. 29710 insofar as it related to the limitation on maximum rate of production from Well RG-304 and the limitation of total amount of water that may be appropriated in any year under Permit 1677, Declaration No. 01278 and Permit RG-304.

NOW, THEREFORE, I, S. E. Reynolds, State Engineer of the State of New Mexico, by virtue of the authority vested in me by the laws of said State, do hereby grant to the Public Service Company of New Mexico, City of Santa Fe, County of Santa Fe, State of New Mexico, this License No. 1677, with a priority as of the date of filing Notice of Intention No. 1677, being the 11th day of September 1925, to appropriate from the Santa Fe River of the Rio Grande Stream System the quantity of 3500 acre feet of public water per annum for domestic, municipal and related purposes in and adjacent to the City of Santa Fe; storage units and diversion systems covered by this License are McClure (Granite Point) Reservoir located on the Santa Fe River at a point in the Santiago Ramirez Grant whence the West one-quarter corner of Section 19, Township 17 North, Range 11 East, N.M.P.M., bears South 84° 01' East, 3945.7 feet distant, Nichols (Four Mile) Reservoir located on the Santa Fe River at a point in the SE¼NE¼ Section 21, Township 17 North, Range 10 East, N.M.P.M., whence the East one-quarter

corner of said Section 21, bears South 74° 00' East, 1052.5 feet distant and Well RG-304 located in the NE¼NE¼SE¼ Section 34, Township 17 North, Range 9 East (projected into the Santa Fe Grant); the maximum rate of production of water from Well RG-304 under this License shall not exceed 1,000 gallons per minute; storage under this License shall not exceed 2979.04 acre feet in McClure (Granite Point) Reservoir and 660 acre feet in Nichols (Four Mile) Reservoir and the total combined storage in both reservoirs shall not exceed 3500 acre feet; this License is to be used as stated above and can be changed only as provided by law, and further provided that this License be not exercised to the detriment of any other person having prior and existing rights to the use of the waters within the Rio Grande Stream System.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal this 31st. day of December, 1969.

S. E. Reynolds
State Engineer

By: D. E. Gray
D. E. Gray
Chief
Water Rights Division

APPENDIX D

DECLARATION OF OWNERSHIP OF WATER RIGHT

PERFECTED PRIOR TO MARCH 19, 1907

(FORM TO BE EXECUTED IN DUPLICATE ACCOMPANIED BY FILING MAP.)

(A FEE OF $1.00 SHALL ACCOMPANY THIS FILING)

Date of receipt .... Declaration No. 01278

I/We Arthur Prager, President of and in behalf of Public Service Company of New Mexico, a New Mexico corporation, with principal office being in Albuquerque, N.M., P.O.Box 1360; and its Santa Fe Division being located at

a resident / residents of City of Santa Fe, County of Santa Fe

State of New Mexico, being first duly sworn, upon my oath ~~xxxxxxxxxxx~~

declare that ~~I am / We are~~ it is the (Sole or Partial) owner ~~xxxxx~~ of a right to make beneficial use of water from the Santa Fe River a tributary of Rio Grande through its distribution system, for power, irrigation, domestic, municipal and commercial purposes, under its franchise as a public utility, to supply the City of Santa Fe and its inhabitants, and make these several statements relative thereto:

1. The City of Santa Fe Municipal Water Supply System, owned now by Declarant, was initiated by construction of dam, reservoir and distribution lines about the year 1880, under franchise from Board of County Commissioners of the County of Santa Fe October 27th, 1880, to Declarant's predecessor in interest, to operate a public water utility for municipal and domestic needs of the City of Santa Fe and its inhabitants; and from said date of construction said waters have been progressively and increasingly applied to such beneficial uses, and said system of works enlarged and extended to meet the growing demands of said City, all as more fully set forth in the Declaration of Ownership filed in the Office of the State Engineer, November 20, 1950, and held (See office letter of May 2, 1951) as "supporting data" for this declaration.

2. The filing maps, particularly the map "Exhibit B" accompanying the Declara tion of Ownership held as "supporting data" fully covers point of diversion, location and hydraulic properties of storage works, distribution system etc. as of the present time, into which present construction and works all construction and works as of March 19, 1907, have merged; also shows maximum storage capacity of reservoirs as of present time. Does not show "irrigated lands and their respective ownerships," for reasons given under statement 3. For detail as of March 19, 1907, see (supporting data," paragraphs 1-6, and consumption table, p. 9.

It is impossible to furnish this data; it not being applicable. The word "irrigation," as used herein and in supporting data, refers only to lawns, shrubs, trees, gardens etc. as incidental to municipal and domestic use. Principal use was and is as municipal supply for the City of Santa Fe and its inhabitants, for the uses for which water is commonly used in cities, and under franchise as public utility originally granted by the Board of County Commissioners and renewed by City of Santa Fe. Water was and is supplied in pipes, underground, constituting distribution system, to connected users. These water rights have not become appurtenant to any lands, and there are no priority rights as among users.

RECEIVED
AUG 20 1951
STATE ENGINEER
BY

(OVER)

SUBDIVISION	SEC.	TWP.	RGE.	ACREAGE	OWNER	PRIORITY DATE

The quantity of water applied to beneficial use on the lands equals.....acre feet per irrigated acre. The irrigation season is from.....to .....of each year. Foregoing not applicable.

Water is used for ~~XXXXXX~~ domestic purposes.....
(Give Period of Use, If Any)

I ~~We~~ hereby declare that to the best of my ~~Our~~ knowledge and belief the above statements are true and correct and that water has been continuously, uninterruptedly, openly, notoriously and peaceably applied to beneficial uses on the above described lands from the date of the inception of the right to the present time. I ~~We~~ hereby give notice of the ownership of said water right as appurtenant to said lands by said Public Service Company of New Mexico, for utility purposes as aforesaid.

Declarant: [signature]

Title+ President of and in behalf of
Public Service Company of New Mexico,
Owner and Declarant.

Title+ .....

Title+ .....

Title+ .....

Title+ .....

*Owner, Commissioner, Co-Owner, Director, etc.

Subscribed and sworn to before me this 14th day of August 19 47.

[signature]
Notary Public
My Commission Expires September 3, 1951

APPENDIX E

RIO GRANDE COMPACT COMMISSION REPORT

RIO GRANDE COMPACT

The State of Colorado, the State of New Mexico, and the State of Texas, desiring to remove all causes of present and future controversy among these States and between citizens of one of these States and citizens of another State with respect to the use of the waters of the Rio Grande above Fort Quitman, Texas, and being moved by considerations of interstate comity, and for the purpose of effecting an equitable apportionment of such waters, have resolved to conclude a Compact for the attainment of these purposes, and to that end, through their respective Governors, have named as their respective Commissioners:

For the State of Colorado	M. C. Hinderlider
For the State of New Mexico	Thomas M. McClure
For the State of Texas	Frank B. Clayton

who, after negotiations participated in by S. O. Harper, appointed by the President as the representative of the United States of America, have agreed upon the following articles, to- wit:

ARTICLE I

(a) The State of Colorado, the State of New Mexico, the State of Texas, and the United States of America, are hereinafter designated "Colorado," "New Mexico," "Texas," and the "United States," respectively.

(b) "The Commission" means the agency created by this Compact for the administration thereof.

(c) The term "Rio Grande Basin" means all of the territory drained by the Rio Grande and its tributaries in Colorado, in New Mexico, and in Texas above Fort Quitman, including the Closed Basin in Colorado.

(d) The "Closed Basin" means that part of the Rio Grande Basin in Colorado where the streams drain into the San Luis Lakes and adjacent territory, and do not normally contribute to the flow of the Rio Grande.

(e) The term "tributary" means any stream which naturally contributes to the flow of the Rio Grande.

(f) "Transmountain Diversion" is water imported into the drainage basin of the Rio Grande from any stream system outside of the Rio Grande Basin, exclusive of the Closed Basin.

(g) "Annual Debits" are the amounts by which actual deliveries in any calendar year fall below scheduled deliveries.

(h) "Annual Credits" are the amounts by which actual deliveries in any calendar year exceed scheduled deliveries.

(i) "Accrued Debits" are the amounts by which the sum of all annual debits exceeds the sum of all annual credits over any common period of time.

(j) "Accrued Credits" are the amounts by which the sum of all annual credits exceeds the sum of all annual debits over any common period of time.

(k) "Project Storage" is the combined capacity of Elephant Butte Reservoir and all other reservoirs actually available for the storage of usable water below Elephant Butte and above the first diversion to lands of the Rio Grande Project, but not more than a total of 2,638,860 acre feet.

(l) "Usable Water" is all water, exclusive of credit water, which is in project storage and which is available for release in accordance with irrigation demands, including deliveries to Mexico.

(m) "Credit Water" is that amount of water in project storage which is equal to the accrued credit of Colorado, or New Mexico, or both.

(n) "Unfilled Capacity" is the difference between the total physical capacity of project storage and the amount of usable water then in storage.

(o) "Actual Release" is the amount of usable water released in any calendar year from the lowest reservoir comprising project storage.

(p) "Actual Spill" is all water which is actually spilled from Elephant Butte Reservoir, or is released therefrom for flood control, in excess of the current demand on project storage and which does not become usable water by storage in another reservoir; provided, that actual spill of usable water cannot occur until all credit water shall have been spilled.

(q)"Hypothetical Spill" is the time in any year at which usable water would have spilled from project storage if 790,000 acre feet had been released therefrom at rates proportional to the actual release in every year from the starting date to the end of the year in which hypothetical spill occurs; in computing hypothetical spill the initial condition shall be the amount of usable water in project storage at the beginning of the calendar year following the effective date of this Compact, and thereafter the initial condition shall be the amount of usable water in project storage at the beginning of the calendar year following each actual spill.

ARTICLE II

The Commission shall cause to be maintained and operated a stream gaging station equipped with an automatic water stage recorder at each of the following points, to-wit:

(a) On the Rio Grande near Del Norte above the principal points of diversion to the San Luis Valley;

(b) On the Conejos River near Mogote;

(c) On the Los Pinos River near Ortiz;

(d) On the San Antonio River at Ortiz;

(e) On the Conejos River at its mouths near Los Sauces;

(f) On the Rio Grande near Lobatos;

(g) On the Rio Chama below El Vado Reservoir;

(h) On the Rio Grande at Otowi Bridge near San Ildefonso;

(i) On the Rio Grande near San Acacia;

(j) On the Rio Grande at San Marcial;

(k) On the Rio Grande below Elephant Butte Reservoir;

(l) On the Rio Grande below Caballo Reservoir.

Similar gaging stations shall be maintained and operated below any other reservoir constructed after 1929, and at such other points as may be necessary for the securing of records required for the carrying out of the Compact; and automatic water stage recorders shall be maintained and operated on each of the reservoirs mentioned, and on all others constructed after 1929.

Such gaging stations shall be equipped, maintained and operated by the Commission directly or in cooperation with an appropriate Federal or State agency, and the equipment, method and frequency of measurement at such stations shall be such as to produce reliable records at all times. (Note: See Resolution of Commission printed elsewhere in this report.)

ARTICLE III

The obligation of Colorado to deliver water in the Rio Grande at the Colorado-New Mexico State Line, measured at or near Lobatos, in each calendar year, shall be ten thousand acre feet less than the sum of those quantities set forth in the two following tabulations of relationship, which correspond to the quantities at the upper index stations:

DISCHARGE OF CONEJOS RIVER

Quantities in thousands of acre feet

Conejos Index Supply (1)	Conejos River at Mouths (2)
100	0
150	20
200	45
250	75
300	109
350	147
400	188
450	232
500	278
550	326
600	376
650	426
700	476

Intermediate quantities shall be computed by proportional parts.

(1) Conejos Index Supply is the natural flow of Conejos River at the U.S.G.S. gaging station near Mogote during the calendar year, plus the natural flow of Los Pinos River at the U.S.G.S. gaging station near Ortiz and the natural flow of San Antonio River at the U.S.G.S. gaging station at Ortiz, both during the months of April to October, inclusive.

(2) Conejos River at Mouths is the combined discharge of branches of this river at the U.S.G.S. gaging stations near Los Sauces during the calendar year.

DISCHARGE OF RIO GRANDE EXCLUSIVE OF CONEJOS RIVER

Quantities in thousands of acre feet

Rio Grande at Del Norte (3)	Rio Grande at Lobatos less Conejos at Mouths (4)
200	60
250	65
300	75
350	86
400	98
450	112
500	127
550	144
600	162

RIO GRANDE COMPACT

DISCHARGE OF RIO GRANDE EXCLUSIVE OF CONEJOS RIVER--Con.
Quantities in thousands of acre feet

Rio Grande at Del Norte (3)	Rio Grande at Lobatos less Conejos at Mouths (4)
650	182
700	204
750	229
800	257
850	292
900	335
950	380
1,000	430
1,100	540
1,200	640
1,300	740
1,400	840

Intermediate quantities shall be computed by proportional parts.

(3) Rio Grande at Del Norte is the recorded flow of the Rio Grande at the U.S.G.S. gaging station near Del Norte during the calendar year (measured above all principal points of diversion to San Luis Valley) corrected for the operation of reservoirs constructed after 1937.

(4) Rio Grande at Lobatos less Conejos at Mouths is the total flow of the Rio Grande at the U.S.G.S. gaging station near Lobatos, less the discharge of Conejos River at its Mouths, during the calendar year.

The application of these schedules shall be subject to the provisions hereinafter set forth and appropriate adjustments shall be made for (a) any change in location of gaging stations; (b) any new or increased depletion of the runoff above inflow index gaging stations; and (c) any transmountain diversions into the drainage basin of the Rio Grande above Lobatos.

In event any works are constructed after 1937 for the purpose of delivering water into the Rio Grande from the Closed Basin, Colorado shall not be credited with the amount of such water delivered, unless the proportion of sodium ions shall be less than forty-five percent of the total positive ions in that water when the total dissolved solids in such water exceeds three hundred fifty parts per million.

ARTICLE IV

The obligation of New Mexico to deliver water in the Rio Grande at San Marcial, during each calendar year, exclusive of the months of July, August, and September, shall be that quantity set forth in the following tabulation of relationship, which corresponds to the quantity at the upper index station:

RIO GRANDE COMPACT COMMISSION REPORT

DISCHARGE OF RIO GRANDE AT OTOWI BRIDGE AND AT SAN MARCIAL
EXCLUSIVE OF JULY, AUGUST AND SEPTEMBER

Quantities in thousands of acre feet

Otowi Index Supply (5)	San Marcial Index Supply (6)
100	0
200	65
300	141
400	219
500	300
600	383
700	469
800	557
900	648
1,000	742
1,100	839
1,200	939
1,300	1,042
1,400	1,148
1,500	1,257
1,600	1,370
1,700	1,489
1,800	1,608
1,900	1,730
2,000	1,856
2,100	1,985
2,200	2,117
2,300	2,253

Intermediate quantities shall be computed by proportional parts.

(5) The Otowi Index Supply is the recorded flow of the Rio Grande at the U.S.G.S. gaging station at Otowi Bridge near San Ildefonso (formerly station near Buckman) during the calendar year, exclusive of the flow during the months of July, August and September, corrected for the operation of reservoirs constructed after 1929 in the drainage basin of the Rio Grande between Lobatos and Otowi Bridge.

(6) San Marcial Index Supply is the recorded flow of the Rio Grande at the gaging station at San Marcial during the calendar year exclusive of the flow during the months of July, August and September.

The application of this schedule shall be subject to the provisions hereinafter set forth and appropriate adjustments shall be made for (a) any change in location of gaging stations; (b) depletion after 1929 in New Mexico at any time of the year of the natural runoff at Otowi Bridge; (c) depletion of the runoff during July, August and September of tributaries between Otowi Bridge and San Marcial, by works constructed after 1937; and (d) any transmountain diversions into the Rio Grande between Lobatos and San Marcial.

Concurrent records shall be kept of the flow of the Rio Grande at San Marcial, near San Acacia, and of the release from Elephant Butte Reservoir to the end that the records at these three stations may be correlated. (Note: See Resolution of Commission printed elsewhere in this report.)

RIO GRANDE COMPACT

ARTICLE V

If at any time it should be the unanimous finding and determination of the Commission that because of changed physical conditions, or for any other reason, reliable records are not obtainable, or cannot be obtained, at any of the stream gaging stations herein referred to, such stations may, with the unanimous approval of the Commission, be abandoned, and with such approval another station, or other stations, shall be established and new measurements shall be substituted which, in the unanimous opinion of the Commission, will result in substantially the same results so far as the rights and obligations to deliver water are concerned, as would have existed if such substitution of stations and measurements had not been so made. (Note: See Resolution of Commission printed elsewhere in this report.)

ARTICLE VI

Commencing with the year following the effective date of this Compact, all credits and debits of Colorado and New Mexico shall be computed for each calendar year; provided, that in a year of actual spill no annual credits nor annual debits shall be computed for that year.

In the case of Colorado, no annual debit nor accrued debit shall exceed 100,000 acre feet, except as either or both may be caused by holdover storage of water in reservoirs constructed after 1937 in the drainage basin of the Rio Grande above Lobatos. Within the physical limitations of storage capacity in such reservoirs, Colorado shall retain water in storage at all times to the extent of its accrued debit.

In the case of New Mexico, the accrued debit shall not exceed 200,000 acre feet at any time, except as such debit may be caused by holdover storage of water in reservoirs constructed after 1929 in the drainage basin of the Rio Grande between Lobatos and San Marcial. Within the physical limitations of storage capacity in such reservoirs, New Mexico shall retain water in storage at all times to the extent of its accrued debit. In computing the magnitude of accrued credits or debits, New Mexico shall not be charged with any greater debit in any one year than the sum of 150,000 acre-feet and all gains in the quantity of water in storage in such year.

The Commission by unanimous action may authorize the release from storage of any amount of water which is then being held in storage by reason of accrued debits of Colorado or New Mexico; provided, that such water shall be replaced at the first opportunity thereafter.

In computing the amount of accrued credits and accrued debits of Colorado or New Mexico, any annual credits in excess of 150,000 acre feet shall be taken as equal to that amount.

In any year in which actual spill occurs, the accrued credits of Colorado, or New Mexico, or both, at the beginning of the year shall be reduced in proportion to their respective credits by the amount of such actual spill; provided that the amount of actual spill shall be deemed to be increased by the aggregate gain in the amount of water in storage, prior to the time of spill, in reservoirs above San Marcial constructed after 1929; provided, further, that if the Commissioners for the States having accrued credits authorize the release of part, or all, of such credits in advance of spill, the amount so released shall be deemed to constitute actual spill.

In any year in which there is actual spill of usable water, or at the time of hypothetical spill thereof, all accrued debits of Colorado, or New Mexico, or both, at the beginning of the year shall be cancelled.

In any year in which the aggregate of accrued debits of Colorado and New Mexico exceeds the minimum unfilled capacity of project storage, such debits shall be reduced proportionally to an aggregate amount equal to such minimum unfilled capacity.

To the extent that accrued credits are impounded in reservoirs between San Marcial and Courchesne, and to the extent that accrued debits are impounded in reservoirs above San Marcial, such credits and debits shall be reduced annually to compensate for evaporation losses in the proportion that such credits or debits bore to the total amount of water in such reservoirs during the year.

ARTICLE VII

Neither Colorado nor New Mexico shall increase the amount of water in storage in reservoirs constructed after 1929 whenever there is less than 400,000 acre feet of usable water in project storage; provided, that if the actual releases of usable water from the beginning of the calendar year following the effective date of this Compact, or from the beginning of the calendar year following actual spill, have aggregated more than an average of 790,000 acre feet per annum, the time at which such minimum stage is reached shall be adjusted to compensate for the difference between the total actual release and releases at such average rate; provided, further, that Colorado, or New Mexico, or both, may relinquish accrued credits at any time, and Texas may accept such relinquished water, and in such event the state, or states, so relinquishing shall be entitled to store water in the amount of the water so relinquished.

ARTICLE VIII

During the month of January of any year the Commissioner for Texas may demand of Colorado and New Mexico, and the Commissioner for New Mexico may demand of Colorado, the release of water from storage reservoirs constructed after 1929 to the amount of the accrued debits of Colorado and New Mexico, respectively, and such releases shall be made by each at the greatest rate practicable under the conditions then prevailing, and in proportion to the total debit of each, and in amounts, limited by their accrued debits, sufficient to bring the quantity of usable water in project storage to 600,000 acre feet by March first and to maintain this quantity in storage until April thirtieth, to the end that a normal release of 790,000 acre feet may be made from project storage in that year.

ARTICLE IX

Colorado agrees with New Mexico that in event the United States or the State of New Mexico decides to construct the necessary works for diverting the waters of the San Juan River, or any of its tributaries, into the Rio Grande, Colorado hereby consents to the construction of said works and the diversion of waters from the San Juan River, or the tributaries thereof, into the Rio Grande in New Mexico, provided the present and prospective uses of water in Colorado by other diversions from the San Juan River, or its tributaries, are protected.

ARTICLE X

In the event water from another drainage basin shall be imported into the Rio Grande Basin by the United States or Colorado or New Mexico, or any of them jointly, the State having the right to the use of such water shall be given proper credit therefor in the application of the schedules.

ARTICLE XI

New Mexico and Texas agree that upon the effective date of this Compact all controversies between said States relative to the quantity or quality of the water of the Rio Grande are composed and settled; however, nothing herein shall be interpreted to prevent

recourse by a signatory state to the Supreme Court of the United States for redress should the character or quality of the water, at the point of delivery, be changed hereafter by one signatory state to the injury of another. Nothing herein shall be construed as an admission by any signatory state that the use of water for irrigation causes increase of salinity for which the user is responsible in law.

ARTICLE XII

To administer the provisions of this Compact there shall be constituted a Commission composed of one representative from each state, to be known as the Rio Grande Compact Commission. The State Engineer of Colorado shall be ex-officio the Rio Grande Compact Commissioner for Colorado. The State Engineer of New Mexico shall be ex-officio the Rio Grande Compact Commissioner for New Mexico. The Rio Grande Compact Commissioner for Texas shall be appointed by the Governor of Texas. The President of the United States shall be requested to designate a representative of the United States to sit with such Commission, and such representative of the United States, if so designated by the President, shall act as Chairman of the Commission without vote.

The salaries and personal expenses of the Rio Grande Compact Commissioners for the three States shall be paid by their respective States, and all other expenses incident to the administration of this Compact, not borne by the United States, shall be borne equally by the three States.

In addition to the powers and duties hereinbefore specifically conferred upon such Commission, and the members thereof, the jurisdiction of such Commission shall extend only to the collection, correlation and presentation of factual data and the maintenance of records having a bearing upon the administration of this Compact, and, by unanimous action, to the making of recommendations to the respective States upon matters connected with the administration of this Compact. In connection therewith, the Commission may employ such engineering and clerical aid as may be reasonably necessary within the limit of funds provided for that purpose by the respective States. Annual reports compiled for each calendar year shall be made by the Commission and transmitted to the Governors of the signatory States on or before March first following the year covered by the report. The Commission may, by unanimous action, adopt rules and regulations consistent with the provisions of this Compact to govern their proceedings.

The findings of the Commission shall not be conclusive in any court or tribunal which may be called upon to interpret or enforce this Compact.

ARTICLE XIII

At the expiration of every five-year period after the effective date of this Compact, the Commission may, by unanimous consent, review any provisions hereof which are not substantive in character and which do not affect the basic principles upon which the Compact is founded, and shall meet for the consideration of such questions on the request of any member of the Commission; provided, however, that the provisions hereof shall remain in full force and effect until changed and amended within the intent of the Compact by unanimous action of the Commissioners, and until any changes in this Compact are ratified by the legislatures of the respective states and consented to by the Congress, in the same manner as this Compact is required to be ratified to become effective.

ARTICLE XIV

The schedules herein contained and the quantities of water herein allocated shall never be increased nor diminished by reason of any increase or diminution in the delivery or loss of water to Mexico.

ARTICLE XV

The physical and other conditions characteristic of the Rio Grande and peculiar to the territory drained and served thereby, and to the development thereof, have actuated this Compact and none of the signatory states admits that any provisions herein contained establishes any general principle or precedent applicable to other interstate streams.

ARTICLE XVI

Nothing in this Compact shall be construed as affecting the obligations of the United States of America to Mexico under existing treaties, or to the Indian Tribes, or as impairing the rights of the Indian Tribes.

ARTICLE XVII

This Compact shall become effective when ratified by the legislatures of each of the signatory states and consented to by the Congress of the United States. Notice of ratification shall be given by the Governor of each state to the Governors of the other states and to the President of the United States, and the President of the United States is requested to give notice to the Governors of each of the signatory states of the consent of the Congress of the United States.

IN WITNESS WHEREOF, the Commissioners have signed this Compact in quadruplicate original, one of which shall be deposited in the archives of the Department of State of the United States of America and shall be deemed the authoritative original, and of which a duly certified copy shall be forwarded to the Governor of each of the signatory States.

Done at the City of Santa Fe, in the State of New Mexico, on the 18th day of March, in the year of our Lord, One Thousand Nine Hundred and Thirty-eight.

(Sgd.) M. C. HINDERLIDER

(Sgd.) THOMAS M. McCLURE

(Sgd.) FRANK B. CLAYTON

APPROVED:

(Sgd.) S. O. HARPER

RATIFIED BY:

Colorado, February 21, 1939
New Mexico, March 1, 1939
Texas, March 1, 1939

Passed Congress as Public Act No. 96, 76th Congress,

Approved by the President May 31, 1939

RESOLUTION ADOPTED BY RIO GRANDE COMPACT COMMISSION
AT THE ANNUAL MEETING HELD AT EL PASO, TEXAS, FEBRUARY 22-24, 1948, CHANGING
GAGING STATIONS AND MEASUREMENTS OF
DELIVERIES BY NEW MEXICO

RESOLUTION

Whereas, at the Annual Meeting of the Rio Grande Compact Commission in the year 1945, the question was raised as to whether or not a schedule for delivery of water by New Mexico during the entire year could be worked out, and

Whereas, at said meeting the question was referred to the Engineering Advisers for their study, recommendations and report, and

Whereas, said Engineering Advisers have met, studied the problems and under date of February 24, 1947, did submit their Report, which said Report contains the findings of said Engineering Advisers and their recommendations, and

Whereas, the Compact Commission has examined said Report and finds that the matters and things therein found and recommended are proper and within the terms of the Rio Grande Compact, and

Whereas, the Commission has considered said Engineering Advisers' Report and all available evidence, information and material and is fully advised:

Now, Therefore, Be it Resolved:

The Commission finds as follows:

(a) That because of change of physical conditions, reliable records of the amount of water passing San Marcial are no longer obtainable at the stream gaging station at San Marcial and that the same should be abandoned for Compact purposes.

(b) That the need for concurrent records at San Marcial and San Acacia no longer exists and that the gaging station at San Acacia should be abandoned for Compact purposes.

(c) That it is desirable and necessary that the obligations of New Mexico under the Compact to deliver water in the months of July, August, September, should be scheduled.

(d) That the change in gaging stations and substitution of the new measurements as hereinafter set forth will result in substantially the same results so far as the rights and obligations to deliver water are concerned, and would have existed if such substitution of stations and measurements had not been so made.

Be it Further Resolved:

That the following measurements and schedule thereof shall be substituted for the measurements and schedule thereof as now set forth in Article IV of the Compact:

"The obligation of New Mexico to deliver water in the Rio Grande into Elephant Butte Reservoir during each calendar year shall be measured by that quantity set forth in the following tabulation of relationship which corresponds to the quantity at the upper index station:

RIO GRANDE COMPACT COMMISSION REPORT

DISCHARGE OF RIO GRANDE AT OTOWI BRIDGE AND ELEPHANT BUTTE EFFECTIVE SUPPLY

Quantities in thousands of acre-feet

Otowi Index Supply (5)	Elephant Butte Effective Index Supply (6)
100	57
200	114
300	171
400	228
500	286
600	345
700	406
800	471
900	542
1,000	621
1,100	707
1,200	800
1,300	897
1,400	996
1,500	1,095
1,600	1,195
1,700	1,295
1,800	1,395
1,900	1,495
2,000	1,595
2,100	1,695
2,200	1,795
2,300	1,895
2,400	1,995
2,500	2,095
2,600	2,195
2,700	2,295
2,800	2,395
2,900	2,495
3,000	2,595

Intermediate quantities shall be computed by proportional parts.

(5) The Otowi Index Supply is the recorded flow of the Rio Grande at the U.S.G.S. gaging station at Otowi Bridge near San ildefonso (formerly station near Buckman) during the calendar year, corrected for the operation of reservoirs constructed after 1929 in the drainage basin of the Rio Grande between Lobatos and Otowi Bridge.

(6) Elephant Butte Effective Index Supply is the recorded flow of the Rio Grande at the gaging station below Elephant Butte Dam during the calendar year plus the net gain in storage in Elephant Butte Reservoir during the same year or minus the net loss in storage in said reservoir, as the case may be.

The application of this schedule shall be subject to the provisions hereinafter set forth and appropriate adjustments shall be made for (a) any change in location of gaging stations; (b) depletion after 1929 in New Mexico of the natural runoff at Otowi Bridge; and (c) any transmountain diversions into the Rio Grande between Lobatos and Elephant Butte Reservoir."

Be it Further Resolved:

That the gaging stations at San Acacia and San Marcial be, and the same are hereby abandoned for Compact purposes.

Be it Further Resolved:

That this Resolution has been passed unanimously and shall be effective January 1, 1949, if within 120 days from this date the Commissioner for each State shall have received from the Attorney General of the State represented by him, an opinion approving this Resolution, and shall have so advised the Chairman of the Commission, otherwise, to be of no force and effect.

(Note: The following paragraph appears in the Minutes of the Annual Meeting of the Commission held at Denver, Colorado, February 14-16, 1949.

"The Chairman announced that he had received, pursuant to the Resolution adopted by the Commission at the Ninth Annual Meeting on February 24, 1948, opinions from the Attorneys General of Colorado, New Mexico and Texas that the substitution of stations and measurements of deliveries by New Mexico set forth in said resolution was within the powers of the Commission").

RIO GRANDE COMPACT COMMISSION REPORT

RULES AND REGULATIONS FOR ADMINISTRATION OF THE RIO GRANDE COMPACT

A Compact, known as the Rio Grande Compact, between the States of Colorado, New Mexico and Texas, having become effective on May 31, 1939 by consent of the Congress of the United States, which equitably apportions the waters of the Rio Grande above Fort Quitman and permits each State to develop its water resources at will, subject only to its obligations to deliver water in accordance with the schedules set forth in the Compact, the following Rules and Regulations have been adopted for its administration by the Rio Grande Compact Commission; to be and remain in force and effect only so long as the same may be satisfactory to each and all members of the Commission, and provided always that on the objection of any member of the Commission, in writing, to the remaining two members of the Commission after a period of sixty days from the date of such objection, the sentence, paragraph or any portion or all of these rules to which any such objection shall be made, shall stand abrogated and shall thereafter have no further force and effect; it being the intent and purpose of the Commission to permit these rules to obtain and be effective only so long as the same may be satisfactory to each and all of the Commissioners.

GAGING STATIONS /1

Responsibility for the equipping, maintenance and operation of the stream gaging stations and reservoir gaging stations required by the provisions of Article II of the Compact shall be divided among the signatory States as follows:

(a) Gaging stations on streams and reservoirs in the Rio Grande Basin above the Colorado-New Mexico boundary shall be equipped, maintained, and operated by Colorado in cooperation with the U.S. Geological Survey.

(b) Gaging stations on streams and reservoirs in the Rio Grande Basin below Lobatos and above Caballo Reservoir shall be equipped, maintained and operated by New Mexico in cooperation with the U.S. Geological Survey to the extent that such stations are not maintained and operated by some other Federal agency.

(c) Gaging stations on Elephant Butte Reservoir and on Caballo Reservoir, and the stream gaging stations on the Rio Grande below those reservoirs shall be equipped, maintained and operated by or on behalf of Texas through the agency of the U.S. Bureau of Reclamation.

The equipment, method and frequency of measurements at each gaging station shall be sufficient to obtain records at least equal in accuracy to those classified as "good" by the U.S. Geological Survey. Water-stage recorders on the reservoirs specifically named in Article II of the Compact shall have sufficient range below maximum reservoir level to record major fluctuations in storage. Staff gages may be used to determine fluctuations below the range of the water-stage recorders on these and other large reservoirs, and staff gages may be used upon approval of the Commission in lieu of water-stage recorders on small reservoirs, provided that the frequency of observation is sufficient in each case to establish any material changes in water levels in such reservoirs.

/1 Amended at Eleventh Annual Meeting, February 23, 1950.

RULES AND REGULATIONS

RESERVOIR CAPACITIES /1

Colorado shall file with the Commission a table of areas and capacities for each reservoir in the Rio Grande Basin above Lobatos constructed after 1937; New Mexico shall file with the Commission a table of areas and capacities for each reservoir in the Rio Grande Basin between Lobatos and San Marcial constructed after 1929; and Texas shall file with the Commission tables of areas and capacities for Elephant Butte Reservoir and for all other reservoirs actually available for the storage of water between Elephant Butte and the first diversion to lands under the Rio Grande Project.

Whenever it shall appear that any table of areas and capacities is in error by more than five per cent, the Commission shall use its best efforts to have a re-survey made and a corrected table of areas and capacities to be substituted as soon as practicable. To the end that the Elephant Butte effective supply may be computed accurately, the Commission shall use its best efforts to have the rate of accumulation and the place of deposition of silt in Elephant Butte Reservoir checked at least every three years.

ACTUAL SPILL /2, /3, /4

(a) Water released from Elephant Butte in excess of Project requirements, which is currently passed through Caballo Reservoir, prior to the time of spill, shall be deemed to have been Usable Water released in anticipation of spill, or Credit Water if such release shall have been authorized.

(b) Excess releases from Elephant Butte Reservoir, as defined in (a) above, shall be added to the quantity of water actually in storage in that reservoir, and Actual Spill shall be deemed to have commenced when this sum equals the total capacity of that reservoir to the level of the uncontrolled spillway less capacity reserved for flood purposes, i.e., 1,998,400 acre-feet in the months of October through March inclusive, and 1,973,400 acre- feet in the months of April through September, inclusive, as determined from the 1999 area- capacity table or successor area-capacity tables and flood control storage reservation of 50,000 acre-feet from April through September and 25,000 acre-feet from October through March.

(c) All water actually spilled at Elephant Butte Reservoir, or released therefrom, in excess of Project requirements, which is currently passed through Caballo Reservoir, after the time of spill, shall be considered as Actual Spill, provided that the total quantity of water then in storage in Elephant Butte Reservoir exceeds the physical capacity of that reservoir at the level of the sill of the spillway gates, i.e. -1,830,000 acre-ft in 1942.

(d) Water released from Caballo Reservoir in excess of Project requirements and in excess of water currently released from Elephant Butte Reservoir, shall be deemed Usable Water released, excepting only flood water entering Caballo Reservoir from tributaries below Elephant Butte Reservoir.

DEPARTURES FROM NORMAL RELEASES /5

For the purpose of computing the time of Hypothetical Spill required by Article VI and for the purpose of the adjustment set forth in Article VII, no allowance shall be made for the difference between Actual and Hypothetical Evaporation, and any under-release of usable water from Project Storage in excess of 150,000 acre-ft in any year shall be taken as equal to that amount.

/1 Amended at Eleventh Annual Meeting, February 23, 1950.
/2 Adopted at Fourth Annual Meeting, February 24, 1943.
/3 Amended September 9, 1998.
/4 Amended March 22, 2001; made effective January 1, 2001.
/5 Adopted June 2, 1959; made effective January 1, 1952.

EVAPORATION LOSSES /6, /7, /8

The Commission shall encourage the equipping, maintenance and operation, in cooperation with the U.S. Weather Bureau or other appropriate agency, of evaporation stations at Elephant Butte Reservoir and at or near each major reservoir in the Rio Grande Basin within Colorado constructed after 1937 and in New Mexico constructed after 1929. The net loss by evaporation from a reservoir surface shall be taken as the difference between the actual evaporation loss and the evapo-transpiration losses which would have occurred naturally, prior to the construction of such reservoir. Changes in evapo-transpiration losses along stream channels below reservoirs may be disregarded.

Net losses by evaporation, as defined above, shall be used in correcting Index Supplies for the operation of reservoirs upstream from Index Gaging Stations as required by the provisions of Article III and Article IV of the Compact.

In the application of the provisions of the last unnumbered paragraph of Article VI of the Compact:

(a) Evaporation losses for which accrued credits shall be reduced shall be taken as the difference between the gross evaporation from the water surface of Elephant Butte Reservoir and rainfall on the same surface.

(b) Evaporation losses for which accrued debits shall be reduced shall be taken as the net loss by evaporation as defined in the first paragraph.

ADJUSTMENT OF RECORDS

The Commission shall keep a record of the location, and description of each gaging station and evaporation station, and, in the event of change in location of any stream gaging station for any reason, it shall ascertain the increment in flow or decrease in flow between such locations for all stages. Wherever practicable, concurrent records shall be obtained for one year before abandonment of the previous station.

NEW OR INCREASED DEPLETIONS

In the event any works are constructed which alter or may be expected to alter the flow at any of the Index Gaging Stations mentioned in the Compact, or which may otherwise necessitate adjustments in the application of the schedules set forth in the Compact, it shall be the duty of the Commissioner specifically concerned to file with the Commission all available information pertaining thereto, and appropriate adjustments shall be made in accordance with the terms of the Compact; provided, however, that any such adjustments shall in no way increase the burden imposed upon Colorado or New Mexico under the schedules of deliveries established by the Compact.

TRANSMOUNTAIN DIVERSIONS

In the event any works are constructed for the delivery of waters into the drainage basin of the Rio Grande from any stream system outside of the Rio Grande Basin, such waters shall be measured at the point of delivery into the Rio Grande Basin and proper allowances shall be made for losses in transit from such points to the Index Gaging Station on the stream with which the imported waters are comingled.

/6 Amended at Tenth Annual Meeting, February 15, 1949.

/7 Amended at Twelfth Annual Meeting, February 24, 1951.

/8 Amended June 2, 1959.

RULES AND REGULATIONS

QUALITY OF WATER

In the event that delivery of water is made from the Closed Basin into the Rio Grande, sufficient samples of such water shall be analyzed to ascertain whether the quality thereof is within the limits established by the Compact.

SECRETARY /8

The Commission, subject to the approval of the Director, U.S. Geological Survey, to a cooperative agreement for such purposes, shall employ the U.S. Geological Survey on a yearly basis, to render such engineering and clerical aid as may reasonably be necessary for administration of the Compact. Said agreement shall provide that the Geological Survey shall:

(1) Collect and correlate all factual data and other records having a material bearing on the administration of the Compact and keep each Commissioner adviser thereof.

(2) Inspect all gaging stations required for administration of the Compact and make recommendations to the Commission as to any changes or improvements in methods of measurement or facilities for measurement which may be needed to insure that reliable records be obtained.

(3) Report to each Commissioner by letter on or before the fifteenth day of each month, except January, a summary of all hydrographic data then available for the current year - on forms prescribed by the Commission - pertaining to:

(a) Deliveries by Colorado
(b) Deliveries by New Mexico
(c) Operation of Project Storage

(4) Make such investigations as may be requested by the Commission in aid of its administration of the Compact.

(5) Act as Secretary to the Commission and submit to the Commission at its regular meeting in February a report on its activities and a summary of all data needed for determination of debits and credits and other matters pertaining to administration of the Compact.

COSTS /1

In February of each year, the Commission shall adopt a budget for the ensuing fiscal year beginning July first.

Such budget shall set forth the total cost of maintenance and operating of gaging stations, of evaporation stations, the cost of engineering and clerical aid, and all other necessary expenses excepting the salaries and personal expenses of the Rio Grande Compact Commissioners.

Contributions made directly by the United States and the cost of services rendered by the United States without cost shall be deducted from the total budget amount; the remainder shall then be allocated equally to Colorado, New Mexico and Texas.

/8 The substitution of this section for the section titled "Reports to Commissioners" was adopted at Ninth Annual Meeting, February 22, 1948.

/1 Amended at Eleventh Annual Meeting, February 23, 1950.

Expenditures made directly by any State for purposes set forth in the budget shall be credited to that State; contributions in cash or in services by any State under a cooperative agreement with any federal agency shall be credited to such State, but the amount of the federal contribution shall not so be credited; in event any State, through contractual relationships, causes work to be done in the interest of the Commission, such State shall be credited with the cost thereof, unless such cost is borne by the United States.

Costs incurred by the Commission under any cooperative agreement between the Commission and any U.S. Government Agency, not borne by the United States, shall be apportioned equally to each State, and each Commissioner shall arrange for the prompt payment of one-third thereof by his State.

The Commissioner of each State shall report at the annual meeting each year the amount of money expended during the year by the State which he represents, as well as the portion thereof contributed by all cooperating federal agencies, and the Commission shall arrange for such proper reimbursement in cash or credits between States as may be necessary to equalize the contributions made by each State in the equipment, maintenance and operation of all gaging stations authorized by the Commission and established under the terms of the Compact.

It shall be the duty of each Commissioner to endeavor to secure from the Legislature of his State an appropriation of sufficient funds with which to meet the obligations of his State, as provided by the Compact.

MEETING OF COMMISSION /1, /10

The Commission shall meet in Santa Fe, New Mexico, on the third Thursday of February of each year for the consideration and adoption of the annual report for the calendar year preceding, and for the transaction of any other business consistent with its authority; provided that the Commission may agree to meet elsewhere. Other meetings as may be deemed necessary shall be held at any time and place set by mutual agreement, for the consideration of data collected and for the transaction of any business consistent with its authority.

No action of the Commission shall be effective until approved by the Commissioner from each of the three signatory States.

(Signed) M. C. HINDERLIDER

M. C. Hinderlider

Commissioner for Colorado

(Signed) THOMAS M. McCLURE

Thomas M. McClure

Commissioner for New Mexico

(Signed) JULIAN P. HARRISON

Julian P. Harrison

Commissioner for Texas

Adopted December 19, 1939.

/1 Amended at Eleventh Annual Meeting, February 23, 1950.

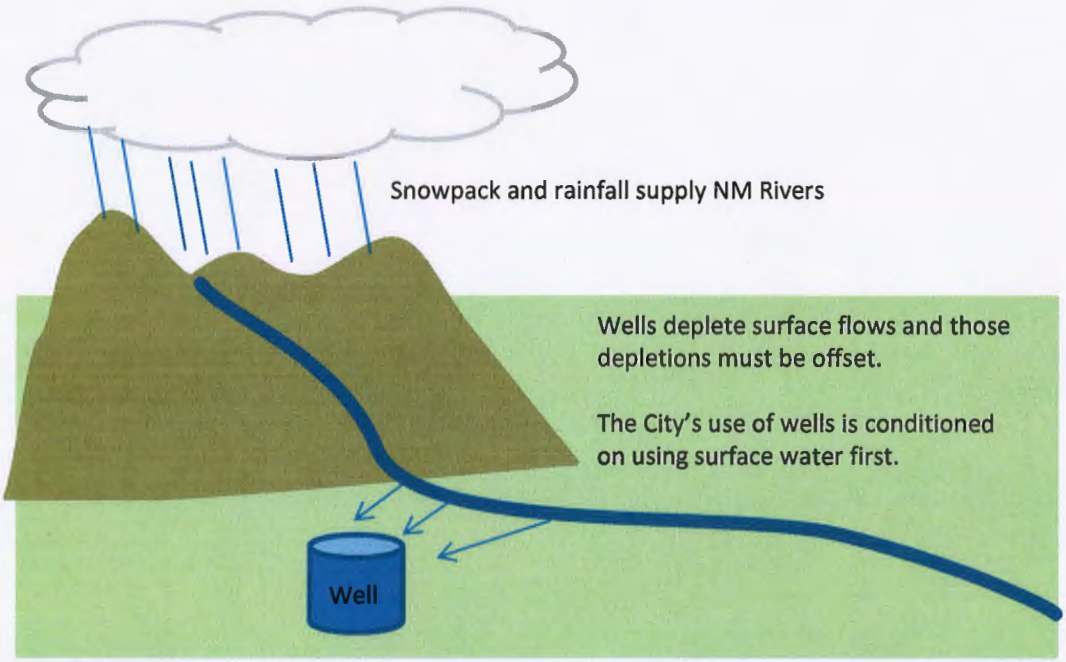
/10 Amended at Thirteenth Annual Meeting, February 25, 1952.

APPENDIX F

Groundwater Use Limitations & Offsets

To understand what an offset is in water law, one must first recognize that surface and groundwater are hydrologically connected. What that means is that surface water can feed and slowly recharge groundwater, while pumping groundwater can and will deplete surface water.

When the City pumps groundwater from the Buckman Wells (RG-20516 et al), the City must run a computer simulation modelling the pumping effects on surface water streams. These effects are quantified in acre-feet/year and must be "offset" by retiring a like amount of surface water. Practically, the City must acquire surface water from the Rio Grande, La Cienega, Nambe, Pojoaque, and Tesuque stream systems and "retire" those surface water rights to equal or exceed the effects of groundwater pumping. "Retiring" surface water rights means that the surface water may no longer diverted (normally for irrigation purposes) but allowed to simply flow and augment the stream to counter-balance the quantity of groundwater that the City pumps over time.



This offset obligation is the reason why the City requires developers to purchase and transfer water rights to the City's Buckman well-field permit. Developers, and the City, are actually purchasing offsets and dedicating them to the Buckman well-field permit.

The legal requirement for offsets was established in New Mexico in 1962 out of case that went to the New Mexico Supreme Court, *City of Albuquerque v. Reynolds*, 1962-NMSC-173. After noting that the surface waters of the state were fully appropriated, the Court upheld the State Engineer's authority to condition the use of groundwater by requiring that

"surface water would be retired to the extent necessary to offset the effects of the [groundwater] appropriation on the Rio Grande."

> Under proper application the appropriator may take advantage of ground water that can be removed from storage without impairment of existing rights, and can take advantage of an accounting of the return flow from his appropriation. The permits applied for could be granted without danger of any impairment of existing surface water rights under the following conditions: 1) That the amount of water pumped be measured. 2) That the amount of return flow be measured. 3) That existing rights to the consumptive use of surface water would be retired to the extent necessary to offset the effects of the appropriation on the Rio Grande.

City of Albuquerque v. Reynolds, 1962-NMSC-173, ¶ 21.

One difference between the City of Albuquerque's case and the City of Santa Fe's is that Santa Fe must offset stream depletions on more than just the Rio Grande (these include the lower Santa Fe River/La Cienega reach, the Nambe, Pojoaque, and Tesuque stream systems). These tributary offsets are exceedingly difficult to find.

Moreover, the City's permits for using wells also require that the City use surface water first. For example, the temporary NW Well permit, has the following condition:

> The continuing exercise of Permit No. RG-68302 into RG 1113 thru RG-1118 shall be contingent upon the timely filing of periodic report acceptable to the State Engineer showing that Applicant is diligently pursuing development of other renewable supplies of water. Applicant shall file such reports with the State Engineer, specifically addressing its progress toward completion of a direct diversion of San Juan-Chama project water from the Rio Grande, or demonstrating development of other alternatives acceptable to the State Engineer, by the 10th day of January 2004, 2007, and 2010.

Similarly, the Buckman Well permit has the following condition:

> The continuing exercise of this Permit, No. RG-20516-S10 through RG 201516-S-13, shall be contingent upon the filing of two reports by the Permittee, on or before the 10th day of January 2007 and 2010, that are acceptable to the State Engineer and that confirm that the Permittee is diligently pursuing development of other renewable supplied of water including progress toward completion of a direct diversion of San Juan-Chama project water from the Rio Grande or demonstrating development of other alternative supplies of water.

The permanent NW Well permit drafts have even stronger language prioritizing surface water as a municipal supply over groundwater. This means that the first water that the City uses should be surface water as a municipal supply. Our use of groundwater permits is

conditioned on using surface water, so that if we do not use surface water, the City's ability to use groundwater to supplement the surface water is jeopardized.

Although the City and County have completed building the Buckman Direct Diversion Project, by itself, the Project does not supply the total needs of the City, roughly 10,000 acre-feet/year in demand. However, combined with the Santa Fe River, the City can theoretically meet its full supply through renewable surface water sources.

Notwithstanding these permit limitations, the Living River Ordinance requires that the City release up to 1,000 acre-feet per year. This means that the Living River Ordinance City may require the City to violate the conditions for using groundwater wells, in which case the City will have insufficient water to meet demand.

APPENDIX G

ANNUAL WATER REPORT

2015

City of Santa Fe • Water Division

CITY OF SANTA FE, NEW MEXICO

Javier M. Gonzales, Mayor
Brian Snyder, City Manager

City Councilors

Peter N. Ives, Mayor Pro Tem, District 2
Renee Villarreal, District 1
Signe I. Lindell, District 1
Joseph M. Maestas, District 2
Carmichael A Dominguez, District 3
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Utility Billing & Customer Service Division
Wastewater Division
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For more information visit www.santafenm.gov/water_division

Cover Photo: Nichols Reservoir in the Upper Santa Fe Municipal Watershed

TABLE OF CONTENTS

Executive summary 1

Water Supply 2

- Water Rights 3
- Surface Water 3
- Ground Water 3
- Water Rights Used for "Offsets" 3
- Relinquishment Credits 4
- Water Production 4
- Production by Supply Source 4
- Treated Effluent Deliveries 4
- Drought and Precipitation 5

Water Demand 7

- Per Capita Consumption 7
- Contractual and Other Water Demands 7
- Santa Fe River 7
- Wholesale Water Deliveries 8
- Water Bank 8

Water Resources Planning 9

- Fiscal Responsibility 9
- 2016 Water Demand and Supply Picture 9

LIST OF FIGURES & TABLES

Water Supply Sources Map, Figure 1 2

Construction on new intake structure at McClure Reservoir, Figure 2 3

Diversion Water Rights and Supply Portfolio, Table 1 3

2015 Projected vs Actual Monthly Production by Supply Source, Figure 3 4

City of Santa Fe Wastewater Treatment Plant, Figure 4 4

City's Treated Effluent Contractors, Figure 5 5

Drought Comparisons for July 1, 2014 and December 30, 2014, Figure 6 5

2015 SNOTEL Data for Santa Fe Watershed, Table 2 6

Upper Santa Fe Municipal Watershed, Figure 7 6

2015 Demand by Sector, Figure 8 7

GPCD with Population, Figure 9 7

Santa Fe River Target Flow Hydrograph, Figure 10 8

2016 Projected Monthly Production by Supply Source, Figure 11 9

EXECUTIVE SUMMARY

The purpose of this report is to provide information about the state of the City of Santa Fe's Water Division and the water supplies we depend upon.

