CDM

City of Santa Fe

Adopted September 2008

Appendices

Long-Range Water Supply Plan

Appendix A
References, Acronyms, Acknowledgments, and Exclusions

Table A-1 lists references used in developing the Water Plan and describes the relationship between previous work and this Water Plan. In most cases, these references represent a previous study or report that provided valuable information on which to base and further develop the Water Plan. In turn, many older studies not listed here were relied upon by the studies listed below. Acronyms used throughout the Water Plan are defined in Table A-2 on the following page. This appendix also lists the contributors, individually and collectively, that have worked diligently to complete this Water Plan.

Table A-1 References

Reference	Relationship To or Use in this Plan
Boyle Engineering Corporation 1997: Feasibility Study for Rio Grande Diversion System, Technical Report	Used for estimate of approximate pumping goal from Buckman Well Field.
CDM 1998: Treated Effluent Management Plan (City of Santa Fe)	Initial basis for Water Plan effluent irrigation option, including unit quantities and components of conceptual infrastructure that would be required. Initial concept for effluent return flow credits included pumping effluent up to discharge in the upper Santa Fe River.
CDM 2001: Water Supply Analysis for the City of Santa Fe	Background information regarding City's existing water supplies, capacities, and water rights.
CDM 2002: Feasibility Study and Recommendations for San Juan-Chama Diversion (City of Santa Fe and Santa Fe County)	Details, capacities, unit quantities, and costs for Buckman Direct Diversion facilities and similar infrastructure.
CDM 2005: WaterMAPS Model User Manual (City of Santa Fe)	Describes features and use of WaterMAPS model developed as part of Water Plan project.
Daniel B. Stephens & Associates 2001: Jemez y Sangre Regional Water Plan (Jemez y Sangre Water Planning Council)	Source of population projections from which Water Plan population projections were derived. Conceptual description of several water supply options included in Water Plan analysis.
John Shomaker & Associates 1998: Sustainable Ground-Water Production from the City Well Field (City of Santa Fe)	Used for estimate of approximate sustainable yield from City Well Field (also known as Urban Well Field).
McAda, D.P. and M. Wasiolek 1988: Simulation of the Regional Geohydrology of the Tesuque Aquifer System near Santa Fe, New Mexico; revised by the NM Office of the State Engineer into the regional water rights administrative groundwater model for the Santa Fe area	Used in development of CDM groundwater model, as basis of SURFS model, and for quality assurance checks.
Tetra Tech 2004: Long-Range Water Supply Program Coarse Screening of Alternatives – Internal Draft Review Report (City of Santa Fe)	Initial identification of several water supply options. Identification of initial objectives used as basis for Water Plan objectives.

Table A-2 Acronyms

Acronym	Definition
$/AF	dollars per acre-foot
$/yr	dollars per year
AF	acre-feet (1AF = 325,851 gallons)
AFY	acre-feet per year
BDD	Buckman Direct Diversion
CDM	Camp Dresser & McKee Inc.
CDP	Criterium Decision Plus
City	City of Santa Fe
CRWTP	Canyon Road Water Treatment Plant
EIS	Environmental Impact Statement
FN	file name
ft/yr	feet per year
gpcd	gallons per capita per day
gpm	gallons per minute
ISC	Interstate Stream Commission
JAN	Jicarilla Apache Nation
mgd	million gallons per day
MRC	Municipal Recreation Complex
NMED	New Mexico Environment Department
NPT	Rio Nambe, Rio Pojoaque, Rio Tesuque
O&M	operations and maintenance
OSE	New Mexico Office of the State Engineer
PUC	City of Santa Fe Public Utilities Committee
RFC	return flow credits
ROW	right-of-way
SDWC	Sangre de Cristo Water Division, City of Santa Fe
SJC	San Juan-Chama Project
SURFS	Stream Unit Response Function Solver
TEMP	Treated Effluent Management Plan (1998)
USGS	United States Geological Survey
Water Plan	Long-Range Water Supply Plan
WaterMAPS	Water Management and Planning Simulation Model
WTP	water treatment plant
WWTP	wastewater treatment plant

It should be noted that throughout the Appendices, any language referring to the Santa Fe River is analagous to the Canyon Reservoirs.

Acknowledgements

The Water Plan was commissioned in 2004 through the vision of the City of Santa Fe Governing Body, the Sangre de Cristo Water Division staff, and the Santa Fe community. Critical to the development of the Water Plan was a diverse team of contributors and reviewers. The following individuals have dedicated significant time and effort to shaping a reliable, sustainable water future for Santa Fe:

City of Santa Fe

- Galen Buller – City Manager, former Director of Sangre de Cristo Water Division
- Gary Martinez – Director, Sangre de Cristo Water Division
- Claudia Borchert – Long-range Water Supply Plan Project Manager, Sangre de Cristo Water Division
- Rick Carpenter – Senior Water Resources Coordinator, Sangre de Cristo Water Division
- Michael Gonzales – Source of Supply Manager, Sangre de Cristo Water Division
- Jim Montman – former Public Utilities Director
- Kyle Harwood – former Assistant City Attorney

Consultants and Advisors

- Kelly DiNatale – CDM
- Norman Gaume – Consulting Water Resources Engineer
- Enrique Lopez Calva – CDM
- Lucy Moore – Lucy Moore and Associates
- Jason Mumm – formerly with Integrated Utilities Group
- John Rehring – CDM
- Neva Van Peski – League of Women Voters
- Kelley Weaver – CDM
- Lee Wilson – Lee Wilson and Associates

In addition, the planning team would like to thank the public and governmental agencies for their attention, participation, ideas, and input.

Exclusions

Although the planning process has been comprehensive, this Water Plan does not:

- Include water quality goals, except as a criteria for comparing various water supply options; the assumption made herein is that all current and future water supply will meet necessary federal and state safe-drinking water quality standards.
- Aim to satisfy the requirements of New Mexico Statute 72-1-9 regarding 40-year water development plans.
- Explain the City's comprehensive water conservation programs in great detail. More information is included in the City's 2005 Water Conservation Plan.
- Analyze future water supply infrastructure needs including transmission, storage, and distribution peak-day demand needs.
- Explicitly include a utility reserve; however, the reliability and redundancy of the City's Water Plan is evaluated.
- Consider the water supply needs of the greater Santa Fe region; however, some policies protect the regional water supply source and others encourage regional cooperation. This evaluation process could be expanded to include a larger geographic extent.
- Explicitly analyze potential impacts to City's water supplies from global warming or the carbon footprint associated with future water supply production; the City's conjunctive use of surface and groundwater provides some resilience to potential water supply impacts which is discussed in Appendix J.
- Consider storm water as a potential source of supply.

Appendix B
Framework for Plan Development

The Water Plan applied an integrated, multi-objective approach to developing and evaluating alternative water supply alternatives, or portfolios, that could meet the City's projected 2045 demands. This approach reflects the complex nature of satisfying multiple and potentially conflicting objectives in meeting future water demands. Evaluations of water supply portfolios were conducted in an open and collaborative manner, including the integration of public input received at several key points throughout the planning process (Appendix H).

A conceptual overview of the process used to develop and evaluate portfolios of future supply is provided in Section 2 of this report. Figures B-1 and B-2 summarize the basic steps in that process.

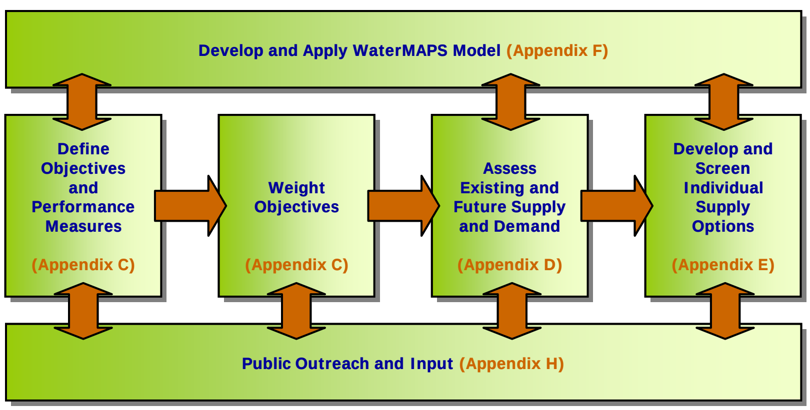


Figure B-1 Initial Elements of Plan Development

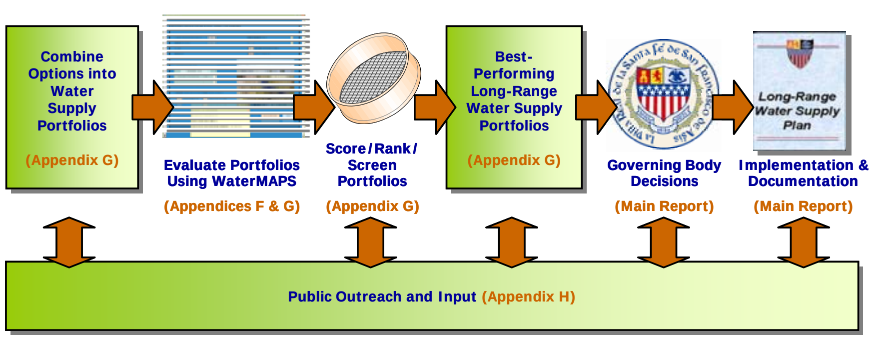


Figure B-2 Development and Evaluation of Portfolios

The portfolio scoring process employed is illustrated with a hypothetical example and numbers in Figure B-3 on the following page. That process is described as follows:

- Step 1 is to determine the "raw" performance (i.e., the value before standardizing scores) for each portfolio against each of the performance measures. In this hypothetical example, the raw performance cost for Portfolio 6 was $1,200/AF.
- Step 2 standardizes the raw performance scores into comparable numeric scores within a range of 1-5, (with higher scores indicating better performance). This is necessary because the performance measures will have inconsistent units of measure (e.g., $/AF, percent of years with restrictions, unitless qualitative scores). In this hypothetical example, Portfolio 6 has relatively high costs when compared to the other portfolios, so the standardized score for this objective (between 1 and 5) is 1.7, a fairly low performance.
- Steps 3 and 4 calculate the partial score for the portfolio, based on the standardized score (between 1 and 5) and the weight for the objective. In this hypothetical example, the cost objective was given a weight of 32 percent (out of a possible 100 percent). The partial score for this objective is the standardized score (1.7) multiplied by the objective weight (32 percent), which equals 0.54.
- Step 5 includes plotting the partial score of 0.54 for Portfolio 6, and this procedure is repeated for all of the other objectives for Portfolio 6 until a total score for the portfolio is calculated (Step 6).

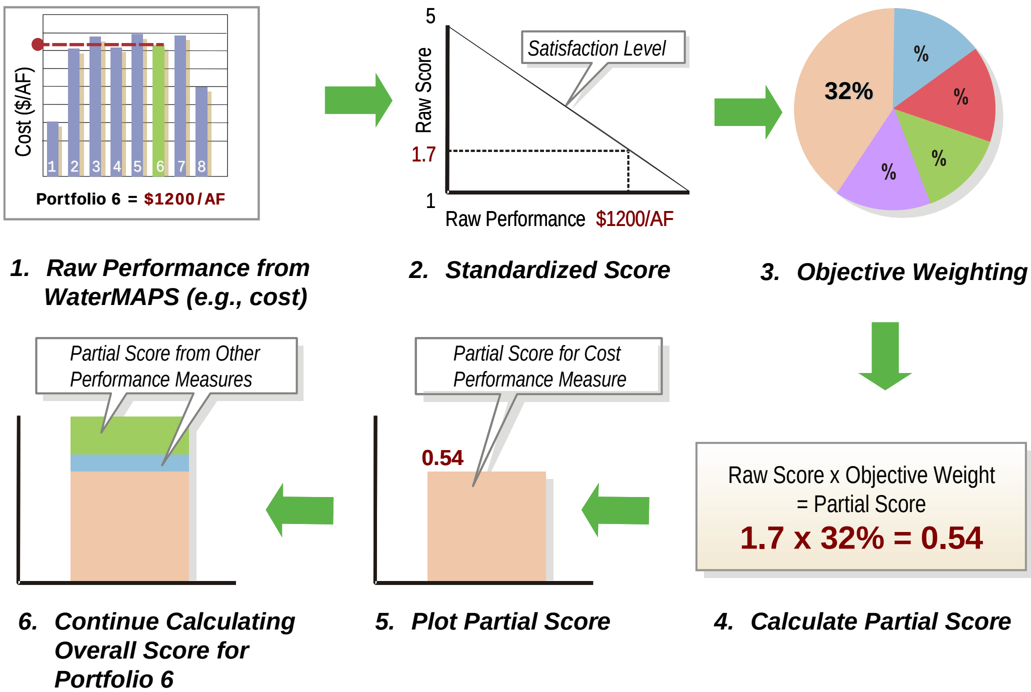


Figure B-3 Portfolio Scoring Process

Commercially-available software called *Criterium Decision Support* (CDP) was used to facilitate the analyses. While the calculations could be conducted manually or via spreadsheet, CDP allows easy manipulation of the data and results, and also provides the ability to conduct certain sensitivity analyses. This process was used to develop total scores for each portfolio, the process and results of which are further described in Appendix G.

The portfolio evaluation process was used to evaluate and screen out a wide range of possible water supply strategies. The scoring was used to narrow down this range to a short list of portfolios that best met the objectives and their relative importance, as expressed by the governing body and other participants. The selection of a preferred strategy was not a direct outcome of the scores resulting from the portfolio evaluation process described above. Rather, the strategy to be implemented was based on decisions by the City's governing body, using the results of the scoring to illustrate the tradeoffs between alternative water supply portfolios in meeting the objectives. Discussion of the direction received from the governing body and how the selected long-range water supply portfolio will be implemented is provided in the main section of this report.

Appendix C Development and Weighting of Objectives

This appendix describes the objectives, or evaluation criteria, used to evaluate water supply portfolios in the Water Plan. Section C.1 describes the objectives and specific performance measures developed to facilitate these evaluations. Section C.2 describes the process and results of objectives weighting, which was used to indicate the relative importance each objective carries in scoring the water supply portfolios and selecting a preferred portfolio or strategy for implementation.

C.1 Development of Objectives and Performance Measures

To provide a common basis for evaluation, a set of objectives was developed for the Water Plan. The objectives were designed to be:

- Distinctive: objectives should be developed to distinguish between one portfolio and another
- Measurable: objectives should be able to be measured either quantitatively or qualitatively in order to determine if they are being achieved
- Non-Redundant: objectives should not substantially overlap with each other
- Understandable: objectives should be easily explainable
- Concise: objectives should be kept to manageable numbers

A preliminary list of objectives was developed as part of the Coarse Screening analysis and adapted for use in the Water Plan's analyses of alternative portfolios.

The six objectives were further defined by identifying the components or sub-objectives associated with each major objective.

"Performance measures" were developed to quantitatively describe the degree to which each portfolio achieves the objectives and sub-objectives. Performance measures can be either quantitative or qualitative by nature and ultimately answer the question "How well is the portfolio meeting the objectives?"

In cases where performance against the objectives could not be quantified, a relative scale of qualitative performance was used to gauge the degree to which each portfolio met the objectives. At least one performance measure is required for each sub-objective.

The objectives used in alternative evaluations are listed here. In the following sections, each objective is described in further detail, including sub-objectives and performance measures, and rating scales for qualitative performance measures.

Objectives Used in Water Plan Evaluations

- Manage Costs
- Improve Reliability and Sustainability
- Ensure Technical Implementability
- Protect the Environment
- Ensure Acceptability
- Ensure Timeliness

Qualitative performance measures were scaled from 1 to 5. A higher score indicates that the option meets the objective better than a lower score. Many quantitative measures, like cost of the portfolio, reliability, sustainability, and protect the environment were evaluated in part using output from the WaterMAPS model. A description of the portfolios and the score for each portfolio against each of the performance measures is presented in Appendix G.

A brief description of each objective is provided below. In each case, the relative importance of each performance measure was determined by the City's planning team, as described below.

C.1.1 Manage Costs

Sub-objective`	Performance Measures
Manage costs and rate impacts	Cost of the portfolio ($/AF)
Maximize outside funding opportunities	Potential for Outside Funding (qualitative score)

Both capital and O&M costs were developed for each supply option. These costs included capital and O&M for new infrastructure as well as O&M costs for existing facilities. Costs were integrated into the WaterMAPS model, such that the overall cost of using both new and existing water supplies and infrastructure was determined for each portfolio evaluated. Costs were calculated as the overall $/AF of water supplied by each option and each portfolio. Additional information on costs is provided in Appendices E (Section E.3) and G (Section G.3).

A second performance measure was defined to assess the potential for outside funding of the alternative. The potential for outside funding performance measure was determined using the qualitative criteria indicated below.

Sub-objective	Rating	Characteristics for Rating
Maximize Outside Funding	5	Innovative; Regional; Broadly supported
	4	Non-structural or demand management-oriented
	3	Neutral
	2	
	1	Proven technology; Controversial project

The relative importance of each performance measure in meeting this objective, as determined by the City's planning team, is indicated below.

Performance Measure	Relative Importance in Achieving Main Objective	Rationale
Cost of the portfolio ($/AF)	80%	Significant uncertainty in availability of outside funding, particularly for long-range implementation; trend for outside funding is toward loans/loan guarantees in place of grants.
Potential for Outside Funding (qualitative score)	20%	

C.1.2 Improve Reliability and Sustainability

Sub-objective`	Performance Measures
Meet demands under different hydrology conditions	Available reserve capacity in driest year (AFY) Percent occurrence of deficits under different hydrology conditions
Sustainably manage the aquifer to ensure groundwater availability for dry periods	Average net drawdown change in a 40-year period for the Buckman Well Field (feet) Average net drawdown change in a 40-year period for the City Well Field (feet)

Supply reliability was based on the ability to meet projected demands under different hydrology conditions. The WaterMAPS model was used to calculate deficits by evaluating each portfolio under 2045 demand conditions for 60 different historical hydrology conditions. The reliability was in part measured as the probability (expressed as a percentage of those 60 hydrologies) that a given portfolio would not produce the amount of water required by the demand. A second measure of reliability, also calculated using WaterMAPS, was the total available reserve capacity (AFY) of supply in the driest hydrology in 2045. This second measure was used to assess the degree to which the City would be protected against temporary catastrophic loss of one or more major sources of supply.

The performance measures for sustainability were directed at sustainably managing the City's aquifers to ensure groundwater availability during dry periods. Sustainability was measured as (a) the average net drawdown change in a 40-year period for the

Buckman Well Field, and (b) the same parameter for the City Well Field.

The relative importance of each performance measure in meeting this objective, as determined by the City's planning team, is indicated below.

Performance Measure	Relative Importance in Achieving Main Objective	Rationale
Available reserve capacity in driest year (AFY)	33%	Reliability is key to long-range water supply planning, and to some degree is or will be contingent on sustainability. Reliability comprises 2/3 of the importance of reliably and sustainably meeting future needs. Sustainability of the City Well Field is slightly more important than that of the Buckman Well Field, as it is a local resource
Percent occurrence of deficits under different hydrology conditions	33%	
Average net drawdown change in a 40-year period for the Buckman Wellfield (feet)	12%	
Average net drawdown change in a 40-year period for the City Well Field (feet)	22%	

C.1.3 Ensure Technical Implementability

Sub-objective`	Performance Measures
Use technology appropriate for Santa Fe resources	All portfolios will use appropriate technology
Maintain or improve water quality	Water quality score relative to regulations based on average concentration of constituents of concern in 2045 (qualitative score)

There are two components of the technical implementability objective: use technology appropriate for Santa Fe resources and maintain or improve water quality. The use of appropriate technology was deemed by the City's planning team to be a non-discriminating factor, in that it is essentially a required "pass/fail" criterion. That is, no portfolio would be brought forth that would be technologically inappropriate. This performance measure was thus given no weight in the evaluation, other than to serve as an initial "gate" for any consideration under the Water Plan.

The assessment of water quality was based on the concentration of specific solutes estimated for each water supply source. These included the calculated average for arsenic, total dissolved solids, total organic carbon, manganese, and uranium, as selected by City staff and calculated in WaterMAPS for each individual supply source and aggregated concentrations. Concentrations for each portfolio were determined based on historic records and/or projected water quality of options currently not in place.

This measure was assessed qualitatively as indicated below.

Sub-objective	Rating	Characteristics for Rating
Maintain or Improve Water Quality	5	Average concentration of all key constituents is relatively low
	4	
	3	
	2	
	1	More than two key constituents have relatively high concentrations

C.1.4 Protect the Environment

Sub-objective`	Performance Measures
Protect local and regional environment	Protect local-regional environment (non-water) (qualitative score)

The evaluation of how well each portfolio would protect the environment incorporated many of the concerns expressed in public meetings held as part of developing the Water Plan. The first is maintaining existing flows in the Rio Grande, its tributaries, the Santa Fe River, and La Cienega. The second was to minimize impacts on the environment, considering terrestrial and other non-water resources in the local and regional area.

The performance measure for flow was to maintain flow in existing rivers, tributaries, and at La Cienega. Because of the range of surface waters that could be affected by a given portfolio, this was evaluated as a qualitative measure of the overall impact to flows. The performance measure for minimizing impacts was measured by the amount of land disturbance and the amount of new infrastructure that would be required, and the potential for subsidence associated with heavy use of groundwater resources. To maintain separation between the major objectives, groundwater drawdown effects were not included as a measure of environmental protection, because drawdown was used to measure the sustainability of supplies under the Improve Reliability and Sustainability objective.

Qualitative performance measures were evaluated based on the guidance shown below.

Sub-objective	Rating	Characteristics for Rating
Sustain Existing River, Tributaries, and La Cienega Flows	5	Significant positive impacts to stream flow
	4	Some positive impacts to stream flow
	3	No direct impact on stream flow
	2	Some negative impacts to stream flow
	1	Significant negative impacts to stream flow
Protect local and regional environment	5	Non-structural options, minimal disturbance
	4	Water in the Santa Fe River with minimal disturbance
	3	Some land disturbance or subsidence potential
	2	Significant land disturbance or subsidence potential
	1	Significant land disturbance and subsidence potential

The relative importance of each performance measure in meeting this objective, as determined by the City's planning team, is indicated below.

Performance Measure	Relative Importance in Achieving Main Objective	Rationale
Surface water flows score (qualitative score)	50%	Both components are equally important in protecting the environment
Protect local-regional environment (non-water qualitative score)	50%	

C.1.5 Ensure Acceptability

Sub-objective`	Performance Measures
Minimize impacts on water rights of other parties	Relative impacts on groundwater and surface water (qualitative score)
Increase Santa Fe River flows	Santa Fe River flow (qualitative score)
Reduce reliance on drought management stages	Percentage of years in which drought management is used
Ensure overall public and institutional acceptance	Public and institutional acceptance (qualitative score)
Treated water aesthetics	Percent of water from wells (more well use scores lower)

Acceptability of a given portfolio reflects a wide range of community values. Five sub-objectives were identified that addressed concerns expressed at public meetings. The sub-objectives were:

- Minimize impacts on water rights of other parties
- Increase Santa Fe River flows
- Reduce reliance on drought management stages
- Ensure overall public and institutional acceptance
- Treated water aesthetics

Water rights are a sensitive issue and the acceptability of an option may suffer even if the rights are offset to meet legal requirements. Maintaining or increasing flow in the Santa Fe River was a concern expressed numerous times in public meetings. Drought management stages (e.g., Stage 2 or 3) were invoked in response to drought conditions for several years preceding and including the 2004 to 2006 timeframe during which public meetings were held. The portfolios were scored based on the percentage of years that drought management stages were predicted to be imposed. The potential for public and institutional acceptance was assessed qualitatively for factors not measured elsewhere in this analysis. Finally, recognizing that tap water aesthetics are important to the public, the percent of water coming from groundwater sources was measured, reflecting the fact that the generally harder nature of Buckman groundwater has been expressed by the public as being less acceptable than Santa Fe's softer surface water supplies.

Because each of these five factors is an important component in measuring public and institutional acceptance, each was given equal weight toward meeting the acceptability objective.

Qualitative performance measures were evaluated based on the guidance shown below.

Sub-objective	Rating	Characteristics for Rating
Minimize impacts on water rights of other parties	5	No offsets on tributaries, La Cienega, etc. required
	4	
	3	Moderate amount of offsets on tributaries, La Cienega, etc. required
	2	
	1	Significant offsets on tributaries, La Cienega, etc. required
Increase Santa Fe River flows	5	Augment Santa Fe River flow with native water
	4	Augment Santa Fe River with effluent
	3	Conservation; neutral
	2	Some negative impacts to stream flow
	1	Significant negative impacts to stream flow
Ensure overall public and institutional acceptance	5	Faces no potential public acceptance obstacles
	4	Faces no identifiable public acceptance obstacles to implementation
	3	
	2	Can easily overcome public acceptance obstacles to implementation
	1	Requires major efforts to overcome obstacles to implementation

C.1.6 Ensure Timeliness

Sub-objective`	Performance Measures
Ensure portfolios can be implemented by the time they are needed	▪ Ability to implement by time needed (qualitative score)

For this Water Plan, timeliness was defined and measured by the ability to implement a given portfolio by the time it is needed. In many cases timely implementation may be driven by legal issues and regulatory/ environmental permitting. This single measure for ensuring timeliness was later determined to be a "pass/fail" criterion for consideration of any portfolio. That is, no portfolio was considered further if it could not be implemented by the time it would be needed. This was qualitatively evaluated using the guidance shown below.

Sub-objective	Rating	Characteristics for Rating
Ensure portfolios can be implemented by the time they are needed	5	Can be implemented by time needed (based on permitting, easement requirements, technology)
	4	
	3	May have issues delaying implementation
	2	
	1	Cannot be implemented by time needed

C.2 Objectives Weighting

In any decisionmaking process, the objectives are generally not all equally important. Some objectives may be more relevant for the decisionmaker than others. As an example, for a given individual, environmental protection may be more important than ensuring timeliness. Moreover, these relative weightings vary from person to person, reflecting each individual's values. Thus, weighting objectives is necessary to better reflect the range of values and preferences present in the decisionmaking process.

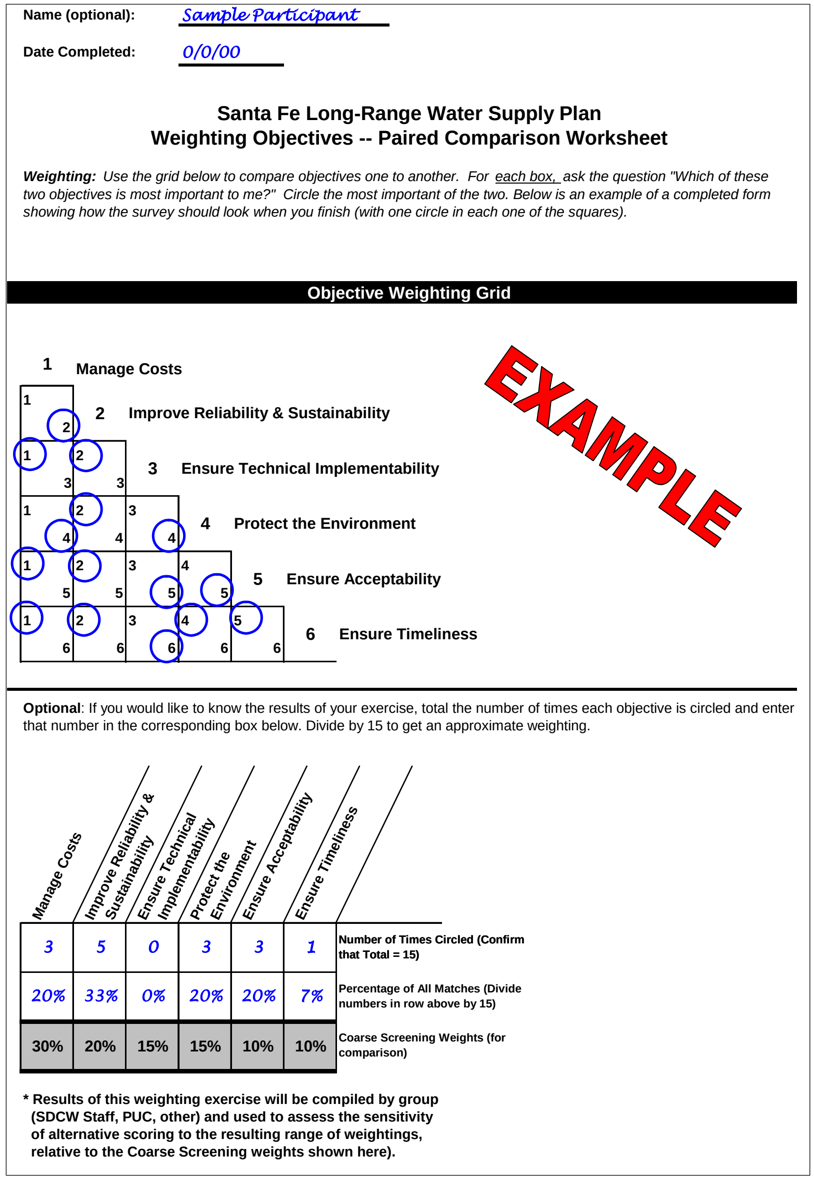
For this Water Plan, the objectives were weighted by using a method known as "paired comparison." The method is based on the fact that when presented with a series of elements, a decision as to the relative importance of those elements against each other is more simply made when the elements are compared separately in pairs. The results of the comparison of each pair of elements are later aggregated to determine the overall importance of every element.

