Santa Fe Water Reuse Feasibility Study

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CITY OF SANTA FE / SANTA FE COUNTY

SANTA FE WATER REUSE FEASIBILITY STUDY

DRAFT
September 2016

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CITY OF SANTA FE / SANTA FE COUNTY

SANTA FE WATER REUSE FEASIBILITY STUDY

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This study builds on previous work conducted by the City of Santa Fe and Santa Fe County. Examples of previous studies that served as a foundation for this project include the City's 1998 Treated Effluent Management Plan, the City's 2008 Long Range Water Supply Plan, the City's 2013 Reclaimed Water Resource Plan, and the 2015 Bureau of Reclamation Santa Fe Basin Study developed in partnership with the City and County.

LIST OF ABBREVIATIONS AND ACRONYMS

AF	acre-foot
AFY	acre-feet per year
ASR	aquifer storage and recovery
ATW	advanced treated water
AWTF	advanced water treatment facility
BAC	biological granular activated carbon
BAF	biologically active filtration
Basin Study	Bureau of Reclamation 2015 Santa Fe Basin Study
BDD	Buckman Direct Diversion
bgl	below ground level
BLM	Bureau of Land Management
BOD	biochemical oxygen demand
BRWTF	Buckman Regional Water Treatment Facility
CCP	critical control point
COP	critical operating point
CEC	constituent of emerging concern
CDPH	California Department of Public Health
City	City of Santa Fe
cfs	cubic feet per second
Cl_2	chlorine
County	Santa Fe County
CRMWD	Colorado River Municipal Water District
CRWTF	Canyon Road Water Treatment Facility
DAF	dissolved air flotation
DBP	disinfection byproduct
DDW	State of California Department of Drinking Water
DO	dissolved oxygen
DPR	direct potable reuse
DWTF	drinking water treatment facility
EC	electrical conductivity
EfOM	effluent organic matter
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESB	engineered storage buffer
Feasibility Study	Santa Fe Title XVI Water Reuse Feasibility Study
FRT	failure response time
ft	feet
ft/day	feet per day
ft/sec	feet per second
GAC	granular activated carbon
GIS	geographic information system
gpm	gallons per minute
GWRS	Groundwater Replenishment System
HP	horsepower
in	inches
IPR	indirect potable reuse
JSAI	John Shomaker & Associates, Inc.
kgal/d	thousand gallons per day

LACSD	Los Angeles County Sanitation Districts
LF	linear foot
LRV	log removal value
LRWSP	Long Range Water Supply Plan (2008)
LT2	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	maximum contaminant level
MF	microfiltration
MFL	million fibers per liter
mgd	million gallons per day
mg/L	milligrams per liter
MPN/L	most probable number per liter
MRC	Municipal Recreation Complex
MSL	mean sea level
NA or N/A	not applicable
NDMA	N-Nitrosodimethylamine
NEPA	National Environmental Policy Act
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NPDES	National Pollutant Discharge Elimination System
NPR	non-potable reuse
NPV	net present value
NRC	National Research Council
NTU	nephelometric turbidity units
NWRI	National Water Research Institute
O&M	operation and maintenance
O_3	ozone
OCP	operational control point
OCWD	Orange County Water District
OM&R	operation, maintenance, and replacement
PDT	pressure decay testing
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic acid
ppb	parts per billion
psi	pounds per square inch
RAS	return activated sludge
Reclamation	U.S. Department of Interior Bureau of Reclamation
RO	reverse osmosis
RRT	response retention time
RWPF	Raw Water Production Facility
RWRP	Reclaimed Water Resource Plan (2013)
SAT	soil aquifer treatment
SFR	Santa Fe River
SJCP	San Juan-Chama Project
SMCL	secondary maximum contaminant level
SVOC	semi-volatile organic compound
SWPPP	Stormwater Pollution Prevention Plan
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDH	total dynamic head
TDS	total dissolved solids

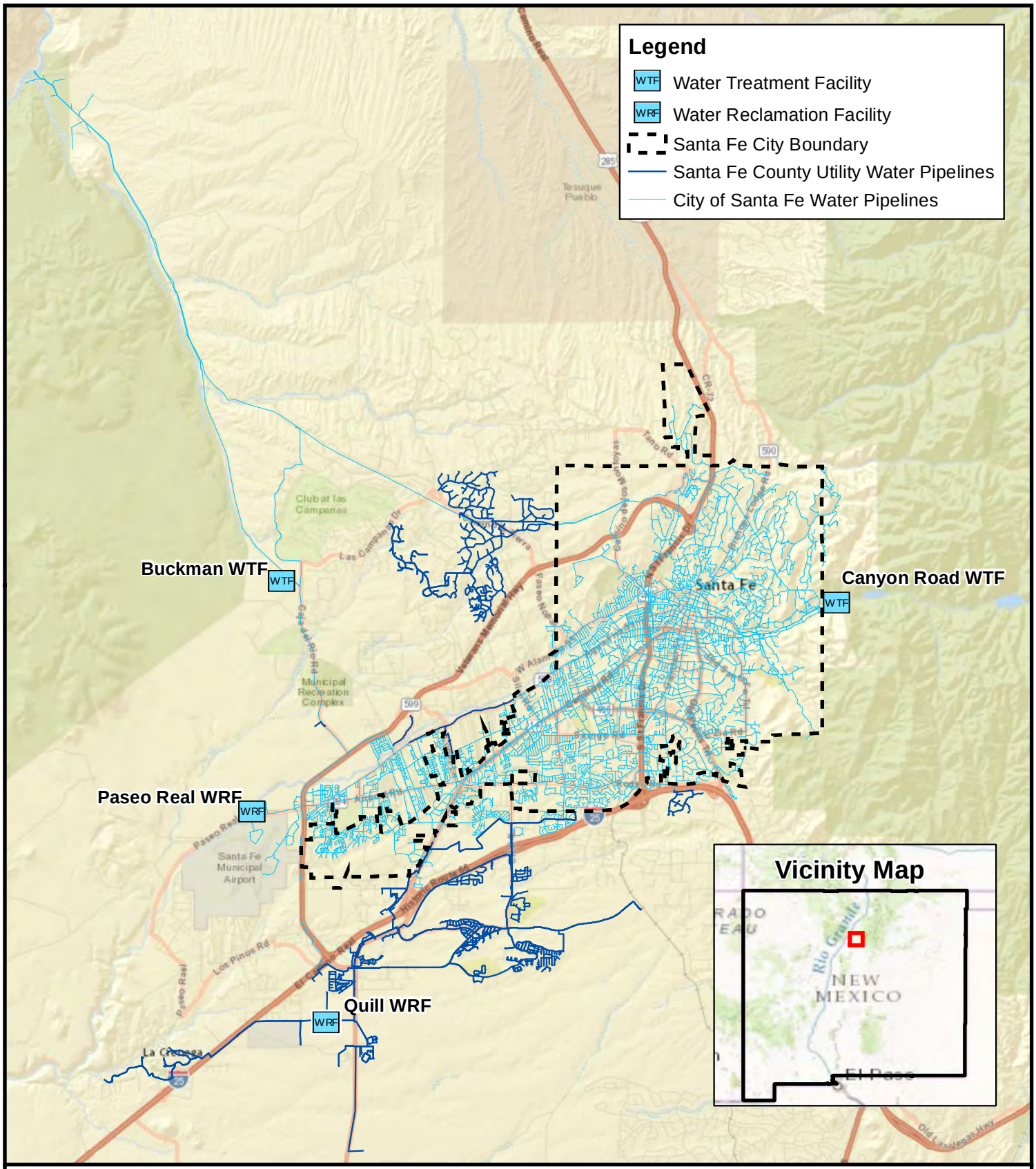
TEMP	Treated Effluent Management Plan (1998)
TOC	total organic carbon
TSS	total suspended solids
UF	ultrafiltration
US	United States
USACE	US Army Corps of Engineers
USFS	United States Forest Service
USR	Underground Storage and Recovery
UV	ultraviolet light disinfection
UV-AOP	ultraviolet light disinfection / advanced oxidation process
VOC	volatile organic compound
WAS	waste activated sludge
WRD	Water Replenishment District of Southern California
WRF	water reclamation facility
WRRF	WateReuse Research Foundation
WTF	water treatment facility

1.0 INTRODUCTION

The City of Santa Fe (City) and Santa Fe County (County) provide water service to over 85,000 people in northern New Mexico. One of the oldest cities in the United States, Santa Fe has diversified its water supply to include local surface water and groundwater and imported surface water to reliably meet the community's water needs. The City and County are the non-federal project sponsors that worked in partnership with the U.S. Department of Interior Bureau of Reclamation (Reclamation) to develop this Santa Fe Title XVI Water Reuse Feasibility Study (Feasibility Study).

The City and County employ a diverse portfolio of surface water and groundwater supplies to meet annual total demand and peak day demands in the respective service areas. The City water supply system is interconnected with the County's system, including co-ownership of the Buckman Direct Diversion (BDD) system that initiated operations in 2011. The County system surrounds the City's system to the north, south, and east of the City boundary and service area. The Study Area for this Feasibility Study generally encompasses the City and County service areas (Figure 1.1). The City's service area is generally within the City limits, but not exclusively so. The County's current service area is shown with the extent of its distribution network in Figure 1.1. Some reclaimed water alternatives examined in this study extend beyond these boundaries to provide water supply, as detailed in Section 5.0.

Water supply planning and consideration of future conditions is vital in light of projections that the City and County's service area population are projected to nearly double to about 170,000 by 2055, as documented in the Bureau of Reclamation 2015 Santa Fe Basin Study (Basin Study). The Basin Study highlighted the implications of climate change on Santa Fe area water supplies and demands. Under anticipated climate change conditions, the City and County's supplies are projected to fall short of demands by as much as 9,323 acre-feet per year (AFY) by 2055. The Basin Study identified expansion of water reuse as one of the most viable strategies for mitigating the projected shortages in Santa Fe. That finding motivated the City and County to partner with Reclamation to develop this Feasibility Study to assess alternatives for water reuse.



STUDY AREA

FIGURE 1.1

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CITY OF SANTA FE / SANTA FE COUNTY

SANTA FE WATER REUSE FEASIBILITY STUDY

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This Feasibility Study builds on a long-standing commitment to water reuse in Santa Fe, dating back to at least the 1950s. Today, up to about 1,500 AFY of recycled water is used to offset potable demands including: dust control and other construction purposes; irrigation of sports fields and other landscaping at the Municipal Recreation Complex (MRC); infield landscaping at the Downs of Santa Fe, the Santa Fe Equestrian Center, the Marty Sanchez Links de Santa Fe and the Santa Fe Country Club; dust control at the regional landfill; and livestock watering on the Caja del Rio. Contracts for water reuse establish supply and operational requirements, but the City does not recover any cost or value for the water provided to existing reuse customers. The City has identified the potential opportunity for conservation savings in the use of recycled water at several of these sites.

Other relevant water supply planning studies include the City's 1998 Treated Effluent Management Plan (TEMP), the City's 2008 Long Range Water Supply Plan (LRWSP) and the City's 2013 Reclaimed Water Resource Plan (RWRP). The TEMP provided strategies for expanding Santa Fe's non-potable water reuse system, and introduced some of the concepts that are evaluated in detail in this Feasibility Study (e.g., return flow credits to the Rio Grande for exchange against additional water rights, and pumping reclaimed water to a point of discharge on the Santa Fe River to create a Living River through central Santa Fe). The LRWSP showed how water reuse can fit into the City's current and future water supply portfolios. The RWRP provides a summary of current water reuse customers in Santa Fe, constraints on expanding the non-potable reuse system, and concepts for augmenting the community's existing water sources with potable water reuse.

The water reuse alternatives considered in this Feasibility Study include expansion of the existing non-potable reuse system, water resource exchanges, and potable reuse alternatives including indirect potable reuse (IPR) via augmentation of local surface or groundwater supplies and direct potable reuse (DPR). Alternatives were selected for analysis in this Feasibility Study using concepts previously considered informally or formally for Santa Fe (e.g., in previous planning documents) and trends and precedents in potable and non-potable water reuse observed nationally. The non-Title XVI project investigated in this study provides for purchase of additional native surface water rights on the Rio Grande for diversion through the BDD system, with significant costs and environmental implications, while underutilizing a significant available local water supply in water reclamation return flows that could instead be beneficially used to help offset projected shortages.

The primary objective of this Feasibility Study is to identify the highest value use of the reclaimed water currently available from the Paseo Real Water Reclamation Facility (WRF) and potential future flows from the Quill WRF, while respecting downstream flow maintenance for cultural and ecological purposes on the lower Santa Fe River.

This Feasibility Study evaluates and compares seven water reuse alternatives and provides a structured process for prioritizing investments toward mitigating the projected climate-change induced shortages. Detailed descriptions and maps of each reclaimed water alternative are provided in Section 5.0.

2.0 REUSE WATER QUALITY REGULATIONS

Alternatives considered in this Feasibility Study include expansion of the City's existing non-potable water reuse system, reuse by exchange, several IPR options, and DPR. State-level regulatory structures in place and under development for non-potable and potable reuse were used to guide the development of reuse alternatives. This section provides a summary of state-level regulatory requirements for water reuse that are primarily focused on water quality and protection of public health and the environment. Other legal and institutional requirements, including water rights and other interagency permitting and approvals, are described in Section 9.0 of this report.

The New Mexico Environment Department (NMED) has established guidance for non-potable water reuse projects (NMED 2007). NMED is currently developing potable reuse regulations, with the latest information on potential regulatory criteria developed by the National Water Research Institute (NWRI) (NWRI 2015a and NWRI 2016). NMED has also developed a draft DPR Preliminary Assistance Work Plan that will be used to guide entities seeking to implement a DPR project in New Mexico. These regulatory guidance documents are summarized below. The analysis of treatment systems for potential new water reuse projects was based upon the recommendations of this section.

2.1 Non-Potable Water Reuse

Non-potable water reuse regulations are defined by NMED, with the latest regulatory update in 2007 (NMED 2007). Non-potable water reuse is grouped into four categories, Class 1A, 1B, 2, and 3. The Class designation correlates with a degree of public health exposure, as shown in Table 2.1. The water quality requirements for each Class are shown in Table 2.2. NMED does not specify treatment processes to be used to meet the water quality requirements, other than the following language from NMED (2007):

> *"The specified quality levels for Class 1B, Class 2, and Class 3 assume a minimum of conventional secondary wastewater treatment plus disinfection. Class 1A assumes treatment to remove colloidal organic matter, color, and other substances that interfere with disinfection, thereby allowing for the use of the reclaimed wastewater for urban landscaping adjacent to dwelling units or occupied establishments."*

Table 2.1	**Approved Users for Reclaimed Wastewater by Class Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County**
Class of Reclaimed Wastewater	**Approved Uses**
Class 1A	All Class 1 uses. No setback limit to dwelling unit or occupied establishment. Backfill around potable water pipes Irrigation of food crops(1)
Class 1B	Impoundments (recreational or ornamental) Irrigation of parks, school yards, golf courses(2) Irrigation of urban landscaping(2) Snow making Street cleaning Toilet flushing Backfill around non-potable piping
Class 2	Concrete mixing Dust control Irrigation of fodder, fiber, and seed crops for milk-producing animals Irrigation of roadway median landscapes Irrigation of sod farms Livestock watering Soil compaction
Class 3	Irrigation of fodder, fiber, and seed crops for non-milk-producing animals Irrigation of forest trees (silviculture)

Notes:
(1) Irrigation of food crops should only be allowed for food crops when there is no contact between the edible portion of the crop and the wastewater. Spray irrigation is prohibited for food crops.
(2) If reclaimed wastewater is applied using spray irrigation, the setback limitations for "Spray Irrigation" should be observed.