This report is submitted pursuant to City Code Section 25-9.6 SFCC 1987 and summarizes information about the City of Santa Fe's Water Division including water supply, water rights, water demand, types of water use, drought and precipitation, and water utility management information.

The City's surface water supply comes from the **Santa Fe River** and **Rio Grande**, both of which are treated through conventional and advanced treatment processes.

The **City Well Field** is mostly located in close proximity to the Santa Fe River and consists of 7 active wells located within the City limits of Santa Fe. The **Buckman Well Field** consists of 13 wells located near the Rio Grande, approximately 15 miles northwest of Santa Fe.

This report contains water data through December 2015 and anticicipated 2016 data projections.

The Water Division supplied 8,062 acre-feet of water to its water utility customers and an additional 105 acre-feet to the Santa Fe County Water Utility, for a total production of 8,167 acre-feet for 2015. Also, the Water Division met its acequia irrigation deliveries and provided over 2,000 acre-feet of "Living River" flows to the Santa Fe River.

The City of Santa Fe continued its water conservation efforts which, in part, contributed to a service-area gallons per capita per day (GPCD) demand of 90.

The overall goal of the Water Division is to ensure that our water resources are managed and protected in an efficient and responsible manner to provide the Santa Fe community with clean, reliable and safe drinking water.

WATER SUPPLY SOURCES

The City of Santa Fe has four sources of water supply (see Figure 1):

- Santa Fe River
- San Juan-Chama surface water via the Rio Grande
- City well field
- Buckman well field

Also, the Water Division utilizes reclaimed wastewater and water conservation to reduce demand on the total supply of potable water.

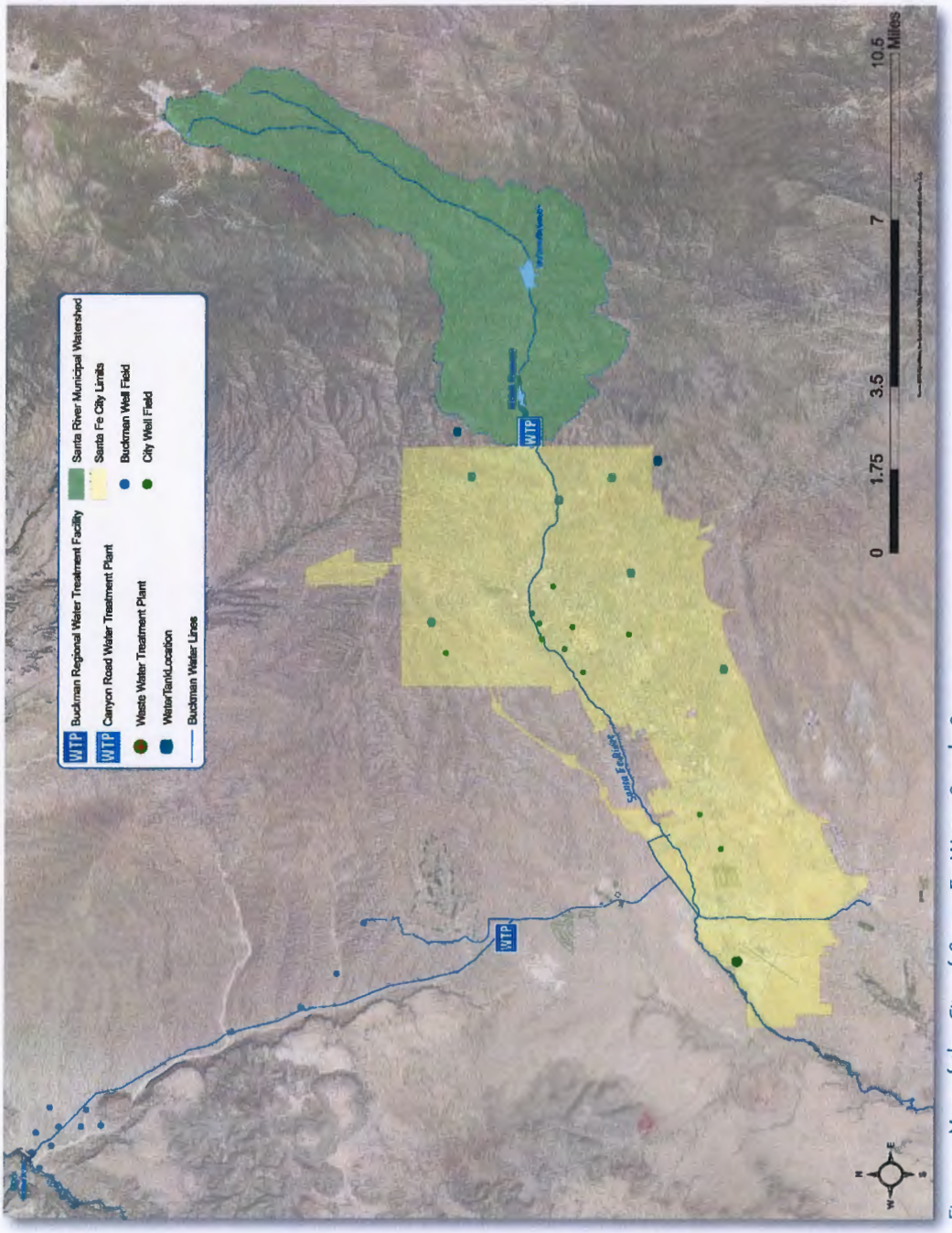

Figure 1. Map of the City of Santa Fe Water Supply Sources.

WATER RIGHTS

Surface Water

The City of Santa Fe has a license to store up to 3,985 acre-feet (combined) per year of Santa Fe River water in McClure and Nichols Reservoirs. Both municipal drinking water supply reservoirs are located east of the City within the closed upper Santa Fe River municipal watershed (see Figure 1). In 2015, reservoir improvements took place and were completed at McClure Reservoir (see Figure 2).

The Buckman Regional Water Treatment Plant provides drinking water from the federal Bureau of Reclamation's San Juan-Chama Project's surface water supply via the Rio Grande. As a contractor of the San Juan-Chama Project, the City of Santa Fe can provide up to 5,230 acre-feet per year of drinking water supply from the Buckman Regional Water Treatment Plant directly to the City's water utility customers. The Buckman Regional Water Treatment Plant and the Buckman Direct Diversion Project facilities are governed by a joint City of Santa Fe and Santa Fe County board.

Figure 2. A new intake tower was installed at McClure Reservoir in 2015. In November 2014, McClure Reservoir was drained to repair the dam and install a new intake tower, replacing the old vertical tower that was built in the 1920s. Construction was completed in December 2015, at which time the City closed valves outlets to allow for snow runoff to fill the reservoir.

Groundwater

The City of Santa Fe has seven active groundwater wells within the City limits, most of which are focused near the Santa Fe River (see Figure 1). Combined, the wells can produce up to 4,865 acre feet per year of drinking water supply for Santa Fe.

The City also has thirteen groundwater wells in the Buckman well field, which is located near the Rio Grande, approximately 15 miles northwest of Santa Fe (Figure 1). The Buckman Wells are associated with several water rights, but are operated under one permit that allows the City of Santa Fe a maximum pumping rate of 10,000 acre-feet per year for drinking water supply. However, the City rarely pumps more than 1,000 acre-feet annually from these wells. The newest Buckman wells are about 2,000 feet deep and began producing water in 2003.

Water Rights Used for "Offsets"

In addition to water rights that the City of Santa Fe can directly divert for its water supply, Santa Fe maintains a portfolio of 'offset' surface water rights that are associated with the Buckman well field and the Northwest Well. The purpose of these acquired water rights is to keep the nearby stream systems 'whole' or unaffected by the impacts that pumping groundwater has on surface water.

The City of Santa Fe has acquired sufficient water rights to satisfy its current obligation on the Rio Grande, Rio Tesuque, and Rio Nambe/ Rio Pojoaque through a combination of acquired surface water rights and the City's San Juan-Chama surface water.

Source	Water Rights	Available Water
Santa Fe River	5,040	Up to 5,040 plus 1,000 to living river (when available)
City Wells	3,507/4,865	Sustainable use when needed
Buckman Wells	10,000	Sustainable use when needed
Buckman Direct Diversion	5,230*	Less water quality and/or NEPA permit restrictions

Table 1. Diversion Water Rights and Supply Portfolio (acre-feet)

*City of Santa Fe's San Juan-Chama Project water

Relinquishment Credits

New Mexico receives relinquishment credits when the quantity of Rio Grande water provided to Texas is above that required by the Rio Grande Compact. Relinquishment water allows the City to store relinquishment 'credit' water in the municipal reservoirs during times when the Rio Grande Compact would otherwise limit the City's right to store surface water.

The New Mexico State Engineer administers relinquishment credits to the City. As an alternative to using relinquishment credits, the City often releases its San Juan-Chama Project water into the Rio Grande in exchange for the permission to store Santa Fe River water, which would otherwise be prohibited by the Rio Grande Compact. The City has a current balance of 7,207 acre-feet in relinquishment credits.

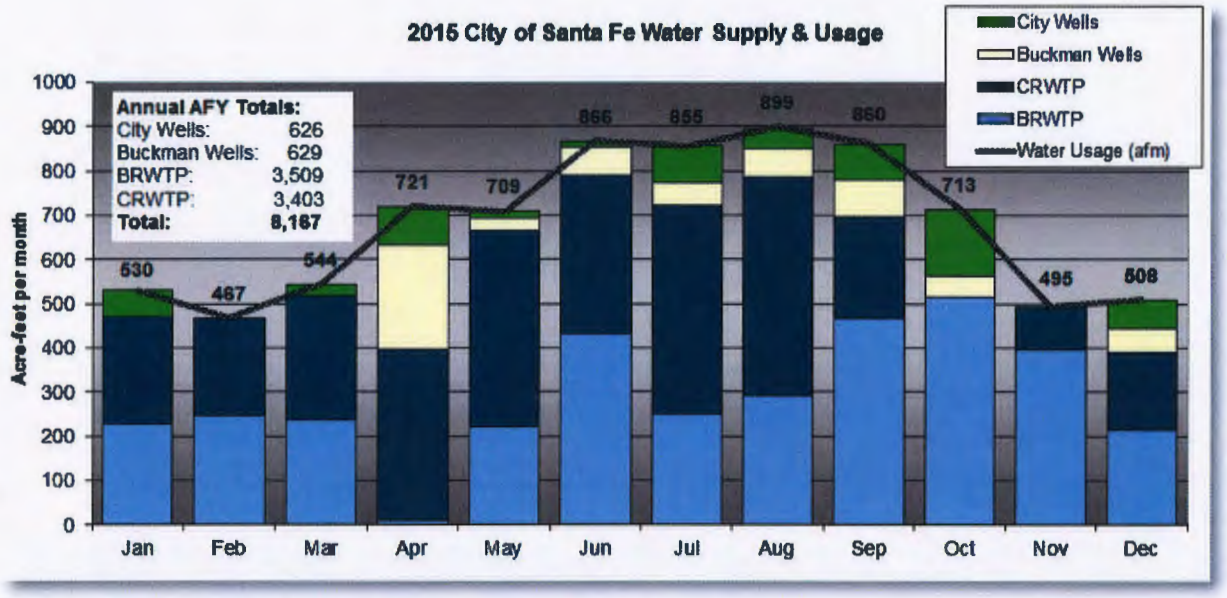

Figure 3. 2015 Monthly Production by Supply Source and Customer Usage

WATER PRODUCTION

Production by Supply Source

As shown in the Production by Source graph above (Figure 3.), the City has continued to take advantage of increased availability of surface water from the Buckman Regional Water Treatment Plant to decrease use of the City and Buckman well fields, allowing the wells to rest for use in drier years when surface water is not as readily available. In 2015, production for the City of Santa Fe's utiltiy customers was 8,062 acre-feet, with an additional 105 acre-feet of water produced for Santa Fe County Water Utility.

Treated Effluent Water Deliveries

The City of Santa Fe's reclaimed wastewater (treated effluent) has many uses including irrigation to recreational fields and local golf courses; dust control at the regional landfill and for other construction projects; watering for livestock and wildlife on the Caja del Rio mesa; contributing to the

Figure 4. City of Santa Fe Wastewater Treatment Plant

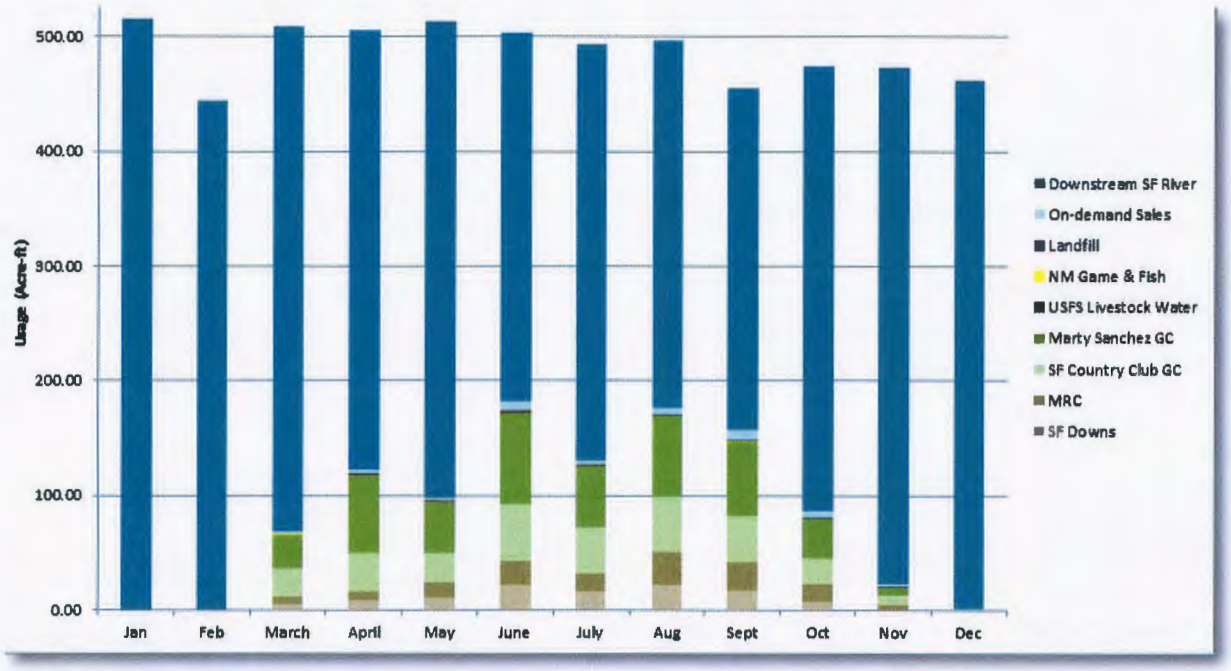

Figure 5. 2015 Treated Effluent Deliveries, by contractor

on-site, wildlife, educational pond at the NM Game & Fish facility; and enabling flow in the lower Santa Fe River downstream of the City's wastewater treatment plant which supports the riparian ecosystem and local agriculture in the La Cienega and La Bajada areas.

The reclaimed wastewater from the City's treatment plant is sold directly to contractors via an onsite stand pipe. The total production of reclaimed wastewater was 1,904 million gallons (5,844 acre-feet) in 2015, 18% of the treated wastewater was reused and the remaining 82% (1,562 million gallons) flowed into the lower Santa Fe River (see Figure 5 above).

DROUGHT & PRECIPITATION

Drought is a normal recurrent feature in the arid southwest. Santa Fe has a very dry, high desert climate with intense sunlight. On average, the city experiences more than 300 sunny days per year. The highest temperatures in July and August are 80-90 °F with only 3-6 days per year with 90+°F highs.

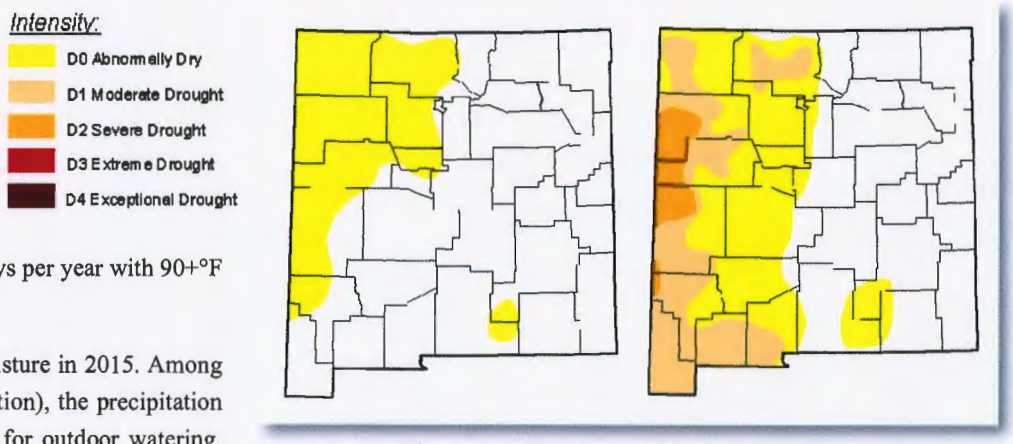

Figure 6. Drought comparisons for July 7, 2015 and December 29, 2015. The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. Data is mapped weekly by National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture (USDA), and the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln.

Overall, Santa Fe received ample moisture in 2015. Among other factors (see Water Demand section), the precipitation likely contributed to a reduced need for outdoor watering, which accounts for approximately 40 percent of Santa Fe's total water use.

In 2015, precipitation in New Mexico was near to above normal and was ranked as the 5th wettest year on record, and

the wettest since 1986. Spring 2015 snowmelt and subsequent runoff started early and was well below normal for the 5th year in a row. Well above normal temperatures in early spring quickly receeded the snowpack. But the early summer months produced scattered to numerous showers and thunderstorms and July saw the development of a strong monsoon pattern, which dimished in August and September. Moisture picked up again in October, which was 244 percent of normal. November was above normal, coming in at 121 percent. The first half of December 2015 started out dry, but by the end of the month a very active weather pattern returned to the state and the year ended with a historic blizzard event that buried much of east central and southeast New Mexico in 10 to 30 inches of snow.

SNOTEL Station	Elevation (Feet)	Accumulated Precipitation
Santa Fe	11,445	46.7 inches
Elk Cabin	8,210	36.3 inches

Table 2. 2015 NRCS SNOTEL Data, Santa Fe Watershed as of June 2015.

According to the Western Regional Climate Center, Santa Fe receives on average 13.84 inches annually of precipitation. National Resource Conservation Service (NRCS) 'SNOTEL' weather stations measure accumulated precipitation. There are two SNOTEL weather stations in the upper Santa Fe River municipal watershed (see Table 2).

Precipitation data is also gathered in two additional locations in Santa Fe. 'Santa Fe Watershed' which is located approximately 3 miles east of the Santa Fe plaza, reported 22.82 inches for the year of 2015. This was 60 percent of the annual precipitation of 13.70 inches for this location. Seton Village (approximately 4.5 miles south of downtown Santa Fe) reported 17.22 inches for the year 2015. This was 85 percent of the annual precipitation of 14.65 inches for this location.

Figure 7. Upper Santa Fe Municipal Watershed. In 2015, precipitation in New Mexico was near to above normal and was ranked as the 5th wettest year on record, and the wettest since 1986.

WATER DEMAND

Per Capita Consumption

A common metric for comparing annual water use and water conservation effectiveness is gallons per capita per day (gpcd). It's derived by dividing the amount of water supplied to the City of Santa Fe by the population of utility customers served. The calculated gpcd *does* include deliveries to wholesale customers, such as Santa Fe County. In 2015, the City's water customers decreased average daily water use from 95 gpcd in 2014 to 90 gpcd in 2015.

The gpcd calculation is based upon the New Mexico Office of the State Engineer's (NM OSE) methodology*, which bases the population served upon the number of water division residential customers multiplied by 2014 American Community Survey (ACS)-derived vacancy rate, and an ACS-based residents per occupied household value. The submittal of the NM OSE gpcd fulfills a compliance requirement with the NM OSE's diversion permit for surface water to the Buckman Direct Diversion facility.

Although water conservation outreach and education programs contribute to the overall decrease in water consumption, there are several other factors to take into account. The city experienced a net loss in water customers after annexation to the county in which the typically high water use communities of La Tierra and La Campanas were transferred to Santa Fe County. Additionally, outdoor watering accounts for about 40 percent of the City's total annual water use, and as a result of ample precipitation during the monsoon season in 2015, the need for outdoor watering was reduced (see Drought & Precipitation on page 5).

*Prior to utilizing the NM OSE gpcd methodology, the City of Santa Fe Water Division gpcd method, used for the previous seventeen years, determined the population served upon the most recent (2010) U.S. Census population data (adjusted for households that rely solely on domestic well water) and updated it annually utilizing growth rates from annual housing permits.

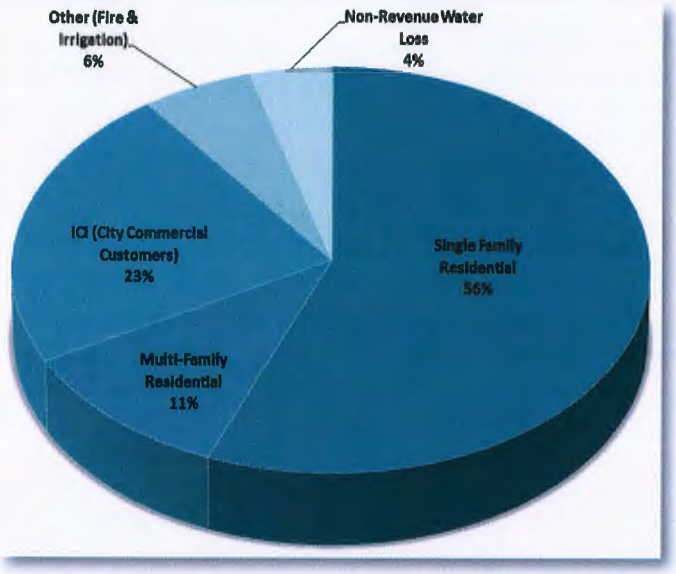

Figure 8. City of Santa Fe 2015 Gallons per Capita per Day. Demand by Sector

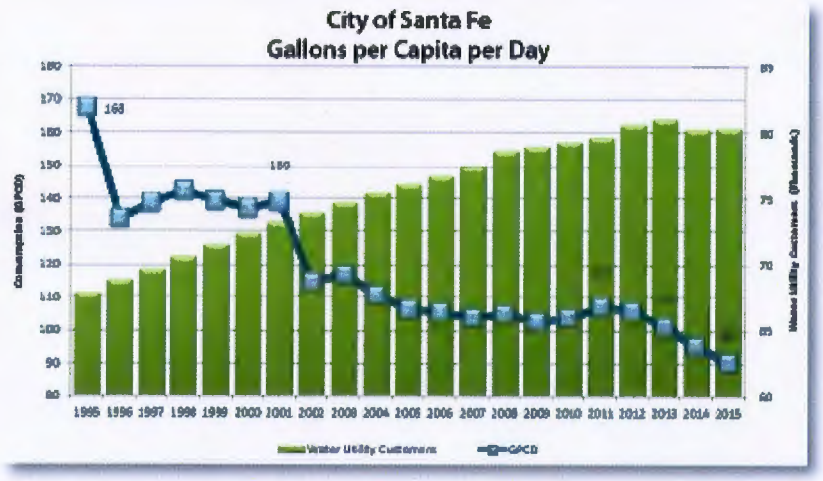

Figure 9. City of Santa Fe gpcd with population, 1995-2015

Contractual & Other Water Demands

Santa Fe River

As directed by ordinance, in mid-April of each year the annual target flow allocation is determined based upon projections for the year's anticipated watershed yield. The 2015 flow target was set at 600 acre-feet based upon moisture content in the upper Santa Fe watershed snowpack, with total flows to the Living River amounting to over 2,000 acre-feet in 2015 (see the 2015-16 Santa Fe River Target Flow Hydrograph in Figure 10 on following page).

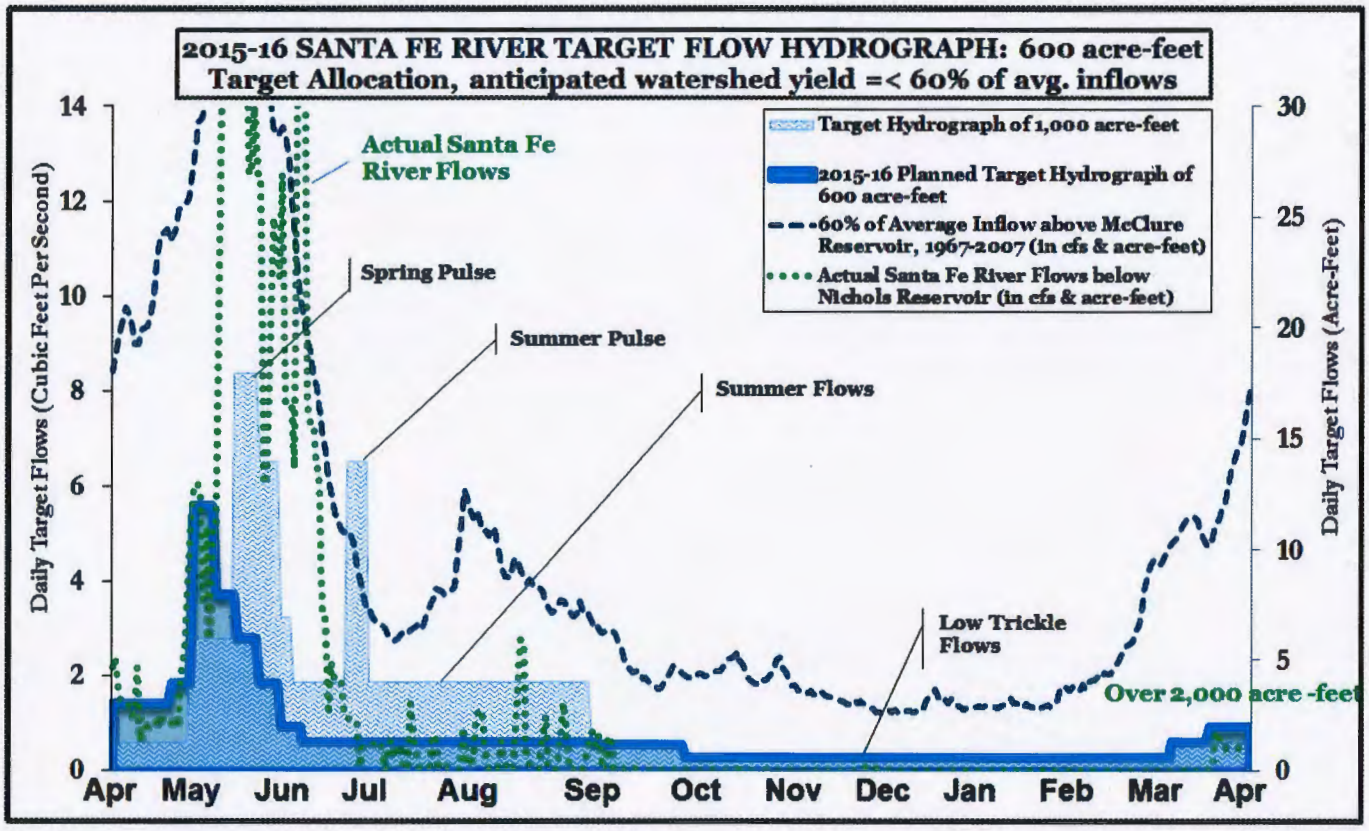

Figure 10. Santa Fe River Target Flow Hydrograph, 2015-16.

Wholesale Water Deliveries

The City has contracts to deliver wholesale water to the Santa Fe County Water Utility. Since 2011 the Buckman Direct Diversion (BDD) has become the primary source of water for Santa Fe County's water utility. Las Campanas' potable water needs are being met by Santa Fe County's Water Utility under the terms stipulated in a bulk water agreement between Santa Fe County and Las Campanas. The 2005 City/ County Water Resources Agreement provides Santa Fe County with up to 500 acre-feet per year of wholesale delivery water from the City of Santa Fe, with an additional 850 acre-feet available under drought and emergency conditions.

The Santa Fe County Water Utility typically is delivered potable water from the City of Santa Fe when the BDD facility is not producing drinking water due to poor water quality conditions in the Rio Grande. Under the water resources agreement with the City of Santa Fe, Santa Fe County Water Utility took delivery of 105 acre-feet of water in 2015.

Water Bank

New water demand on the City water system requires a water credit from the Water Bank in an equal amount, with the goal being no "net" increase in demand on the water system. The City has a series of ordinances* that require all new projects to offset their water demand to the City of Santa Fe Water Division supply, the options of which include water rights acquisition and water conservation in existing development. By the end of 2015, 214 acre-feet of water was available for allocation to the City's needs or City supported efforts (e.g. new parks, municipal buildings, convention centers, affordable housing dwelling units, and the Santa Fe River). An additional 77 acre-feet was available for sale to small developers. In 2015, 1.8 acre-feet was allocated to affordable housing units, leaving an ending balance of 21 acre-feet. The private developers held a total of 573 acre-feet of water rights and 185 acre-feet of toilet retrofit credits.

*The City's water bank tracks the inflows (credits), allocations (debits), ownership, and designated use. For detailed information, please refer to the following ordinances and city code: 2005 Water Transfer Ordinance, 2009-38 Water Budget Requirements (effective January 1, 2010), and Water Conservation provisions in City Code Chapter 25.

WATER RESOURCES PLANNING

The overall goal of water resources planning is to ensure that our water supplies are managed and protected in an efficient and responsible manner so that the City of Santa Fe's drinking water supply is safe, reliable, and sustainable. Ongoing planning necessitates the management of a suite of water rights purchasing, leasing, and permit compliance efforts.

The management role of water resources planning involves administration of the City's "water bank," which seeks to tie land use development with the availability of requisite water rights (see Water Bank section on page 8).

The other management responsibility is source water protection and watershed management under the City of Santa Fe's Municipal Watershed Management Program, protecting 40% of the City's drinking water supply. Water resources planning and management efforts cover a broad range of duties, including being a good steward of the precious and finite resource: water.

Fiscal Responsibility

The Water Division is committed to managing the water utility to maintain fiscal responsibility to its customers. This is achieved by an annual review of the finance plan and the capital improvement plan (CIP) with the goal of maintaining a high level of service while increasing effectiveness and efficiency. In early 2009, the City Governing Body approved a water rate increase in the amount of 8.2% for five consecutive years. The water utility rate increase was needed to pay for the Buckman Direct Diversion Project, a key component in providing the community with a safe and reliable supply of drinking water, and approximately $100 million of infrastructure improvements. The last rate increase went into effect July 1, 2013 and the City does not project another increase to take place until 2021.

2016 Water Demand and Supply Picture

In the chart below, the 2016 projected demand (black line) is approximately 9,547 acre-feet over the 12 month period. The BDD annual production is projected to be 4,576 acre-feet, Canyon Road Water Treatment Plant is projected to produce 3,200 acre-feet, the City Wells are projected to produce 1,133 acre-feet, and Buckman Wells are projected to produce 638 acre-feet over the 12 month period.

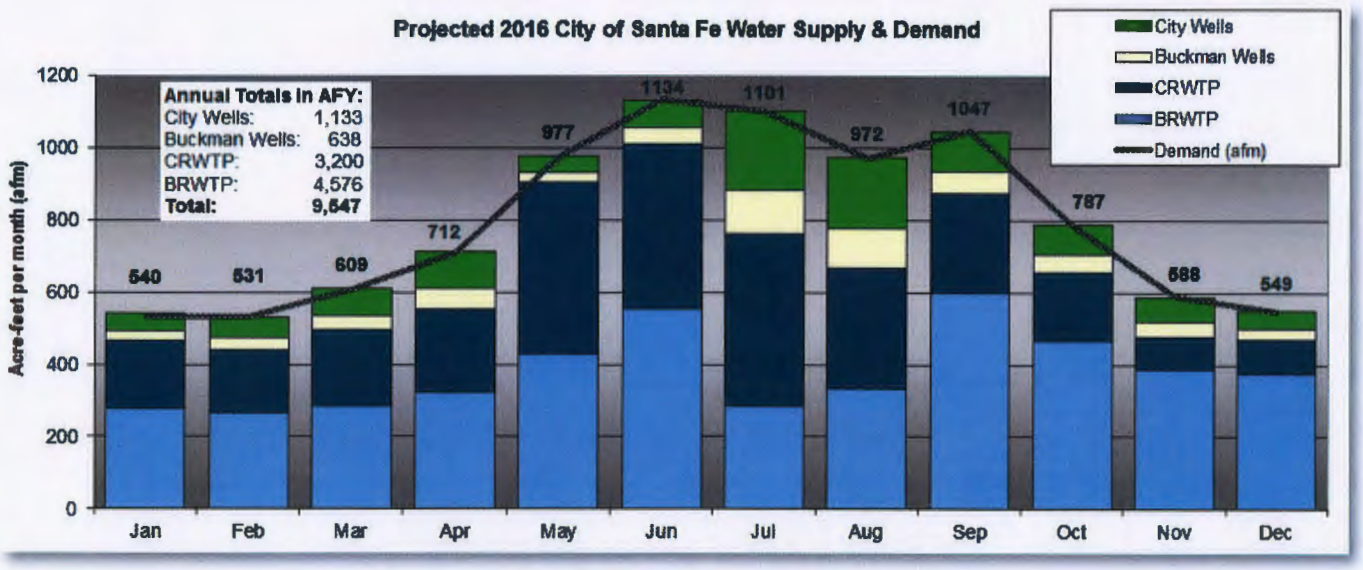

Figure 11. 2016 Projected Monthly Production by Supply Source

APPENDIX H

FIRST JUDICIAL DISTRICT COURT
COUNTY OF SANTA FE
STATE OF NEW MEXICO

No. 43,347

ENDORSED

JUL 05 1990

FIRST JUDICIAL DISTRICT COURT
SANTA FE, RIO ARRIBA &
LOS ALAMOS COUNTIES
P.O. Box 2268

HENRY P. ANAYA, et al.,

Plaintiffs,

vs.

PUBLIC SERVICE COMPANY OF NEW MEXICO, et al.,

Defendants,

ORDER

THIS MATTER having come before the Court upon the Court's order to Public Service Company of New Mexico ("PNM") to show cause why it should not be required to release water to landowners served by the Acequia Madre Community Ditch Association ("Acequia Madre") and the Acequia Cerro Gordo Community Ditch Association ("Acequia Cerro Gordo") pending final adjudication of this matter, and the Court having considered the evidence presented and the oral and written arguments, and having issued its Decision of the Court and Findings of Fact and Conclusions of Law, and being fully advised in the premises and good cause appearing,

IT IS ORDERED THAT:

A. PNM shall release from its reservoirs on the Santa Fe River sufficient water so that 65.31 acre feet per year are available for diversion at the headgate

of the Acequia Madre and 8 acre feet per year are available for diversion at the headgate of the Acequia Cerro Gordo.

B. PNM's releases of water to the acequias shall occur during the months of April through October at such times and at such rates as may be requested by the acequias; provided, however, that PNM shall not be required to release water in quantities greater than would otherwise be available to the acequias from stream flow, assuming no impoundment or diversion by PNM; and provided further that no water shall be released prior to certification by the State Engineer as provided below.

C. The State Engineer shall inspect the acequias and shall certify to the Court that they are in sufficient condition to receive and deliver water to the tracts of land identified on Attachment "A." This certification shall occur annually before any water is released.

D. PNM shall continue to release water as provided herein until further order of the Court.

E. The Court retains jurisdiction over this matter to modify, supplement or enforce this order as circumstances may require upon proper notice and hearing.

F. The acequias are awarded their reasonable costs of suit.

G. This order is an interlocutory order which does not practically dispose of the merits of the action and involves a controlling question of law as to which there is substantial ground for difference of opinion and an immediate appeal from this order may materially advance the ultimate determination of the litigation.

Art Encinias

DISTRICT JUDGE

APPROVED AS TO FORM:

WHITE, KOCH, KELLY & McCARTHY, P.A.

By: Benjamin Phillips

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1/BP/ACQ-ORDER

ATTACHMENT "A"
TO ORDER

ACEQUIA MADRE TRACT	ACEQUIA CERRO GORDO TRACT
11.80	2.1A
11.81	2.1B
11.94	2.2A
11.97-B	2.3A
11.97-C	2.3B
11.99	2.3C
11.104-C	2.3D
11.104-D	2.3E
11.105	
11.111	
11.112	
11.116	
11.120-B	
11.127	
11.381	
11.382	

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Maxine Morales

FIRST JUDICIAL DISTRICT COURT
COUNTY OF SANTA FE
STATE OF NEW MEXICO

NO. D-101-CV-1971-43347

HENRY P. ANAYA, *et al.*,

Plaintiffs,

Vs.

PUBLIC SERVICE COMPANY OF NEW MEXICO, *et al.*,

Defendants.

ORDER ON ACEQUIA MADRE DE SANTA FE'S MOTION TO AMEND JULY 5, 1990 ORDER

This matter comes before the Court on the Motion of the Acequia Madre de Santa Fe Community Ditch Association ("Acequia Madre") for an order amending the Court's Order entered July 5, 1990 ("Order") (which was subsequently supplemented on August 20, 1991 by the Court's Order on Acequia Cerro Gordo's Motion for Supplemental Order on Interim Priority Enforcement). The Acequia Madre and the City of Santa Fe have reached agreement on the form of the Order and on an Amended Stipulated Operating Agreement which they request the Court to enter. The State of New Mexico does not oppose the proposed Order or Amended Stipulated Operating Agreement.

The Court having considered the matter and being advised in the premises, finds that the amounts of water rights adjudicated to members of the Acequia Madre under Consent Orders 11.381/11.382, 11.381/11.382A, 11.381/11.382B, 11.381/11.382C, 11.381/11.382D and 11.381/11.382E should be reflected in the Order, that the amount of water to be delivered to the

Acequia Madre should be commensurately increased, and that the proposed Order and Amended Stipulated Operating Agreement should be entered.

NOW, THEREFORE, IT IS ORDERED that the Order is amended as follows:

1. Attachment "A" to the Order is amended to add Acequia Madre tracts 11.381/11.382, 11.381/11.382A, 11.381/11.382B, 11.381/11.382C, 11.381/11.382D and 11.381/11.382E.

2. Paragraph A of the Order is amended to read, "The City of Santa Fe shall release from its reservoirs on the Santa Fe River sufficient water so that 82.404 acre feet per year are available for diversion at the headgate of the Acequia Madre and 11.08 acre feet per year are available for diversion at the headgate of the Acequia Cerro Gordo; …."

3. Paragraph C of the Order is amended to read with respect to the Acequia Madre only, "The Acequia Madre shall provide the City and the State the opportunity to inspect the Acequia Madre and shall certify to the City and the State that it is in sufficient condition to receive and deliver water to the tracts of land identified on Attachment A prior to the release of any water."

IT IS FURTHER ORDERED THAT the Amended Stipulated Operating Agreement attached hereto is approved.

JAMES J. WECHSLER
Presiding Judge

SUBMITTED BY:

CUDDY & McCARTHY, LLP

BY: _____

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By: _____

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SUBMITTED BY:

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APPENDIX I

FIRST JUDICIAL DISTRICT COURT
COUNTY OF SANTA FE
STATE OF NEW MEXICO

NO. 43,347

HENRY P. ANAYA, et al.,

Plaintiffs,

vs.

PUBLIC SERVICE COMPANY OF NEW MEXICO, et al.,

Defendants,

and

State of New Mexico, ex rel.
State Engineer,

Plaintiff-in-Intervention.

STIPULATED OPERATING AGREEMENT

The Acequia Cerro Gordo and the Acequia Madre de Santa Fe Community Ditch Associations, Sangre de Cristo Water Company, a division of Public Service Company of New Mexico, and the State of New Mexico ex rel. State Engineer, for the purpose of resolving the acequias' motion for enforcement of the July 5, 1990 interim release order and Sangre de Cristo's motion to prohibit the acequias from diverting seepage, stipulate and agree as follows:

1. This stipulation describes an interim operating procedure to implement the Court's July 5, 1990 interim release order and the Court's order of August 20, 1991 and to ensure that the acequias are guaranteed the minimum amount of water required to meet their

irrigation needs consistent with such orders, pending final adjudication of water right claims or further order of the Court.

2. The stipulations, agreements, descriptions of water right "requirements" and all other matters set forth herein are solely for the purpose of settlement of the aforementioned motions and are without waiver of or prejudice to any water right claims or any positions taken in respect to such claims, or other rights or defenses of the parties, and do not constitute a concession of the validity of any position asserted in either motion.

3. Table 1 is a schedule of irrigation water requirements in an average weather year for 11.25 irrigated acres served by the Acequia Madre, exclusive of fallow land (12.08 acres less 7 percent fallow as assumed in the hydrographic survey):

Table 1

Month	Monthly Distrib. Factor	CIR (acre-ft)	FDR (acre-ft)	PDR (acre-ft)
Apr	0.039	0.64	1.28	2.55
May	0.143	2.33	4.67	9.34
Jun	0.214	3.49	6.98	13.97
Jul	0.246	4.02	8.04	16.07
Aug	0.182	2.97	5.94	11.88
Sep	0.128	2.09	4.18	8.36
Oct	0.048	0.78	1.56	3.13
Totals (acre-ft/yr)		16.32	32.65	65.30

Key: CIR=consumptive irrigation requirement; FDR=farm delivery requirement; and PDR=project or off-farm diversion requirement.

4. Table 2 is a schedule of irrigation water requirements in an average weather year for 1.91 irrigated acres served by the Acequia Cerro Gordo, exclusive of fallow land (2.04 acres less 7 percent fallow as assumed in the hydrographic survey):

Table 2

Month	Monthly Distrib. Factor	CIR (acre-ft)	FDR (acre-ft)	PDR (acre-ft)
Apr	0.039	0.11	0.22	0.43
May	0.143	0.40	0.79	1.58
Jun	0.214	0.59	1.18	2.37
Jul	0.246	0.68	1.36	2.73
Aug	0.182	0.50	1.01	2.02
Sep	0.128	0.35	0.71	1.42
Oct	0.048	0.14	0.27	0.53
Totals (acre-ft/yr)		2.77	5.54	11.08

Key: CIR=consumptive irrigation requirement; FDR=farm delivery requirement; and PDR=project or off-farm diversion requirement.

5. Flumes have been installed by Sangre de Cristo at the head of the Acequia Cerro Gordo and the head of the Acequia Madre and have been inspected by representatives of the State Engineer Office. Pursuant to the recommendation of that office, Sangre de Cristo will relocate the Acequia Madre flume approximately 50 feet downstream of the Alameda Street bridge. After the Acequia Madre flume has been relocated, the State Engineer Office will rate the Acequia Madre and Acequia Cerro Gordo flumes and any necessary corrections will be made.

6. The flumes will be read by Sangre de Cristo at least twice daily at approximately eight-hour intervals and the measurements recorded. The measurements shall be furnished to the acequias weekly.

7. All water that passes through the flumes and is measured shall be counted against the "project diversion requirement" shown in Tables 1 and 2 except that:

(a) In the Acequia Madre, a flow of less than .66 cfs shall not be counted;

(b) When flow exceeds the highest calibration on a flume, the portion of the flow above the highest calibration shall not be counted; and

(c) In the Acequia Cerro Gordo, water returned to the river through the outlet valve on the Cerro Gordo conveyance pipe downstream of the flume shall not be counted. If it appears from inspection that the outlet valve is open and that none or only a negligible amount of water is exiting the pipe and entering the ditch, then none of the flow measured in the flume shall be counted. If in times of spillage or other unusually high flows of water in the river it appears from inspection that the outlet valve is open but that more than a negligible amount of water is exiting the pipe and entering the ditch, then 50 percent of the water measured in the flume shall not be counted. If the valve is closed, all of the water measured in the flume shall be counted, subject to subparagraph (b) above. A "negligible amount of water" is an amount insufficient to reach Cerro Gordo Tract 2.1A.

None of the exceptions as set forth in this paragraph 7(a) through (c) shall apply to water flowing in the river due to a release requested by the acequias pursuant to the July 5, 1990 interim release order.

If any dispute arises under this paragraph 7, Sangre de Cristo and the acequias will attempt in good faith to reach a settlement of the dispute and if they are unable to do so, will consult with the State Engineer Office in an effort to do so.

8. Subject to the qualifications contained in the preceding paragraph, the sum of the average of daily measurements taken at the flumes during each calendar month will constitute the amount of

project diversion in that month. After the monthly project diversion requirements as set forth in Tables 1 and 2 have been met together with any carryover under paragraph 10 below, Sangre de Cristo's obligation to release water will be deemed satisfied for that month.

9. The acequias may divert water in excess of the monthly project diversion requirements set forth in Tables 1 and 2, provided that no more than 2.7 acre feet per acre per year is diverted at each tract and that excess water is returned to the Santa Fe River stream system without waste. The acequias will endeavor to measure the return flows to the Santa Fe River if such measurement is found necessary.

10. The annual release requirements of 65.30 acre-feet for the Acequia Madre and 11.08 acre-feet for the Acequia Cerro Gordo shall be divided into months in accordance with the PDR in Tables 1 and 2 above. The portion of any monthly PDR not released to the acequias upon request shall be carried over to the succeeding month, provided that requests for releases in any month may not exceed 120 percent of the PDR for that month as shown in Tables 1 and 2.

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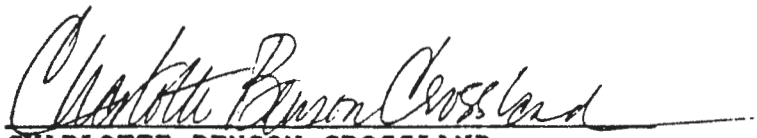

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FIRST JUDICIAL DISTRICT COURT
COUNTY OF SANTA FE
STATE OF NEW MEXICO

~~**NO. 43,347**~~
D-101-CV-1971-43347

HENRY P. ANAYA, *et al.*,

Plaintiffs,

Vs.

PUBLIC SERVICE COMPANY OF NEW MEXICO, *et al.*,

Defendants.

AMENDED STIPULATED OPERATING AGREEMENT

The Acequia Madre de Santa Fe Community Ditch Association ("Acequia Madre"), the City of Santa Fe ("City") and the State of New Mexico ex rel. State Engineer (collectively referred to herein as "the Parties") stipulate and agree as follows:

1. This Amended Stipulated Operating Agreement ("Amended Stipulation") amends the September 11, 1990 Stipulated Operating Agreement ("1990 Stipulation"), previously entered into by these parties or their predecessors-in-interest, a copy of which is attached hereto as Attachment 1. This Amended Stipulation only amends and supersedes those provisions of the 1990 Stipulation as expressly stated herein and all provisions of the 1990 Stipulation not amended herein remain in effect.
2. The amended stipulations, agreements, descriptions of water right "requirements" and all other matters set forth herein are solely for the purpose of settlement and are without waiver of or prejudice to any water right claims or any positions taken in respect to such

claims, or other rights or defenses of the parties, and do not constitute a concession of the validity of any position asserted by the Parties.

3. Paragraph 3 of the 1990 Stipulation is deleted and replaced by the following:

"3. This Amended Stipulation is based on a total number of irrigated acres served by the Acequia Madre of 15.26 acres. The Parties agree that the irrigation water requirements in an average weather year for the 15.26 irrigated acres served by the Acequia Madre is as follows: total Project Delivery Requirement ("PDR") is 82.404 acre feet per year (15.26 times the per acre PDR of 5.4); total Farm Delivery Requirement ("FDR") is 41.202 acre feet per year (15.26 times the per acre FDR of 2.7)."

4. Paragraphs 9 and 10 of the 1990 Stipulation, as they pertain to the Acequia Madre only, are replaced by the following:

"9. The Acequia Madre may divert water in the total amount of 82.404 acre feet per year as set forth in amended Paragraph 3 during the months of April through October, provided that no more than 2.7 acre feet per acre per year is diverted at each tract and that excess water is returned to the Santa Fe River stream system without waste. The Acequia Madre will endeavor to measure the return flows to the Santa Fe River if such measurement is found necessary."

5. The City believes it has the authority to regulate the floodplain pursuant to NMSA 1978, § 3-18-7, and SFCC § 14-3.10, in the event of a flood emergency. Without waiving the Acequia's rights on this issue, the parties agree that a new Paragraph 11 shall be added to the 1991 Stipulated Operating Agreement as follows: "In the event of a flood emergency, the City will have access to open the Santa Fe River "sluice gate", the first gate which diverts water from the Santa Fe River into the Acequia Madre at the Acequia

Madre's headworks, to protect the health, safety, and welfare of the City residents within the floodplain, provided that the City provides prior telephonic and email notice to a designee of the Acequia Madre whose name and contact information the Acequia provides to the City of Santa Fe Source of Supply Manager.