All City Council members and the general public were invited to complete the paired comparison exercise in 2005. For each group, and particularly for the self-selected group of 15 members of the public who chose to participate, the process cannot be construed to be statistically significant. Rather, this exercise and the portfolio evaluation process was intended to show the range of values present in the community and to seek out one or more portfolios that robustly meet the range of values expressed by the governing body and the community.

In the paired comparison exercise, each possible pair of primary objectives was compared. Each participant then chose which objective was more important. The results were summed in order to get a relative percentage weight of importance for each objective. Each stakeholder's individual weightings for the objectives were preserved and used to rank alternatives (later described in Appendix G). A total is then derived and a percent weight is calculated for each objective and for each participating individual. Figure C-1 shows an example paired comparison form.

Higher percent weightings indicate a higher importance placed by a given participant on a given objective. In the example shown above, the hypothetical participant placed the most importance on improving reliability and sustainability, and moderate importance on managing costs, protecting the environment, and ensuring acceptability. Minimal importance was placed by the hypothetical participant on ensuring timeliness and technical implementability.

All City Councilors were asked to complete the Paired Comparison exercise in April 2005. Members of the general public were also invited to complete the exercise at Public Meeting Number 2 (July 2005) and via materials posted to the City's web site. Six Councilors returned completed exercises, as did 15 members of the public. The members of the public who participated represent "self-selected" individuals who chose to complete an exercise. As such, the public participants did not represent a statistical sampling of the values of the community. However, their input was used to score and rank supply portfolios, which in turn was provided as input to the governing body for consideration in its decisionmaking.



Name (optional): Sample Participant

Date Completed: 0/0/00

Santa Fe Long-Range Water Supply Plan
Weighting Objectives -- Paired Comparison Worksheet

Weighting: Use the grid below to compare objectives one to another. For each box, ask the question "Which of these two objectives is most important to me?" Circle the most important of the two. Below is an example of a completed form showing how the survey should look when you finish (with one circle in each one of the squares).

Objective Weighting Grid

Optional: If you would like to know the results of your exercise, total the number of times each objective is circled and enter that number in the corresponding box below. Divide by 15 to get an approximate weighting.

Manage Costs	Improve Reliability & Sustainability	Ensure Technical Implementability	Protect the Environment	Ensure Acceptability	Ensure Timeliness	
3	5	0	3	3	1	Number of Times Circled (Confirm that Total = 15)
20%	33%	0%	20%	20%	7%	Percentage of All Matches (Divide numbers in row above by 15)
30%	20%	15%	15%	10%	10%	Coarse Screening Weights (for comparison)

* Results of this weighting exercise will be compiled by group (SDCW Staff, PUC, other) and used to assess the sensitivity of alternative scoring to the resulting range of weightings, relative to the Coarse Screening weights shown here).

Figure C-1 Example Paired Comparison Exercise

The objectives weighting results from the Paired Comparison exercise are presented in Figure C-2. These results indicate that improving reliability and sustainability, and protecting the environment, are the qualities most important to the community in choosing a long-range water supply strategy. In contrast, the values used in the City's initial Coarse Screening analysis (conducted prior to initiation of the Water Plan) assumed that cost was the most important criterion in comparing supply options.

The average values for each objective's weight shown in Figure C-2 were used in the scoring and ranking of water supply portfolios. Separate scoring and ranking computations were completed for the governing body and the public participants, as further described in Appendix G. The scoring method employed requires the weights of all objectives to sum to 100 percent. Therefore, averages were used instead of median weighting values. This had a negligible effect on the scoring process, as in nearly every case, the median value for a given group (governing body or public) and a given objective differed from the average value by less than three percentage points.

It can be expected that individuals' and groups' values will change over time. In light of that, and toward achieving broadly-acceptable strategies for future water supply, the City's planning team sought to identify the water supply portfolio or portfolios that best meet the entire range of objectives and weightings. In doing so, the most "robust" portfolio can be identified which will best position the City to meet its long-range water needs.

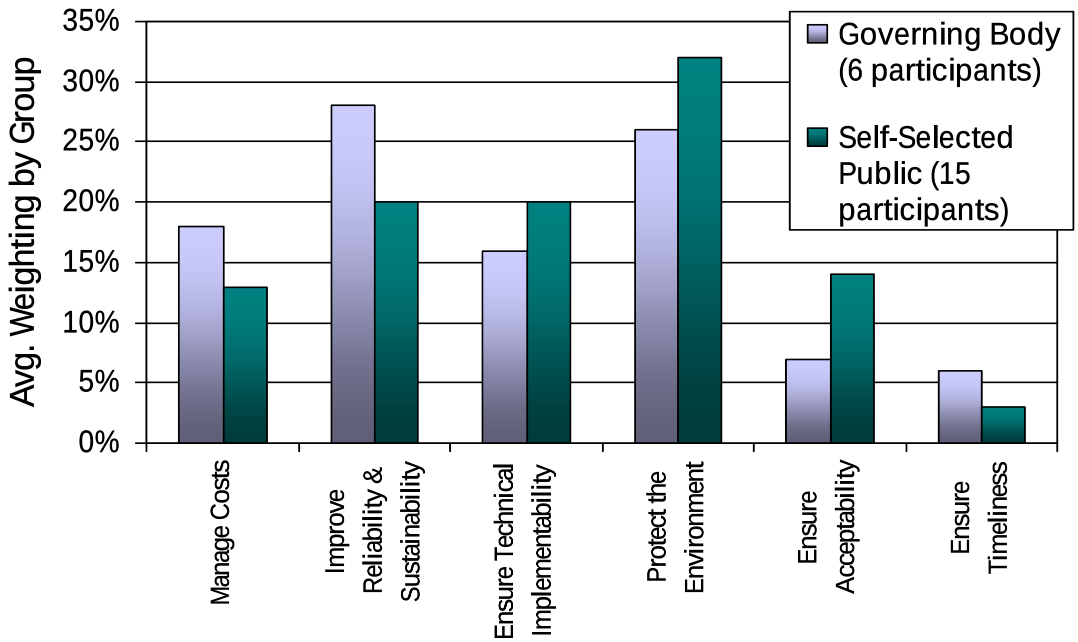


Figure C-2 Results of Objective Weighting from Paired Comparison Exercise

One of the key foundations of developing the Water Plan was identifying the projected demand for water associated with the City's customer base and its other obligations for water service. The projected demands were compared to available supplies under varying hydrology conditions using the WaterMAPS model. This information was then used to develop estimates of the anticipated "gap" between future water demands and the City's current sources of supply (as constrained by water rights, "wet water" availability, infrastructure, and operations). Water supply portfolios geared toward reducing or eliminating the projected gaps in supply were later developed by packaging together combinations of one or more supply options with existing supply capabilities.

Significant input was received in public meetings regarding growth in Santa Fe and the assumptions about future populations and water demands. The primary concerns of the participating public was supporting a living Santa Fe River, adequate water supply to meet growth, and exceeding the natural resource carrying capacity of the region. This Water Plan addresses anticipated water supply needs based on current growth management policies and available population projections. However, it should be noted that any variation between the demand projections developed in the Water Plan and what actually occurs in the future will likely only affect the timing of the actions taken to meet increasing demands. That is, should growth in demands occur at a slower pace than anticipated in the Water Plan (whether due to changes in population growth, per capita demands, or growth management policies adopted by the governing body), new supplies or other actions will simply need to occur later as demands warrant. The reverse is also true.

D.1 Overview of Method

Demand projections were developed by:

- Projecting population within the City's service area
- Multiplying the projected population by a per capita water use rate to calculate the total demand within the City's service area
- Including demands that are currently met with treated wastewater effluent or that could be met in the future with treated wastewater effluent
- Adding demands associated with the City's agreements with and obligations to other entities

Each of these components is described in the sections that follow.

D.2 Population Projections

D.2.1 Base Population (2000)

Estimates of the City's service area population were based on information provided by City Water Division staff (Michael Rodriguez, February 2005). According to this information, for the year 2000 the population served by the City water system was as follows.

- City population = 62,203. Directly from the 2000 census.
- 10,905 persons served outside the City limits (3,635 households at 3 persons each). The household count was based on a May 2003 list of specific developments outside the City that are connected to or are approved for the City water system. For each development there was a count or estimate of existing units; the total of 3,792 was then extrapolated back to 2002. (Note there are 1,079 units yet to be served as of that count.) For the spreadsheet, a density of 3 persons per household was assumed; this

reflects census results for the southwest quadrant.

- 717 City residents not served per personal communication between Lee Wilson (Lee Wilson & Associates) and City staff in March 2005. This estimate is based on 652 permitted domestic wells in the City in 2000 (672 on WATERS database counted in 2002, extrapolated back by assuming 10 added per year). It is assumed that 50 percent of these rely exclusively on their wells and are not on the system at all; and that 2.2 persons per household populate the remaining 326 households.

The 2000 City population, plus those served outside the City, less the number of City residents not served, equates to a 2000 service area population of 72,391.

D.2.2 Population Growth

A paper prepared in 2003 by Amy Lewis, a consulting hydrologist, cites specific growth rates as having been estimated by the Bureau of Business and Economic Research for the Santa Fe Basin; the application of these rates is evident in Appendix E of the Jemez y Sangre regional plan, but the rates themselves could not be confirmed in that appendix. By e-mail on March 9, 2005, Ms. Lewis provided a spreadsheet that shows the actual rates. Those rates were confirmed with Ms. Lewis as being the ones that she relied on in her 2003 paper. The rates of growth are indicated in Table D-1, along with an estimate by year through 2045 for the City's service area population. These projected population values were used in developing estimates of future water demand.

As noted in the introduction to this appendix, the nature of a service-area population is such that it is approximate (and almost certain to be inaccurate in at least some respects). This does not present a major planning problem, because as long as the overall direction and magnitudes are in the right range, and growth of a particular amount can be expected, it is simply a matter of timing. With more or less growth the timing becomes shorter or longer, respectively. Actual investments will typically be initiated 5 to 10 years from a time of need, and thus can be based on actual growth rates and updated projections as appropriate.

Table D-1 Population Estimates for City's Service Area

Year	Growth Rate*	Population	Year	Growth Rate*	Population
2000	—	72,391	2023	1.0122	101,438
2001	1.0172	73,636	2024	1.0122	102,675
2002	1.0172	74,903	2025	1.0122	103,928
2003	1.0172	76,191	2026	1.0095	104,915
2004	1.0172	77,501	2027	1.0095	105,912
2005	1.017	78,819	2028	1.0095	106,918
2006	1.017	80,159	2029	1.0095	107,934
2007	1.017	81,522	2030	1.0095	108,959
2008	1.017	82,907	2031	1.0084	109,875
2009	1.017	84,317	2032	1.0084	110,798
2010	1.017	85,750	2033	1.0084	111,728
2011	1.0137	86,925	2034	1.0084	112,667
2012	1.0137	88,116	2035	1.0084	113,613
2013	1.0137	89,323	2036	1.0076	114,477
2014	1.0137	90,547	2037	1.0076	115,347
2015	1.0137	91,787	2038	1.0076	116,223
2016	1.0128	92,962	2039	1.0076	117,107
2017	1.0128	94,152	2040	1.0076	117,997
2018	1.0128	95,357	2041	1.0068	118,799
2019	1.0128	96,578	2042	1.0068	119,607
2020	1.0128	97,814	2043	1.0068	120,420
2021	1.0122	99,007	2044	1.0068	121,239
2022	1.0122	100,215	2045	1.0068	122,063

* Represented as a multiplier value, e.g., 1.0172 is equal to 1.72 percent annual growth

D.3 Per Capita Water Use Rates for Potable Demands

The per capita rate of water use has a significant effect on the overall water demands for any major water supply system such as the City's. Per capita water rates, as calculated by the City's Water Division, encompass the total water demand within the City's service area, divided by the estimated service area population. As such, this figure "rolls in" the water used not only by residential users, but also by commercial and industrial users in the overall per capita rate. For example, tourism in Santa Fe increases the calculated per capita rate, since water used by visitors also gets incorporated into the per capita estimates.

Santa Fe has one of the lowest per capita rates of water among major water providers in the southwest United States. Until about 1997, Santa Fe per capita rates averaged about 170 gpcd – a value well below what many communities still use today. Through a series of conservation programs, the City's customer base cut its use dramatically.

In 2000, the City implemented mandatory demand management measures (e.g., outdoor watering restrictions, high use rate surcharges) in times of drought. The severity of restrictions increases with the intensity of drought conditions, increasing in severity from the City's voluntary Stage 1 restrictions up to the most severe restrictions, Stage 4, which prohibits all outdoor watering. Stage 4 restrictions have not been implemented to date.

It should be noted that since 2005, the City has revised the numeric naming convention for the drought management categories (Stage 1 through 4) to a color convention which is described in Appendix J.

Figure D-1 shows the approximate timing of the implementation of the various stages of drought management, and the community's associated per capita demands each year. While direct correlations cannot be drawn, it is clear that conservation measures plus the implementation of Stages 1 through 3 have driven reductions since 1997 in per capita demands. Weather conditions also affect water use in Santa Fe, and it should be noted that 2005 was a particularly wet year after years of dry conditions that included record dry conditions in 2002.

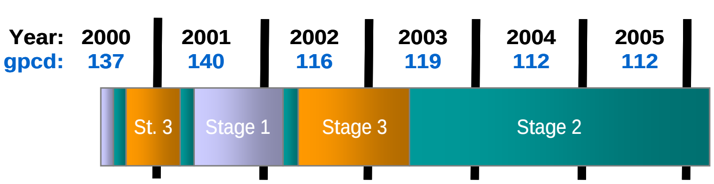


Figure D-1 Recent Years' Drought Management Stages and Per Capita Demands

Using historical data as a guide, per capita water demands were assumed for use in the Water Plan. Demands dropped from the pre-1997 range of 170 gpcd down to about 140 gpcd between 1997 and 2001. Per capita demands between 2002 and 2005 were significantly lower (Figure D-1), ranging between about 110 and 120 gpcd.

To project an unconstrained demand for long-range planning purposes, the City planning team:

- Chose a cautious approach to future demand, recognizing the uncertainty associated with both the gpcd numbers and customer use behavior.
- Recognized that per capita demands might have been higher than observed during the analysis period of 2002 to 2005, had drought management measures not been in place.
- Considered the effects of the City's aggressive conservation and retrofit programs, and in particular the Water Budget Ordinance, which requires new development offset future demand by retrofitting high-flow toilets.
- Considered which effects of the City's aggressive conservation and retrofit programs were elastic versus which will result in 'hard-plumbed' demand reductions likely to continue into the future.
- Incorporated the high-level of community awareness and significant progress in conservation.
- Recognized that some of the utility's demand, as analyzed in the Utility Demand Analysis, fall under prior written agreements and may not be subject to water offsetting policies.

For the 2005 analyses, the planning team selected 130 gpcd as the assumed normal (i.e., unconstrained by mandatory drought management measures) rate of water use for long-range planning purposes. This value was consistent with the Water Conservation and

Drought Management Plan for the City of Santa Fe. The Water Plan also contemplated two demand management options as components of future water supply portfolios (Appendix G):

- Implementing additional, more aggressive conservation measures to reduce per capita demands to 120 gpcd on a permanent basis
- Implementing temporary mandatory drought management measures during times of drought to temporarily reduce demands to an annualized equivalent of 110 gpcd

Given the actual 2004 and 2005 per capita demands, the use of 110 gpcd for a minimum drought-period demand (under temporary mandatory drought management measures) was deemed appropriate and conservative for planning.

Figure D-2 provides an overview of historical per capita demands and those used in the 2005 analyses for the Water Plan. Per capita rates used in the 2005 analyses (130 gpcd) reflect the significant progress Santa Feans have made in conserving water. Since 2005, even though the City has repealed mandatory water use restrictions, the City's gpcd continues to drop (Appendix I) and it is now estimated to be at 110 gpcd for potable demand used in 2008.

The analysis for the Water Plan, however, are premised on the 2005 projected demand and gap which assumed a per capita potable use of 130 gpcd.

It is important to note that the plan will still assume that the 2008 demand of 110 gpcd could still be lowered through additional conservation efforts (100 gpcd in Figure D-2) and even temporarily lowered under mandatory drought restrictions in the future, although the temporary drought reductions become increasingly difficult as the permanent per capita use is decreasing due to demand hardening.

It is also important to realize that variations in actual per capita demand rates, much like variations from population projections, will simply affect the timing of the required water supply portfolio additions over time (Refer to Section 3). The recommended supply options resulting from this planning process will not change.

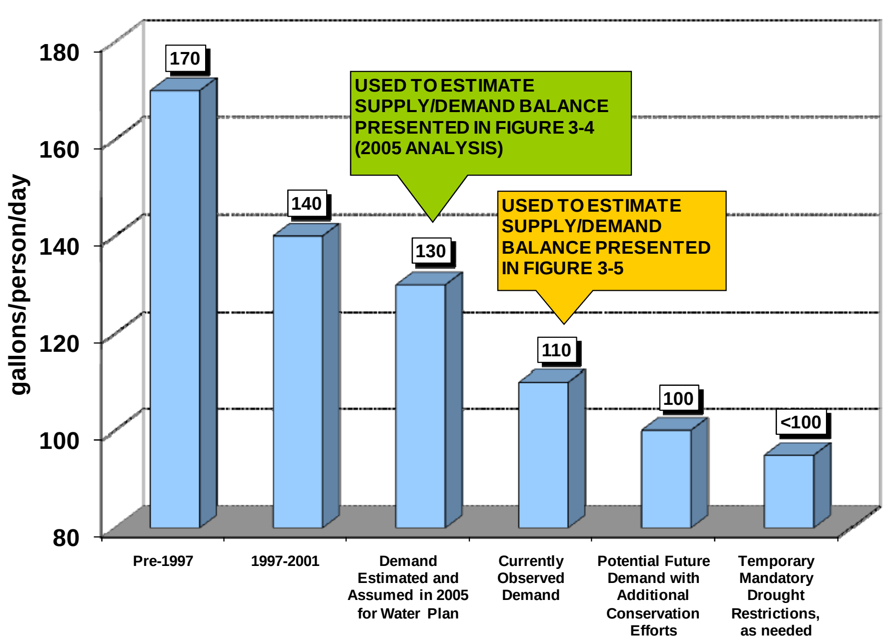


Figure D-2 Historical and Projected Per Capita Potable Water Demands

The Jemez y Sangre Regional Water Plan (2003) assumed a per capita use rate of 163 gpcd. Simply by maintaining Santa Fe's existing conservation programs and keeping demands at 130 gpcd, the community will use 20 percent less water than assumed in the recent Jemez y Sangre plan. That translates to a savings of about 4 mgd by 2045, or 4,500 AFY.

Santa Fe's per capita use, including the 130 gpcd value used as a baseline for planning, is outstanding compared to other community's rates of use.

Figure D-3 compares Santa Fe's rate of use to other New Mexico communities in 2000, based on a study of use by the New Mexico OSE. While OSE's values differ slightly from those prepared by the City, it is clear that even before Santa Fe implemented many conservation programs to further increase water use effectiveness, Santa Fe's use achievements were exemplary.

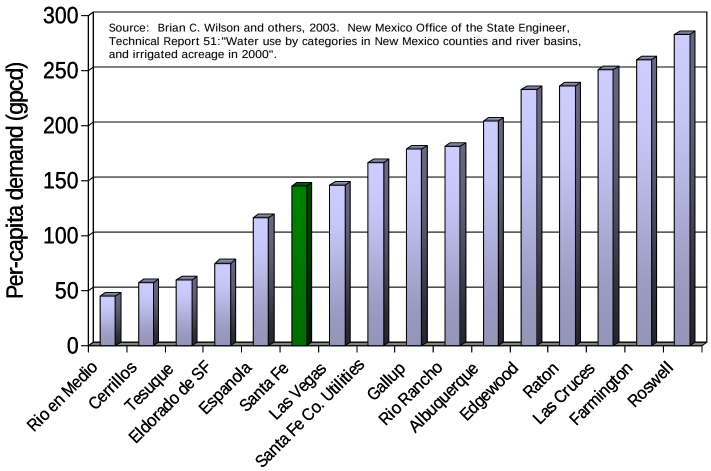


Figure D-3 Selected New Mexico Per-Capita Demands in 2000

D.4 Nonpotable Demands

The City has a long history of using treated wastewater effluent to satisfy certain nonpotable demands, such as irrigation at facilities relatively close to the City's WWTP. For most applications, such uses avoid what would otherwise be an additional demand on the City's potable water supply sources, including the regional aquifer. Recognizing that some water needs can be met via reuse of treated effluent, and that those demands are likely to grow over time in concert with population growth, nonpotable demands were also incorporated into the Water Plan's demand analyses.

Data from the City's WWTP influent and effluent were reviewed and compared to data on water demand. Issues were identified with the quality of data prior to 2003, including atypical severe drought conditions in 2002, variations in return flow percentage from month to month, and apparent issues with flow metering at the WWTP. The data for 2003 and 2004 appear more reliable and were used to estimate nonpotable demands. Table D-2 summarizes the relevant 2003-2004 data.

Table D-2 WWTP Return Flows

Year	Water Use (mgd)	WWTP Influent (mgd)	WWTP Effluent (mgd)	Effluent as % of Water Use	WWTP Effluent (AFY)
2003	9.92	5.76	5.60	56.5%	6,290
2004	9.24	5.37	5.31	57.5%	5,970

Based on this analysis, future effluent supply was estimated to be equivalent to 57 percent of water demand. Clearly, the actual percentage could change depending on indoor/outdoor use aspects of demand as they may reflect differences in new customers and old, and/or assumptions about conservation and/or mandatory restrictions. Detailed assessments of those issues were conducted as part of the Water Plan.

Monthly effluent supply was also estimated as a percent of annual totals. The data from 2003-2004 show a pattern similar to earlier studies (Table D-3). Slightly higher summer values may be caused by increased tourism, and thus indoor water use, in those months.

Table D-3 Monthly Effluent as a Percent of Total Annual Effluent Flows

Month	2003-2004	2002 Wastewater Reuse Advisory Task Force	1993-1997 (from TEMP Report, Appendix B)
January	8.25%	7.90%	7.68%
February	7.59%	7.01%	7.84%
March	8.28%	9.01%	7.05%
April	8.15%	9.11%	8.67%
May	8.50%	9.37%	8.50%
June	8.50%	9.04%	9.72%
July	9.18%	9.51%	9.54%
August	9.37%	9.62%	9.19%
September	8.17%	7.14%	8.67%
October	8.36%	7.26%	8.33%
November	7.70%	7.04%	7.84%
December	7.95%	8.00%	6.90%

In 2004, the total use of effluent under agreements between the City and various users was approximately 1,059 AFY. Dividing that amount by the estimated 2004 City service area population results in a per capita effluent demand of about 12 gpcd. It is expected that some contract effluent use will continue indefinitely in Santa Fe, even though many effluent contract currently have near-term termination dates. As further explained in Appendix G, two different scenarios were assumed under the various portfolios evaluated in detail:

- Contract effluent use continues at a constant annual volume, i.e., 1,059 AFY every year, indefinitely through the planning period (without analyzing whether that demand would come from existing contract users and/or others)
- Contract effluent use continues at a constant per capita rate, i.e., 12 gpcd, indefinitely through the planning period.

The latter approach inherently assumes that as population increases in Santa Fe, the amount of large irrigated area suitable for being supplied by effluent will increase proportionally. That is, additional contracts for effluent would likely be required over time as new opportunities to use treated effluent arise. By 2045, this would equate to an increase in effluent use of 580 AFY effluent use, plus the current 1,059 AFY rate of use, for a total of about 1,640 AFY in 2045.

Appendix G describes the amount of contract effluent use assumed in each portfolio.

D.5 Projected Demands and Gaps in Supply

The City's projected demands were estimated as the sum of:

- City service area potable demands
- City service area nonpotable demands
- Obligations for water deliveries to wholesale customers like the Santa Fe County Water Utility and Las Campanas
- Additional commitment to Santa Fe County Utilities during drought conditions

Potable demands for the City's service area were calculated as the per capita use rate of 130 gpcd, multiplied by projected population in each year from Table D-1. Water demand estimated in the City's 2003 Utility Demand Analysis is included in the City's service area potable demands. Nonpotable demands in the City were calculated similarly, using the nonpotable per capita rate of 12 gpcd.

The City's outside obligations for water service include a requirement to provide up to 875 AF of water to Santa Fe County and water from the Buckman Well Field to Las Campanas until the BDD comes online (anticipated 2011). After the BDD is online, the City is obligated by the Water Resources Agreement between the City of Santa Fe and Santa Fe County (2005) to provide 500 AFY to Santa Fe County on an ongoing basis, plus up to an additional 850 AFY "under drought/ catastrophic conditions (extreme drought, acts of sabotage, water quality restrictions, OSE/ISC restrictions)." The 2003 Settlement Agreement between the City and Las Campanas specifies that after the BDD is online, Las Campanas will no longer be provided potable water by the City.

Including all annual and potential delivery obligations in any given year, unconstrained potable and nonpotable demands (i.e., no additional conservation measures and no use of drought management stages) are expected to be as high as 20,900 AFY in 2045. That compares to around 11,000 AFY total demand in 2005 (including effluent use). The Water Plan's projected demand is 850 AFY more than will be realized most years (unless Santa Fe County calls for the delivery of the emergency back-up water supply). Prudent planning requires that the City be prepared to make those deliveries at any time by including the potential deliveries in every year's demand.

The total demand in any given year, less the available supply, provides an estimate of the deficit or gap (if any) between demand and supply. For purposes of prudent water planning, the available supply is typically estimated under drought conditions. In the Water Plan, the existing infrastructure, water rights, and operational protocol were modeled in WaterMAPS to estimate the current drought-year water supply capacity. The result indicated that with the addition of the BDD project in 2011, the City's existing water supply system could be expected to reliably produce about 15,400 AFY under drought conditions and reliably and sustainably produce 19,900 under non-drought conditions, as indicated in Figure D-4.

Figure D-5 shows a comparison of the 15,400 AFY drought year supply against the projected demands indicates that supply deficits could reappear by as early as about 2015 under drought conditions, and grow to as much as 5,500 AFY in 2045. This 5,500 AFY gap was used as the target value for developing future water supply portfolios.

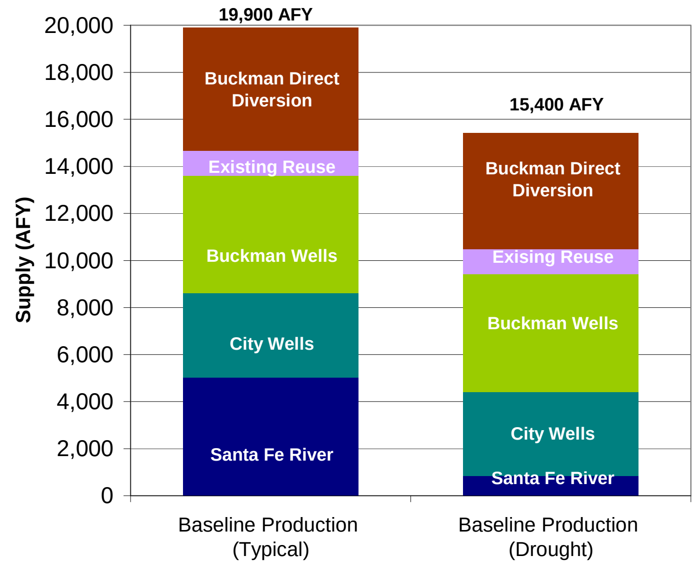


Figure D-4 Effect of Drought on Existing Supply Reliability

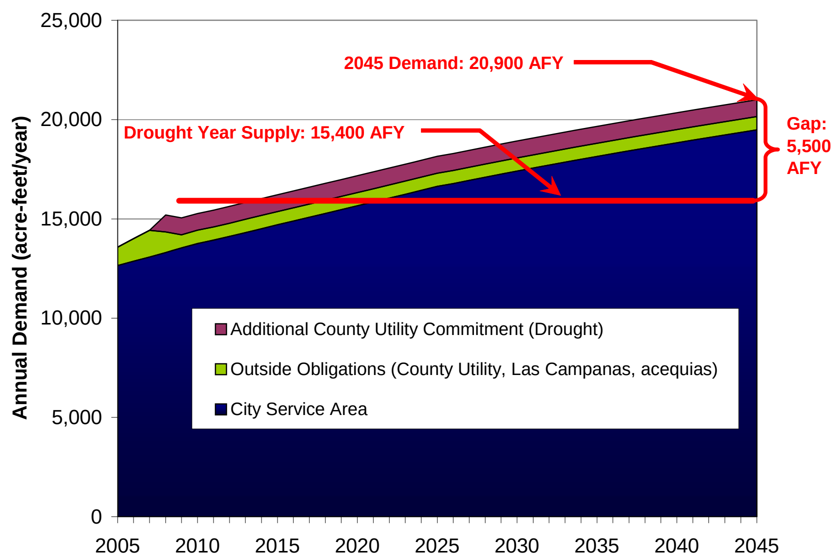


Figure D-5 Summary of Projected Demands and Gap

E.1 Initial Identification and Screening of Options

Individual water supply options (e.g., new infrastructure, water rights, or demand management measures) represent the "building blocks" of future water supply portfolios. The Water Plan sought to identify the most promising supply options that could subsequently be brought forth, along with existing supplies, for packaging into alternative water supply portfolios. The City's Coarse Screening analysis provided an initial foundation for identifying and screening water supply options. The 2004 Draft Coarse Screening Report identified and ranked 18 supply options, but did not make specific recommendations regarding which of those options, if any, should be screened out or carried forth for further evaluation.