Table 2.2 Non-Potable Water Reuse Water Quality Criteria[(1)]
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Class	Turbidity, Ave, NTU	Turbidity, Max, NTU	TSS, Ave, mg/L	TSS, Max, mg/L	BOD, Ave, mg/L	BOD, Max, mg/L	Fecal Coliform, Ave, #/100 mL	Fecal Coliform, Max, #/100 mL
1A	<3	<5	--[2]	--[2]	<10	<15	<5	<23
1B	--[2]	--[2]	<30	<45	<30	<45	<100	<200
2	--[2]	--[2]	<30	<45	<30	<45	<200	<400
3	--[2]	--[2]	<75	<90	<30	<45	<1000	<5000

Notes:
(1) Average criteria is based upon a running 30-day average. Maximum criteria is based upon a single not to exceed value.
(2) BOD = biochemical oxygen demand.
(3) TSS = total suspended solids.
(4) NTU = nephelometric turbidity units.
(5) No criteria for this parameter for this Class of water.

2.2 Potable Water Reuse

Potable water reuse regulatory guidelines are under development by NMED, with the first phase of guidance prepared for the Village of Cloudcroft's DPR PURe Water project (NWRI 2015a). A second more general guidance document for use across New Mexico is under development has also been completed by the NWRI 2016. Both documents are relevant to any IPR or DPR project in New Mexico, with particular details provided below as they may apply to a Santa Fe potable water reuse project. This section provides information on the basic treatment and water quality requirements for safe implementation and operation of a potable water reuse system. Additional detail is provided in Appendix A.

With respect to public health protection, the goal of advanced treatment is to minimize risk through the destruction and removal of specific microbial and chemical constituents. To meet this goal, DPR treatment trains should be designed to minimize potential chronic risks (best exemplified by chemical constituents) and eliminate acute risks (best exemplified by pathogens) (Salveson et al. 2014). NWRI (2015a) provides the following guidance on risk minimization:

> *"With few exceptions, the standards for organic compounds in drinking water are based on the chronic risk they pose (i.e., the risk of illness or death that a person faces as a result of drinking the water over a 70-year lifetime). In contrast, pathogens in drinking water pose an acute risk as illness can be caused by a single exposure to an infectious agent. When considering standards for DPR, it has been recognized that the greatest risk to a*

consumer is the acute risk that may result from a treatment system failure that allows pathogenic organisms to pass through the treatment system and be introduced into the distribution system. A similar failure might expose the community to chemical constituents, but over such a short time that the chronic risk would be insignificant. This distinction has two consequences. First, performance criteria for AWTFs [advanced water treatment facilities] for DPR application are primarily based on pathogen removal. Second, it is important that a robust and effective monitoring program be established to rapidly detect system failures to prevent pathogen exposure. There is an implicit assumption that such a monitoring system will also suffice to prevent exposure to chemical constituents that pose a chronic risk to the public."

2.2.1 Direct Potable Reuse

There are two forms of planned DPR:

- Advanced treated water (ATW) produced in an advanced water treatment facility (AWTF) is introduced into the raw water supply immediately upstream of a drinking water treatment facility (DWTF). To date, permitted operational DPR projects in the United States (all in Texas) involve the use of this form of DPR. This type of DPR is what is proposed for the PURe Water project in Cloudcroft.

- Finished water produced in an AWTF that is also permitted as a DWTF is introduced directly into a drinking water supply distribution system, either downstream of a DWTF or within the distribution system.

Both these forms of DPR may or may not involve the use of an engineered storage buffer (ESB), which is a storage facility used to provide retention time before the ATW is introduced into the DWTF or distribution system. The ESB concept is detailed in Salveson et al. (2015), and provides increased confidence in the continuous production of high quality water that is protective of public health. The ESB is used to: (1) provide a failure response time (FRT) that allows for testing to evaluate water quality; and (2) hold the reclaimed water in the event it does not meet water quality specifications.

2.2.2 Indirect Potable Reuse

In planned IPR projects, ATW or tertiary effluent is introduced into an environmental buffer (e.g., a groundwater basin or surface water reservoir) before being withdrawn for potable purposes. The environmental buffer provides storage, transport, and (in some cases) an additional barrier for the protection of public health. The two forms of IPR in use today include:

- In groundwater augmentation, tertiary effluent is applied by spreading to take advantage of soil aquifer treatment, whereas ATW can be applied by spreading or direct injection.

- In surface water augmentation, ATW is added to a surface water reservoir or other water body that serves as the environmental buffer; however, when the volume of the reservoir or other water body does not provide substantial dilution and storage time requirements, the proposed IPR project becomes a DPR project.

2.2.3 Critical Control Points

Critical Control Points (CCPs) are defined by NWRI (2015b) as "a point in advanced water treatment where: (1) control can be applied to an individual unit process to reduce, prevent, or eliminate process failure; and (2) monitors are used to confirm the CCP is functioning correctly." CCPs are individual treatment processes that provide control for pathogens (including the provision of log reduction credits) and chemical constituents. CCPs are supplemented with critical operating points (COPs), which are production focused and used to manage other unit processes not used directly for pathogen or chemical control (Walker et al. in press).

CCP monitoring would include a set of alarms with alert levels and critical limits that are supported by a relationship to the water quality if those critical limits are exceeded. Example CCPs for an AWTF treatment train, along with corresponding monitoring requirements, are listed in Table 2.3.

Table 2.3 Examples of Pathogen Treatment Critical Control Points for a Typical AWTF Treatment Train (adapted from NWRI 2015b)
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

CCP	CCP Monitor	Concerns
Primary and secondary treatment	No currently defined CCP monitor	Online virus and protozoa testing are not viable. Online measurement of bacteria removal (or concentrations) is possible, allowing some measure of secondary effluent microbiological quality.
Microfiltration (MF)	Daily Pressure Decay Testing (PDT)	Online turbidity measurement is insufficient to prove membrane integrity. Typically, PDT is performed daily, so ESB with sufficient storage is required to obtain protozoa reduction credits.

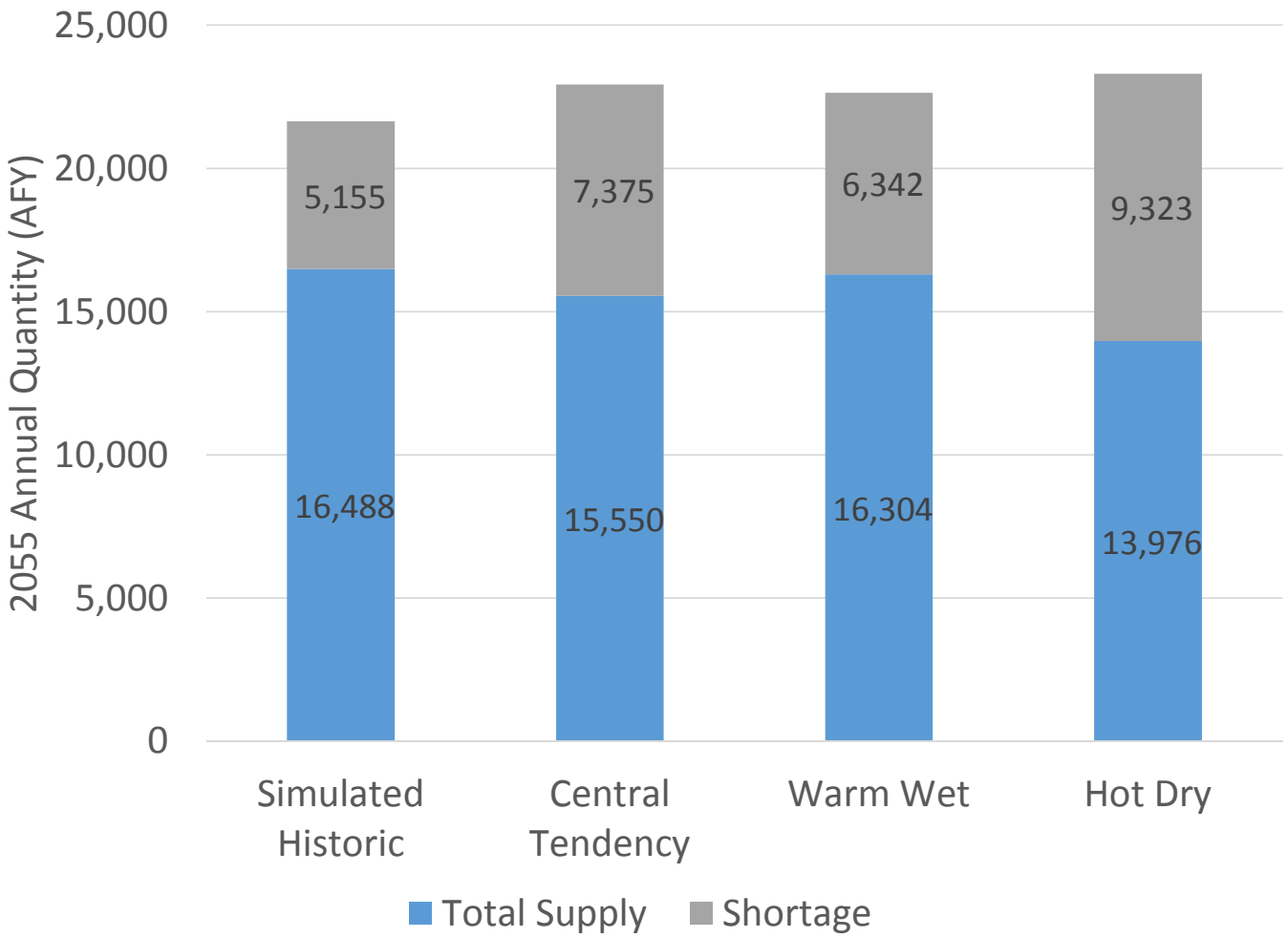
Table 2.3	Examples of Pathogen Treatment Critical Control Points for a Typical AWTF Treatment Train (adapted from NWRI 2015b) Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County	
CCP	**CCP Monitor**	**Concerns**
Reverse Osmosis (RO)	Online EC or Online TOC	Removal of salts [e.g. electrical conductivity (EC)] or total organic carbon (TOC) provides confidence in a minimum level of pathogen removal. With enhanced monitoring of the RO process, including the use of fluorescent dyes, credit may be given for 3+ log removal of pathogens.
UV-AOP	Intensity Sensors	Minimal concerns if properly calibrated sensors are used following U.S. EPA guidelines (2006b).
ESB	Online Cl_2	Minimal concerns. Disinfection credit based upon extended storage and free chlorine residual CT values (U.S. EPA 1990).

3.0 PROBLEMS AND NEEDS

3.1 Need for a Reclamation and Reuse Project

Expanded water reuse is a viable solution for reducing projected water supply shortages in Santa Fe. The 2015 Santa Fe Basin Study assessed several climate change-induced water supply and demand scenarios that projected 2055 supply deficits for the City and County, with the City comprising the majority of demands and associated shortages. Climate change conditions were developed from the Reclamation work products to establish five sets of scenarios, representing the range of variability expected in basin hydrology. Of those scenarios, three were selected to represent the range of probable temperature and precipitation changes: Warm-Wet, Hot-Dry, and Central Tendency. The City's municipal supply operations model, WaterMAPS, was used in the Basin Study to generate supply availability projections for these three scenarios and a "simulated historic" baseline scenario without further climate change.

In addition to supply impacts, shortages were also assessed based on projected impacts to water demands under each of the climate change scenarios. As shown in Figure 3.1, projected 2055 deficits under current management practices range from 5,155 AFY without considering future climate change up to 9,323 AFY under the most significant (Hot-Dry) climate change scenario evaluated.



PROJECTED 2055 WATER SUPPLY SHORTAGES FOR THE CITY AND COUNTY UNDER CLIMATE CHANGE SCENARIOS

FIGURE 3.1

The 2015 Basin Study concluded that the City and County face a near 100 percent probability of water shortages in 2055 based on projected population and climate change. With climate change, water demands could increase by as much as 7.7 percent, while available supplies could decrease by as much as 15 percent. Resulting deficits could reach as much as 40 percent of projected demands, approaching twice the magnitude of the 2055 shortage that will occur independent of climate change. Agricultural, environmental, and cultural demands coupled with municipal demand and population growth increase the uncertainty surrounding available water supply.

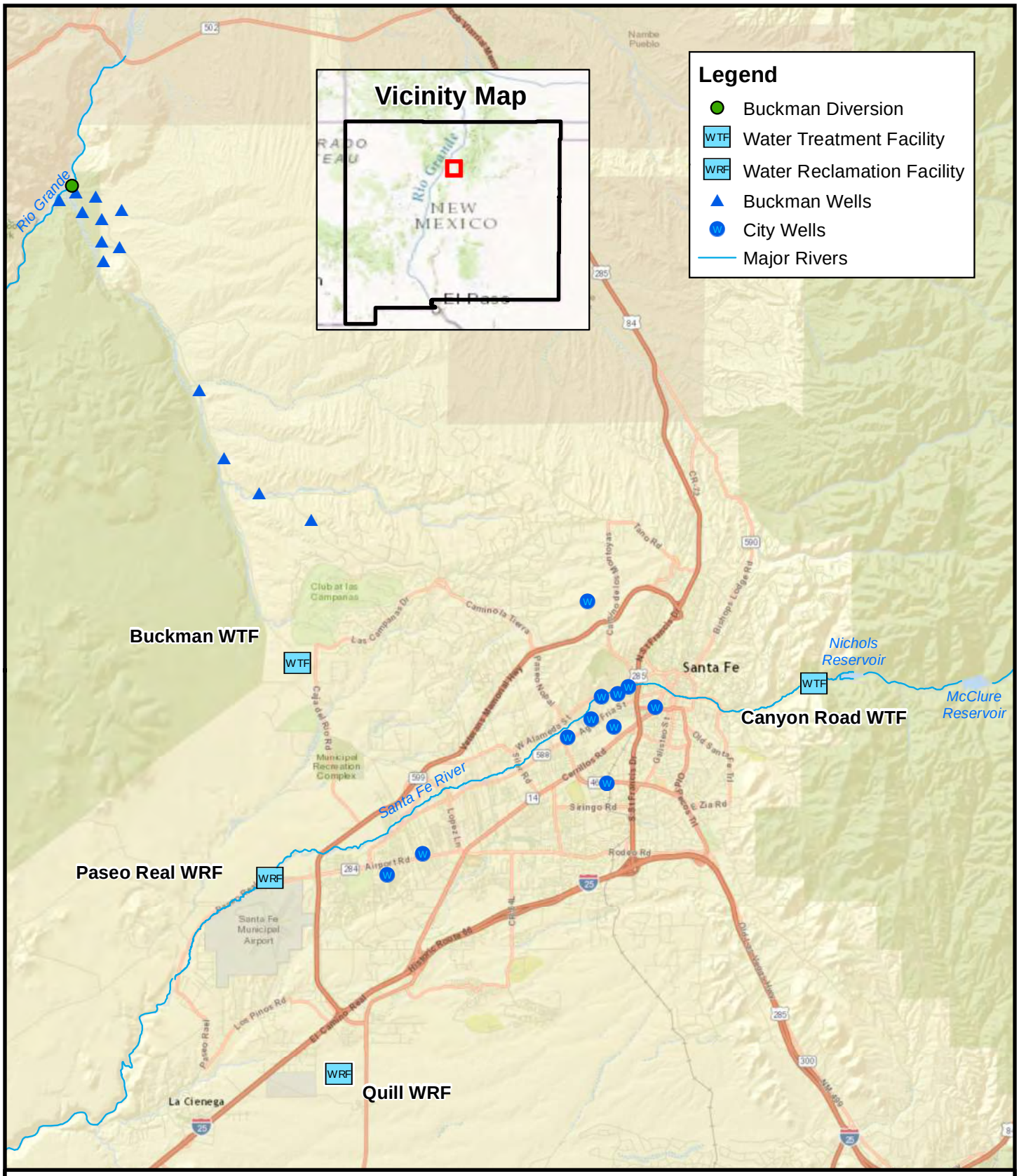
The dire consequences of not addressing the projected shortages include the inability to meet peak-day and annual needs of the community. Associated impacts are likely to include the unsustainable use of local and regional supplies in the study area, severe economic impacts of shortages, and ecological and cultural impacts of overuse of Rio Grande and Santa Fe Basin surface water and groundwater supplies.

3.2 Current and Projected Supplies

The City and County draw upon a diverse portfolio of water supplies, with use governed by water rights, management targets, and administrative requirements. The primary water supplies available are surface water supplies from Reclamation's San Juan-Chama Project (SJCP) and the Santa Fe River Watershed, and groundwater from the City Well Field and Buckman Well Field. Locations of the primary sources of water are shown in Figure 3.2.