6. A new Paragraph 12 shall be added to the 1991 Stipulated Operating Agreement as follows: "The parties agree that the City will install functioning totalizing meters approved by the State Engineer at a location and in a manner acceptable to the State Engineer to measure water delivered by the City to the Acequia Madre at the Acequia Madre's headgate. Once the City installs such a meter, the City's water deliveries to the Acequia Madre will be calculated from the meter. When the City installs the new meter at the Acequia Madre's headgate, paragraphs 6 and 7 of the 1991 Stipulated Operating Agreement, shall no longer have any force or effect with respect to the Acequia Madre."

DATE: January 28, 2015

ACEQUIA MADRE DE SANTA FE
COMMUNITY DITCH ASSOCIATION

By:

Phillip Bové, Commissioner

José Gonzales, Commissioner

David Maes, Commissioner

Gilbert Montoya, Commissioner

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STATE OF NEW MEXICO EX REL.
OFFICE OF THE STATE ENGINEER

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APPENDIX J

Upper Santa Fe River Acequia Surface Water Totals

Acequia	Length	Irrigable Acres	Acre-Feet/Year Farm Delivery Requirement (FDR)	Acre Feet/ Year Present Delivery Obligation	Acre-Feet/Year Project Delivery Requirement (PDR)
Madre	7.6 miles	14.21	38.37	82.40[1] (PDR)	82.40
Cerro Gordo	2,200 feet	1.91	5.16	11.08 (PDR)	11.08
Llano	8,200 feet	17.77	47.98	47.98 (FDR)	103.01 [2]
Muralla	3,200 feet	5.58	15.07	15.07 (FDR)	32.36
Totals	**10.18 miles**	**39.47**	**106.58**	**156.53**	**228.85[3]**

[1] The PDR for Acequia Madre and Cerro Gordo were determined in a Court proceeding with the Office of the State Engineer.

[2] At present, there is no Project Delivery Requirement (PDR) for acequias Llano and Muralla, but using the PDR calculation that the Court employed for Acequia Madre and Cerro Gordo (5.7987 acre-feet/acre), we can estimate the PDR for the four upper acequias on the Santa Fe River.

[3] This table is for illustrative purposes only and does not represent an admission by the City of Santa Fe in the Anaya adjudication or any other claim to determine water rights in the Santa Fe River.

APPENDIX K

25-13 SANTA FE RIVER TARGET FLOW.

25-13.1 Short Title.

Section 25-13 may be cited as the "Santa Fe River Target Flow Ordinance." (Ord. #2012-10, §2)

25-13.2 Legislative Findings.

The governing body finds that:

A. Through the adoption of Resolution No. 2009-47, Resolution No. 2010-15 and Resolution No. 2011-28 the governing body authorized the city to support a living Santa Fe River by allowing water to bypass McClure and Nichols reservoirs in 2009, 2010 and 2011.

B. The Santa Fe river is an important element of the city of Santa Fe and the city's origin was due to the existence of the river.

C. There is widespread community support for maintaining a living Santa Fe river for recreational and cultural purposes.

D. A healthy river provides riparian habitat for wildlife and minimizes erosion and flood damage, removes pollutants from storm water and helps recharge groundwater.

E. The city has put to beneficial use its water right under Declaration No. 01278 and License 1677, (as issued by the state engineer) and intends to continue to put that water to beneficial use, and the adoption of this ordinance will not adversely affect the city's water right under Declaration No. 01278 and License 1677.

F. Implementation of this ordinance will not cause the city to operate the municipal water utility in any way that is inconsistent with any local, state or federal rules, regulations or laws. (Ord. #2012-10, §3)

25-13.3 Purpose.

The purpose of Section 25-13 SFCC 1987 is to formalize the city's commitment to provide for a target flow within the Santa Fe River in order to enhance and further the objective of restoring the Santa Fe river as a living river by committing to use up to one thousand (1,000) acre-feet per year (AFY) of the city's water supply, depending upon hydrologic conditions in the Santa Fe River watershed. This section shall be interpreted to further this objective. (Ord. #2012-10, §4)

25-13.4 Definitions.

As used in Section 25-13 SFCC 1987:

Administrative procedures means the Administrative Procedures for the Santa Fe River Target Flows Ordinance, adopted by resolution of the governing body, that describe how city staff will implement Section 25-13 SFCC 1987 in order to provide up to one thousand (1,000) AFY in target flows to the Santa Fe river. The administrative procedures shall include the following:

A. The operations of the city's water division and other city staff necessary to provide for the up to one thousand (1,000) acre-feet target flow below Nichols reservoir;

B. Target flow hydrographs that support the city's identified ecological and social outcomes;

C. Adjustments to the target flows and target hydrograph under less than average anticipated watershed yield;

D. Provisions to adaptively manage the target flows based on ecological and social outcomes because of precipitation events, stream flows and effects;

E. Adjustments to the target flow due to emergencies;

F. Requirements for monitoring, accounting, and reporting target flow; and

G. Other operational and administrative procedures that may be required to fulfill the purpose of this section.

Anticipated watershed yield means the expected annual yield of water to the Santa Fe river and the municipal reservoirs within the Santa Fe river upper watershed, expressed as the percentage of the historical average; the anticipated watershed yield is estimated as of April 15th using the best available information including the amount of snow, both as depth (in inches) and snow-to water equivalent (in inches) at the weather stations in the upper watershed (Santa Fe and Elk Cabin); the Santa Fe basin forecast predictions from Natural Resource Conservation Service (NRCS); weather forecast from the National Weather Service and NOAA; and any other pertinent appropriate weather-related information.

Below Nichols gage means the stream gaging station 08316505 located below Nichols reservoir, or at a comparable location of measurement at or below the outlet from Nichols dam; this is the measuring point for target flows administration pursuant to the administrative procedures.

Bypass flow means, generally, water that flows past a diversion or storage facility. In the administrative procedures, it refers to water that the city chooses not to store in the municipal reservoirs and thus allows to flow to the Santa Fe river below Nichols reservoir provided that the rate at which the bypass flow is passed through the outlet works of Nichols reservoir dam is always equal or less than the stream inflow at the 'above McClure' gage.

Hydrograph means a graphic representation of stream discharge, in cubic feet per second, plotted against time.

Target flow means the daily, seasonal or annual amount of water (as a volume or a rate) desired in the river as measured at the "below Nichols" stream gage or at a comparable location of measurement at or below the outlet from Nichols dam. The quantity is variably identified in several sections of the administrative procedures, depending upon the anticipated watershed yield.

Target hydrograph means the graphical representation of the daily target flow necessary to provide up to one thousand (1,000) AFY of bypass water in the Santa Fe river as measured at the below Nichols gage. The quantity of water is variably identified in several sections of the administrative procedures, depending upon anticipated watershed yield.
(Ord. #2012-10, §5)

25-13.5 Santa Fe River Target Flow.

The city water division shall operate the city's system of reservoirs to ensure that a bypass target flow of up to one thousand (1,000) AFY of river water flows into the Santa Fe river below Nichols reservoir. In average and wet conditions, the target flows will be one thousand (1,000) AFY. In drier years, seventy-five percent (75%) of the average watershed yield or less, the target flows shall be scaled in such a way that the target flows will equal the percentage anticipated watershed yield multiplied by one thousand (1,000) AFY. When the anticipated watershed yield is equal or less than thirty percent (30%) average watershed yield, the target flows will be three hundred (300) AFY. Additional information regarding the daily target flow pattern is provided for in the administrative procedures. Water that is released and/or spilled for flood management will count toward the daily target flows and target hydrograph when the flows are within the daily target flows of the target hydrograph. If water greater than the daily target flows is released or spilled into the river, the quantity of water that exceeds the daily bypass target flow will not be counted toward the target hydrograph. Except for flood management as described above, the water for the target hydrograph shall not include water released for any other purpose at the time of release, provided that nothing in this section shall require the release of bypass water if the release might jeopardize the city's water right under License 1677 and Declaration 01728. (Ord. #2012-10, §6)

25-13.6 Coordination with Santa Fe River Community Events.

When possible, target flows and target hydrographs shall be patterned to support community events scheduled along the Santa Fe river. (Ord. #2012-10, §7)

25-13.7 Water Emergency Target Flow Adjustment.

A. Pursuant to subsection 25-5.6 SFCC 1987, upon declaration of a water emergency, the city manager is authorized to adjust target flows to the Santa Fe river.

(1) For the "Water Warning — Orange" implementation stage, target flows to the Santa Fe river may be suspended.

(2) For the "Water Emergency — Red" implementation stage, target flows to the Santa Fe river shall be suspended.

B. The administrative procedures provide the detailed process for adjusting target flows to the Santa Fe river during a declared water emergency.
(Ord. #2012-10, §8)

25-13.8 Reporting and Review.

Annually city staff shall provide a report to the governing body summarizing the previous year's target flows and projection for the next year's target flows. The annual report shall provide the governing body the opportunity to review this section. Additional information regarding accounting and reporting is provided for in the administrative procedures. (Ord. #2012-10, §9)

25-13.9 Effective Date.

This section shall become effective five (5) days after publication of adoption. (Ord. #2012-10, §10)

APPENDIX L

Exhibit A

CITY OF SANTA FE

ADMINISTRATIVE PROCEDURES FOR SANTA FE RIVER TARGET FLOWS

Adopted by: Resolution No. 2012-28
Date Adopted: February 29, 2012

Table of Contents

1. **Article I**
   Introduction
2. **Article II**
   - **2.1 Title**
   - **2.2 Authority**
   - **2.3 Applicability**
   - **2.4 Purpose**
   - **2.5 Interpretation**
3. **Article III – Definitions of Terms Used**
4. **Article IV – Administrative Procedures**
   - **4.1 Objectives**
     - 4.1.1 Target Flow Objectives
     - 4.1.2 Use of Objectives for Adaptive Management
   - **4.2 Target Hydrograph and Target Flow Seasons**
     - 4.2.1 Development of the Target Hydrograph and Target Flow Season
     - 4.2.2 Target Hydrograph and Target Flows
   - **4.3 - Dry and Critically Dry Year Hydrographs**
     - 4.3.1 Reduction of Target Flows in Dry and Critically Dry Years
     - 4.3.2 Dry Year Hydrographs
     - 4.3.3 Critical-Dry Year Hydrograph
   - **4.4 Wet Year Flows**
   - **4.5 Management and Accounting of Releases and Spills**
     - 4.5.1 Management of Municipal Reservoir Flood Flows
     - 4.5.2 Accounting of Releases and Spills vis-à-vis the Target Hydgrograph
   - **4.6 Water Rights**
     - 4.6.1 Use of the City's Santa Fe River Water and Storage Rights
     - 4.6.2 Bypass Constraint
     - 4.6.3 Recognition of Other Surface Water Right Users
   - **4.7 Management and Operational Procedures**
     - 4.7.1 Flow Management
     - 4.7.2 Flow Operations
     - 4.7.3 Flow Adjustment Infrastructure
   - **4.8 Emergencies and Flow Suspension**
     - 4.8.1 Water Emergency Implementation Stages
   - **4.9 Monitoring**
     - 4.9.1 Stream Flow
     - 4.9.2 Wetted Distance
     - 4.9.3 Future Monitoring
   - **4.10 Accounting and Reporting**
     - 4.10.1 Flow Accounting
     - 4.10.2 Flow Reporting
   - **4.11 Adaptive Management**
     - 4.11.1 Adaptive Management Goals
     - 4.11.2 Adaptive Management Triggers
5. **Article V – Annual Fishing Derby**
6. **Article VI – Miscellaneous Provisions**
   - 6.1 Amendments
   - 6.2 Severability

Article I: Introduction

These administrative procedures describe how City staff will implement Section 25-13 SFCC 1987 to provide 1,000 AFY in target flows to the Santa Fe River.

As the City of Santa Fe has worked in recent years to further diversify its water supply portfolio, it has also worked on a range of initiatives to make substantial improvements along the Santa Fe River and within the river's broader watershed. These improvements have included forest management practices in the upper watershed; riparian rehabilitation projects along the entire river corridor; a variety of erosion control and storm water management projects; construction of significant new reaches of the Santa Fe River Trail; and enhancements within the City's parklands along the river's banks. Consistent with these efforts to protect the City's water supply, improve the drainage and hydrologic functions of the river system, support greenery, shade and wildlife habitat, and to beautify the corridor with aesthetic enhancements, the City also seeks to increase water flows in the river below the City's reservoirs.

A commitment to manage water resources in ways that allow for a programmatic approach to provide for water flows in the Santa Fe River is consistent with the City's Long Range Water Supply Plan (LRWSP). The LRWSP states that, "The City will provide water to maintain a living Santa Fe River, except under drought or emergency conditions." Further, the Plan states, "After the BDD (the Buckman Direct Diversion facility) is online in 2011 and barring legal restrictions, the City will, in accordance with public input, initially release approximately 1,000 AFY [acre feet per year] of water from the Santa Fe River canyon reservoirs to the Santa Fe River, except under drought or emergency conditions."

Following successful river flow programs that were implemented during 2009, 2010 and 2011, the City now seeks to formalize its commitment to provide for river flows in the Santa Fe River in future years. These Administrative Procedures, along with enabling legislation (City ordinance and resolution), establish an approach to codify and give guidance for the City's river flow commitment.

Prior year flows administered for the Santa Fe River yielded valuable information regarding the management of flow regimes; resulted in positive impacts within the riparian corridor; and were extremely popular with people who visited the river, experienced water flowing through the City, and sat or played along the river's banks. These Administrative Procedures address issues such as ideal and contingent flow scenarios; flow volume accounting procedures; adjustments to flow scenarios due to water surpluses or shortages; and other operational details.

Article II: Title, Authority, Applicability, Purpose & Interpretation

2.1 **Title.** Administrative Procedures for Target Flows in the Santa Fe River shall be cited and referred to herein as the "Administrative Procedures."

2.2 **Authority**. Administrative Procedures for Target Flows in the Santa Fe River are adopted pursuant to the Santa Fe River Target Flow Ordinance, Article 25-13 SFCC 1987 and Resolution No. 2012-____.

2.3 **Applicability**. Pursuant to the Santa Fe River Target Flow Ordinance, these Administrative Procedures apply to target flows on or after February 29, 2012, the date of adoption of the Santa Fe River Target Flow Ordinance.

2.4 **Purpose.**
Ord. No. 2012-10 directs the City of Santa Fe to bypass flow to the Santa Fe River downstream of Nichols Reservoir. These administrative procedures describe the means and methods by which the flows will be administered, monitored, measured, adapted to variable conditions and reported in order to ensure that the objectives for the flows are met to the greatest extent possible.

2.5 **Interpretation.**
These Administrative Procedures shall be liberally interpreted to accomplish the purposes set forth in Article 25-13 To the extent of ambiguity, omission or clear error in these Administrative Procedures, City staff and the flow manager shall have authority to interpret and clarify any such matter during implementation of these regulations and procedure so as to effectuate the intent of Article 25-13.

Article III - Definitions of Terms and Phrases

Defined Terms and Phrases. The following defined terms and phrases shall apply to the Administrative Procedures.

1. **"above McClure gage":** the stream gaging station 08315480 (or 08315479 for low flows) located above McClure Reservoir; this is the measuring point for flows entering McClure Reservoir.
2. **"acre-foot (af)":** a quantity or unit of water that is equal to the amount of water required to fill an area of 1 acre with 12 inches (i.e., 1 foot) of water; one acre-foot is equal to 325,851 gallons.
3. **"actual daily flow":** the daily rate of stream flow at the below Nichols gage as recorded by the flow operator.
4. **"annual target":** the quantity of water in af to be bypassed to the river based upon anticipated watershed yield, within the target year.
5. **"anticipated watershed yield":** the expected annual yield of water to the Santa Fe River and the municipal reservoirs within the Santa Fe River upper watershed, expressed as the percentage of the historical average; the anticipated watershed yield is estimated as of April 15th using the best available information including the amount of snow, both as depth (in inches) and snow-to water equivalent (in inches) at the weather stations in the upper watershed (Santa Fe and Elk Cabin); the Santa Fe Basin forecast predictions from Natural Resource Conservation Service (NRCS); weather forecast from the National Weather Service and NOAA; and any other pertinent appropriate weather-related information.
6. **"below Nichols gage":** the stream gaging station 08316505 located below Nichols Reservoir, or at a comparable location of measurement at or below the outlet from Nichols Dam; this is the measuring point for target flows administration under these Administrative Procedures.
7. **"Buckman Direct Diversion Project (BDD)":** a water supply project that provides water supply to the region using the San Juan Chama Project water and Rio Grande surface waters; the project began producing water in January of 2011 and is expected to be fully operational by July of 2011.
8. **"bypass constraint":** an operating principle that requires the rate at which water is passed through the outlet works of Nichols Reservoir dam is always equal or less than the stream inflow at the 'above McClure' gage.
9. **"bypass flows":** generally, water that flows past a diversion or storage facility. In these Administrative Procedures, it refers to water that the City chooses not to store in the municipal reservoirs and thus allows to flow to the Santa Fe River below Nichols Reservoir

provided that the rate at which the bypass flow is passed through the outlet works of Nichols Reservoir dam is always equal to or less than the stream inflow at the 'above McClure' gage.

10. **"critical-dry year":** a year in which the anticipated watershed yield is less than 30% of the historical average watershed yield.
11. **"critical-dry year hydrograph":** the graphical representation of the desired target flows in critically dry years in which the annual discharge is 300 afy.
12. **"cubic feet per second (cfs)":** a *rate* of water flow; one cubic feet per second equals two acre-feet per day and 0.65 million gallons per day
13. **"daily target flow":** the desired daily stream flow at the below Nichols gage.
14. **"dry year":** a year in which the anticipated watershed yield is between 30% and 75% of the historical average watershed yield.
15. **"dry year hydrograph":** the graphical representation of the desired target flows in dry years in which annual discharge is scaled down from 1000afy (to between 300 and 700 afy) based on decreased, anticipated watershed yield.
16. **"flow manager":** a member of City of Santa Fe staff responsible for managing releases of water to the River, record-keeping, reporting, and determining changes to daily target flows as prudent under adaptive management; the flow manager is the River and Watershed Coordinator, unless otherwise designated by the City Manager.
17. **"flow operator":** a water Division staff member responsible for making water utility system adjustments to meet the daily target flow and for measuring and recording the actual stream flow.
18. **"historical average watershed yield":** the average of annual yield of stream flow in the Santa Fe River within the Santa Fe River upper watershed as determined by stream flow measurements at USGS gage 08316000 (Santa Fe near Santa Fe) and USGS gage 08315479 and 08315480 (18-inch and 8-foot above McClure Reservoir, respectively); between 1914 to 2007 the average annual yield measured at Santa Fe near Santa Fe gage was 4,909 af.
19. **"hydrograph":** a graphic representation of the variation in stream discharge, in cubic feet per second, plotted against time.
20. **"municipal reservoirs":** the reservoirs on the Santa Fe River in the upper watershed - Nichols and McClure with 684 and 3,256 acre-feet of capacity, respectively.
21. **"natural hydrograph":** the graphical representation of stream flow as it varies over time in response to climatic (snow melt, precipitation) and man-made (storage, urban storm flow runoff) conditions. The natural hydrograph herein refers to the condition prior to the addition of the target flows governed by these Administrative Procedures, as measured on the Santa Fe River at the existing stream gage locations.
22. **"public process":** the public engagement and community outreach process through which the objectives for river flows were developed. From December 2010 through February 2011 input was gathered through conversations with over thirty stakeholders (including many River Commissioners) and two community meetings with over ninety, culturally and generationally diverse participants.
23. **"river":** The Santa Fe River reach that begins below Nichols Reservoir
24. **"release flows":** the flows from the outlet works of Nichols Reservoir that are discharged from Nichols dam in order to manage flood or potential flood flows.
25. **"spills":** flows from Nichols Reservoir that are discharged over the Nichols dam spillway when the reservoir is full.
26. **"target flows":** the daily, seasonal or annual amount of water (as a volume or a rate) desired in the river as measured at the below Nichols stream gage. The quantity is variably identified in various sections of the Administrative Procedures depending upon the anticipated watershed yield.
27. **"target hydrograph":** means the graphical representation of the daily target flow

necessary to provide up to 1,000 acre-acre of water in the Santa Fe River as measured at the below Nichols gage. The quantity of water is variably identified in several sections of the Administrative Procedures for Target Flows in the Santa Fe River depending upon anticipated watershed yield.

28. **"target year":** the period beginning April 15th and continuing through April 14th the following year; this definition allows the flow manager to adjust the target flows as necessary according to anticipated watershed yield from the mountain snow pack.
29. **"upper river":** the reach in the river for which target flows are maintained year-round to support all aspects of a healthy riverine and riparian ecosystem; at a minimum as far as Two-Mile Pond, and ideally, as far as the head gate for the Acequia Madre.
30. **"water service":** water provided to a customer through the municipal water utility system.
31. **"water service emergency":** a situation that would cause an interruption in the Water Division's ability to provide water service or that threatens public health and safety.
32. **"water system":** the water utility system owned and operated by the City, and includes without limitation all the physical plant, wells, pumps, transmission and distribution facilities, water treatment facilities, storage facilities and all water rights and rights to water owned by the City for use in its water utility.

Article IV – Administrative Procedures

4.1 Objectives

4.1.1 Target Flow Objectives

a) Create an ecologically healthy vegetative corridor
b) Benefit the entire community with flows (e.g., equity)
c) Nurture a beautiful, natural urban greenspace with water in an arid environment
d) Provide an educational resource for schools and steward the resource for the community

4.1.2 Adaptive Management to Address Objectives and Purpose

The hydrographs presented in these Administrative Procedures provide guidance, or examples, for the administration of flows in a manner that meets the objectives and purpose of the target flows. Actual flows may be adjusted in response to watershed yield forecasts, evolving seasonal conditions and/or feedback from monitoring. When changes to daily target flows are necessary or merited (i.e., adaptive management), the flow manager and/or flow operator shall take into consideration the objectives identified above and the purpose identified for the various components of the hydrographs.

4.2 Target Hydrograph and Target Flow Seasons

4.2.1 Target Hydrograph and Target Flows

The target hydrograph (Figure 1) contains stream flow targets in cfs and af and a schedule for increasing and decreasing flows. The total volume of the target hydrograph is 1,000 afy. The target hydrograph will be adjusted in dry and critical-dry years to conform with the dry year hydrographs and critical-dry year hydrograph as described in Section 3. The schedule is approximate and subject to modification under the guidelines in the Article 4.11: Adaptive Management.

The target hydrograph includes the following aspirational goals:

- **Low Flows for the Upper River.** Flows are 0.3 cfs during the colder season from mid-

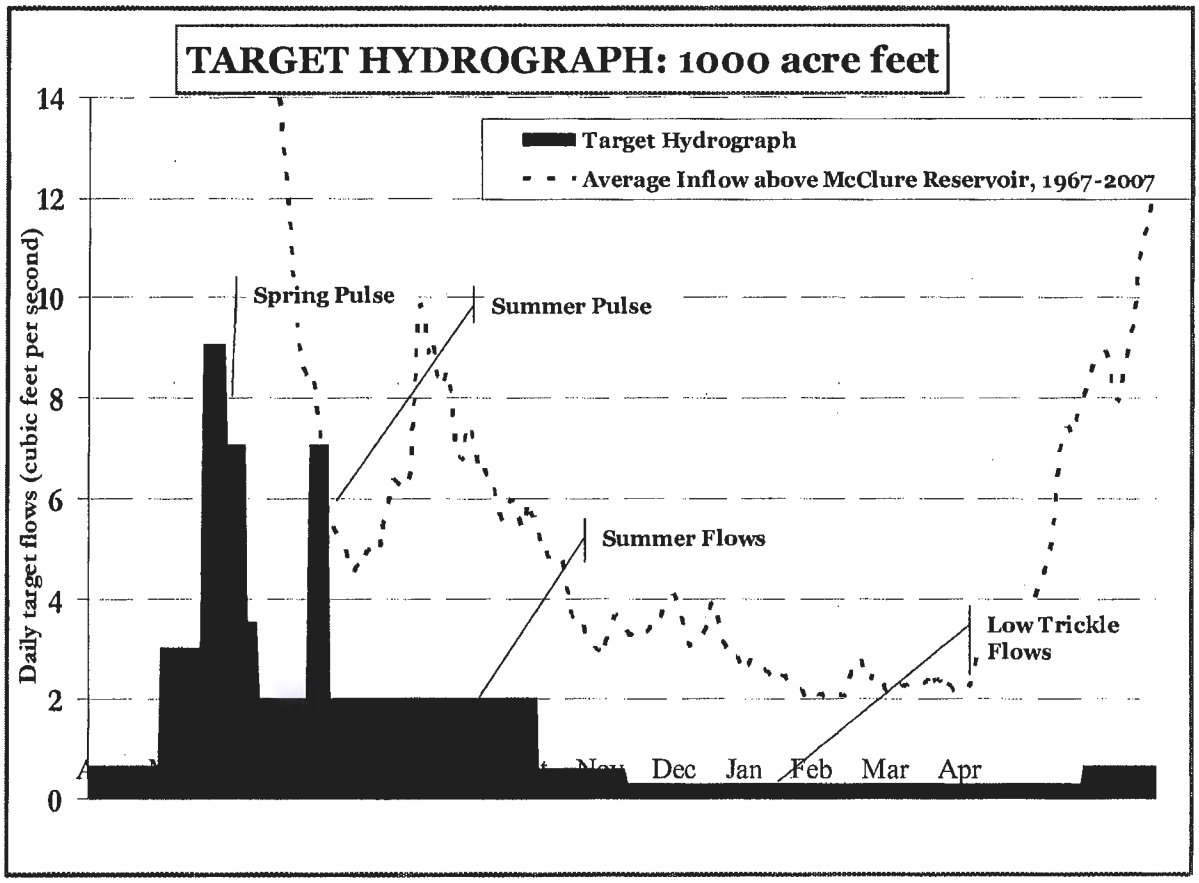
October to mid-March when vegetation is dormant. Flows increase to 0.6 cfs from mid March to early May and from mid-September to mid-October. The purpose of the mid-September to early May flows is to provide for flows in the upper river to:

- support plant life with irrigation and maximize riverine and riparian ecological health;
- recharge ground water, subsurface flows and bank storage during periods of plant dormancy to increase availability of water in the warmer months;
- maintain a wet environment to support the life cycles of macroinvertebrates;
- recharge local groundwater and sub-surface flows;
- ensure a wetted river bed so that spring and summer flows will travel farther and more efficiently along the river course.

- **Spring Pulse.** Flows are 3 cfs for two weeks beginning in early May, then increase to 9 cfs for a week following, and then drop to 7 cfs for a week in early June. The purpose of the spring pulse is to provide as much water to the river reach (including San Ysidro crossing and the intersection with Route 599) as feasible. The timing and magnitude of the spring pulse is designed to provide necessary flows through downtown for the Fishing Derby and River Festival and for the blessing of the river in the village of Agua Fria around the day of San Ysidro, patron of the crops. The purpose of the spring pulse is to:
  - mimic natural spring runoff that is provided by the melting of accumulated winter snows;
  - irrigate the trees and other vegetation along the river corridor to support the typical spring time activities within tree/plant (and faunal) annual life cycles as plants are beginning to draw water, beginning to produce buds and leaves;
  - extend surface water flows as far as possible with the objective of reaching beyond the San Ysidro crossing down to the City's Waste Water Treatment Plant;
  - recharge local groundwater and sub-surface flows;
  - continue the process of ground water recharge that will benefit plant life into the summer months.
- **Summer Flows.** Flows are an average of 2 cfs from mid-June to mid-September. The flow manager may increase or decrease the flow rates to meet flow objectives, with particular regard for major events in Santa Fe, provided that the average is maintained and flows are not reduced below .3 cfs.

  The purpose of the summer flows is to:
  - provide flows through downtown, and the Santa Fe River Park, for aesthetic and social benefit;
  - supply irrigation to enhance the river's function as an appealing urban greenbelt;
  - recharge local groundwater and sub-surface flows;
  - maintain the wetted river bed so that flows from rainfall events will travel downstream farther and more efficiently.
- **Summer Pulse.** Flows are 7 cfs for one week in early July. The purpose of the summer pulse is to:
  - push flows once again downstream to San Ysidro Crossing and the river's intersection with Route 599 during the hot and dry periods in advance of the summer monsoon rains;
  - sustain vegetation during the hottest time of year, with moisture for new/germinating seedlings, and ultimately enhancing the river corridor as an appealing urban greenbelt;
  - provide flows for river bank irrigation and wetting of the river bed in the period between spring runoff and the likely arrival of monsoon rainfall.

Figure 1



4.3 Dry and Critical-Dry Year Target Flow Reductions

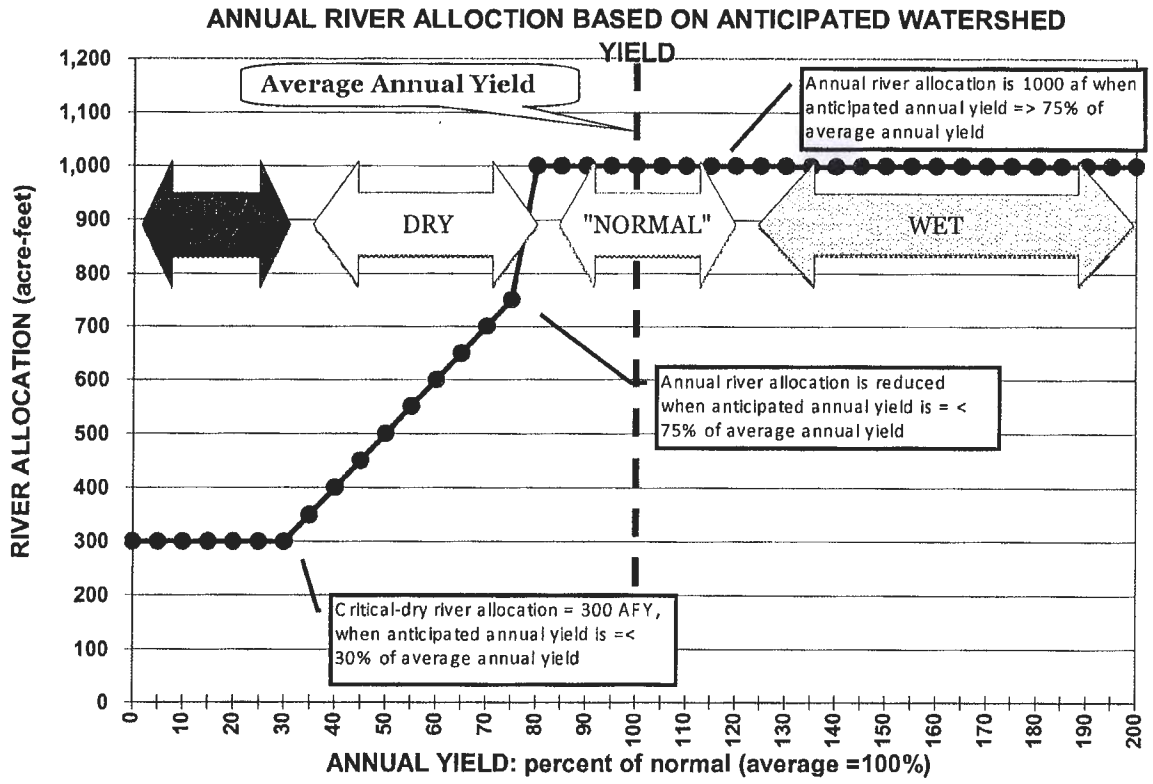
4.3.1 Reduction of Target Flows in Dry and Critically Dry Years

A dry year is defined as a year in which the anticipated watershed yield is equal to or less than 75% but greater than 30% of historical average. A critical-dry year is a year in which the anticipated watershed yield is equal or less than 30% of the historical average. In dry and critical-dry years, the total volume of the target hydrograph (1,000 af) will be reduced, by multiplying 1,000 by the percentage of the anticipated watershed yield:

$$TargetHydrograph \times AnticipatedWatershedYield_{yearX} = target\ flows_{yearX}$$

For example, in a year where the anticipated watershed yield is 65% of average, the target flow for the target year is calculated by 1,000 afy x 65% = 650 af. The reduction calculation is depicted graphically in Figure 2.

Figure 2



4.3.2 **Dry Year Hydrographs**

In dry years, the flow manager will allot the timing and magnitude of the daily target flows in a manner consistent with the following guidelines:

(a) reduction in summer flows,

(b) scaling-down – but not eliminating – the spring pulse and,

(c) reduction in low flows from 0.30 cfs to 0.15 cfs.

The timing and magnitude of dry year target flows for 700 af, 600, afy, 500 afy, and 400 afy are described in the Dry Year Hydrographs in Appendix A.

While scaling back the quantity of the annual target flow in dry years, the priority is to provide for spring and summer pulses to fulfill the purposes of the pulses as outlined for the 1000 afy target flow in section 4.2.1 above.

4.3.3 **Critical-Dry Year Hydrograph**

In critical-dry years, in which the total target flows equal 300 af per target year, the daily target flows will be managed in a manner consistent with the following guidelines and as illustrated by Figure 3:

a) sustained low flows of 0.15 cfs,

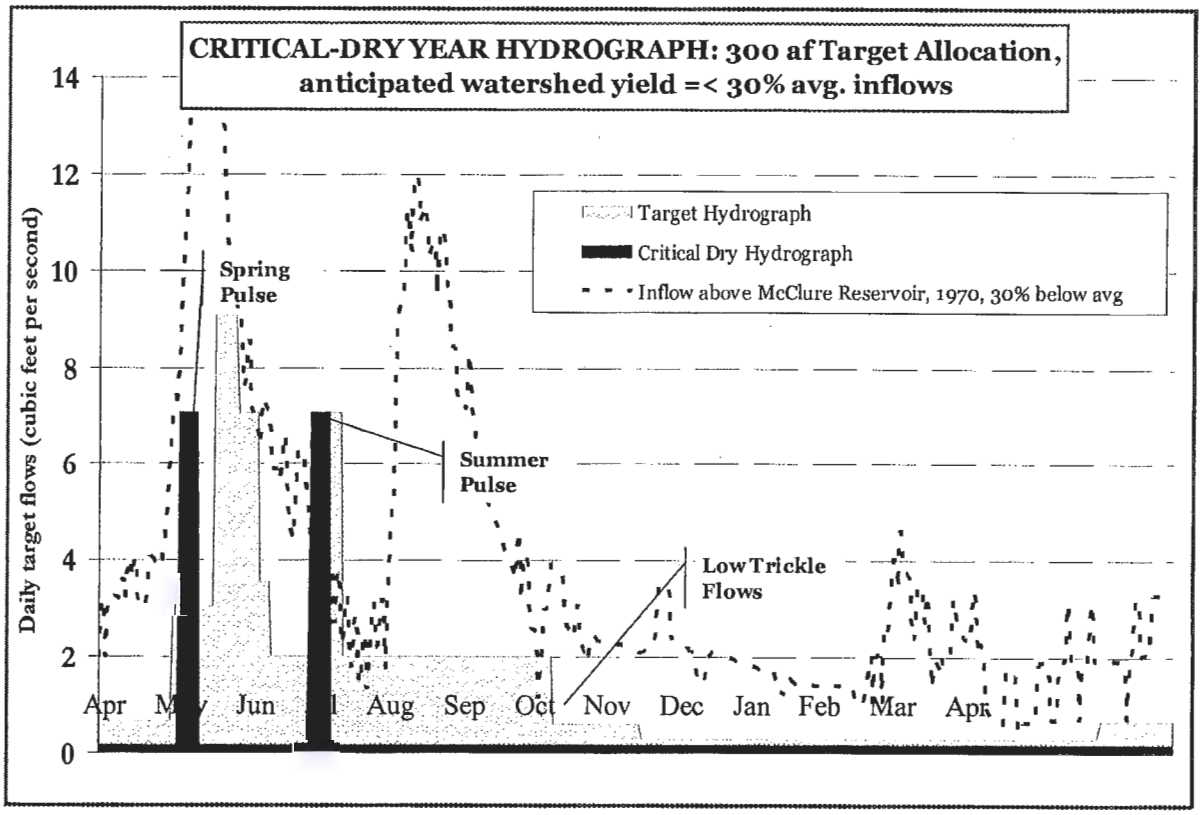
(b) one spring and one summer pulse, each of approximately 100 afy.

The schedule of the pulses shall generally follow the timing of the pulses in the target

hydrograph. The magnitude of the pulses shall be approximately 7 cfs, provided that the daily target flows are within the bypass constraint. The river shall retain flows of at least 300 afy barring an emergency or unforeseen infrastructure constraint (e.g., failure of Nichols's Reservoir outfall structure). The purpose of the critically dry year hydrograph is to maintain a wet corridor in the upper river for riverine and riparian ecological benefit while providing two downstream pulses for the purposes of the pulses as outlined for the 1000 afy target flow in section 4.2.1 above.

In critical-dry years, since the daily target flows for the Fishing Derby cannot be reliably met, the Fishing Derby will be suspended.

Figure 3



4.4 Wet Year Flows

During wet years, defined as when the anticipated watershed yield is greater than the historical average, the river will be allocated water according to the target hydrograph (e.g., 1,000 afy) in the target year. In wet years, the actual daily flows will likely be greater because of flow contributions from reservoir flood management, and because of greater flows within the urban watershed. These greater daily flows will meet many of the objectives described in Article 4.1. Furthermore, the irrigation needs of the river corridor will be supplemented by the above-average spring precipitation. By not increasing the target hydrograph in a wet year, in wet years the City may be able to put the full amount of the City's Santa Fe River water rights under License 1677 to beneficial use and thus rest the City's well fields and use of local groundwater resources.

4.5 Management and Accounting of Releases and Spills

4.5.1 Management of Municipal Reservoir Flood Flows

The City manages the municipal reservoirs in part, in a way that protects the river and the urban watershed from floods. Flood management includes both the capture of peak inflows from the upper watershed and the management of release flows and spills from Nichols and McClure Reservoirs.

Pursuant to Article 25-13 SFCC 1987, the flow manager and flow operator are directed to manage, as much as possible, the release of flows and spills in a manner consistent with the target hydrograph and the objectives herein. This includes:

a) matching the timing and magnitude of the flows,
b) scaling the additional release flows in a manner which increases the magnitude of the spring pulse
c) discharging the release flows in a manner to augment the magnitude of the low flow.

4.5.2 Accounting of Releases and Spills vis-à-vis the Target Hydrograph

Water that is released and/or spilled for flood management will count toward the daily target flows and target hydrograph, when the flows are within the daily target flows of the target hydrograph. If water greater than the daily target flows is released or spilled into the river, the quantity of water that exceeds the daily target flow will not be counted toward the 1,000 afy of the target year. For example, if the total planned target flow for a period of May 20 to June 3 is 300 af, but necessary reservoir management results in actual flow of 1,000 af, then 300 af shall be counted toward the planned commitment and 700 af shall not be counted, provided that the 300 af met the daily flow targets desired under the target hydrograph.

The purpose of allowing water spilled or released to count toward the 1,000 af target hydrograph is so that the municipal water utility can store excess water in wet years for water supply to compensate for the additional use of groundwater required in critically dry years. The water released or spilled in excess of the target hydrograph and daily target flows cannot be stored and released for the river later in the season because of the water right and storage limitation discussed in the next section.

4.5.3 Except as described above in section 4.5.2, the 1000 acre-feet volume of water shall not include water released for any other purpose at the time of release.

4.6 Water Rights

4.6.1 Use of the City's Santa Fe River Water and Storage Rights

The City is not using any of the water rights under License 1677 and Declaration No. 01278 to comply with Article 25-13 SFCC 1987. The City will continue to periodically put all the water rights under License1677 and Declaration No. 01278 to beneficial use.

4.6.2 Bypass Constraint

In order the assure that the administration of Ord. No. xxxx does not adversely interfere with the storage, diversion and use of water under License 1677 and Declaration No. 01278, the flow manager and flow operator will manage the daily target flows in a manner such that the target flows will not come out of water stored under License 1677 and Declaration No. 01278 in the municipal reservoirs. This means that the City will not discharge water to the river that it has stored. To accommodate this constraint, the flow operator will regulate the daily target flow in a

manner such that discharges from Nichols Reservoir to the river shall not be greater than the daily inflow into McClure Reservoir; hence the flow operator will only bypass water for daily target flows.

4.6.3 Recognition of Other Surface Water Right Users

The City recognizes that there are other surface water right holders of Santa Fe River surface water, including those with partially adjudicated rights. Nothing in these Administrative Procedures should be construed to define, manage or be in conflict with the valid rights of other surface water right holders.

4.7 Management and Operational Procedures

Management and administration of daily target flows to the river require participation by the flow manager, flow operator, the Water Division director, other Water Division staff, and the River Commission Chair to ensure that flows are released in a timely manner according to the target hydrograph, dry year hydrographs, or the critically dry year hydrograph.

4.7.1 Flow Management

The flow manager, in consultation with the Water Division staff, shall be responsible for determining the quantity of water allocated to the target year based on the anticipated watershed yield. The flow manager will also determine the daily target flows of the target hydrograph, or deviations therefrom based on the anticipated watershed yield, by fitting the annual target and associated hydrographs to the upcoming target year. The flow manager will annually present the hydrograph for the upcoming target year to the River Commission at its April meeting for review. The flow manager will provide a copy of the target year hydrograph to the Water Division Director, the Water Division source of supply manager and the Level Four operators at the Canyon Road Water Treatment Plant for implementation.

When necessary, the flow manager may alter the daily flow targets in a manner consistent with the adaptive management objectives described in Section 11. These alterations may incorporate consultation with the River Commission Chair or designee, the flow operator, and the Water Division director. The flow manager will be the city's river and watershed coordinator or another member of city staff designated by the city manager. All adjustments to the daily target flow shall be made via email to the Water Division Director, the Source of Supply Manager, the Canyon Road Water Treatment Plant Level 4 Operators. The River Commission Chair shall be copied (cc:) on all communications directing the adjustment of daily target flows.

4.7.2 Flow Operations

The flow operator shall be the Water Division Source of Supply staff person on duty and responsible for controlling the daily release rates. The flow operator will adjust the discharge water from Nichols Reservoir in accordance to the daily target flow, and record the actual daily flow at the below Nichols gage. The flow operator may reduce the daily flow target to match daily inflow at the McClure reservoir, should the daily flow target exceed the daily inflow.

4.7.3 Flow Adjustment Infrastructure

The flow operator adjusts the daily target flows for the river by regulating the "splitter box" valve at the Canyon Road Water Treatment Plant control panel, and then sending a system operator to the below Nichols gage to see what effect the adjustment had on the actual instantaneous flow. Because of the cumbersome nature of this procedure, the daily flow targets in these Administrative Procedures are adjusted no more than weekly. Should, in the future, the outlet works be reengineered to be more nimble, and the below Nichols gage provide real time data, the daily target flows may be managed and adjusted more frequently, in particular in response to

climatic conditions.

4.8 Emergencies and Flow Adjustment

To help prevent an interruption in water service and to protect public health and safety, target flows to the river may be adjusted during a water emergency. Upon implementation of a Water Emergency Management Plan, target flows to the Santa Fe River will be adjusted pursuant to Chapter 25-5.6 and Exhibits C (Water Warning Orange) and D (Water Emergency – Red) SFCC 1987.

4.8.1 **Water Emergency Implementation Stages**

If the operational water system supply as determined by the water division director's sole discretion, equals between eighty percent (80%) and ninety-nine percent (99%) of operational water system demand, the city manager may declare a "Water Warning - Orange" water emergency implementation stage. If the operational water system supply as determined by the water division director's sole discretion, is less than eighty percent (80%) of operational water system demand, the city manager may declare a "Water Emergency - Red" water emergency implementation stage.

Chapter 25-5, Exhibit C (Amended: November 30, 2011 by Ord. No. 2011-38) states that under "Water Warning – Orange" water emergency implementation stage, target flows to the Santa Fe River may be suspended.

Chapter 25-5, Exhibit D (Amended: November 30, 2011 by Ord. No. 2011-38) states that under "Water Emergency – Red" water emergency implementation stage, target flows to the Santa Fe River shall be suspended.

4.9 Monitoring

The City shall monitor the impacts of providing daily target flows to the river, to determine whether the objectives identified in Section 4.1 are being met. Monitoring will provide the feedback necessary for the flow manager to institute adaptive management as identified in Article 4.11; and/or to amend these Administrative Procedures to ensure that the objectives and purposes of the target flows are being met to the fullest extent possible. City staff will coordinate and collaborate with community volunteers, local non-governmental organizations and other agencies to implement a monitoring program.

4.9.1 **Stream flow**

The City will continue to monitor stream flow (in cfs) at 15 minute increments at the below Nichols gage and the above St. Francis gage. Each of these gages will be calibrated periodically to assure high quality data.

4.9.2 **Wetted Distance**

The City, in conjunction with community volunteers and cooperating agencies, shall develop a methodology by which the distance the daily target flows have traveled can be measured.

4.9.3 **Future Monitoring**

The City shall consider additional river monitoring that will assist in adaptive management and in determining appropriate daily target flows in the future. Potential parameters include:

Soil moisture: to understand the water available for riparian vegetation under varying daily target flows, hydrographs, and climatic conditions;

Ecological health indicators: the presence, location, and characteristic of flora and fauna in the river corridor;

Storm flow peak: to understand if or the how the target flows have altered the timing and magnitude of urban storm runoff;

Water quality: to understand if or the how the target flows have altered the water quality in the river;

Surface water infiltration: to understand the temporal and spatial distribution of stream flow loss;

Surface/ groundwater interaction: to understand the fate of stream flow infiltration, and the contribution, if any, of groundwater to surface water.

4.10 Accounting and Reporting

4.10.1 Flow Accounting

The flow manager, with data provided by the Water Division and flow operator, shall account quarterly for the volume of water released per target year at the below Nichols gage using the assumption that all water passing the gage has either been discharged pursuant to Article 25-13 SFCC 1987, spilled or released. The flow manager shall make adjustments as necessary to manage the target year water allocation. The basis of the volumetric accounting will be the official below Nichols gage record, and shall identify the periods of time during which flow estimates were estimated (missing stream flow data results from frozen equipment, battery failure, equipment vandalism, etc). Interim estimates can be made using the actual daily flow as recorded by the flow operator and reported on the daily water report. Released or spilled water shall be accounted as described in Section 5.

4.10.2 Reporting

The City shall endeavor to keep elected officials, the River Commission, the city manager, the Water Division director and the public informed regarding the activities associated with Article 25-13 SFCC 1987. The reports outlined below identify specific reporting recommendations.

Report on Annual Target and Hydrograph for Upcoming Year

After April 15th, the flow manager will report by email to the River Commission, the Water Division director, Public Utilities Committee and the city manager the target year hydrograph based on the anticipated watershed yield. The report shall include the relevant information on which the anticipated watershed yield was based (e.g., NRCS basin forecasts, snow-to-water equivalent from SNOTEL sites in the upper watershed, climate predictions for the National Weather Service and NOAA). The target year hydrograph will be posted on the City's website.

Annual report

At the end of each year, the flow manager shall prepare reports which describe the previous year's activity relevant to Article 25-13 SFCC 1987. For the previous target year the report shall include the daily actual stream flow data (daily mean and cumulative), the annual volume released, and annual flow, a summary of routine or special activities along the river (e.g., Fishing Derby, River Festival) a description and explanation of deviations from the target hydrograph, observations or recommendations related to adaptive management, and an estimate of the amount of groundwater pumped to accommodate the daily target flows. For the current target year, the

report shall include the annual target quantity and the target hydrograph. The flow manager will submit the report to the River Commission, the Public Utilities Committee, the City Council, and post the report to the City's website.

Periodic Actual Stream Flow Report
The flow operator and Water Division staff will record and track actual daily flow at the below Nichols gage in an Excel-compatible spreadsheet. The flow operator shall send the electronic spreadsheet to the flow manager approximately monthly.

Daily Water Report
The flow operator and Water Division staff will report actual daily flow at the below Nichols gage on the Daily Water Report, which is emailed to any interested party and posted on the City's website.

4.11 Adaptive Management

4.11.1 Adaptive Management Goals

The goal of Article 25-13 SFCC 1987 is to provide for flows in the river, while providing the City with flexibility in managing both the water supply system and river flows. The target hydrograph, dry year hydrographs and critically dry year hydrograph are designed to match Article 25-13. \, and these Administrative Procedures, that the flows to the river be managed in a manner to optimize the benefits of the flows to meet the objectives. Hence, these procedures allow for and encourage adaptive management, provided that the annual target is not impacted.

4.11.2 Adaptive Management Conditions and Considerations

The following conditions and considerations may influence or provide cause for adaptive management:

a. High flows or flood risk
b. Timing, intensity and/or scale of monsoon events
c. Periods of exceptionally dry weather
d. Scheduled community events
e. Maintenance/improvement work within the river channel or on water supply infrastructure
f. Maintaining daily target flows equal or below inflow into McClure Reservoir
g. Feedback from monitoring data
h. Change in snowpack or watershed yield conditions (e.g., late snowfall) after the beginning of the flow year

5. Annual Fishing Derby

The City of Santa Fe's Annual Fishing Derby takes place each year on the first Saturday in June. The Fishing Derby provides opportunities for children and families to join with neighbors to experience a fun and engaging day by the river, to learn about the Santa Fe River and riparian ecology, and to learn fishing skills.