All 18 Coarse Screening options and the analysis thereof were carried forth into the initial set of options considered under the Water Plan. Fifteen additional supply options identified in the Water Plan via workshops with City Water Division staff were added to this list.

Table E-1 lists all 33 preliminary options considered, along with the rationale for screening out or retaining each. In many cases, options that were similar to one another in the Coarse Screening analysis were compared to one another. The highest-scoring option among each set of similar options (e.g., BDD options SW6A, SW6B, SW6C, SW6D) was generally carried forward while the others were screened out and not considered further.

E.2 Description of Short-Listed Options

The 18 short-listed supply options were renumbered (1 through 18) and categorized as follows:

- Demand management
- Expand or modify use of existing surface water resources
- Expand or modify use of existing groundwater resources
- New sources

A description of each short-listed option, by category, is provided below.

E.2.1 Demand Management

Option 1

Reduce Per Capita Demand to 120 gpcd with More Aggressive Conservation Measures

Source of Water & Rights:

- Demand management

Infrastructure & Capital:

- No new facilities required
- City capital costs incurred via washing machine rebate program and turf replacement rebate

Key Assumptions:

- Current conservation measures continued/ strengthened to maintain 132 gpcd (including 120 gpcd base demand plus 12 gpcd irrigation demand)
- Payment of rebates/incentives by City to customers is required to achieve permanent 10 gpcd reduction
- 15 percent of 10 gpcd reduction will come from high efficiency washer rebates ($200 rebate per washer): savings of 5,000 gallon/washer retrofit/year

Table E-1 Screening of Initial Supply Options

Approach	Coarse Screening or New Option ID	Retain?	Short-Listed Option No.	Preliminary Name for Option	Rationale for Retaining/Screening Option
Storage (various sources)	ASR	Yes	7	Recharge Groundwater Using Rio Grande Water from BDD with No New BDD Infrastructure	Consider integrating into portfolios to address storage/peaking needs.
New Sources	GW1	Yes	17	Deep Wells in Caja del Rio Area	Reduced implications on NTP tributary offsets vs. Buckman Well use.
New Sources	GW2	No	N/A	Deep Wells Near Nichols Reservoir	Poor CS score (cost, tech impl, institutional); production likely inadequate.
New Sources	GW3	No	N/A	Estancia Basin High TDS Groundwater	Indefinitely postponed by Council 1/26/05; evaluate imported water needing treatment.
Maximize Local	GW4	Yes	11	Purchase and Rehabilitate Existing Private Wells	Use in regional drought protection alternative.
New Sources	GW5	No	N/A	Estancia Basin Medium TDS Groundwater	Indefinitely postponed by Council 1/26/05; evaluate imported water needing treatment.
Maximize Local	NEW1	Yes	6	Conjunctive Use of Local Surface and Groundwater Rights	Only as part of regional drought protection alternative. Not considered in CS.
Expanded Buckman	NEW10	No	N/A	RG Rights & New Buckman Wells	5,500 AFY Gap can be addressed with intensive Buckman Well pumping, without exceeding existing rights (incl. JAN, excl. tribs) or needing additional new wells.
Maximize Local	NEW11	Yes	2	Reduce Per Capita Demand to 110 gpcd via Temporary Emergency Drought Management	Could choose plan around "never" using this option, or could integrate it into portfolios to mitigate drought conditions and avoid building infrastructure for infrequent droughts.
Maximize Local	NEW12	Yes	8	Increase Use of Existing St. Michael's Well	Baseline gap assumes current use at max of approx 240 AFY; infrastructure and rights allows higher use in some years.
Expanded Buckman	NEW13	Yes	9	Intensive Pumping of Existing Buckman Wells	Could help address supply gaps.
New Sources	NEW14	Yes	18	New Imported Water from Unspecified Distant Source(s)	Generic source from 50 miles away, 200-foot elevation gain, with conventional treatment assumed necessary.
New Sources	NEW2	Yes	16	Collector Wells at San Ildefonso	Compare to SW6A/B then assess whether to put into an alternative. Advantage of different water rights pool above Otowi Gage. Not considered in CS.
Maximize Local	NEW3	Yes	1	Reduce per capita Demand to 120 gpcd with More Aggressive Conservation Measures	This is already working and potential for more reduction evident through drought levels. Not considered in CS.
Maximize Local	NEW4	Yes	10	Rehabilitate City Wells to Increase Production	Could be key component in dry year. Not considered in CS.
Expanded Buckman	NEW5	No	N/A	RG Rights & Expanded Use of Existing Buckman Wells	5,500 AFY Gap can be addressed with intensive Buckman Well pumping, without exceeding existing rights (incl. JAN, excl. tribs).
Expanded Buckman	NEW6	No	N/A	RFC + RG Rts & Expanded Use of Existing Buckman Wells	5,500 AFY Gap can be addressed with intensive Buckman Well pumping, without exceeding existing rights (incl. JAN, excl. tribs) or needing additional new wells.
Maximize Local	NEW7	Yes	5	Augment Santa Fe River Flow Recharge with Canyon Reservoir Releases	Required per Council direction.
Maximize Local	NEW8	Yes	3	Increase Storage Capacity in Santa Fe River Canyon	Required per Council direction.
New Sources	NEW9	No	N/A	Estancia Basin Engineered Option	Indefinitely postponed by Council 1/26/05; evaluate imported water needing treatment.
Maximize Local	RR1	Yes	12	Additional Landscape Irrigation with Effluent	Evaluate opportunity costs & tradeoffs vs. other uses (e.g., RFC).

Table E-1 Screening of Initial Supply Options

Approach	Coarse Screening or New Option ID	Retain?	Short-Listed Option No.	Preliminary Name for Option	Rationale for Retaining/Screening Option
Maximize Local	RR2	No	N/A	Direct Potable Reuse	Lowest CS score; public and regulatory acceptability issues.
Maximize Local	RR3	No	N/A	Augment Santa Fe River Resvs with Reuse	Low CS score (cost, reliability, tech impl, institutional, expediency); nonpotable uses for effluent are available and preferred.
Maximize Local	RR4	Yes	13	Recharge City Wells with Effluent via Injection Wells	Can increase sustainability, increased storage in system, not counted against water rights when pumped.
Maximize Local	RR5	Yes	14	Augment Santa Fe River Flow through Town with Effluent	Significant community interest.
New Sources	SW1	No	N/A	RFC & Collector Wells at San Ildefonso	SW6C scored higher for RFC in CS (all objectives); cannot move RFC above Otowi Gage
New Sources	SW2	No	N/A	RFC & Shallow wells at Caja del Rio	SW6C scored higher for RFC in CS (all objectives).
New Sources	SW3	No	N/A	RFC & Direct Diversion at Cochiti Resv.	SW6C scored higher for RFC in CS (all objectives except reliability).
New Sources	SW4	No	N/A	RFC & Shallow wells at Pena Blanca	SW6C scored higher for RFC in CS (all objectives).
New Sources	SW5	No	N/A	RFC & Direct Diversion at Abiquiu Resv.	SW6C scored higher for RFC in CS (all objectives); cannot move RFC above Otowi Gage.
Expanded Buckman	SW6A&B	Yes	4	Increased Use of BDD with No New Infrastructure	Maximizes the use of existing infrastructure.
Expanded Buckman	SW6C	Yes	15	Return Flow Credit and Increased Use of BDD with No New BDD Infrastructure	Maximizes the use of existing infrastructure.
Expanded Buckman	SW6D	No	N/A	RFC + RG Rts & Expanded BDD Use	No need to pursue both RFC and RG rights; 5,500 AFY gap could be met using either/or, as covered in SW6A/B & SW6C.

ASR	Aquifer Storage & Recovery
CS	Coarse Screening (Draft Report 6/04)
GW	Groundwater
RFC	Return Flow Credit
RG	Rio Grande
SW	Surface Water

- About 13,300 conversions needed by 2045
- 85 percent of 10 gpcd reduction will come from landscaping (turf replacement) rebate ($0.60 rebate per square foot [/sf] of high water use landscaping permanently replaced): net savings of 15 gallons per year/sf of high water use landscaping replaced
- Replacement of about 580 acres needed by 2045 (average about 500 sf/household in 2045)
- Ongoing administrative costs for advertisement/program management is required
- Generally consistent with conservation options presented in Jemez y Sangre white paper (e.g., rebate programs and reduction of outdoor water use), excluding options already implemented in Santa Fe (e.g., toilet retrofits)

Estimated Yield:

- Increasing over time to a total of 1,367 AFY in 2045
- Need to identify "phasing in" curve (i.e., how many gpcd in each year, eventually reaching 10 gpcd reduction by 2045, and associated capital cost curve)
- Based on projected population in 2045 at 10 gpcd reduction in use

Option 2

Reduce Per Capita Demand to 110 gpcd via Temporary Emergency Drought Restrictions

Source of Water & Rights:

- Demand management

Infrastructure & Capital:

- No new facilities required

Key Assumptions:

- Reduction in water use of 10 gpcd (if Option 1 Conservation in effect) or 20 gpcd (if Option 1 Conservation is not in effect)
- Administration costs only; these costs would be reduced by 50 percent if Option 1 Conservation is in effect, since Conservation administration (staff, enforcement) would already be in place
- Anticipated use as a temporary "emergency" tool during droughts, to avoid building infrastructure to fully meet demands in infrequent drought conditions
- 122 gpcd can be achieved on temporary basis, gaging from 2004 data (i.e., actual 2004 use of 112 gpcd plus effluent use)

Estimated Yield:

- Increasing over time to 1,367 AFY or 2,734 AFY in 2045
- Based on projected population in 2045 at 10 gpcd or 20 gpcd reduction in use (depending on whether Option 1 is in place)

E.2.2 Expand or Modify Use of Existing Surface Water Resources

Option 3

Increase Storage Capacity in Santa Fe River Canyon

Source of Water & Rights:

- Santa Fe River runoff (existing rights)

Infrastructure & Capital:

- New reservoir with 1,000 AF capacity assumed for costing
- Other options may be available; new/expanded reservoir used as basis of initial costing; also check feasibility of using the 20 percent "dead pool" instead of increasing physical storage capacity

Key Assumptions:

- The CRWTP is not expanded, but off-peak capacity is used more frequently
- No additional Santa Fe River water rights

Estimated Yield:

- Minimal yield benefit per WaterMAPS modeling; water rights constraints yield under most conditions for this option
- Can evaluate further in portfolios by turning additional storage capacity "on" and "off"

F.1 Systems Simulation Model Overview

F.1.1 Purpose of Systems Model

The City's complex water system consists of diverse existing sources of supply, interdependence of these sources, and future alternative sources of water supply. To optimize the use of its existing sources of supply and to facilitate decisions on long-range supply options, a system model was developed. This tool is appropriate for strategic level decisionmaking, with the ability to look at comprehensive systems in an integrated manner. Systems models combine natural, physical, and social systems to help decisionmakers understand impacts and trade-offs. Systems simulation models are also dynamic, meaning they can evaluate parameters through time. Such dynamic evaluation is crucial for long-range water supply planning.

The generic systems simulator STELLA, developed by Isee Systems, Inc., was selected as the modeling platform for the City's systems model. The modeling platform was selected because of its flexible and relatively simple programming environment. In addition, the STELLA software was selected because it provides graphical interfaces that create an engaging virtual environment; increasing the ability of technical staff to share their understanding of the system with decisionmakers and stakeholders. CDM customized STELLA to create the City's water supply model, referred to as the WaterMAPS Model (Water Management and Planning Simulation Model).

The City's water supply systems model was developed to: (1) represent the physical water delivery system; (2) simulate the projected demands and required operations of existing and future water supplies over various hydrology years; and (3) evaluate system performance for various supply options and planning objectives.

F.1.2 Conceptual WaterMAPS Model

The systems model is designed to simulate both long-term planning and short-term operational water resources decisions for the next 40 years. Both simulations track the flow of water (in AF) from the available supply sources to projected water demands. The long-term planning simulation runs on monthly unit time, while the operational simulation runs on daily unit time. Both simulations perform calculations on a dt time step equal to 0.125 of the respective unit time.

Future Year Planning Simulation

The long-term planning simulation requires two types of analyses. The first analysis represents a single future planning year (i.e., the annual demand is constant throughout the simulation). The selected supply portfolio is tested with the entire hydrologic period of record to determine the system performance for any type of hydrology condition. This type of simulation provides a probabilistic approach to planning decisions.

Forty-Year Sequential Time Series Simulation

The second planning simulation represents a forty-year sequential time series, with increasing demands over time. The supply portfolio is tested with forty-year hydrology sequences that were selected from the historical hydrology data. The purpose of this type of simulation is to model the impacts of groundwater pumping to aquifer drawdown and stream depletions over time.

Operational Simulation

The operational simulation is designed to model the current water system. The system performance is determined based on a user-input quantity of supply from the available water sources. This type of simulation can be used for short-term tactical decisions based on "what if" scenarios. This mode of simulation was not used for this Water Plan, and is therefore not discussed in this report. For a detailed description of the operational mode of simulation, refer to the WaterMAPS Model User Manual.

The model parameters (Figure F-1) include: water demands, hydrology, existing water supply delivery system (McClure and Nichols Reservoirs, CRWTP, City Well Field, Buckman Well Field, BDD, SJC Project reservoirs, and treated effluent), groundwater depletions and drawdown, potential water supply options, water quality, costs, as well as limits/ constraints (water rights, sustainability, Rio Grande Compact agreements, and infrastructure capacity).

The model development process included: (1) depicting the City's water supply system, including the groundwater and surface water systems, and associated water rights and capacity constraints; (2) defining water supply options to include in the model; (3) defining the outputs required; (4) identifying the general relationships between the water supply options and the components within each option; (5) developing a conceptual model; (6) validating the performance of the surface water system with historical data; (7) data collection; (8) programming; and (9) developing a simulation protocol.

F.1.3 Use of WaterMAPS in the Water Plan

The WaterMAPS model was used to determine the projected 2045 water deficit, or gap, based on the use of existing water sources and future water demands. The WaterMAPs model was also used to calculate values specific performance measures of several future water supply portfolios. With long-term planning objectives, the Forty-Year Sequential Time Series and Future Year Planning modes of simulation were used in WaterMAPS.

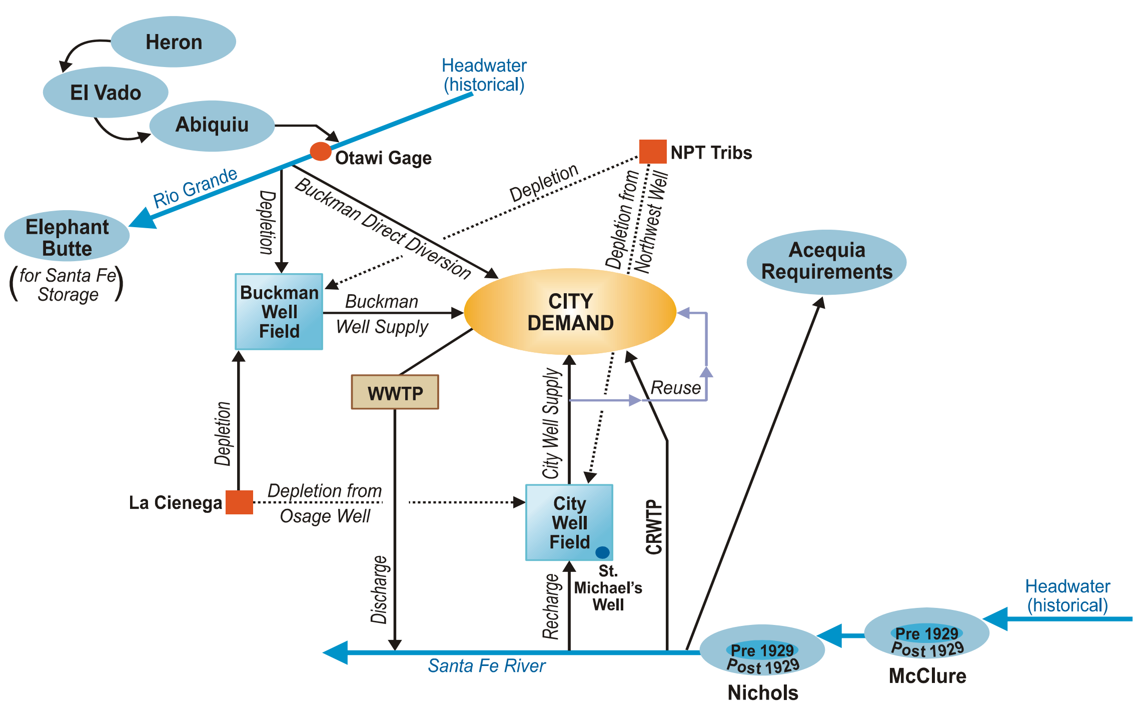


Figure F-1 WaterMAPS System Schematic

Gap Analysis

Prior to development of alternative water supply solutions, a gap analysis was performed in order to quantify the deficit probability (given different hydrology conditions) and maximum deficit for the 2045 planning year, given the existing sources of supply. The following baseline condition assumptions were used for the gap analysis in the WaterMAPS model:

- Base City Demand of 142 gpcd (130 gpcd potable plus 12 gpcd non-potable)
- Twenty percent Minimum Carryover Storage in McClure and Nichols Reservoirs
- Maximum use of St. Michael's Well of 241 AFY
- Existing Water Rights Constraints Outlined in the 2001 Water Supply Analysis Report
- CRWTP Maximum Capacity of 8 mgd
- Buckman Well Pumping is Limited to 5,000 AFY
- No additional deliveries of 850 AFY drought-year additional County obligation for the Forty-Year Sequential Time Series
- Additional deliveries of County 850 AFY for the Future Year Planning Simulation
- BDD is online in 2011, providing a supply of 5,230 AFY

The results of the gap analysis show that for the above baseline conditions, a maximum deficit of 5,500 AFY is anticipated in 100 percent of the hydrology conditions for the 2045 planning year.

Portfolio Analyses

The gap analysis catalyzed the development of future water supply options, which were programmed into the WaterMAPS model. Combinations of future water supply options were grouped into water supply portfolios, and simulated using WaterMAPS. The resulting WaterMAPS output was the basis for specific performance measures used to rank the water supply portfolios. The baseline assumptions for the portfolios are the same as the above-listed assumption for the gap analysis. However, the future water supply option of "Increasing the use of Buckman wells" limits the pumping to 10,000 AFY, instead of 5,000 AFY. A more detailed description of the gap analysis results, water supply options, and portfolios are provided in Appendices D, E, and G, respectively. The following provides information about the assumptions, relationships, and input parameters in the WaterMAPS model.

F.2 WaterMAPS Model Parameters

F.2.1 Hydrology

The availability and dependability of supply from the CRWTP is a function of streamflow in the Santa Fe River. Streamflows into McClure Reservoir were obtained from a previous analysis titled, "City Water Supply Analysis for the City" dated January 2001, prepared by CDM. A detailed description of the hydrology data is provided in the 2001 report. To summarize, a USGS stream flow gage was recently installed upstream of McClure Reservoir. Data from this gage is available from 1998 to 2002. Historical streamflow upstream of McClure prior to 1998 was calculated based on USGS gage 08316000, located between McClure Reservoir and Nichols Reservoir. Streamflows into McClure Reservoir were calculated from January 1943 to June 1998.

Future Year Planning Simulation

The future planning year analysis is simulated with the entire 59-year period of hydrologic record, from January 1943 to December 2002. The historical streamflows into McClure Reservoir for the entire hydrology period is shown in Figure F-2.

Forty-Year Sequential Time Series Simulation

The forty-year sequential time series has two hydrologic conditions that may be simulated, both of which are based on the historical hydrology data. The first condition is a dry start – normal end hydrology sequence, which represents hydrology data from January 1951 to December 1990. The second condition is a normal start – dry end hydrology sequence, which represents hydrology data from January 1981 to December 2002, January 1943 to December 1957, and January 2000 to December 2002. The streamflows into McClure for the two forty-year hydrology conditions is shown in Figures F-3 and F-4.

F.2.2 Demands

In addition to meeting its own water demands, the City is also responsible for contractual obligations to meet a portion of the County demands, Las Campanas demands, and Acequias demands. For the planning analyses, the model is simulated with unconstrained demand, meaning that there is no reduction in demand due to emergency drought management. The model calculates the size of monthly deficits, and determines the water emergency management stage required per the City Ordinance Section 25-5.7. Demand estimates are described in Appendix D.

City of Santa Fe Demand

For the planning simulations, the City demand projections are based on a per capita demand of 130 gpcd. Population projections for the City were provided by Lee Wilson and Associates, and are shown in Table F-1. Annual population projections were interpolated based on the 10-year population projections.

Table F-1 Projected City Service Area Population

Year	Service Area Population
2000	72,391
2010	85,780
2020	97,814
2030	108,959
2040	117,997
2045	122,063

In order to represent increased demand in peak summer months, seasonal demand factors were calculated based on historical monthly total production data dating back to January 1980. The results of the seasonal demand factor calculations for the City demands are shown in Figure F-5. The monthly seasonal factors are applied to annual projected City water demands.

County Demand

Once the BDD is online, the City is obligated to provide up to 500 AFY to the County in any given year. However, if it is a drought situation, or the County is not able to meet demands, the County may request that the City provide an additional 850 AFY of water. Therefore, the County demands in the model are programmed to be 500 AFY, with functionality to evaluate the additional 850 AFY to test the potential higher demands that may be induced under the County's agreement with the City.

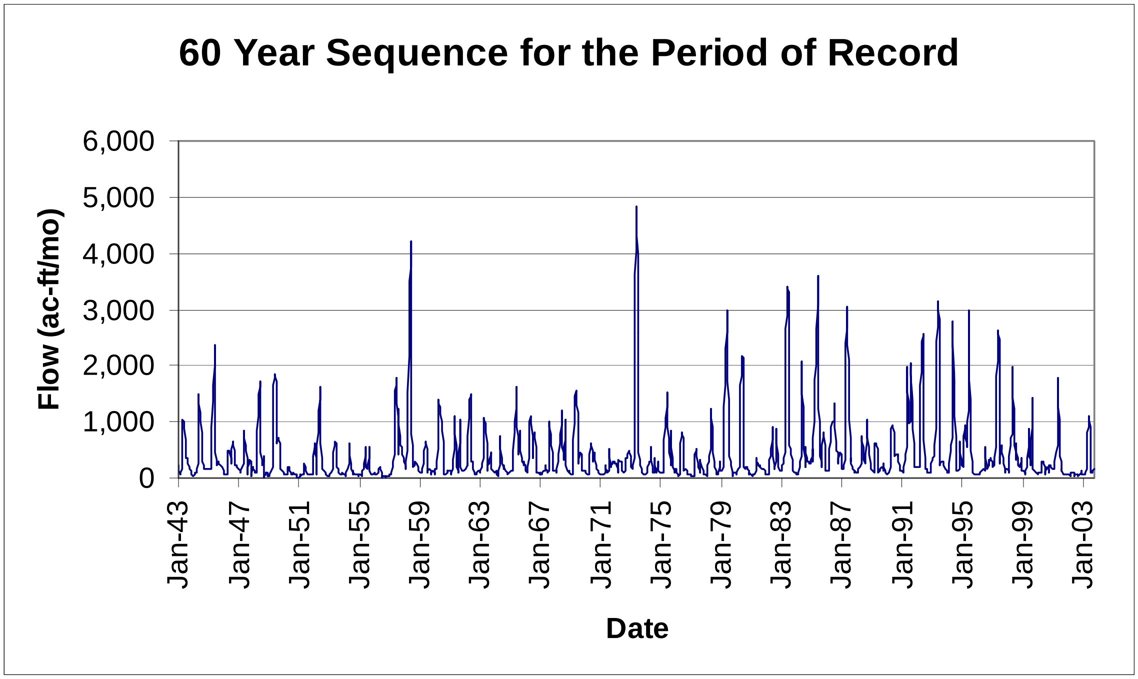


Figure F-2 Historical Streamflows into McClure Reservoir for the entire hydrologic period of record, from January 1943 to December 2002
[Source FN: Hydrology Analysis.wls]

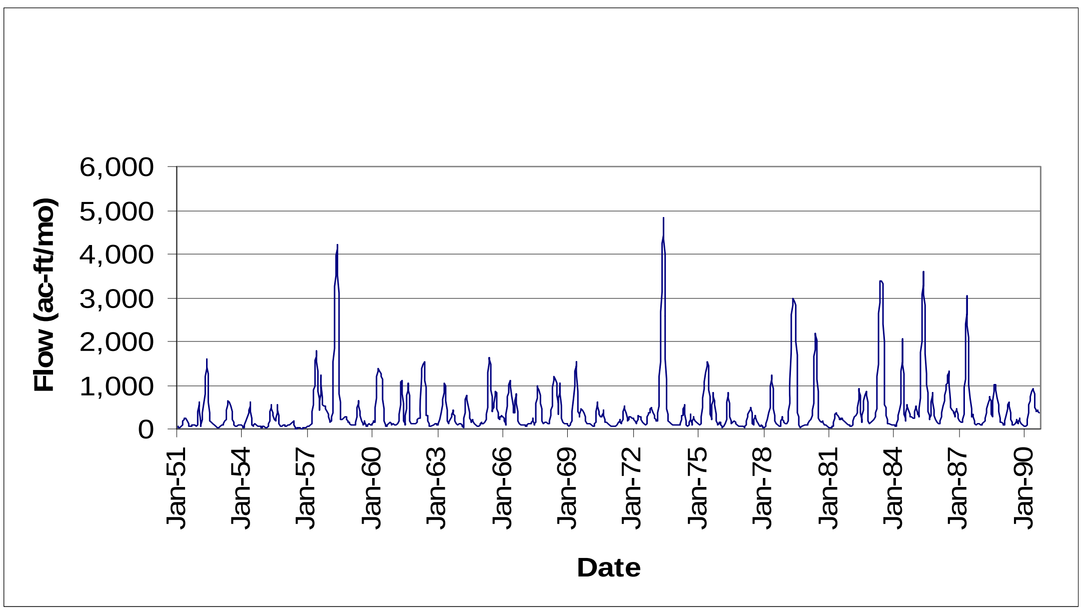


Figure F-3 Forty-Year Sequential Time Series Dry Start - Normal End Hydrology Sequence of Streamflows into McClure Reservoir
[Source FN: Hydrology Analysis.xls]

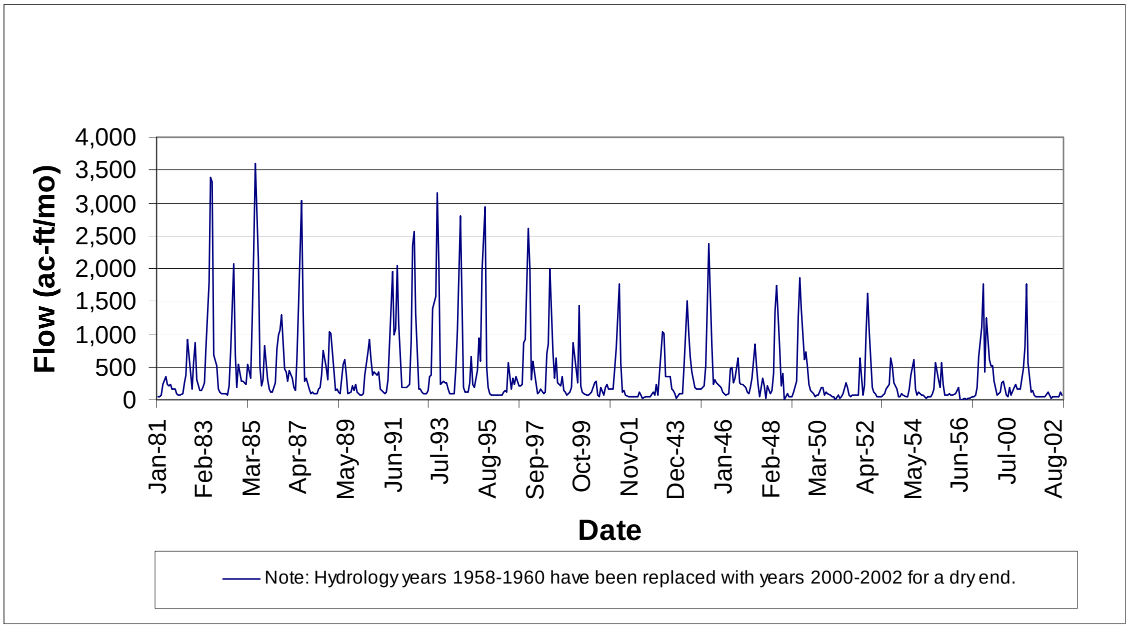


Figure F-4 Forty-Year Sequential Time Series Normal Start - Dry End Hydrology Sequence of Streamflows into McClure Reservoir. *[Source FN: Hydrology Analysis.wls]*

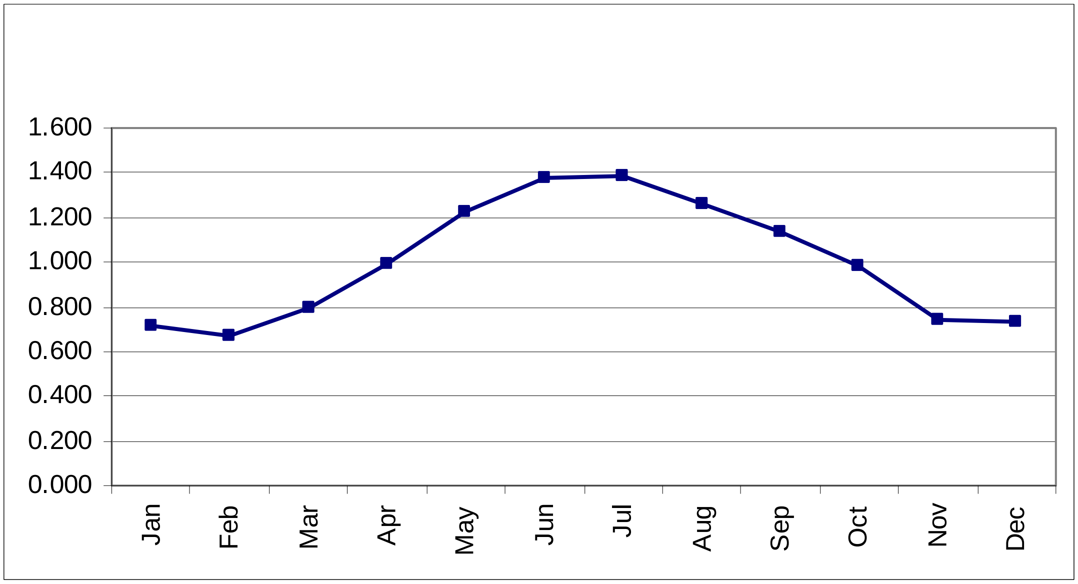


Figure F-5 City of Santa Fe Monthly Seasonal Demand Factors

Las Campanas Demand

The demands for Las Campanas are outlined in the Settlement Agreement dated September 30, 2003. Per the agreement, the Las Campanas treated water demands currently met by the City's Buckman Well supply will terminate once the BDD is constructed. Therefore, a user-input switch is provided on the management panel to indicate whether the BDD is constructed, which determines whether Las Campanas demands are included in the total potable demand calculations.