Surface water currently provides about 70 percent of the City and County water supply, depending on annual hydrology and operational decisions. The City and County divert SJCP water through the BDD located about ten miles west of the City limits, which is conveyed to the Buckman Regional Water Treatment Facility (BRWTF) for treatment to potable standards. The City holds a contract for 5,230 AFY of SJCP water that is delivered via the Rio Grande. The County holds a contract for 375 AFY of SJCP water and owns 1,325 AFY of native Rio Grande water rights. The County plans to acquire a supplementary 590 AFY of Rio Grande native water rights as a source of additional water.

The Santa Fe River flows from its headwaters in the Sangre de Cristo Mountains through downtown Santa Fe toward the Rio Grande. McClure and Nichols Reservoirs, both owned and operated by the City, store water from the upper watershed for diversion and treatment at the City's Canyon Road WTF (CRWTF). The City holds 5,040 AFY of water rights in the Santa Fe River watershed, but supply availability varies significantly with snowpack and hydrologic conditions each year. Of the Santa Fe River rights, 1,540 AFY have a priority date of 1880 and 3,500 AFY have a priority date of 1925. Most of these rights are exercised by storing runoff from the Santa Fe watershed in Nichols and McClure Reservoirs, east of the City. A portion of the 1925 right may be diverted by pumping of the St. Michael's well.



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EXISTING SOURCES OF WATER SUPPLY

FIGURE 3.2

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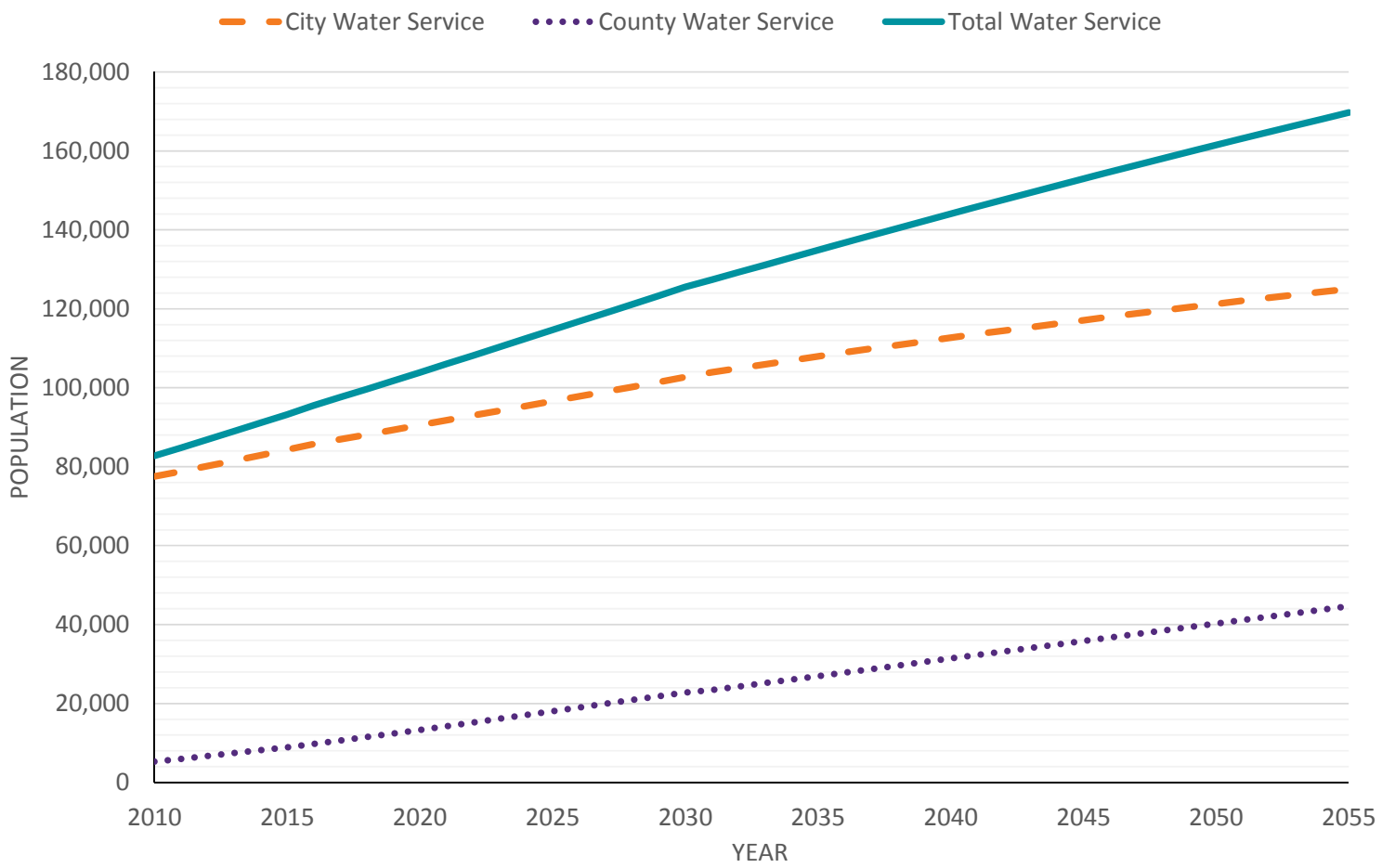
Groundwater currently provides approximately 30 percent of the City and County water supply, but its use varies in response to drought and operational factors. The City Well Field along the Santa Fe River consists of 11 wells, 8 of which are operating. The Well Field includes Osage, Northwest, St. Michael's, and other wells located within the City limits. The City has rights to produce 4,865 AFY from this well field, but anticipates a future restriction from the Northwest Well settlement that will cap City Well Field production to 35,070 AFY over a 10-year period. The Buckman Well Field consists of 13 wells outside the City limits between the Rio Grande and the west side of the city. This well field has a capacity of over 17,000 AFY that provides critical peak capacity, but water rights and permits cap its use at 10,000 AFY and historical use has not exceeded about 5,900 AFY. Water rights offsets and other management restrictions limit pumping to around 3,000 AFY as a sustainable yield. Bringing the BDD online in 2011 allowed the City to significantly reduce its use of the Buckman Well Field, and water levels have recovered considerably as a result. The County also owns a series of small wells outside the City limits that are equipped for utility production.

3.3 Current and Projected Demands

The 2015 Santa Fe Basin Study projects significant growth in water demand for the City and County's systems. In 2015, the City of Santa Fe Water Division supplied water to an estimated service area population of 77,501, while the County served an estimated population of 8,904. By 2055, the City and County are expected to serve a combined population of nearly 170,000, with the City service area comprising about 125,000 (73.5 percent) of that total (Figure 3.3).

Total demands were estimated in the Basin Study based on these population projections, summarized in Table 3.1. Significant growth in demand is projected for both the City and the County. County service area demands are predicted to increase at a faster rate (averaging 4.1 percent per year over the planning period) than City service area demands (averaging 1.0 percent per year over the same period), but the magnitude of the 40-year increase in demand is slightly larger for the City's service area (5,197 AFY) than for the County's service area (4,568 AFY). Growth in the County service area is attributable partly to population growth and partly to connection of existing developed areas to the County's water system.



CITY AND COUNTY WATER SERVICE POPULATION PROJECTIONS

FIGURE 3.3

Table 3.1	Projected Water Demands Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County		
Year	**Santa Fe County Demand (AFY)**	**City of Santa Fe Demand (AFY)**	**Total Demand (AFY)**
2015	1,137	10,767	11,904
2020	1,697	11,563	13,260
2025	2,305	12,333	14,637
2030	2,912	13,111	16,024
2035	3,443	13,783	17,225
2040	4,008	14,387	18,395
2045	4,574	14,954	19,528
2050	5,139	15,482	20,621
2055	5,705	15,964	21,643

3.4 Water Quality Concerns for Water Supplies

Santa Fe's diverse water supplies exhibit a corresponding range of source water quality. Each existing source has unique attributes and potential water quality concerns, as follows:

- **Upper Santa Fe River (McClure and Nichols Reservoirs):** The protected watershed of the Upper Santa Fe River typically yields very high quality raw water for treatment at the CRWTF. However, water quality is subject to the risk of a fire in the watershed and subsequent debris and water quality impacts to the reservoirs. A catastrophic fire in one of Denver Water's watersheds in 2002 caused erosion and sediment issues that Denver Water continues to address to this day. A June 2016 fire above McClure Reservoir reinforced the potential risk to Santa Fe, although the fire was not large enough to cause significant water quality issues.

  Extended drought can also impact the water quality in the reservoirs, as evidenced in 2002 when reservoir levels approached 20 percent of capacity. Projected climate change conditions could increase the frequency or magnitude of drought, resulting in a higher incidence of low reservoir levels. It could also increase the potential for a catastrophic fire in the watershed.

- **City Well Field:** A subset of the City Wells has been impacted by legacy organic pollutants in areas of the aquifer. Regular monitoring also has identified low levels of nitrate. The City has taken management and treatment measures so that well field operations produce water that is fully compliant with Safe Drinking Water Act regulations. Nonetheless, as with any groundwater contamination, there is the potential for further migration of pollutants that could impact City Well Field operations, particularly to the degree that aquifer recharge/recovery and groundwater management strategies are considered.

- **Buckman Well Field:** Certain Buckman Wells exhibit levels of naturally-occurring uranium and arsenic that are of potential concern for water quality. The City employs management strategies that assure that the water produced by the Buckman Well Field meets all Safe Drinking Water Act standards. As with the City Well Field, future implementation of an aquifer recharge and recovery program could pose the potential for further mobilization of these constituents, warranting further evaluation before such a program would be implemented.

- **BDD:** Use of the BDD is governed by its Environmental Impact Statement Record of Decision (U.S. Forest Service and Bureau of Land Management 2007). Diversions at the BDD are curtailed under certain low flow conditions in the Rio Grande. BRWTF staff also follow self-imposed operational protocol to temporarily suspend diversions under certain high-turbidity conditions in the Rio Grande to reduce the impacts of high sediment loads to sediment removal and treatment facilities.

- Potable reuse has the potential to gradually increase salinity concentrations in a community's potable water distribution system. Salinity management in the context of potable reuse alternatives and Santa Fe's source waters was evaluated for this Feasibility Study, as described in Section 4.9.4.

3.5 Wastewater Disposal Options and Treatment Needs

The City’s Paseo Real WRF provides wastewater treatment for the entire City service area, producing water quality suitable for discharge to the Santa Fe River (under the terms of National Pollutant Discharge Elimination System [NPDES] permit NM0022292) and for existing non-potable water reuse applications (per the requirements described in Section 2.0). The Paseo Real WRF has a design capacity of 13 million gallons per day (mgd) and the process train is described in Section 4.5.1. The lower Santa Fe River below the facility is currently listed by NMED as impaired for nutrients and eutrophication and generally has no surface flow other than the discharge from the Paseo Real WRF.

The NPDES discharge permit for the Paseo Real WRF expired on July 31, 2015, and has been administratively extended to allow ongoing operations. The City's Wastewater Management Division received the draft renewal permit in the spring of 2016, and is actively negotiating the terms of its permit renewal with NMED and U.S. EPA. The draft permit has new, more stringent discharge limits for total nitrogen and total phosphorus. Optimization of existing processes may allow compliance with the proposed limits. However, discussion with NMED and U.S. EPA indicates that extremely stringent nitrogen and phosphorous requirements are anticipated in the future (e.g., the subsequent permit renewal in about 5 years).

These requirements are expected to drive a need for major capital improvements at the facility. The City is studying the potential implications of the near- and long-term anticipated permit conditions, in terms of the capital improvements that would be required, the benefit to the receiving stream in light of other nonpoint source water quality impacts, and the potential financial benefits of reducing discharge flows and associated treatment needs through increased water reuse.

The County's Quill WRF has a permitted capacity of 280,000 gallons per day of wastewater treatment using a process centered on aerated impoundments, stabilization impoundments, and disinfection. The facility serves the New Mexico Penitentiary Complex, the New Mexico National Guard Complex, the Santa Fe County Detention Center, the Valle Vista Subdivision, the Santa Fe County Business Park Development, and the New Mexico Film Studio. Effluent is land applied via irrigation on a 95 acre area under the terms of NMED Groundwater Discharge Permit DP234. The County is actively considering connection of additional service areas to the facility and associated upgrades to the facility.

Based on input from the County, this Feasibility Study assumed that up to 0.5 mgd of effluent from the Quill WRF could be made available for regional reuse in partnership with the City, depending on future decisions by the County on how best to manage this resource. Potential integration of these flows into a regional water reuse system is discussed in Section 4.5.4.

4.0 WATER RECLAMATION AND REUSE OPPORTUNITIES

4.1 Potential Uses of and Markets for Reclaimed Water

The potential uses of and markets for reclaimed water can be divided into two categories: non-potable water reuse and potable water reuse. The market for potable water is relatively straightforward, with growth in demand driven by projections of population growth and climate change. Together, these factors are expected to result in significant supply shortages in Santa Fe, as discussed in Section 3.0 on Problems and Needs. Increasing potable water supplies through potable water reuse could directly reduce the projected shortages.

Non-potable water reuse could offset the need to provide potable water to Santa Fe customers, thereby reducing the projected shortages. Existing contracts for water reuse establish supply and operational requirements, but the City does not recover any cost or value for the water provided to existing reuse customers. The City has identified the potential opportunity for conservation savings in the use of recycled water at several of these sites. Unlike potable water supply, however, there are limits on where and how non-potable reclaimed water could be used. This section therefore focuses on assessing the markets for non-potable reclaimed water.

Cost-effective use of non-potable reclaimed water can best be achieved by minimizing treatment, transmission, and distribution costs. Reclaimed water produced by the City's Paseo Real WRF meets the NMED requirements for Class 1B applications, which includes landscape irrigation where public physical exposure to reclaimed water is avoided through access controls, application methods, and setback distances. Therefore, no treatment improvements are necessary for using this source. In contrast, significant treatment improvements would be required to allow use of reclaimed water from the County's Quill WRF for non-potable reuse applications.