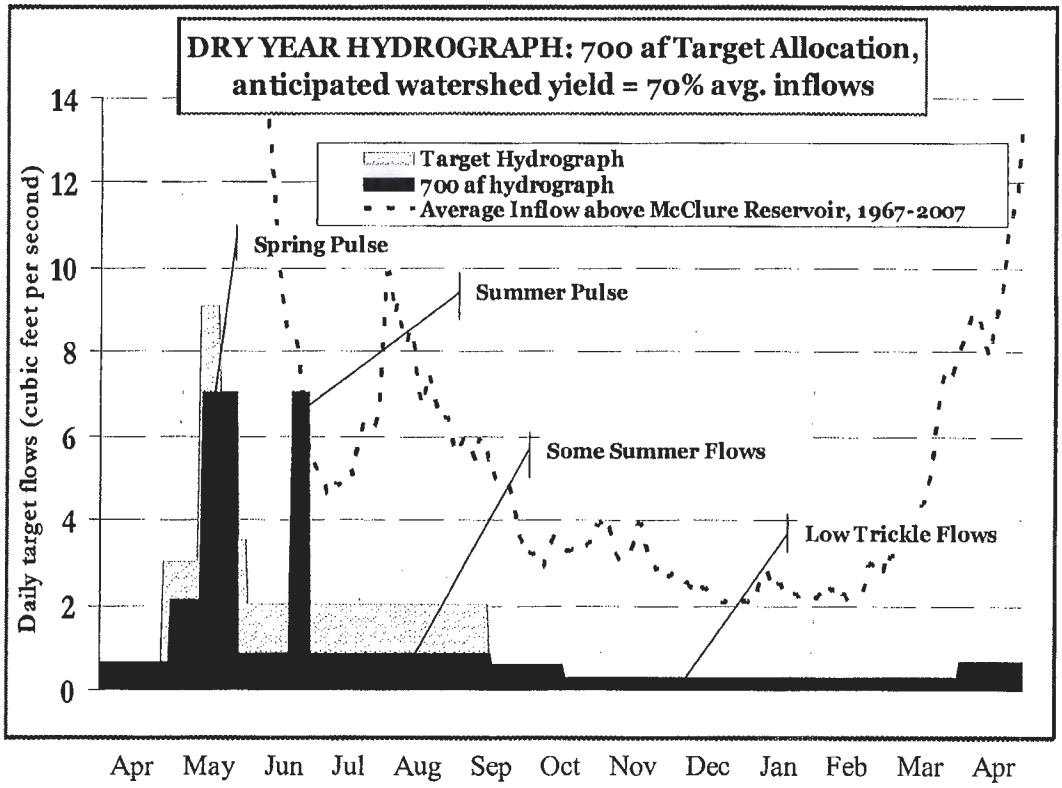
In dry years when the anticipated watershed yield is less than 50%, or, if for other climatic or hydrologic reasons daily target flows adequate for the Fishing Derby cannot be met, the Fishing Derby will be suspended.

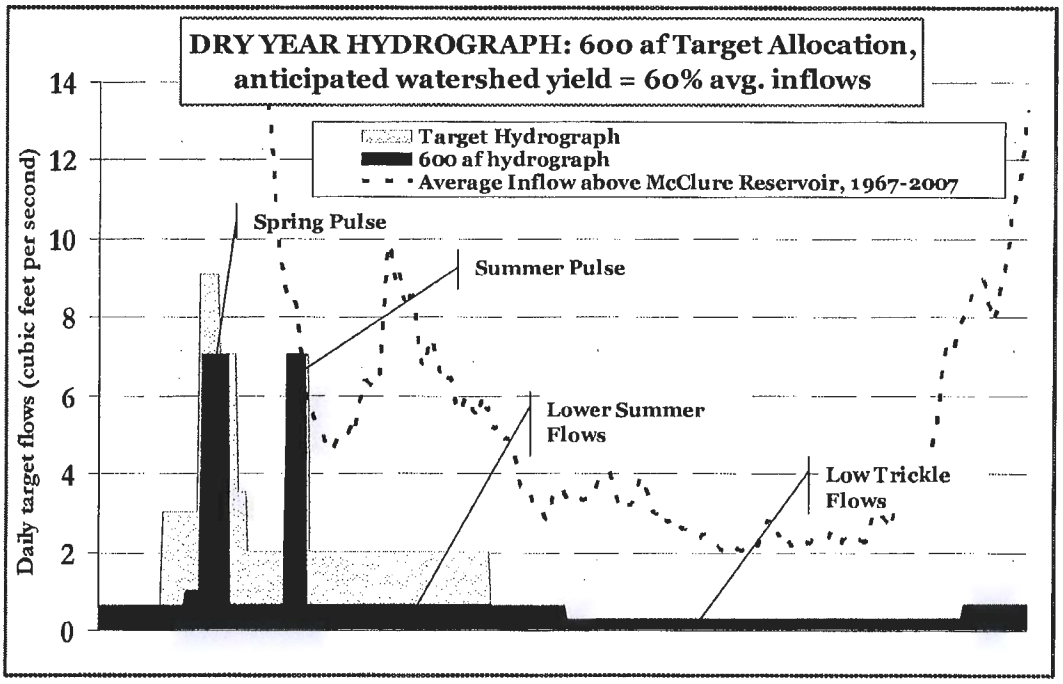
6. Miscellaneous Provisions

6.1 **Amendments.** These Administrative Procedures may only be amended pursuant to a duly adopted resolution of the Governing Body.

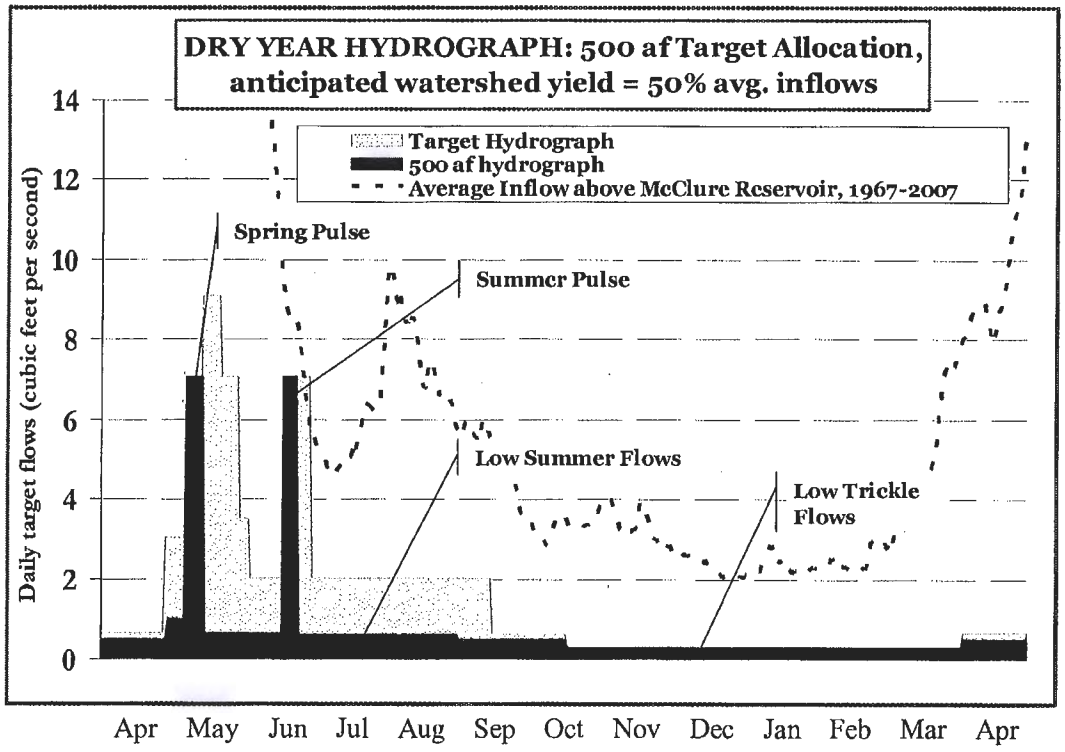
6.2 **Severability.** In the event that a court of competent jurisdiction shall determine that any provision these Procedures are invalid, unlawful or unenforceable, the remainder of these Administrative Procedures shall remain in full force and effect.

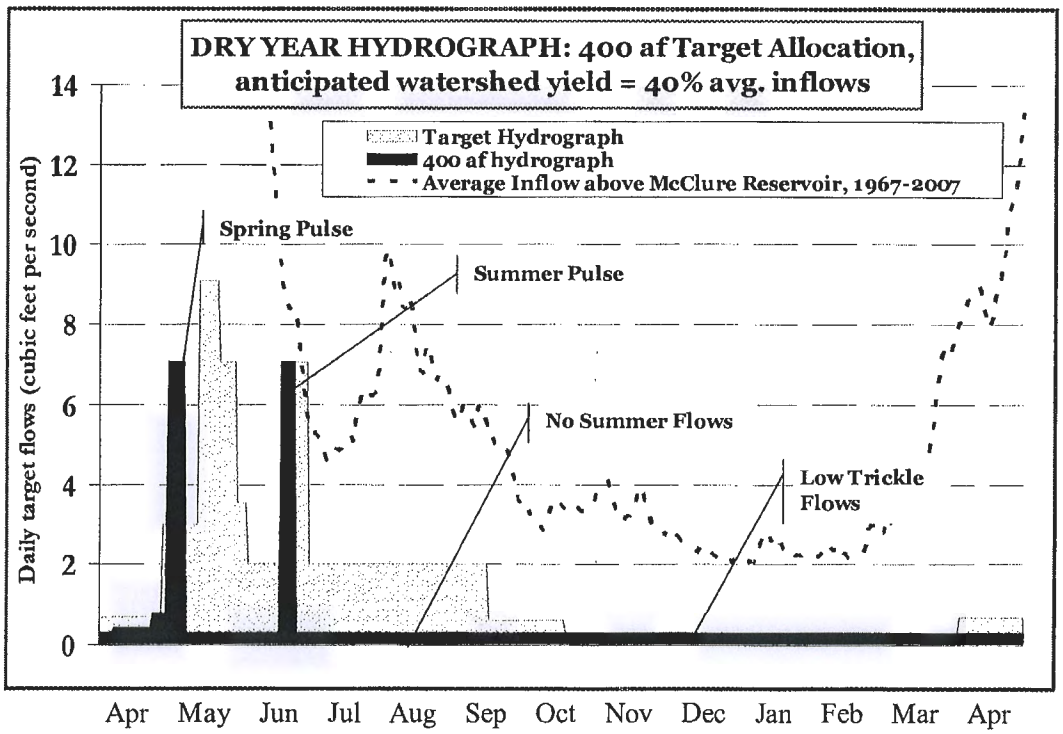
Appendix A
Dry Year Hydrographs





Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr





APPENDIX M

City of Santa Fe
Santa Fe River Projects

	Project	Year Completed		Cost (approx)
1	CIP #460D SF River Trail/E. Alameda Ped	2016	$	450,000.00
2	CIP 412A, Bishop's Diversion and St. Francis Grade Control Structures	2013	$	135,000.00
3	CIP 413 B, Santa Fe River Park /Parque del Rio	2013	$	1,800,000.00
4	CIP 823, DeFouri and Guadalupe Bridges	2017	$	1,300,000.00
6	CIP 920 St. Francis Channel Improvments	2000	$	1,900,000.00
7	CIP # 460B-2, SF River Trail Phase Two	2017	$	680,000.00
8	Alameda Rain Garden at Sicomoro; Cathedral; Escondido	2017	$	75,000.00
9	CIP 500 B, River Restoration Phases 2 and 3	2013	$	3,700,000.00
10	C412 A, Camino Alire Grade Control Repair	2017	$	260,000.00
11	CIP 500B, Crossvane Repair	2016	$	300,000.00
12	CIP 428 A, Nopal Drainge Improvement	2016	$	150,000.00
13	CIP 455 A, Bank Improvements and Erosion Control	2015	$	250,000.00
14	**Santa Fe County** Greenway Project: Trail and Channel Improvements	2017	$	4,000,000.00
			$	**15,000,000.00**

Proj 1
Proj 2
Proj 3
Proj 4
Proj 6
Proj 7
Proj 8
Proj 9
Proj 10
Proj 11
Proj 12
Proj 13
Proj 14

Santa Fe

1,000 500 0 1,000 Feet

N

Date: 11/30/2016
Prepared By: ASD/ITT/GIS DSB
Coordinate System:
NAD 1983 StatePlane New Mexico Central FIPS 3002 Feet
Datum: North American 1983

This information is for reference only. The City of Santa Fe assumes no liability for errors associated with the use of these data. Users are solely responsible for confirming data accuracy when necessary.

Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

APPENDIX N

BYPASS FLOWS IN THE SANTA FE RIVER
PUBLIC FACILITATION & COMMUNITY OUTREACH

Reports, Notes and Related Documents

2.23.11

Submitted by:
Toby Herzlich of Toby Herzlich & Co
Erin English, PE LEED AP, of Natural Systems International

NATURAL SYSTEMS INTERNATIONAL
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Santa Fe, NM 87507
(505)-988-7453
www.naturalsystemsinternational.com

TOBY HERZLICH & COMPANY
119 La Joya Rd
Santa Fe, NM 87501
(505) 984-1284

TABLE OF CONTENTS

BYPASS FLOWS IN THE SANTA FE RIVER
PUBLIC FACILITATION & COMMUNITY OUTREACH
Reports, Notes and Related Documents
2.23.11

1. Cover Letter
2. Summary
3. Report of Recommendations
4. Additional Considerations
5. Stakeholder Interviews Summary – January 4, 2011
6. Community Meeting #1 Notes – January 13, 2011
7. Community Meeting #2 Notes – February 3, 2011
8. Core Working Group Meeting #1 Notes – January 4, 2011
9. Core Working Group Retreat Agenda – January 21-22, 2011
10. Core Working Group Retreat Notes – January 21-22, 2011
11. Core Working Group Retreat: Flip Chart Notes – January 21-22, 2011
12. Core Working Group Contact List
13. Community Meeting #1 Sign-In Sheets
14. Community Meeting #2 Sign-In Sheets

February 23, 2011

Brian Drypolcher
River and Watershed Coordinator
City of Santa Fe
PO Box 909
Santa Fe, NM 87504

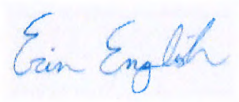
Dear Brian,

Toby Herzlich & Co and Natural Systems International have compiled the following documents from the Public Facilitation & Community Outreach Process for the "Bypass Flows for the Santa Fe River – 1000 AFY" project. We feel that the community and key stakeholders were successfully engaged through this public process and we hope that these results prove useful to the City as you move to approve an ordinance and administrative procedures.

We have also provided a digital draft of administrative procedures that are based upon the recommendations in this document, copies of the flow hydrograph/calculations and digital versions of this report.

We have enjoyed working with the City through this process and wish you the best of luck in moving forward from here.

Regards,



Toby Herzlich & Erin English

THE QUESTIONS – AND HOW THE PROPOSED FLOW HYDROGRAPH ADDRESSES THEM

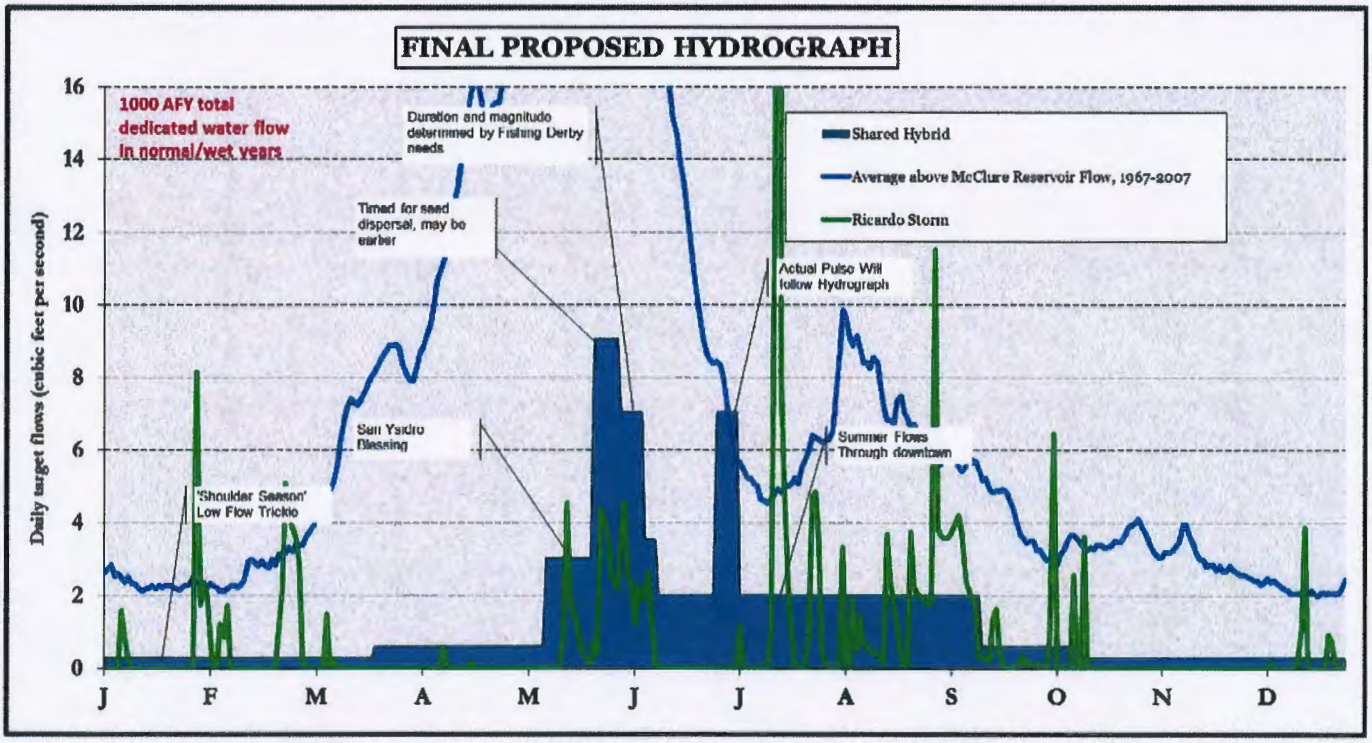
1. *Community Objectives for 1000 AFY Flows?*
    a. Create an Ecologically Healthy Vegetative Corridor
    b. Benefit the Entire Community with Flows
    c. Nurture a Beautiful, Natural Urban Greenspace w/ water in arid environment
    d. Provide an Educational Resource for Schools & Community Stewardship
2. *Target Flow Season? Start/End Dates?*
    a. Year-Round Trickle during 'Shoulder Seasons' (Jan-Mar & Oct-Dec)
    b. Spring Pulse to San Ysidro/Rt. 599 (Mid May-Mid June)
    c. Summer Flows through Downtown (Mid June-Mid Sept)
    d. Summer Pulse to San Ysidro/Rt. 599 (Early July)
3. *Preferred Flow Regime? Desired Flow Season Hydrograph?*
    a. See Target Flow Season/Start-End Dates above.
    b. The proposed hydrograph represents an average; operators need the flexibility to shift pulses, dates and minimum flows based upon seasonal triggers such as seed dispersion, community cultural events, snowpack levels and monsoonal storm activity.
4. *Adjustments during dry years?*
    a. The proposed general philosophy is to support flow in the River even during dry years/drought.
    b. 1,000 acre-feet annual dedication will be maintained in conditions equal or greater to 75% of average watershed yield.
    c. When watershed yield drops to levels 75% or lower of average snowpack on April 15th, the 1000AFY will be proportionately reduced according the percentage of average watershed yield. For example, in a year with a 55%-below-average-yield, the water dedicated to the River will be: 1000 AFY x 55% = 550 acre feet.
    d. In extremely dry years, defined as watershed yield <30%, flows will be kept at a minimum amount needed for two 100 acre-foot pulses, plus year round flows of 0.15 CFS, for a total of approximately 300 AFY.
5. *What constitutes an 'emergency' to suspend that flow?*
    a. Flows may be adjusted or curtailed by the City Water Division in response to an emergency situation: to prevent an interruption in water service and to protect public health and safety.
6. *Adjustments during wet years?*
    a. Flows will not be increased above 1000 AFY, but 'spills' may provide additional flows in the River. Any water 'spilled' may count toward the dedicated flow for that day or period, but will not substitute for dedicated flows scheduled before or after the 'Spill' period.
    b. The reason that a portion of some spills are counted toward the 1000 AFY is to balance benefits between wet and dry years, allowing the 'resting' of groundwater wells during the wet years and dedication of water to the River in drought years.
7. *Other Considerations*
    a. Working toward water management agreements with local Acequia associations.
    b. Infrastructure improvements for controlling and measuring water releases from Nichols Reservoir more efficiently.

NORMAL & WET YEAR FLOW HYDROGRAPH

Note: 1 cubic-foot-per-second (cfs) = 448 gpm and 1 acre-foot (AF) = 325,851 gallons

1. **Low Trickle Flows during "Shoulder" Seasons** (0.3 CFS from Jan 1-Mar. 20 & Oct. 15-Dec. 31) to support upper watershed section as an ecological refuge. Increase flows to 0.60 CFS from Mar. 21-May 9 & Sept. 15-Oct. 14.
2. **Spring Pulse** (3 CFS May 10-23, 9 CFS from May 24-31 and 7 CFS from June 1-7) to push flows downstream to San Ysidro Crossing/Rt. 599 and create substantial flows through downtown. Spring Pulse helps distribute tree/plant seeds, moisten the river channel, keeps downstream trees alive and also coincides with the Fishing Derby/River Festival and the San Isidro River Blessing.
3. **Summertime Low Flows** (average of 2 CFS June 14-Sept. 14) through downtown to enhance the public's greenspace.
4. **Early Summer Pulse** (7CFS from July 1-7) to push flows once again downstream to San Ysidro Crossing/Rt. 599 during one of the hottest and driest periods in advance of monsoon season rains. The Early Summer Pulse is crucial to sustain vegetation and provide moisture for new/germinating seedlings and enhanced public greenspace.

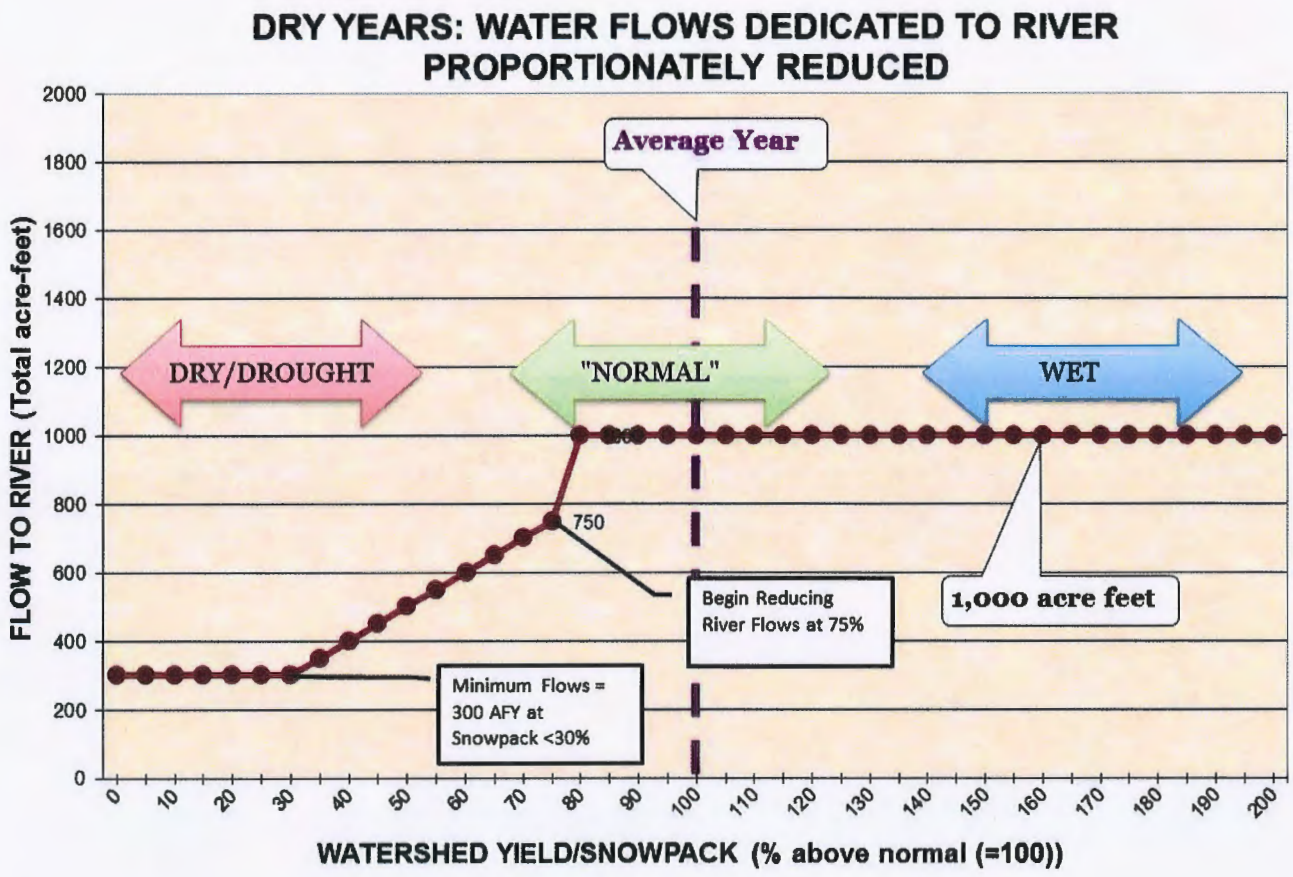
The legal constraint on the City's allocation of water to the River is limited by the rate of inflow to the reservoir. The rate at which the City bypasses water to the River (in CFS) cannot exceed that flowing into McClure Reservoir.



DRY YEAR FLOW REDUCTIONS

During Dry Years (defined as <75% of average snowpack on April 15th), the City will proportionately reduce flows to the River according to the graph and table below. If average snowpack levels are very low (<30% of average), dedicated flows will be reduced to approximately 300 AFY, which will be released in 2 pulses of 100 AFY each and an annual sustained trickle at 0.15 CFS.

75% of average snowpack = 750 AFY
65% of average snowpack = 650 AFY
55% of average snowpack = 550 AFY
45% of average snowpack = 450 AFY
30% or less of average snowpack = 300 AFY (2 pulses and a 0.15 CFS year-round trickle)

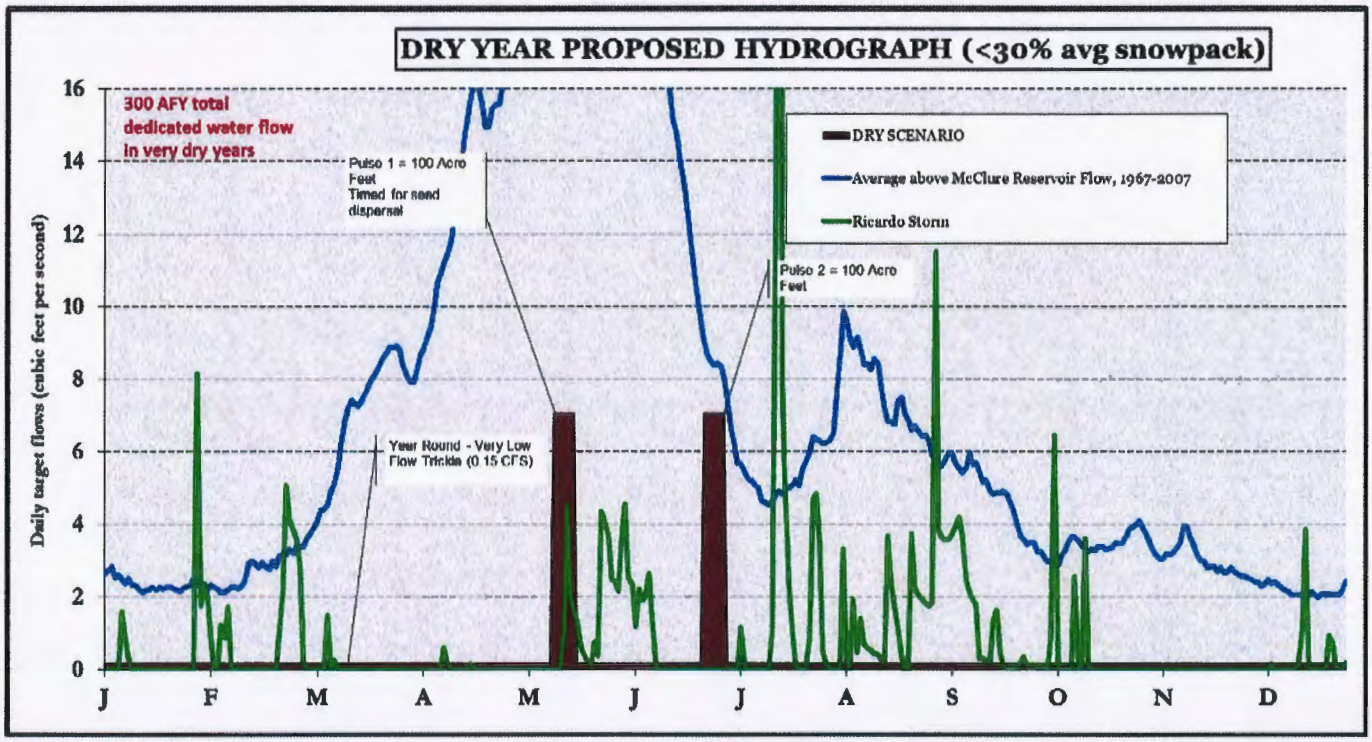


Changes to reduced flows will happen through:

1. Reduction in average summer flows
2. Scaling down of spring pulse
3. Reduction in shoulder season flows from 0.30 cfs to 0.15 cfs

CRITICAL DRY YEAR FLOW HYDROGRAPH

The following 'Critical Dry Year' hydrograph has been developed to guide flows of dedicated water in years where the watershed yield/snowpack is 30% or less than average. The Critical Dry Year hydrograph includes two 100 acre-foot pulses and a year-round trickle of 0.15 cfs. This Critical Dry Year hydrograph attempts to maintain a constantly wet corridor in the upper reach of the River below the dams to maintain ecological function while providing two downstream pulses for community enjoyment and support of riparian vegetation.



Introduction

The City of Santa Fe is in the process of formalizing its commitment to dedicate 1000 acre-feet of water per year (AFY) to the Santa Fe River and is gathering public input to craft the ordinance and administrative procedures that will guide these 'dedicated flows'. The primary objectives for the City are to create a set of recommendations, which include a flow hydrograph and contingency plans in the event of wet or dry years, or an emergency. The City posed the following questions to the community; a summary of responses that evolved from the public outreach process are summarized below:

1. *Community Objectives for 1000 AFY Flows?*
    a. Create an Ecologically Healthy Vegetative Corridor
    b. Benefit the Entire Community with Flows
    c. Nurture a Beautiful, Natural Urban Greenspace w/ water in arid environment
    d. Provide an Educational Resource for Schools & Community Stewardship
2. *Target Flow Season? Start/End Dates?*
    a. Year-Round Trickle during 'Shoulder Seasons' (Jan-Mar & Oct-Dec)
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3. *Preferred Flow Regime? Desired Flow Season Hydrograph?*
    a. See Target Flow Season/Start-End Dates above.
    b. The proposed hydrograph represents an average; operators need the flexibility to shift pulses, dates and minimum flows based upon seasonal triggers such as seed dispersion, community cultural events, snowpack levels and monsoonal storm activity.
4. *Adjustments during dry years?*
    a. The proposed general philosophy is to support flow in the River even during dry years/drought.
    b. 1,000 acre-feet annual dedication will be maintained in conditions equal or greater to 75% of average watershed yield.
    c. When watershed yield drops to levels 75% or lower of average snowpack on April 15th the 1000AFY will be proportionately reduced according the percentage of average watershed yield. For example, in a year with a 55%-below-average-yield, the water dedicated to the River will be: 1000 AFY x 55% = 550 acre feet.
    d. In extremely dry years, defined as watershed yield <30%, flows will be kept at a minimum amount needed for two 100 acre-foot pulses, plus year round flows of 0.15 CFS, for a total of approximately 300 AFY.
5. *What constitutes an 'emergency' to suspend that flow?*
    a. Flows may be adjusted or curtailed by the City Water Division in response to an emergency situation: to prevent an interruption in water service and to protect public health and safety.
6. *Adjustments during wet years?*
    a. Flows will not be increased above 1000 AFY, but 'spills' may provide additional flows in the River. Any water 'spilled' may count toward the dedicated flow for that day or

period, but will not substitute for dedicated flows scheduled before or after the 'Spill' period.

b. The reason that a portion of some spills are counted toward the 1000 AFY is to balance benefits between wet and dry years, allowing the 'resting' of groundwater wells during the wet years and dedication of water to the River in drought years.

7. *Other Considerations*
   a. Working toward water management agreements with local Acequia associations.
   b. Infrastructure improvements for controlling and measuring water releases from Nichols Reservoir more efficiently.

Proposed Hydrograph Overview& Introduction

The proposed flow hydrograph (i.e. flow pattern) to guide the dedication of 1000 AFY of water to the Santa Fe River from the City's reservoirs was developed directly from input from over 30 local stakeholders (including the Mayor and various City Councilors), a 90+ attendee community meeting, a 13 community-member Core Working Group and City technical staff. The Core Working Group (CWG), who took public and stakeholder contributions into careful consideration, ensured that the proposed hydrograph effectively integrated community values, water supply limitations, legal constraints, biological/ecological needs and infrastructure shortcomings.

The result of an intensive 2-day workshop with the Core Working Group and City Staff, the proposed hydrograph and wet/dry year and emergency scenarios were thoroughly vetted – checked and checked again - against the community objectives and various constraints. Using the best information available, the Core Working Group and City Staff arrived at the proposed hydrograph and dry/wet/emergency scenarios with *full consensus.*

Creation of the hydrograph and dry/wet/emergency scenarios required diligent balancing of objectives, needs and constraints, while still accommodating numerous 'unknowns'. Efforts were made to account for the highly variable nature of weather patterns in this region and the resultant watershed yield, snow pack, rainfall patterns, monsoonal rainfall and temperature fluctuations. Although useful studies have been completed, much remains unknown about aquifer recharge beneath the river, the distance dedicated water will travel in the river bed, and the amount of moisture it takes to support new and established native riparian plants and trees.

Biologists, ecologists and restoration specialists provided insight into the needs of the native riparian vegetation, wildlife and aquatic organisms. Technical staff from the City provided historical weather data, daily and annual flows at various points along the river, watershed yield, reservoir levels and management of the data needed to create an acceptable hydrograph. Community members active in cultural activities and development of parks and open space ensured that the needs of south/west side communities along the river were met in addition to those downtown.

Proposed Hydrograph/Flow Pattern – Highlights

1. **Low Trickle Flows during "Shoulder" Seasons** (0.3 cfs from Jan 1-Mar. 20 & Oct. 15-Dec. 31) to support upper watershed section as an ecological refuge. Increase flows to 0.60 CFS from Mar. 21-May 9 & Sept. 15-Oct. 14.
2. **Spring Pulse** (3 cfs May 10-23, 9 cfs from May 24-31 and 7 cfs from June 1-7) to push flows downstream to San Ysidro Crossing/Rt. 599 and create substantial flows through downtown. Spring Pulse helps distribute tree/plant seeds, moisten the river channel, keeps downstream trees alive and also coincides with the Fishing Derby/River Festival and the San Ysidro River Blessing.
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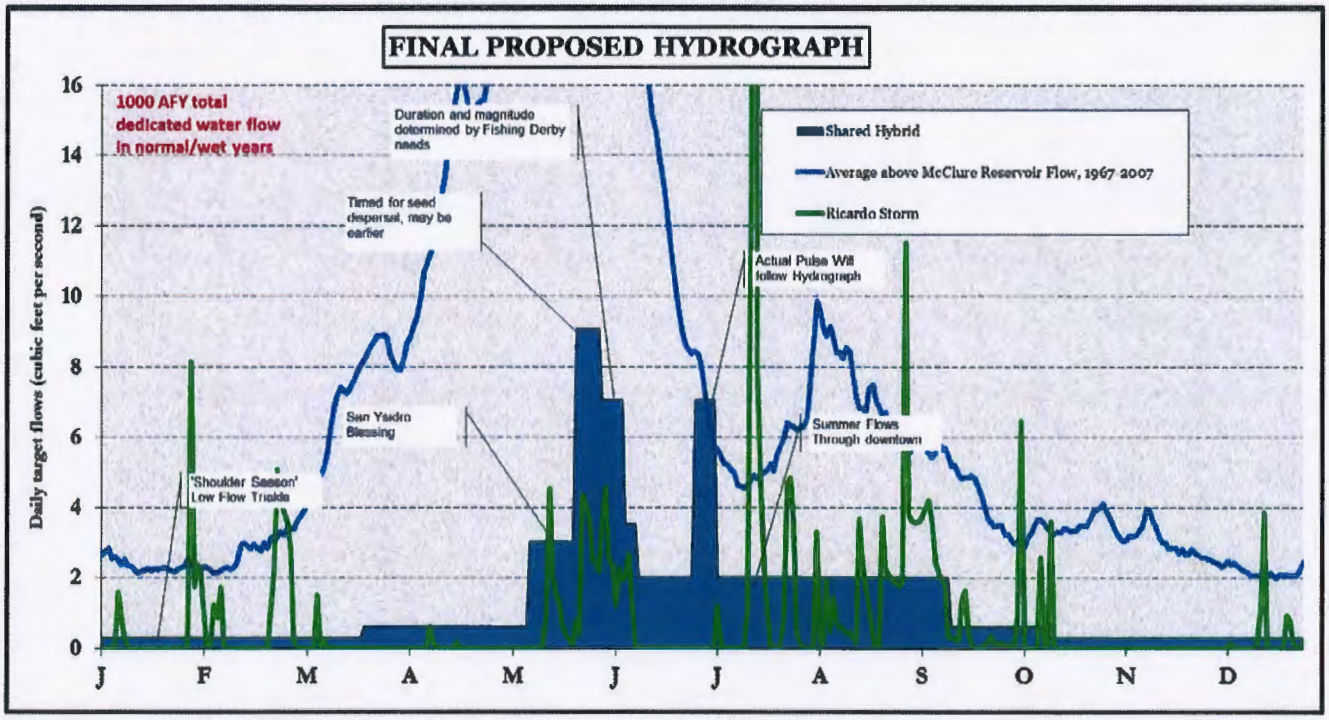
4. **Early Summer Pulse** (7cfs from July 1-7) to push flows once again downstream to San Ysidro Crossing/Rt. 599 during one of the hottest and driest periods in advance of monsoon season rains. The Early Summer Pulse is crucial to sustain vegetation and provide moisture for new/germinating seedlings and enhanced public greenspace.

The legal constraint on the City's allocation of water to the River is limited by the rate of inflow to the reservoir. The rate at which the City bypasses water to the River (in cfs) cannot exceed that flowing into McClure Reservoir. This legal constraint – referred to as the 'bypass concept' – means that the City is not permitted to bypass water to the River that it has 'stored'.



Community Objectives – Basis of Creation of Hydrograph/Flow Pattern

The following four objectives arose out of the question – "what is important to you about the River?" – posed to over 30+ stakeholders and the 90+ participants in the first community meeting. Responses were counted, tallied and used to define these top four priorities for managing water in the River.

1. Create an Ecologically Healthy Vegetative Corridor
    a. With the limited amount of water available, strive to support the maximum amount of riparian plantings and wildlife habitat along the river.
    b. Create a constantly-wet section of river in the upper watershed by providing a year-round trickle of flows. This section will serve as a river refuge to seed downstream reaches with river life.
2. Benefit the Entire Community with Flows
    a. Use the water equitably to benefit as much of the Santa Fe community as possible – not just downtown residents and visitors.
    b. Provide flow 'pulses' that run for 1 week or more and that reach at least to San Ysidro Crossing (Village of Agua Fria) and Rt. 599/Camino Real River Park.
    c. Provide flows for Community Events such as the Fishing Derby/River Festival and the Village of Agua Fria River Blessing, all important cultural events associated with the River.
3. Nurture a Beautiful, Natural Urban Greenspace w/ water in arid environment
    a. Create access to nature and open space within the urban environment.
    b. Support native riparian vegetation and plantings along the River from the upper watershed to at least Rt. 599/Camino Real River Park through flow pulses targeted to provide crucial moisture to new and established plantings.
    c. Time the 'spring pulse' to coincide with the release of tree seeds to aid in their dispersal and germination.
4. Provide an Educational Resource for Schools & Community Stewardship
    a. Provide spring pulse flows to facilitate school river-planting and celebration activities.
    b. Create flowing river opportunities for children and families to access during the summertime.

Although various other objectives – aquifer recharge, acequia use, tourism, erosion control – were discussed and valued by the community – they did not score as highly as the four above. Thus these four objectives represented the primary guiding principles as the Core Working Group and City Staff created the proposed hydrograph/flow pattern and dry/wet/emergency scenarios.

Built-In Flexibility: River Flows & Water Resources Management

The proposed flow hydrograph and wet/dry/emergency scenarios provide the City with flexibility in managing the River flows and their water supply system, while also ensuring that there will always be at least some flows of dedicated water in the Santa Fe River.

Weather in the Santa Fe region is historically highly variable in terms of rainfall and snowfall, two of the primary sources of water for the Santa Fe River. The City must properly and sustainably manage its drinking/potable water resource mix – including the watershed's reservoirs, City wells, Buckman Wells and the new Buckman Direct Diversion (BDD). Water conservation efforts over the past ten years have brought Santa Fe's average per-person water consumption down by an astounding 38%, and with the addition of the Buckman Direct Diversion water (Spring 2011) as a source of supply, the City is now positioned to more confidently dedicate a portion of the watershed flows into the Santa Fe River, while resting the groundwater well fields.

Historically, before the City established a resolution or ordinance guiding the release of water into the River, in a 'normal' year, no water would be 'spilled' from the reservoirs – i.e. all of the water that flowed into the reservoirs would be used to supply potable/drinking water. So, in 'normal' and 'dry' years – which combined occur approximately 55% of the time -- the Santa Fe River would be 100% dependent upon only rainfall and snowmelt that occurred downstream of the reservoirs. In 'wet' years – which occur approximately only 33% of the time -- some water would have to be spilled to manage water levels in the reservoirs, and thus the River has historically only seen releases during these 'wet' years.

The proposed hydrograph assures that 1000 AFY of water will be dedicated to the River during 'normal' and 'wet' years. Flows will be proportionally reduced (by percentage), and hit a minimum 'bare-bones' level during 'dry' years. Only in the case of an emergency (such as fire in the watershed, failure of the BDD, etc.) will flows to the River be temporarily suspended as a precautionary measure. In 'wet' years, the River will likely see flows somewhat or substantially over 1000 AFY. The wet/dry/emergency scenarios are outlined in further detail below.

Wet/Dry Year and Emergency Scenarios

Wet Years

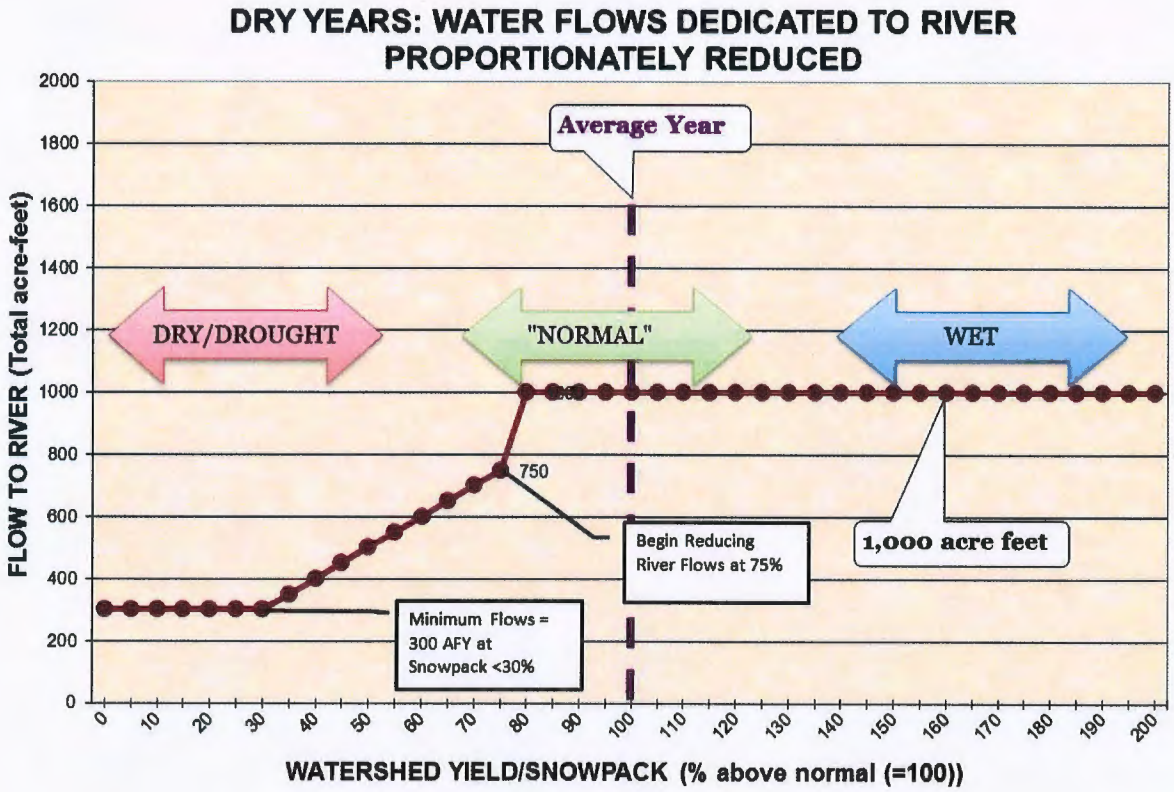
During Wet Years (defined as average snowpack on April 15th>135% of normal), a full 1000 AFY will be dedicated to the River. During the Spring Pulse defined on the hydrograph, if additional water – above and beyond the daily flow (in cfs) *prescribed by the proposed hydrograph pulse* - must be 'spilled' from Nichols Reservoir to manage water levels and minimize flooding, this water will *not be counted* toward the 1000 AFY of total flows. It will count, however, toward the 1000 AFY flows prescribed for those specific days/time periods. Thus in wet years, the River could receive more than 1000 AFY of water. The counting of a portion of spilled water toward the 1000 AFY total allows the groundwater wells to potentially be rested in wet years. The bypass constraint identified earlier restricts the City, even in a very wet Spring, from being able to store an abundance of water in the Spring to re-release later in the Summer, Fall or Winter when weather could be drier.

As noted before, the limit on the City's releases of water is the *rate of inflow into the reservoirs*. This limit prevents the City from storing water in one season and using it for River releases in a later season. However, matching releases with inflows reflects the amount of water flowing into the reservoirs at a given time and therefore follows the natural hydrograph.

Dry Years

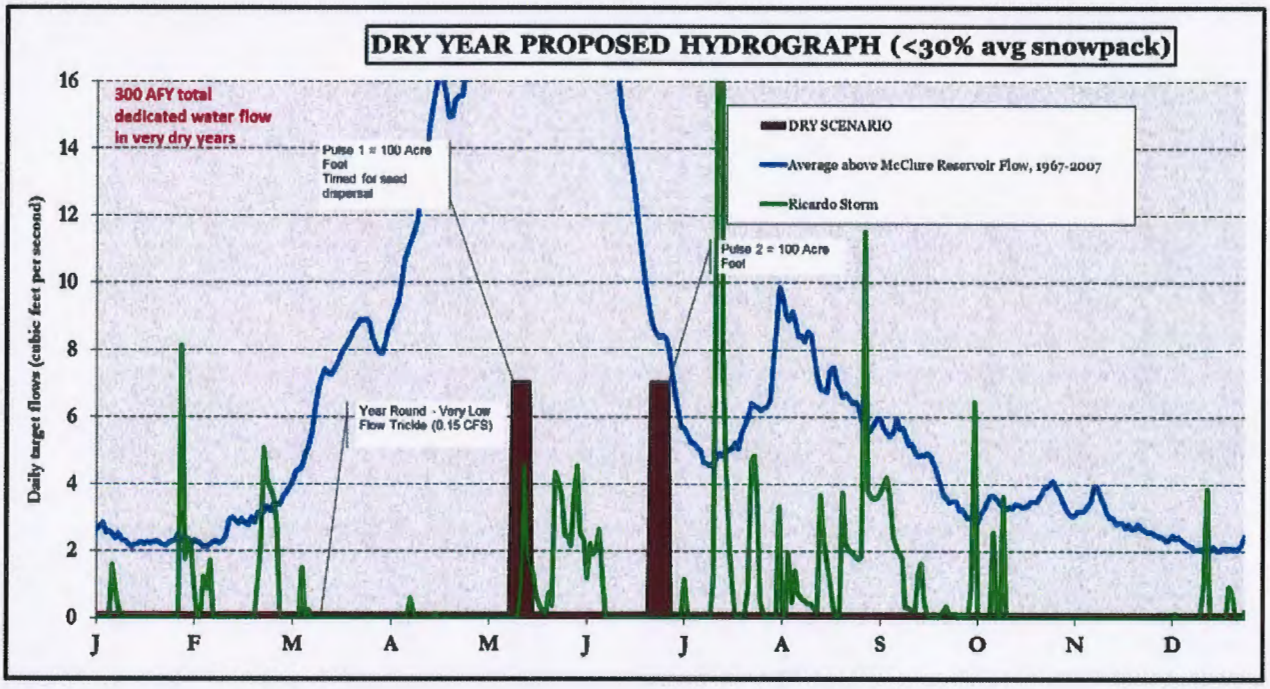
During Dry Years (defined as <75% of average snowpack on April 15th), the City will proportionately reduce flows to the River according to the graph and table below. If average snowpack levels are very low (<30% of average), dedicated flows will be reduced to approximately 300 AFY, which will be released in 2 pulses of 100 AFY each and an annual sustained trickle at 0.15 cfs.