If the "BDD Constructed" switch is turned off, the Las Campanas demands for golf course and commercial/domestic uses are included in the calculations. The monthly golf course irrigation schedule of demands for Las Campanas is provided in the Settlement Agreement. For Las Campanas commercial/ domestic uses, the maximum annual demand stated in the agreement of 650 AFY was assumed, for purposes of the model. A monthly seasonal percentage distribution was applied to the annual commercial/domestic water demands. The seasonal distribution was provided by Lee Wilson & Associates in an e-mail dated January 10, 2005.

Acequias Demand

The City has an agreement to provide water for the Acequias demands. The deliveries are provided at four diversion points, three of which are treated water diversions. The fourth diversion point is directly from the Santa Fe River, downstream of Nichols Reservoir releases. For purposes of the model, the maximum agreement deliveries were used for the model. The treated water deliveries were added to the total demand from the City.

F.2.3 Physical Water Supply System

The City's three current primary sources of supply include:

- Surface water from the Santa Fe River watershed
- Groundwater from the City Well Field along the Santa Fe River
- Imported water from the Buckman Well Field near the Rio Grande

The City is also in the process of constructing the BDD to access surface water from the Rio Grande.

Due to cost, availability, and quality of source water, the use of the above water sources is prioritized as follows for purposes of the model:

1. Local surface water from the Santa Fe River watershed
2. Imported water via the BDD
3. Local groundwater from the City Well Field along the Santa Fe River
4. Imported water from the Buckman Well Field near the Rio Grande

Water rights and sustainability constraints require that the total supply from each primary source be modeled in further detail. In addition, conservation reduced total demand and is therefore considered a source of "supply." The detailed supply sources in the model are prioritized as follows:

1. Conservation
2. Minimum Buckman Pumping (default is 1,000 AFY)
3. CRWTP
4. BDD
5. Osage Well Supply
6. St. Michael's Supply
7. Northwest Well Supply
8. Other City Wells Supply
9. Additional Supply from Buckman Wells

During the beginning months of the year, the CRWTP, BDD, and City Wells have the capacity to meet projected demands without much supplemental supply from the Buckman Wells. However, water rights constraints limit the use of the CRWTP and City Wells, potentially leaving only the BDD and Buckman Wells to meet demands at the end of the year, which results in shortages due to capacity constraints. In order to prevent overuse of the CRWTP and City Well field at the beginning of the year, the minimum Buckman pumping is provided as a supplemental source of supply throughout the year, thereby reducing shortages caused by source prioritization assumptions and water rights constraints.

The sources of supply are subject to various water rights, sustainability, and capacity constraints, are described in the "City Water Supply Analysis for the City" dated January 2001, prepared by CDM. The system capacity constraint is an automatic physical constraint. However, the water rights and sustainability constraints are managerial objectives. Therefore, it is important to know if either water rights or sustainability is impacting system performance. The future year planning simulation allows the groundwater system to be tested under each of the following scenarios:

1. Water Rights and Capacity Constraint
2. Sustainability and Capacity Constraints
3. Capacity Constraint Only

Surface water rights compliance is enforced for every type of groundwater option listed above. Surface water sources of supply are not subject to sustainability constraints, so it is not necessary to test whether water rights or sustainability are impacting system performance.

F.2.3.1 Canyon Reservoirs

McClure and Nichols Reservoirs are modeled with the following components: historical streamflows into McClure, evaporation, capacity, spills, and controlled releases. Historical streamflows into McClure are discussed in the Hydrology section of this report.

Average monthly net evaporation rates are multiplied by the dynamic surface area of the reservoirs, which is determined with a volume-area relationship. The results of the average monthly net evaporation calculations for each reservoir are shown in Table F-2.

Table F-2 Calculated Monthly Net Evaporation Rates*

Month	McClure Average Net Evaporation, in/mo.	Nichols Average Net Evaporation, in/mo
Jan	0.76	0.83
Feb	0l68	0.74
Mar	2.01	2.15
Apr	3.74	3.98
May	4.80	5.10
Jun	6.38	6.75
Jul	4.09	4.42
Aug	3.32	3.60
Sep	3.14	3.37
Oct	2.19	2.35
Nov	1.19	1.29
Dec	0.21	0.26

* From McClure and Nichols Reservoir. Calculations are based on data received from the City.

In order to ensure mass conservation, a mass balance approach was used to calculate the spills from McClure and Nichols Reservoirs. Essentially, the reservoir spills when the storage volume reaches the maximum reservoir capacity. The maximum capacity of McClure Reservoir is 3,257 AF, and the maximum capacity of Nichols Reservoir is 685 AF.

Future Year Planning and Forty-Year Sequential Simulations

For the planning simulations, Nichols releases are calculated as the minimum of demand, CRWTP capacity, remaining annual water rights, or the available water in the reservoir and there is demand for the water releases. McClure releases are equal to Nichols releases, provided the water is available in McClure. McClure releases are also triggered if

Nichols Reservoir storage is below the specified storage goal. The default storage goal in Nichols Reservoir is 70 percent of Nichols capacity. This promotes transfer of water from McClure to Nichols, in order to increase the availability of storage in McClure to receive Santa Fe River inflows. Both reservoirs have a minimum storage volume as percent of total capacity, which the user can adjust based on desired carryover storage. The default minimum storage volume is 20 percent of the reservoir capacity.

F.2.3.2 Canyon Road Water Treatment Plant

The CRWTP has a default capacity of 8 mgd. However, the simulation may also be executed with an upgraded plant capacity.

Future Year Planning and Forty-Year Sequential Simulations

For the planning simulation, the CRWTP supply is calculated as the minimum of remaining demand, plant capacity, remaining water rights, or amount of water available in the Santa Fe River after meeting Acequia raw water demands. The model keeps track of how much water is supplied from the plant in a given year. Since the surface water rights for the CRWTP are in conjunction with St. Michael's Well, both the CRWTP and St. Michael's Well will operate until the cumulative production reaches the conjunctive annual water rights of 3,500 AFY. At that point, St. Michael's Well shuts off for the rest of the year, and the CRWTP continues to operate until the total surface water rights of 5,040 AFY are reached.

In order to increase CRWTP production in peak summer months, a seasonal supply factor was used to provide a monthly supply distribution based on historical CRWTP production data dating back to 1980. The results of the seasonal supply factor calculations for the CRWTP are shown in Figure F-6. The monthly CRWTP seasonal supply factor is applied to annual water rights constraints.

In drought years, it is more efficient to shut off the plant in the winter months, using the relatively small amount of reservoir water that is available to meet peak demands in summer months. This supply option can be tested in the model by turning off the CRWTP production during winter months of drought years. For this option, the seasonal supply factors distribute the

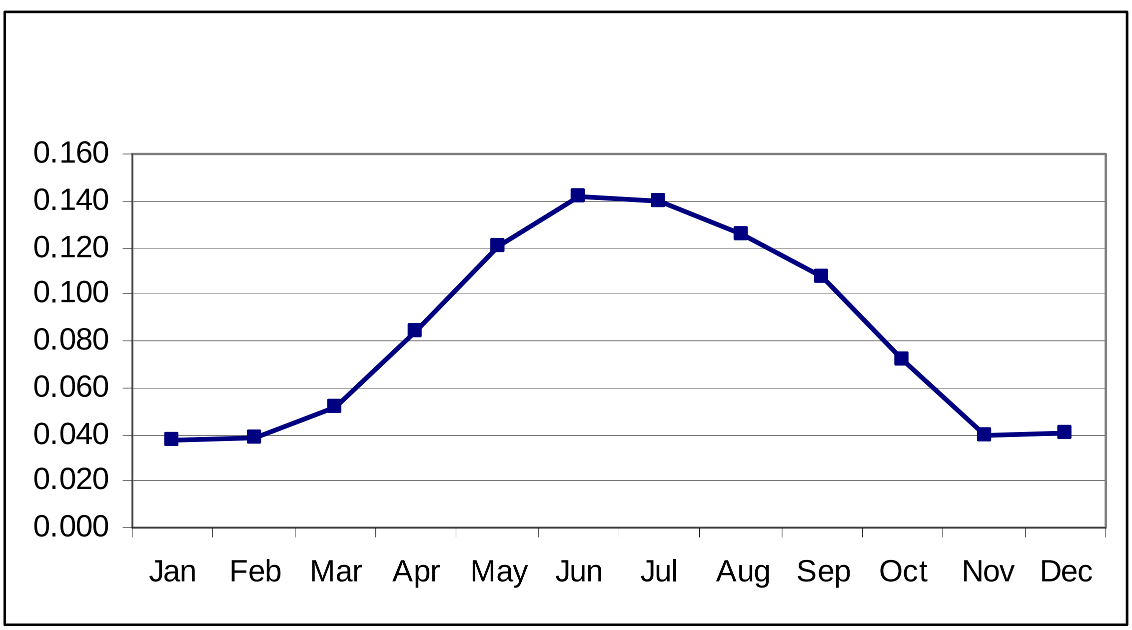


Figure F-6 Canyon Road Water Treatment Plant Seasonal Supply Factors

CRWTP supply over peak demand summer months, as shown in Figure F-7. Note that the results of this option assume ideal plant operation and the human decision to completely shut off the plant during winter months of future drought years.

F.2.3.3 City Wells

Future Year Planning Simulation

For the future year planning simulation, the model calculates the required supply from Osage, Northwest, St. Michael's Well, and "Other City Wells." The Osage, Northwest, and St. Michael's wells were modeled as individual sources of supply due to separate water rights constraints. The "Other City Wells" were grouped together as a single supply source, and include Agua Fria, Torreon, Alto, Ferguson, Santa Fe, and Hickox wells. The supply from each of the four well sources is determined as the minimum of demand, capacity, remaining water rights, or the "Pumping Limit." The "Pumping Limit" is a cap in yearly pumping introduced in the planning process to address sustainability concerns. That level can be changed in the model to reflect sustainability yields as more information becomes available in the future. The capacity, water rights, and pumping limit associated with each of the well sources are shown in Table F-3.

Table F-3 Summary of City Wells Water Rights, Capacity, and Sustainability Constraints

Well Source	Capacity (AFY)	Water Rights (WR) (AFY)	Sustainable Yield (AFY)
Osage	Assume equal to Water Rights	77.68	Included with other City Wells
Northwest	2,342	900	500
St. Michael	766	5,040 (combined WR with CRWTP)	241
Other City Wells	3,323	4,865 (w/o Northwest Well) 3,507 (with Northwest Well)	2,984 (includes Osage Well)

Once the supply calculated from the "Other City Wells" group source is determined, the supply from each individual well is calculated, based on default well distributions provided in the SURFS model. The SURFS well distributions of supply were normalized to exclude St. Michael's, Northwest, and Osage Wells. The normalized supply distribution from each well is shown in Table F-4. The sensitivity of the planning results to this distribution is not significant.

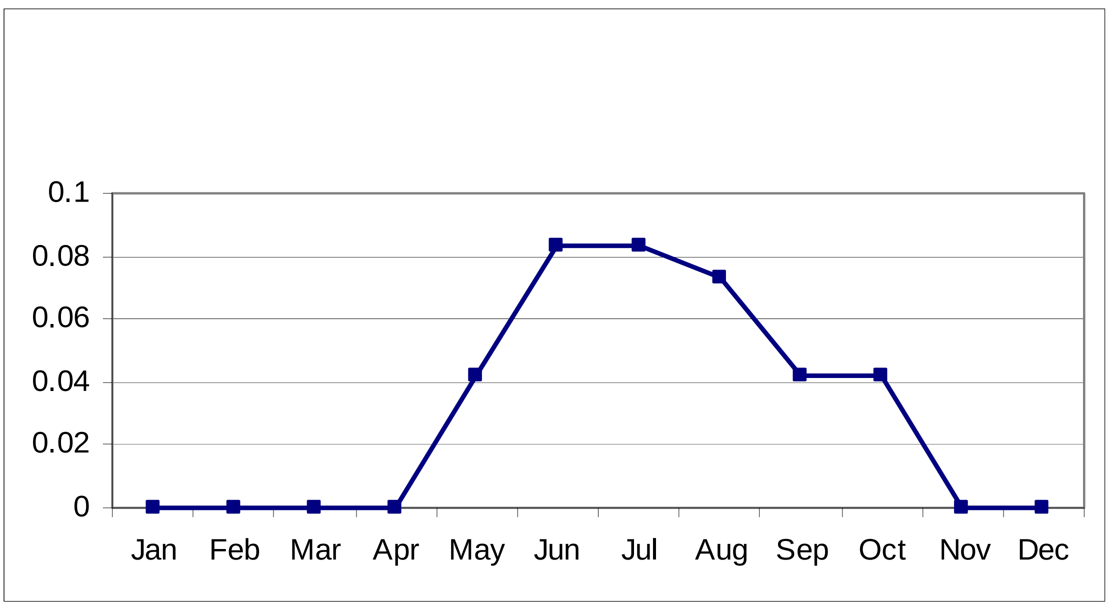


Figure F-7 Canyon Road Water Treatment Plant Monthly Seasonal Supply Factors for the Efficient Use in Dry Years Option

Table F-4 Distribution of Individual Well Supply as part of "Other City Wells" Group Supply

Well Name	Fraction of Total "Other City Wells" Supply
Agua Fria	0.423
Torreon	0.228
Alto	0.113
Ferguson	0.116
Santa Fe	0.119
Hickox	0

Seasonal supply factors were applied to Osage, Northwest, St. Michael's Well, and the remaining other City Wells in order to replicate the historical use patterns based on monthly production data available since 1980. The results of the seasonal supply factor calculations for the City Wells are shown in Figures F-8 through F-12.

The initial drawdown for the planning year is linked to SURFS calculations, and additional drawdown due to pumping required for the planning year is calculated in STELLA based on a response function developed from SURFS output.

Forty-Year Sequential Simulation

For the forty-year sequential time series, the groundwater pumping rate and drawdown for each well is linked to SURFS output. The supply determined in SURFS governs over the simulated remaining demand or water rights. Therefore, the correct supply to meet future demands is an iterative procedure between SURFS and STELLA for the forty-year sequential time series simulation.

F.2.3.4 Buckman Wells

Future Year Planning Simulation

For the future year planning simulation, the minimum pumping from Buckman Wells is user specified. This minimum Buckman pumping is allocated equally throughout the year on a monthly basis in order to supplement other sources of supply that have a higher use priority. Any additional pumping required from Buckman Wells is calculated by the model as the minimum of remaining demand, capacity, remaining water rights, or remaining pumping limit. A summary of the Buckman Wells' capacity, water rights, and sustainability constraints is shown in Table F-5.

Table F-5 Summary of Buckman Wells Water Rights, Capacity, and Sustainability Constraints

	Trunk Capacity (AFY)	Water Rights	Sustainable Yield
Buckman Wells 1-13	9,969	10,000	5,000

The Buckman supply is also constrained by a maximum annual pumping limit. In dry years, the maximum pumping limit is subject to seasonality factors that distribute the maximum pumping limit over the entire year. Since maximum pumping limit may be less than the trunk capacity, the seasonal factors prevent the use of all allowable pumping in the first half of the year during dry hydrology conditions when Buckman Wells are used extensively. If the maximum pumping limit is greater than the trunk capacity, the factors are not applicable. The seasonality factors are based on historical monthly production data dating back to 1980. The results of the seasonal supply factor calculations for the Buckman Wells are shown in Figure F-13.

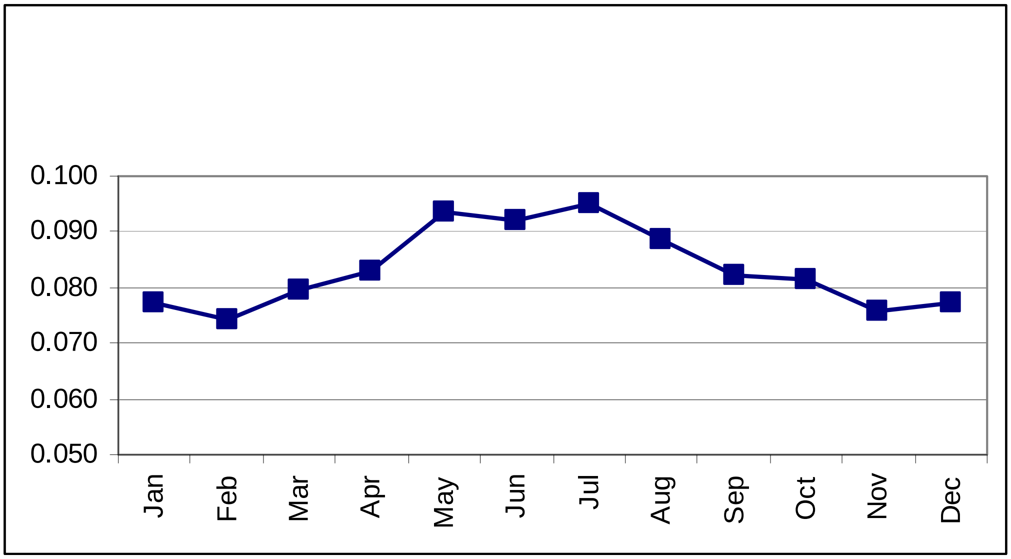


Figure F-8 Seasonal Supply Factors for "Other City Wells" with Northwest Well Offline

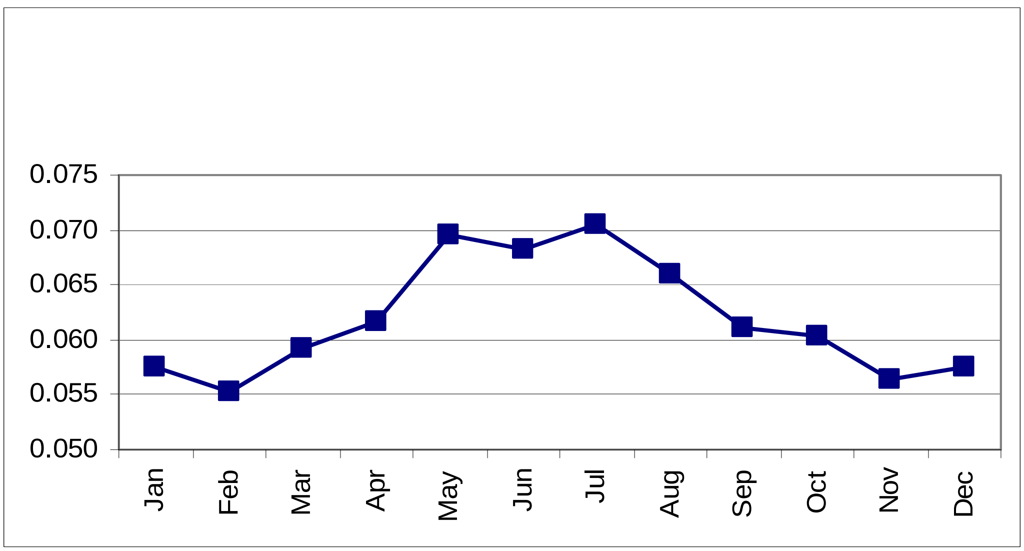


Figure F-9 Seasonal Supply Factors for "Other City Wells" with Northwest Well Online

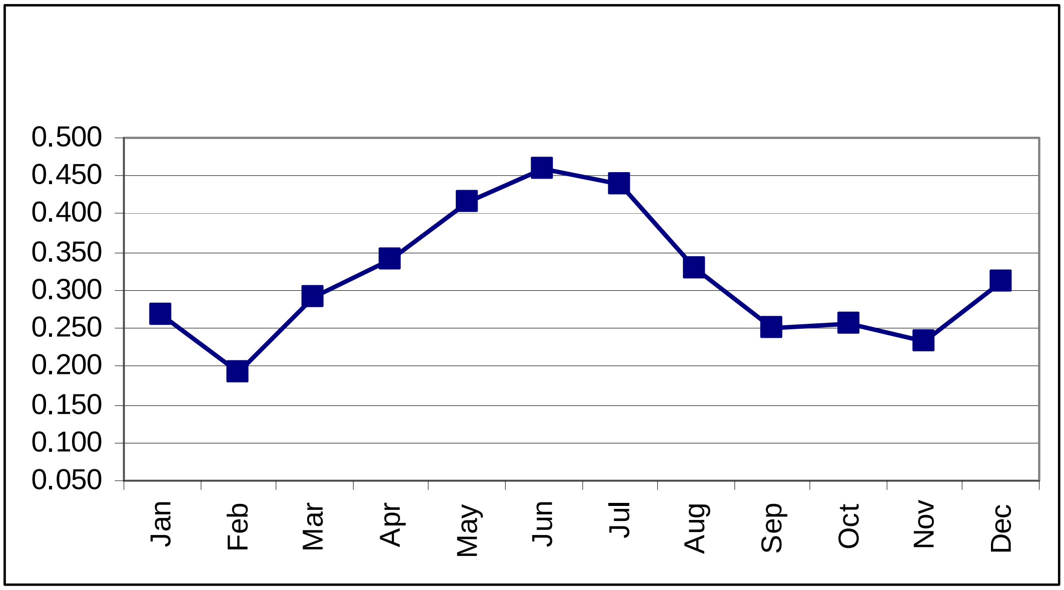


Figure F-10 Seasonal Supply Factors for St. Michael's Well

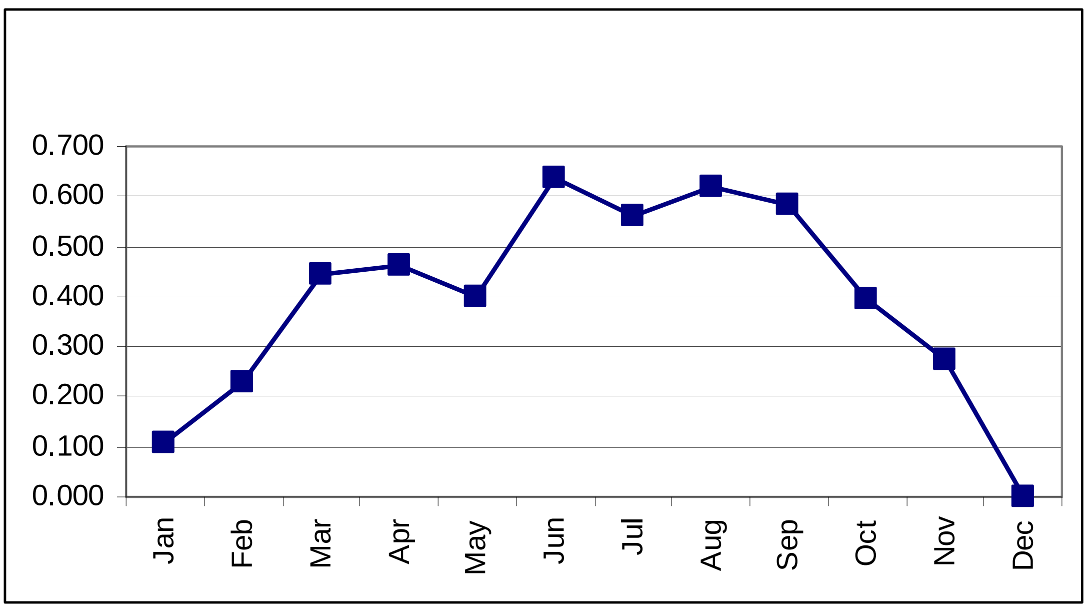


Figure F-11 Seasonal Supply Factors for Northwst Well

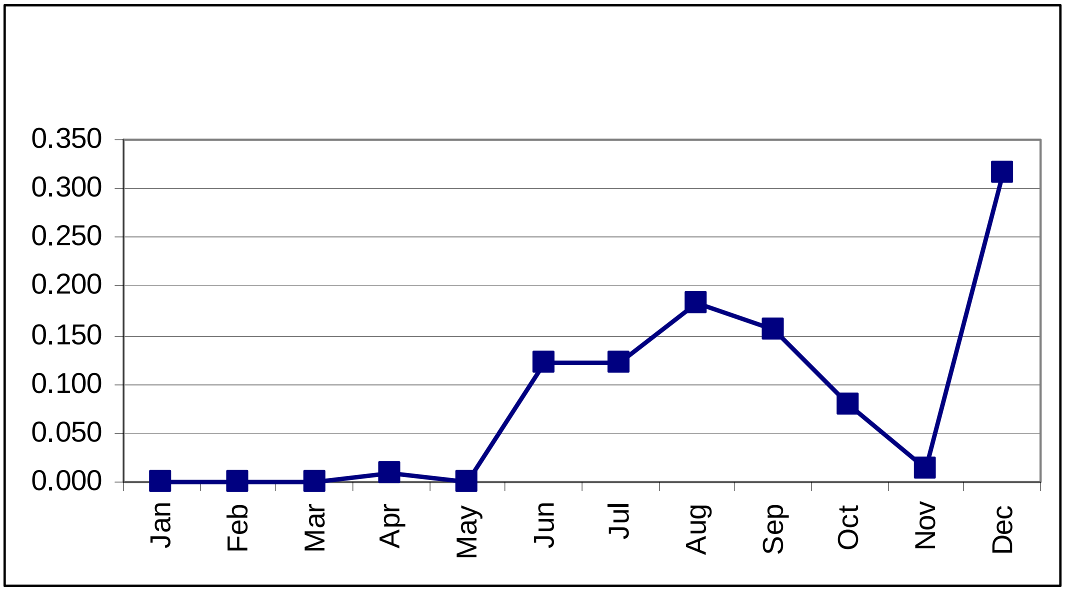


Figure F-12 Seasonal Supply Factors for Osage Well

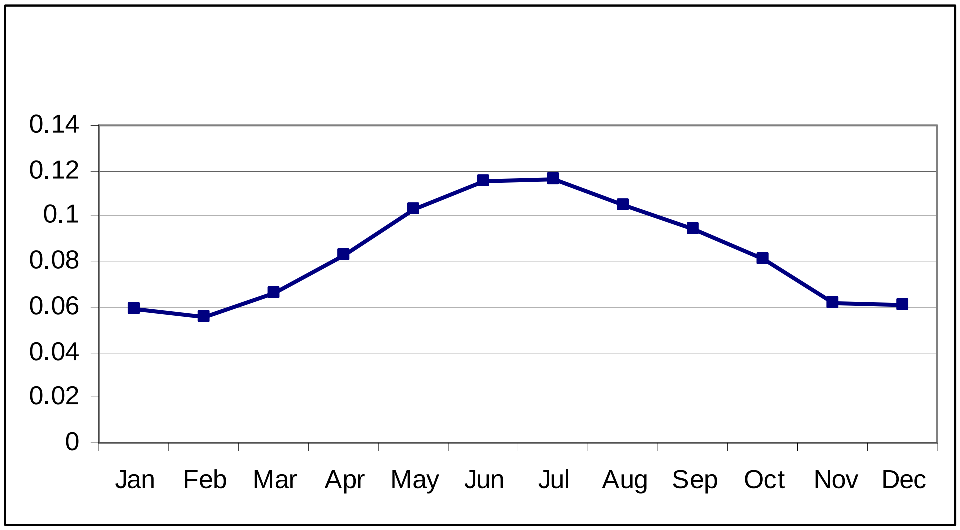


Figure F-13 Buckman Wells Seasonal Supply Factors that are Applied to the Maximum Specified Buckman Pumping Limit in Dry Hydrology Years

Once the required total supply from Buckman Wells has been determined, the model calculates the pumping from each of the 13 wells, based on supply distributions given in the SURFS model. The supply distribution from each well is shown in Table F-6. The sensitivity of the planning results to this distribution is not insignificant.