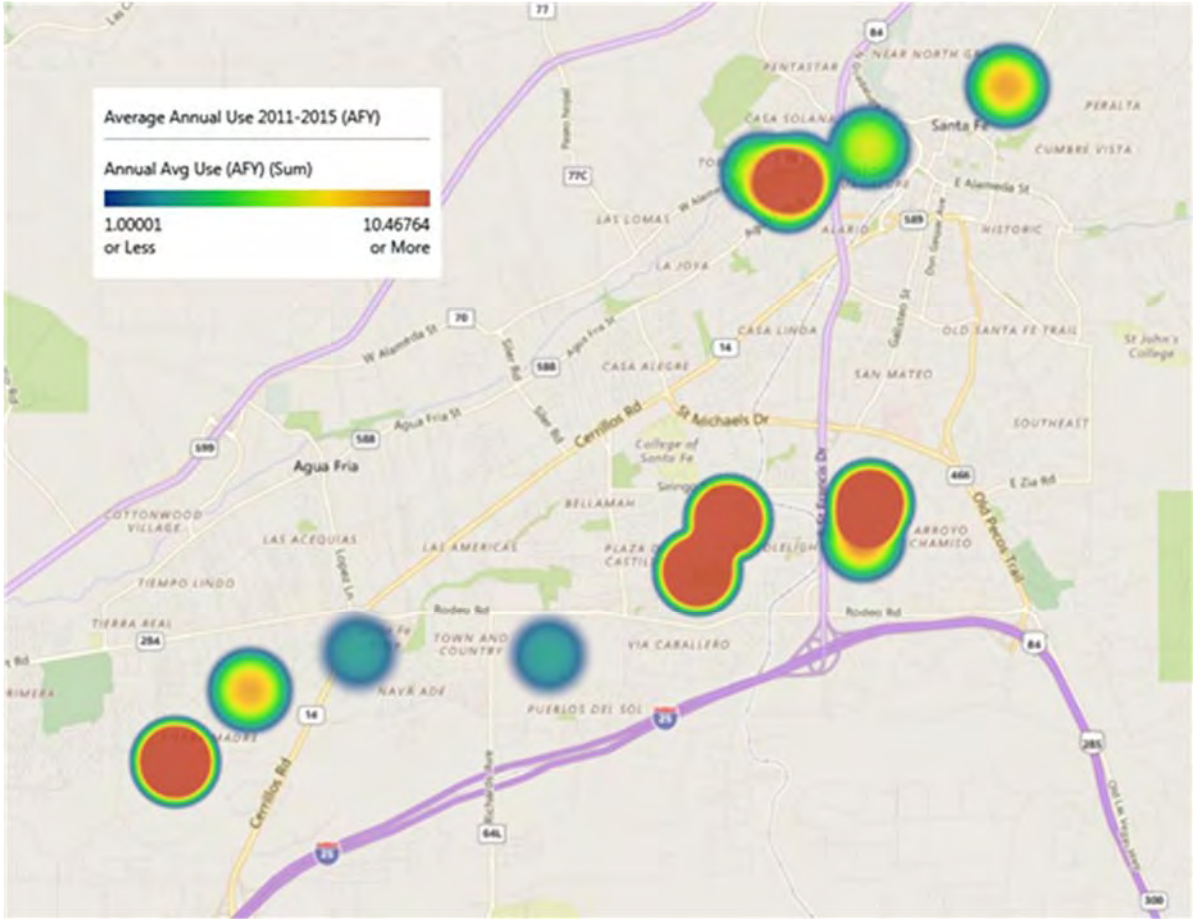
Minimizing transmission and distribution costs can be accomplished by serving a geographically-concentrated set of non-potable demands. In Santa Fe's case, this can further be achieved by extending non-potable water transmission and distribution off the City's existing reclaimed water network (sometimes referred to as the "purple pipe" system, due to the color designation for recycled water piping and appurtenances). Therefore, this analysis focused on the landscape irrigation sites closest to the City's Paseo Real WRF that are not already served by the City's reuse system. These sites include parks and schools located generally between the City's central historic district and the Paseo Real WRF in the southwest corner of the City.

Potential non-potable reuse sites meeting these general criteria were identified by the City. Table 4.1 lists these sites along with their annual average and peak month water use. At all of the potential sites, reclaimed water would be used for irrigation. The "heat map" in Figure 4.1 illustrates the data from Table 4.1 in graphical format, using color to denote the annual average water use at each site. The heat map guided grouping of non-potable reuse sites and routing of the transmission system for the most cost-effective expanded non-potable reuse system for Santa Fe.

Table 4.1 Potential Non-Potable System Expansion Sites
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Site	Annual Average Water Use[1] (AFY)	Peak Month Use[1] (kgal/d)
Villa Linda Park	2.9	9.5
Ragle Park	27.6	70.0
Alto Park	10.5	14.8
Fort Marcy Park	8.8	20.1
Santa Fe River Park 1	7.4	14.8
Santa Fe River Park 2	6.9	19.9
Aspen Community School	11.2	23.0
Capital High School	30.3	77.3
Capshaw Middle School	9.6	21.1
Pinon Elementary School	3.0	6.2
Santa Fe High School	26.3	44.3
Ortiz Middle School	8.7	36.3
St. Michael's High School	24.9	60.2

Notes:
(1) Based on City 2011 through 2015 monthly water use records.
(2) kgal/d = thousand gallons per day.



HEAT MAP OF POTENTIAL SITES FOR ADDITIONAL NON-POTABLE USES

FIGURE 4.1

Further analysis of the identified sites and their demands, using the heat map for guidance, identified a grouping of "northern" sites located north of Cerrillos Road (Alto Park, Fort Marcy Park, Santa Fe River Park sites 1 and 2, and Aspen Community School) and "southern" sites located south of Cerrillos Road and St. Michael's Drive (all other sites in Table 4.1). The northern sites constitute an annual demand of 44.9 AFY, while the southern sites' combined demand would be over 130 AFY. Serving the northern sites would require significantly more infrastructure to extend the existing non-potable water distribution system to this area than would the southern sites. Given the additional investment required to serve a relatively small amount of additional demand, the northern sites were rejected from further consideration. However, they could potentially be served as an offshoot of transmission piping from one of the potable water reuse alternatives considered in Section 5.0. Extension of the non-potable reuse system to the southern sites was considered as Alternative 1 in Section 5.0.

4.2 Addressing Potential Hurdles Associated with Reclaimed Water Uses

Expanding water reuse in Santa Fe comes with numerous potential challenges, whether the expanded reuse is for non-potable applications or for augmenting potable water supplies directly (DPR) or indirectly (IPR). To fully reflect the tradeoffs between alternatives, an initial list of seven reuse alternatives was evaluated based on a set of screening criteria established as part of this Feasibility Study, as detailed in Section 6.0 of this report. The alternatives that best met the screening criteria were characterized and compared in more detail using a triple bottom line approach (considering economic, social, and environmental aspects) that also considered technical aspects related to timely implementability and operability and project risk mitigation, as detailed in Section 7.0 of this report. They were also compared, in concept, to the non-Title XVI project which would not expand reuse and instead increase supply through purchase of additional native Rio Grande water rights for diversion and treatment through the BDD system.

One key foundation to any expansion of water reuse is the availability of effluent for the proposed uses, including both legal availability (e.g., water rights), and physical supply availability ("wet water").

The City has long held that it has the right to fully reuse its effluent. Past analyses and dialogue with the New Mexico Office of the State Engineer (NMOSE) have separated discussions of rights to reuse effluent based on the source of the water used to generate the effluent. On average, about 60 percent of the City's water use is returned to the Paseo Real WRF, although this value changes significantly seasonally based on outdoor consumptive water use that is not returned to the Paseo Real WRF. It has historically been assumed that the water returned to the Paseo Real WRF is proportionately associated with local and imported water based on source usage.

It is generally accepted that the City could fully reuse effluent that is derived from imported sources of supply (i.e., sourced at the Buckman Wells or BDD). The NMOSE considers that SJCP water may be 100% consumptively used. In past discussions with the City, NMOSE has expressed a position that some or all of the locally derived effluent (sourced in the Upper Santa Fe River watershed and the City Well Field) may be required to be returned to the lower Santa Fe via discharges from the Paseo Real WRF. The NMOSE position on reuse of locally derived effluent has not been conclusively resolved.

Water rights constraints for expanding non-potable reuse are not constraining at the levels of non-potable reuse considered in Alternative 1 (Section 5.0) for this Feasibility Study. Potable reuse alternatives evaluated in this study look to reuse around 2,000 AFY. At a 60 percent rate of return (source water diversions returned to the Paseo Real WRF), this 2,000 AFY of reuse would be associated with about 3,300 AFY of fresh water use. The City plans to fully utilize its full 5,230 AFY of imported SJCP water each year, which is significantly more than the 3,300 AFY noted above. SJCP water is very reliable, given upstream storage facilities (e.g., Abiquiu, Heron, and El Vado Reservoirs). Therefore, the proposed potable reuse quantities could be fully supplied with return flows to the Paseo Real WRF that originated as imported water. In light of this finding, the City was presumed to have the legal right to use reclaimed water for the proposed potable alternatives.

A third type of water reuse alternative (relative to non-potable reuse and potable reuse) would be to exchange the treated effluent against diversion of additional Rio Grande flows at Buckman using the BDD conveyance and treatment system. Precedent for this type of approach has been established in New Mexico by the Albuquerque Bernalillo County Water Utility Authority, serving as a full-scale "proof of concept" in terms of both the technical and permitting aspects of such an exchange. The Authority is thereby fully diverting and utilizing its SJCP water. Similarly, this approach would allow Santa Fe to make full consumptive use of its imported water supplies, while potentially avoiding Rio Grande Compact and Rio Grande Environmental Impact Study concerns.

Previous analyses suggest that locally-derived effluent may not be useable for return flow credits. At a 60 percent return rate, imported effluent from the 5,230 AFY of SJCP water use would return about 3,100 AFY of imported effluent to the Paseo Real WRF that could be used toward return flow credits on the Rio Grande. Return flows sent to the Rio Grande could also help Santa Fe satisfy the need to provide offsetting water rights in the Rio Grande to account for stream depletions associated with Buckman Well Field pumping. The amount of water pumped to the Rio Grande could be adjusted based on the actual imported effluent supply availability. The return flow credit alternative is explored in more detail in Sections 5.0 and 6.0 of this Feasibility Study.

The City is seeking to utilize seepage from effluent discharges from the Paseo Real WRF to satisfy permit obligations for offsetting the lagged groundwater and spring depletions associated with its Buckman wellfield pumping. The City is also sensitive to the environmental benefits associated with continuous flow in the river downstream of the

facility. Under most conditions, 100 percent of the flow in the lower river originates from the City's WRF discharges, though there are segments of the lower river that gain flow (and other segments that lose flow) to or from groundwater.

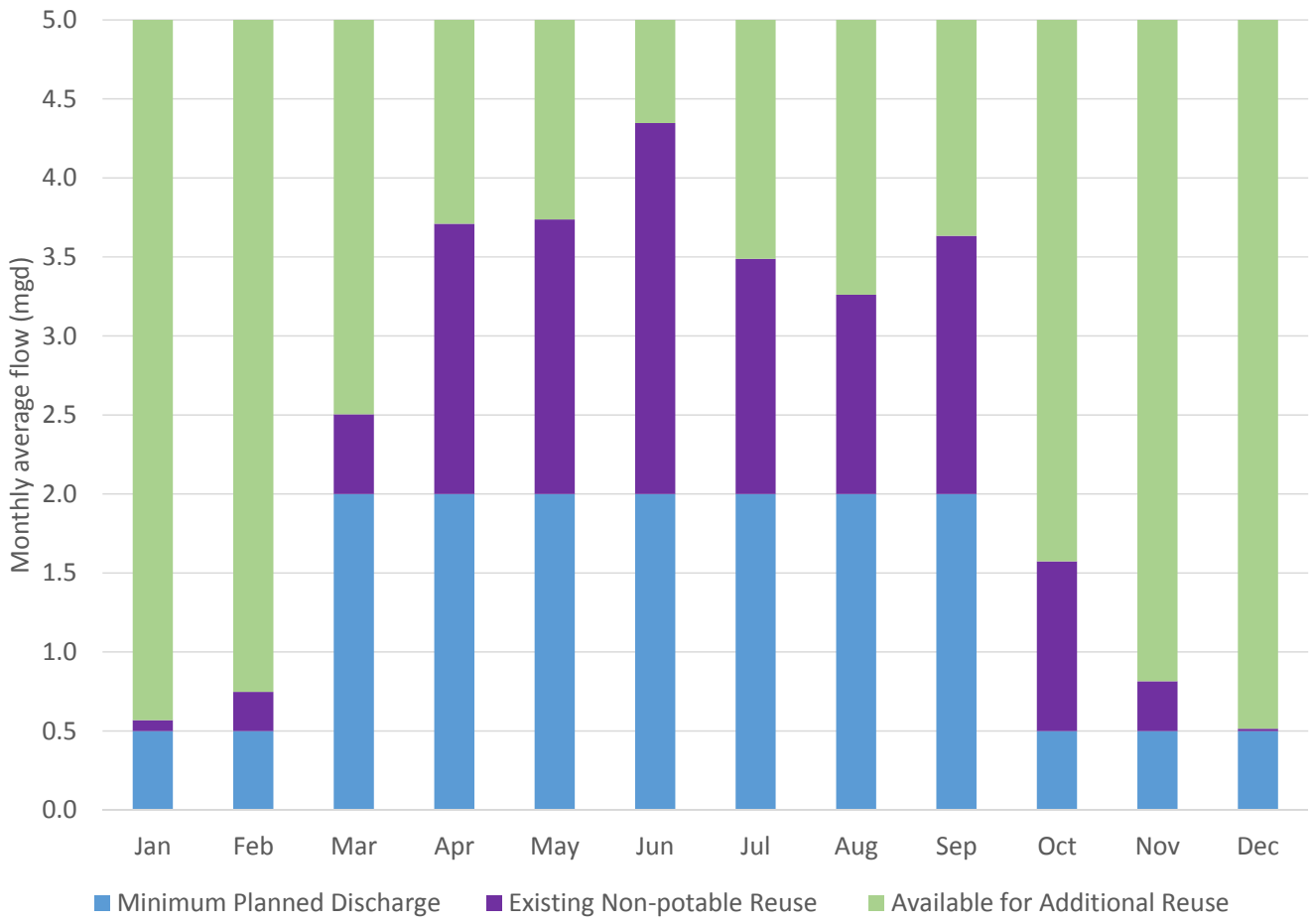
To address all of these needs, a seasonal pattern of minimum discharges was assumed for Feasibility Study analyses. The actual minimum discharges that will be implemented are subject to confirmation and potential revision as part of implementation activities.

The Feasibility Study assumed that a minimum of 0.5 mgd would be discharged to the Santa Fe River from the Paseo Real WRF in winter months, and a minimum of 2.0 mgd would be discharged in months with potential downstream irrigation uses. All alternatives analyzed in the Feasibility Study were sized to meet or exceed these minimum values. These values were established by the City as the basis for this Feasibility Study, but are subject to revision at any time. Winter and irrigation-season months were assumed to match those in the City's 2013 Reclaimed Water Resource Plan, including October through February for winter months and March through September for irrigation-season months. Analyses conducted by the City outside this Feasibility Study indicate that these will more than meet the projected offset requirements for Buckman Wellfield pumping, while helping to support downstream ecological resources and communities.

The City's Paseo Real WRF, which is the source of reclaimed water considered for this study, currently produces about 5 mgd of effluent. Considering a balance between projected population growth and an aggressive conservation effort, the City's 2013 RWRP, projects no increase in effluent production throughout the planning horizon (City of Santa Fe 2013). This projection was also used as the basis for the current Feasibility Study. Details of existing contracts for non-potable reuse are provided in the RWRP.

Existing commitments for non-potable reuse sourced from the City's Paseo Real WRF were assumed to be honored and fulfilled in perpetuity for purposes of this Feasibility Study. Reuse customers are predominantly using recycled water for landscape irrigation, resulting in recycled water demands that peak in the summer and approach zero in winter months. Figure 4.2 shows a chart of existing monthly non-potable reuse compared to total plant flow and the minimum monthly average flow discharges assumed for this study. For this analysis, the two most recent full years of data were assessed, representing recent system demands for non-potable reuse. System-wide non-potable reuse demands were 1,180 acre-feet in 2014 and 1,050 acre-feet in 2015, according to City records. To provide a more conservative basis for this study, the higher year's demands (2014) were used to define the availability of reclaimed water for additional water reuse (i.e., less water available to provide a water supply benefit via expanded water reuse).

Notably, the availability of additional water for potential reuse drops to a monthly average of about 0.7 mgd in the peak use month (June). On any given day, peak daily reuse demands can be much higher than the monthly average values shown in Figure 4.2. On peak summer demand days, there is little or no reclaimed water available for additional reuse.



Note: Based on RWRP projection of constant 5 mgd total effluent flow and 2014 actual non-potable reuse demands.

MONTHLY AVAILABILITY OF PASEO REAL WRF RECLAIMED WATER FOR ADDITIONAL WATER REUSE

FIGURE 4.2

Therefore, Santa Fe's largest opportunity for expanding reuse is in the winter season, in terms of availability of supply for additional reuse. However, the largest non-potable and potable water demands also peak in the summer. Potable water use continues year-round, while non-potable uses examined in this Feasibility Study are primarily associated with outdoor water use that drops to near zero in winter months. Therefore, the reclaimed water that is available for potential additional reuse may be better suited to potable reuse applications or exchanges than expanded non-potable reuse.

Seasonal storage of non-potable reclaimed water to carry over supplies from winter production to summer use was evaluated conceptually and was found to be impractical and financially non-viable for Santa Fe, since it would require significant volumes of lined open storage or closed (tank) storage. Therefore, without storage, an expansion of the non-potable reuse system is severely limited since supplies will not be available when demands are highest. Moreover, the Feasibility Study determined that there are limited opportunities to offset irrigation potable water use with non-potable recycled water supplies, limiting the water supply benefit of this approach and the viability of seasonal storage.