75% of average snowpack = 750 AFY
65% of average snowpack = 650 AFY
55% of average snowpack = 550 AFY
45% of average snowpack = 450 AFY
30% or less of average snowpack = 300 AFY (2 pulses and a 0.15 cfs year-round trickle)



Changes to reduced flows will happen through (1) reduction in average summer flows, (2) scaling-down of the spring pulse and (3) reduction in shoulder season flows from 0.30 cfs to 0.15 cfs.

The following 'Critical Dry Year' hydrograph has been developed to guide flows of dedicated water in years where the watershed yield/snowpack is 30% or less than average. The Critical Dry Year hydrograph includes two 100 acre-foot pulses and a year-round trickle of 0.15 cfs. This Critical Dry Year hydrograph attempts to maintain a constantly wet corridor in the upper watershed to maintain ecological function while providing two downstream pulses for community enjoyment and support of riparian vegetation.



The 'flow year' is defined as April 15th through April 14th of the following year for the purposes of flow management based upon snowpack level readings on April 15th.

Emergencies

During an emergency, water dedicated to the River may be suspended until the situation is rectified. The Core Working Group and Community Meeting participants did not directly address the question of what constitutes an emergency. General discussion, however, indicated that it would be appropriate for the City/Water Division to adjust or curtail flows in response to an emergency situation in order to prevent an interruption in water service and to protect public health and safety.

Associated Recommendations/Challenges

- Acequia agreements: Can the City work with the Acequia groups to minimize the impact of their withdrawals on 'bypass water'? For example, measure and report diversions regularly, time diversions with abundant flows, use irrigation conservation measures (like watering at night), etc?
- Infrastructure upgrades at the gages and outlet structures to make the physical release and measurement of water more efficient, adaptable and accurate.

Recommendations that were not fully discussed and agreed-upon at the CWG retreat but that did receive some discussion:

Dedicated Flows to the Santa Fe River may be altered if the City experiences a water supply emergency. Although no definitive definition of 'emergency' was decided upon by the group, several scenarios were mentioned as possibilities. The overarching goal is to permit the Water Division to avoid interruptions in water service and to protect public health and safety.

Examples of emergencies could include:

- Events that could cause an interruption in service or threaten public health and safety.
- A fire in the watershed that threatens water quality and/or quantity flowing into the Reservoirs.
- A failure of the water infrastructure that permits control and monitoring of flows into the River, including valves, gauges, gates, piping, etc.
- A failure of the Buckman Direct Diversion project (BDD), the Canyon Road Water Treatment Plant, transmission lines or other water infrastructure.

Definitions

a. **Acre Feet (AF) or Acre Feet per Year (AFY):** term to describe the *quantity* of water. An acre-foot is the amount of water required to fill an area of 1 acre with 12" (i.e. 1 foot) of water. One acre-foot is equal to 325,851 gallons.
b. **Average Watershed Yield**: defined as yield of water expected from the upper watershed annually as of April 15th as compared to the historical record average. The anticipated watershed yield is measured as a % of average snowpack. The watershed's approximate average yield is ~5,000 AF.
c. **Buckman Direct Diversion Project (BDD):** Water supply project that will utilize surface waters from the Rio Grande. Expected to be fully operational in late Spring 2011.
d. **Cubic Feet per Second (cfs):** term to describe the flow *rate* of water.
e. **Dedicated Flows:** The amount of water the City has dedicated to the River – during Normal/Wet years it is equal to 1000 acre-feet per year (AFY); during Dry Years it is equal to 300 acre-feet per year (AFY).
f. **Emergency:** defined as a situation that would cause an interruption in the Water Division's ability to provide water service or that threatens public health and safety.
g. **Natural Hydrograph:** The natural hydrograph (in cfs) can be shown either for water naturally entering the upper-most reservoir (McClure) or for water passing through a gauge further downstream (Ricardo Gauge, for example). In either case, the hydrograph 'line' created represents water that enters either the reservoir or River naturally based upon snowfall, stormflows, etc.

h. **Proposed Hydrograph:** The proposed flow rate (in cfs) of dedicated water in the Santa Fe River as measured at the gauge just below Nichols Reservoir. The hydrograph 'line' created by the proposed flow rate represents the flow rate of the water that enters the River intentionally as 'dedicated water' toward the 1000 AFY. The proposed hydrograph line does not show storm flows, 'spills' or other flows that occur naturally downstream of the Nichols gauge. The area beneath the line (shown in solid colors) represents the total annual *amount* of water dedicated to the River (typically 1000 AFY). Also referred to as 'flow pattern'.

i. **Spills:** The water that the City allows to flow out of the reservoirs (typically in the Spring) to control water levels in the reservoirs; spills are most often a response to a high snowmelt period. Spills do not necessarily occur every year, but they often do occur during wet years.

Prepared by:
Erin English, PE LEED AP
Feb. 2, 2011

Additional Considerations
BYPASS FLOWS IN THE SANTAFE RIVER

Additional Recommendations gathered during the Public Engagement and Community Outreach Process

The following recommendations emerged from the Community Outreach Process and are considered to be supplemental to the Administrative Procedures:

1. The City should explore establishing **flow reporting agreements with Acequias** to create records of the surface water withdrawals by the Acequia Associations that have rights to the water. The City may also want to consider working with the Associations to help improve the water efficiency of their operations (watering at night, install more flow monitoring, etc).

2. Based upon existing infrastructure challenges, **improvements in infrastructure should be implemented** to allow for more nimble adjustments so that flows can be more quickly and/or frequently adjusted. Upgrades may also include improved flow monitoring during winter periods when the stream may be frozen.

3. A more comprehensive **Monitoring Plan** is needed to adequately assess the impact of Dedicated Flows and to ensure that the City releases water in accordance with the Community Objectives. The Monitoring Plan can be used as a tool for Adaptive Management. Several related topics arose during Community Process:

    a. **The community – through coordinated efforts of community groups, schools and/or the Watershed Association – may be interested in assisting** with ongoing monitoring of water flow and ecological health indicators. The City should consider building a website (with possible social network integration) that updates the community on flow events and provides a vehicle for gathering feedback or river reports. The City may want to consider pursuing outside funding (or assisting the Watershed Association in doing so) for these initiatives.

    b. **Additional Monitoring** – Several ideas about additional monitoring capabilities that the City should consider emerged from the Core Working Group workshop. These included the use of soil moisture meters and potentially shallow groundwater monitoring wells that would help the City understand the needs of riparian vegetation and movement of subsurface water.

4. The City should **maintain flexibility in scheduling flows** and may need to fine-tune flow releases around the Fishing Derby dates. If the City finds a conflict with the hydrograph (in terms of meeting bypass flow constraints or other scenario), a shift in dates for the Fishing Derby should be considered.

5. The City should **remain sensitive to the equity issues** surrounding the use of Dedicated Flows and when possible, aim to provide as much water to points further downstream as possible (i.e. Village of Agua Fria and/or the intersection with Rt. 599).

Parking Lot Issues
The following considerations are not directly related to the release of Dedicated Flows, but were discussed by Stakeholders, Community Members and/or Core Working Group Members

1. Improve **stormwater management** throughout the developed areas of town to slow and filter the release of stormflows to the River and help reduce erosion.

2. Improve **stream channel design** to maximize the impact of stormwater flows (i.e. spread flows to the floodplain, etc).

3. Several suggestions were made to **develop small pools or impoundments** within the river corridor to create wet zones that would retain water for a longer period of time after flow pulses or storm events.

4. Continue to improve and expand upon **water conservation initiatives** to help reduce water demand.

5. **Wastewater Reuse.** Consider pumping reclaimed wastewater effluent from the treatment plant through the downtown portions of the river channel and/or implement small-scale decentralized wastewater treatment projects. Release these flows to the river channel at locations above the wastewater treatment plant. Consider using reclaimed effluent to irrigate riparian vegetation.

Santa Fe River 1000afy Flows
Stakeholder Interviews Summary
January 4, 2011

The purpose of the Santa Fe River Flows pubic engagement process is to determine community values about the management of 1000afy of flows in the Santa Fe River, and to make a set of recommendations to the City about how to direct and administer such flows. During the initial stages of this initiative, the consultant interviewed 37 community stakeholders, including City and County officials, representatives of community groups, environmental restoration groups, businesses, tourism industry leaders, acequias, and neighbors living along all stretches of the river (please see appendix for a list of people interviewed). About a dozen of those people volunteered to serve on a Core Working Group (CWG) to synthesize community input from interviews and community meetings and develop concise recommendations for the City.

This paper summarizes the findings of the stakeholder interviews, particularly peoples' views about what is important to them about having water in the river, the objectives that this water should meet, and suggested strategies for how to manage the flows to serve these priorities. In addition, several key questions were raised for consideration in the process. The aim of this paper is to provide guidance to the CWG and other interested parties within the City as context for more detailed deliberations, and the lay a foundation for the design of two broader community meetings.

Values / Priorities – *What is important about a living river to you and your constituents and for what purposes would you want to see the river flow?*
Stakeholder comments included the following set of objectives for flows in the Santa Fe River. Asterisks indicate the number of respondents who specifically mentioned the corresponding objective:

Improve ecological conditions and resiliency	**********
Thriving cottonwood and willow plantings (care for investment)	*********
Habitat for birds, animals	****
Fish downtown	*
Aquatic insects in some part of the reach	*
Aesthetic urban greenspace (place to be in nature, near water, in arid lands)	*******
Continuous flow downtown	**
Recharge aquifer, private wells, and city well fields	****
Prevent erosion damage from flood events	***
Including issues re. property values	*
Connect us as a community across culture and geography	***
Build ecological stewardship values	***
Equity of benefitting entire community (flow downstream)	*******
Get acequias running	*
Recreation - general	**
Playing in water with kids and families	***
Tourism Draw	***
Schools use as outdoor classroom	**

Strategies – *What would you consider an ideal flow regime, balancing factors of flow volume, distance, length of season? What to do in case of drought?*

Stakeholders offered a range of ideas for how to manage the 1000afy flow allocations. The comments below represent specific ideas that were mentioned during interviews. Asterisks indicate the number of people who made this comment or a comment very similar. Some of the comments are complementary, while others are contradictory. The biggest variation tended to be in recommendations about what to do in case of drought – some felt that it is important to reduce flows when water is scarce; others felt that the river allocations not be sacrificed more than community uses, and that reductions should be mutual and proportional.

Significant spring pulse (or snowmelt runoff), followed by much smaller flows into July (2 cfs?). Hopefully the monsoon rains will then kick in. The high runoff will create a sponge effect for riparian systems, which will then retain water in the river channel even as the flows become a trickle. Native vegetation can take root again in downtown and will slowly migrate through the system.	*****
Try to mimic flow patterns as much as possible	*****
Periodic summer pulses at higher flow rates (every three weeks?) to saturate downstream plantings, at least for a few years until willows and cottonwoods get established at San Ysidro. Plant requirements as bottom line.	*****
Release in mid-spring until mid-fall. Time summer pulses to correspond to when people can enjoy the water – weekends, holidays	*****
Larger, less frequent releases lead to more beneficial results – watering downstream trees, community engagement, higher flows for kayaking	
Create dams or small retaining ponds every quarter mile or so to keep water in the river longer	***
During wet years, start releases later in the season, or time for before and after spillovers	
Counting the spring spillover toward the 1000afy will create early season imbalances	
Spread the water through the full year, even though it won't go past St. Francis	
Experiment for the first three years with different regimes and monitor the results	**
Consider building in a review process into the ordinance, with annual reporting requirements. Include groundwater monitoring to check aquifer recharge.	**
Improve the regulation system so that flow rates can be adjusted more nimbly. Turn off during monsoon rains. (consider setting priorities now that can be implemented later when infrastructure improves)	**
Consider shutting off flows at night	***
Work with County to use some of their excess capacity from SJC diversion	
Release "1000afy in addition to the legal obligations to the acequias"	

Look at the river and the community as co-equal in importance. Don't shut off river because of drought – river should be proportionally reduced with community reductions.	***
If there is a drought in the Santa Fe watershed, consider bringing in more Rio Grande water	
It would be an error to turn off the river in drought years and risk losing the investment in downstream riparian plantings – they are not easily replaced	
In drought times, if reservoirs drop to a certain level, reduce river flows by x%.	***
It's OK to ebb and flow in response to weather and human demand.	
We live in a dry climate. Don't create expectations that the river is immune to drought. Is it realistic to put water in the river in a dry year?	

Key Questions

Several questions came up in interviews that stakeholders felt need to be addressed as part of the deliberation process:

- To what degree does the river flow affect the baseline of the water table?
- What do we know about aquifer recharge from river flows?
- What would have happened naturally to the river in drought years (pre-development?)
- Is the 1000afy in addition to spring spillover?
- How much flexibility in flow patterns will the current infrastructure allow? Can we create a flow management plan that is responsive to weather patterns?
- How much additional water with the BDD provide, and how does that affect the assumptions about how much we need to keep in the reservoir?
- What is better for keeping riparian plantings alive? – periodic pulses or an ongoing trickle?
- Can the CWG continue to serve a function in decision-making around adjusting flows in drought years or times of emergency?

People interviewed (as of Jan 4, 2011)

City Officials
Mayor, David Coss
Councilor Rebecca Wurtzburger
Councilor Patti Bushee
Councilor Carmichael Dominguez
Marcos Martinez - City Attorney

Santa Fe County Officials
County Commissioner Virginia Vigil

City Staff and Contractors
Brian Drypolcher – River Coordinator
Marcos Martinez – Assistant City Attorney
Claudia Borchert – Water Division
Amy Lewis - Hydrologist

Santa Fe River Commission
Jerri Jacobi-Chairman
Melinda Romero Pike
Richard Ellenberg
Jim Cutropia
Dale M. Doremus
Samuel Gerberding

Community Groups
Old Santa Fe Foundation-Tim Maxwell
RiverSource - Rich Schrader
Santa Fe Art Institute - Diane Karp
The Camino Real River Connection - Nichoe Lichen
Santa Fe Watershed Association - Felicity Broenner
BDD member at large - Conci Bokum
League of Women Voters - Neva Van Peski
Historic Design Review Board - Cecilia Rios
Saint Francis Cathedral – Jim Cutropia

Neighborhood Groups / Acequias
Canyon Road HOA, Richard Ellenberg
Acequia Muralla - BC Rimbeaux
Acequia Madre - Phil and Eleanor Bove
Riverside landowner – David Baca
Agua Fria Villiage – Melinda Romero Pike, William Mee

Environmental Groups
Wild Earth Guardians - Jim Madison
Nature Conservancy - Bob Findling
Earth's Birthday project - Cliff Ross
Audobon Center – Steve Cary
WaterCulture.org - David Groenfeldt

Santa Fe Watershed Association – John Utton

Business Groups

Chamber of Commerce - Simon Brackley, Fidel Gutierrez
Downtown Hotels Focus group –
- Stefan Huber, Inn at Loretto
- Debbie Swanson, Inn on the Alameda
- Michael Newbrand – Hilton Hotel
- Robert Ruiz – Garretts Desert Inn
- Sam Gerberding – Inn of the Governors

State Water Professionals

State of NM RERI Program - Karen Menetry
Groundwater Quality Bureau – Phyllis Bustamante

Water in the Santa Fe River – 1000 AFY

Community Meeting #1 REPORT

January 13, 2011

Meeting Participants

Public Attendees: Approximately 85 people participated in the meeting, with a wide range of ages and interest areas, including participation from all over town (a complete list of participants and neighborhood distribution will follow as an attachment)

Public Officials: Mayor David Coss and Councilor Carmichael A. Dominguez were present, as were City staff members Brian Drypolcher, Claudia Borchert, Marcos Martinez and City Attorney Geno Zamora.

Introduction by Mayor Coss

Mayor Coss provided the introduction to the public at the meeting and gave an overview to frame this meeting and the overall public process. The Living River Initiative is a unique and significant effort for Santa Fe and within the greater Southwest; it is history-making and precedent-setting to dedicate a significant portion of a municipality's potential water supply to the ecological health of the river and to the community benefits that come with it. The Mayor welcomed everyone to the meeting, thanking the Attorneys, City Staff and participants at the meeting.

Overview by Toby Herzlich

Toby introduced the crowd to the public process and the specifics of this first public meeting. She asked the crowd several questions and implored them to raise their hand or to stand up:

Toby asked participants to stand up or raise their hands for the following:

- If you were in this room 3 years ago for an earlier meeting about the River – 1/3 of the room.
- If you have been part of dreaming this into being in some way – most of the group.
- Lifelong member of the community – 20 people
- New to the community, less than a few years – 10 people
- Student or Teacher or educational involvement – 10 people
- Work in Business – 10 people
- Work in the Arts – 15 people
- Work in environmental field – 50-60
- Play involved in natural environment –50-65

The purpose of the process we are undertaking is to advise the City about how to manage the 1000 acre feet per year (AFY) of flows for the River. The reason why the City is undertaking this process is that although it's a very big deal to create a law governing flows of 1000 AFY, it's not enough water to create an entirely 'living river' for the whole stretch all year long.

This public conversation is about the way in which to use this water – to benefit the River, the community, and the community's relationship with its natural environment. That is what we are here to discuss. The result of this process will be presented to the Mayor and City Council. We will grapple tonight with tradeoffs. We are looking for direction on how to "spend" this 1000 acre feet, and are looking for the range of views of what is important. Really, this is a community values exercise – what is important to us as a community. We need to listen to each other and appreciate differing viewpoints.

Groundrules

- Listen to Learn
- Welcome Diverse Views
- Focus on Interests, not positions
- Stay focused on Task at Hand
- Take Breaks as Needed
- Help out Facilitators

Agenda

- Welcome & Overview
- Groups – what's important to us about the River?
- Education – 1000 acre feet – why? What? How?
- Groups: Review possible scenarios for flows
- Next Steps

Group Exercise #1 – Community Values around the River

Toby directed each table of 8 to first introduce themselves, and tell the group why they were there. Table members were then to discuss the list of values around the river that had been generated through a series of more than 30 interviews with community stakeholders. Each person received 3 stickers with which to prioritize their top 3 values or objectives. The data from the tables were collected and the results tabulated; see below. Additional comments pulled from notes taken by each table are included at the end of this document as a supplement.

Since the Stakeholders and Community Meeting #1 participants were asked to evaluate a similar set of questions about 'values' around the river, both sets of totals are included below (numbers should be evaluated in relation to other topics in the same column, to assess the relative priority among the values). Topics in red received the largest share of votes from the public meeting.

Summary of Community Objectives for the 1000afy flows. It is clear that when the results from the public meeting and the stakeholder interviews are cross-referenced, the value of ***"Improve ecological conditions and resiliency"*** and the sub-categories of trees/vegetation and animal habitat, are the top values shared across the board.

Second in priority ranking is the objective of ***"connect us as a community across culture and geography"***, with an emphasis on creating "***equity of benefitting the entire community"*** with flows throughout the reach of the river.

"Creating an aesthetic urban green space" with water access in an arid landscape ranked highly as a priority objective, as did ***"Education / School engagement / Building ecological stewardship values.***

"WHAT IS MOST IMPORTANT TO YOU ABOUT FLOWS IN THE RIVER?" COMMUNITY OBJECTIVES FOR 1000 AFY FLOWS	TOTAL	PERCENT %	Stakeholder Interviews
Improve ecological conditions and resiliency	45	18.4	13
Thriving cottonwood and willow plantings (care for investment)	21	8.6	9
Habitat for birds, animals	20	8.2	4
Fish downtown	3	1.2	1
Aquatic insects in some part of the reach	1	.4	1
Connect us as a community across culture and geography	23	9.4	3
Equity of benefitting entire community (flow downstream)	25	10.2	3
River events (river festival, blessing on San Ysidro day)	3	1.2	7
Aesthetic urban greenspace (place to be in nature, near water, in arid lands)	26	10.7	7
Continuous flow downtown	5	2.0	2
Education / School engagement / Build ecological stewardship values	20	8.2	2
Recharge aquifer, private wells, and city well fields	16	6.6	4
Acequias and agricultural use	15	6.1	1
Recreation – general	3	1.2	2
Playing in water with kids and families	5	2	3
Fishing Derby	0	0	N/A
Prevent erosion damage from flood events	6	2.5	3
Including issues re. property values	1	.4	1
Tourism Draw	6	2.5	3
Retain water for Municipal uses only (i.e. 'not in the River')	0	0	N/A

Presentation by City Staff – Brian Drypolcher, Claudia Borchert and Marcos Martinez
The City staff prepared a Powerpoint presentation to outline the technical aspects of the Living River Initiative, the ways in which water gets into the River, the details of the City's water supply portfolio (groundwater, surface water mix) and legal considerations. Claudia then outlined three flow scenarios as examples of how the 1000 acre-feet per year could be administered.

The three flow scenarios include:
1. Year-Round flows to Patrick Smith Park (Northeastern end of downtown)
2. Summer flows to Guadalupe Street
3. May through October pulsed flows to San Ysidro Crossing and beyond

Claudia outlined these scenarios through the use of three graphs showing the historical flows at Nichols Reservoir (which represent water that would naturally enter the river if there were no reservoirs), the 'average' year flows that are released below the reservoirs (based on 2008) and the proposed distribution of the 1000 acre-feet per year. Each scenario's '1000 AFY' graph varied according to the release pattern. Copies of these graphs were distributed to each table.

Group Exercise #2 – Discussion and Prioritization of the Flow Patterns
Toby directed each group to consider the three flow scenarios – and possible hybrids – and to rank them according to preference. Groups were to discuss the pros and cons of each scenario.

Overall, Scenario #1 – *Year-round flows to Patrick Smith Park* – received the lowest level of support since it did not reach very far into town. Some participants pointed out, however, that this section of river would be very much 'alive' and hold the potential to revitalize downstream reaches over time.

Scenario #2 – *Summer flows to Guadalupe Street* – received mixed reception, with some support linked to its potential to create a much more robust river corridor through the downtown area and the opportunity of supporting a basic level of aquatic organisms and riparian vegetation.

Scenario #3 – *pulsed flows to San Ysidro and beyond* – received the most support, being most popular within the room for the following reasons:

- Equity – this scenario has the largest potential benefit for the whole community since a much longer stretch of river would receive water, at least periodically. Many Village of Agua Fria residents, among the majority of others, supported this idea.
- Riparian Vegetation support – creation of a green belt along the greatest length of river is most possible with this scenario.
- Downtown flows- these would be substantial when the river is flowing.

Some potential revisions were suggested to enhance Scenario #3:

- Building in some flexibility into the operational plan to adapt the pulses based upon the levels of annual spring snowmelt runoff.
- Reducing the Sept-Oct pulses to more closely match the river's natural hydrograph
- Shifting flows somewhat to provide a small amount of year-round baseflow (i.e. 'trickle') along with the pulses, so that the river doesn't entirely dry out in between pulse periods – some of this baseflow water may possibly be obtained by reducing the late fall pulses to more closely match the hydrograph.
- More clearly describing and outlining the goals and objectives associated with this scenario.
- Don't call this "the irrigator" strategy

Final Summary Comments

At the conclusion of the meeting Toby asked for additional input, comments, or questions from the participants:

- Can there be flexibility built into the flow management so the pulse scenario (#3) can be adjusted seasonally based upon snow pack?
- A suggestion was made to develop small pools or impoundments within the river corridor to create wet zones that would retain water for a longer period of time after flow pulses or storm events
- Some of the youth attendees felt strongly that 'water is not for tourists' and should be used to benefit the entire community, particularly those living on the Southside who would also appreciate the experience of a flowing river.
- A drought scenario is needed to ensure that water still flows to the River even in dry times. The City has developed policies to ensure that public park landscaping does not dry out and die during drought years and this concept could/should be applied to the river, too.

APPENDIX – ADDITIONAL NOTES AND COMMENTS GATHERED FROM THE FIRST PUBLIC MEETING

January 13, 2011

Note Card Comments

Note cards were available for comments. Most comments related directly to "Parking Lot" issues (issues distinct from the management of 1000 afy) and are thus recorded there. The following comment was also submitted:

City has 5000 A.F. right to use. 1000 A.F. of that 5000 A.F. should be dedicated to river. Overflow (above 5000 A.F.) should also always be dedicated to flow in the river.

Parking Lot Issues (On Board and Submitted via Note Card)

- water to new development and not to existing people
- restoring a natural river by having this philosophy and it meets all the goals on the sheet
- stormwater management
- traditions of Agua Fria Village to have flowing river, acequias and farmed fields
- growth policy which says limit growth, conservation important
- lack of ecological knowledge that decision makers have
- finish adjudication on Santa Fe Basin
- spiritual health of community
- should be all-inclusive because river extends beyond city limits. Reservoirs are in National Forest, not City land.
- maximize benefits from storm flows, especially in summer
- acequias: flow and water rights
- City's growth vs. river flows
- ecological knowledge
- what counts as 1000 A.F.?
- what is a drought?
- small scale, localized wastewater treatment

Table Comments – Group Exercise #1: Summary/Excerpt of Notes from Each Table

General Comments

-Ecological, Fish important
-Don't trust city
- Need a Growth mgmt plan
-Natural area, Birds (don't tease), Children, Tradition of flowing, Beauty
- Water and river are sources of life
- If the Plaza is the 'heart' of Santa Fe, the River is the 'blood' of the community
-Want to see County more involved
-Enough flow to reach through Agua Fria
-Riparian environment living

-River/ Acequias as life blood of community
-Continue what's been working for years up near Casa Solana
-Any river is better than no river.
-It would be nice to see pockets of small green oases
-Community pride around the river is highly important. Also, parts of the river are the historic Camino Real
-Community pride around the river and the habitats are key points (high school students)
-Hearing the river outback of my house at The Commons is amazing and I don't want to lose that

Follow up thoughts:
- Community education about the river, its historic role and its environmental role are key
- Signs near bridges that cross the river that read "Do you miss the River" with accompanying before and after pictures could be beneficial
- Maybe have a fish Mascot a la Smokey the Bear to go to local schools to reintroduce the river to kids who have grown up without it
- Ecological justice is important
- Controlling erosion is important – stop the incising

Points regarding different options of 1000 AF use:
- Focus on ecology first. Once that returns and things green a bit, the community pride, education etc. will follow
- The overflow should NOT be counted as part of the 1000 AF. That's a bonus from mother nature
- Pulses should be fluctuated to account for stormwater
-Small ponds could be constructed or water could be retained close to downtown for short periods. Legally you can detain water for 72 hrs.?
- As the city grows, use decentralized wastewater treatment and let treated effluent flow into the river
-If the pulses are weekly, maybe there could be a community focus on it. "Take me to the River days"
-Look into conveying the water from the dam closer to downtown before allowing it to infiltrate. That way more people can benefit from it.

Comments from the wall

The long sheet of paper posted on the wall at the back of the room was used as a space for people to contribute comments during the meeting. Comments were linked to questions (identified in ***bold italics)***:

How can we provide optimal benefit to and from our river?

- Understand the importance of a living river
- Commit to having a living river
- Make the necessary sacrifices as humans to keep nature alive
- Don't throw trash and don't take the water from the river because it won't work

Agua para toda la comunidad!

Is there a realistic benefit in timing minimal releases of this 1000 AF to coincide or 'bookend' periods of higher relative humidity? In other words, restricting release during extremely dry periods / during the

hottest time of the day, etc.

The entire Santa Fe community (city and county) should benefit from the river flow, Southside as much as Northside. Work towards a year-round flow to all. Use new technology and research to improve it.

Ensure that 1000 AF/yr is released in intervals and volumes that are enough for all communities downstream to receive equal benefit (vegetation)

Important: Clear growth policies, adaptive river management with flexibilities, continued water conservation policies/incentives

What does our community need from the river?

- Bring it back to be the heart of the city
- Complete flows all the way downstream to county-wide communities
- Life and nature

My name is Fifi the Fish and I want to be the mascot of the project

Diagram: 'Life' in center and 'Community', 'People', 'Plants/trees' & 'critters' feeding into it

Piezometers to see if localized groundwater is providing a source of surface water to the instream flows

What does the river need?

- Water (to keep plants alive), intermittent flows above a minimum
- Make sure that it gets all the way to the 'end', ie Agua Fria/treatment plant, not just downtown
- It needs water for the plants and the animals

Keeping the river clean from pollution (trash), also chemical pollution

That putting water into the river will last. It won't be a wasted effort

Let us be provocative! And put signs on the bridges saying: I am crossing WATER

We need a broader plan for limiting growth and increasing conservation. Creating a living river is awesome. It's not awesome that its viability is somewhat riding on the unsustainable shoulders that is the Buckman Diversion

Bring the river all the way to 599!

What is important to you about flows in the river?

- Optimize the ecosystem-bring it alive!
- Keeping plants alive for wildlife habitat
- Making sure that historic communities downstream get an equal share
- Because the nature needs it
- The flows in the river need to be clean and free from pollution

Education to younger generations about how important the river is would be beneficial

Additional (Raw) Table Notes from Group Work

Project: Santa Fe River – 1000 AFY Initiative
Date: 1-13-11
Location: Chavez Community Center

Table Guests:

Rick Martinez, Deanna I., William M. (Agua Fria Village), Louis M. (Agua Fria Village), May Montoya (Agua Fria Village), Jennifer Hacket (San Isidro Crossing), Dwight Hacket (Agua Fria Village)

Initial Thoughts Upon Introductions:
-Ecological
-Fish
-Don't trust city
-Growth mgmt plan
-Natural area
-Birds (don't tease)
-Beauty
-Children
-Tradition of flowing
-Beauty
-Want to see County more involved
-Ecological reasons
-Well water
-Enough flow to reach through Agua Fria
-Riparian environment living
-River/ Acequias as life blood of community

Scenarios:
- We should benefit from what 'mother nature' gives us. Excess should not count towards 1000 A.F. "Don't take from us again"
-Spread pulsing out if high precipitation year
-Sustaining remnant pools along the river

Initial Thoughts Upon Introductions:

-Ecologic justice
-Historic conditions
-Water in acequias, discharge to south side
-Stop incising
-1000AF not much water
-Community draw

Table Guests:
Justin Lyon (NSI), Frank Moran (40 year resident), Jerry Jakoby (Biologist with the Mayor's office), Art Balmer (Ecologist), Francois Patori (President of the SF Watershed Assoc.), Nicole Lichen (Camino Real Non Profit), Two local Navajo high school student, Maria Jose (Teacher with Americorp)
Initial Thoughts Upon Introductions:

-Continue what's been working for years up near Casa Solana (Frank)
-Any river is better than no river (Art)
-It would be nice to see pockets of small green oases (Francois)
-Community pride around the river is highly important. Also, parts of the river are the historic Camino Real (Nicole)
-Community pride around the river and the habitats are key points (high school students)
-Hearing the river outback of my house at the commons is amazing and I don't want to lose that (latecomer sans name tag)

Follow up thoughts:
- Community education about the river, its historic role and its environmental role are key
- Signs near bridges that cross the river that read "Do you miss the River" with accompanying before and after pictures could be beneficial
- Maybe have a fish Mascot a la Smokey the Bear to go to local schools to reintroduce the river to kids who have grown up without it

Points regarding different options of 1000 AF use:
- Focus on ecology first. Once that returns and things green a bit, the community pride, education etc. will follow
- The overflow should NOT be counted as part of the 1000 AF. That's a bonus from mother nature
- Pulses should be fluctuated to account for stormwater
-Small ponds could be constructed or water could be retained close to downtown for short periods. Legally you can detain water for 72 hrs.?
- As the city grows, use decentralized wastewater treatment and let treated effluent flow into the river
-If the pulses are weekly, maybe there could be a community focus on it. "Take me to the River days"
-Look into conveying the water from the dam closer to downtown before allowing it to infiltrate. That way more people can benefit from it.

Thoughts:
-enjoy the river
-use 'old ways' of irrigating
-build 4 holding tanks below Canyon and Lopez for storage. Install pumps to recirculate water in dry times so that 1000 AF goes further and lasts longer.
-designate times for higher/lower flows so different groups can meet their needs
-in favor of constant flow to feed a 'living river' (1.5 CFS throughout the year)
-7000 AF flow into Nichols per year. Only 5000 goes to the city. Shouldn't that leave 2000 for the river?
-interested mainly in downtown, for tourism.
-ecological concerns
-flow at higher levels less frequently to feed more of the river and so more people down river can enjoy it.

Initial Thoughts Upon Introductions:
-more willows
-vegetation
-ecological justice
-acequias, diverting through smaller channels
-ecology
-water is life
-community draw unites
-return environment to natural state
-dragonflies, life

Initial Thoughts Upon Introductions:
-city language be careful SF Water
-Hybrid- trickle + 3 +follow hydrograph
-short term choice might be different than long term choice
-long term benefit should be as natural environment as possible
-focus upstream with managed storm flow in the short term
-river that stays consistently wet and moves downstream
-guidance on what I'm getting w/ different choices
-equity: whole community benefits
-tapered surges: high season/ low season
-impoundments, pulses with ponds/pools (way to sustain)
-adamant that 1000 AF guaranteed, but each year looks different depending on conditions
Table Guests:

Live on river (Upper Canyon), lived in SF most of life, Canyon Neighbors Association, South Side, have walked river for years, live on river on W. Alameda, Agua Fria Village,

Initial Thoughts Upon Introductions:

-concern that the flow be steady
-trying to get cottonwoods to grow naturally
-concern over small reservoir that was drained in November. Was great habitat
-river as place to go and enjoy run-off
-want to restore it to its natural flow
-should return it to its natural state
-do something beneficial to community that is sustainable and realistic
-address and make wise use of what is a healthy drinking water supply, keep that as high priority
-historic value to restore, economic value, environmental value
-restoring the riparian area
-historically the river went dry, flood downtown
-river should be able to flow to Frenchy's Park
-how precisely they can regulate the flow due to surrounding environment and weather conditions?
-walk dogs in arroyos
-restore river to what is natural
-want to walk in more natural river
-'living heart' of city
-aware of the symbolism of the river can be the spiritual pulse of the community
-concerned about how we bring the water back
-how can we use the garbage (old cars, etc.)?
-would like to see water flow to south side so everyone can enjoy it
-would like to see water return to historic area
-have to consider that restoring the river upstream is different than downstream
-natural flow to Patrick Smith Park until it gets channeled.

Scenarios:

- spread pulses over whole year: operator can take into account snow/rain and not pulse if not needed.
-perhaps do fewer pulses of magnitude
-pulses vary by month
-what was the river before human influence?
-what if we have a drought and we have lush vegetation that might not be able to be sustained?
-is there a way to have a corridor with fish or riparian corridor that would survive?
-think about the 5-10yr effect
-thinking about 10yr scenario, takes into consideration the storm rates
-adapt over time
-hybrid of river flowing all the time and pulses?

Table Guests:

Bill Armstrong, fire specialist USFS; Felicity, Watershed Association & Santa Fe native; Melinda Park; Betty Booth; Diane Karp, resident of 9yrs, Santa Fe Art Institute; Tricia Watts, moved here from California 2 weeks ago; Francesca Lemids, Agua Fria; Milee Griego Rotunno, Santa Fe native

Initial Thoughts Upon Introductions:

-interest in connecting people to natural environment
-disconnects between food, fuel, water, etc.
-improving ecological resiliency
-importance to kids and families
-need to know where water comes from
-cannot live without it
-morally & spiritually the river is supposed to be a river from headwaters to its end at the Pacific
-connectivity w/ animal life, children, flora, survival, food production
-ancestors experienced the severity of dry river from the dams
-if the plaza is the heart, the river has been the blood. watch people and animals play is like watching the blood flow. Connectivity is major
-use the arts to build stronger communities and explore issues through arts
-cultural freedom and environmental justice
-stunned that river is not at top of everyone's list
-river has not functioned as meeting & joining but has become a case of 'ownership' of land and water.
-returning health to community
-shocking to see river dry
-love running water
-lack of water takes away some of life
-recharging is important
-interested in getting water back
-art that addresses environmental issues
-'water is life'
-property values along river are of interest to owners
-flash floods take away property
-excited about river trail
-memories of river- taught to value and treasure it
-family history of love for water and who we are

Scenarios:

- We should benefit from what 'mother' nature gives us

Table Guests

Veronica (Mexico):
8 years living in Santa Fe, spanish speaker.
Magalli (Mexico):
8 years living in Santa Fe, student.
Marcos (Santa Fe, NM):
Native from Albuquerque, 5 years leaving in Santa Fe NM, Lawyer at the city of Santa Fe.
David (California):
Gardener, NGO, agriculture programs and sustainable technologies as main interests.
Sergio (Santa Fe, NM):
Student of Navajo language at UNM
Alan (Colombia):
8 months living in Santa Fe, Environmental for NSI.

Importance and relationship with the river

Veronica:
Interested in environmental issues
Knowing more about the river
Magalli:
Interesting in help with the health of the river
Water and river are sources of life
Interested in a healthy environment
Marcos:
Interested in water legislature
Interested in future laws about the river and future generations
Interested in laws to protect the river
David:
The river needs to be improved step by step
Education about the river is important
Bring ideas about the creation of a healthy river is also needed
Sergio:
The river brings life to the community
Plants, animals, people benefit from the river

Selection of scenarios
Marcos:
Scenario #2 – similar to natural hydrograph
David:
Scenario #3 – He lives around this area that will be favored with this scenario; river no just for tourist but for the community.

Sergio:
Scenario#3 – The San Isidro area is a healty place for the river. Guadalupe area has many areas with concrete and erosion problems. Water from the river also must benefit southern communities of the city. We do not need water in the river just for tourists.
Rosa:
Scenarion #3 – water from the river close to the plaza won't help nature because the concrete on the edges of the channel. The river must be used for the ecosystem helping nature.
Alan:
Scenario #3 – The river must be a place of life where people and communities can get together in order to create a better place for all Santa Fe. Soil, plants and animals further down the stream along the city also will benefit from this scenario.

PHOTOGRAPHS

Community/Public Meeting #2 Notes
February 3, 2011
5:30-7:30 pm

Attendees:
Despite the cold weather, approximately 50 people attended the meeting (this includes 6-8 core working group members). Approximately 1/3 of the people in the room were not at the first community meeting.

Overview
Toby presented the agenda for the evening and outlined the work that the Core Working Group has been doing after the 1st Community Meeting.

She showed a slide show to go over several concepts

- Living River Initiative
- Definitions of Acre Feet and Cubic Feet per Second
- The 'Task' at hand
    - *Community Objectives for 1000 AFY Flows?*
    - *Target Flow Season? Start/End Dates?*
    - *Preferred Flow Regime? Desired Flow Season Hydrograph?*
    - *Adjustments during dry years?*
    - *What constitutes an 'emergency' to suspend that flow?*
    - *Adjustments during wet years?*
    - *Other Considerations*
    - Goal = creation of administrative procedures to support an ordinance that will go to City Council and the Mayor
- Where are we now?
    - Completed 30+ Stakeholder Interviews
    - Community members, including some already involved with the river
        - Watershed groups
        - Business Community
        - Acequia members
        - Community-oriented non-profits
        - Biologists, ecologists, restoration specialists
        - Mayor, City Council
    - Completed 1st Community Meeting
    - Completed 2-day Working Group Retreat
    - Drafted Preliminary Recommendations
    - Final community review -- reflection, comments, support
- Community Objectives from 1st Meeting
    - Create an Ecologically Healthy Vegetative Corridor
    - Benefit the Entire Community with Flows

    - Nurture a Beautiful, Natural Urban Greenspace w/ water in arid environment
    - Provide an Educational Resource for Schools & Community Stewardship
- Proposed Hydrographs for Typical and Dry Years
- How can we best engage with the River as Stewards?
    - Have we missed anything?
    - Community monitoring and reporting?
    - Connections to schools and community groups?
    - Web/Social Media site for community reporting about the River?

Several Core Working Group Members stood to discuss the challenges with determining a hydrograph and explained the reasoning behind the decisions. They also addressed how the hydrograph meets the 4 Community Objectives.

The community members present raised several questions and points:

- Ensure that equity issues truly are addressed by the hydrograph
- Engage community groups to provide ecological monitoring – perhaps school groups too.

Core Working Group Meeting #1 Notes
January 4, 2011
5-7 pm

Introduction and thanks by Mayor

Introductions of Core Working Group Members

Jerry Jacoby – River Commission Chair. Aquatic biologist by training with a passion for rivers. Wants to see a living river with life in it. Coming at from a biological sense. Legacy – giving the aquatic community a chance to create its own form of a system.

Jim Cutropia – Cathedral. They own 7.2 acres adjacent to the river on Alameda. Seems that the river bed is not healthy; its eroded, silted, etc. Interested in a plan to remedy this. Will also be partially in charge of development of the Church's property over the next several years. Legacy – a healthy river.

Felicity Broennan – Director of SF Watershed Association. She grew up in SF and spent much time in her youth along the river. Interested in a health river, trees, community access. Legacy – an overall healthy river.

Richard Ellenberg – Canyon Road HOA, Acequia de Llano, on the River Commission, Chair of Santa Fe County. healthy river system is important to him. Would like to see more trees and water and birds and animals through town.

William Mee – President of Agua Fria Village association, well and acequia association. Concerned with erosion at Rt 62, various sewer lines, etc. Interested in vegetation, water recharge of wells.

Nichoe Lichen – Camino Real River Connection group. To her a river is a commons, a source of cultural pride for the community, place for kids to play. Why? Water is Life.

Phyllis Bustamante – NMED Groundwater Quality Borough. Interested in returning the river to its natural state.

Neva – League of Women Voters. No particular goal or aim for the river; enjoys it when water in it.

Brian Drypolcher – City's River and Watershed Coordinator. Been working for the City for a few years, and before that TPL as project manager for Railyard Park & Plaza. He is interested in being involved in his community and helping to shape the experience of the built environment. Legacy – river to be a great place so that when people arrive, they think 'what a great place' to experience, making it more accessible, function better, etc.

Jim Matison – Restoration Director w Wild Earth Guardians. Has been involved for years with restoration projects along the river. Has a passion for riparian areas from growing up in Tuscon. Legacy – restore the ecological function of its river to its maximum potential so it can become self-sustaining ecologically.

John Utton – Water Attorney that represents a number of water users in the State. Is representing himself as a city resident. Interested in the connections with people, the cultural values, people seeing the river. Would like to see the River be an asset to the community, and people connecting to it.

Fidel Guitierrez– LANB, Chair of Board of SF Chamber of Commerce and SF Children's Museum. Grew up in Santa River, and the topic of the river was often a joke – but when it ran, it was quite an event. Interested in children learning about the environment, and sustainability. Is interested in helping create a living river, a place for people to gather.

Claudia Borchert – Staff for the City, Water Division. Makes sure we have enough drinking water but has also been working on the river for years. Has been doing analysis to balance supply and river. She is an avid outdoorsperson. Legacy – Great Place, Opportunity (for accessibility, experience the outdoors/nature), Connection.

Erin English – Working with City to help with this process; lives along the River in the Village of Agua Fria. Enjoys walking and playing by the river.

Rich Schrader – Director of RiverSource; lives along the Santa Fe River. Has been doing education work for years along the river. Has worked on conceptual restoration plans for work along the Santa Fe River. Walks along the Santa Fe River daily and appreciates the rejuvenating effect on community when there is water in the river. Legacy – reconnecting people to the river so that they have a sense of place, a place to care for, and reconnecting our wildlife to this place.

Steve Cary – The Butterfly Guy. Studied river geomorphology. Has worked with the Environment Department over the years and with New Mexico State Parks. Now working at the Audubon Society as naturalist director. Respects natural qualities and functions, but recognizes the spiritual aspects as well. Lives near the river. Legacy – Help the River help itself.

How have we gotten to this point?

Brian Drypolcher - There are numerous moving parts to this 1000 AFY project. These include technical, legal, political, community, etc parts. They City staff see them selves as one-step-back participants to serve as resources to the Working Group who is charged – as representatives of the community – to do the work.

Living River Initiative
There are building blocks for a Living River – examples include stormwater, conservation, channel morphology, property protection, policy, vegetation along the river to support the natural systems. There will be temptations to address some of these other 'blocks'.

The focus for this group is 1000 acre-feet, however, and Brian asks that we stay focused on this task.

There have been resolutions in the past to give direction to the staff; 1st year 200 acre-feet, then 700 acre-feet and 800 acre-feet last year. Last year several thousand acre-feet were released because it was a good runoff year.

The Mayor has requested an ordinance to strengthen the City's commitment to itself to put more water in the river. The Ordinance in simple terms says "the City will allow 1000 acre feet per year in the river". That's fine, but the how, when, in what and to accomplish what goals gets down to administrative procedures.

The work of this group is to help the City with the ordinance, but more importantly, to create the administrative procedures for how the ordinance is regulated. There will also be a new resolution to direct staff to comply with the ordinance and procedures.

This is very much a citizen led initiative and value for water in the river. The Mayor also sees himself as a champion of the River. Although the resolutions in the past have passed relatively easily, this ordinance may face more scrutiny. Examples include questions on cost, dedicate of highest-quality, least expensive water, etc.

There are a host of surrounding issues that should be considered as we draft these procedures.

Richard suggested language that frames this as a 'supplement' to what is happening naturally; part of the building block idea as the 1000 afy builds upon what is already there.

How does this relate to our water supply?

Claudia Borchet – The City feels that it can have a sustainable water supply and allow some of the water in the river in normal and wet years. In drier and dry year scenarios, there are still some challenges. The primary reason the 1000 acre feet is on the table is from conservation. The community has done an amazing job in conserving – the lack of need to supply a bunch of extra water has allowed the City to consider giving some to the river.

The 1000 acre feet makes up about 1/5 to 1/6 of the watershed's yield. There are some legal constraints; the way they have been operating currently is the 'Bypass Concept'. The Bypass Concept is defined by not allowing more water to flow out of the bottom of the reservoir than flows in.

Key Question – how do we balance the fact that we want to use our water resources for many things. We want low rates, clean water, water in our taps, etc. We are trying to figure out a way to find the triple bottom line or win-win.

The Administrative Procedure Questions

Toby frames this as ultimately a values question - what do we want this water to do?

Toby has been interviewing around 40 community stakeholder members and she will circulate the summary of these meetings to the group.

Community Meeting

There is a community meeting coming up Jan. 13th at the Chavez Center
We will be meeting the 21st and 22nd at the Audubon Center facilities.

Santa Fe River – 1000 afy flows
Core Working Group Workshop
Jan 21-22, 2001
AGENDA

Day 1 – Friday, Jan 21

9:00 **Welcome and overview**
Clarifying our assignment
Presentation from City Staff
Summary of Community Objectives – stakeholder interviews and community meeting

- Discussion – recommendation for key objectives for 1000 afy

12:00 *Lunch*

Tour of Nichols Reservoir release infrastructure – *Limitations to the system -- How responsive/flexible can our management practices be?*

1:30 **Flow Season and Practice under normal years**

- Need to determine and recommend:
  - Start dates
  - End dates
  - Timing of releases
  - Desired hydrograph

1000 afy in relation to spring spillover

- Claudia presents information about tradeoffs
- Come to decision and recommendation

Preview tomorrow's work

5:00 *close*

Day 2 – Saturday, Jan 22

9:00 **Reflection and overview**
Adjustments to target flows: what to do in wetter conditions?

- Come to decision and recommendation

Adjustments to target flows: what to do in drought conditions?

What would constitute and "emergency?"

12:00 *Working lunch*

What else needs to be considered?

- Review additional questions
- Go through draft ordinance

Summary and next steps

3:00 *Close*

Core Working Group Retreat
Meeting Notes
January 21-22, 2011
The Audubon Center, Santa Fe, NM

Day 1 – Friday, January 21, 2011

Attendees:

Rich Schrader:	RiverSource (& The Commons) – interests and passions of families in the area.
Phyllis Bustamante:	Citizen & background in water and water quality.
William Mee:	Agua Fria Village. Passion from traditional community that was tied to the River and acequias.
Felicity Broennan:	Santa Fe Watershed Association. Passionate constituents
Jerry Jacoby:	Chairman of the River Commission. Aquatic biologist. Member of American Fishers Society.
Fidel Guitierrez:	LANB, Chair of Chamber of Commerce & Children Museum.
Steve Cary:	Audubon staff & Citizen. Brings a sense of natural function of rivers.
Richard Ellenberg:	Lives nearby. Canyon Neighborhood Association & Chair of the Democratic Party. Bringing a non-expert passion and experience with the various viewpoints.
Niva Van Peski:	Has collected statistics on water and river for a number of years, also a member of League of Women's Voters
John Utton:	Board of Santa Fe Watershed Association, lives along River near Alto. Water lawyer, represents a few acequia groups and Santa Fe County.
Jim Matison:	Wild Earth Guardians. Has worked on re-vegetation over the past 10 years.
Nichoe Lichen:	Camino Real River Connection. Wants to help heal the River to honor historic and prehistoric ties along the River, and to restore dignity.
Jim Cutropia:	Works for the Cathedral whose property is adjacent to the River and are in the process of developing that property. Interested in a healthy River and its importance for tourism.

City Staff Present:

Claudia Borchert:	Water Division. Job is to assure sustainable and viable water supply for the City.
Brian Drypolcher:	City's River & Watershed Coordinator. Brings various perspectives & a keen desire for this process to be successful; a viable solution that feels good for all parties.
Marcos Martinez:	Attorney for the City. Can provide legal background but will also be listening

Purpose of the CWG Workshop & Introduction by Toby
"Advise the City about 1000 AFY Flows for the Santa Fe River"

This is an advisory body (not necessarily an elected or appointed body) who will advise the City on the administrative procedures. The CWG workshop is a major step – but not the last one – in this process of creating an ordinance. After this workshop, Erin, Toby & City Staff will take the recommendations to craft into a draft ordinance. The ordinance will be reviewed by City Staff and then sent to Council and the Mayor.