Table F-6 Distribution of Individual Well Supply Comprising the Total Buckman Well Supply

Buckman Well Name	Fraction of Total Buckman Supply
BW 1	0.053
BW 2	0.030
BW 3	0.035
BW 4	0.043
BW 5	0.024
BW 6	0.122
BW 7	0.102
BW 8	0.081
BW 9	0.058
BW 10	0.137
BW 11	0.137
BW 12	0.110
BW 13	0.069

Forty-Year Sequential Simulation

For the forty-year sequential time series, the groundwater pumping rate for each well is linked to SURFS output. The supply determined in SURFS governs over the simulated remaining demand or water rights. Therefore, the correct supply to meet future demands is an iterative procedure between SURFS and STELLA for the forty-year sequential time series simulation.

F.2.3.5 San Juan Chama Reservoirs

The City has water rights to SJC Project surface water from the upper Rio Grande in the amount of 5,605 AFY, and an additional 3,000 AFY of Jicarilla water. The SJC project water passes through three reservoirs, known as Heron, El Vado, and Abiquiu, which are located along the upper Rio Grande. The City is allowed to store water in El Vado and Abiquiu until there is a need for use. However, any unused water stored in Heron Reservoir is lost to the Bureau of Reclamation at the end of the year. Therefore, storage preference is given to El Vado and Abiquiu, in order to maximize attainment of the City's water. For purposes of the model, only the City's portion of the water in the SJC reservoirs is modeled. It is assumed that this water is reliable, and is available every year.

Since the City may store water in El Vado and Abiquiu for extended periods of time, there are some losses due to evaporation. Average monthly evaporation percentages of City water were calculated for each reservoir based on historical evaporation volumes allocated to the City's portion of the water. Average monthly evaporation percentages are based on data from January 1983 to December 2003. The average annual evaporation of the City's water is approximately 4.0 percent of the water stored in El Vado, and 6.8 percent of the water stored in Abiquiu.

Releases from the reservoirs in the model are triggered by Canyon Reservoir water accounting allocations to the SJC pool, depletion offsets caused by groundwater pumping near the Rio Grande, supply via the future BDD pipeline, and user-specified additional releases.

F.2.3.6 Buckman Direct Diversion

The City is in the process of constructing a diversion system to transport and treat surface water from the Rio Grande in order to access its allocation of water rights. Although the BDD pipeline has a peak capacity of 15 mgd, it is anticipated that the County peak water demands on the BDD facilities will be 3.7 mgd by the year 2020, which limits the City's portion of the BDD peak capacity to 11.3 mgd for planning purposes. The City's portion of annual BDD water rights is limited to 60 percent of the capacity (5,230 AFY), per the City and County Regional Water Resource and BDD Principles of Agreement, dated October 7, 2004. BDD diversions may be affected by the amount of streamflow at Otowi gage on the Rio Grande. Therefore, historical Otowi gage streamflow data corresponding to the selected hydrology sequences was used to model the potential efficiency of the BDD. For all simulations, the user enters the monthly BDD supply, providing seasonal variation if desired. For both types of simulations, the model calculates the BDD supply as the minimum of demand, the City's portion of peak BDD capacity, user-entered BDD supply, the City's portion of annual rights, or BDD efficient capacity, provided the water is available in the Rio Grande after meeting water commitments such as depletion offsets, Canyon Reservoir water accounting SJC pool allocations, and other user-specified obligations.

F.2.3.7 Effluent

Since the wastewater effluent is considered a potential source of water supply, using the total calculated water supply to estimate the wastewater influent would create a circular reference in the model programming. Therefore, the influent to the wastewater treatment plant is based on total unconstrained water demand (before conservation and reclaimed water reductions in total demand). The portion of water demand into the WWTP is approximately 60 percent on an annual basis. Based on a comparison of historical production data and raw WWTP inflows from January 1993 to May 1996, monthly seasonal factors were developed to represent the seasonal variation of wastewater inflows. The results of the seasonal wastewater influent factor calculations are shown in Figure F-14.

The WWTP is assumed to have a treatment capacity of 13 mgd, and the plant is assumed to be 98 percent efficient.

The current effluent use is assumed to be 12 gpcd, which offsets total water demand. The seasonality of current effluent demands are based on the seasonal effluent demands shown in Figure 4-3 of the May 1998 City TEMP prepared by CDM. The City is obligated to provide up to 450 AFY of treated effluent for Las Campanas golf course irrigation demands, per the Settlement Agreement dated September 30, 2003. The monthly delivery schedule of treated effluent is outlined in the Settlement agreement.

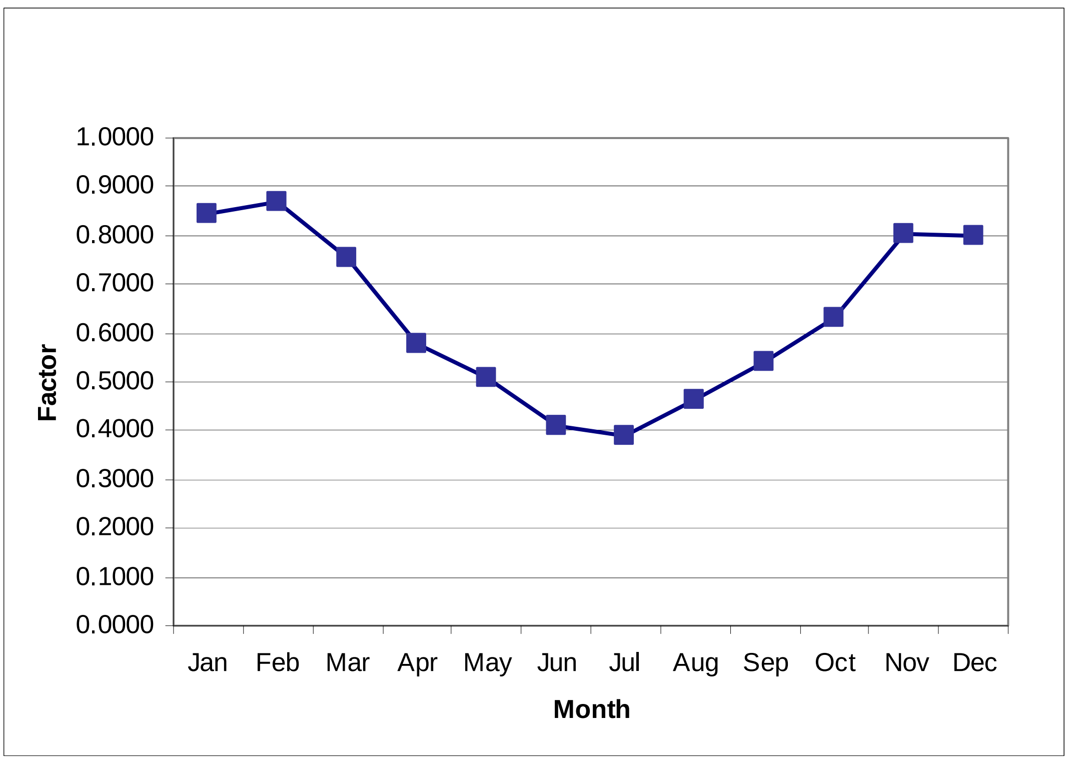


Figure F-14 Seasonal Wastewater Influent Factors Relative to Total Water Demand

Effluent produced in excess of the current effluent demands and Las Campanas obligations may to be used for the following future effluent options in the model, in this priority: (1) additional effluent contracts, (2) return flow credits to the Rio Grande to offset groundwater depletions caused by pumping, and/or (3) augment Santa Fe River flows through upstream reaches for environmental benefits and groundwater recharge. All additional excess effluent is discharged to the Santa Fe River at the WWTP.

F.2.3.8 Future Water Supply Options

The future water supply options are intended for use only in the Planning Future Year Simulations and the Forty-Year Sequential Time Series simulations. The future water supply options that are programmed in the WaterMAPS model include:

Option 1

Reduce Per Capita Demand to 120 gpcd with More Aggressive Conservation Measures

This is implemented throughout the simulations.

Option 2

Reduce Per Capita Demand to 110 gpcd Short-Term via Emergency Drought Management

This is triggered only if a deficit situation occurs, after all other existing and future water sources have been exhausted in a given month.

Option 3

Increase Storage Capacity in Santa Fe River Canyon Reservoirs

This option increases the capacity of McClure Reservoir in the model.

Option 4

Expand Use of BDD with No New Infrastructure

The amount of Rio Grande water available for this option is dependent on the user-specified new water rights purchased. The expanded use of the BDD capacity is limited by (1) the efficient capacity of the BDD, which is a function of the total BDD capacity and Rio Grande flows at Otowi Gage; and (2) the City's available BDD capacity, which is assumed to be 11.3 mgd based on a total BDD capacity of 15 mgd and projected County demands of 3.7 mgd on the BDD facilities. The City's available 11.3 mgd BDD capacity is assumed to occur for only 9 months of the year (March-November). This is the amount of time is would take to receive an additional 5,500 AFY through the BDD, provided the base BDD supply of 5,230 AFY is delivered at a constant rate throughout the year.

During the portfolio analysis, it was determined that the reliability of this option could be increased by eliminating the seasonal supply factors applied to Buckman Wells in dry years of the Future Year Planning simulation.

Option 5

Create "Living" Santa Fe River with Canyon Reservoir Releases

These releases do not occur in dry hydrology years (approximately 25 percent of the simulated hydrology years). For the portfolio analyses, a release of 5 cfs from June through August was assumed.

Option 6

Conjunctive Use of Local Surface and Groundwater Rights

This option combines the City's total Santa Fe River (and St. Michael's Well) surface water rights of 5,040 AFY with the City Wells water rights (excluding Osage Well). The City Well water rights are dependent on the use of Northwest Well. If Northwest Well is offline, the City Wells water rights are 4,865 AFY; if Northwest Well is online, the City Wells water rights are 3,507 AFY.

For the portfolio analyses, Northwest Well was assumed to be offline for the Conjunctive Use of Local Surface and Groundwater Rights (Option 6), in order to maximize the City Well water rights. The resulting total conjunctive water right is 9,905 AFY. This water rights constraint could potentially limit the cumulative annual supply from the CRWTP, St. Michael's Well, and/or the City Wells. This option also assumes that the total City Well capacity (excluding St. Michael's, Osage, and Northwest Wells) will be increased by 500 AFY.

Option 7

Recharge Santa Fe River Groundwater Using Rio Grande Water from BDD with No New Infrastructure

The amount of Rio Grande water available for this option is dependent on the user-specified new water rights purchased. The expanded use of the BDD capacity is limited by (1) the efficient capacity of the BDD, which is a function of the total BDD capacity and Rio Grande flows at Otowi gage; and (2) the City's available BDD capacity, which is assumed to be 11.3 mgd based on a total BDD capacity of 15 mgd and projected County demands of 3.7 mgd on the BDD facilities. The City's available 11.3 mgd BDD capacity is assumed to occur for only 9 months of the year (March-November). This is the amount of time it would take to receive an additional 5,500 AFY through the BDD, provided the base BDD supply of 5,230 AFY is delivered at a constant rate throughout the year.

The user-specified desired recharge will occur in normal to wet hydrology years during the months of October and November. The remaining specified new water rights purchased go directly to demands. During dry hydrology conditions, all of the new water rights go directly to demands. In the unlikely scenario that expanded BDD supply exceeds demands in a dry year, the additional water is recharged.

During the portfolio analysis, it was determined that the reliability of this option could be increased by eliminating the seasonal supply factors applied to Buckman Wells in dry years of the Future Year Planning simulation.

Option 8

Increase Use of Existing St. Michael's Well Capacity

For this option, the capacity of St. Michael's Well is limited to 75 percent of the total rated capacity of 645 AFY to account for operational downtime. For the Future Year planning simulation, this option is implemented only during dry hydrology years and the St. Michael's seasonal supply factor is not used. For the Forty-Year Sequential Time Series, the pumping for St. Michael's Well is linked to SURFS output. Therefore, this option is activated by adjusting SURFS input for the City Wells pumping.

Option 9

Intensive Pumping of Existing Buckman Wells

For the Future Year planning simulation, this option is activated with the user-specified maximum annual Buckman pumping limit. For the Forty-Year Sequential Time Series, the pumping for Buckman Wells is linked to SURFS output. Therefore, this option is activated by adjusting SURFS input for the Buckman Wells pumping.

Option 10

Rehabilitate City Wells to Increase Production

For the Future Year Planning simulation, this option increases the City Well capacity by 1,865 AFY, excluding St. Michael's, Osage, and Northwest Wells. For the Forty-Year Sequential Time Series, the pumping for City Wells is linked to SURFS output. Therefore, this option is activated by adjusting SURFS input for the City Wells pumping.

Option 12

Additional Landscape Irrigation with Effluent

The user-specified annual effluent contracts are converted to monthly quantities, and multiplied by seasonality of current effluent demands.

Option 14

Augment Santa Fe River Flow through Town with Effluent

The user-specified annual effluent discharged is converted to monthly quantities, and multiplied by seasonality of current effluent demands.

Option 15

Return Flow Credit and Expanded Use of BDD with No New BDD Infrastructure

The user specifies the desired amount of effluent to send to the Rio Grande via a new pipeline. The model calculates the actual effluent available after meeting the existing effluent demands, Las Campanas effluent demands, and additional effluent contracts (Option 12, if activated). The actual effluent available is then used to offset any remaining depletions that exist after the available Rio Grande water rights (131 AFY) are used. The remaining effluent is used for return flow credits, which triggers the expanded use of the BDD supply.

The expanded use of the BDD capacity is limited by (1) the efficient capacity of the BDD, which is a function of the total BDD capacity and Rio Grande flows at Otowi Gage; and (2) the City's available BDD capacity, which is assumed to be 11.3 mgd based on a total BDD capacity of 15 mgd and projected County demands of 3.7 mgd on the BDD facilities. The City's available 11.3 mgd BDD capacity is assumed to occur for only 9 months of the year (March-November). This is the amount of time it would take to receive an additional 5,500 AFY through the BDD, provided the base BDD supply of 5,230 AFY is delivered at a constant rate throughout the year.

During the portfolio analysis, it was determined that this option is much more reliable when used in conjunction with the Expanded Use of BDD with SJC storage option.

Option BDD/SJC

Expand Use of BDD with SJC Storage

This option is triggered during only dry hydrology years; assuming water is available in the Rio Grande after meeting depletion offsets, Canyon Reservoir water accounting SJC pool allocations, other user-specified obligations, and the base BDD supply.

The expanded use of the BDD capacity is limited by (1) the efficient capacity of the BDD, which is a function of the total BDD capacity and Rio Grande flows at Otowi Gage; and (2) the City's available BDD capacity, which is assumed to be 11.3 mgd based on a total BDD capacity of 15 mgd and projected County demands of 3.7 mgd on the BDD facilities. The City's available 11.3 mgd BDD capacity is assumed to occur for only 9 months of the year (March-November).

For portfolios in which Options 4, 7, 15, and BDD/SJC are simulated simultaneously, the available capacity for the expanded use of BDD will be prioritized as follows:

1. Option 7: Recharge Santa Fe River Groundwater Using Rio Grande Water from BDD with No New Infrastructure.
2. Option 4: Expand Use of BDD with New Water Rights.
3. Option 15: Return Flow Credit and Expanded Use of BDD with No New BDD Infrastructure.
4. Option BDD/SJC: Expand Use of BDD with SJC Storage.

F.2.4 Water Quality

The model tracks the concentrations of various water quality constituents at major blending points in the water supply distribution system. The water quality constituents that are monitored include: Total Organic Carbon (TOC), Total Dissolved Solids (TDS), Arsenic (As), Uranium (U), and Manganese (Mn). These constituents were selected due to their conservative nature, as well as their importance as water quality indicators. The constituents were agreed upon by members of both the City and CDM as constituents that are, or may be, of particular concern related to the City's water sources.

Source water quality related to each of the selected constituents was determined based on historical concentration averages. The model calculates the concentrations of the selected water quality constituents at representative major blending points in the distribution system. The major blending points of interest include Buckman Tank, Two MG Tank, Hydro Tank, Southwest Tank, Net Buckman Wells, and Net City Wells. A schematic showing the sources comprised at each of the major blending points is shown as Figure F-15. For locations where source flows split to separate endpoints in the system, fractions of the source flow to blending points of interest were assumed based on discussions with the City Facility Operations Department. The assumed flow fractions through the system can be adjusted by the user on the management panel, in order to examine alternative distribution system hydraulic scenarios.

F.2.5 Water Accounting

The water accounting module of the systems model is one of the most complex components in the system in terms of understanding the logic. Storage in the Canyon reservoirs is subject to several management strategies and conditions. The available water accounting pools to which Canyon Reservoir storage may be allocated include the Pre-Compact Pool, the Post-Compact pool, the SJC pool, and the Relinquishment pool. In order to simplify the method of tracking water accounting decisions in the model, the logic in Tables F-7 and F-8 was assumed for increases and decreases in Canyon Reservoir storage.

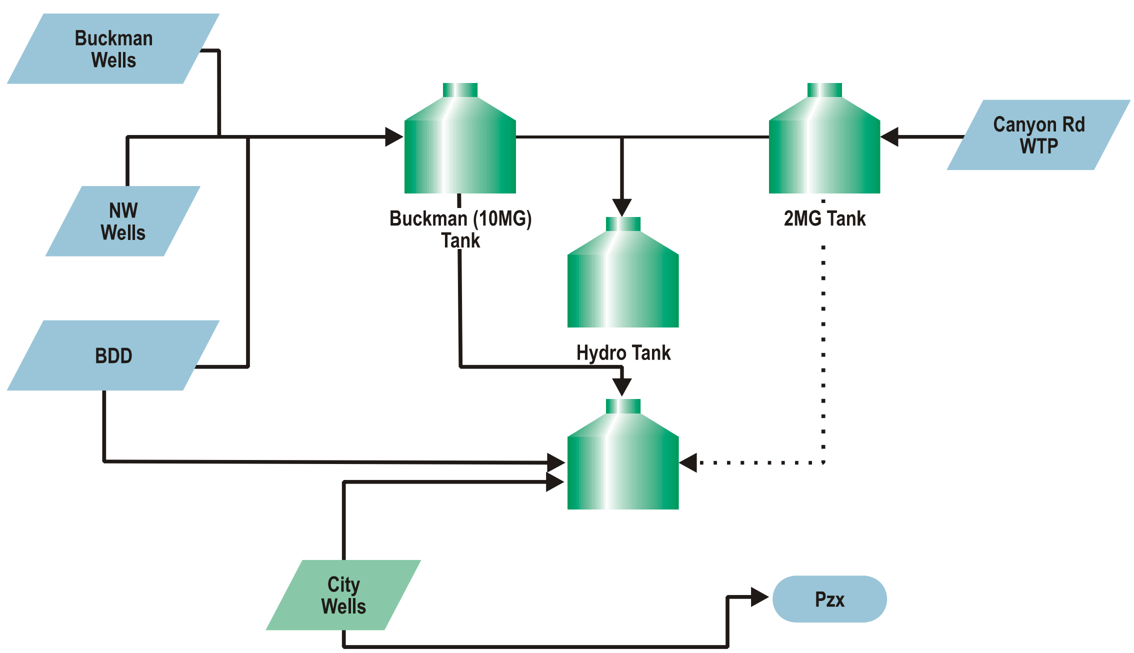


Figure F-15 Major Blending Points in the City of Santa Fe's Water Distribution System

Table F-7 Water Accounting Logic for Increases in Canyon Reservoir Storage (Credit will be given to the available water accounting pools with the following priority.)

Pool Credit Allocation	Assumptions
1. Pre-Compact pool	Up to the limit of 1,061 AF
2. Post-Compact pool	Only if Elephant Butte storage > 400,000 AF
3. SJC pool	Only if there are depletion offsets have been met, and there is no available storage in SJC reservoirs
4. Relinquishment pool	Allocated water to the relinquishment pool in the Canyon reservoirs is actually subtracting from the total relinquishment credit available. It is assumed that the total relinquishment credit does not expire at a given point in time.

Table F-8 Water Accounting Logic for Decreases in Canyon Reservoir Storage (Withdrawals/releases will be taken from the water accounting pools with the following priority.)

Pool Credit Allocation	Assumptions
1. Pre-Compact pool	Only if Elephant Butte Storage > 400,000 AF and it is not a Debit situation. If there is water in the Post-compact pool, and it is a debit situation, transfer the water to other pools with the logic used for increases in storage (Pre-Compact, SJC, Relinquishment)
2. Pre-Compact pool	
3. Relinquishment pool	The prioritization of Relinquishment and SJC is subject to review. According to the City, the Relinquishment pool and SJC pool have the same priority for decreasing the pool volumes.
4. SJC pool	The prioritization of Relinquishment and SJC is subject to review. According to the City, the Relinquishment pool and SJC pool have the same priority for decreasing the pool volumes.

F.2.6 Cost Estimates

The total operational cost of the CRWTP, City Wells, Buckman Wells, and BDD are included in all types of simulations. Total operational costs of existing sources are based on average 2002-2004 electrical cost data, and 2003-2004 budgeted cost data for labor, chemicals, facility maintenance, and other. The total operational costs of existing sources are divided into fixed annual costs (labor, facility maintenance, etc.) and variable costs (chemicals, power, etc). The total annual fixed cost ($/yr) of operating the CRWTP, City Wells, and Buckman Wells are estimated to be $1,334,361, $359,699, and $505,704, respectively. The total variable cost per acre-ft ($/AF) of operating the CRWTP, City Wells, and Buckman Wells are estimated to be $113/AF, $91/AF, and $185/AF, respectively. The total anticipated cost of operating the future BDD facilities are approximately $500/AF.

The Planning Future Year simulation and Forty-Year Sequential Time Series simulation also account for the costs incurred for simulated future water supply options included for portfolio analysis. Appendix E provides a description of the capital and O&M costs associated with each of the future water supply options. For each of the future water supply options that are programmed in the WaterMAPS Model, the total O&M costs were divided into Fixed O&M (labor, maintenance, etc.) and Variable O&M (mainly chemicals and power). The Variable O&M costs are dependent on the actual volume of water used for the option in the model.

The Planning Future Year simulation calculates the present value cost of the future water supply options based on 2005 cost estimates. The capital costs are assumed to be financed over a 30-year period, with and interest rate of 4 percent.

The Forty-Year Sequential Time Series simulation inflates the 2005 cost over time for the future water supply options, with an annual inflation rate of 3 percent. The capital costs are assumed to be financed over a 30-year period (beginning in the user-specified year of implementation), with an interest rate of 4 percent. The total (existing and future sources) cumulative costs over the 40-year period are then discounted at a rate of 4 percent to calculate the present value cost.

F.3 Quality Control and WaterMAPS Model Validation

Model development was subject to a quality control process. All data used in the model was obtained from information developed or compiled by technical staff, and was reviewed by senior staff. The overall model structure and the modeling approach were discussed with the City in several work sessions on a periodic basis.

Validation of the Canyon reservoirs portion of the systems model was performed by comparing model results to average monthly historical storage levels. The mean error (over the 59 hydrology year simulation) was approximately 2 percent for the Canyon Reservoir storage levels. A plot showing the comparison of results is shown in Figure F-16.

In addition, the systems model results were compared with results from a reservoir model of the Canyon Reservoirs developed by CDM for the report titled "Water Supply Analysis for the City" dated January 2001. The results show very similar mass balance calculations. There is a small discrepancy in the numbers when the reservoirs are near full, due to the method of spill calculations. Using the same method of spill calculation the error is corrected. The effect of the discrepancy on the overall results, when the method is different is considered negligible.

The Canyon Reservoir pool accounting portion of the model was validated by comparing model results with example pool allocations provided by the City under various storage conditions and strategies. The results showed that the model replicates the example pool allocations provided by the City.

Production from each source was validated by comparing model results with actual production data for dry, normal, and wet hydrology years. The selected years for comparison were 1990, 1995, and 2000. The results show that the model replicated historical production patterns, on both a monthly and annual time scale. It is important to consider that the model could be programmed to more closely reflect the past trends in the use of the different sources with minor modifications to the logic of each source use. We have decided instead to keep the existing logic to allow the model to be more flexible in meeting demands in the planning and 40-year simulations. In the case of the operational model, the user actually enters the desired operation of the sources, so the calibration of the model by source is not necessary.

The model results for hydrology years from 1980 to 2002 were compared with annual CRWTP production data, and showed that the model production results are comparable with actual plant operation. The validation of CRWTP production is shown in Figure F-17.

While STELLA can be used to program groundwater, it was decided to include a separate model, SURFS, which works in tandem with STELLA and is also a stand-alone tool that can be used to solve simple groundwater pumping scenarios for depletions and drawdown. The following section includes information on the calibration and validation of SURFS.

F.4 Simulation Process

A detailed description of the model running protocol for the future year planning, forty-year sequential time series, and operational simulations is included in Section 5 of the City WaterMAPS Model User Manual.

F.5 Stream Unit Response Function Solver (SURFS)

Model Overview

The SURFS model was developed to enable quick estimates of stream and aquifer response to local well field pumping. A time series of stream depletions due to a user-specified pumping schedule are calculated through numerical convolution of unit response functions (URFs). URFs describe the time series of depletions expected for a given stream and well field based on a single unit of well field pumping over a single timestep. The model can also simulate aquifer drawdown as a function of local well pumping rates. Well drawdown levels are calculated using the Theis analytical solution and simple convolution in both time and space. The SURFS model operates on a monthly timestep

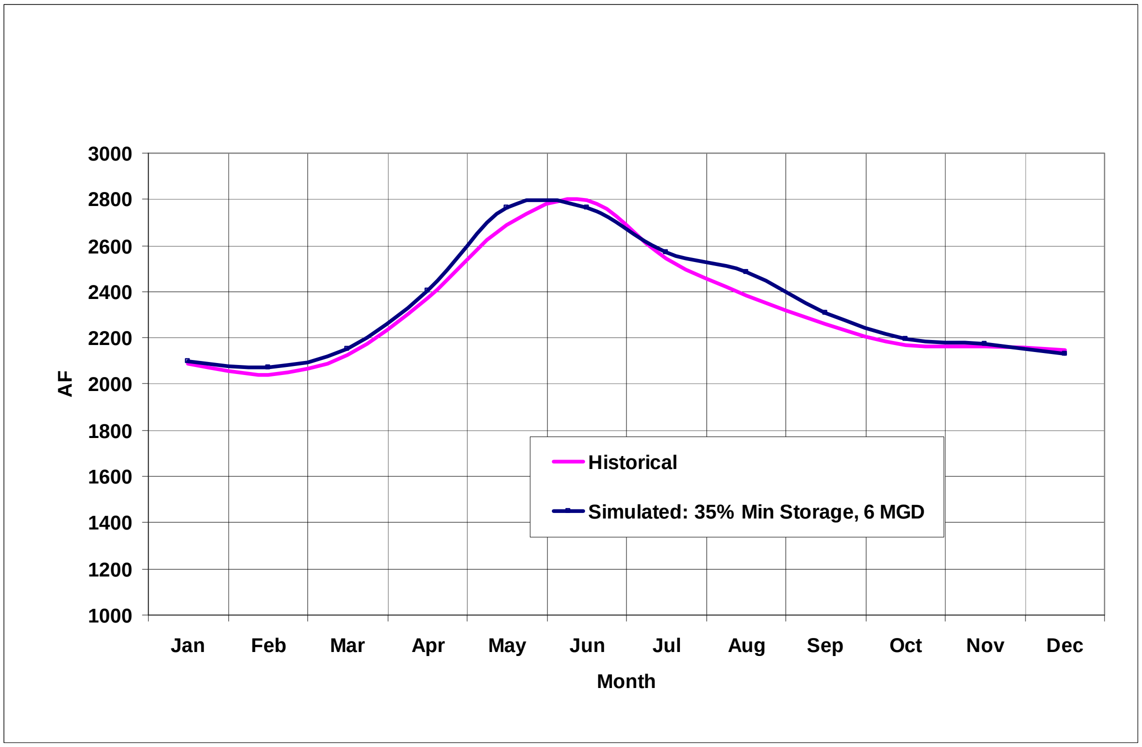


Figure F-16 Comparison of Historical and Simulated Average Monthly Canyon Reservoir Storage

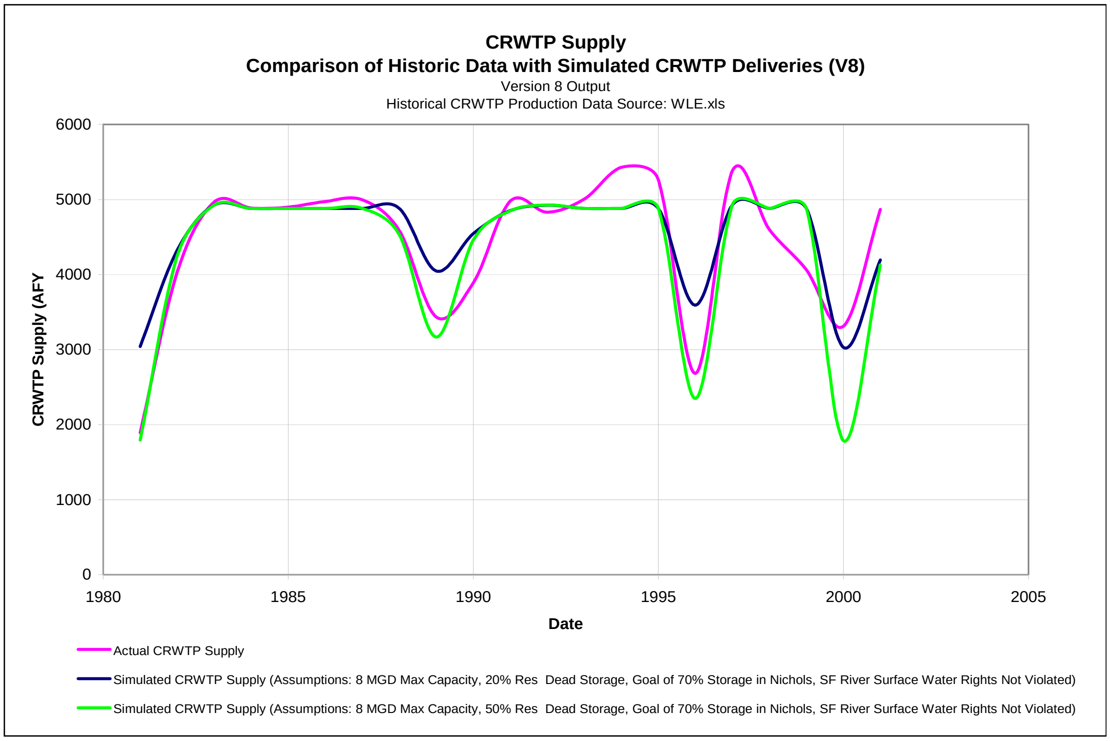


Figure F-17 Comparison of Simulated and Historical Annual Canyon Road Water Treatment Plant Production

For the City model, URFs associated with the Rio Grande, Tesuque, Pojoaque, and La Cienega streams, in response to Buckman Well Field and North West Well pumping, and were generated through multiple simulations of the City's numerical groundwater model. Current URFs in the model were generated by State Engineer's so-called "McAda-Wasiolek" model. The City's SURFS model has been tailored to accommodate pumping from any combination of Buckman Wells with depletions predicted for the four streams listed above. Depletions due to the Northwest Well, part of the City Well Field, can also be simulated.