Potable reuse, whether implemented as IPR or DPR, also faces implementation challenges. These can be broadly characterized as regulatory, public acceptance, and technical. IPR is increasingly common in the U.S. The country's only operational DPR project as of September 2016 is the Colorado River Municipal Water District's facility in Big Spring, Texas. This system is described in Section 5.9. A DPR system for Cloudcroft, New Mexico is under construction and has been the subject of significant state regulatory development, working in conjunction with NMED.

Specific challenges associated with implementing reuse alternatives that best met the screening criteria (the water rights credit/exchange alternative and the three potable reuse alternatives) are described further in Sections 7 through 10.

4.3 Jurisdictional Issues

Several jurisdictional characteristics affect the management of water supply in Santa Fe. The City and County co-own the BDD system and BRWTF. Therefore, any modified use of the facility (e.g., integrating it into a reuse system) must be approved by both the City and the County, acting through the BDD Board of Directors.

Other jurisdictional issues include the legal right to reuse reclaimed water from the City's Paseo Real WRF. This topic is addressed in Section 4.2.

Land ownership can also have an effect on the ability to procure an easement and/or obtain the necessary permits for construction. For example, for construction of the BDD, the use and crossing of federal lands triggered a multi-year environmental impact statement (EIS). Some permitting challenges can be avoided through the use of existing easements and rights-of-way where possible. The BDD transmission lines were ultimately constructed, with no major jurisdictional or permit-related issue encountered during construction of the BDD infrastructure.

The City requires all non-potable reuse customers to construct, own, and operate all water delivery components from the point of diversion off the Paseo Real WRF effluent channel to the point of use. This offers significant capital and operational cost benefits to the City. However, without ownership of this infrastructure, the City's ability to reuse or repurpose existing non-potable reuse infrastructure or modify its operations is limited.

4.4 Potential Sources of Reclaimed Water

Two potential sources of reclaimed water were considered in this Feasibility Study, including the City's Paseo Real WRF and the County's Quill WRF. These facilities are described in Section 3.5. The City's Paseo Real WRF is the primary source of reclaimed water considered for this Feasibility Study, due to the size of the facility and the amount of reclaimed water produced and the treatment process in place.

The Paseo Real WRF produces approximately 5 mgd of reclaimed water, with portions of that flow being dedicated to downstream flow maintenance for cultural and ecological purposes and existing non-potable reuse contracts as described in Section 4.2. The Paseo Real WRF process is sufficient for meeting discharge permit requirements to the Santa Fe River and NMED Class 1B non-potable reuse standards. The Quill WRF was assumed to produce up to 0.5 mgd of reusable reclaimed water in the future, after significant process improvements. Potential integration of Quill WRF reclaimed water supplies into a regional water reuse system is described in Section 4.5.4.

For the Paseo Real WRF, availability of flows for additional water reuse is summarized in Figure 4.2 in Section 4.2. Inspection of that figure shows that the availability of reclaimed water for additional use peaks in November through February at 4.2 to 4.5 mgd. Reuse systems could be sized to utilize this full amount. However, sizing reuse conveyance and treatment systems to this full amount would result in significant underutilization of the associated investment for the other 8 months of the year.

Reuse alternatives and their facilities in this Feasibility Study were assumed to have a maximum capacity of 3 mgd for the following reasons:

- Always meets minimum discharge goals to Santa Fe River.
- Reduces peak use of the potable reuse supply source, and associated infrastructure sizing and capital for treatment, pumping, and transmission piping.
- Avoids having more than about 50 percent of winter supply be sourced from potable reuse (vs. typical wintertime City demands of around 6 mgd), for supply balance and anticipated public acceptance reasons.

By assuming all reuse alternatives are sized with this capacity constraint, they can be compared on an equal basis. Further analysis of the tradeoffs associated with sizing the reuse systems with less than 3 mgd capacity or more than 3 mgd capacity should be

conducted as part of project implementation and design activities. A summary of the water supply availability for the Paseo Real WRF, after accounting for downstream flow maintenance and existing non-potable reuse contracts, is provided in Table 4.2. For the Quill WRF, at a future capacity of 0.5 mgd (after capacity and treatment process upgrades), the maximum availability of water for reuse would be about 560 AFY.

Table 4.2 Potential Reclaimed Water Availability for Additional Reuse from the Paseo Real WRF
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Month	Available for Water Reuse (mgd)	Available for Water Reuse (AF)	Available for Water Reuse with 3 mgd Limit (AF)
January	4.4	422	285
February	4.3	365	258
March	2.5	237	237
April	1.3	123	123
May	1.3	120	120
June	0.7	66	66
July	1.5	143	143
August	1.7	165	165
September	1.4	130	130
October	3.4	326	285
November	4.2	385	276
December	4.5	427	285
Annual Total		**2,909**	**2,376**

Notes:
(1) Values indicate available flow after accounting for minimum releases to the Santa Fe River and existing non-potable reuse commitments. Availability on individual days will vary from the monthly averages shown here.

4.5 Description of Potential Source Water Facilities

As noted previously, the City's Paseo Real WRF is the primary source of reclaimed water considered for this Feasibility Study, due to the size of the facility and the amount of reclaimed water produced and the treatment process in place. The Paseo Real WRF is located at 73 Paseo Real, Santa Fe, New Mexico 87507. Consideration was also given to potential future reuse of reclaimed water from the County's Quill WRF, located at 4311 Hwy 14, Santa Fe, New Mexico 87504.

4.5.1 City of Santa Fe Paseo Real WRF

The Paseo Real WRF process train includes preliminary, primary, secondary, and tertiary treatment steps, with a design capacity of 13 mgd. Preliminary treatment includes a rock collector and fine-screened bar screen prior to two wet wells for flow equalization, followed by two aerated grit tanks which overflow into a primary splitter box. Two primary clarifiers are fed from this location.

Primary effluent is combined with various return flows and the return activated sludge (RAS) in a rapid mix tank, which feeds four 325,000 gallon bioselectors that can be aerobic, anaerobic, or a combination thereof. These serve to denitrify, and help control the growth of filamentous organisms in conjunction with optional chlorine gas feed to the RAS wet well. From here, water flows to aeration basins for BOD removal and nitrification. Anoxic zones support denitrification. The mixed liquor is separated in six 460,000 gallon secondary clarifiers.

Biosolids are collected in the RAS/WAS wet well, thickened using dissolved air flotation (DAF), and stabilized through anaerobic digestion, producing Class B biosolids and biogas, which is used to provide supplemental heat to the digesters.

Secondary effluent is treated by either one of two sand filters (5.5 mgd peak flow, each) or one of three 10-micron disc filters (6.75 mgd peak flow, each). A bypass valve allows the filters to be bypassed in an emergency. Filtered effluent is then ultraviolet light (UV) disinfected (using up to 4 parallel channels) and is then re-aerated in the post-aeration basin to meet a 5 mg/L minimum dissolved oxygen (DO) concentration for discharge.

Further description of the facility is provided by the City (City of Santa Fe 2016).

The effluent meets NMED requirements for Class 1B non-potable water reuse. Reuse customers pull tertiary effluent from a channel located between the UV disinfection facility and the effluent reaeration basin. Per City policy, reuse customers own the individual pump stations and transmission lines that convey reclaimed water from the channel to the point of use. As such, the reuse customers are responsible for all capital and operating and maintenance costs associated with pumping and transmission of the purple pipe systems.

4.5.2 Santa Fe County Quill WRF

The County's Quill WRF has a permitted capacity of 280,000 gallons per day of wastewater treatment using a process centered on aerated impoundments, stabilization impoundments, and disinfection. Treated effluent produced at the facility does not meet discharge or reuse standards, and is land applied. The County is actively considering connection of additional service areas to the facility and associated upgrades to the facility, with anticipated future capacity of 0.5 mgd. In light of the potential future upgrades, the existing facility was not characterized in detail in this Feasibility Study.

4.5.3 Evaluation of Treatment Provided by the Paseo Real WRF

An assessment of how the Paseo Real WRF provides treatment toward pathogen removal and other water quality goals is provided in Section 4.9.1. Generally speaking, industry research supports a conclusion that increasing the solids retention time in secondary treatment processes will increase the removal of constituents of emerging concern (CECs). Primary and secondary treatment processes in place at the Paseo Real WRF improve water quality for UV disinfection at the facility as well as downstream advanced water purification processes (as applicable for each alternative). UV disinfection also provides effective protozoa removal. Of note is that the current practice of using chlorination on RAS for filamentous organism control may produce disinfection byproducts (DBPs) of concern for subsequent potable supply uses. Further investigation into the generation of DBPs from this practice would need to be conducted before implementing a potable reuse alternative.

4.5.4 Role of Quill WRF Reclaimed Water in Regional Reuse System

Reclaimed water from the Santa Fe County Quill WRF could be managed in conjunction with the proposed water reuse alternatives to provide additional water supply benefits. Santa Fe County is contemplating a range of potential uses for reclaimed water from the Quill WRF, and its effluent therefore may or may not be available for integration into a regional management system in collaboration with the City, supplementing the City's management of reclaimed water from the Paseo Real WRF.

The Quill WRF is a non-discharging facility that would require process upgrades for essentially any local discharge or reuse of its effluent. In the event that reclaimed water from the Quill WRF is made available, it could be integrated into the Santa Fe regional water reuse program in one of several ways.

Potential Quill WRF effluent management strategies identified in this Feasibility Study include:

- Discharge to the Santa Fe River at the site of the Paseo Real WRF to help satisfy water rights offset requirements. This would require significant process upgrades to the Quill WRF to meet discharge standards (e.g., advanced nutrient removal), and construction of pump station and pipeline infrastructure for conveyance. This would reduce the amount of discharge needed from the Paseo Real WRF into the Lower Santa Fe River, thus freeing up additional Paseo Real WRF reclaimed water for reuse under any of the four short-listed reuse alternatives.

- Discharge to Guicu and/or Cienega Creek to help satisfy water rights offset requirements. Similar to the Santa Fe River discharge scenario, this would likely require significant process upgrades to the Quill WRF to meet discharge standards. Losses in conveyance through natural drainage channels could be significant, and may warrant consideration of pipeline infrastructure for conveyance to a discharge point closer to the offsetting water rights compliance point.

- Interconnection to the City's nearby non-potable water reuse distribution system to supplement City non-potable reuse supplies from the Paseo Real WRF. This would likely require significant process upgrades to the Quill WRF to meet non-potable reuse standards, and new conveyance facilities and pumping facilities to match the pressure in the distribution system at the point of connection. This would reduce the amount of effluent used from the Paseo Real WRF to meet non-potable reuse demands, and free up additional Paseo Real WRF reclaimed water for increased reuse under any of the reuse alternatives.

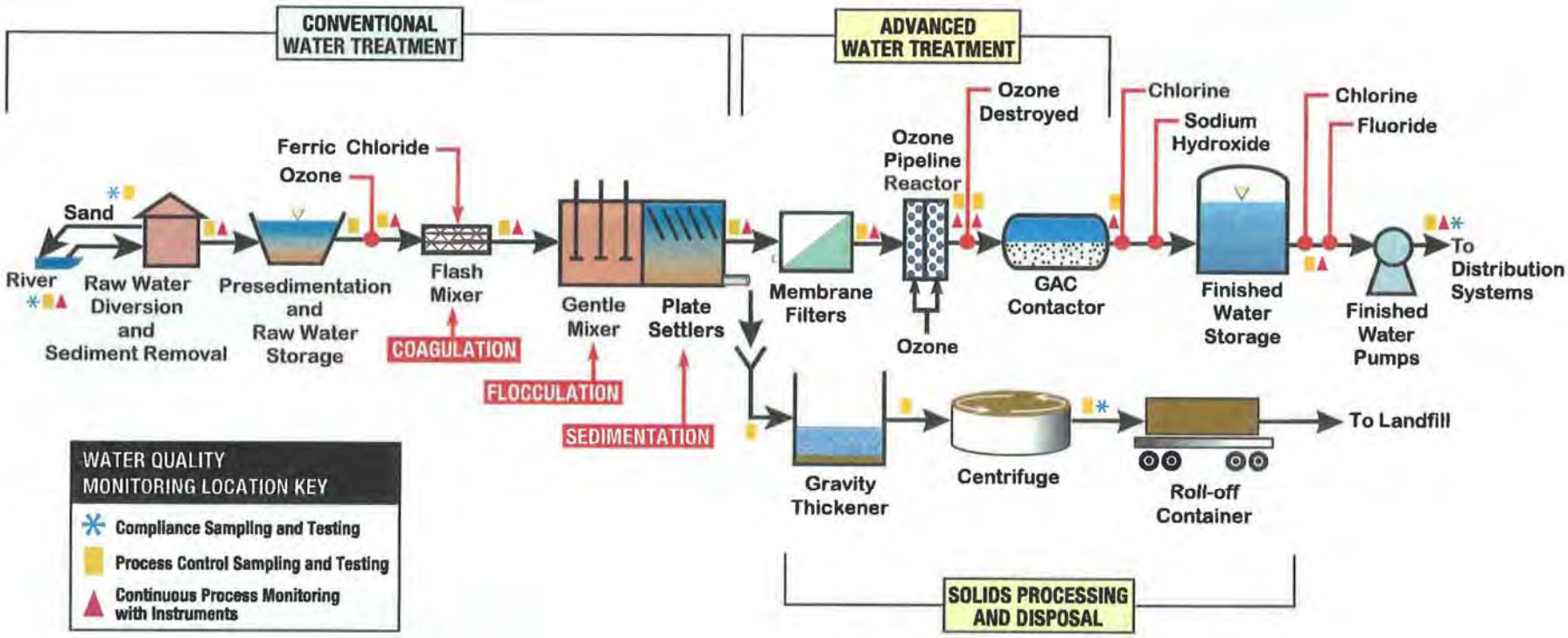
A more fully-integrated water management concept would include decommissioning of the Quill WRF, installation of a lift station, and conveyance of raw County wastewater to the Paseo Real facility for co-treatment with City wastewater. While this alternative has significant policy implications and would affect the capacity and sizing of the Paseo Real WRF, it would increase the availability of water at the Paseo Real WRF for flexible management of local resources under any of the four short-listed alternatives.

Additional investigations are necessary under any of the potential scenarios described above before the concepts could be moved forward. Chief among these is an identification of whether Quill WRF flows could be made available for such conjunctive reuse management systems. From there, the projected quantity of flow available for conjunctive reuse could be compared to water quality requirements for any of the scenarios described above, which in turn will drive the cost of capital improvements at the WRF necessary to meet the treated effluent requirements.

4.6 Description of Potential Recipient Water Treatment Facility

The BRWTF treats surface water diverted via the BDD intake on the Rio Grande using conventional and advanced treatment processes, as shown in Figure 4.3. Large particles are screened out at the sediment removal facility near the intake structure before water is pumped to the plant site, where smaller solids are settled out during raw water storage. The water is pre-ozonated, then coagulated with ferric chloride, flocculated, and settled using plate settlers. Clarified water is further treated through 0.1 micron membrane filters, ozonated again to destroy organic constituents, and passed through biological granular activated carbon (GAC) units for polishing. Finally, the water is disinfected with chlorine and pH is adjusted with caustic, as needed, prior to storage. Post-storage, disinfection is boosted with additional chlorine injection, fluoride is added to promote dental health, and corrosion inhibitors are added to control release of lead and copper in the distribution system.

In addition to providing conventional water treatment, the advanced treatment processes used at the BRWTF provide significant additional treatment for pathogens and pollutants. The advanced treatment portion of the BRWTF uses several of the processes proposed for advanced treatment of the tertiary effluent from the Paseo Real WRF in the potable reuse alternatives. A new AWTF is proposed for augmenting existing treatment trains (at Paseo Real WRF and BRWTF, as applicable to the alternative) to provide the necessary levels of treatment for public health and environmental protection.