Outcomes
Recommendations on Five Questions – then other issues
Consultive Process – Consensus?
Material for Toby & Erin to Use in Drafting

Agenda
Friday

- Welcome & Overview – clarify assignment
- Why? What? What's Possible? City Staff Presentation
- Summary of Community Objectives
- Recommendation: Key Goals for 1000 AFY Flows
- Lunch – Tour of Nichols Reservoir
- Flow Season + Management in 'Normal' Years
- Recommendations: Target Flows
- Spring Spillover + 1000 AVF – Relationship?
- Preview Tomorrow

Saturday

- Reflection & Overview
- Adjustments to Target Flows – Wetter Years, Recommendation?
- Adjustments to Target Flows – Dry Years, Drought? Recommendations
- Working Lunch
- What else need to be considered
- Roundup and Conclusions

Groundrules

- Listen to Learn
- Suspend Certainty
- Welcome Diverse Views
- Focus on *Interests*, not Positions
- Honor Timeframes
- Work Toward Best Solution for the Group as a Whole

Clarify our Assignment

1. Community Objectives for 1000 AFY Flows
2. Target Flow Season? Start/End Dates?
3. Preferred Flow Regime? Desired Flow Season Hydrograph?
4. Adjustments during dry years? What constitutes 'emergency' to suspend that flow?
5. Adjustments during wet years?
6. What else?

Presentation from City Staff – Brian, Claudia, Marcos

Brian provided an overview:

- Living River Initiative
- A New Ordinance and Administrative Procedures
    - Ordinance is a law to enforce upon itself
    - Ordinance is supported by a set of administrative procedures
- Public Engagement Process
    - Stakeholder Interviews
    - Community Meetings (2)
    - Working Group that drafts recommendations for Council approval
    - City Council approval process (4 council meetings)
- Living River Initiative
    - Ecology- habitat, plant life, stormwater management
    - Aesthetics – flowing water, greenery, parklands
    - Social Life – places for people to gather, connectivity, recreation, walkable-bikeable city
    - Economics – water supply, property values, supporting local businesses & tourism
- Why The Living River Initiative
    - Because the community said so
        - River Corridor Master Plan 1995
        - Long Range Water Supply
    - Because the City leadership said so, Mayor and City Council
        - City funds river work on a consistent basis
- How?
    - Conservation
    - City's Long Range Water Supply Plan and Supporting research by the Water Division
    - Buckman Direct Diversion
    - Thoughtful approach to managing our water supply
- Building Blocks of the Living River
    - Stormwater, restoration, wastewater, conservation, spring runoff

Claudia outlined:

- Watershed Map
  - Below Nichols Gauge, Above St. Francis Gauge & Ricardo Gauge
- River Water Balance
  - Outlined how water gets into the river and where much of it goes.
- Water Structure
  - Outlined the water supply portrait and how water gets into the River.
- Santa Fe's Conjunctive Water use
  - Actual Use versus projected use, and the positive impact of conservation.
  - Santa Fe's conservation has resulted in a 40% reduction in gpcd water use.
  - Currently using about 12 gpcd of treated effluent for irrigation.
  - 60% of the water we produce ends up in the WWTP. Reusing 10% of what comes in.
- How does the 1000 AFY impact the need to rely on groundwater supply?
  - B/C of conservation, moderate groundwater use levels can be sustained
  - Need to be aware of our challenges with the water supply portfolio and the impacts on groundwater pumping. Without the 1000 AFY in the River, we are likely to pump 2,300 afy versus 1,300 afy if we used the 1000 AFY for water supply.
  -
- Groundwater Flow Conditions in the Tesuque aquifer system
  - Groundwater flows from East to West
  - Depth to Water <20 to >500 ft
  - Steep gradients near Agua Fria Village
  - Areas of high transmissivity follow the Santa Fe River, and are likely remnants of River deposits.
  - Can see the zone of depression from pumping city wells near downtown and at the Buckman wells.
  - If water levels have dropped more than 250 ft, this is a time to be concerned about groundwater.
  - Current drawdowns around 50-100 ft in downtown and 150 ft in the Buckman area. Water levels have been flattening or rising over the past 10 years.
- Schematic of Surface-water to Groundwater Interaction
  - Losing reach (e.g. water infiltrates) Seepage studies
  - Shallow Groundwater is perched; regional has seen up to 150+ ft of decline level monitoring.
  - Connection between perched and regional exists
  - Fate of infiltrated water not yet identified
  - 0.4 cfs/mile in upper reach and 0.3 cfs/mile in the lower reach. We are using low flow loss rates.
  - Loss rates change upon conditions – has it been wet recently, high flows lose differently than low flows.
  - No definitive answer about which areas are losing, though some sense this may be just downstream of St. Francis.

- Analysis for the Long-Range Water Supply Plan was a little different
    - 1000 AFY to SF River in average and wet years
    - 5 cfs constant flow for 100 days
    - No water released in dry years (when emergency drought management would be triggered)
    - Assumed BDD is fully operational
    - Water MAPS (Management and Planning Simulation) modeled annual water supply = 4,481 afy vs 4,900 afy
    - RWater MAPS assumed City's ability to manage sources flexibly included SF River water from all hydrologic sources: flood flow, reservoir storage, late season flow
    - Identified that legal
    -
- Supply Probability of the Santa Fe River as a Source
    - Overviewed the probability graphs and projected modeling of impacts of allowing 1000 AFY in the River.
    - Serves as a tool to understand the risk and the results show that there is a risk – not huge – of releasing water into the River.
- Illustration of Spring Releases and Abundant Precipitation
    - Risks to water supply (in terms of cost and wet water) associated with how we release water during dry years, average years and wet years.
    - Do you take 1000 AFY in addition to the 'spill' that occurs only in wet years, what is the risk to the water supply?
    - The typical year would not create a 'spill' over the resov.
    - Starting in mid-June, we are using more water than is in-flowing – i.e. starting to rely on storage.
    - If we take all the 1000 AFY during the 'accumulation' time, this can impact the water supply.
    - What if we reserved some 'bank' from excessive years to help reserve water for the river in the event that a drought year occurred the next year.
    - Question – was there any effort to link a 'percentage' to the River based upon the Watershed yield as opposed to "1000 AFY". Would a scalable number make more sense than a 'fixed' number.
    - Can the 'calendar' year be shifted to June or some other month instead of January. The time we know the most is around April 1-15. Still have no information about thunderstorms at that time.
    - Discussion on rate – is there a public process about water rates.
    - Variability is a natural pattern and hydrologic function of rivers, particularly in the West and we should be careful to not totally disrupt this pattern.
- Summary – the decision is not yet clear – this is part of the Flow Regime question. We cannot decide the flow regime, until we've made a clear examination of the community recommendations.

Legal Context – Marcos

- City has a right to beneficially use 5040 AFY from the River. Beneficial uses include domestic, outdoor irrigation, typical commercial uses (i.e. municipal permit).
- Releases to the Santa Fe River by-pass the City's storage and diversion of water and, thus, do not draw from the City's water right.
- A 'bypass' refers to water allowed to flow past a storage structure. In this case, the bypass term refers to water that passes through the reservoirs when water inflow is equal to or greater than the water flowing out. (I.e. Outflow cannot exceed the inflow)
- The City intends to beneficially use its full permitted right, however, because of this proposal to allow by-passed flows to the Santa Fe river, the City may only be able to do so in in exceptional years.
- There are other appropriators with rights on the River (acequias).
- The City cannot administer the water rights of other users because that responsibility lies with the State.
- Therefore, it would be more constructive to work with other surface appropriations, whose lawful appropriations may impact flows in the Santa Fe river.
- Once the City puts water in the River, it has no ability to control who uses. City needs to understand how the acequias use the water.
- Is the water release 1000 AFY + Acequia use (70-100 AFY) or only a total of 1000 AFY (inclusive of Acequias?)? This is a question. The City has no way to control how much water the acequias use (the OSE is responsible) and may or may not have a right to measure how much water the acequias are taking.
- We are not proposing to change the water right, but if we pull water out of storage, this raises a potential legal question. The limiting factor is how much water is flowing in versus how much water is flowing out.
- There may be ways to work with the acequias but something we need to address as part of the Bike Rack or as an additional, separate discussion.
- From a legal perspective, taking a % of the natural inflow instead of a 'fixed' amount, allows releases to the River to follow the hydrograph and not exceed the inflow. This would be a solid approach legally.

Feedback on Community Meeting/Objectives

- Observations from the First Community Meeting
    - There was correlation between the goals and inspirations of people at the 1st CWG meeting, the Public Meeting & Stakeholder meetings.
    - Some technical information may have been lost on some of the crowd, particularly the younger folks.
- For Reference (Jerry): River 3 ft wide, 6 inches deep – window of 1.5 sq ft, water moving through it 1 cfs. One acre-foot is an area a little smaller than a football field, covered with 1 ft of water. This is around 325,000 gallons of water (enough for 5-6 households).

Small Group Exercise – review the top objectives generated from the Community Meeting and Stakeholder interviews. Does this fit with our objectives for the flow?

OBJECTIVES

1. Ecologically Healthy Vegetative Corridor (Resiliency)
2. Benefit Entire Community with Flows (Equity)
3. Beautiful Natural Urban Greenspace w/ water in arid environment
4. Educational Resource for Schools & Community Stewardship

Group 1

- Improve ecological conditions and resiliency – everything else is related to this and tied together. Green space, tourism, etc all tied to the ecological portion. Healthy environment reflects a healthy community. Everything flows from the ecological resiliency piece.

Group 2

- Thought the line was drawn in the right place – no need to rank them, but hold them all.
- Some community objectives may not have an impact on the release regimes?

Group 3

- Building block is #1 (Ecological health) and all other things come from it.
- Recharging groundwater & well fields can also fall under #1.

Discussion on developing consensus:

- Question on how much info is submitted about these top objectives...will we list sub-categories and also those that did not make the cut?
- Better summarize the totals from each main of the 4 categories.
- Can we feed the subsets into the main 4 categories and figure out where they belong above?

Basis of consensus:

1. Site these 4 as the primary objectives, with subcategories included beneath it
2. Show in weighted order
3. Plug in other values under these 4 categories

Result: Complete consensus

Field Visit to the base of Nichols Reservoir and to the gauge below Nichols.

Take-aways from visit:

- Systems more antiquated than the kind of management we want to do with it
- Can't measure winter flows the way we want to because of frozen water surfaces

Flow Scenarios

- Scenario 1 – Year Round to Patrick Smith – off the table
- Scenario 2 – Summer flows to Guadalupe – somewhat mimics the '20% of hydrograph' option
- Scenario 3 – Pulsed flows to San Ysidro
- Hybrid 1 – Pulsed flows with small trickle baseflow
- Hybrid 2 – 20% of the Hydrograph

Planting Considerations

To keep the trees to regenerate on their own, you want overbank flooding at some point during the time that you have seed dispersal. Historically sometime between May and June. 5-10 week window for those species to germinate. If you have one strong pulse at the end of June, but will need another strong pulse (hopefully from Monsoon) in Aug/Sept. Also depends upon how new the plants are – older plants with deeper roots will do better. If Monsoons do not kick in, you may need to add some pulses.

If the goal was to create a green corridor. A small pulse of 2 cfs that is not making it to Frenchy's may well be making it to San Ysdiro subsurface.

A good spring pulse all the way through (to WWTP) with reliance on Monsoon. If monsoon does not kick in, consider another pulse or two (once per month) to make up for it.

Considerations:

- NM rivers undergo wild fluctuations in flow and are able to tolerate changes.
- Rate of Inflow is a legal constraint and if we vary from it we need to remain aware.
- We are far from having a natural hydrograph in the City; the City has also invested a substantial amount of effort into tree planting. Just mimicking the natural hydrograph may not be enough and we may want to consider a pulse.
- Ensure the administrative procedures (which can be changed by resolution) are flexible to allow for changes based upon seasonal variability in weather conditions.
- Is there a possibility to recommend a moving average – a 1000 afy average over 5 years.
- From Nichols to Acequia Madre (2.5 miles) is almost perennially wet with trees and willows – and can act as a seed bank. Use this resource to help move seeds further downstream and 'seed' downtown and beyond. Keep flows minimal in the winter when the trees are not transpiring and the acequias are not diverting.
- There are events that require water – River Derby (1st weekend in June) & San Ysidro Day

Group Exercise Feedback – Flow Scenario

Group #1 –

Fidel, John, Jim M, Niva

Suggest a scenario most similar to 'Summer Flows to Guadalupe' and ensure 'two big flows' – makes one big release/cleanout in the spring, and the other flows mimic the natural hydrograph. Start April 15 (2 CFS) with pulse for Fishing Derby and then following 2 CFS, but ADD another pulsed release around mid/late August (to mimic natural hydrograph above McClure). End Mid September. This could act as a

supplement to Monsoon. Like the idea of the piezometers so that can be ready with pulse if Monsoons don't come. Didn't feel that the shoulder season (Jan-March) and (Nov-Dec) was as crucial and possibly not getting all the 'bang for the buck' during this season. Would rather see more water flowing mid-April through mid-Sept. Was hoping for continued leak to help support the upper river area. Did discuss whether there was some minimum (or maximum?) amount in drought times.

Group #2 –
Jim M., Richard, Jerry, Claudia, Phyllis
Wanted to maximize pulses to San Ysidro – 5 total pulses of approximately 1 week each with a small trickle year-round. (The first pulse is 2 weeks). Shoulder season trickle accounts for nearly ¼ of the annual flows.

Extended the 8 CFS initial event out a week so it was further along into June. This would help to facilitate seeding (which may roll into June). End of June/beginning of July is the warmest part of the season and it is when there is no monsoon – they wanted to add a pulse during this time to help with watering and minimize impact of a bad monsoon season on the plantings. Adding another pulse in August in hopes that they have a normal monsoon season; just in case there is not, there is another designated flow to adapt to it. They recognize the importance of natural patterns of water in the system for a year round period of time as is dictated in the natural hydrograph. They suggest 0.60 during the early part of the year and 0.80 CFS during the shoulder seasons. August and Sept. pulses could be variable – in a good Monsoon, these could be shifted downward to help bank some of this water for the next year. This scenario reaches most of the community with flowing water. Shoulder season water may help keep upper reaches alive.

Do semi-saturated conditions, when a storm comes does this condition help attenuate flashy runoff patterns?
Rough rule-of-thumb: Look at CFS flow – and double it – to estimate how far (in miles) that water will flow. i.e. a 6 CFS pulse will maybe make it 12 miles.

Group #3 -
Steve, Felicity, William, Rich, Jim C
Recognized a few things – early part of the hydrograph (snowmelt) is easiest for us to measure, predict and mirror. Winter is dormant time, there is already some leakage, snows and melts with little demand, and so eliminated the Nov-March water and re-allocate it. Water was added to bulk up spring pulse. Stair-Steps could be based upon % of water going into McClure. For the Summer, suggest fewer, higher peaks (to be more typical of a monsoon), but if this could be flexible, could allocate more in a dry year and in a wet year allocate less. Three main pulses outside of the spring pulse. Want piezometers to help measure wet/dryness in areas with plantings to get feedback.

Common Threads for all 3

- Strong Spring 'Flush' Pulses that gets through San Ysidro.
- All had 2-3 or 4-5 San Ysdiro Pulses

- All have April-Sept base flows

Biggest Differences between all 3

- Releases during shoulder season (Nov.- March) when soils are more likely to be saturated, trees are not up-taking an acequias are not diverting. Flows are more likely to go further during the winter than the summer.
- Shoulder season water may help set up the river for seasonal pulses and help create a small section of 'living' river in the upper reaches. Challenge: current infrastructure is not conducive to measurement of these flows and would require upgrades.

Summary and Discussion of the Flow Scenarios

Question – do any of these scenarios do damage? Not as far as the group can imagine.
Key Tradeoff – If we want the 'whole' year of flow, we are sacrificing the amount of water available for the rest of the year during the growing season. March is a time that we may want to start some of the flow to benefit the trees (to hit bud emergence and counter potential warm days). Jim suggested March 15-Oct. 15 (hence slight extension of shoulder but not necessarily the whole season). March 15th may be more important than Oct. 15th.

Scenario 3 – has many of the features that everyone agrees are important. With flows continuing into June, past the fishing derby. Reduce 10 cfs peak a little, tweak numbers to get to 1000 afy.

Conclusions – listened well, learned a lot of new things we didn't know. Can make better decisions. The breakouts worked well with coming together to share the ideas. Facilitator kept us focused but did not kill conversation.

Day 2 – Saturday, January 22, 2011

Agenda

- Reflection & Overview
- Adjustments to Target Flows – Wetter Years? Recommendations
- Adjustments to Target Flows – Dry Years & Drought? 'Emergency'? Recommendation
- Working Lunch
- What else needs to be considered?
- Summary & Next Steps

Reflection & Overview

- Niva has a suggestion from a friend who worked on regulation in Texas. Build a series of very low dams that hold just slightly less than the max permitted amount (~9.5 ac-ft).

- There is additional property from Rt. 599 to Cottonwood Mobile Home Park – Camino Real River Park (1 mile long) that is a joint City/County project and will open sometime this year. Nichoe recommended that we try to get water to this park? Can we pump effluent to that park.
- Erosion control is important (William Mee) as the downstream reaches of the River are being impacted. There are threats (in 5 places) to the City's sanitary sewer line. Small portion of Agua Fria Villager's property in some cases has fallen into the River.
- Hybrid 5/Scenario 3 – Works well but may need to be paired down slightly to stay within 1000 AFY.
- Jerry – providing shoulder flow, some life can be maintained. Turning it off completely will let much of the river life to die, and when it is turned back on again, everything must start again. John's concern is that if we provide shoulder water that we may have to reduce the flows during the summer between the peaks.
- Jim pointed out that we have heard about 3 different places to get water to – need to decide how far we want to get those pulses before we finalize our pulse volumes.
- Steve thinks that adding shoulder flows would support some more robust life in the upper reaches and this may be worthy even though not everyone lives along this reach.
- Jim said that yesterday that we were looking for a spring pulse to distribute seeds to the WWTP, with a few more monthly to San Ysidro.
- Nichoe mentioned that there are thousands of kids near the Camino Real Park (which is about to become City property) that would benefit from flows to San Ysidro and beyond.
- Richard mentioned that getting shoulder flows through Santa Fe Canyon Preserve (property below this is all private to Patrick Smith Park). He also suggested a spring pulse to 599, a summer pulse and 2 CFS summer flows through DeVargas Park.
- Jerry said that maintaining 2 CFS gets flow through downtown with a slight spill over St. Francis.
- William suggested 180 days @ 2 CFS and XX days @ X CFS.
- Phyllis said that most of the community input was that they wanted to river to go down further into the community where more people access it.
- Rich recommended that we at least keep 1/3 CFS in the shoulder season – even if the leak is fixed – to maintain what we have in place right now.
- Jim C. recommended taking an average year's storm flow to augment the 1000 AFY and examine this impact. Redistribute the 1000 AFY based upon flow projections from rainfall.
- Steve said that the downstream reaches have different weather/river patterns than the reservoirs and can receive water from rainfall/runoff. The uppermost reaches are not going to benefit from this runoff and are thus very dependent upon releases from the dam/reservoirs.
- Phyllis added that stormwater runoff coming from downtown has quality issues and we should try to send good quality water downstream too.
- Claudia: 4 things we do:
    - SF Canyon Preserve – 200 AFY
        - Very low flow during non-growing season (0.15 CFS?)
        - Double during growing season
    - Spring Pulse – 450 AFY (to 599?)
        - Fishing Derby/River Festival

        - San Ysidro Blessing
        - Nutrient Cycling/Flush
        - Cottonwood/Seed Germination
        - Steep declining limb?
        - Make it to 599
        - Be mindful of mid/late-June period
    - SF Downtown – 200 AFY
        - Make it St. Francis or De Vargas Park
        - Flow on weekends? Daytime? Holidays? Once system is upgraded, can we provide this level of control?
    - Additional Pulses above & beyond Monsoon – 150 AFY
        - Make it to 599 once after spring?
        - Enjoyment?
        - How many pulses? Timing? Distance?
        - Mindful of bypass

Claudia suggested that we keep the framework of the ordinance and administrative procedures general and overarching without the details of the 'numbers' and to allow flexibility for year-to-year. Need to build in the 'If/Thens'.

Claudia will work through this scenario and present it after lunch.

Individual Process

Participants to fill out worksheets from Toby for "If-Then" scenarios. Run scenarios for Wet and Dry years, and pass around table to gather comments. Work as a group to come up with 3 'If/Thens' for Wet and Dry.

Table 1 – Results (Richard, John, Rich, Felicity, Jerry)

- Conjunctive use of the wells - in dry years use them more, in wet years use them less.
- In Wet Years, use some of the 'spill toward the 1000 AFY for the River' to reduce the amount of water used for the wells (rest the wells?)
- Would like to see overbank flow every 5 years or so.
- Dry Years – still want 1 or 2 surges in even very dry years to help protect the riparian habitat.
- If inflow is below average (but not 'severe' drought) we still want our 1000 AFY. Would the River 'share' the burden of dryness by following the hydrograph. I.E. river to not share shortage proportionately since the reservoir is its only source of water (unlike the city, which has other sources).
- In a 'Severe Drought' – we would reduce the pulses, but still have a 'minimum' of 500 acre feet. This would be subject to physical constraints (i.e. getting water out of the reservoirs).

Table 2 - Results (Phyllis, Brian, Niva, Jim M)

- This river water is the cheaper water for the City to supply; if we are in a severe drought conditions, we still want to release 1000 AFY and use other supply sources, it becomes more expensive for the City to produce the water.
- Want to be sure to establish plantings that can adjust to dry periods.
- Have 'trigger' points:
    - Snowpack (scale back when snowpack drops)
    - Reservoir Level (%)
    - Cut-off entirely based upon reservoirs
    - OR use all watershed water for the river as an investment
- Allow the 1000 AFY until the reservoir hits 20% and then cut it off.

Table 3 – Results (Nichoe, Jim C, Erin, Steve)

- Concerned with public perception with trying to maintain 1000 AFY in a time of water restrictions or other such measures. We may have to cut back – perhaps follow 20% of the inflow hydrograph.
- Trigger points for 'decision-making' – April 15/Snowpack, Monsoon Pattern
- Use these decision points to shift the release hydrograph further down-season
    - Snowpack – adjust up or down the spring pulse or interstitial flows
    - Monsoon – adjust up or down the late summer flows, pulses or Oct. pulse

Overview

- Need to think about drought, but expand our thinking beyond just 'proportional' burden. In severe drought reduce flows somewhat, in a non-severe drought keep river running. Essentially 'bank' water in the wells.
- Rate impacts may be possible depending upon long term operations of this process.
- How to define stages of drought? Use % snowpack or some other terminology?

Goals for the Ordinance & Administrative Procedures

We need to provide a solid foundation on which the adaptive management can take place.
Ordinance needs to have a trigger of 'successful operation of BDD'.

Overview of Shared Hybrid Flow Regime

- Shift August/Monsoon Pulse from August to Late June/Early July, to supplement plantings in June. Although this depends/bets upon Monsoons to provide pulses in July/Aug, it is still better to water the plantings in June than it is in August.
- Trigger/Decision point at Late June/Early July period to examine forecasts for monsoon.
- What is the 'trigger point' for seed germination late May into June?

Associated (i.e. additional) Recommendations – Shared Hybrid Flow Regime

- Dams/Ponds along the way to hold water
- Erosion Control needed in the San Ysidro River
- Can we move Fishing Derby – to June 8th (or so – about 1 week later) to accommodate this? Probably not easily.
- Could we remove the shoulders for the first year – since the gauge may not be working in the winter for now – and dedicate that water to the summer/spring? Claudia will have to check about the ability to measure flows during the wintertime (it may be possible).
- Hydrograph accommodates San Ysidro Day, Fishing Derby, River Park, Irrigation during hottest time (& July 4th weekend), downtown flows, flows year round in the upper reaches for ecological preserve, water downtown through fiesta.

If-Then Summary

- Trigger points – snowpack? Drought stages? Linking it to the watershed yield is a very good way to define what we are anticipating as storage (i.e. snowpack). Likelihood of getting into those restrictions now is diminished due to BDD.
- Base flows into the River on snowpack or straight 1000 AFY?
- Proposal from Claudia
    - Normal = 85% of average
    - In Wet Year, the river will see a lot of water in the above-average year (spill, precip, stormflow, etc)
    - Trigger of 75%-80%. At 20% automatically put some amount in the river no matter what. Accordingly, if it was 60% of average, you still hit the pulses, but scale down the other flows to hit the quantity of water you are looking for.
    - Water Spills or not? Supplying water in dry years and in peak demands is the highest cost of water –most expensive water you have to plan for. Best option for environment, most expensive option for the water utility.
    - Claudia suggests that spills are a wash. How does the spill and 1000 ACY work per year?
        - Not saying not 'counting' 1000 AFY during the Spill time, but will continue to follow the pattern for post-spill time.
        - Using carry-over storage and resting the wells. No additional pulses unless nature provides them.
        - In dry years, river never goes dry, never lose the 2 pulses, keep the pulses and scale the other flows to deal with the less water that is available.
        - Trigger of 75% of snowpack? Triggers 'dry year' scenario.
        - In a 75% we get 3,500 AFY. Putting 1000 AFY into the river leaves us with 2,500 AFY, which is approximately 50% of our surface water right. This would happen 1/3 of the time.
        - If we were to follow the 'hydrograph' of say, 20%, the 75% year, which yields 3,500 AFY, the water release would be 0.20*3,500 = 700 AFY.
        - John proposes that at 75% of snowpack reduce how much goes to the river, but the minimum required would be what is required to provide 3 pulses

throughout the year as a minimum maintenance flow for keeping vegetation alive. We think its somewhere between 300 and 500 acre feet?

- Claudia modifies to two pulses and a low-low flow year-round (<0.30-0.50 CFS) at the top of the watershed.
- Could be either-or: Either 3 pulses OR 2 pulses and a low base flow of 0.30 CFS.

Finishing Up & Wrap Up

- Feb. 3rd meeting – feed back to the community their objectives, here are the ways we have come up with addressing these objectives, celebrations about work that has done. Key questions -- did we miss anything or big gaps? We heard you and we feel really good about it even through all of the constraints.
- Synthesize, bring to community meeting, then after meeting work it into the form of an ordinance and administrative procedures.
- Jerry would be interested, William, Felicity, Nichoe, Richard, John, Fidel.
- Who is interested in keeping to weigh-in: John, Richard, Felicity, Jerry, Jim C.
- Next meeting? How about 3:30 Tuesday Feb. 1st
- Dry Hydrograph Scenario for 'spending' water
    - 60-70 AF for 5 days @ 7-8 CFS – provide 3 pulses to keep the River alive and vegetation alive.

Bike Rack

- Way water is taken out of the River – can we take it from the 'bottom' to help clean out sediments from the bottom, thus increasing the storage capacity.
- Acequia agreements – can they water at night? Can they add additional flow monitoring? Is this a separate process of discussion with them?
- Infrastructure upgrades at the gauges and outlet structures...need for design/engineering and upgrades.

Core Working Group Retreat
Flip Chart Notes
1-21/22-2011

Welcome + Overview

- Clarify Assignment
- Why? What? What's Possible?
- City Staff Presentation
- Summary of Community Objectives
- Recommendation: Key goals for 1000 afy flows
- Lunch-Tour of Nichols Release
- Flow Season + Management in "normal" years
- Recommendation: Target Flows
- Spring Spillover + 1000 afy -> relationship?
- Preview tomorrow

Our Purpose:
Advise the City about 1000 afy flows for the Santa Fe River.

Ideas:
Dams along the way to hold water.

Outcomes:

- Recommendations on five questions – then other issues.
- Consultative process – consensus?
- Material for Toby & Erin to use in drafting.

Objectives

- Ecologically healthy vegetative corridor (esp. trees, habitat for birds and animals)
- Benefit Entire Community with Flows (Equity downstream)
- Beautiful natural urban greenspace with water in air environment.
- Educational resource for schools + community stewardship.

Bike Rack

- Does City have a right to measure amount of water acequias are taking?
- Acequia agreements? – can they water at night?
- Resources/staff to engineer infrastructure improvements?
- Can we modify legal constraints?
- Need to study/monitor how far saturated soils go in flow CFS flows

Associated Recommendations

- Erosion controls needed in Agua Fria Village area
- Move Fishing Derby to accommodate needs of River?
- Meet with Acequias – agreements re: flows, schedule and monitoring
- Pursue changing law to allow in-stream beneficial use
- When does 'water year start'? April 15th?
- Variability as function of river?
- Agreements with Acequias about the timing and amount of the their use?
- Flow regime – consider using % of inflow as guide and measure

AGENDA-Day 2

- Reflection + overview-complete flow pattern.
- Adjustments to target flows; wetter years; recommendation.
- Adjustments to target flows; dry years + drought? "Emergency"?; recommendation.
- Working Lunch
- What else needs to be considered?
- Summary + next steps

What to Consider?

- How to keep trees alive? Tree Regeneration; May-June overbank flooding.
- Spring Pulse to flush system.
- If no monsoon...then-monthly pulse through end of September.
- Consider natural (intermitten) stream habits.
- Rate of inflow-legal constraint.
- "Seed Bank" in upper 2.5 mile reach.

GROUP 1 – Start with Scenario 2

- April 15 Start and end September
- Pulse at Fishing Derby
- Maintain 2 cfs
- 2nd pulse in August
- Piezometers – ready to pulse further down if monsoons are weak
- 20-25% of McClure averages
- Conjunctive use of wells. Dry=move well use; Wet=less well use
- Wet Years – use some spill water for river
- Every 5=10 years –overbank event
- Dry years:
    - If inflow below average, but no senese, retain 1000 afy
    - If sever, reduce to 1 pulse

- Subject to op. constraints; 500 afy min to river

GROUP 2 – Start with Scenario 2

- Base on natural hydrograph; maximize pulses to San Ysidro.

#1 8 cfs pulse at peak of natural hydrograph – 2weeks.
#2 Pulse at end of June-hottest time of summer-6 cfs in case monsoon is late.
#3 Pulse in August as "insurance"

CFS year round; won't release if no water coming in.

- Trigger Points –
  - If inflow below average, but no senese, retain 1000 afy
  - Scale back totally rlated to res. Levels – 20%
  - or consider retaining flows to protect vegetation

GROUP 3 – Start with Scenario 2

- Dormant in Winter; Startup with Scenario 2-Nov-March
- Flexible pulses – related to monsoon events?
- Piezometer feedback for later in the season?

Triggers connected to Phases:

1. Snowpack at certain date:

   ↙ ↘

   Dry Wet

   Dry: Match hydrograph river hit proportionately
   Wet: Begin spills earlier; duration or volume of spring

2. Monson Progress:
   Weak: Retain pulse
   Strong: Extend fall shoulder; bigger October Pulse

Emergencies: Five; well contamination; system failure

Banking?

- Release 1000 afy on average over several years.
- or release in early shoulder season

Consistent

- Strong spring flush pulse

- 2-3 (4-5) pulses to San Ysidro.
- Ongoing low summer flow: April-End of September

Differences – Shoulder Seasons

- Amount in spikes
- Minimum between spikes

Proposal:

- Shoulder .5 cfs season (to SFCP?)
- Spring spike
- Summer flows to DeVargas (2 cfs between spikes)

4 Values

- SFCP - 200 afy?
- Spring Pulse – 450?
- Downtown – 200
- Other Pulses – 150

Dry Years

In low years – maintain %

Minimum:

- Retain two pulses
- Mountain trickle cfs through year

Worst Case Scenario:

- Keep 2-3 pulses of 5 days @ 7-8 cfs
- Cannot violate bypass unless there is change in the law.

Check-In

- People in community connecting with & embracing Santa Fe River
- Great Place, connection opportunity
- Stormwater as way to connect river to its watershed
- River belongs to us
- Butterflies on river
- Help river help itself

What is important to us?

- Aquatic community biologically
- Healthy river
- Trees further downstream

- Protect from erosion
- Cultural pride – access for everyone
- Return to more natural state
- Habitat
- River to be "Great Place": beauty, access ability, functional
- Restore ecological function

City of Santa Fe
Santa Fe River - 1000 afy

CORE WORKING GROUP			
Participant List			
Name	**Organization**	**Phone #**	**E-mail**
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MEETING SIGN-IN SHEET

Project: Santa Fe River – 1000 AFY	**Meeting Date:** 1/13/2011
Facilitator: Toby Herzlich, Erin English	**Place/Room:** Genoveva Chavez Comm. Center

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Name	Neighborhood or Street	How did you hear about meeting?	E-Mail
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MEETING SIGN-IN SHEET

Project: Santa Fe River – 1000 AFY	**Meeting Date:** 1/13/2011
Facilitator: Toby Herzlich, Erin English	**Place/Room:** Genoveva Chavez Comm. Center

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MEETING SIGN-IN SHEET

Project: Santa Fe River – 1000 AFY	**Meeting Date:** 2/3/2011
Facilitator: Toby Herzlich, Erin English	**Place/Room:** Convention Center

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Deanna Einspak	La Joya	Email	
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MEETING SIGN-IN SHEET

Project: Santa Fe River – 1000 AFY	**Meeting Date:** 2/3/2011
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Chip Conway	Roberto		
Alice Liska	3 Estrada Calabasa	New Mexican	
Don Liska	3 Estrada Calabasa	New Mexican	
Rich Schrader	Frenchy's Park		
Fidel Guiterrez			
Matthew McQueen	Galisteo		
Dan Groenfeldt	Camino Santander		
Jaggers Family		Rich Schrader	

APPENDIX O

WTP Operator Stream Flow Monitoring

= Measurements, to be entered daily
= Use gage rating curve tables to derive discharge
= Measurements of the staff gage below Nichols
= Optional discharge measurements, downstream

**Note on recording time of measurement: Use military time, and round to nearest quarter hour in fractions of hours (e.g. 1:10 pm would be 13.25)

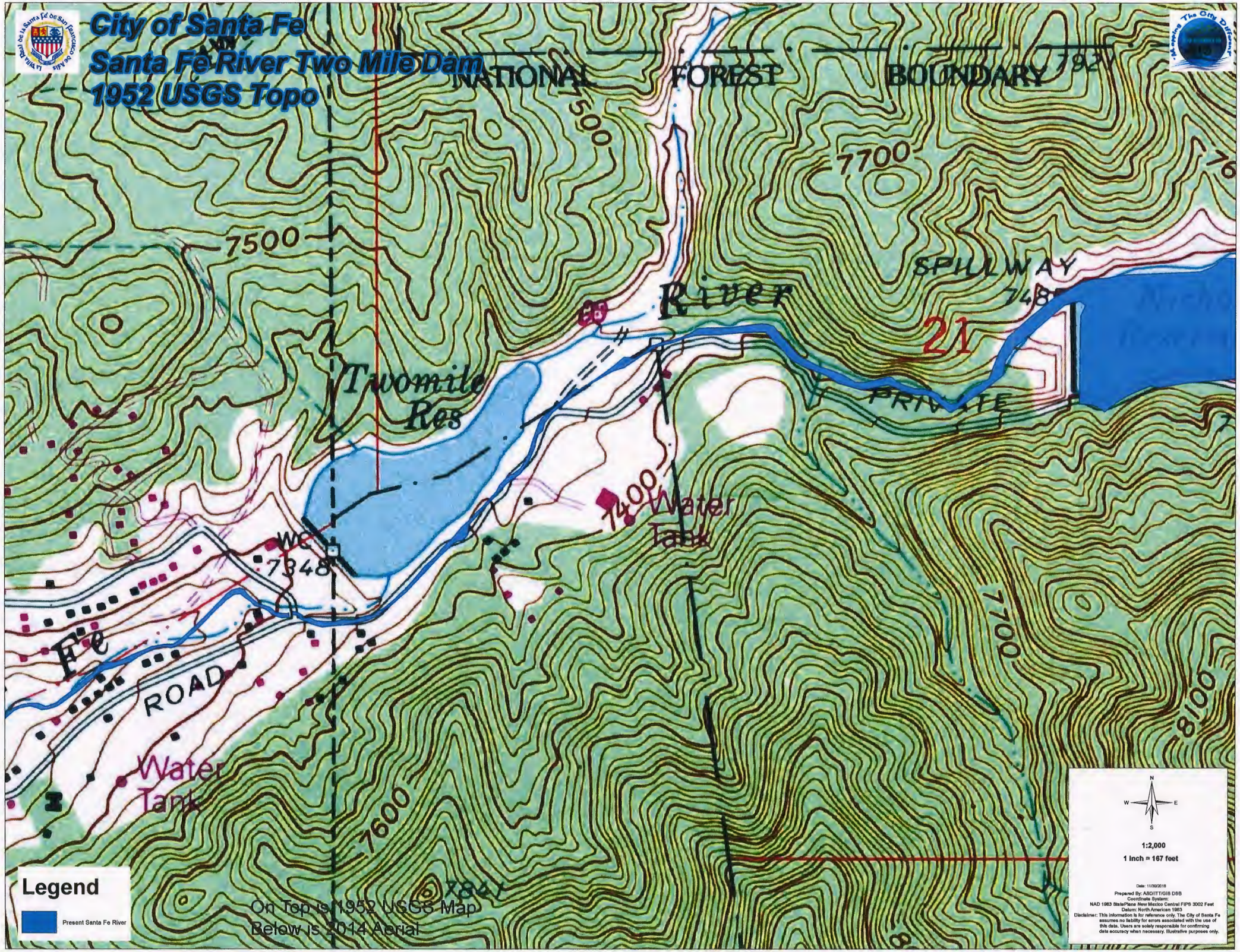
---------- Denotes end of the monitoring week, Monday thru Sunday
= Estimates of Flow @ Below Nichols Gage based upon nearest day(s) value.

	WTP 24" raw water inflow		Nichols Reservoir Discharge		Target Flows	Below Nichols Reservoir Staff Gage Daily Reading			Daily Pass-Through Volume		Staff Gage @ TNC Reference Channel			Filter Plant Flume				SF River at Acequia Madre 24" Flume		
Date	gpm	mgd	Hour** measured (round to nearest 1/4 hour)	cfs* (using discharge from Nichols outlet)	cfs	stage height (ft)	Hour** measured (round to nearest 1/4 hour)	cfs (using stream rating curve)	mg	af	stage, ft	Hour** measured (round to nearest 1/4 hour)	cfs (using flume rating curve)	stage, 6" flume, ft	stage, 24" flume, ft	Hour** measured (round to nearest 1/4 hour)	cfs (using flume rating curve)	stage, ft	Hour** measured (round to nearest 1/4 hour)	cfs (using flume rating curve)
07/01/2016	4879	7.03	4.00	3.200	5.00	?		?	2.1	6.3	1.00	12.50	0.89	0.48	0.00	12.50	0.65	0.00	13.00	0.00
07/02/2016	4454	5.27	9.00	3.700	5.00	?		?	2.4	7.3	1.00	12.50	0.89	0.48	0.00	12.50	0.65	0.00	13.00	0.00
07/03/2016	4432	6.38	?	2.870	5.00	?		?	1.9	5.7	1.00	12.50	0.89	0.48	0.00	12.50	0.65	0.00	13.00	0.00
07/04/2016	4538	6.53	5.00	1.000	1.00	?		?	0.6	2.0	1.00	12.50	0.89	0.48	0.00	12.50	0.65	0.42	13.00	2.30
07/05/2016	4258	6.13	1.25	1.000	1.00	?		?	0.6	2.0	1.00	12.50	0.89	0.44	0.00	12.50	0.56	0.42	13.25	2.09
07/06/2016	4381	6.31	1.20	1.000	1.00	?		?	0.6	2.0	1.00	12.50	0.89	0.40	0.00	7.50	0.48	0.32	9.50	1.37
07/07/2016	4408	6.35	24.00	1.000	1.00	1.04	8.00	0.156	0.6	2.0	0.86	9.00	< 0.01	0.40	0.00	7.50	0.48	0.00	7.50	0.00
07/08/2016	4826	6.95	24.00	1.000	1.00	1.06	9.00	0.222	0.6	2.0	0.90	8.50	0.22	0.56	0.00	9.00	0.82	0.00	9.50	0.00
07/09/2016	4987	7.18	24.00	1.000	1.00	1.06	9.00	0.222	0.6	2.0	0.90	8.50	0.22	0.56	0.00	9.00	0.82	0.00	9.50	0.00
07/10/2016	5054	7.28	24.00	1.000	0.75	1.06	9.00	0.222	0.6	2.0	0.44	10.00	< 0.01	0.56	0.00	9.00	0.82	0.00	9.50	0.00
07/11/2016	5372	7.74	24.00	1.500	0.75	1.18	8.00	1.091	1.0	3.0	0.00	9.00	0.00	0.38	0.00	7.50	0.45	0.00	7.50	0.00
07/12/2016	5656	8.15	24.00	0.750	0.75	1.08	8.00	0.307	0.5	1.5	0.00	9.50	0.00	0.38	0.00	7.50	0.45	0.00	9.50	0.00
07/13/2016	5649	8.13	24.00	0.750	0.75	1.06	8.00	0.222	0.5	1.5	0.00	9.25	0.00	0.34	0.00	7.50	0.37	0.00	9.50	0.00
07/14/2016	5638	8.12	24.00	0.750	0.75	1.06	8.00	0.222	0.5	1.5	0.00	9.50	0.00	0.34	0.00	7.50	0.37	0.00	9.50	0.00
07/15/2016	5634	8.11	24.00	0.750	0.75	1.06	8.50	0.222	0.5	1.5	0.00	10.00	0.00	0.34	0.00	8.25	0.37	0.00	10.00	0.00
07/16/2016	5649	8.13	24.00	0.750	0.75				0.5	1.5	0.00	10.00	0.00	0.34	0.00	8.25	0.37	0.00	10.00	0.00
07/17/2016	5598	8.06	24.00	0.750	0.75				0.5	1.5	0.00	10.00	0.00	0.34	0.00	8.25	0.37	0.00	10.00	0.00
07/18/2016	5587	8.05	8.50	0.750	0.75	1.08	8.00	0.307	0.5	1.5	0.00	10.00	0.00	0.30	0.00	10.00	0.31	0.20	10.00	0.66
07/19/2016	5592	8.05	24.00	0.000	0.75	1.16	8.00	0.877	0.0	0.0	0.00	9.50	0.00	0.36	0.00	7.50	0.41	0.00	7.50	0.00
07/20/2016	5621	8.09	24.00	0.750	0.75	1.08	8.00	0.307	0.5	1.5	0.00	9.50	0.00	0.36	0.00	7.50	0.41	0.00	7.75	0.00
07/21/2016	5644	8.13	24.00	0.750	0.75	1.08	8.00	0.307	0.5	1.5	0.00	9.50	0.00	0.36	0.00	7.50	0.41	0.00	8.25	0.00
07/22/2016	5712	8.22	24.00	0.750	0.75	1.08	8.00	0.307	0.5	1.5	0.00	9.50	0.00	0.36	0.00	7.50	0.41	0.00	9.50	0.00
07/23/2016	5667	8.16	24.00	0.750	0.75	1.08	8.00	0.307	0.5	1.5	0.00	9.50	0.00	0.36	0.00	7.50	0.41	0.00	9.50	0.00
07/24/2016	5106	7.35	24.00	0.750	0.75	1.08	7.00	0.307	0.5	1.5	0.95	6.00	0.55	0.45	0.00	7.00	0.58	0.00	7.50	0.00
07/25/2016	4285	6.17	24.00	0.750	0.75	1.00	8.00	0.067	0.5	1.5	0.00	9.50	0.00	0.38	0.00	7.50	0.45	0.14	9.75	0.00
07/26/2016	4819	6.94	24.00	0.750	0.75	1.10	9.00	0.412	0.5	1.5	N/D	N/D	N/D	0.40	0.00	9.00	0.48	0.00	10.50	0.00
07/27/2016	5047	7.27	24.00	0.000	0.75	1.08	8.00	0.307	0.0	0.0	0.88	9.50	0.08	0.54	0.00	7.50	0.78	0.00	9.50	0.00
07/28/2016	5106	7.35	24.00	0.750	0.75	1.04	8.00	0.156	0.5	1.5	0.00	9.50	0.00	0.30	0.00	7.50	0.31	0.00	9.50	0.00
07/29/2016	5024	7.24	24.00	0.750	0.75	1.00	8.00	0.067	0.5	1.5	0.00	9.50	0.00	0.34	0.00	7.50	0.37	0.00	9.50	0.00
07/30/2016	5129	7.39	24.00	0.750	0.75	1.00	8.00	0.067	0.5	1.5	0.00	9.50	0.00	0.34	0.00	7.50	0.37	0.00	9.50	0.00
07/31/2016	4769	6.87	24.00	0.750	0.75	1.00	8.00	0.067	0.5	1.5	0.00	9.50	0.00	0.34	0.00	7.50	0.37	0.00	9.50	0.00
08/01/2016	4922	7.09	8.75	0.000	0.75	1.24	8.00	1.745	0.0	0.0	0.00	9.75	0.00	0.40	0.00	7.50	0.48	0.42	9.50	2.09
08/02/2016	4918	7.08	8.50	0.000	0.75	1.24	7.50	1.745	0.0	0.0	0.00	9.50	0.00	0.44	0.00	9.50	0.56	0.00	9.50	0.00
08/03/2016	4316	6.22	24.00	0.750	0.75	0.92	8.00	0.008	0.5	1.5	0.00	9.50	0.00	0.36	0.00	9.50	0.41	0.00	9.50	0.00
08/04/2016	3617	5.17	24.00	0.750	0.75	0.86	8.00	0.000	0.5	1.5	0.00	9.50	0.00	0.38	0.00	7.50	0.45	0.00	9.50	0.00
08/05/2016	4372	6.30	24.00	0.750	0.75	1.06	8.75	0.222	0.5	1.5	0.00	10.00	0.00	0.42	0.00	8.50	0.52	0.00	10.50	0.00
08/06/2016	4886	7.04	24.00	0.750	0.75	1.06	8.75	0.222	0.5	1.5	0.00	10.00	0.00	0.42	0.00	8.50	0.52	0.00	10.50	0.00
08/07/2016	3956	5.70	24.00	0.750	0.75	1.06	8.75	0.222	0.5	1.5	0.00	10.00	0.00	0.42	0.00	8.50	0.52	0.00	10.50	0.00
08/08/2016	4577	6.59	24.00	0.000	0.75	0.84	7.50	0.000	0.0	0.0	0.00	9.50	0.00	0.38	0.00	9.30	0.45	0.24	9.30	0.88
08/09/2016	5514	7.94	24.00	0.750	0.75	1.20	8.00	1.340	0.5	1.5	0.00	9.50	0.00	0.36	0.00	7.50	0.41	0.00	9.50	0.00
08/10/2016	5619	8.09	24.00	0.000	0.75	1.08	8.00	0.307	0.0	0.0	0.00	9.50	0.00	0.38	0.00	7.50	0.45	0.00	9.50	0.00
08/11/2016	5662	8.15	24.00	0.750	0.75	1.08	8.00	0.307	0.5	1.5	0.00	9.50	0.00	0.40	0.00	7.50	0.48	0.00	9.50	0.00
08/12/2016	5702	8.21	24.00	0.750	0.75	1.08	8.00	0.307	0.5	1.5	0.00	9.50	0.00	0.40	0.00	7.50	0.48	0.00	9.50	0.00
08/13/2016	5619	8.09	24.00	0.750	0.75	1.04	7.75	0.156	0.5	1.5	0.00	9.00	0.00	0.38	0.00	9.00	0.45	0.00	9.50	0.00
08/14/2016	4916	7.08	24.00	0.000	0.75	1.04	8.00	0.156	0.0	0.0	0.00	9.00	0.00	0.38	0.00	9.00	0.45	0.00	10.00	0.00
08/15/2016	4990	7.19	24.00	0.000	0.75	1.20	7.50	1.340	0.0	0.0	0.00	7.50	0.00	0.38	0.00	9.00	0.45	0.30	9.00	1.24
08/16/2016	5034	7.25	24.00	0.000	0.75	1.16	8.25	1.248	0.0	0.0	0.00	8.25	0.00	0.36	0.00	9.50	0.41	0.00	10.00	0.00
08/17/2016	5048	7.26	24.00	0.000	0.75	1.10	8.25	0.412	0.0	0.0	0.00	9.75	0.00	0.36	0.00	10.00	0.41	0.00	10.00	0.00
08/18/2016	5070	7.30	24.00	0.750	0.75	1.00	8.25	0.067	0.5	1.5	0.00	9.50	0.00	0.35	0.00	9.50	0.39	0.00	10.00	0.00
08/19/2016	5013	7.22	24.00	0.750	0.75	1.00	8.25	0.067	0.5	1.5	0.00	9.50	0.00	0.35	0.00	9.50	0.39	0.00	10.00	0.00
08/20/2016	5003	7.21	24.00	0.750	0.75	1.00	8.25	0.067	0.5	1.5	0.00	9.50	0.00	0.35	0.00	9.50	0.39	0.00	10.00	0.00
08/21/2016	4714	6.78	24.00	0.000	0.75	1.00	8.25	0.067	0.0	0.0	0.00	9.50	0.00	0.35	0.00	9.50	0.39	0.00	10.00	0.00
08/22/2016	3299	4.75	24.00	0.000	0.75	1.00	8.25	0.067	0.0	0.0	0.00	9.50	0.00	0.42	0.00	7.40	0.52	0.00	10.00	0.00
08/23/2016	2147	3.09	24.00	0.750	0.75	1.10	8.25	0.412	0.5	1.5	0.00	10.00	0.00	0.35	0.00	10.00	0.39	0.00	10.00	0.00
08/24/2016	3134	4.51	24.00	0.000	0.75	1.04	9.00	0.156	0.0	0.0	0.00	9.50	0.00	0.30	0.00	10.50	0.31	0.00	10.50	0.00
08/25/2016	3504	5.05	24.00	0.750	0.75	1.04	9.00	0.156	0.5	1.5	0.00	9.50	0.00	0.30	0.00	10.50	0.31	0.00	10.50	0.00
08/26/2016	4035	5.81	24.00	0.750	0.75	1.06	8.50	0.222	0.5	1.5	0.85	10.50	<0.013	0.36	0.00	10.75	0.41	0.00	11.00	0.00
08/27/2016	4156	5.99	24.00	0.750	0.75	1.06	8.50	0.220	0.5	1.5	0.85	10.50	<0.013	0.36	0.00	10.75	0.41	0.00	11.00	0.00
08/28/2016	4208	6.06	24.00	0.000	0.75	1.06	8.50	0.220	0.0	0.0	0.85	10.50	<0.013	0.36	0.00	10.75	0.41	0.00	11.00	0.00
08/29/2016	4110	5.92	24.00	0.000	0.75	1.06	8.50	0.220	0.0	0.0	0.00	10.00	0.00	0.35	0.00	10.15	0.39	0.21	10.30	0.71
08/30/2016	4132	5.95	24.00	0.750	0.75	1.07	8.25	0.262	0.5	1.5	0.00	9.50	0.00	0.34	0.00	10.25	0.37	0.00	9.50	0.00
08/31/2016	3594	5.18	24.00	0.750	0.75	1.02	9.50	0.105	0.5	1.5	0.00	9.50	0.00	0.36	0.00	9.25	0.41	0.00	9.00	0.00
09/01/2016	2944	4.24	24.00	0.750	0.75	1.02	9.50	0.105	0.5	1.5	0.00	9.50	0.00	0.35	0.00	11.25	0.39	0.00	9.00	0.00
09/02/2016	3575	5.15	24.00	0.750	0.75	1.02	9.50	0.105	0.5	1.5	0.00	9.50	0.00	0.35	0.00	9.50	0.39	0.00	9.00	0.00

09/03/2016	3515	5.06	24.00	0.750	0.75	1.02	9.50	0.105	0.5	1.5	0.00	9.50	0.00	0.35	0.00	9.50	0.39	0.00	9.00	0.00
09/04/2016	3499	5.04	24.00	0.000	0.75	1.02	9.50	0.105	0.0	0.0	0.00	9.50	0.00	0.35	0.00	9.50	0.39	0.00	9.00	0.00
09/05/2016	3517	5.07	24.00	0.000	0.75	1.02	9.50	0.105	0.0	0.0	0.00	9.50	0.00	0.35	0.00	9.50	0.39	0.00	9.00	0.00
09/06/2016	3538	5.09	24.00	0.000	0.75	1.30	7.50	2.466	0.0	0.0	0.84	9.00	<0.013	0.46	0.00	9.25	0.60	0.56	10.75	3.26
09/07/2016	3539	5.09	24.00	0.000	0.75	1.30	8.50	2.466	0.0	0.0	0.85	10.00	<0.013	0.45	0.00	10.25	0.58	0.55	10.50	3.17
09/08/2016	3343	4.81	24.00	0.200	0.75	0.86	8.50	0.000	0.1	0.4	0.00	9.75	0.00	0.38	0.00	10.00	0.45	0.00	10.25	0.00
09/09/2016	3103	4.47	24.00	0.200	0.75	0.92	9.00	0.008	0.1	0.4	0.00	10.00	0.00	0.40	0.00	10.00	0.48	0.18	10.50	0.00
09/10/2016	3445	4.96	24.00	0.200	0.75	0.92	9.00	0.008	0.1	0.4	0.00	10.00	0.00	0.40	0.00	10.00	0.48	0.18	10.50	0.00
09/11/2016	3516	5.06	24.00	0.000	0.75	0.92	9.00	0.008	0.0	0.0	0.00	10.00	0.00	0.40	0.00	10.00	0.48	0.18	10.50	0.00
09/12/2016	3501	5.04	24.00	0.000	0.75	1.20	8.50	1.340	0.0	0.0	0.00	8.50	0.00	0.37	0.00	8.00	0.43	0.40	7.50	1.93
09/13/2016	3446	4.96	24.00	0.000	0.75	1.28	8.25	2.210	0.0	0.0	0.00	8.25	0.00	0.40	0.00	10.25	0.48	0.51	10.25	2.82
09/14/2016	3453	4.97	24.00	0.000	0.75	1.04	8.25	0.156	0.0	0.0	0.00	9.50	0.00	0.38	0.00	9.75	0.45	0.21	10.00	0.71
09/15/2016	3452	4.97	24.00	0.000	0.75	0.84	8.50	0.000	0.0	0.0	0.00	10.00	0.00	0.37	0.00	10.25	0.43	0.21	10.50	0.71

APPENDIX P

City of Santa Fe
Santa Fe River Two Mile Dam
1952 USGS Topo



APPENDIX Q

U.S. Fish and Wildlife Service

National Wetlands Inventory

SF River Wetland

November 22, 2016

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

APPENDIX R

2015

	Acequia del Llano	Acequia Cerro Gordo	Acequia Madre (Upper)	Acequia Madre (Lower)	Acequia Muralla	**Total**
Estimated Deliveries	32.49 MG	3.4 MG	4.74 MG	20.7 MG	? MG	61.33 MG (Million Gallons for the Year)
	99.7 AF	10.4 AF	13.7 AF	63.5 AF	? AF	187.3 AF (Acre-Feet for the Year)

2016

	Acequia del Llano	Acequia Cerro Gordo	Acequia Madre (Upper)	Acequia Madre (Lower)	Acequia Muralla	**Total**
Estimated Deliveries	37.7 MG	3.4 MG	7.7 MG	26.7 MG	? MG	75.50 MG (Million Gallons for the Year)
	115.6 AF	10.4 AF	23.6 AF	81.9 AF	? AF	231.50 AF (Acre-Feet for the Year)

APPENDIX S

HISTORIC AMERICAN ENGINEERING RECORD
TWO MILE RESERVOIR
Santa Fe, New Mexico

I. INTRODUCTION

Location:	Two miles east of the plaza in Santa Fe, New Mexico near the intersection of Upper Canyon Road and Cerro Gordo Road, Santa Fe County.
Quad:	Two Mile Dam, New Mexico
UTM:	East 419080, North 3949400
Date of Construction:	1893
Present Owner:	Sangre de Cristo Water Company, a subsidiary of Public Service Company of New Mexico

Present Use:

Prior to the initiation of Historic American Engineering Record (HAER) documentation, the reservoir was drained, sludge was removed, and plans for the emergency breach were in progress. Currently the dam has been breached, and a 10 acre foot (12,335 m^3) pond has been created on the upstream side. Most water runs through the diversion channel at the southern edge of the reservoir, but some runs through pipes in the Old Stone Dam and a small tri-level, stone filter system down the natural river channel to the pond (Drawing 2/4). Water is expected to run through the breach only when there is a standard project flood or other such emergency flow situation.