Aquifer drawdown levels at each well can be simulated for both the Buckman and City Well Fields. Drawdown is calculated using a polynomial approximation to the Theis Equation (Abramowtz and Stegun 1968). Application of the equation has been extended in the model to handle time-variable pumping rates and calculates drawdown at each timestep as a function of pumping rates and radial distances between wells. Radial distances between wells are pre-set in the model.

Other key features of the SURFS model are:

- User-friendly *Excel*-based interface
- Output easily linked (dynamic) to City's Long-Range Planning STELLA model
- Input and output units available in units of either mgd or AFY/AFM
- Pumping rates specified according to:
  - Monthly time series vs. annual time series vs. annual totals
  - Lumped well fields vs. individual wells
  - For annual rates, ability to specify constant yearly changes and constant monthly distributions of rates

"Main" Worksheet

In this worksheet, the user specifies the simulation period (in months) and the simulation starting month (1 = January, 12 = December). Input (pumping) and output (depletions) units are also specified. Simulation options, e.g., inclusion of well drawdown calculations and inclusion of depletion impacts from pumping of the Northwest Well, are also specified here. Once the model has been properly populated, e.g., with well pumping data, the simulation is started using the "Start Simulation" button on this worksheet.

"Buckman Well Field" Worksheet

In this worksheet, the user specifies pumping rates for the Buckman Well Field. The Buckman Well Field can either be represented as a single lumped well field, as two lumped sub-well fields (Wells 1 through 9 and Wells 10 through 13), or as a group of individual wells (any or all of Wells 1 through 13). For the lumped approach, a single pumping rate (or timeseries of pumping rates) is specified. This rate, or series of rates, is automatically distributed across the 13 Buckman Wells according to the preset distribution provided in Table F-9. This distribution is based on actual historical pumping patterns in the well field. The same distribution pattern is followed for the two well field lumped approach with the distribution percentages normalized to the lumped totals.

Table F-9 Distribution of Pumping Rates for Lumped Well field Approaches

Well	Percentage of Total Pumping, Single Lumped	Percentage of Group Pumping, 2 Well field Lumped
Buckman 1	5.30	9.69
Buckman 2	3.00	5.48
Buckman 3	3.50	6.40
Buckman 4	4.30	7.86
Buckman 5	2.40	4.39
Buckman 6	12.20	22.30
Buckman 7	10.20	18.65
Buckman 8	8.10	14.81
Buckman 9	5.70	10.42
Buckman 10	13.70	30.24
Buckman 11	13.70	30.24
Buckman 12	11.00	24.28
Buckman 13	6.90	15.23

Pumping rates can either be specified as a constant annual rate or as a time series of annual or monthly rates. For the annual rates options, monthly distributions are assumed according to user-specified percentages. Additionally, for the constant annual rate option, an annual percentage increase/ decrease in the specified rate can be input. In other words, a starting annual rate is specified along with a percent increase (or decrease), which is applied at the start of every calendar year to update the pumping rate.

For both the two well field lumped and the individual well approaches, an additional "pumping sheet" must be added, using the button provided, to specify pumping rates. For the individual well option, pumping rates must be specified for each of the individual wells selected in the list-box on the original well field input sheet. Note: individual wells must be selected (highlighted) in the list box to be included in the simulation. For the two-well field lumped approach, only pumping rates for the two preset groupings (Wells 1 through 9 and Wells 10 through 13) need to be input.

For the single well field lumped approach, pumping rates are specified on the original well field input sheet ("Buckman Well Field") and no additional input sheets are required.

"City Well Field" Worksheet

If City Well Field drawdown simulations are to be performed (check box on Main screen), a worksheet named "City Well Field" will be created. The input format for this worksheet is similar to that described above for the Buckman Well Field. The pumping input schemes available for this well field are:

- Fully lumped: single pumping rate distributed across well field according to pre-set percentages
- Three-part lumped: pumping rates are required for St. Michael's Well, Northwest Well, and the remaining seven City Wells lumped together
- Individual wells: each of the nine wells in the well field requires explicit pumping rate inputs

Also available on this worksheet is the option to include an additional, un-named, "new well" as part of the simulation. Inclusion of a new well in the drawdown calculations requires only an input of an associated pumping rate and an update to the radial distance matrix. The intention here is to allow for planning for future groundwater supply options.

Output

Outputs are displayed in new worksheets created for each simulation. The units associated with the output data, as indicated on the output sheet, are selected by the user on the "Main" worksheet. The outputs are provided in monthly timeseries format for easy graphing or other post-processing.

Model Troubleshooting

The following important points should be followed when using the SURFS model:

- The "Main" and "Buckman Well Field" input sheet names should not be altered (the model calculations refer to these named sheets)
- New pumping worksheets created using the "Add Pumping Sheet" button can be renamed per user preference
- The text labels in Cells (1,1) for both the "Buckman Well Field" input sheet and any added pumping sheet should not be altered
- Generic *Excel* worksheets can be added and deleted, e.g., for additional spreadsheet calculations, without affecting model calculations
- The maximum allowable simulation period is 600 months (50 years)

Model Testing

The SURFS model was tested against simulations of the City groundwater numerical model. Two test simulations were used: one with irregular pumping patterns for 10 years on, 10 years distributed evenly over three wells only (Buckman 1, 7, and 8). The second test case involves pumping at all wells at irregular patterns, again for 10 years on followed by 10 years off. Pumping rates for the two test cases are provided in Table F-10. Results of the tests are shown in Figures F-18 and F-19. As can be seen, a very close match between the SURFS results and the numerical groundwater model results was achieved.

Table F-10 Model Testing Pumping Rates (AFY)

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yrs 11-20
Test 1:											
Buckman 1	33.3	66.7	100	33.3	66.7	100	33.3	33.3	66.7	66.7	0.0
Buckman 7	33.3	66.7	100	33.3	66.7	100	33.3	33.3	66.7	66.7	0.0
Buckman 8	33.3	66.7	100	33.3	66.7	100	33.3	33.3	66.7	66.7	0.0
Test 2:											
Buckman 1	33.3	100.0	166.7	33.3	100.0	166.7	33.3	100.0	166.7	33.3	0.0
Buckman 2	66.7	133.3	33.3	66.7	133.3	33.3	66.7	133.3	33.3	66.7	0.0
Buckman 3	66.7	133.3	33.3	66.7	133.3	33.3	66.7	133.3	33.3	66.7	0.0
Buckman 4	66.7	133.3	33.3	66.7	133.3	33.3	66.7	133.3	33.3	66.7	0.0
Buckman 5	100.0	100.0	300.0	100.0	100.0	300.0	100.0	100.0	300.0	100.0	0.0
Buckman 6	150.0	100.0	200.0	150.0	100.0	200.0	150.0	100.0	200.0	150.0	0.0
Buckman 7	33.3	100.0	166.7	33.3	100.0	166.7	33.3	100.0	166.7	33.3	0.0
Buckman 8	33.3	100.0	166.7	33.3	100.0	166.7	33.3	100.0	166.7	33.3	0.0
Buckman 9	150.0	100.0	200.0	150.0	100.0	200.0	150.0	100.0	200.0	150.0	0.0
Buckman 10	300.0	100.0	500.0	300.0	100.0	500.0	300.0	100.0	500.0	300.0	0.0
Buckman 11	400.0	300.0	300.0	400.0	300.0	300.0	400.0	300.0	300.0	400.0	0.0
Buckman 12	200.0	400.0	200.0	200.0	400.0	200.0	200.0	400.0	200.0	200.0	0.0
Buckman 13	100.0	200.0	100.0	100.0	200.0	100.0	100.0	200.0	100.0	100.0	0.0

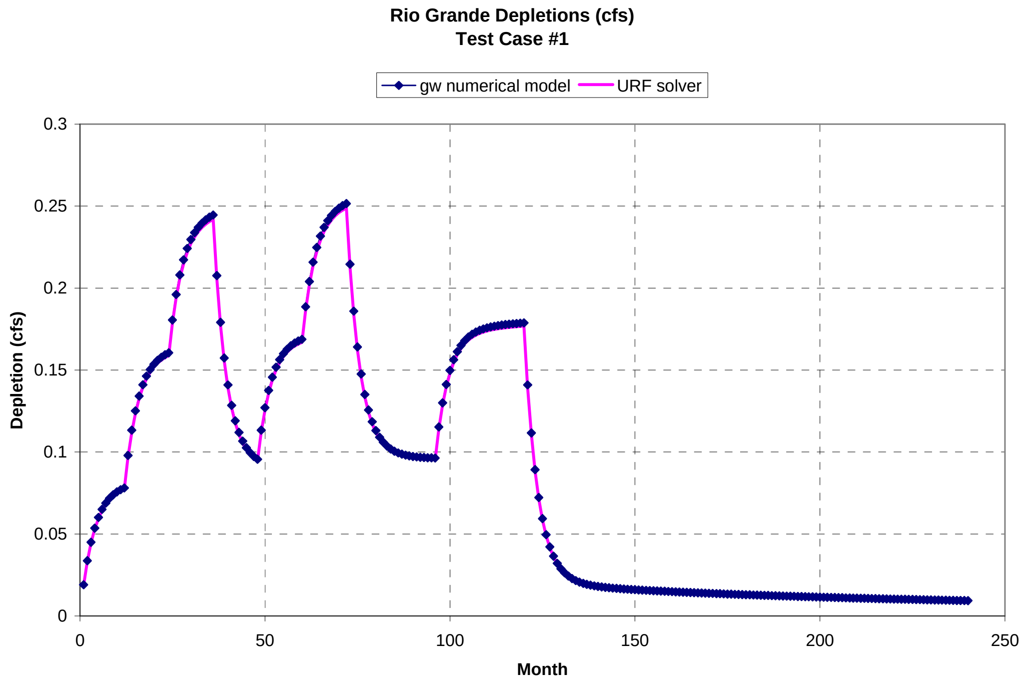


Figure F-18a

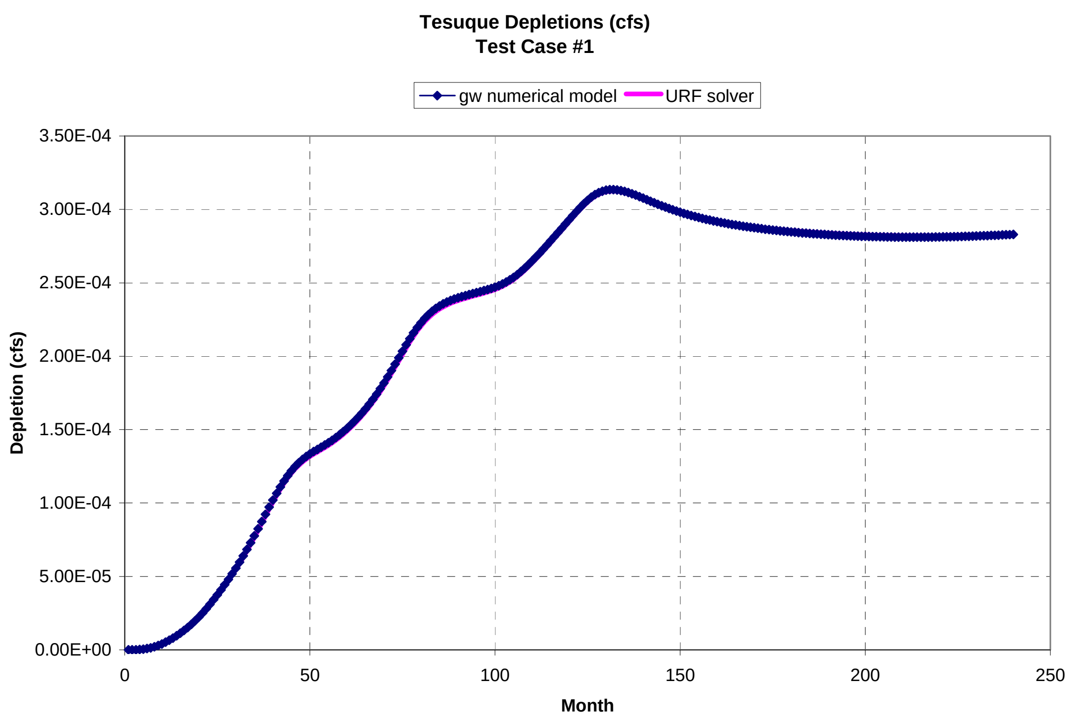


Figure F-18b

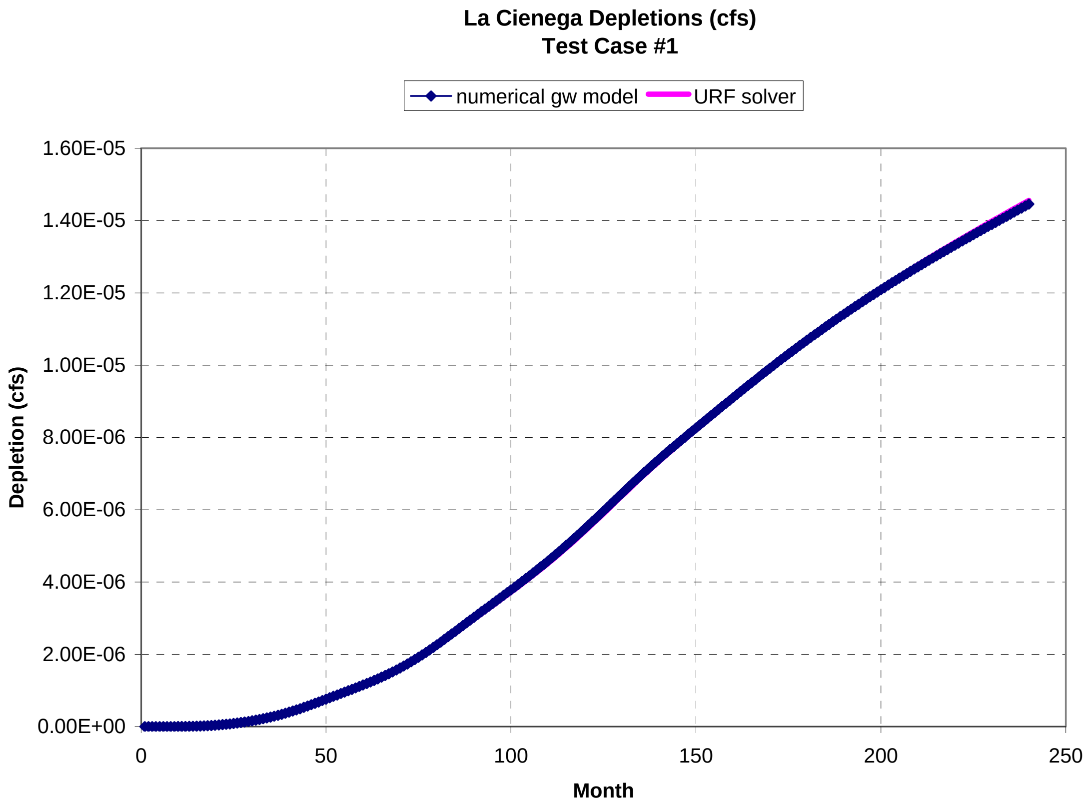


Figure F-18c

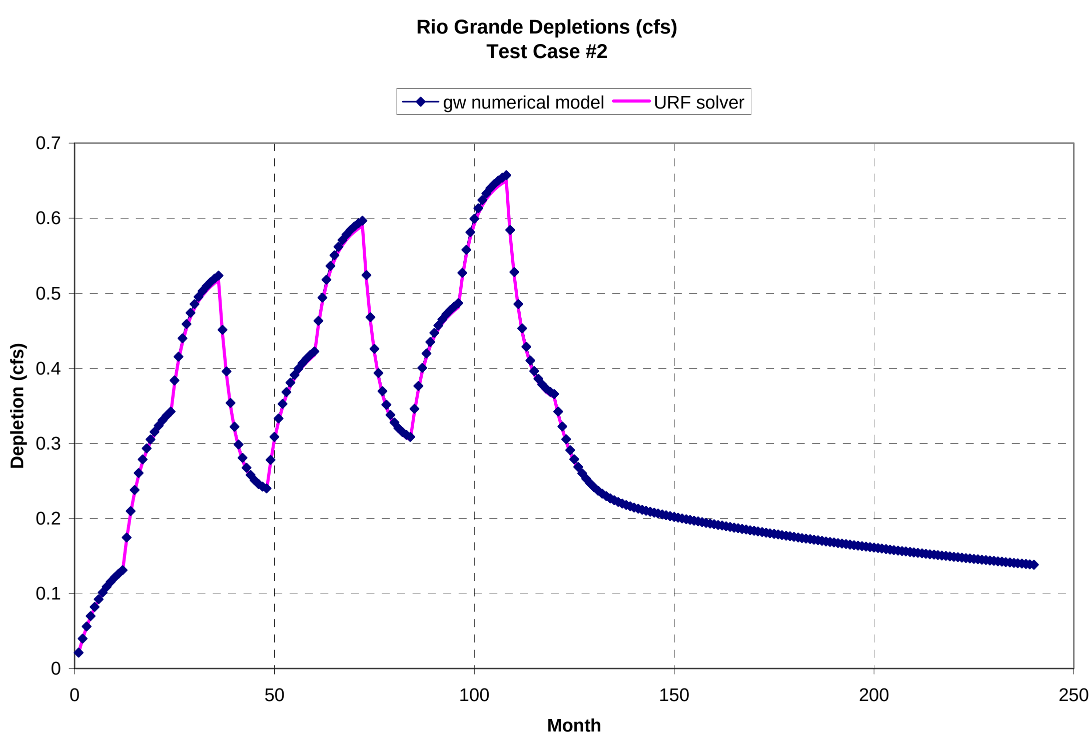


Figure F-19a

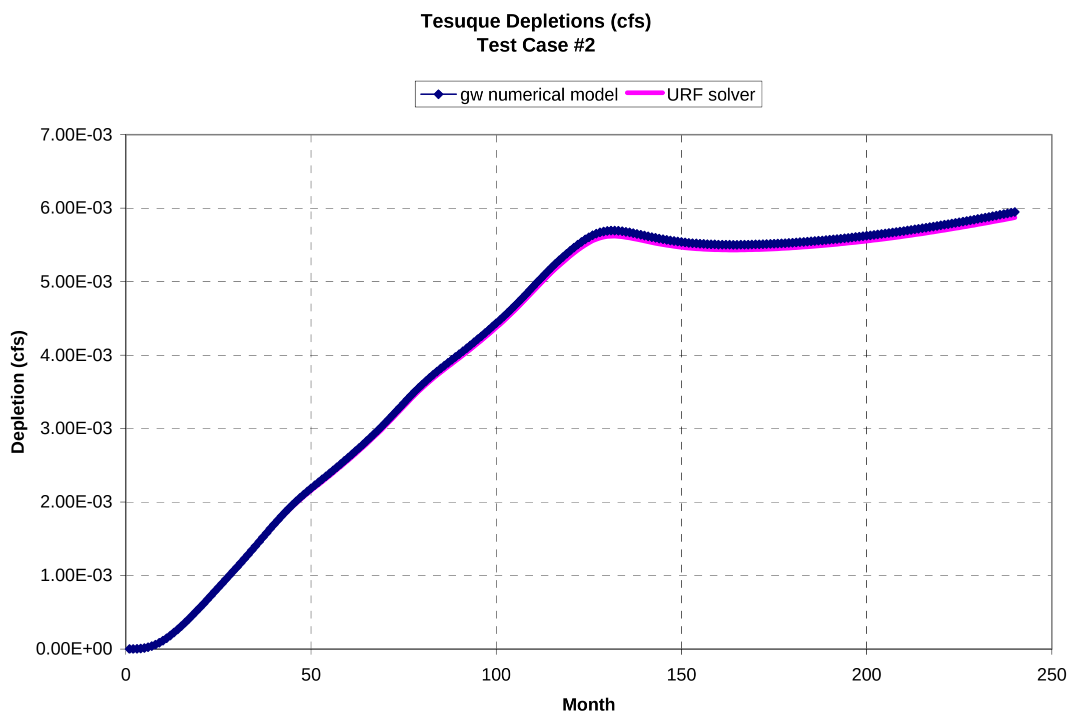


Figure F-19b

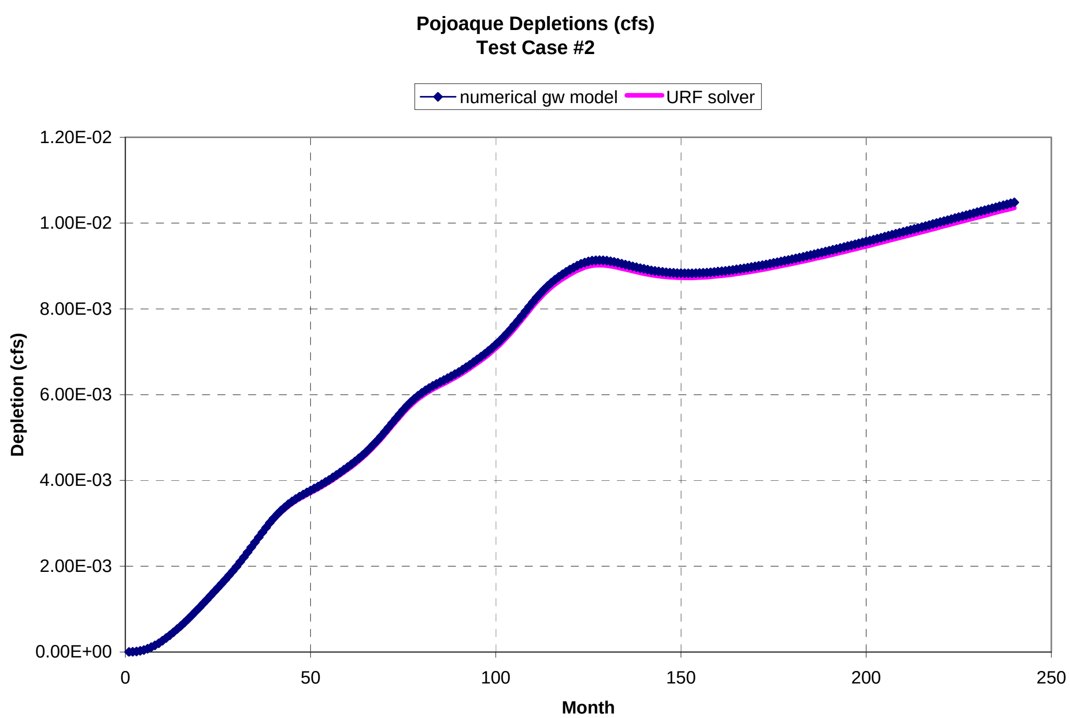


Figure F-19c

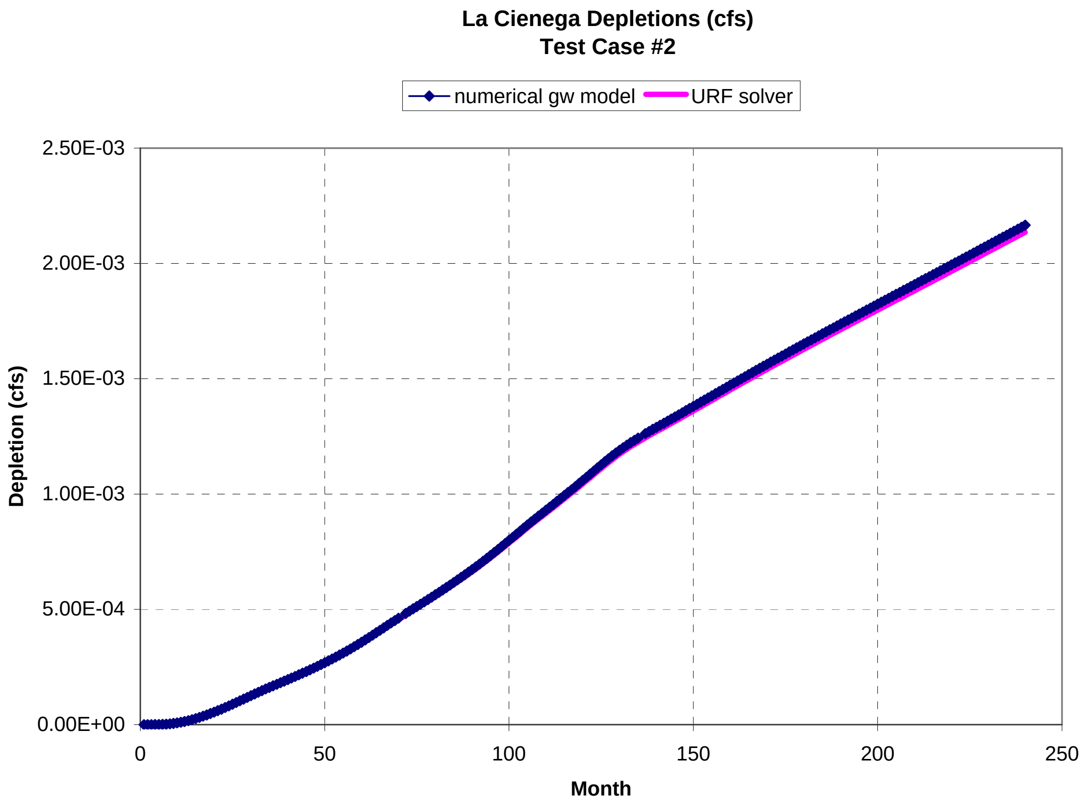

La Cienega Depletions (cfs)
Test Case #2
numerical gw model
URF solver
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
Depletion (cfs)
0
50
100
150
200
250
Month

Figure F-19d

Appendix G Portfolios Development and Evaluation

A water supply portfolio is a combination of existing supplies plus one or more new supply options (including demand management options). Initial efforts to compile supply portfolios were directed at eliminating the projected 5,500 AFY gap between existing (with BDD online) drought year supplies and 2045 demands (Appendix D).

This appendix presents the following materials:

- Development of portfolios
- Description of portfolios
- Results of portfolio scoring and ranking

The preferred water supply portfolio, based on direction received from the City's governing body, was a blend of the best-scoring portfolios from this evaluation. Further information about the preferred portfolio, and implementation thereof, is presented in the main body of this Water Plan's report. As noted in Appendix B, the portfolios evaluation process was used to illuminate tradeoffs and facilitate discussion, but was not used as the sole basis of decisionmaking.