Source: Buckman Regional Water Treatment Facility

SCHEMATIC OF THE BRWTF PROCESS TRAIN

FIGURE 4.3

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An additional layer of protection at the BRWTF for water sourced through the BDD is an Early Notification System. This system uses real-time computerized flow gauges and control logic to automatically stop diversions at the BDD if flows from the Los Alamos Canyon (an upstream tributary to the Rio Grande) exceed 5 cubic feet per second (cfs). This system was implemented to prevent the potential for larger storm events to mobilize legacy pollutants at the upstream Los Alamos National Laboratory, which are prevented from entering the BDD through this control system.

4.7 Current Reuse Practices

The City has successfully practiced non-potable water reuse for decades. Today, the City supplies reclaimed water meeting NMED Class 1B standards from the Paseo Real WRF for several reuse sites via a network of user-owned pumping and conveyance infrastructure. A map of the existing non-potable reuse distribution system is provided with the maps of individual reuse alternatives in Section 5.0.

As noted in Section 4.2, existing contractual commitments for reclaimed water sourced from the City's Paseo Real WRF were assumed to be honored and fulfilled in perpetuity for purposes of this Feasibility Study. Reuse customers are predominantly using recycled water for landscape irrigation, resulting in recycled water demands that peak in the summer and approach zero in winter months. A total of up to about 1,500 AFY of reclaimed water from the Paseo Real WRF is used for non-potable reuse, but this value varies annually based on irrigation need (e.g., dry versus wet years) and other drivers of reclaimed water use at each site. Further description of existing reuse practices is provided in the City's RWRP (City of Santa Fe 2013). Ongoing modernization of irrigation controls would increase the efficiency of reclaimed water use.

Section 4.2 described how the City's current non-potable demands often exceed the current (and projected future) available supply during peak days in summer demand months. This limits the availability of reclaimed water for additional reuse in the summer, which coincides with peak demands for existing and potential future non-potable uses. Section 4.2 also described how seasonal storage of reclaimed water for peak summer non-potable water reuse demands was considered but deemed infeasible.

Reclaimed water is conveyed to multiple non-potable reuse sites from a series of pump houses along the effluent channel at the Paseo Real WRF.

4.8 Current Water Reclamation Technology

Current water reclamation technology consists of the processes in place at the Paseo Real WRF for non-potable (Class 1B) reuse. A description of the facility and process was provided in Section 4.5.1. Improvements to the Quill WRF would be required if that facility were to be used to supply reclaimed water in the future. Additional treatment processes to augment the capabilities of the existing Paseo Real WRF to allow potable reuse are described in Section 4.9.

4.9 Treatment for Potable Reuse

Treatment goals for potable reuse were defined in Appendix A, Section A-1.1 (for pathogens) and Section A-1.2 (for chemicals). Approaches assessed in this Feasibility Study for meeting those goals are described below.

4.9.1 Pathogen Treatment Credits for Existing Infrastructure

As discussed in Appendix A, Section A-1.1, for the purpose of evaluating alternatives in the absence of pathogen (virus and protozoa) data for the secondary effluent, the log removal goals required by the State of California Department of Drinking Water (DDW) for treatment of raw wastewater were used as the basis of analysis:

- 12-log virus
- 10-log *Giardia*
- 10-log *Cryptosporidium*

In each of the potable reuse scenarios, treatment credit is assigned to existing infrastructure as follows:

- The actual pathogen removal levels at the Paseo Real WRF are not regularly quantified, so the facility was conservatively assigned 1.9-log virus, 0.8-log *Giardia*, and 1.2-log *Cryptosporidium* credit, in accordance with the lowest 10th percentile removal in existing literature (Rose et al. 2005).
- The BRWTF was conservatively assigned 4-log virus, 3-log *Giardia*, and 3-log *Cryptosporidium* credit in accordance with its current designation as a Bin 1 facility under the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2) (U.S. EPA 2006a).
- Finally, 4-log credit for virus and protozoa are given for soil aquifer treatment (SAT) experienced by the water in the Santa Fe River as it percolates into the ground and recharges the aquifer, in accordance with previous studies of pathogen inactivation through SAT (Hogg et al. 2013).

4.9.2 Advanced Treatment Concept for Potable Reuse

For all potable reuse alternatives, a treatment train is proposed that includes three core processes:

- Ozone (O_3). The organic matter contained in effluent (EfOM) is characterized by the presence of recalcitrant compounds which bypassed the biodegradation processes of the water reclamation facility. Ozonation of the effluent produces an advanced oxidation process, by which hydroxyl radicals oxidize chemical constituents and break them into more bioavailable components. Ozone is also a very effective disinfectant, and will be assigned 5-log virus removal credit for the purposes of this evaluation. It will also provide additional, but herein uncredited inactivation of *Giardia* and potentially *Cryptosporidium*. A potential issue with ozone is the formation of NDMA and bromate, which must be tracked during piloting and potentially mitigated.

- Biologically active filtration (BAF). The organic constituents made bioavailable by the preceding ozonation step are transformed and mineralized during BAF, reducing the TOC content of the water by up to 40 percent. NDMA formed during ozonation is also removed. No disinfection credits are assigned to BAF, though significant potential for removal of protozoa exists.

- Ultraviolet light disinfection (UV). The primary purpose of the UV reactor in this treatment plant concept is disinfection. A given UV dose will provide significantly more log inactivation of protozoa than virus. The sizing of the UV step is dependent on the amount of disinfection credit required to meet the treatment goals for individual alternatives. However, in no case is more than 6-log credit given for any organism.

Additional process steps are included in certain alternatives as needed:

- Ultrafiltration (UF). Ultrafilters are low pressure membrane filters that are assigned 4-log removal credit for protozoa. They also provide additional benefit by removing particles and turbidity ahead of the UV reactors, making these more efficient.

- Chlorine (Cl_2). Chlorine disinfection is provided for some alternatives for additional virus removal (up to 4-log, based on U.S. EPA Ct Tables) and to provide residual disinfectant in engineered storage and conveyance.

It is important to note that none of the treatment processes considered for this evaluation remove salinity. Salinity management is discussed in Section 4.9.4.

A summary of the pathogen log removal value (LRV) credits assigned to existing treatment components and proposed advanced treatment processes is provided in Table 4.3.

Table 4.3	Pathogen Log Removal Value Credits Assigned to Project Elements Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County		
	LRV Credits		
	Virus	**Giardia**	**Crypto**
Existing Treatment Components			
Paseo Real WRF(1)	1.9	0.8	1.2
CRWTF(2)	4	3	3
BRWTF(2)	4	3	3
Soil Aquifer Treatment (SAT)(3)	4	4	4
Advanced Treatment Processes			
Ozone	5	0	0
Biologically Active Filtration (BAF)	0	0	0
Ultraviolet (UV) Disinfection	up to 6	up to 6	up to 6
Ultrafiltration (UF)	0	4	4
Chlorine (Cl_2)	up to 4	0	0

Notes:

(1) The pathogen LRV credits assigned to the Paseo Real WRF are estimated based on taking the 10th percentile values observed in a study examining the removal in six different water reclamation facilities (Rose et al. 2005)

(2) Pathogen inactivation at both water treatment facilities are conservatively assessed at its current requirements corresponding to a Bin 1 designation under the Long-Term 2 Enhanced Surface Water Treatment Rule.

(3) SAT is assigned LRV credits based on work by Hogg et al. 2013.

4.9.3 Chemical Treatment Goals

In terms of chemical parameters, the treatment trains selected for this and all subsequent potable reuse alternatives (whether direct or indirect) are intended to address chemical parameters that may be of potential concern. For the purposes of evaluating alternatives in the absence of analytical data, any treatment train will include core processes that provide a robust barrier against regulated and unregulated chemicals.

Prior to design of such a treatment facility, significant sampling must be conducted to confirm the assumptions made herein. Additional measures to remove nitrate (if needed), limit issues related to disinfection byproduct formation, and/or address other unforeseen treatment issues would be addressed during subsequent demonstration-scale testing.

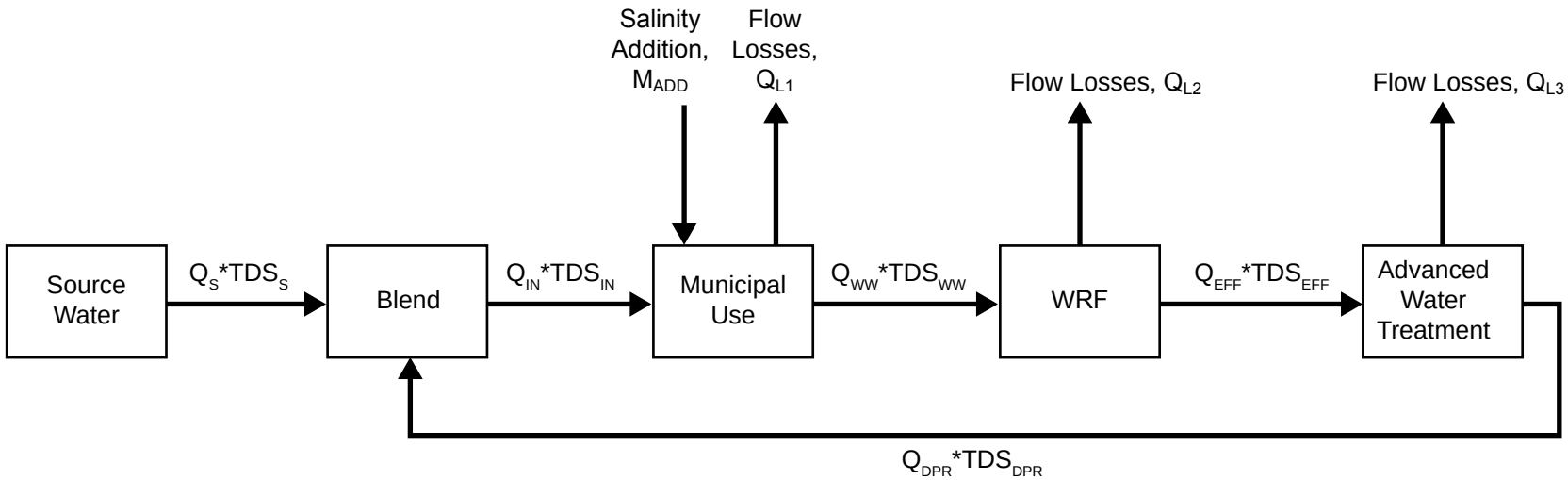
4.9.4 Salinity Management in Potable Reuse Systems

Human use adds salinity to wastewater. Unless this salt is removed in treatment, creating a potable reuse system therefore necessarily leads to an increase in potable water salinity. However, many loss mechanisms exist, including irrigation, leaks, discharge, or other consumptive uses of water throughout the urban water cycle. This means that any potable reuse system that does not intend to include a desalination step (such as RO) should undergo a detailed salinity mass balance that quantifies the salt inputs and outputs to the system, in order to determine that salinity levels do not equilibrate at an unacceptable level. Alternatively, if the potential exists of reaching unacceptable levels of salinity, the system can be managed proactively through, for example, strategic system flushing (taking the potable reuse system offline) during times of higher surface water flows.

In Santa Fe, the seasonal availability of water from the Paseo Real WRF will necessarily reduce the contributions of potable reuse supply to the overall system in the summer, offering opportunities to mitigate salinity accumulation in the system.

Regulated parameters with respect to salinity include total dissolved solids (TDS), sulfate, and chloride, which have secondary MCLs of 500 mg/L, 250 mg/L and 250 mg/L, respectively. Based on a preliminary and conservative analysis, the future effluent from the Paseo Real WRF might exceed 500 mg/L TDS. However, when blended with the current water sources, the concentration of water served to the City's customers would be well below this level. Therefore, while additional analysis is warranted before design, for the purposes of this evaluation, salinity removal is not considered a requirement of advanced treatment for potable reuse in Santa Fe.

The effects of a DPR approach without salinity removal on steady-state potable water salinity can be estimated using a simple mass balance approach, which is graphically represented in Figure 4.4. The mass balance equations that can be derived from this figure are detailed in Appendix A.



Legend

Q = Flow (mgd)
TDS = Total Dissolved Solids (mg/L)
M = Mass Loading Rate (kg/day)
Subscripts:

- S = Supply from Potable Source
- IN = Potable Water Supplied to Residents
- WW = Wastewater
- EFF = Treated Effluent
- DPR = Advanced-Purified Water from DPR
- L = Loss

SALINITY MASS BALANCE SCHEMATIC

FIGURE 4.4

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The TDS at various points in the City water system that was calculated for winter and summer scenarios is presented in Table 4.4. Due to lower water use, DPR is a larger fraction of the winter supply, resulting in the highest TDS levels expected in the system. This represents a conservative estimate of the highest steady-state salinity concentrations anticipated in the case of a DPR project without desalination.

Table 4.4 Salinity Level Analysis Findings
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Parameter	Units	Winter	Summer
DPR proportion of total water portfolio		30%	10%
TDS in treated DPR stream	mg/L	586	470
TDS in local blended water(1)	mg/L	350	271
TDS in overall blended water	mg/L	350	234

Notes:
(1) BRWTF Entry Point

Therefore, no average system salinity concerns are identified in either scenario, although the salinity of the steady-state DPR water during the winter is calculated to be slightly above the maximum concentration goal beyond which one must consider blending ratios with existing treated water in order to ensure that no portions of the distribution system receive water that exceeds the 500 mg/L TDS goal.

Thus, salinity removal is not a critical feature of the advanced treatment process for this project. Based on the above, coupled with a lack of practical disposal options for RO concentrate from an advanced treatment facility and the desire to recapture as much of the flow as possible, the project team selected the ozone-biofiltration treatment concept for further evaluation.

5.0 DESCRIPTION OF ALTERNATIVES

5.1 Non-Federal Funding Condition

Santa Fe faces significant future water supply shortages, as described earlier in this report and in the 2015 Basin Study. The non-Title XVI project alternative considered in this Feasibility Study represents the likely alternative path for avoiding such shortages if no expansion of water reuse is pursued in Santa Fe. The non-Title XVI project alternative comprises the purchase of additional native Rio Grande water rights for diversion and treatment using the existing BDD diversion and treatment facilities. No new infrastructure for diversion, conveyance, or treatment was assumed necessary for this alternative, because it would use existing facilities and capacities to treat and deliver water.

Purchase prices for water rights are variable depending on seniority and other market conditions. Along the Rio Grande, all of the surface water was allocated prior to the creation of the New Mexico Office of the Territorial Engineer – now the NMOSE – in 1907. For this reason, it is necessary for a water right to be pre-1907 in order to be useful for the City's purposes. For pre-1907 rights, City staff estimated that current water rights purchases on the Rio Grande would cost on the order of $20,000 to $30,000 per AFY. For purposes of this Feasibility Study, the higher value was used because of the potential for a major purchase to drive market costs upward.

The non-Title XVI project was not evaluated in the alternatives screening process, because it was automatically carried forward for comparison to the reuse alternatives remaining after the screening process. For purposes comparing this alternative on an equal basis with the reuse alternatives, this alternative was assumed to include purchase of 2,376 AFY of new native Rio Grande rights. While larger amounts could, in theory, be purchased to mitigate the entire projected water shortage, assuming so would make the alternatives produce different yields and bias the costs in favor of the Title XVI reuse alternatives considered here.

The estimated cost to purchase 2,376 AFY of additional water rights (using the same yield as in the reuse alternatives considered in this Feasibility Study, documented in Table 4.2) is approximately $71 million. Purchasing this quantity of senior native Rio Grande rights may not even be feasible, given the scarcity of resources and the profusion of competitors for those resources on the Rio Grande. Moreover, purchasing additional water rights that would impact flows on the Rio Grande and have the potential to impact nonconsumptive and consumptive uses throughout the Rio Grande valley, while underutilizing the available and sustainable local reclaimed water supply, runs counter to Santa Fe's approach to environmental stewardship and cultural preservation.

If federal funding is not provided for the Santa Fe water reclamation and reuse project, difficult decisions will need to be made by the community with respect to whether and how the community can support the tremendous investment in a water reuse expansion project and/or additional water rights from the Rio Grande watershed. It is also possible that the necessary supply projects would not or could not be financially supported. In this event, Santa Fe would have difficult choices between drastic measures such as building moratoria or substantial mining of groundwater resources at unsustainable pumping rates. Neither approach is viable in the long-term, and overpumping of groundwater (e.g., Buckman Wells and City Wells) would eventually make that drought-resistant resource unreliable. Moreover, increased reliance on groundwater would increase the required surface water offsetting water rights – which would further compound the economic impact of not moving forward with a Title XVI project and which could create a situation in which Santa Fe was unable to utilize available surface water due to permitting obligations associated with previous years' groundwater pumping.