Significance:

Two Mile Dam, constructed in Santa Fe, New Mexico in 1893, embodies the distinct characteristics of a tamped earth dam, through its design and construction techniques. These methods began in the 18th century and with some modifications are still being used today. The dam was designed to reduce interior hydrostatic pressure and was constructed using goats to puddle the earth.

The engineered design incorporated methods, including seepage collars and variation of material, to reduce the amount of water inside the structure. Concrete seepage collars stop water from travelling along the tunnel underneath the dam (Drawing 2/1). Earthen material was varied to slow the movement of water through the dam. The upstream portion of the dam was constructed using small particle fill, such as silt and clay, and was packed to achieve high density and the downstream portion of the dam was constructed using larger fill, consisting of sand and gravel (Drawing 2/1). Earthen dams have a line of saturation that should exist in relative equilibrium (Drawing 5/6). Varying the material to create a relatively impervious upstream slope and a pervious downstream slope aids in protecting the dam from failure through saturation.

Two Mile Dam is one of the largest embankment dams in New Mexico, was the largest dam constructed at the time, and was used for both irrigation and potable water supply. Montezuma Dam, an earthen dam near Las Vegas, New Mexico, constructed after Two Mile, was approximately 20-25 ft (6-7 m) high and retained water for ice skating and ice supply.[1] The construction of Two Mile Reservoir was a large undertaking which created substantial water supply for the City of Santa Fe, gained national attention, and was a catalyst for the urbanization of Santa Fe.

II: ADMINISTRATIVE SUMMARY

Historian: Karen Lewis, Mariah Associates, Inc.

Date of Research: May and June 1994

Sources Searched:
American Society of Civil Engineers, New York City
Bureau of Land Management
Linda Hall Library, Kansas City
Museum of New Mexico, Records and Archives
New Mexico State Engineer's Office
New Mexico State Records Center & Archives
PNM Forerunners
Public Service Company of New Mexico Archives
Randall Davey Audobon Society
Sangre de Cristo Water Company Archives
Santa Fe City Library
Santa Fe County Courthouse
SHB AGRA Reports and Drawings
State of New Mexico Library
University of New Mexico, Engineering Library

Methodology:

Mariah Associates, Inc. (Mariah) was contracted on May 16, 1994 by the Public Service Company of New Mexico (PNM) to complete the work stipulated by the Two Mile Dam and Reservoir Memorandum of Agreement between the New Mexico State Historic Preservation Office (SHPO) and PNM. At that time, the State Engineer had required an emergency breach to be completed by the end of May for public safety reasons. The dam had been deemed unsafe

due primarily to excessive rodent and tree root holes on the downstream slope. The tight deadline left little time to secure proper documentation before the demolition began.

Prior to initiation of the Mariah HAER contract, Environmental Compliance and Development Corporation (ECD) had been hired to remove years of sediment which had been washed into the reservoir from the treatment plant decant ponds. While engaged in pumping sediment from the bottom of the dam to pools on the southern edge near the spillway, Chava Trucking, ECD's sub-contractor, inadvertently damaged the upstream side of the dam (Photographs HAER No. NM-4-2, NM-4-5, NM-4-6). Also, when the strainer inlet was being cleaned by ECD divers (Photographs HAER No. NM-4-7, NM-4-8), water rushed through the tunnel and disturbed earthen areas on the downstream side of the dam around the tunnel and gate valves, as well as pulling one of the divers against the outlet.

Thus, prior to visiting the site, there was damage to the cultural resource; each day Sangre de Cristo Water Company hoped to begin demolition in order to meet the State Engineer's deadline. Given this situation, the Mariah team immediately began on-site documentation, in order to retrieve as much information as possible prior to demolition. Ms. Lewis consulted the Corps of Engineers (COE) and the SHPO, and developed a list of important features to document, since there was not time to conduct archival research to identify these elements. The site was mapped with a total station and data collector, 4 x 5 large format photographs were taken of the dam and site features, and important features were mapped with the total station and further dimensioned with a 100 ft (30 m) tape measure.

The impacted features were documented prior to the initiation of demolition. In addition to the dam itself, the Mariah team mapped two groups of stone alignments inside the reservoir. The features that were not completely documented for the emergency breach but were completed at a later date, included the spillway and the diversion channel. Once demolition began, Ms. Lewis was on-site to monitor the work. It was expected that the contractors would unearth the concrete

seepage collars that were shown in the 1893 drawings. The collars were not located, but some small artifacts, such as shovel heads, leather straps, and miscellaneous metal tool parts were recovered during the breach excavation.

A foundation on top of the dam, not integral with the structure of the dam, was noted prior to initiation of the breach (Drawing 3/6). Before the breach demolition began, the foundation was unearthed and documented. It appears that the small building may have been a powerhouse or small gate valve control facility. The top of the dam also had two "brass caps" that were removed during demolition. One was a USGS section corner and the other a Santa Fe Control Monument.

Once the earth moving for the breach had been completed, Ms. Lewis began the archival research. *Daily New Mexican* articles contained more information about construction of the 1881 Old Stone Dam than about Two Mile Dam. The Sangre de Cristo Water Company archives revealed historic drawings, many photographs, *Daily New Mexican* transcripts, a history manuscript, reports, letters, and meeting minutes about Two Mile Dam throughout its history. There were no original construction drawings giving sections or dimensioned details at Sangre de Cristo Water Company, PNM, or the City of Santa Fe. The Santa Fe City Library collection consisted primarily of resources about the acequia systems and laws in northern New Mexico, and the State of New Mexico Library provided various planning documents. The New Mexico State Records Center & Archives provided additional newspaper clippings with reference to the breach, maps, deed information, and census data. The Santa Fe County Courthouse provided historic deeds, agreements, and other legal documents. The University of New Mexico, Engineering Library provided a microfilm copy of the *Engineering News and American Railway Journal* article and historic books on the construction of earthen dams. SHB AGRA reports and construction documents were used to trace dam failure and develop HAER documentation graphics. The Museum of New Mexico, Records and Archives provided documents about dams in New Mexico, and photographs and maps of the reservoir area. The State Engineer provided

some historical data and information about earthen dams in New Mexico. The Bureau of Land Management (BLM) provided some plat information and PNM provided some maps of the dam and surrounding area. The PNM Forerunners provided some oral history and knowledge of the dam systems. The Randall Davey Audobon Society is housed in one of the old mills but could not provide much information.

The American Society of Civil Engineers (ASCE) recommended the Linda Hall Library in Kansas City. The Linda Hall Library is an independent library in the areas of science and technology. The library will be receiving the ASCE collection at some point in the future. ASCE does not have an operational library, since they are planning to send their collection to the Linda Hall Library, and apparently the transfer is tied up in the New York Supreme Court. Although Linda Hall searched for information on the Two Mile Dam engineers and did not turn up any sources, they believe when they receive the ASCE collection they may have relevant information.

Deed and Plat information gathered at the Santa Fe County Courthouse and the BLM was used to develop base maps to trace ownership of the Reservoir Land. Unfortunately, plat and deed drawings and descriptions did not lead to a comprehensive layout or history of the land and land transactions.

III: HISTORICAL INFORMATION

Date of Erection: 1893

Engineer: J. M. Howells, C.E. (Chicago)
P. E. Harroun, C.E. (Santa Fe)

Developer: Santa Fe Water and Improvement Company

Historical Narrative:

In October of 1880, the Board of County Commissioners, Santa Fe, in the Territory of New Mexico, executed a legal instrument which provided the Santa Fe Water and Improvement Company with the exclusive right and privilege of erecting dams and reservoirs for impounding water on the Santa Fe River. The commissioners felt that a water system would be beneficial to Santa Fe's image through its civilizing effects. The water company board consisted of Dr. E. Andrews, President; Fred Sandoval; J. P. Kennedy; P. F. Herlow; S. H. Lewis; and Enos Andrews. The grant to the water company included exclusive rights to impound water in "an easterly direction of ten miles," to erect roads and railroads to provide transportation to and from the dam and reservoir, and to construct telegraphic, telephonic and phonographic lines. The grant also allowed for the "...construction, introduction, distribution, maintenance and operation of electric lights, sewers, sluices, drains, aqueducts, conduits and waterways...provided that this grant shall in no manner be construed to affect the rights of private individuals."[2]

In return for the above, the Santa Fe Water and Improvement Company was required to furnish an adequate water supply to the city by completing a series of three reservoirs and installing water pipes within 3 mi (4.8 km) in every direction from the center of the monument in the Santa Fe plaza. In addition, the water company was to supply the water at reasonable rates. It was the rights of private individuals initially, and later the high rates, that caused controversy over the reservoir system and the water company. Early on, there was a disparity between those who

supported the development of the water company and those who wanted water rights to remain as they had since the founding of Santa Fe. This developed into on-site altercations during the construction of the Old Stone Dam in 1881. By the time Two Mile Dam was constructed, the residents had either accepted impoundment of water on the Santa Fe River or become quietly resigned to the fact, since there is no evidence of controversy through the newspapers or legal documents.[3]

The differences in opinion were split basically along the lines of the older families and mayordomos of the acequias, and newer settlers in Santa Fe. Water rights in New Mexico began with the mayordomo/acequia system, established by the Royal Ordinances given to Don de Peralta in 1609 when he laid out Santa Fe. The system called for irrigation water to be available to all residents.[4] Irrigation water was made available through open channel waterways, called acequias. The water was distributed from the acequias in direct proportion to the quantity of land to be irrigated, larger plots received more water than smaller plots. Each acequia was shared and maintained by the community that had access to the water, and each community was headed by a mayordomo who coordinated the acequia upkeep, water distribution, and the arbitration of disputes. The mayordomo was usually a highly respected, older member of the community and had significant political and social power.[5]

In the late 1800s, the Anglo population of Santa Fe "...predominated among merchants, military personnel, and government officeholders...their role in agriculture was almost nonexistent."[6] The desire for a water company to supply water to the city was to modernize Santa Fe, but those whose families had settled Santa Fe and who had inherited the acequias and water rights policies had no reason to change. In fact, those who were most affected by the construction of the dams published a notice to the water company in the *Daily New Mexican* stating that the residents would resist any encroachment on their rights. The following statement is from the June 1881 public hearing about water rights and building dams in Santa Fe canyon, which was translated from Spanish to English, transcribed in both and given to the *Daily New Mexican*:

We, the majority of the people of Santa Fe, declare and maintain that whereas we have been entitled to the water in the Santa Fe river since the conquest of this country, have used it for the purpose of irrigating our fields and quenching the thirst of our families, that the water has been given to us by the sublime will of God, and

Whereas some individuals have associated with a view of controlling the water of said river by building dams in Santa Fe Canon and to interrupt the free course of the current with the purpose of retaining and speculating with the water by selling it to the poor people of Santa Fe, thus damaging the whole community, and Whereas the people of Santa Fe will in no way permit such proceedings, be it:

Resolved that the people of Santa Fe will by all legal means cause the said water works company to stop abusing and appropriating the rights belonging exclusively to the people, will prevent their converting the same to their own pecuniary welfare, leaving the community helpless and subject to their charity, and depriving them of all the sacred rights which nature has given them merely to satisfy ambition. The people of Santa Fe in meeting assembled and in view of the injustice and prejudices which the said company will cause to Santa Fe people by stopping the free course of the water in the river and prevent them from irrigating their lands hereby. Resolved that the water company is hereby cautioned to stop all work in the canon of Santa Fe river interrupting the current of the stream and injuring the community, which action is hereby declared an outrage on the people and that said community will in no way permit such action.

Resolved, that the people of Santa Fe are and will be opposed to consenting that the water works company shall abuse the people and appropriate to themselves their rights which they consider a legal and divine gift from Almighty God, and which rights belong and shall belong to the people, and who will in no way permit that any company shall jump their rights. Resolved that the Hons. Sol Spiegelberg, Jas. Donovant, Nasario Gonzales, Board of County Commissioners and Hon. Gaspar Ortiz, Probate Judge in and for Santa Fe County, are authorized to represent the people of Santa Fe and are required to arrange the matter with the water works company, avoid their control of the water of Santa Fe river which they resolved to do in prejudice of the community and to caution said company to let the said waters run for the benefit of the people, who will use all legal rights with this object in view.

Resolved, that the Hon. Juan Garcia, C. Martinez of Precinct No. 3, Aniceto Abeyta and B. M. Reed of Precinct No. 4, and Jose Antonio Romero of Precinct

> No. 5 are hereby appointed a committee to cooperate with the County Commissioners and the Probate Judge in reference to the settlement of the matter.
>
> Resolved that we will employ all legal means to defend our rights and will, if necessary, ask the protection of the executive department.
>
> Resolved that we swear to stand by the constitution and the form of government and protest against violence, and request the proper authorities to enforce the laws.
>
> Resolved, that if said company persists in carrying out their works they shall be considered open enemies of the public.[7]

The reaction to the water company was over more than water for irrigation; most residents had their own water-operated grist mills and carding machines, which could not function without a running river. Some of the residents with property to the west of the Old Stone Dam would not allow the right-of-way for the pipes that were to take water into the city of Santa Fe. The committee noted above met with the water company and was able to gain the company's assurance that the flow of the river would not be reduced to the extent that it would shut down the acequias.[8] This assurance did not calm the fears of the canyon residents. On June 23, 1881, an altercation between residents and the stone dam laborers was reported in the *Daily New Mexican*.[9] Eventually, the canyon residents allowed the pipes to run through their property, and by October 14, the public was so anxious to have water, it was introduced into houses by residents of the City of Santa Fe rather than by the water company as scheduled.[10]

By December of 1881, the original water company had gone bankrupt and was sold to a new group. The new company was called the Santa Fe City Water Works, and its officers were Alexander G. Irvine, President; Q. Monier, Treasurer; and S. D. Lassier, Secretary. The new company was granted a franchise to operate the water works. Following incorporation in 1891, the City of Santa Fe granted a new 25 year franchise to the water company.[11]

The first dam, the 1881 stone dam, was 28 ft (8.5 m) high and held 25.33 acre feet of water (Photographs HAER No. NM-4-17, NM-4-18, NM-4-19, NM-4-23). In February of 1893, the water company began construction on Two Mile Dam by placing concrete for a tunnel. This second dam provided an additional 387 acre feet of water to the City of Santa Fe (Photographs HAER No. NM-4-1, NM-4-22). There is no evidence of public outcry over its construction, apparently due to a variety of factors, such as the public having grown accustomed to the old reservoir, the involvement of different individuals, and the fact that the second reservoir was planned to provide surplus water to irrigate up to 1000 acres of fruitland.[12]

The main controversy during the construction of Two Mile Dam was the drought of 1893. In March of 1893, the President of the water company posted a notice to the people of la Acequia del Cerro Gordo that the water company would continue to supply their acequia with water throughout the construction of Two Mile Dam. By June 9th, water was being supplied through a concrete tunnel, but by June 26th water restrictions limited irrigation to the hours of 6:00-9:00 a.m. By July 5th, the water company had ended the use of water for irrigation until further notice. On July 17th, the company met with citizens and agreed to alternate water use: four days for acequia use then four days for water company supply.[13] On August 17th, the rain finally came, and the water in the reservoir rose 7 ft (2 m) in one hour. The water filled the reservoir's "flat area," topped the spillway and damaged the old reservoir.

The only available technical information about the construction of Two Mile Reservoir is the 1893 *Engineering News* article. The construction began with excavating to and cleaning bedrock on the northern side of the dam and pouring a concrete trench and seepage collars, which were referred to in the Engineering News article as "heart walls." The concrete trench acted as the base of the dam tunnel, protected the existing water main during construction, and allowed water to flow during the construction of Two Mile Dam. The "heart walls" were made of hydraulic cement, and one inch thick boards were used for triple sheeting that rose above and were perpendicular to the tunnel. The article also describes an 80 ft (24 m) tall stone intake chamber,

or well, as tall as the dam that was to be used to allow different levels of water to enter the distribution system (Drawing 2/1). There is no other mention or evidence of this intake chamber; currently the intake is a metal strainer outlet raised three to four feet above the top of a concrete dome, which is the upstream end of the tunnel under the dam. The earliest evidence of this concrete dome is a 1938 drawing of the pipe system (Photographs HAER No. NM-4-11, NM-4-12, NM-4-13). In 1893, the downstream toe of the dam had a 60 ft (18 m) diameter, circular basin into which a 10 inch pipe discharged as a fountain (Drawing 1/1). This provided the water with final aeration before it travelled through the city mains.

The 1893 article also notes a 5 ft (1.5 m) circular tunnel "...through rock, part or all of it lined with 7 to 12 ins. of concrete..."[14] was being constructed from the Old Stone Dam to convey water to discharge below the new spillway. This was designed to provide water downstream when desired, or when the water was running muddy, and was converted to a channel in 1904 to become the existing diversion channel (Drawings 1/6, 2/6). The tunnel under the dam was of similar construction, but its diameter was 8 ft (2.4 m), and it rested on a 1 ft (0.3 m) bedrock wall (Drawings 3/5, 4/5). Gate valves were installed at both ends of the tunnel to provide control of the water flow (Photographs HAER No. NM-4-14, NM-4-15, NM-4-16).

As described previously, the construction method for the dam was divided: the downstream portion was primarily sand and gravel, and according to the 1893 article, was not puddled, while the upstream portion of the dam was clayey earth puddled by a herd of goats. The goats were kept in motion from "12 m. to 1 p.m. and from 5 to 6 p.m."[15] According to J. M. Howells, in a letter to the editor of *Engineering News*, the schedule for using the goats changed once they discovered that the puddling did not interfere with the material delivery teams. When they discovered they could use the goats during regular hours, as opposed to the odd schedule already noted, they were able to reduce the required number of goats. The number was reduced from several hundred to 115 and they were able to keep the work on schedule.[16]

In the same letter to the editor, Mr. Howells described some of the aspects of puddling the dam. The goats were able to puddle for 30 wheel scrapers (Field Photograph: 1893 Construction) and averaged 14 ft^3 per load on a 500 ft (152 m) haul. The earth was spread as it was being dumped, levelled into a three inch layer by a dragged beam, then sprinkled, and finally puddled by the goats. The surface of each layer was left rough so the next layer could key into the last. Mr. Howells also stated that the goats tired easily at the beginning, because they had only been scantily fed on juniper brush, but once they were fed a diet of peas and refuse, they perked up and even butted each other around the corral after a full day's work.

On July 3, 1894, the *Daily New Mexican* reported that the mayor had officially accepted the work as being in compliance with the franchise. The next step was the development of hydroelectric power. The company developed a plant near Talaya Hill[17], which consisted of a service basin, "power pool," and a power house. Water from the reservoir and a power ditch uphill from the reservoir travelled through a 15 inch diameter pipe to the power house and was then forced uphill by pressure into the Talaya Hill "power pool." When power was needed, the water flowed downhill to the powerhouse to create electricity and was then discharged into the service basin (Drawing 3/2). In February of 1895, the hydroelectric plant was complete.

The series of three reservoirs that were required in the original grant were not completed until 1943. In fact, it was this requirement for three reservoirs that caused the foreclosure of the first two water companies, through financial burdens. In 1900, the Santa Fe City Water Works was turned over to the Santa Fe Water and Light Company. On March 14, 1900, the new company was incorporated in New Jersey.

In October of 1904, New Mexico experienced an enormous flood, which affected most of northern New Mexico and resulted in communities being virtually cut off from the outside world. The flood destroyed buildings, railway lines, and communications lines, and resulted in loss of life. The *Daily New Mexican* praised Two Mile Dam for protecting Santa Fe from extensive

flooding and reported that many pipes required replacement. The main problem at the time, in terms of the water supply, was that the water turned brown. The water system relied on still water from Two Mile Reservoir, so organic matter and debris would sink to the bottom leaving the potable water on top. With the tumultuous flood, water in the reservoir was turbid and required time to settle again.

In 1919, the city made its first unsuccessful attempt at a water company buyout, spurred on by dissatisfaction with service, supply, and the fear of how city growth would affect the supply. In 1921, a series of city council meetings addressed how to purchase the company or at least to ensure reasonable rates. At this time, the company was without a franchise and was unresponsive to the letters from the city council. During a special meeting, the city council asserted that the water company:

> ...is ineffective, uneconomical and unsatisfactory; and in connection with such investigation...has come to the conclusion that the rates charged by the Santa Fe Water and Light Company are unfair, excessive, exorbitant, unjust and discriminatory...[18]

By 1925, the company was again in receivership. U.S. District Judge O. L. Phillips took control of the situation, required meters to be installed, and also developed criteria for the next owner of the water and light company. Under Judge Phillip's guidance a new franchise was drawn up, and performance bonds were secured for the new purchaser. In 1926, the New Mexico Power Company (NMPC) was incorporated in the state of New Jersey, authorized to do business in the state of New Mexico, and merged with the existing water company.[19] As a result of Judge Phillip's efforts and the NMPC merger, by 1930 the entire city of Santa Fe was metered, McClure Reservoir was constructed (1926-28) and Nichols Reservoir was constructed (1942-43).

In 1929, the City of Santa Fe, the New Mexico Power Company, and the Forest Service worked together to close the Two Mile Reservoir watershed. The effort was not entirely successful, so in 1932 the Secretary of Agriculture legally closed the watershed through a Closing Order. This

order excluded "...bathing, fishing, camping, picnicking, and other forms of human occupancy of the Santa Fe watershed..."[20]

In 1946, the Public Service Company of New Mexico (PNM) came into being through the merge of the Albuquerque Gas and Electric Company, the Deming Ice and Electric Company, Las Vegas Light and Power, and NMPC. The company operated on an even keel until 1971, when there were complaints of poor water quality. Until 1971, the water provided to Santa Fe was from Two Mile Reservoir and was purified primarily by natural settlement. The reservoir water was treated with an acceptable algicide and required long periods of sedimentation in the Spring and Fall to reduce turbidity. In response to the water quality complaints, PNM hired an Aquatic Biologist to analyze the water coming from Two Mile Reservoir. Samples were taken in town, and it was determined that copepoda and nematoda worms, some as large as 2 mm, as well as a small quantity of rotifers and protozoans of the genus *Ceratium* existed in the water supply at Two Mile Reservoir. The sedimentation process was supposed to allow these plankton to sink to the bottom, keeping top layers of water clean and potable. The determination was that the natural purification processes were not working.[21]

In August of 1971, a letter from Black & Veatch Consulting Engineers to the Vice President, Division of Operations at PNM outlined recommendations for the treatment plant system that is in operation today. Treatment includes addition of floculants to aid in sedimentation, filtration to remove particulants, disinfection and fluoridation, and stabilization by the addition of polyphosphate. The system used included a check dam below Nichols Reservoir to divert water to the treatment plant, chemical building, two clarifloculators, four dual-media filters, two five million gallon tanks, waste wash water reclamation basins, two earthen lagoons to receive sludge from clarifloculators and a four million gallon pump from Two Mile Dam to permit the use of its water (Drawing 2/2).[22] The water from the upper two reservoirs was the primary source, and water from Two Mile Reservoir became the backup supply. During this 1971-72 conversion of

the water supply, the stone spillway was grouted as a safety stabilization effort (Drawings 1/5, 2/5).

Again in 1973, the City of Santa Fe contemplated the purchase of the water company. The city hired R. W. Beck and Associates to determine whether purchase was feasible. It was determined that if the city purchased the company, the rates would double,[23] so the city did not pursue purchase. In 1974, a five year franchise was granted, and in 1976, a Water System Task Force was developed to analyze whether purchase or condemnation of the water system was feasible. PNM made it clear that it would not be a willing seller. The City pursued condemnation, but even with condemnation, it was determined that the cost would be too high.[24]

In 1978, the SHPO notified PNM that Two Mile Reservoir had been placed on the State Register of Cultural Properties,[25] and in the same year, the National Dams Safety Program inspected Two Mile Dam since it was listed as a high-hazard dam on the National Dam Inventory. The report recommended a "watch and warn" inspection system, the primary concern was the overflow of the upper dams affecting the stability of the earthen dam.[26] In 1985, Two Mile Dam and Reservoir were nominated and accepted as an American Water Landmark.

In 1992, the reservoir was drained for safety reasons, primarily rodent holes and tree-roots had caused the downstream slope to destabilize.[27] The water company had discovered a 40 ft (12 m) long crack along the top of the reservoir and a 20 ft (6 m) slump on the downstream slope the line of saturation had exceeded safety levels. Draining the reservoir resulted in a twenty million gallon loss in the cheapest water source for the City of Santa Fe. After the reservoir was drained, Councilor Steven Farber called for the repair of the dam to maintain the "historical, cultural and economic well-being of Santa Fe and its present and future water supply."[28] The fact that the reservoir marks the eastern boundary of the city was as much a concern as the water supply. Preserving the reservoir would preserve a cultural resource and an inexpensive water supply, as well as provide a boundary for development at the end of Upper Canyon Road.

In March of 1993, PNM announced that it had plans to sell Sangre de Cristo Water Company as part of a reorganization,[29] and in May, the Santa Fe voters decided to purchase the water company. After eighty years, the City of Santa Fe had finally succeeded in buying the company. The purchase of the water company only included the water and appurtenances, not the land. Once plans to breach the dam were announced, there was public concern over what would happen to the reservoir land. In June of 1993, PNM announced that they were offering 100 acres of the 240 acres that comprise the Two Mile Reservoir property area to the City of Santa Fe.[30] It had been determined that the cost to repair the dam would be prohibitive, and the breach of the dam would be cost effective as well as eliminate the concern that the earthen structure might fail in the future.[31] The Sangre de Cristo Water Company decided to retain less than 10 acre ft in the reservoir area for aesthetics, and in preparation to turn the land over to the City of Santa Fe.

IV. ENGINEERING INFORMATION

Construction:

Two Mile Dam was engineered by J. M. Howells, C.E. of Chicago and P. E. Harroun, C.E. of Santa Fe and was constructed from 1893-94. A drawing of the dam, which appeared in both *Engineering News and American Railway Journal* and the *American Society of Irrigation Engineers Annual* in 1893, shows a series of four concrete seepage collars running parallel to the longitudinal centerline of the dam (Drawing 2/1). These collars were described as being set into freshly broken bedrock, made of the "very best hydraulic cement," and topped with triple sheet piling. The collars were to serve partially as a foundation and primarily as waterproofing to aid in the stability of the dam over time.

Modern earthen dam construction began in the late 18th century,[32] and the development of design elements was fairly standard by the late 1800s. In fact, "...the design principles had evolved leading to safe and fairly reasonably economic large earth dams."[33] The elements which had become standard details include variation of material, impervious cores, seepage collars, and puddling of clayey materials. The building of the dam included not only the proven design details, but sound construction techniques. The use of goats to puddle the clayey earth provided a roughness in the layers of earth in the dam, which aided in the prevention of water flow through the structure. Modern equipment provides a fairly even surface that can allow water a passage through the dam, and requires other techniques to minimize water flow.

During the 1994 demolition of the dam (Photographs HAER No. NM-4-3, NM-4-4), Karen Lewis, a preservation specialist was on-site throughout the work to monitor demolition and document the concrete core and seepage collars when they were uncovered. The top of the dam was at elevation 7,348 and the breach occurred at 7,285, the depth of the breach was 63 feet and according to the Engineering News drawings the center seepage collar should have been

unearthed at approximately elevation 7,295. No concrete collars were uncovered, so the collars are not as tall as the 1893 drawing suggested. At least one collar exists under the remaining portion of the dam as the Engineering News photograph shows a collar during construction. The collar in the photograph is formed concrete running over the top of the stone tunnel. There is no point of reference to identify where this concrete wall is along the tunnel, but it appears to be approximately 3 ft (1 m) above the tunnel (Field Photograph: 1893 Construction).

During demolition there were seemingly unrelated, horizontal lenses of clay and rubble. In retrospect, these may have defined a core, but the bulldozer and scraper method of earthwork made it difficult to distinguish a pattern. These lenses varied in length and color, but were usually near the centerline and approximately 2 to 3 feet wide. The lenses were usually green (Munsell, 5Y 6/2, light olive gray) or almost white (Munsell, 8Y 8/1, white), while the regular layers of earth were reddish (Munsell, 5YR 5/4, reddish brown) or dark brown (Munsell, 10YR 5/2, grayish brown). Some of the darker, greenish clay took on the appearance of cement as it dried. Often cement and/or lime is added to soils to act as a stabilizer. Lime, calcium carbonate, is an element of cement and will react with HCl.

Ms. Lewis tested several samples of earth taken from the lenses and the regular layers with HCl. The darker, greenish clay and the white clay from the lenses reacted positively, with the white giving the most vigorous reaction. The reddish and brown soils did not react with the HCl.

All earthen dams have some kind of core, as well as collars to prevent toe flow of water toward the center of the dam. Many dam cores have been constructed of clay to act as seepage barriers;[34] the reaction of the centerline lenses with HCl suggests the lime-containing earth was placed deliberately at the center of the dam. Although calcium carbonate, may occur naturally, judging from the levels where the reactive soils began to appear, it seems that there was a stabilized core of lime or light soil cement. Conclusive results could be gained through continuous borings, soil analysis, and specific tests for lime in the remaining southern portion of

the dam. Results from the "Dam Embankment Stability Investigation" borings are located in Appendix A.

Although there was not a visually discernable core during the demolition, the variation of materials from the eastern to western side was distinctive. This did match the 1893 drawing, in that the downstream side was primarily gravel and the upstream puddled earth. During certain points of the demolition, stratigraphy could be seen, and was photographed, but Ms. Lewis was unable to create a continuous profile. The visible layers were 3-6 inches and alternated from the reddish soil (Munsell, 5YR 5/4, reddish brown) to the brownish (Munsell, 10YR 5/2, grayish brown).

The original drawing also showed a concrete well tower located on the upstream side of the dam, with openings for different stages of water to enter (Drawing 2/1). There is no documentation or evidence of this ever having been built. What exists today is a concrete dome with a metal screen inlet; the metal inlet has been shortened to be just above the dome and is covered with stone, known as riprap. The original design pool elevation was 7,340 ft and the existing pond elevation is 7,290 ft. The original drawing also showed a 1.5:1 slope on the downstream side of the dam and a 2:1 slope on the upstream side. The upstream slope was covered with 3 ft (1 m) of riprap to reduce erosion on the interior of the dam. At the toe of the downstream slope there was an aeration basin. This was a 60 ft (18 m) circular concrete basin with a fountain to provide aeration. This aeration basin is described in an 1895 article in the *Daily New Mexican*:

> The water now served Santa Feans is thoroughly aerated before it enters the companies supply pipes. A pipe below the great dam shoots the water twenty feet into space and thence it falls into a huge basin. The sight is a very pretty one.[35]

The original drawing also shows the stone tunnel that runs under the dam. This tunnel was set into the bedrock and arched to create approximately 8 ft (2.4 m) clearance on the interior. As noted in a 1915 plan of the reservoir, there were 2 pipes that ran through the tunnel (Photograph

HAER No. NM-4-21). A 10 inch pipe was laid in 1881 to provide continuous service during construction and a 15 inch pipe was laid in 1894 to provide service from the new reservoir. Water entered the 10 inch pipe from both the Old Stone Reservoir and a metal strainer on the upstream slope of Two Mile Dam, and the 15 inch pipe took in water solely from the strainer on the top of the concrete dome (Drawing 1/3), or the tower if it was constructed. In 1913, a 36 inch sluice gate was added to the front of the upstream concrete dome (Drawing 3/2), and in 1938, the 10 inch pipe was permanently shut off (Drawing 2/3). In 1953, both pipes were replaced with a 36 inch diameter pipe with a series of geared gate valves (Drawing 3/3). One valve was on the upstream side of the dam, and two were on the downstream side. All valves remain in place, and the two on the downstream side of the dam had extensions added in 1994 to make them operable at the new height of the infill riprap (Drawing 4/3).

The aeration basin seems to have been out of use by 1915, since the 1915 drawing shows a "sluiceway" rather than a basin. In 1994, the tunnel archway and what would have been the aeration basin were filled with riprap to aid in erosion control for the breach. Prior to being filled in, the valves, tunnel opening, and a grouted stone channel were visible, and were recorded as part of this HAER documentation.

Site:

Two Mile Reservoir is one in a series of three reservoirs along the Santa Fe River. McClure, the reservoir farthest upstream, was constructed in 1941-42 and can retain 3,059 acre feet, or 997 million gallons of water. Nichols was constructed in 1926-28 and can retain 684 acre feet or 223 million gallons of water. Two Mile, the farthest downstream, was constructed in 1893-94 and can retain 387 acre feet or 126 million gallons of water (Drawing 1/2).[36]

Two Mile Dam is situated in Precambrian granite and granite gneiss, with some Paleozoic limestone, while the reservoir area consists primarily of alluvium over the geology noted above. The reservoir vegetation consists primarily of piñon and native grasses. Riparian vegetation runs along the southern boundary of the reservoir. The oldest dam along the river is at the upper edge of Two Mile Reservoir, the 1881 Old Stone Dam. The reservoir behind the Old Stone Dam was silted in during the 1904 flood and is currently swampy and vegetated.

When the dam was intact, Two Mile Reservoir could retain 387 acre feet of water.[37] Site elements included a metal silt fence running along the northern edge of the watershed, a 150 ft (46 m), semi-circular spillway (Photograph HAER No. NM-4-9), a masonry tunnel under the dam, and an 1881 stone dam, which marked the upstream boundary. Other elements included a 147 ft (45 m) long concrete weir between the diversion channel and the reservoir near the stone dam, various gate valves, a pumphouse, decant ponds and an upstream checkdam. The concrete weir prevents flood flows from exceeding 5,000 cubic feet per second (cfs) in the diversion channel, by allowing water to overflow into the reservoir. The existing diversion channel is on the site of the 5 ft (1.5 m) diameter concrete tunnel that was constructed to allow water to flow downstream when needed or when muddy. The stone weir, to the south of the spillway, is the remains of the concrete tunnel (Photograph HAER No. NM-4-10). It is believed that after the flood of 1904, the tunnel was opened to allow greater flow for more substantial storms.

Character:

Two Mile Reservoir is no longer recognizable as a reservoir, it has more the feel of a canyon. The earthen dam itself has been breached, with only the southernmost portion intact. A new hill has been created on the southwestern portion of the site, near the spillway, with the sludge and earth taken from the reservoir and dam. The breach is lined with riprap and is being seeded above the riprap to the top of the slope; the curve of the dam does show in the breach (Drawing 2/4). The tunnel and both downstream and upstream valves are still operational, but have been covered with riprap. The spillway, diversion channel, and the Old Stone Dam were not impacted during the emergency breach. Ruins that were discovered in the basin have been left relatively undisturbed (Drawings 2/4, 4/6); some damage occurred prior to the initiation of the preservation portion of the work.

Condition:

The 1893 earthen dam has been breached, leaving a 3:1 slope on the northern portion, a 4:1 slope on the southern portion and a 50 ft (15 m) breach at the center (Drawings 1/4, 2/4). The reservoir has been cleaned of sludge, the earth from the dam has been moved to the southern side of the reservoir, and a new pond containing 10 acre feet of water was created on the upstream side of the old dam. The sediment ponds, located in the reservoir area of the Old Stone Dam, have been cleaned. Also, three stone/filter fabric retaining walls were installed just downstream of the Old Stone Dam to clean the stream before it enters the pond at the toe of the dam breach. The breach was lined with a thick filter fabric and then covered with large riprap. The riprap continues past the previously existing toe of the dam, covering the tunnel opening and the outlet pipes. The final outlet is also lined with filter fabric, so the water that continues downstream is clear.

V: RESERVOIR RUINS

This section will discuss the available archival information with reference to land transactions, census data, and maps of Two Mile Reservoir that may lead to an understanding of the ruins within the reservoir basin. There are two sets of stone alignments in the reservoir just below the Old Stone Dam. These are fully silted and appear to have been in place prior to the construction of Two Mile Dam. The first stone alignment is approximately 100 ft (30 m) long, with what appear to be rooms at either end (Photograph HAER No. NM-4-20). There are some structural wood elements protruding vertically through the silt at various locations. The second ruin is "L" shaped, with rooms that would have been 12 ft (3.7 m) wide and two round structural wood members protruding through the silt. Without excavation, it cannot be determined exactly what these structures were, but due to the scale, the first seems to be of an industrial nature because of its large scale and the second appears to be a small residence (Drawing 2/4).

In 1880, there were three mills in Santa Fe Canyon that were large enough to be included in the 1880 *United States Census Records, Schedule 3 - Manufactures,* and one that was under construction. The three mills were owned by James A. Donovant, David H. Catanach and Herman Strelow. The mill under construction was owned by Teodoro Martinez. An 1883 map shows three mills: one at the eastern corner of Talaya Grant on the southern side of the canyon road; another in the area of Two Mile Reservoir on the northern side of the canyon road; and the final one west of the reservoir on the northern side of the canyon road. An 1894 map identifies the westernmost mill as belonging to a Mrs. Catanack; although the name was spelled differently, it seems that Catanach and Catanack are the same family.

In 1883 the Water and Improvement Company won a suit against Herman Strelow; his land was purchased for $400 and he was given the rights to water to continue running his grist mill.[38] From this information, it seems that the second mill, on the north side of the canyon road, belonged to Herman Strelow, because it is within the boundaries of the land purchased by the

water company. If these conclusions are correct, then the third mill belonged to James A. Donovant. The three mills were of comparable size, with overshoot wheels, and a production capacity of 90 bushels per day. All operated four months full-time and six months half-time, with two idle months.[39] The Strelow mill had a 24 ft (7 m) fall, and the other two mills had falls of 15 ft (4.5 m) and 16 ft (4.9 m).

There are also photographs of three mills in the Santa Fe Canyon from the early 1900s, on file at the Museum of New Mexico. One of the structures is a relatively small adobe "molino," which has a vertical axis wheel, rather than the larger horizontal axis overshoot wheels. One of the other mills is on the northern side of the river and is one story with a gable roof. The third mill is constructed of random rubble, is two stories tall, and has a flat roof. The wheel on this mill is a horizontal axis, overshoot wheel. The section with the wheel is two stories and is approximately 16 ft (4.9 m) long, as the building continues it drops to one story and then the photograph ends. The ruins in the reservoir define rooms at both the eastern and western end, which are similar in size to the structure shown in the third photograph.

At this point, the origin of the ruins in the reservoir is unknown, speculation may lead us to believe that the structure is either a mill or an associated building. The pieces of evidence are not conclusive, but rather suggest a need for additional research. More information could be gathered through archaeological study of the sites and an intensive search for information through oral histories and more intensive research of the architecture of Upper Canyon Road.

1. Interview with Don Lopez of New Mexico State Engineer's Office, September 19, 1994.

2. Santa Fe Water and Improvement Company. 1880 Grant Application from Santa Fe County Commission.

3. The exception would be Herman Strelow, who it appears did not object so much to the impounding of water as he did to losing his land.

4. David Snow, *The Santa Fe Acequia Systems* (Santa Fe: Santa Fe Planning Department, 1988), p. 9.

5. Phil Lovato, *Las Acequias del Norte* (Taos: New Mexico State Planning Office, 1974), p. 28.

6. Terry Jon Lehmann, *Santa Fe and Albuquerque 1870-1900: Contrast and Conflict in the Development of Two Southwestern Towns* (Indiana: Indiana University, 1974), p. 22.

7. Dean Sanborn, *History of Sangre de Cristo Water Company* (Santa Fe: Sangre de Cristo Water Company, 1982), transcribed hearing statement June 1881.

8. Ibid., *Daily New Mexican*, June 14, 1881.

9. Ibid., *Daily New Mexican*, June 23, 1881.

10. Ibid., *Daily New Mexican,* October 14, 1881.

11. Ibid., *Daily New Mexican,* December 22, 1881.

12. Ibid., *Daily New Mexican*, May 6, 1893.

13. Ibid., *Daily New Mexican*, March 14 through July 17, 1893.

14. *Engineering News*, 1893, p. 346.

15. Ibid.

16. Ibid., p. 399.

17. Talaya Hill is referred to as Atalaya in modern documents.

18. Sanborn, Santa Fe City Council Meeting, July 15, 1921.

19. Ibid., *Daily New Mexican,* May 26, 1926.

20. Department of Agriculture, "Santa Fe Watershed Closing Order," November 3, 1932.

21. Mike Snavely, undated letter report in response to April and May 1971 water quality complaints.

22. Black & Veatch, letter dated August 6, 1971.

23. R. W. Beck and Associates, p. I-2.

24. Carole Christiano Letter.

25. In the notification letter, the site was referred to as the Santa Fe Waterworks Reservoir.

26. Bovay Engineers, p. 1-1 and 1-2.

27. SHB AGRA, Dam Embankment Stability Investigation (Albuquerque: SHB AGRA, 1992), p. 12.

28. New Mexico State Archives Newspaper Clipping Files, *Albuquerque Journal*, June 10, 1992.

29. Ibid., March 27, 1993.

30. Ibid., *New Mexican*, June 12, 1993.

31. Ibid., *Albuquerque Journal*, May 13, 1993.

32. Institution of Civil Engineers, *Clay Barriers for Embankment Dams* (London: Thomas Telford Ltd., 1990), p. 74.

33. Ibid., p. 31.

34. Ibid., p. 109.

35. Sanborn, *Daily New Mexican*, July 5, 1895.

36. Harman, O'Donnell & Henninger Associates, Inc. (Santa Fe: 1961), p. 12.

37. One acre foot equals 43,560 ft^3.

38. 1883 Deed, Santa Fe County Courthouse, Book M, p. 335-336.

39. *United States Census Records, New Mexico, 1880.* Schedule 3 - Manufactures, Santa Fe County.

GLOSSARY

Breach - A gap created to reduce the amount of water in the reservoir.

Standard Project Flood - Flood used by the Corps of Engineers as a basis for study, defined as discharges that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the geographical region involved, excluding extremely rare combinations.

Puddle - A method of earthen construction in which bands of soil are compacted and cured to create a structure.

Line of Saturation - The boundary of soil in which the pores are completely filled with water.

Toe - The lowest point on the dam; where the dam meets grade.

Total Station - A field surveying instrument, similar to a transit, with an electronic data collector that enables extremely rapid and accurate collection of locational and descriptive information. The field data points can be loaded into AutoCAD to create digital terrain modeling and contours.

Seepage Collars - Walls parallel to the longitudinal center constructed to prevent water from flowing along a pipe or tunnel that crosses through the dam. These have also been referred to as heart walls.

Appurtenances - A minor piece of property, right or privilege that is considered part of a more important one.

Sluiceway - A channel with a sliding gate to control the flow of water.

Weir - A small dam built in a channel to regulate the flow of water.