G.1 Development of Portfolios

Seven initial portfolios were identified and developed, based on the following themes:

- Maximize use of existing infrastructure (Portfolios 1 through 3)
- Objective-based portfolios (seeking to identify the portfolios that would score best for a given objective; Portfolios 4 through 6)
- Source-based (to demonstrate performance of a portfolio that includes return flow credits; Portfolio 7)

Portfolios 1 through 3 were developed using the judgment of the planning team, as validated through public input and governing body review. The objective-based portfolios were developed by:

- Assigning preliminary scores to each of the 18 options for that objective
- Ranking the 18 options relative to how they scored for that objective
- Adding up the yield of the top-scoring options, until the 5,500 AFY gap was satisfied by the top-scoring one, two, or more options

The preliminary scoring used in developing the three objective-based portfolios is documented in Tables G-1 through G-3.

Once compiled, the seven preliminary portfolios were evaluated using the process described in Appendix B. The results of that analysis suggested that higher-scoring portfolios might be crafted by modifying and combining certain components of the initial seven portfolios. Four "hybrid" portfolios were crafted on the basis of those analyses.

A brief description of each of the seven initial and four hybrid portfolios follows. Key elements common to all portfolios included:

- Additional Rio Grande (native or SJC) rights assumed available if needed
- "Original" BDD delivers 5,230 AFY to City with minimum daily flow of about 5 mgd
- No "instantaneous" BDD capacity is added (peak capacity of diversion, conveyance, treatment)
- Jicarilla Apache Nation SJC water is dedicated to offsetting Buckman Well pumping depletions on Rio Grande

Table G-1 Options Scoring for Low Cost Portfolio

SORTED BY COST SCORE

Option No.	LRWSP Option Name	Cost ($/AF)	Yield (AFY)	MANAGE COSTS: $/AF score	MANAGE COSTS: Outside Funding score	MANAGE COSTS: Weighted Cost Score	MANAGE COSTS: Weighted Cost Score Rank
	Performance Measure Relative Weight (%) -->			*80*	*20*		
2	Reduce Per-Capita Demand to 110 gpcd via Temporary Emergency Drought Management	$146	2,734	5	2	**4.4**	**1**
8	Increase Use of Existing St. Michael's Well	$121	244	5	2	**4.4**	**1**
9	Intensive Pumping of Existing Buckman Wells	$124	5,000	5	1	**4.2**	**3**
10	Rehabilitate City Wells to Increase Production	$484	1,865	4	3	**3.8**	**4**
1	Reduce Per-Capita Demand to 120 gpcd with More Aggressive Conservation Measures	$805	1,367	3	4	**3.2**	**5**
15	Return Flow Credit and Increased Use of BDD with No New BDD Infrastructure	$734	5,500	3	4	**3.2**	**5**
4	Increased Use of BDD with No New Infrastructure	$960	5,500	3	3	**3.0**	**7**
6	Conjunctive Use of Local Surface and Groundwater Rights	$672	640	3	3	**3.0**	**7**
7	Recharge Groundwater Using Rio Grande Water from BDD with No New BDD Infrastructure	$1,864	5,500	2	4	**2.4**	**9**
14	Augment Santa Fe River Flow through Town with Effluent	$1,910	1,358	2	4	**2.4**	**9**
11	Purchase and Rehabilitate Existing Private Wells	$1,592	150	2	3	**2.2**	**11**
13	Recharge City Wells with Effluent via Injection Wells	$1,576	1,000	2	3	**2.2**	**11**
16	Collector Wells at San Ildefonso	$1,423	5,500	2	3	**2.2**	**11**
17	Deep Wells in Caja del Rio Area	$1,541	3,000	2	2	**2.0**	**14**
12	Additional Landscape Irrigation with Effluent	$2,962	523	1	4	**1.6**	**15**
5	Augment Santa Fe River Flow Recharge with Canyon Reservoir Releases		0	1	3	**1.4**	**16**
3	Increase Storage Capacity in Santa Fe River Canyon	$3,772	100 (est.)	1	2	**1.2**	**17**
18	New Imported Water from Unspecified Distant Source(s)	$2,154	5,500	1	2	**1.2**	**17**

Aquifer Storage & Recovery
Coarse Screening (Draft Report 6/04)
Groundwater
Return Flow Credit
Rio Grande
Surface Water

Table G-2 Options Scoring for Maximum Water in Santa Fe Basin Portfolio

SORTED BY ENV / QUALITY OF LIFE SCORE

Option No.	LRWSP Option Name	Yield (AFY)	ENVIRONMENT / QUALITY OF LIFE: Surface water flows	Protect local-regional env.	Accept-ability/ quality of life	Weighted Env/QOL Score	Weighted Env/QOL Score Rank
	Performance Measure Relative Weight (%) -->		*33.33*	*33.33*	*33.33*		
5	Augment Santa Fe River Flow Recharge with Canyon Reservoir Releases	0	5	5	5	**5.0**	**1**
6	Conjunctive Use of Local Surface and Groundwater Rights	640	4	5	3	**4.0**	**2**
8	Increase Use of Existing St. Michael's Well	244	3	5	3	**3.7**	**3**
4	Increased Use of BDD with No New Infrastructure	5,500	2	5	4	**3.7**	**3**
14	Augment Santa Fe River Flow through Town with Effluent	1,358	4	2	4	**3.3**	**5**
1	Reduce Per-Capita Demand to 120 gpcd with More Aggressive Conservation Measures	1,367	3	5	2	**3.3**	**6**
2	Reduce Per-Capita Demand to 110 gpcd via Temporary Emergency Drought Management	2,734	3	5	1	**3.0**	**7**
7	Recharge Groundwater Using Rio Grande Water from BDD with No New BDD Infrastructure	5,500	2	3	4	**3.0**	**7**
10	Rehabilitate City Wells to Increase Production	1,865	2	4	3	**3.0**	**7**
11	Purchase and Rehabilitate Existing Private Wells	150	3	3	3	**3.0**	**7**
12	Additional Landscape Irrigation with Effluent	523	2	3	4	**3.0**	**7**
9	Intensive Pumping of Existing Buckman Wells	5,000	2	3	2	**2.3**	**12**
15	Return Flow Credit and Increased Use of BDD with No New BDD Infrastructure	5,500	2	2	3	**2.3**	**12**
3	Increase Storage Capacity in Santa Fe River Canyon	100 (est.)	1	2	3	**2.0**	**14**
13	Recharge City Wells with Effluent via Injection Wells	1,000	2	2	2	**2.0**	**14**
16	Collector Wells at San Ildefonso	5,500	2	1	3	**2.0**	**14**
17	Deep Wells in Caja del Rio Area	3,000	2	1	2	**1.7**	**17**
18	New Imported Water from Unspecified Distant Source(s)	5,500	2	1	2	**1.7**	**17**

Aquifer Storage & Recovery
Coarse Screening (Draft Report 6/04)
Groundwater
Return Flow Credit
Rio Grande
Surface Water

Table G-3 Options Scoring for High Reliability & Sustainability Portfolio

SORTED BY RELIABILITY SCORE

Option No.	LRWSP Option Name	Yield (AFY)	IMPROVE RELIABILITY & SUSTAINABILITY			
			Availability in Drought	Sustain Aquifer (GW levels)	Weighted Reliability Score	Weighted Reliability Score Rank
	Performance Measure Relative Weight (%) -->		*50*	*50*		
7	Recharge Groundwater Using Rio Grande Water from BDD with No New BDD Infrastructure	5,500	5	5	**5.0**	**1**
13	Recharge City Wells with Effluent via Injection Wells	1,000	5	4	**4.5**	**2**
2	Reduce Per-Capita Demand to 110 gpcd via Temporary Emergency Drought Management	2,734	4	3	**3.5**	**3**
6	Conjunctive Use of Local Surface and Groundwater Rights	640	3	4	**3.5**	**3**
8	Increase Use of Existing St. Michael's Well	244	5	2	**3.5**	**3**
11	Purchase and Rehabilitate Existing Private Wells	150	5	2	**3.5**	**3**
12	Additional Landscape Irrigation with Effluent	523	4	3	**3.5**	**3**
15	Return Flow Credit and Increased Use of BDD with No New BDD Infrastructure	5,500	4	3	**3.5**	**3**
1	Reduce Per-Capita Demand to 120 gpcd with More Aggressive Conservation Measures	1,367	3	3	**3.0**	**9**
5	Augment Santa Fe River Flow Recharge with Canyon Reservoir Releases	0	1	5	**3.0**	**9**
10	Rehabilitate City Wells to Increase Production	1,865	5	1	**3.0**	**9**
14	Augment Santa Fe River Flow through Town with Effluent	1,358	1	5	**3.0**	**9**
17	Deep Wells in Caja del Rio Area	3,000	5	1	**3.0**	**9**
18	New Imported Water from Unspecified Distant Source(s)	5,500	4	2	**3.0**	**9**
4	Increased Use of BDD with No New Infrastructure	5,500	2	3	**2.5**	**15**
9	Intensive Pumping of Existing Buckman Wells	5,000	4	1	**2.5**	**15**
16	Collector Wells at San Ildefonso	5,500	2	3	**2.5**	**15**
3	Increase Storage Capacity in Santa Fe River Canyon	100 (est.)	2	2	**2.0**	**18**

Aquifer Storage & Recovery
Coarse Screening (Draft Report 6/04)
Groundwater
Return Flow Credit
Rio Grande
Surface Water

- Current amount of contract effluent use (about 1,050 AFY) continued indefinitely for nonpotable needs, unless nonpotable reuse is increased via inclusion of Option 12
- Buckman Well pumping limited to 5,000 AFY in any given year, except those portfolios that include Intensive Pumping of Buckman Wells option
- Portfolios that limit Buckman Well pumping to 5,000 AFY have the ability to pump an additional 5,000 AFY under emergency conditions, providing increased reliability
- Additional tributary offsetting rights assumed available if needed; costs for additional tributary rights not included in any portfolio, but tributary impacts accounted for in portfolio scoring

G.2 Description of Portfolios

Descriptions of each portfolio are provided below. Table G-4 provides a "quick reference" for the seven initial and four hybrid portfolios.

G.2.1 Portfolios Emphasizing Use of Existing Infrastructure

Portfolio 1: Intensive Pumping of Existing Buckman Wells

Evaluates the intensive use of Buckman Wells as the only "new" component for meeting future needs. Pumping is allowed up to the permit maximum of 10,000 AFY (8.9 mgd).

- Options Included: #9 (Intensive Pumping of Existing Buckman Wells)
- Source of Water & Rights: Existing Buckman Well Field and offsetting rights

Portfolio 2: Demand Management

Evaluates the use of additional conservation measures (reducing demand to 120 gpcd, including irrigation demands, at all times) and implementing drought management measures (reducing demand an additional 10 gpcd temporarily to 110 gpcd) in very dry years to offset potential deficits in those years.

- Options Included: #1 (Conservation) and #2 (Drought Management)
- Source of Water & Rights: Existing rights plus demand management

Portfolio 3: Increased Use of BDD with New Rio Grande Rights

Includes purchase of water rights but no new infrastructure. BDD would be used to deliver up to an additional 5,500 AFY using its original configuration, during times when the peak BDD capacity would otherwise not be needed.

- Options Included: #4 (Increased Use of BDD with New Rio Grande Rights)
- Source of Water & Rights: Purchase 5,500 AFY of new Rio Grande rights at $10,000/AF

G.2.2 Objective-Based Portfolios

Portfolio 4: Low Cost

Seeks the least-expensive way to meet 2045 demands. Based on the least expensive individual options, calculated as the present value of capital and annual O&M costs divided by expected yield for a given option.

- Options Included: #2 (Drought Management), #8 (St. Mikes), and #9 (Intensive Buckman Well Pumping)
- Source of Water & Rights: Existing rights plus demand management

Table G-4
Portfolio Quick Reference

	Option	Water Yield (AFY)	Unit Cost (AF/Yield) ($/AF)	Option Cost Rank (1=low cost)	Portfolio: 1: Buckman Wells	2: Demand Mgt.	3: Increase BDD Use w/new Rights	4: Low Cost	5: Max. Water in Santa Fe Basin	6: High Reliability/ Sustain-ability	7: Increase BDD Use w/Return Flow Credits	Hybrid Portfolio: A: Maximize Existing	B: BDD w/New Rights & Return Flow Credits	C: Max. Water in Santa Fe Basin	D: Max. Existing plus Santa Fe River Releases
					Max. Use of Existing Infrastructure			Objective-Based Portfolios			Source-Based	Based on Port. 2	Based on Port. 3 & 7	Based on Port. 5 & 6	Port. A + Resv. Releases
Demand Management															
1	Reduce Per-Capita Demand to 120 gpcd with More Aggressive Conservation Measures	1,367	$805	7		✓						✓			✓
2	Reduce Per-Capita Demand to 110 gpcd via Temporary Emergency Drought Restrictions	1,367 - 2,734	$146	3		✓		✓				✓			✓
Expand or Modify Use of Existing Surface Water Resources															
3	Increase Storage Capacity in Santa Fe River Canyon	100 (est.)	$3,772	17											
4	Increased Use of BDD with No New Infrastructure	5,500	$960	8			✓		✓				✓	✓	
5	Create "Living" Santa Fe River with Canyon Reservoir Releases	0	--	--					✓					✓	✓
6	Conjunctive Use of Local Surface and Groundwater Rights	640	$672	5					✓					✓	
7	Recharge Groundwater Using Rio Grande Water from BDD with No New BDD Infrastructure	5,500	$1,864	13						✓				✓	
Expand or Modify Use of Existing Ground Water Resources															
8	Increased Use of Existing St. Michaels Well Capacity	244	$121	1				✓	✓			✓	✓	✓	✓
9	Intensive Pumping of Existing Buckman Wells	5,000	$124	2	✓			Partial				✓			✓
10	Rehabilitate City Wells to Increase Production	1,865	$484	4											
11	Purchase and Rehabilitate Existing Private Wells	150	$1,592	12											
Expand Reuse of Wastewater Effluent															
12	Additional Landscape Irrigation with Effluent	523	$2,962	16											
13	Recharge City Wells with Effluent via Injection Wells	1,000	$1,576	11											
14	Augment Santa Fe River Flow through Town with Effluent	1,358	$1,910	14											
15	Return Flow Credit and Increased Use of BDD with No New BDD Infrastructure	5,500	$734	6							✓		✓		
	Effluent Contracts at Existing Levels of Use	1,050	--	--	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
New Sources															
16	Collector Wells at San Ildefonso	5,500	$1,423	9											
17	Deep Wells in Caja del Rio Area	3,000	$1,541	10											
18	Imported Water Requiring Treatment	5,500	$2,154	15											
Additional Options Used in Hybrid Portfolios															
	Expanded BDD Use in Dry Year Pulling Water from SJC Storage	Portfolio Dependent	--	--								✓	✓		✓
	Additional Effluent Contracts for Major Nonpotable Users, up to a total of 12 gpcd	580	--	--								✓	✓		✓

Portfolio 5: Maximum Water in the Santa Fe Basin

Compilation of the options that, when scored individually, best met the environmental and acceptability/quality of life performance measures. Includes increased use of existing infrastructure, plus flow in the Santa Fe River through town (1000 AFY, or 5 cfs for 100 days/ year). Conjunctive use includes increased use of Santa Fe River source in wet years (above existing 5,040 AFY rights) and rehabilitation of one City Well to increase production by 500 AFY in dry years.

- Options Included: #4 (Increased Use of BDD), #5 (Canyon Releases to SF River), #6 (Conjunctive Use), and #8 (St. Mikes)
- Source of Water & Rights: Purchase 5,500 AFY of new Rio Grande rights at $10,000/AF

Portfolio 6: High Reliability / Sustainability

Similar to Portfolio 3 (increased use of BDD to deliver up to 5,500 AFY of additional Rio Grande rights), except that this portfolio also includes the ability to recharge groundwater in the City Well Field via a new 6.6-mile pipeline from the MRC WTP to a series of 19 two-directional ASR wells. Allows recharge when overall system supplies exceed demands and withdrawal in dry years. May provide some additional reliability with respect to institutional constraints (e.g., minnow) on use of Rio Grande water.

- Options Included: #7 (Recharge Groundwater using New Rio Grande Rights via Increased Use of BDD)
- Source of Water & Rights: Purchase 5,500 AFY of new Rio Grande rights at $10,000/AF

G.2.3 Source-Based Portfolio

Portfolio 7: Return Flow Credits with Increased Use of BDD

Similar to Portfolio 3 (increased use of BDD to deliver up to 5,500 AFY of additional Rio Grande rights), except that this portfolio does not involve the purchase of Rio Grande water rights. Instead, a new pipeline and pump station are constructed and operated to return up to 5,500 AFY of treated effluent from the WWTP to a point just downstream of the BDD.

- Options Included: #15 (Return Flow Credit and Increased Use of BDD)
- Source of Water & Rights: Up to 5,500 AFY of treated wastewater effluent piped to Rio Grande as exchange for over-diversion of Rio Grande water via BDD

G.2.4 Hybrid Portfolios

Hybrid Portfolio A: Maximize Existing Sources and Infrastructure

Based on Portfolio 2 (Demand Management), plus expanded use of other existing sources. These include increased use of St. Michael's Well, intensive pumping of the Buckman Wells, using the BDD to divert and treat stored SJC water in dry years, and expanded contract effluent use up to a total of 12 gpcd.

- Options Included: #1 (Conservation), #2 (Drought Management), #8 (St. Mikes), #9 (Intensive Buckman Well Pumping), use of BDD to divert stored SJC water in dry years, and expanded effluent contracts
- Source of Water & Rights: Existing rights plus demand management; increased effluent use

Hybrid Portfolio B: Maximize Use of BDD with New Rights and Return Flow Credits

Based on Portfolio 3 (increased use of BDD to deliver up to 5,500 AFY of additional Rio Grande rights) and Portfolio 7 (Return Flow Credits) to use the BDD (without new BDD infrastructure) as the primary source of meeting future increases in demand. Also includes using the BDD to divert and treat stored SJC water in dry years and expanded contract effluent use up to 12 gpcd.

- Options Included: #4 (Increased Use of BDD with New Rio Grande Rights), #8 (St. Mikes), #15 (Return Flow Credit and Increased Use of BDD), use of BDD to divert stored SJC water in dry years, and expanded effluent contracts
- Source of Water & Rights: Existing rights plus purchase 500 AFY of new Rio Grande rights at $10,000/AF; treated wastewater effluent piped to Rio Grande as exchange for over-diversion of Rio Grande water via BDD

Hybrid Portfolio C: Maximize Water in the Santa Fe River Basin

Based on Portfolio 5 (Quality of Life) and Portfolio 6 (ASR). Seeks to maximize the amount of water brought into and maintained within the Santa Fe River basin.

- Options Included: #4 (Increased Use of BDD), #5 (Canyon Releases to SF River), #6 (Conjunctive Use), #7 (Recharge Groundwater using New Rio Grande Rights via Increased Use of BDD), and #8 (St. Mikes)
- Source of Water & Rights: Purchase new Rio Grande rights at $10,000/AF

Hybrid Portfolio D: Maximize Existing Sources and Infrastructure plus Water in SF River

Based on Hybrid Portfolio A, plus releases from reservoirs for water in the Santa Fe River. It originally included the ability to divert new Rio Grande rights through increased use of the BDD, though this was not observed to be necessary through WaterMAPS modeling and was therefore eliminated.

- Options Included: #1 (Conservation), #2 (Drought Management), #5 (Canyon Releases to SF River), #8 (St. Mikes), #9 (Intensive Buckman Well Pumping), use of BDD to divert stored SJC water in dry years, and expanded effluent contracts
- Source of Water & Rights: Existing rights plus demand management

G.3 Results of Portfolio Scoring and Ranking

Raw performance scores for each portfolio and each performance measure are tabulated in Table G-5. The weighted scoring of portfolios is presented in Figure G-1, based on the governing body's objective weighting results (see Appendix C). This figure shows the results with a breakdown by objective. Objectives weighted heavily and with high raw scores for a given portfolio score well (large component to that portion of the "stacked" bar in the bar chart). Those objectives not weighted heavily and/or with low raw scores will not contribute significantly to the portfolio's overall score.

Similarly, the overall results using the self-selected public participants' objective weightings are provided in Figure G-2.

Observations evident from inspection of Figures G-1 and G-2 include the following with respect to the portfolios scoring results:

- Overall portfolio scoring and ranking was relatively consistent between the Governing Body and the public participants' objective weighting profiles, even though the reasons behind those scores differed in many cases.
- Portfolios 1, 6, 7, B, and C scored poorly, for both the Governing Body and the Public Participants' objectives weighting profiles. These portfolios were not considered further.
- The hybrid portfolios (A through D), intended to combine components of the best-scoring initial seven portfolios, in some cases scored worse than the initial portfolios they were based on.

Raw Portfolio Scores

Table G-5 Raw Performance of the Portfolios

Objectives	Sub objectives	Performance Measures	Portfolios 1: Intensive Buckman Wells	2: Demand Mgt	3: Incr. BDD Use w/new Rts	4: Low Cost	5: Max Water in SF Basin	6: High Reliability/ Sustain'ty	7: RFC via Increased BDD Use	A: Improved Demand Mgt	B: BDD use	C: Santa Fe Basin	D: A&Releases
1) Manage Costs	Manage costs and rate impacts	$/AF of the portfolio (from WaterMAPS)	401	650	1040	418	1018	1100	719	581	1056	1214	572
	Maximize outside funding opportunities	Potential for Outside Funding Score	1	4	2	2	4	5	3	4	3	5	4
2) Improve Reliability and Sustainability	Sustainably manage the aquifer to ensure groundwater availability for dry periods	Average drawdown in a 40-year period for the Buckman Well Field (ft)	89	86	44	92	47	71	34	80	44	31	80
		Average drawdown in a 40-year period for the City Well Field (ft)	60	47	24	58	20	33	16	32	21	16	32
	Meet demands under different hydrology conditions	2045 driest hydrology reserve capacity	6,403	10,595	10,554	7,309	10,585	16,057	10,494	6,240	11,195	10,585	5,871
		Percent occurrence of deficits under different hydrology conditions	53%	37%	0%	0%	0%	10%	0%	0%	0%	0%	10%
3) Ensure Technical Implementability	Use technology appropriate for Santa Fe resources	All portfolios will use appropriate technology	0	0	0	0	0	0	0	0	0	0	0
	Maintain or improve water quality	Water Quality Score based on avg. conc. of constituents of concern in 2045	2	2	2	2	2	2	2	2	2	2	2
4) Protect the Environment	Protect local and regional environment	Protect local-regional env. (non-water) score	2	5	5	4	4	3	2	4	2	3	4
	Sustain existing river, tributaries and La Cienega	Surface water flows score	1	3	2	2	3	2	2	2	1	2	4
5) Ensure Acceptability	Ensure overall public and institutional acceptance	Public and institutional acceptance score	2	3	4	3	5	5	3	3	4	5	4
		Acceptance due to aesthetics characteristics	1	2	5	1	5	1	5	2	3	4	2
	Reduce reliance on drought management stages	% of time Drought Mgt. stages needed or used	7%	36%	0%	7%	0%	0%	0%	0%	0%	2%	0%
	Increase Santa Fe River flows	Score for Santa Fe river flow	3	3	3	3	5	3	1	3	1	5	5
	Minimize impacts on water rights of other parties	Water rights issues score	1	5	4	2	3	5	2	3	1	4	3
6) Ensure Timeliness	Timeliness score	Timeliness score	3	3	3	3	3	3	3	3	3	3	3

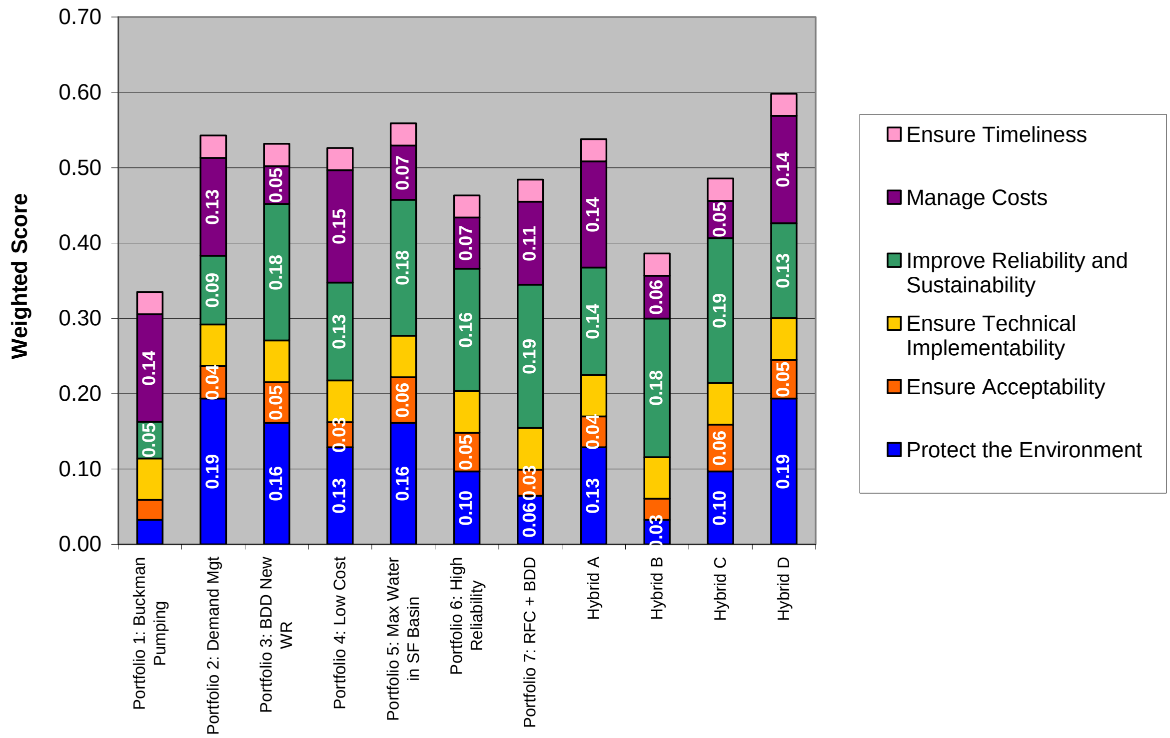


Figure G-1 Portfolio Scoring with Governing Body Weightings

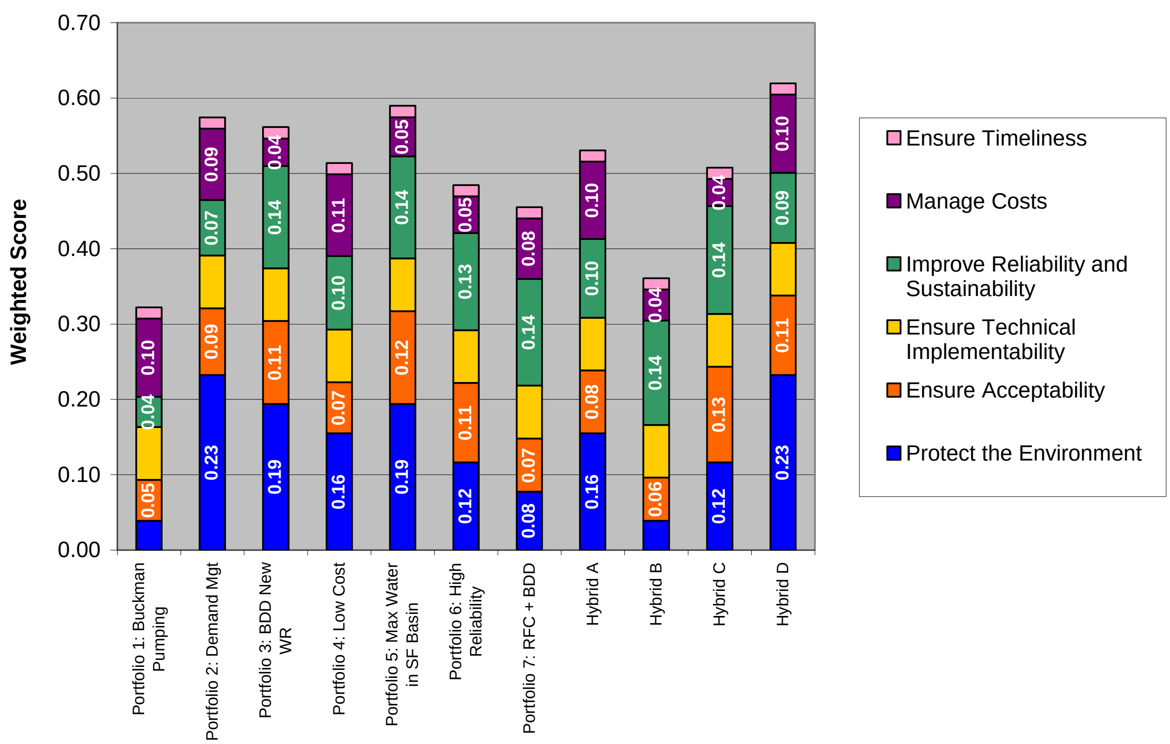


Figure G-2 Portfolio Scoring with Self-Selected Public Participants' Weightings

- Portfolios 3, 5, and D scored well for both the Governing Body weightings and the public participants' weightings. While not the top three highest scoring portfolios, they are among a group of similarly-performing portfolios, and represent three different major strategies.