5.2 Objective of the Project

The primary objective of this Feasibility Study is to identify the highest value use of the reclaimed water currently available from the Paseo Real WRF and potential future flows from the Quill WRF, while respecting downstream flow maintenance for cultural and ecological purposes on the lower Santa Fe River.

5.3 Non-Title XVI Alternative: Other Sources

The non-Title XVI alternative considered in this Feasibility Study is the purchase of additional native Rio Grande rights for diversion through the existing BDD conveyance and treatment system. This alternative is described in Section 5.1.

5.4 Reclamation Project Alternatives and Elements

Seven reuse alternatives were considered in the Feasibility Study, including the following. Each of these is described in the following subsections.

- Alternative 1: Expand Non-Potable Reuse
- Alternative 2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits
- Alternative 3: Enhanced Living River and Aquifer Storage and Recovery
- Alternative 4: Aquifer Storage and Recovery via Lower Santa Fe River
- Alternative 5: Aquifer Storage and Recovery via Buckman Well Field
- Alternative 6: Augment Nichols Reservoir
- Alternative 7: Direct Potable Reuse

Landscape irrigation at St. Michael's High School is one of the sites contemplated for expanded non-potable reuse under Alternative 1.

5.4.1 Alternative 1: Expand Non-Potable Reuse

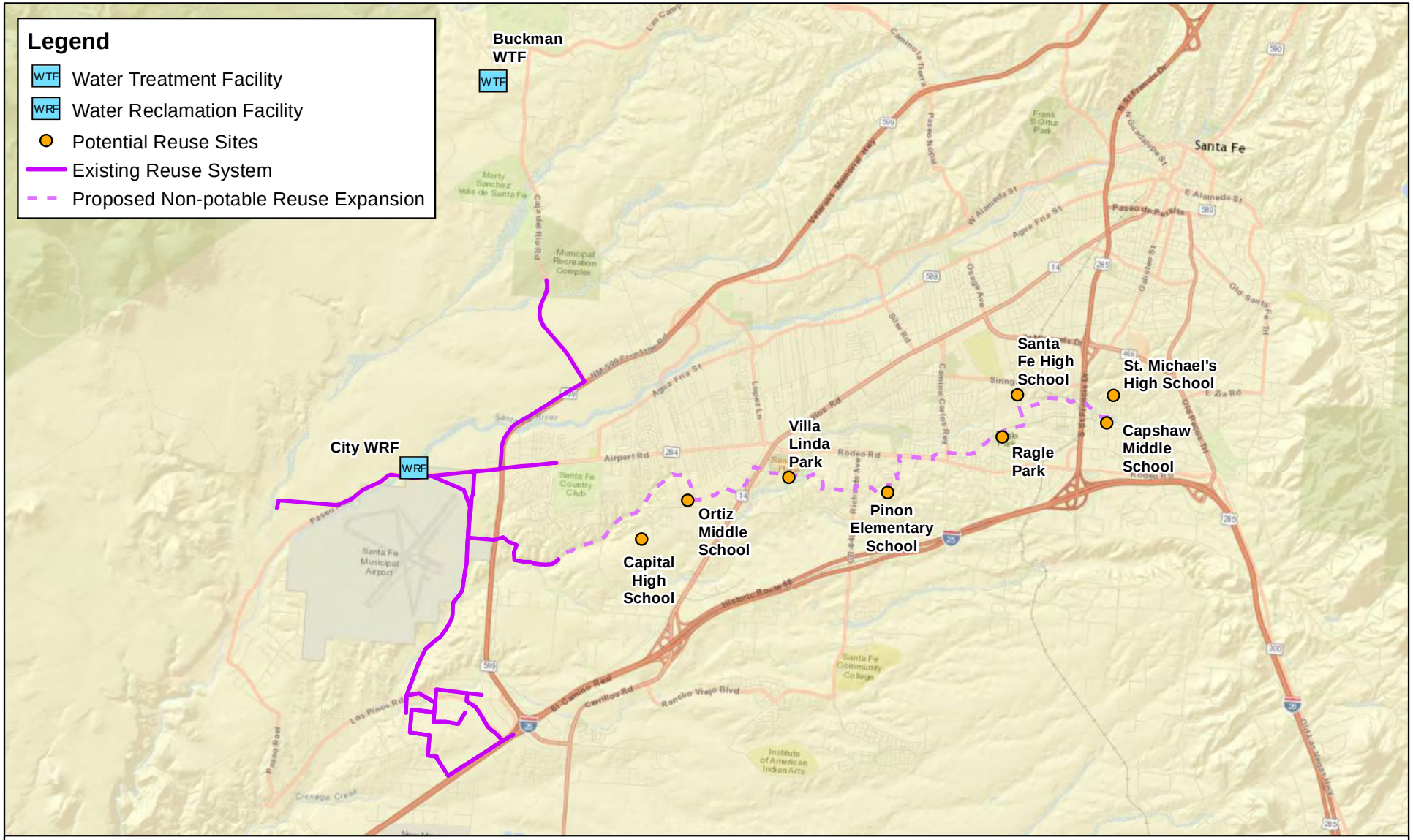
5.4.1.1 Overview

Alternative 1 involves expanding the existing non-potable reuse transmission system to serve additional parks and schools in Santa Fe. Potential sites were selected based on current irrigation water use and relative proximity to the Paseo Real WRF, as shown in Table 5.1 and discussed in Section 4.1. Reclaimed water service would be provided to these sites via an extension off the existing SWAN Park reuse transmission line. A map of this alternative is shown in Figure 5.1. For this analysis, minor piping connections (e.g., from the main transmission line to Capital High School) and associated appurtenances were assumed to be the financial responsibility of each individual user.

Table 5.1 Non-Potable Reuse Expansion Sites
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Site	Annual Average Water Use[1] (AFY)	Peak Month Use[1] (kgal/d)[2]	Order on Proposed Pipeline Extension
Capital High School	30.3	77.3	1
Ortiz Middle School	8.7	36.3	2
Villa Linda Park	2.9	9.5	3
Pinon Elementary School	3.0	6.2	4
Ragle Park	27.6	70.0	5
Santa Fe High School	26.3	44.3	6
Capshaw Middle School	9.6	21.1	7
St. Michael's High School	24.9	60.2	8

Notes:
(1) Data provided by the City of Santa Fe for 2011-2015.
(2) kgal/d – thousand gallons per day.



ALTERNATIVE 1 - EXPAND NON-POTABLE REUSE

FIGURE 5.1

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5.4.1.2 Treatment Goals and Gap Analysis

No additional treatment is required for this alternative, as it maintains and expands on existing uses. The Paseo Real WRF is already capable of meeting NMED Class 1B non-potable reuse requirements. Class 1B requirements are expected to apply to the new reuse sites, similar to how it applies to existing reuse sites, provided that public access is restricted during irrigation and all the users comply with all other applicable NMED non-potable reuse requirements.

5.4.1.3 Description of Project Elements

This alternative would require approximately 8.5 miles of nominal 8" diameter pipe and two 70-horsepower (HP) pump stations to accommodate a peak flow of 1.0 mgd. Sizing of the pipeline assumed that the expanded reuse sites would all be directly fed from the pipeline (with no terminal or onsite storage), with irrigation operations occurring overnight (8 hours per day, 3 days per week), and that the sites would alternate irrigation nights, with half of the sites (measured by peak demand) irrigated one night and the other half irrigated the next night. The pipeline was assumed to have a constant diameter along its entire length, to allow for future extensions. Preliminary pipeline and pumping calculations assume 250-pound per square inch (psi) class ductile iron pipe, with the number of pump stations set to maintain pressures no higher than this.

The pipeline would be extended off the eastern end of the existing non-potable reuse transmission system from the existing termination near SWAN Park. Ground elevations increase from approximately 6282 feet above mean sea level (MSL) at the Paseo Real WRF up to 6886 at the termination of the extended line, for a static pumping head of 604 feet. Total dynamic head was calculated based on estimated friction and minor losses at the maximum in-pipe velocity of 4.3 feet per second (ft/sec).

No additional treatment is required for this alternative, beyond the existing capabilities of the Paseo Real WRF.

Section 4.2 provides detail on how insufficient reclaimed water is available to meet summer peak demands for the expanded reuse sites contemplated in this alternative. On certain peak days, existing non-potable reuse customers utilize all of the available reclaimed water, forcing operational decisions to either under-serve the existing reuse customers' demands or discharge less than the summertime goal of 2 mgd to the Santa Fe River. The lack of supply availability for the proposed non-potable reuse system expansion is essentially a fatal flaw. However, the alternative was carried forward through the screening analysis to determine how it would compare to the others, in the event that seasonal storage or other means to addressing the supply shortage could be implemented in the future.

5.4.2 Alternative 2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits

5.4.2.1 Overview

This alternative includes constructing a new pipeline to convey Paseo Real WRF reclaimed water to a point of discharge to the Rio Grande just downstream of the BDD diversion site to obtain return flow credits for exchange, using return flows generated from diversions of Santa Fe's SJCP contract water delivered via contract with the Bureau of Reclamation. It was assumed based on previous analyses and state precedent that the exchange would allow Santa Fe to divert one acre-foot of additional water through the BDD system for every one acre-foot of reclaimed water discharged (i.e., a 1-for-1 exchange). The exchange would allow Santa Fe to increase the number of AFY diverted and treated, while maintaining the existing infrastructure and treatment sizing at 15 mgd. Given Santa Fe's present rate of consumption of 40 percent of the water diverted, were the City to pursue Return Flow Credits and account for repeated cycles of returns, it could increase the amount of consumable water that could be pulled from the BDD diversion by 150 percent without additional water rights (up to an overall multiplier of up to 2.5 times the original consumable water right).

The actual water supply benefit of the Full Consumption of SJCP Water via Rio Grande Return Flow Credits project would be limited by physical water supply availability at the Paseo Real WRF. Existing commitments to non-potable reuse and minimum target releases to the Santa Fe River from the Paseo Real WRF constrain the supply available for return flow credits at 2,334 AFY under the scenarios contemplated in this Feasibility Study. Increasing the capacity of the return flow credit pipeline for increased wintertime use and implementing additional conservation measures at non-potable reuse sites could increase the amount of water available for exchange under this alternative.

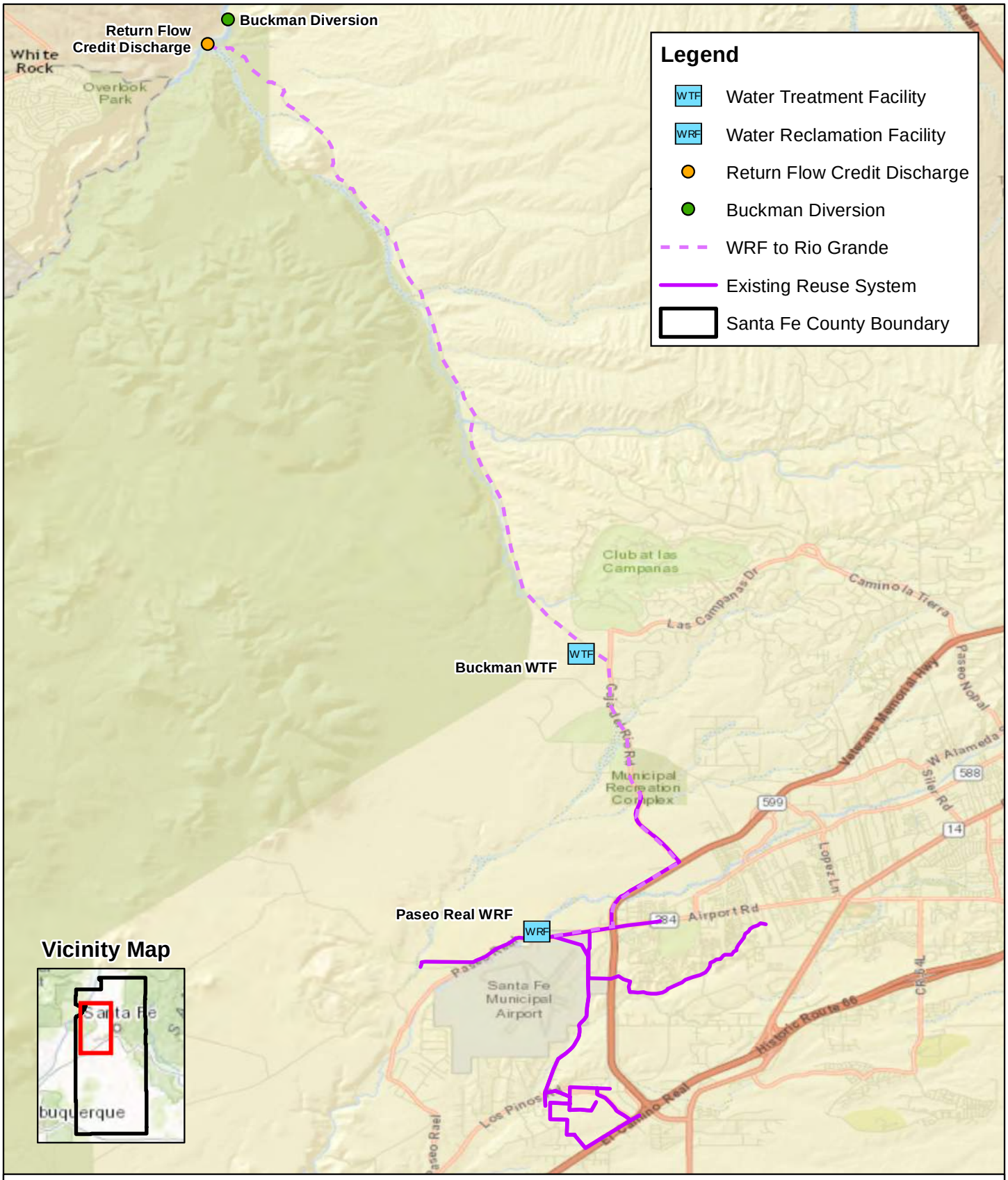
By making this exchange, this alternative comprises an indirect way of reusing the available reclaimed water while not actually diverting, treating, or distributing reclaimed water to Santa Fe's customers. The return flow discharge point was conceptually located immediately downstream of the BDD diversion, to avoid having any significant length of the Rio Grande being impacted by the diversion upstream of return flows.

A map of this alternative is shown in Figure 5.2. The alternative is conceptually identified as diverting exchanged water in annual amounts equal to the amount of water discharged to the Rio Grande.

There may be opportunities to beneficially use water discharged to the Rio Grande in excess of the City's needs (e.g., until demands warrant diversion by exchange of the entire amount of reclaimed water available for return flow credits, and/or in wetter years when existing surface water supplies provide their full yield). This could include augmentation of Rio Grande flows for environmental benefits, temporary/intermittent leasing of water discharged to the Rio Grande to other water users, or utilization for pumping offsets incurred by permitted groundwater pumping in the Buckman Well Field. These opportunities were not considered in detail in this Feasibility Study, but should be considered if and when the project moves forward for implementation.

5.4.2.2 Treatment Goals and Gap Analysis

No additional treatment is proposed for this alternative, given that flow and water quality conditions on the Rio Grande are expected to support permit limits that would be equal or less stringent than the permit requirements for the Paseo Real WRF discharge to the Santa Fe River.



ALTERNATIVE 2 - FULL CONSUMPTION OF SJCP WATER VIA RIO GRANDE RETURN FLOW CREDITS

N

Miles

0 0.5 1 2

FIGURE 5.2

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5.4.2.3 Description of Project Elements

This alternative would require piping reclaimed water from the existing Paseo Real WRF to a point of discharge just downstream of the BDD diversion at the former Buckman townsite. If and when this project moves forward for implementation, additional consideration should be given to the potential for obtaining credit for water discharged from the WRF to the Santa Fe River by returning flows to the Rio Grande through the natural watercourse of the Santa Fe River (above-ground and/or via the alluvium).