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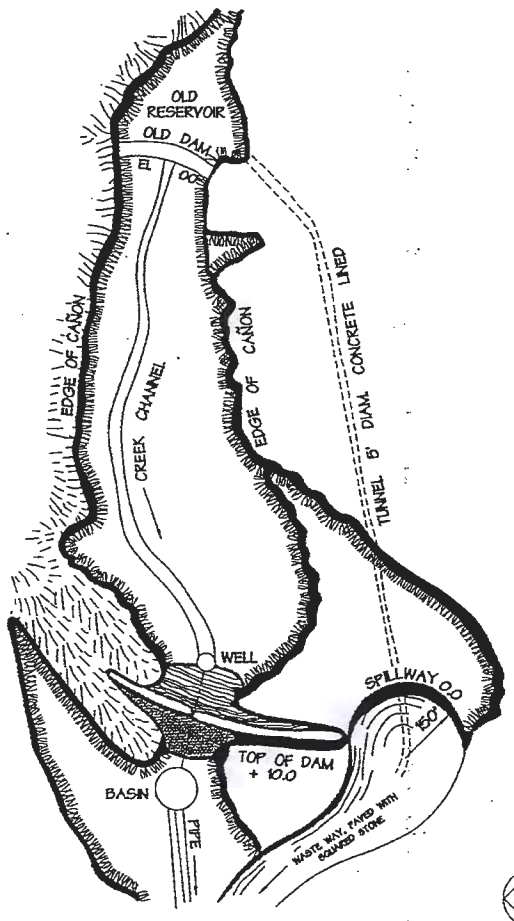
TWO MILE RESERVOIR: 1893

SANTA FE, NEW MEXICO



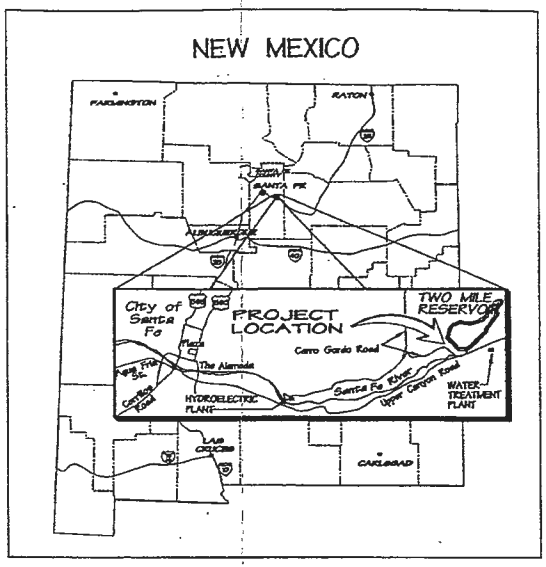
NORTH

In 1893, the Santa Fe Water and Improvement Company constructed an earthen dam across the Santa Fe River and created a reservoir capable of providing 387 acre feet of water to the City of Santa Fe, with surplus for irrigation. The reservoir was located 2.0 mi (3.2 km) from the monument in the center of the town plaza, so it was named Two Mile Reservoir. Prior to the development of the water system, the City of Santa Fe had been primarily agricultural in nature; the advent of company control of water rights marked the beginning of urbanization.

The earthen dam was the second dam along the Santa Fe River. The first, constructed in 1881, was a stone dam. When construction of the earthen dam began, a 5.0 ft (1.5 m) diameter concrete tunnel was constructed at the southern edge of the reservoir to provide the city with water service while the new dam was being constructed. This eventually became an open channel and is now referred to as the diversion channel. Two Mile Dam was constructed with a tunnel and pipes under the dam to control the flow of water, concrete seepage collars to prevent saturation, and puddled earth. The upstream side of the dam was clay and silt puddled using hordes of goats to tamp the earth and provide a key for the next layer. The downstream side was built of sand and gravel. Varying the construction materials was meant to stabilize the interior hydrostatic pressure to avoid failure through saturation or slump.

This recording project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering and industrial works in the United States. The HAER program is administered by the National Park Service, U.S. Department of the Interior. The Two Mile Reservoir Recording Project was completed by Mariah Associates, Inc. under contract with the Public Service Company of New Mexico.

The fieldwork, measured drawings, historical report, and photographs were prepared under consultation with Lysa Wegman-French, of Historical American Buildings Survey/HAER Denver. The recording team consisted of Karen Lewis, Historical Architect; John Evasekovich and David Barsanti, Architectural Delineators; and Bethann McVicker, Wendy Whittenburg, John Evasekovich, and Ben Galleon, CAD Operators. Formal photography was done by Danny Walker of Image Resources.



LOCATION MAP

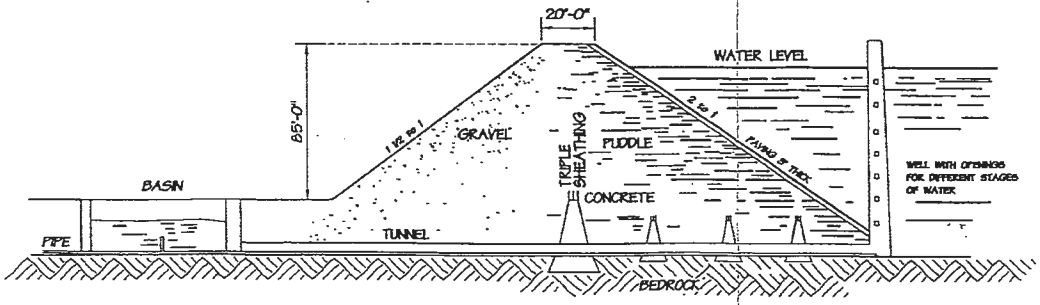
BASED ON SANTA FE, NEW MEXICO (1961, PHOTOREVISED 1977) QUADRANGLE, USGS 7.5' SERIES.

Scale: 1" = 1/2 mi

NORTH

0 1/4 1/2 1 Mile

0 1/4 1/2 2 Kilometers



(1/1) HISTORIC PLAN OF DAM AT SANTA FE, NM
BASED ON ENGINEERING NEWS, APRIL 13, 1893 NOT TO SCALE

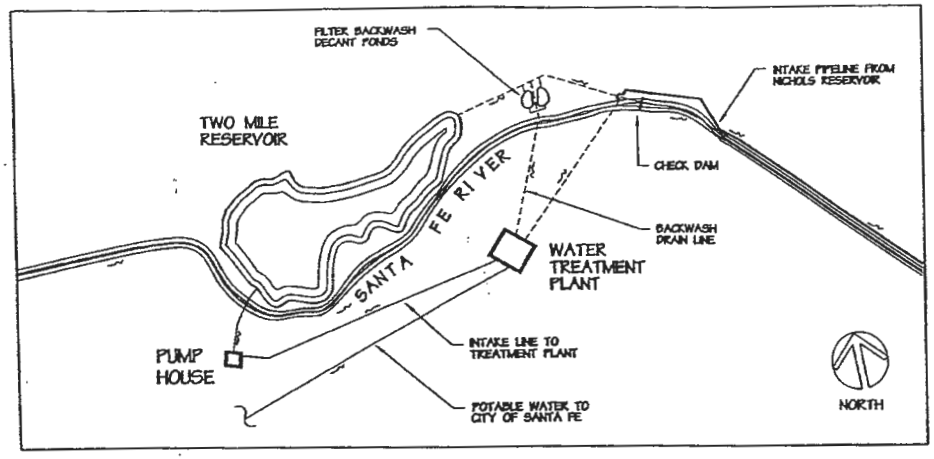
(2/1) HISTORIC SECTION OF DAM AT SANTA FE, NM
BASED ON ENGINEERING NEWS, APRIL 13, 1893. NOT TO SCALE

HISTORIC AMERICAN ENGINEERING RECORD
HAER NM-4
SHEET 1 OF 6

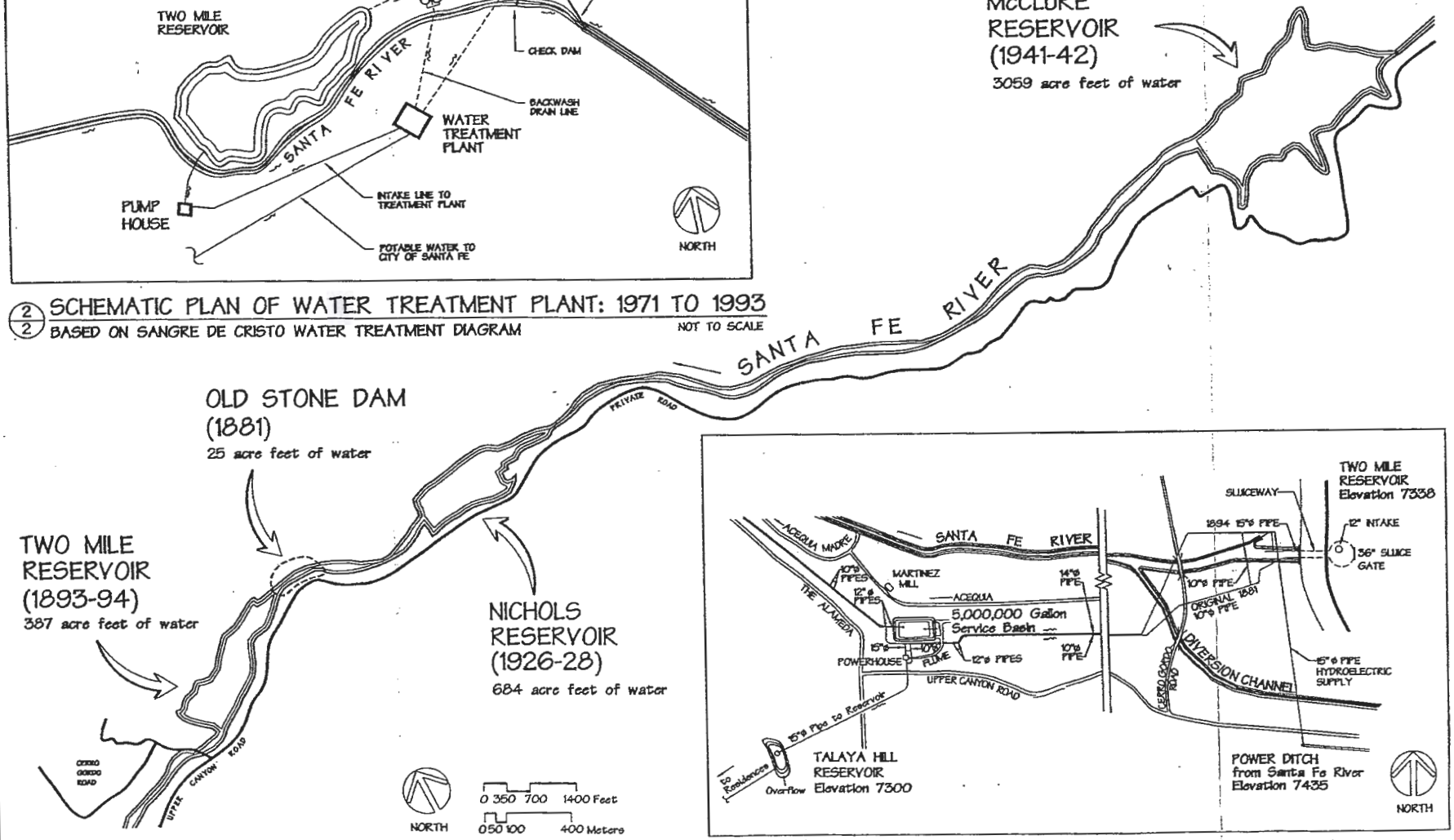
TWO MILE RESERVOIR - 1893
NEAR INTERSECTION OF UPPER CANYON AND CERRO GORDO ROADS - SANTA FE COUNTY NEW MEXICO

TWO MILE RESERVOIR RECORDING PROJECT, SANTA FE

MADE BY: BETHANN MCVICKER AND WENDY WHITTENBURG, 1994



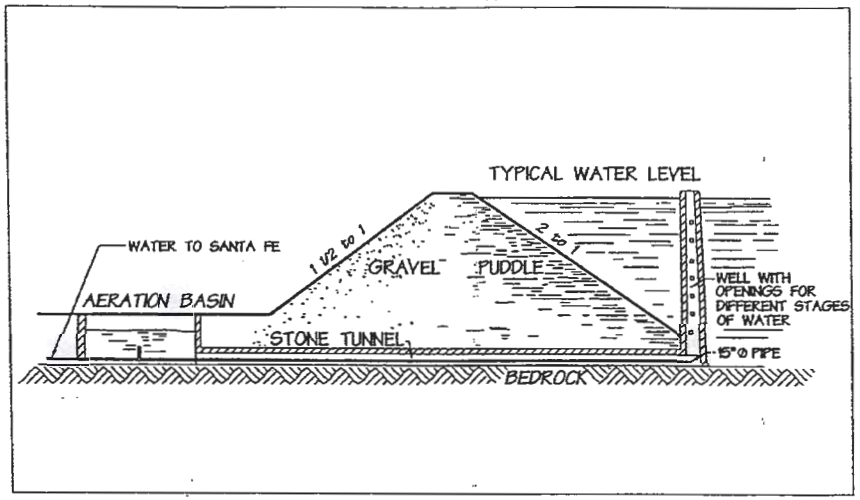
2/2 SCHEMATIC PLAN OF WATER TREATMENT PLANT: 1971 TO 1993
BASED ON SANGRE DE CRISTO WATER TREATMENT DIAGRAM
NOT TO SCALE



1/2 PLAN OF SANTA FE DAM SYSTEM
BASED ON SANTA FE, NEW MEXICO (1961, PHOTOREVISED 1977) QUADRANGLE, USGS 7.5' SERIES
Scale: 1" = 700'

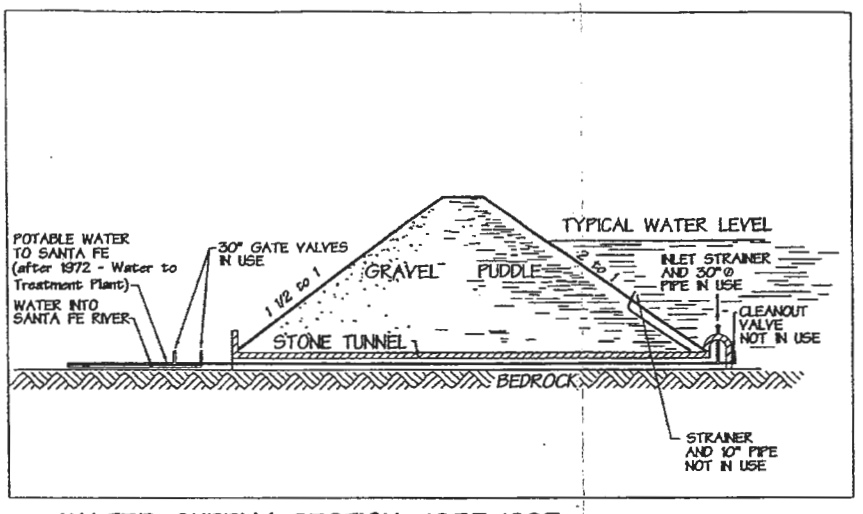
3/2 SCHEMATIC PLAN OF WATER ELECTRIC PLANT
BASED ON SANTA FE WATER AND LIGHT COMPANY MAP OF 1914
NOT TO SCALE

WENDY WHITTENBURG, 1994
TWO MILE RESERVOIR RECORDING PROJECT, SANTA FE
TWO MILE RESERVOIR - 1893
NEAR INTERSECTION OF UPPER CANYON AND CERRO GORDO ROADS - SANTA FE COUNTY NEW MEXICO
HAER NM-4
HISTORIC AMERICAN ENGINEERING RECORD
sheet 2 of 6 sheets



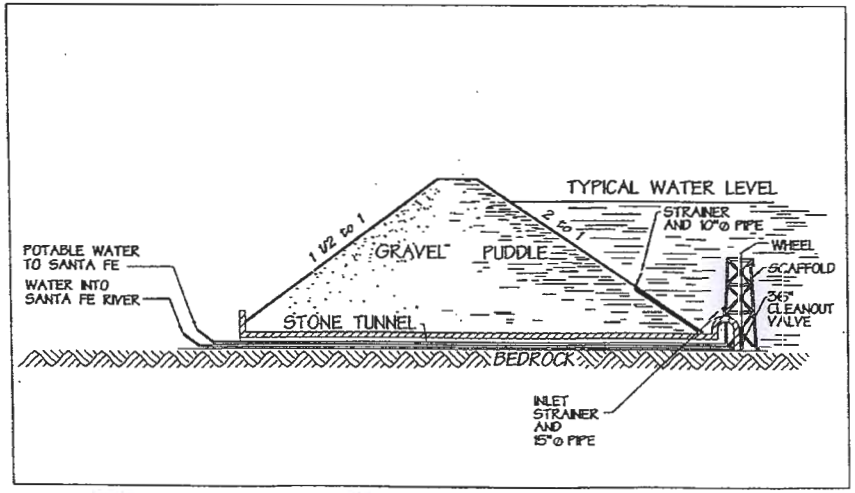
1/3 DESIGNED WATER SUPPLY SECTION: 1893
BASED ON ENGINEERING NEWS, APRIL 13, 1893

NOT TO SCALE



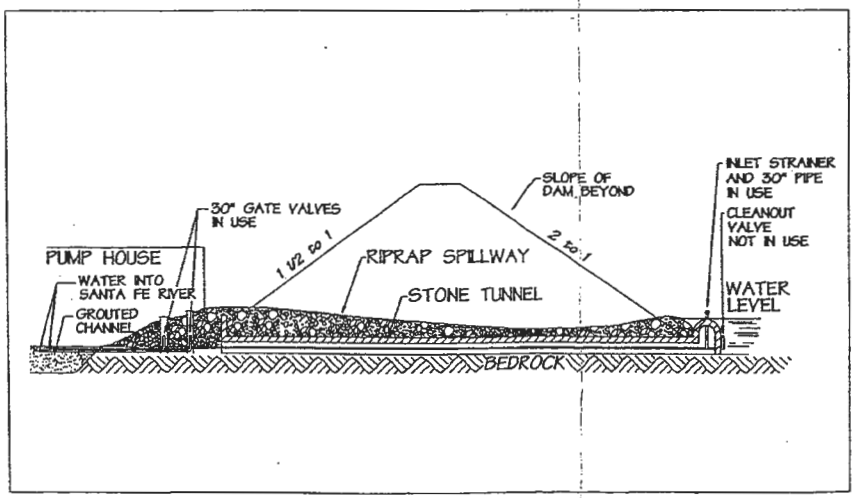
3/3 WATER SUPPLY SECTION: 1953-1993
BASED ON CONSTRUCTION PHOTOGRAPHS

NOT TO SCALE



2/3 WATER SUPPLY SECTION: 1938
BASED ON NEW MEXICO POWER COMPANY DWG. NO. SF-302-C

NOT TO SCALE



4/3 WATER SUPPLY SECTION: 1994

NOT TO SCALE

BEN GALISON AND BETHANN MCVICKER, 1994

TWO MILE RESERVOIR RECORDING PROJECT, SANTA FE

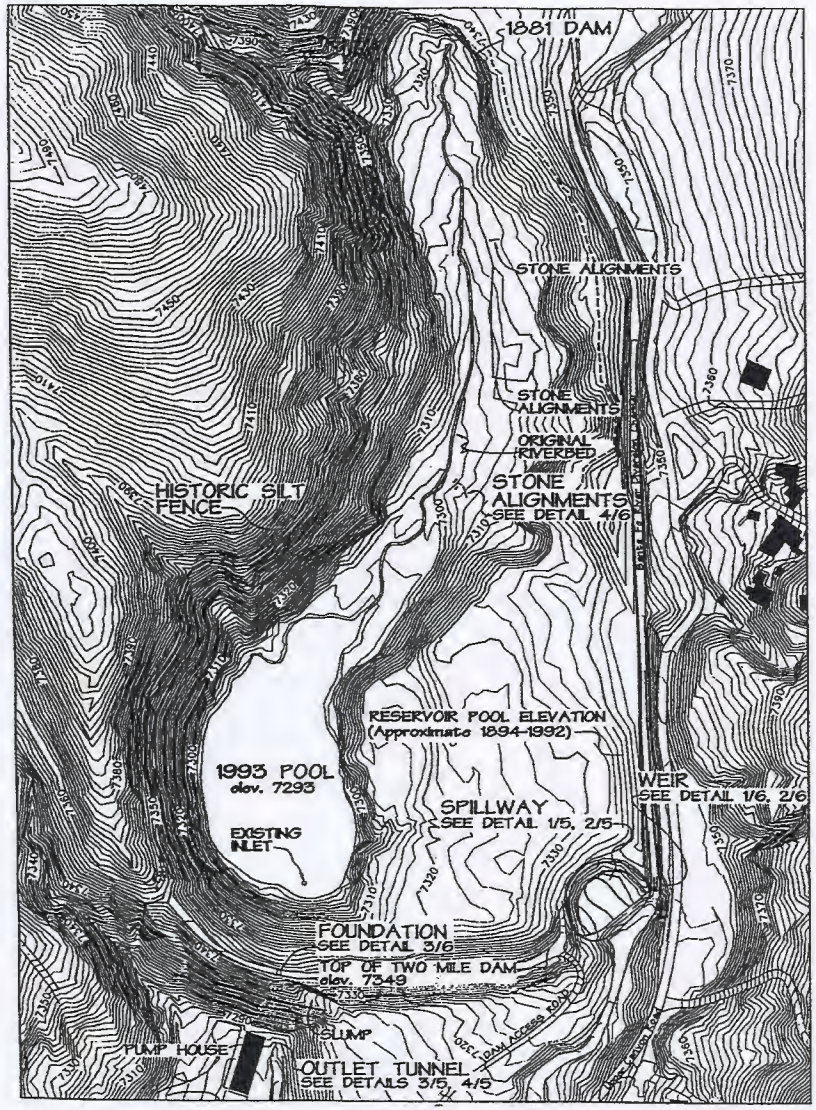
NEAR INTERSECTION OF UPPER CANYON AND CERRO GORDO ROADS - SANTA FE COUNTY NEW MEXICO

TWO MILE RESERVOIR - 1893

HISTORIC AMERICAN ENGINEERING RECORD

HAER NM-4

sheet 3 - 6



1/4 TWO MILE RESERVOIR TOPOGRAPHIC PLAN BEFORE BREACH

BASED ON DIGITAL TERRAIN DATA PREPARED BY BOHANNAN HUSTON INC. ALBUQUERQUE.

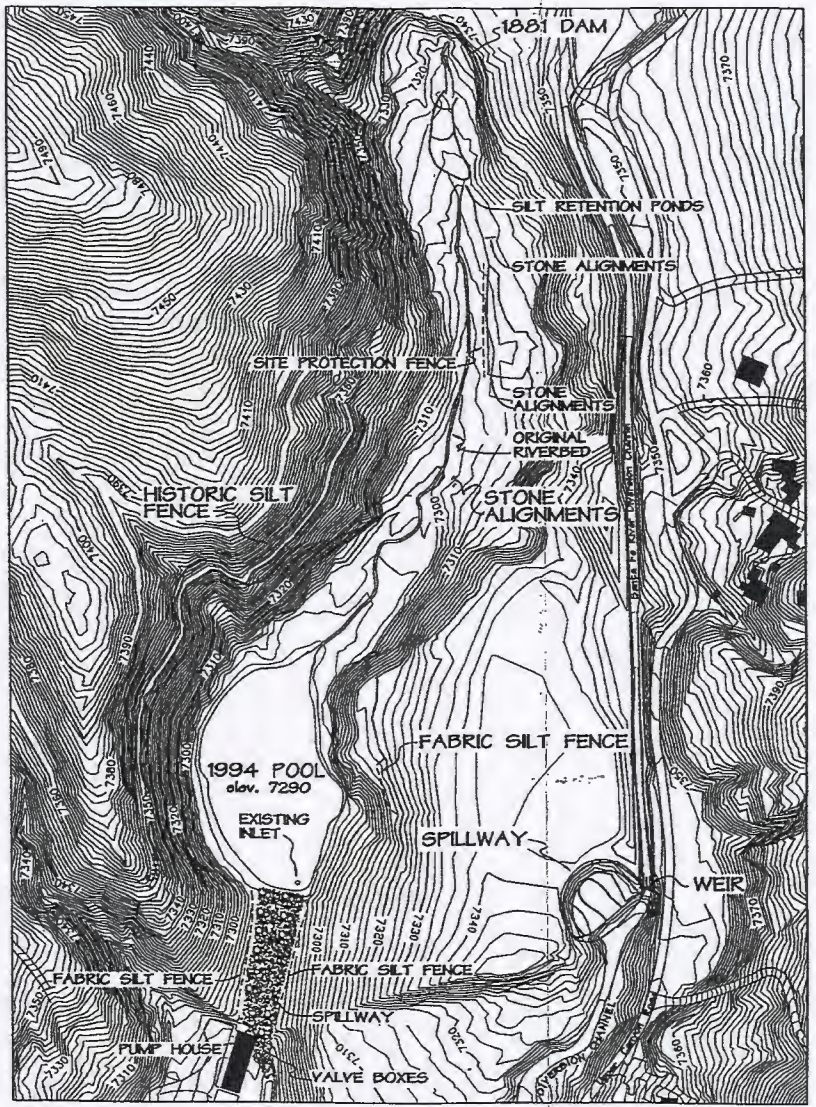
Scale: 1" = 100'

0 100 200 Feet

0 10 60 Meters

TWO FOOT CONTOUR INTERVAL

NORTH



2/4 TWO MILE RESERVOIR TOPOGRAPHIC PLAN AFTER BREACH

BASED ON DIGITAL TERRAIN DATA PREPARED BY BOHANNAN HUSTON INC. ALBUQUERQUE.

Scale: 1" = 100'

0 100 200 Feet

0 10 60 Meters

TWO FOOT CONTOUR INTERVAL

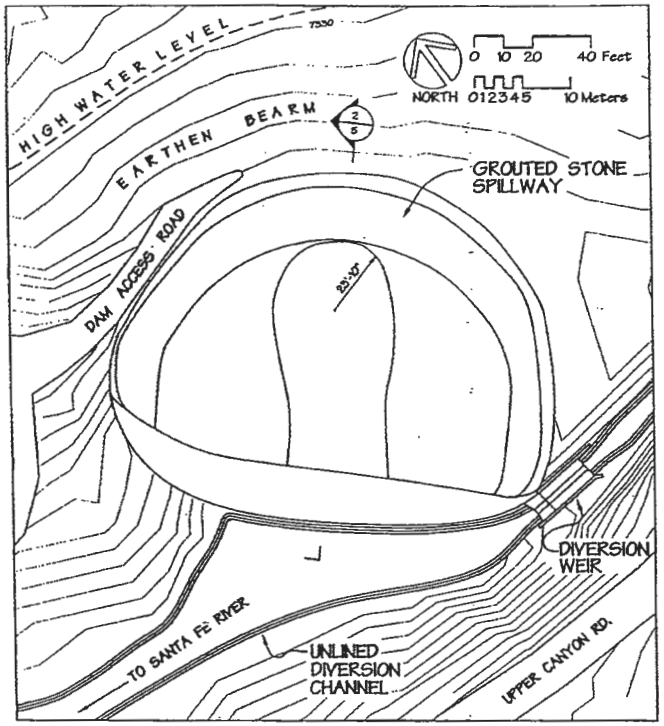
NORTH

JOHN EVASKOVICH AND WENDY WHITTENBURG, 1994

TWO MILE RESERVOIR RECORDING PROJECT, SANTA FE

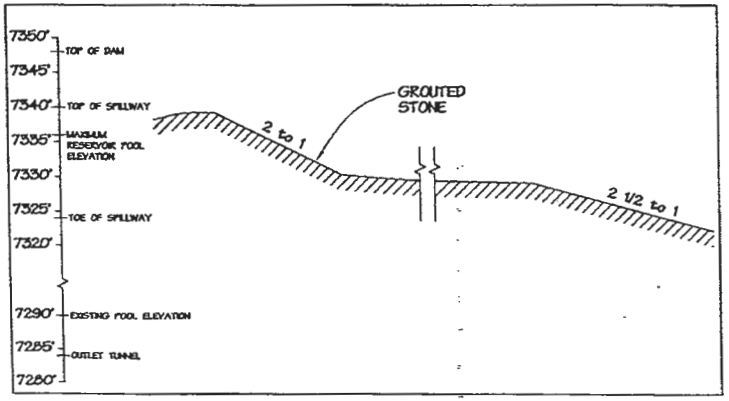
TWO MILE RESERVOIR - 893
NEAR INTERSECTION OF UPPER CANYON AND CERRO GORDO ROADS - SANTA FE COUNTY NEW MEXICO

HISTORIC AMERICAN ENGINEERING RECORD
HAER NM-4
sheet 4 of 6 sheets



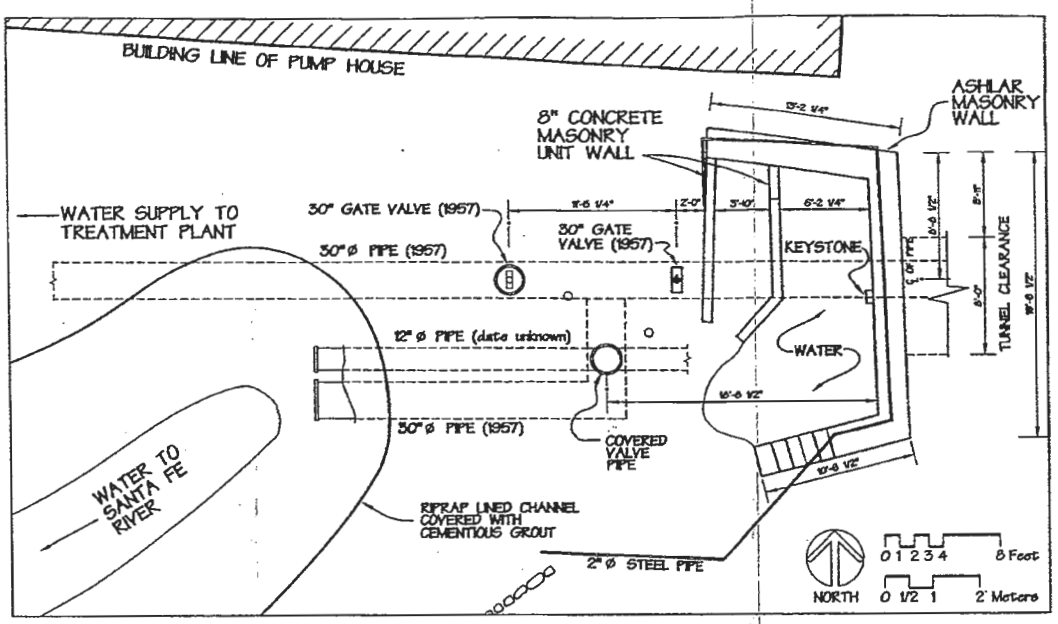
1/5 SPILLWAY PLAN

Scale: 1" = 20'-0"



2/5 SPILLWAY SECTION

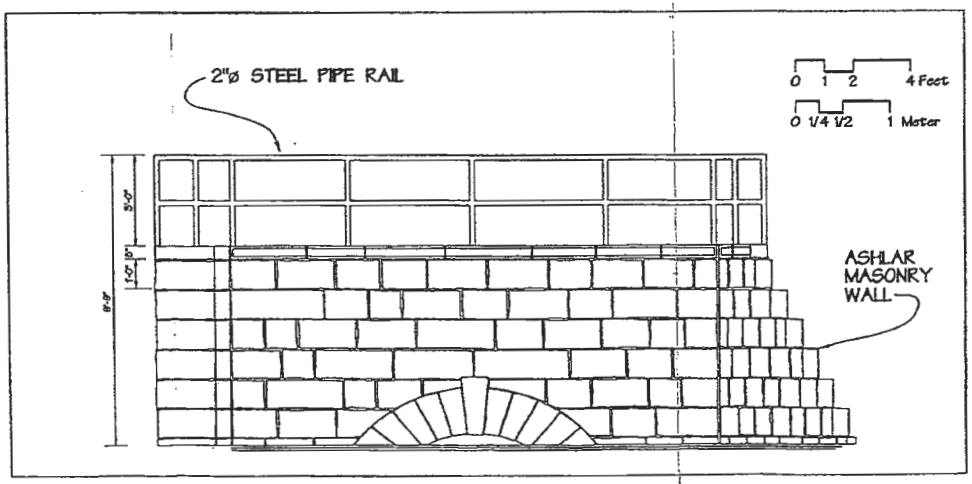
NOT TO SCALE



3/5 OUTLET TUNNEL PLAN

PIPE LOCATIONS BASED ON 1983 TUNNEL IMPROVEMENTS "AS-BUILTS"

Scale: 1/4" = 1'-0"



4/5 OUTLET TUNNEL ELEVATION

Scale: 1/2" = 1'-0"

WENDY WHITTENBURG AND JOHN EVASKOVICH, 1994

TWO MILE RESERVOIR RECORDING PROJECT, SANTA FE

TWO MILE RESERVOIR - 693
NEAR INTERSECTION OF UPPER CANYON AND CERRO GORDO ROADS - SANTA FE COUNTY NEW MEXICO

HISTORIC AMERICAN ENGINEERING RECORD
HAER NM-4
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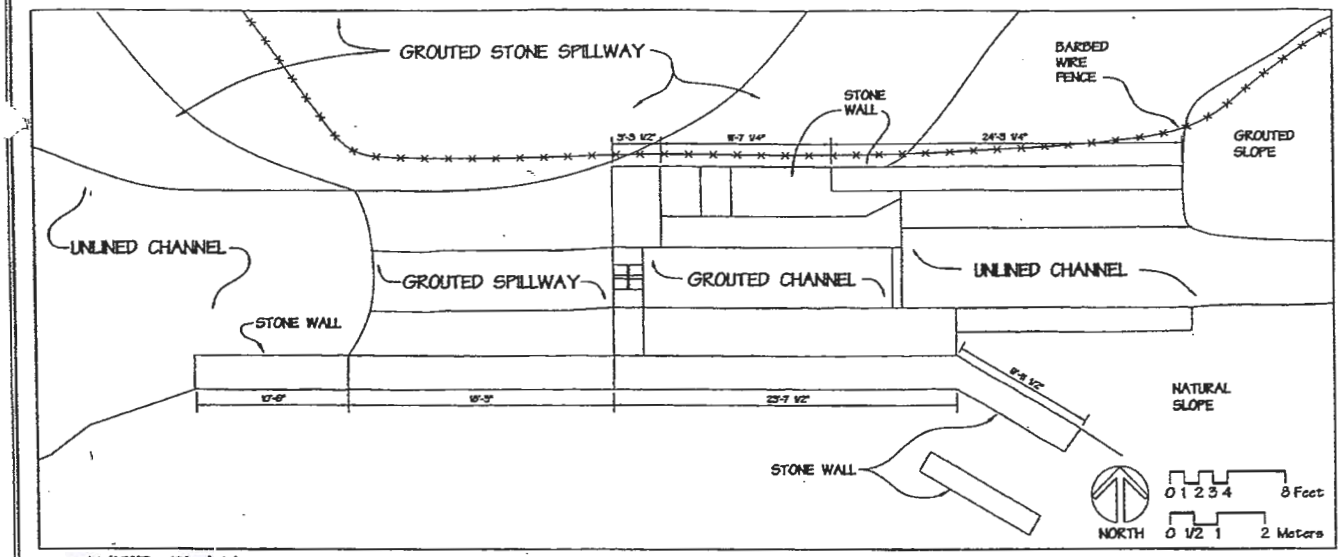
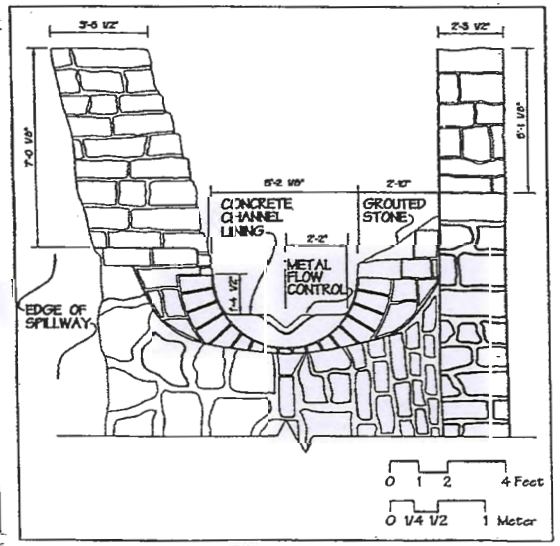


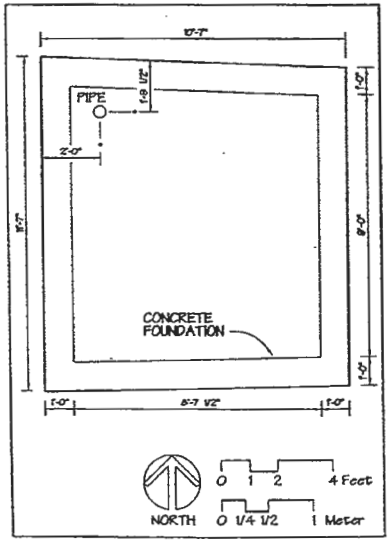
1/6 WEIR PLAN

Scale: 1/4" = 1'-0"



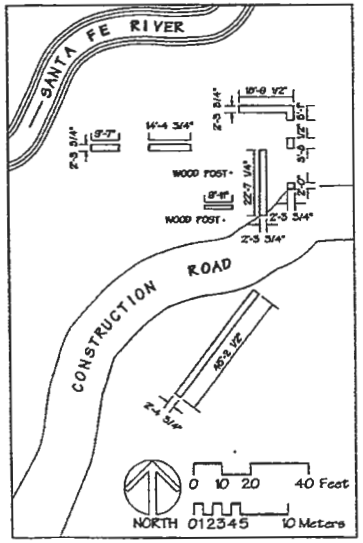
2/6 WEIR ELEVATION

Scale: 1/2" = 1'-0"



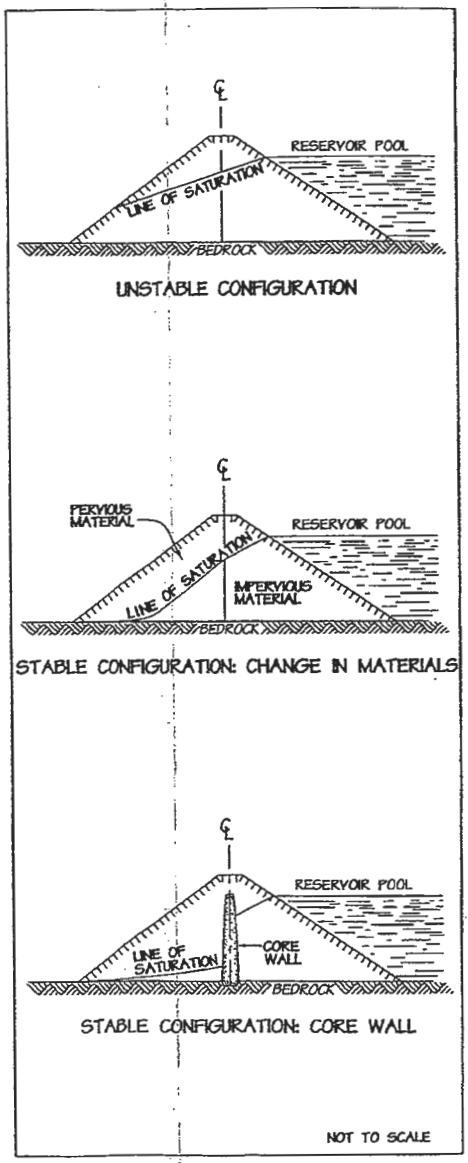
3/6 FOUNDATION PLAN

Scale: 1/2" = 1'-0"



4/6 RUINS PLAN

Scale: 1" = 20'-0"



5/6 SATURATION SCHEMATICS

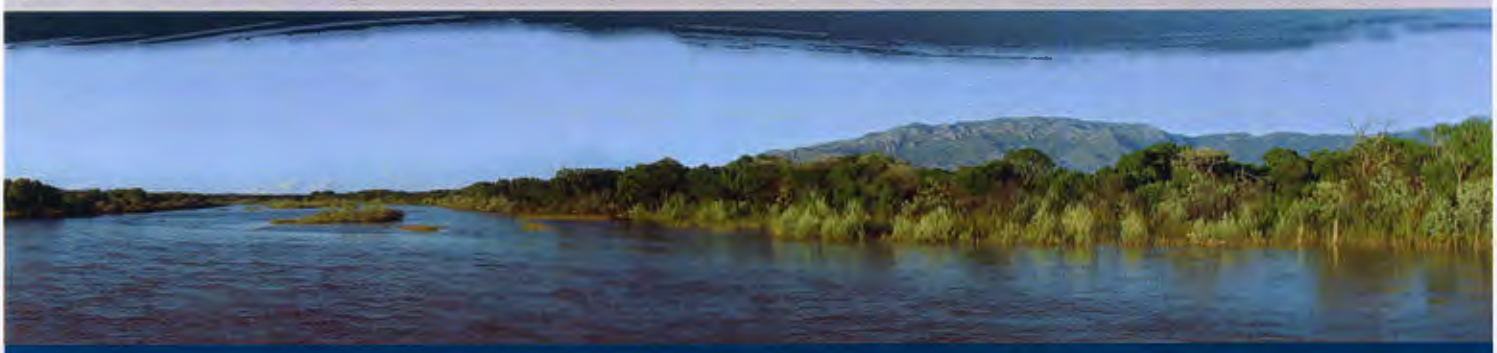
BASED ON EARTH DAM PROJECTS DIAGRAM, CHAPTER V

HISTORIC AMERICAN ENGINEERING RECORD
HAER NM-4
sheet no. 6 of 6 sheets

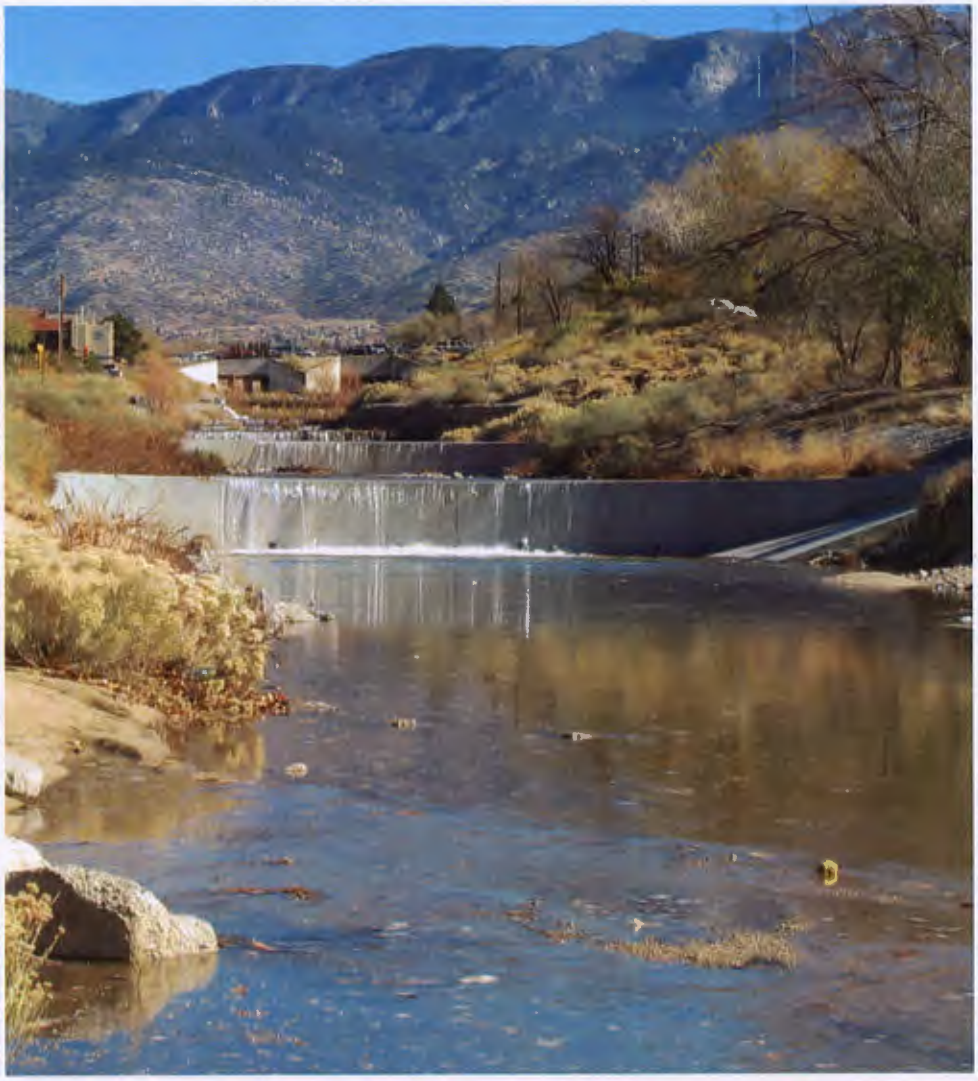
TWO MILE RESERVOIR - 1893
NEAR INTERSECTION OF UPPER CANYON AND CERRO GORDO ROADS - SANTA FE COUNTY NEW MEXICO

WENDY WHITTENBURG, 1994
TWO MILE RESERVOIR RECORDING PROJECT, SANTA FE

APPENDIX T



3b - Aquifer Storage and Recovery



Aquifer Recharge

Even the San Juan-Chama project, which will draw Albuquerque's allotment of San Juan-Chama water from the Rio Grande, will require the aquifer as a backup supply in times of drought.

Unfortunately, we can't always count on San Juan-Chama water. There will be years of low mountain run-off. There will be drought years, and no one can predict the long-term impacts of climate change. That's why the aquifer will always remain a critical water account, our ace in the hole. That's why we have to protect it and replenish it.

The Water Authority's Water Resources Management Strategy calls for a number of measures to ensure the aquifer's long-term health and prevent the land-surface subsidence that can happen when aquifers are over pumped. These measures include regular monitoring of aquifer levels and identification and protection of natural aquifer recharge zones to ensure maximum recharge and prevent aquifer contamination.

More ambitiously, however, the Water Authority in 2007 initiated a pilot program for aquifer storage and recovery, in which a small amount of San Juan-Chama water was released into the Bear Canyon arroyo and tracked to see if it reached the aquifer. results were positive, and the Water Authority is moving forward with plans to recharge the aquifer on a larger scale.

We will be using direct injection as well as infiltration to get the water into the aquifer.We hope to put up to 40,000 acre-feet back into the aquifer in the first couple of years. After that, we will continue to add purified San Juan-Chama water to the aquifer primarily during winter months when demand is low."

Learn more about the Bear Canyon Recharge Project:

- Bear Canyon Schematic

Go to Step 4, Fish Passage

Return to Water System Diagram

Contact Us

Bear Canyon Recharge and Large-Scale Aquifer Storage and Recovery Projects

Albuquerque, New Mexico

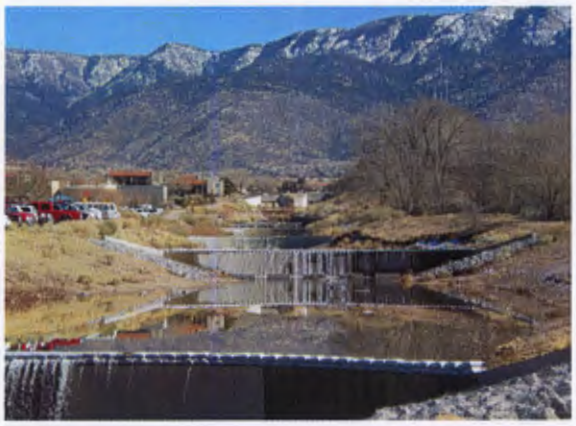
Client

Albuquerque Bernalillo County Water Utility Authority

Highlights

- Recipient of the first full-scale Underground Storage and Recovery permit in New Mexico
- Obtained grant funding
- Establishing long-term drought reserve
- Recharge demonstration using instream infiltration, vadose zone, and deep injection wells
- 2014 New Mexico Chapter of the American Council of Engineering Companies Engineering Excellence Award Winner; Water Resources Category
- 2008 New Mexico Chapter of the American Council of Engineering Companies Engineering Excellence Award Winner; Studies, Research and Consulting Services

For more than a decade, DBS&A has supported the City of Albuquerque and the Albuquerque-Bernalillo County Water Utility Authority (ABCWUA) in developing and implementing the Albuquerque Water Resources Management Strategy. In particular, DBS&A is leading ABCWUA's efforts to design and implement aquifer storage and recovery (ASR) projects for conjunctive management of the surface and groundwater water resources.



The success of the artificial recharge project was critical to demonstrate that aquifer recharge is a viable water management strategy.

DBS&A developed an ASR feasibility study using instream infiltration to recharge the Middle Rio Grande Basin Aquifer and obtained grant funding from the State of New Mexico to design and implement the Bear Canyon recharge demonstration project. The Bear Canyon project was one of the first recharge demonstration projects to be permitted in New Mexico and the project was the first to receive a full-scale permit. The demonstration project included two recharge periods that were conducted in 2008 and 2009, and was a success, with the New Mexico Office of the State Engineer recognizing an initial storage account of 1,073 acre-feet of water.

The ABCWUA plans to operate the Bear Canyon project on an ongoing basis and full-scale operations will begin in fall 2014. The ABCWUA also plans to develop additional recharge projects. DBS&A is currently working on the design and implementation of the Large-Scale ASR Project, which will establish a long-term drought reserve using treated surface water from the ABCWUA's new drinking water treatment plant. DBS&A is providing permitting support, design, construction oversight, and coordinating with the New Mexico Environment Department and the OSE.

The Large-Scale ASR project includes recharge demonstration using vadose zone and deep injection wells at the ABCWUA's drinking water treatment plant, and retrofit of existing production wells for use as injection/extraction wells. Webster Well 1 was the first production well to be retrofitted, and a brief water quality test was completed using Webster Well 1 during the spring of 2013. DBS&A and the ABCWUA are seeking a demonstration permit from the OSE for the Large-Scale ASR project.