The three strategies represented by Portfolios 3, 5, and D were brought forth to a January 18, 2006 study session of the City Council's PUC for feedback and direction. At the study session, the PUC directed Water Division staff to combine certain elements of each of these three portfolios, as further discussed in Section 1 of the main Water Plan report.

G.4 Additional Portfolio Information

This section presents additional information for each of the 11 portfolios analyzed. The following pages include standardized "fact sheets" for each portfolio, using information that was presented at the January 2006 Public Meeting No. 3 and the January 2006 PUC Study Session.

Appendix H Public Outreach and Input

H.1 Introduction

The City's Water Division actively sought public input throughout the planning process. The overall goal of the public communication effort was to inform the public about the City's water planning activities and garner public feedback, input, and support on the specific components of the Water Plan as it moved from early project stages toward implementation of the Water Plan. The public communication activities conveyed the following core messages:

- Santa Fe will be proactive in water management planning via this Water Plan and recent/pending water projects (i.e., "why" the City has undertaken the Water Plan)
- This Water Plan's goal is to identify the best mix of future sources and conservation measures to sustainably meet our community's forty-year needs (i.e., "what" the Water Plan is doing)
- Public is invited/encourage to participate in the Water Plan (i.e., "who" is encouraged to be involved)
- As a community, we need to identify a balanced source-of-supply portfolio that best meets competing objectives
- Water supply reliability hinges on having a diversified portfolio of groundwater and surface water

H.2 Overview of Public Communication Program Activities

The public communication activities were integral to developing the Water Plan. The activities consisted of fact sheets, public meetings, a meeting with public agencies, and involving PUC of the Santa Fe City Council.

In advance of the Water Plan, a series of public meetings was held in development of the Coarse Screening Analysis, feedback from which was shared with the PUC/Governing Body and considered in shaping the Coarse Screening results. The Coarse Screening resulted in 15 options ranked with respect to six weighted criteria.

Two color fact sheets were developed to keep the public informed of the progress of the Water Plan. These fact sheets were distributed at meetings, public buildings in Santa Fe, via a community e-mail contact list, and via the City's water utility website. Three public meetings were held in support of the Water Plan. The meetings focused on project objectives, future supply/demand "gaps," supply options, the WaterMAPS model, and the results of portfolio analyses. The meetings were advertised in the newspaper, discussed on various radio spots in advance of the meetings, announced through an e-mail distribution list, and posted on the City's website. The meetings were each attended by between about 30 and 70 participants.

Early in the Water Plan development process, the City conducted a Public Agency Meeting in Santa Fe to inform and engage representatives of other public agencies and governments with an interest in Santa Fe and regional water supply planning. Notes from the meeting were posted on the website. Finally, several presentations to, and one study session, was conducted with the PUC . The PUC is the primary mechanism through which the City's Governing Body was advised as to the progress of, and asked to provide input and decisions regarding, the Water Plan.

The public communication activities were intended to reach the following audiences: residents of Santa Fe County and Las Campanas, northern New Mexico pueblos, representatives of water supply sources, anti-growth interests, Aamodt group representatives, environmentalists, business interests, tourism/economic base interests, downstream users and competing interests, and water right holders/property owners.

An e-mail distribution list was established and used throughout the course of the Water Plan to distribute relevant materials and notify interested parties (public agencies, other governments, community interest groups, individuals with an expressed interest in water supply, etc.) of upcoming meetings and events.

H.2.1 Fact Sheets

Two color fact sheets and one black and white fact sheet were developed and distributed by the City at public meetings and at City discretion. The fact sheets are briefly summarized below:

- Fact Sheet 1: Completed in July 2005 and posted to the City's website. Includes overview of current supplies and infrastructure; projected demands and future supply "gaps"; supply options considered; objectives against which alternative supply portfolios were measured.
- Fact Sheet 2: Completed in January 2006 and posted to the City's website. Includes highlights of per capita demands; future water needs; objectives weighting results; summary of portfolio scoring results; and key policy questions.
- Water Plan Overview Fact Sheet: Prepared in December 2005 and posted to the City's website. Includes a broad overview of the Water Plan's goals and status.

Copies of these fact sheets are included at the end of this appendix. A final fact sheet is provided as the executive summary of this report.

H.2.2 Public Meetings

H.2.2.1 Public Agency Meeting

On September 20, 2004, the City conducted a Public Agency Meeting (PAM) in Santa Fe to inform and engage representatives of other public agencies and governments with an interest in Santa Fe and regional water supply planning. Attendees at the PAM included representatives from:

- Bureau of Land Management
- USDA Forest Service
- Staff of U.S. Representative Udall and U.S. Senators Bingaman and Domenici
- New Mexico Environment Department
- New Mexico State Land Office
- New Mexico Interstate Stream Commission
- Santa Fe County
- City of Española
- Tribal representatives

At that meeting, background information was presented to and discussed with the attendees. This included the Water Plan background and goals, Water Plan components (systems simulation modeling; long-range planning; public outreach), and project communications and schedule highlights.

The public agency participants were encouraged to continue to monitor the progress of the Water Plan, and were particularly encouraged to participate in the public meetings.

H.2.2.2 Public Meetings

Three public meetings were held in support of the Water Plan. The goals for the public meetings included:

- Providing an open forum to promote two-way communication regarding the proposed Water Plan

- Fostering the public's confidence that portfolios are being developed in an open manner
- Addressing and integrating environmental and other community concerns into the supply portfolios
- Laying out the portfolios to meet community and stakeholder concerns
- Providing information that will assist in the promotion of public confidence and acceptance of the Water Plan, using graphically illustrated documents with layperson-level explanatory text as described under this task

The public was asked to provide input at each of the public meetings; this input was considered in shaping the evaluations and recommendations of the Water Plan. "One-on-one" discussions with the public were held during "open house" sessions immediately preceding Public Meetings 2 and 3. All PUC and Governing Body presentations on the Water Plan were also open to the public.

Public Meeting 1

This meeting was held by the City in order to inform citizens about the City's plans to secure a long-range water supply. A presentation was made that explained current sources for City water, drought impacts on the system, demand projections, and the schedule for developing the Long-Range Water Supply Plan. The presentation stressed the need for public input on the tradeoffs that will be necessary as decisions are made about water supplies. Growth, for instance, may clash with environmental protection; reliability of supplies may prove to be unaffordable; the need to conserve may infringe on quality of life. Public input was also requested on the six water supply and management objectives that were developed in the "Coarse Screening" phase of planning. These six objectives are: manage costs, improve reliability, ensure technical implementability, protect the environment, ensure acceptability, ensure expediency.

About 35 people attended the meeting and commented on the Water Plan, asked questions and gave suggestions to the planners and decisionmakers. The comments were on the following topics:

- Basis for population projections
- Reliability of sources of water, particularly SJC and Jicarilla Leased Water
- Extent of current City water rights
- Coordination with other local governments and within the City
- Existence of regional long-range planning
- Maintaining flow in the Santa Fe River
- Concern about water quality, particularly the potential for contaminants from LANL
- Role of the City in the Aamodt Settlement
- Education on the limitations of water use in arid regions
- Mining the aquifer as evidenced by lowering water levels
- Institute City growth controls to lessen demand
- Emphasize conservation
- Schedule implementing the Water Plan

City staff responded to all comments and concerns expressed, summarized in the meeting notes provided at the end of this appendix.

Public Meeting 2

This second public meeting was held by the City on July 21, 2005. The purpose of the meeting was to update citizens about the City's plans to secure a long-range water supply, and to hear response from the public. Presentations followed a half-hour open house where citizens could learn one-on-one about the aspects of the long-range water supply planning process.

Presentations covered progress to date and the next steps in the project:

- To analyze the individual supply and demand management options and apply the weighted objectives
- Identify the best-performing groups of supply and demand management options (supply "portfolios") that can meet Santa Fe's 2045 water needs
- Present these portfolios to the City's PUC and seek their input
- Present the draft plan to the public and seek their input
- Produce a Water Plan report in 2006

Interested attendees participated in the Paired Comparison to help weight the criteria that were applied to the options. Attendees also provided comments on the presentation, questions and suggestions to the planning team in the following areas:

- Basis of population projection
- Feasibility of desalinated water as a new water source
- Piping water from Abiquiu Reservoir
- Impact of pumping the Buckman Well Field
- Emphasis on conservation
- Reflecting pumping, streamflow, and water rights transfers in WaterMAPS model
- Coordination with Santa Fe County
- Consider treatment and direct reuse of effluent
- Institute growth controls to lessen
- Water supply planning and decisionmaking assisted by modeling and decision support tools
- City as a competitor in the water rights market
- Concern about water quality, particularly the potential for contaminants from LANL

City staff responded to all comments and concerns expressed, summarized in the meeting notes provided at the end of this appendix.

Public Meeting 3

The third public meeting was held on January 10, 2006. Primary goals of the third public meeting were to further explain and gather feedback from public participants on:

- Results of the portfolio analyses
- Rationale for modifying any of the initial portfolios, if applicable, and the associated changes in the results of the portfolios analysis
- Key policy questions that will shape the City's Water Plan
- Recommended components of the Water Plan

As with Public Meeting 2, a pre-public meeting "open house" period was held immediately preceding Public Meeting 3 to facilitate one-on-one dialogue and feedback.

Public feedback and discussion focused largely on the following items:

- Support for making a "living" Santa Fe River through town, even during droughts
- Interest in continuing to conserve water and use drought emergency restrictions when needed
- Concern over the interaction between growth and water supply needs
- Technical questions regarding the WaterMAPS model, costing, and evaluation of portfolios

City staff responded to all comments and concerns expressed, summarized in the meeting notes provided at the end of this appendix. Input from this public meeting was summarized and presented to the PUC's January 18, 2006 Water Plan Study Session.

H.3 Public Utilities Committee

The Santa Fe City Council is the City's governing body. For water supply issues, the City Council is advised by the PUC. The PUC makes recommendations for input and decisions regarding the Water Plan to the City Council. PUC meetings in which components of the Water Plan were presented and discussed included:

- July 21, 2004: Presentation and discussion regarding Water Plan goals, kickoff activities, tasks, schedule, and public communications plan
- March 2, 2005: Presentation and discussion regarding progress on WaterMAPS model and associated activities, long-range planning, and public communications and public agency meeting debriefs; description of anticipated future PUC interactions including request to conduct paired comparison exercise at April 6, 2005 PUC meeting.
- April 6, 2005: Presentation with a description of the role of objectives in portfolio analysis and explanation of the paired comparison exercise. Engaged PUC members (and other interested Councilors) in completing paired comparison exercise.
- June 1, 2005: Presentation and discussion regarding results of paired comparison exercise; presentation, demonstration, and discussion of WaterMAPS model
- December 7, 2005: Results of initial portfolio scoring and synopsis of public meeting #2 and associated input (e.g., public paired comparison results). Introduced major strategies centered around maximizing existing supplies and diverting additional rights through the BDD.
- January 18, 2006: Study session with synopsis of public meeting #3 input, discussion of portfolio scoring and tradeoffs, and input regarding policy decisions, implementing actions, and preferred portfolio for implementation.

H.4 Summary of Public Communications

Stakeholder input has been and will continue to be a critical component of long-range water supply planning for the City of Santa Fe. At key stages in the development of the Water Plan, input from the public, public agencies, and the Santa Fe City Council was sought. In addition to responding to questions and concerns expressed during meetings, members of the public were invited to participate in weighting the criteria used to evaluate the portfolios. Input received through these public forums directly shaped the outcome of the Water Plan. For example, strong support voiced in public meetings for providing water for Santa Fe River flows was reflected in the final portfolio selected for implementation. Similarly, the community's expressed willingness to pursue even higher levels of conservation was documented and incorporated into the final action plan that is documented in this report.

H.5 Attachments

Attached to this appendix are copies of key public outreach materials, provided in the following order:

- Fact Sheets 1 and 2, and Water Plan Overview Fact Sheet
- Public Agency Meeting summary
- Public Meeting No. 1 summary
- Public Meeting No. 2 summary
- Public Meeting No. 3 summary

Appendix I
Financial Implications and Assumptions

Although the Water Plan determined that the City's water needs could be met through 2045 without a major infrastructure project,securing the City's water supply for the next 40 years will require additional investments beyond those being made by the City and its regional partners in the BDD. As mentioned in Section 4, money will be needed for:

- Costs associated with enhanced conservation and reuse programs
- Purchasing additional Rio Grande rights, and/or constructing an effluent return flow credit pipeline, for diversion and treatment through the BDD system
- Offsetting the loss of raw water associated with Canyon Reservoir releases to the Santa Fe River

I.1 Operation and Maintenance Costs

In addition, the costs of operation and maintenance (O&M) of the City's water supply system will increase over time as demands increase. O&M costs will vary from year to year, depending on hydrologic conditions and the relative amount of water provided by each source in any given year.

Tables I-1 and I-2 present capital and O&M costs for two scenarios:

- **Scenario A:** Optimization of existing sources, enhanced conservation, and purchase of new Rio Grande rights for diversion and treatment through the BDD
- **Scenario B:** Same as Scenario A, except instead of purchasing new Rio Grande rights, the City would construct and use an effluent return flow credit pipeline and divert/treat additional exchanged water through the BDD

Key assumptions in developing Tables I-1 and I-2 include:

- Conservation enhancements are a capital project; those expenditures (estimated at about $18 million in 2005 dollars) will occur over a 20-year time period, beginning immediately, and will be equally divided over each of those 20 years
- Diversion and treatment of additional water through the BDD will be required some time between 2015 and 2020
- Water rights purchases and/or construction of the effluent return flow credit pipeline will require expenditures over a 4-year period, with 10 percent of the total expended in the first year and 30 percent of the total expended in each of the next 3 years

Table I-1 Capital and O&M Costs for Scenario A (Optimized Existing Sources and New Rights through BDD)

Year	O&M Existing Sources (2005 dollars)	Capital Cost (2005 dollars)	O&M New Sources (2005 dollars)
2005	$12,460,683		$210,037
2006	$12,610,218	$890,850	$280,231
2007	$12,961,715	$890,850	$352,530
2008	$12,938,516	$890,850	$426,998
2009	$14,375,290	$890,850	$503,700
2010	$14,535,321	$890,850	$582,704
2011	$14,462,308	$890,850	$664,077
2012	$14,564,437	$890,850	$747,892
2013	$14,592,923	$890,850	$834,221
2014	$14,556,131	$890,850	$923,140
2015	$14,608,599	$890,850	$1,014,726
2016	$14,610,154	$6,727,750	$1,109,060
2017	$14,622,195	$18,401,550	$1,206,224
2018	$14,752,149	$18,401,550	$1,306,303
2019	$15,757,110	$18,401,550	$1,409,385
2020	$15,825,142	$890,850	$1,515,558
2021	$15,986,693	$890,850	$1,624,917
2022	$15,961,577	$890,850	$1,737,557
2023	$16,062,904	$890,850	$1,853,576
2024	$16,796,859	$890,850	$1,973,076
2025	$16,802,484	$890,850	$2,096,160
2026	$16,813,801		$2,222,938
2027	$16,280,196		$2,353,518
2028	$16,561,280		$2,488,016
2029	$16,391,982		$2,626,549
2030	$16,650,099		$2,769,237
2031	$16,886,730		$2,916,207
2032	$16,663,832		$3,067,585
2033	$16,394,029		$3,223,505
2034	$16,689,407		$3,384,103
2035	$16,965,180		$3,549,518
2036	$16,751,534		$3,719,896
2037	$16,790,487		$3,895,385
2038	$16,863,517		$4,076,139
2039	$16,896,148		$4,262,315
2040	$16,928,683		$4,454,077
2041	$16,952,219		$4,651,592
2042	$16,992,750		$4,855,032
2043	$16,979,516		$5,064,575
2044	$17,016,036		$5,280,404

- **Scenario A:** Optimization of existing sources, enhanced conservation, and purchase of new Rio Grande rights for diversion and treatment through the BDD

Table I-2 Capital and O&M Costs for Scenario B (Optimized Existing Sources and Effluent Return Flow Credits through BDD)

Year	O&M Existing Sources (2005 dollars)	Capital Cost (2005 dollars)	O&M New Sources (2005 dollars)
2005	$12,460,683		$210,037
2006	$12,610,218	$890,850	$280,231
2007	$12,961,715	$890,850	$352,530
2008	$12,938,516	$890,850	$426,998
2009	$14,375,290	$890,850	$503,700
2010	$14,535,321	$890,850	$582,704
2011	$14,462,308	$890,850	$664,077
2012	$14,564,437	$890,850	$747,892
2013	$14,592,923	$890,850	$834,221
2014	$14,556,131	$890,850	$923,140
2015	$14,608,599	$890,850	$1,014,726
2016	$14,610,154	$3,600,950	$1,109,060
2017	$14,622,195	$9,021,150	$1,206,224
2018	$14,752,149	$9,021,150	$1,306,303
2019	$15,763,039	$9,021,150	$1,963,451
2020	$15,830,505	$890,850	$2,114,745
2021	$16,000,879	$890,850	$2,248,230
2022	$15,966,340	$890,850	$2,387,332
2023	$16,065,757	$890,850	$2,529,915
2024	$16,834,588	$890,850	$2,688,809
2025	$16,844,890	$890,850	$2,835,948
2026	$16,717,682		$2,987,450
2027	$16,284,150		$3,137,201
2028	$16,510,683		$3,303,197
2029	$16,395,648		$3,468,045
2030	$16,608,187		$3,642,683
2031	$16,936,816		$3,814,158
2032	$16,639,608		$3,994,186
2033	$16,246,216		$4,181,792
2034	$16,606,445		$4,374,125
2035	$17,018,413		$4,565,604
2036	$16,748,080		$4,772,242
2037	$16,462,804		$4,982,969
2038	$16,834,926		$5,196,972
2039	$16,870,160		$5,417,705
2040	$16,905,041		$5,645,073
2041	$16,937,076		$5,878,861
2042	$16,968,631		$6,119,920
2043	$16,992,260		$6,367,398
2044	$17,013,377		$6,621,740

- **Scenario B:** Same as Scenario A, except instead of purchasing new Rio Grande rights, the City would construct and use an effluent return flow credit pipeline and divert/treat additional exchanged water through the BDD

I.2 The Plan's Effect on Future Rates

Tables I-1 and I-2 were combined with other anticipated City Water Division expenditures to estimate the rate impacts of implementing the Plan's components. This analysis was based on application of the financial planning model that is currently used for the Water Division. The analysis conducted in this instance includes pre-existing information from the financial planning model and adds the scenario-based information above.

The purpose of the analysis was to determine the effects of each scenario on user rates over time.

The existing 2006 financial plan serves as a baseline for comparison as that plan contemplates no long-term supply investments consistent with either scenario. Figure I-1 summarizes the relative results with the 2006 financial plan baseline shown for comparison.

Neither Scenario A nor Scenario B is expected to cause significant changes in the projected demand on user charge revenues (i.e., revenues from users' rates). In the short-term, both scenarios will cause the projected increases to outpace those projected in the current 2006 plan. Both scenarios will require the City to implement a one-time adjustment of approximately 5 percent during the 2010 fiscal year, rather than a 2 percent increase as currently planned.

After 2010, Scenario A will require additional 2 percent annual increases to rates, while Scenario B will require increases of about 1.7 percent. The current plan shows needed increases of 1.5 percent from 2012 forward. Both Scenarios A and B will require only slightly higher increases than the baseline from approximately 2020 on.

Scenario A will likely require the City to issue additional debt sometime around 2018 to help offset the higher capital costs inherent in that supply option. The financial model sized the 2018 bond issue at approximately $22 million. Based on assumptions as to term structure and interest rates, it is estimated that the additional debt will increase the City's then outstanding debt service obligation from $6.4 million/year (includes debt service from revenue bonds only) to $7.8 million/year. Scenario B will not likely require the City to borrow additional money.

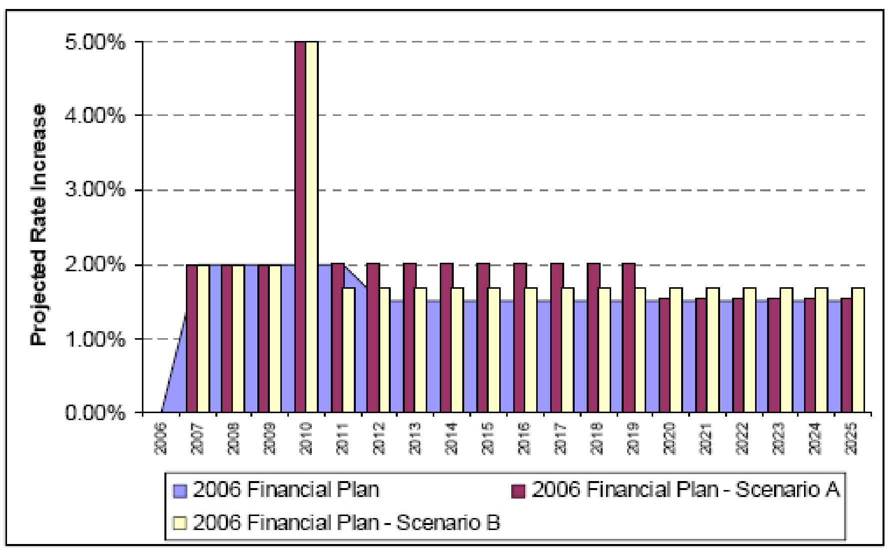


Figure I-1 Comparison of Rate Increases

I.3 Financial Plan Significant Assumptions

The financial plan is filled with a number of assumptions for the purposes of projecting revenues and expenditures. Material assumptions are listed below:

- Fiscal year convention – all years in the financial plan are provided in fiscal years that start July 1 and end June 30th of each year. Fiscal years shown in the model are shown for the fiscal year end. Thus the fiscal year 2006, for example, is for the fiscal year ending June 30, 2006, and so on.

- Capital improvements plan – It was assumed that all of the capital projects currently known and provided for in the 2006 financial plan will remain and there is absolutely no overlap in those project costs and the capital costs for the two scenarios analyzed. It was further assumed that the City's recurring capital costs beyond the current plan's 10-year horizon will be reduced to a $5 million/year (2005 dollars) renewal and replacement program consistent with the Water Division's estimate of the cost of such activity.

- O&M costs – It was assumed that the O&M costs in Tables I-1 and I-2 represent the sum total of the Water Division's supply costs for all years shown in the analyses. The financial planning model, though, is comprehensive and includes all O&M costs, including the supply costs as well as additional O&M costs related to administration and other Water Division departments.

- Inflation – All cost information was given in 2005 real dollars. Inflation estimates were applied for all periods in the analysis of 3 percent per year.

- System growth – Consistent with other financial analyses recently prepared for the City, including the current financial planning model and the Utility Expansion Charge (UEC) model, system growth is assumed at 1.5 percent per year.

- Debt – The existing financial plan already calls for two series of revenue bonds issued in 2007 and 2009 of $25 million and $36 million respectively. No changes to these bond packages were assumed. In certain cases, it was assumed the City would issue new debt when such issuance would be the lowest-cost alternative. For new debt issues, a bond term of 30-years, semi-annual payments, no reserve requirement, 1 percent issuance costs, and interest rates of 5.0 to 5.5 percent were assumed. It was assumed that all bonds would be issued in July of the fiscal year in which the proceeds are needed.

- Grants and contributions – The current financial plan specifies a number of grants and contributions that the City may use to offset specific capital costs. At present, the City can only project the receipt of such proceeds for 2006 and a limited amount for 2007 and 2008. Beyond 2008, it was assumed the City would receive no grants or similar contributions.

- Minimum cash balances – The financial plan is calibrated to a point where the City will not experience a cash balance below a pre-defined point. For the purposes of this analysis, the minimum fund balance constraints were kept at the same level used in the current financial plan, which is to say the same level used to support the issuance of the Water Division's series 2007 and 2009 revenue bonds. Specifically, the plan calls for the following minimum balances:

  - Operating fund: 60-days of average O&M expenses (calculated as total annual O&M costs divided by 365, times 60-days).

  - Capital reserve fund: $2 million.

  - Rate stabilization fund: the City has a goal to fund the rate stabilization fund at $10 million by 2014.

Appendix J

Updates Since the 2005 Analyses

This Water Plan was completed in two phases. The majority of the Water Plan's analyses were completed in 2005. The plan was not subsequently finalized because key state and federal permits for the BDD had not been reviewed. Since then, many key state permits for the BDD have been obtained and federal permitting is far enough along to warrant finalization of the Water Plan. In the interm, however, some assumptions originally used in the analaysis merited revising. This appendix identifies these changed assumptions and discusses how they have been incorporated into the current Water Plan.

The four main reconsiderations to the water supply planning process are:

- The continued reduction in per capita water consumption
- The changes of the City's emergency management stages
- The delay in the BDD project
- The increased understanding of the impacts of climate change on water supplies

Apart from the addition of this appendix and some minor explanatory changes to Appendix A and Appendix D, the appendices reflect the 2005 assumptions and analyses. However, the body of the Water Plan (Executive Summary and Sections 1 through 4) has been updated to reflect observed reductions in per capita water consumption, changes to the resulting projected water demand, and revisions to the BDD implementation schedule.

J.1 Reduction in Per Capita Water Use Rates

At the time of the 2005 analyses, the planning team chose a potable demand of 130 gpcd for projecting the future water needs of the City of Santa Fe. A thorough discussion on the per capita demand methodology is presented in Appendix D. At the time, although the per capita use was significantly lower, mandatory days of the week water use restrictions and high use rate surcharges had been in effect for the past 5 years. The planning team was conservative in estimating what level of conservation would be maintained once these use restrictions were rescinded. Because demand management was evaluated as one of many options for meeting the City's demands, baseline planning demands were intended to reflect conditions without mandatory water use restrictions.

However, since January 2007 and despite the lifting of outdoor water use restrictions, the City water customers have achieved an extraordinary degree of water conservation (see Figure 3-1). Hence, for the final Water Plan, the future water demand analyses has been modified to assume a potable demand of 110 gpcd. This change is reflected in Figure ES-1 and discussed more fully in Section 3 (e.g., Figure 3-1, Figure 3-4, and Figure 3-5). This additional level of conservation reduces the future gap between demand and supply from 5,500 AFY to 2,700 AFY, and delays the time when new water supplies are needed.

J.2 Changes to the Emergency Water Use Restrictions

In January 2007, the City implemented a new water emergency ordinance (Section 25-5 SFCC 1987 Water Emergency Management Plan), which changed the water emergency levels, implementation conditions, and water use restrictions. The emergency levels were changed from Stage 1-4 to Green, Orange, and Red. The criteria for entering water use restriction depends upon the ratio between operational water system supply and operational water system demand. Whereas Stage Green allows for unrestricted outdoor watering (but recommends 2 days/week), Stage Orange mandates only one day/week watering, and Stage Red does not allow any outdoor watering with potable supplies. The ordinance still requires numerous year-round water conservation measures that reflect and are respectful of Santa Fe's high-desert environment. More information on the current water conservation policies can be found at the City's web page at www.santafenm.gov.

With the adoption of the new regulation, the City went from 'Stage 2' to 'Green' on January 1, 2007, permitting the City's water customers unrestricted outdoor water use for the first time since 2002.

J.3 Delay in the Buckman Direct Diversion Project

At the time of the 2005 analyses, the BDD was scheduled to be online by 2008. Extensive federal permitting and complicated contract negotiations have shifted the schedule by 3 years to 2011. The appendices of this Water Plan still assume completion of the BDD by 2008, whereas the Water Plan itself has been adjusted to the current schedule.

J.4 Impact of Climate Change on the City's Water Supplies

Any water utility engaged in water supply planning today needs to consider the effect climate change will have on its water supplies. Although the current climate models have a high degree of uncertainty, climate change (especially the increase in inland temperature) is predicted to affect New Mexico water supply in the following ways (from Impacts of Global Warming on New Mexico Resources, http://agecon.nmsu.edu/bhurd).

- More precipitation will fall as rain rather than snow
- The Sangre de Cristo snowpack will decrease
- The melting of the snowpack will occur sooner, resulting in an earlier streamflow peak
- Evaporation will increase from surface water bodies
- Evapotranspiration will increase as the growing season is extended
- Soil moisture content will decrease
- Outdoor water demand will increase in parallel to a longer growing season

The City of Santa Fe's response to the water supply implications of climate change overlap with sound drought planning that have been addressed in the Water Plan (Section 1). Specifically, the City will:

- Optimize the use of its diverse water supply portfolio
- Reserve groundwater for drought
- Plan for extended droughts

In order to understand the full implications of climate change, the City is also currently engaged in the following actions:

- Using tree-ring studies to reconstruct a longer streamflow record on the Santa Fe River
- Incorporating climate model predictions and long-term streamflow records into the City's WaterMAPS model and associated long-range water supply planning
- Evaluating the use of alternative energies, including self-generated hydropower, to supply current water utility needs and as a criteria for evaluating future water supply alternatives
- Find solutions on a regional level (e.g., aquifer preservation and interregional planning efforts)
- Entering into proactive water supply and sharing-of-shortage agreements
- Evaluating water storage options (e.g., aquifer storage and recovery)
- Evaluating the efficacy of treating effluent to drinking water standards