For purposes of this Feasibility Study, it was conservatively assumed that 100 percent of the return flow credit water would need to be piped to the Rio Grande, and that the point of discharge to the Rio Grande would be immediately below the BDD diversion to minimize or eliminate water rights and/or environmental impacts associated with the exchange. Inherently, those impacts should be effectively "zero" since the amount of additional water diverted by the City would be equal to the amount discharged immediately downstream for exchange. Inspection of the permit governing the operations of a similar exchange on the Rio Grande by the Albuquerque Bernalillo County Water Utility Authority suggests that water rights and permitting of this exchange is feasible but could be a lengthy and challenging process.

Reclaimed water would be pumped to the Rio Grande and exchanged for increased diversions through the BDD system under Alternative 2.

To pump reclaimed water from the Paseo Real WRF would require approximately 17.7 miles of nominal 14-inch diameter pipeline and one 200-HP pump station to convey a peak flow of 3.0 mgd from the City's Paseo Real WRF to a discharge location on the Rio Grande immediately downstream of the current submerged BDD water intake. It was conservatively assumed for purposes of this Feasibility Study that Santa Fe would not have the ability to repurpose the existing 12-inch diameter non-potable reuse pipeline that serves the Municipal Recreation Complex and other users in the vicinity, since the City does not own that pipeline. Moreover, the existing 12-inch diameter pipeline likely does not have the pressure rating necessary to convey 3 mgd. Further investigation of this pipeline's construction, capacity, and availability for use in conveying return flow credits to the Rio Grande should occur as part of preliminary design activities if the project moves forward into implementation.

Preliminary pipeline and pumping calculations assume 250-psi class ductile iron pipe, with the number of pump stations set to maintain pressures no higher than could be handled. The pipeline would originate at the Paseo Real WRF reuse channel and extend primarily along existing public right-of-way and easements utilized for the BDD raw water transmission line (from the BDD diversion to BRWTF). Ground elevations along the pipeline route increase from approximately 6282 feet MSL at the Paseo Real WRF up to a high point of 6535 before descending to the Rio Grande discharge point with elevation of 5465, for a static pumping head of 253 feet. Total dynamic head was calculated based on estimated friction and minor losses at the maximum in-pipe velocity of 3.9 ft/sec.

5.4.3 Alternative 3: Enhanced Living River and Aquifer Storage and Recovery

5.4.3.1 Overview

This alternative involves advanced treatment of up to 3 mgd of effluent for conveyance and discharge into the Upper Santa Fe River for recharge of the local aquifer and the creation of a Living River in the downtown area. Water recharged to the aquifer would be recovered through the City Wells without further treatment. For purposes of the preliminary analysis, it was assumed that the existing Torreon and Alto wells in central Santa Fe would be rehabilitated to better allow them to recover water recharged to the aquifer. This alternative does not contemplate additional water rights or City Well Field capacity improvements. Rather, it assumes that the aquifer recharge would be intended to increase aquifer sustainability relative to the City's current and future use of the City Well Field.

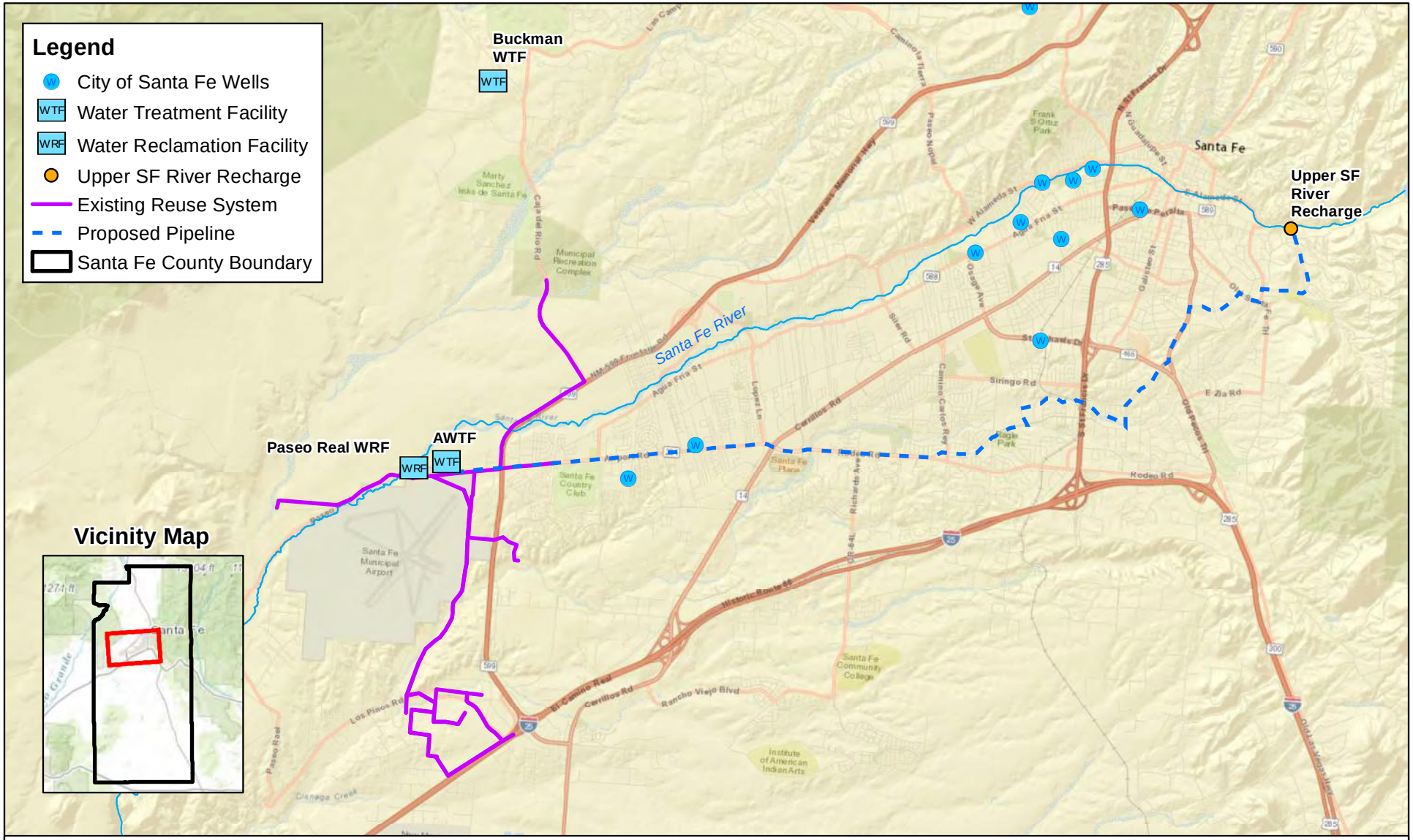
The net yield for Alternative 3 was re-evaluated after preliminary analyses, in light of newly-available results from spring 2016 seepage studies conducted by the City (as further described in Section 6.2). JSAI (2016a) found that seepage into the aquifer for the stretch of river upstream of Torreon and Alto wells was minimal, thereby making the alternative not feasible for aquifer storage and recovery (ASR). Furthermore, Torreon and Alto wells are screened too deep, and not feasible to be rehabilitated to better allow them to recover water recharged to the aquifer.

The Living River discharges could potentially replace a portion of the water that is currently bypassed from the Upper Santa Fe River watershed to create the Living River benefit. However, limitations in the seasonal availability of reclaimed water (due to existing non-potable reuse demands) would require either an alteration of Living River flow patterns, or supplemental Upper Santa Fe River watershed bypass flows to augment Living River flows when reclaimed water availability is inadequate during peak summer non-potable reuse demand periods. A map of this alternative is shown in Figure 5.3.

5.4.3.2 Treatment Goals and Gap Analysis

This is a potable reuse alternative, and as such, requires additional treatment beyond what is being provided at the Paseo Real WRF. As discussed in Section 4.9.1, this alternative must achieve 12-log virus, 10-log *Giardia*, and 10-log *Cryptosporidium* treatment credit. This can be accomplished through a combination of treatment at the Paseo Real WRF, a new AWTF, and SAT.

Reclaimed water would be pumped to the Two-Mile Reservoir site on the upper Santa Fe River to augment Living River bypass flows from the reservoirs and recharge groundwater in Alternative 3.



ALTERNATIVE 3 - ENHANCED LIVING RIVER AND ASR

FIGURE 5.3

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Existing systems (Paseo Real WRF and river bed SAT) provide 5-log virus, 4-log *Giardia*, and 4-log *Cryptosporidium* credit. As shown in Table 5.2, this means an AWTF for this alternative would have to meet *at minimum* 6.1-log virus, 5.2-log *Giardia*, and 4.8-log *Cryptosporidium* goals.

Table 5.2 Alternative 3 Gap Analysis
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

	LRV Credits		
	Virus	**Giardia**	**Crypto**
Goals	**12**	**10**	**10**
Existing Treatment Components			
Paseo Real WRF(1)	1.9	0.8	1.2
Soil Aquifer Treatment (SAT)(2)	4	4	4
Treatment Needed at AWTF	**6.1**	**5.2**	**4.8**

Notes:
(1) The pathogen LRV credits assigned to the Paseo Real WRF are estimated based on taking the 10th percentile values observed in a study examining the removal in six different water reclamation facilities (Rose et al. 2005)
(2) SAT is assigned LRV credits based on work by Hogg et al. 2013.

5.4.3.3 Description of Project Elements

The AWTF would consist of the basic treatment train laid out in Section 4.9.2, with O_3, BAF, and UV, achieving a total log removal of 8-log virus, and 6-log each *Giardia* and *Cryptosporidium* as shown in Table 5.3. This assumes a medium-dose UV system that provides 3-log inactivation of virus, which would not be sufficient if significant removal of NDMA is required. A larger, more powerful UV system could address NDMA removal requirements, and would provide additional disinfection beyond what is assumed in this alternative.

Table 5.3 Alternative 3 Treatment Log Removal Value Summary
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

	LRV Credits		
	Virus	**Giardia**	**Crypto**
Treatment Needed at AWTF	**6.1**	**5.2**	**4.8**
Advanced Treatment Processes			
Ozone	5	0	0
Biologically Active Filtration (BAF)	0	0	0
Ultraviolet (UV) Disinfection	3	6	6
Total Advanced Treatment LRVs	**8**	**6**	**6**

The advanced purified water would then be conveyed along the alignment and to the point of discharge upstream of the downtown area, as shown in Figure 5.3. For this preliminary analysis, the discharge was conceptually located near Monsignor Patrick Smith Park, where Alameda Street crosses the river before becoming Canyon Road. This alternative would require approximately 12.2 miles of nominal 14-inch diameter pipeline and three 220-HP pump stations to convey a peak flow of 3.0 mgd. The discharge location and associated infrastructure costs were revised as part of detailed analyses of this alternative (see Sections 6.2 and 7.1.2).

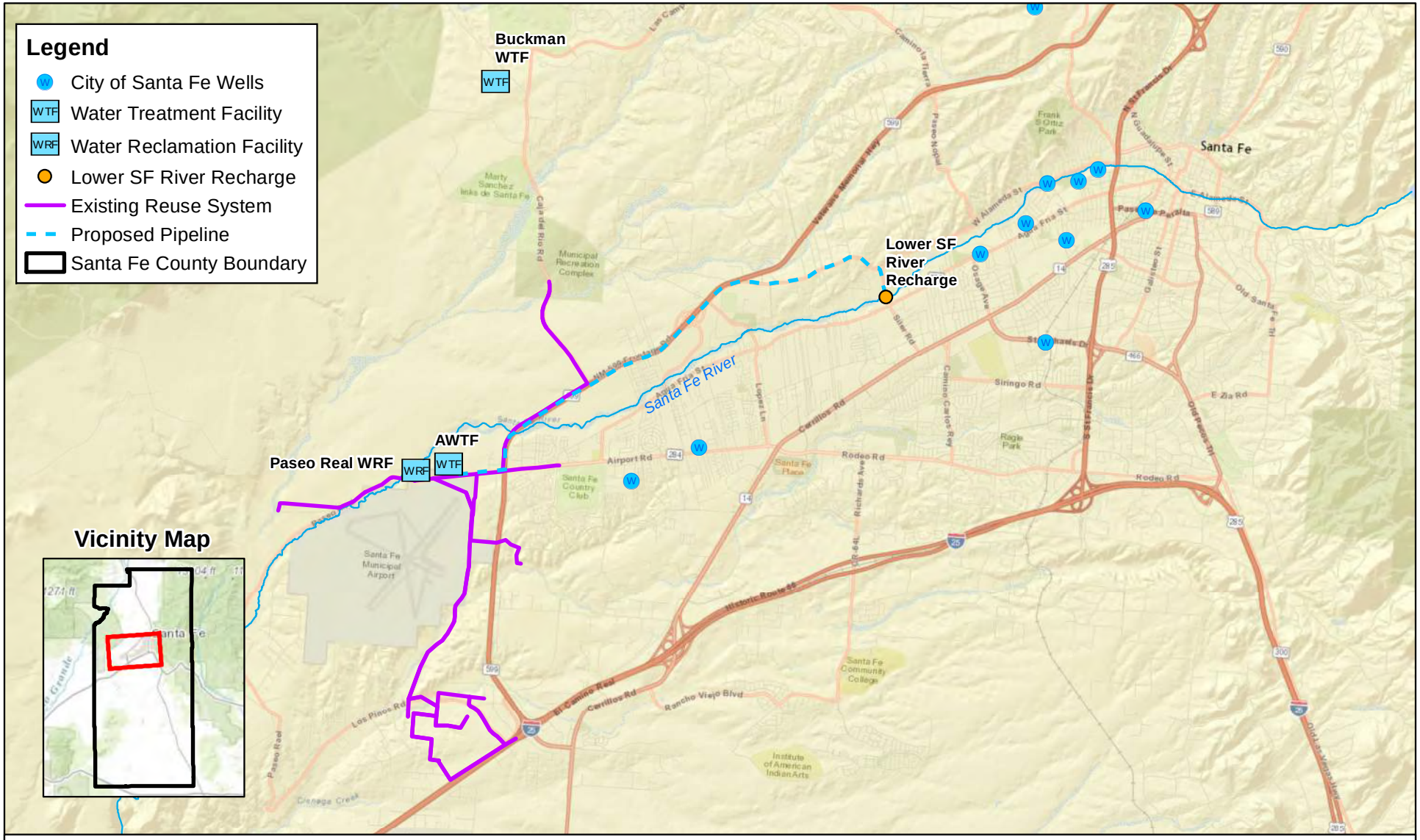
Preliminary pipeline and pumping calculations assume 250-psi class ductile iron pipe, with the number of pump stations set to maintain pressures no higher than this. The pipeline would originate at the AWTF adjacent to the Paseo Real WRF and extend primarily along existing public right-of-way. Routing of the pipeline was conceptually developed to avoid the congested downtown area and potential sensitive cultural resource sites by tracking eastward along existing rights of way in south-central Santa Fe before moving northward to the point of discharge. Ground elevations along the pipeline route increase from approximately 6313 feet MSL at the AWTF site up to a high point of 7319 before descending to the Santa Fe River discharge point with elevation of 7122, for a static pumping head of 1006 feet. Total dynamic head was calculated based on estimated friction and minor losses at the maximum in-pipe velocity of 3.9 ft/sec.

A discharge permit from U.S. EPA Region 6 would be required for discharges to the stream channel. The NMED would certify the permit under Section 401 of the Clean Water Act to ensure it is protective of the river's designated uses and all applicable water quality standards. The designations incurring the most stringent water quality standards for this surface water reach would be coolwater aquatic life and primary contact. It may be possible to modify the existing discharge permit for the Paseo Real WRF (e.g., adding a new outfall). Because no additional diversions of groundwater are planned under this alternative, no water rights permitting issues are anticipated relative to the upstream discharge.

5.4.4 Alternative 4: Aquifer Storage and Recovery via Lower Santa Fe River

5.4.4.1 Overview

This alternative involves additional treatment of up to 3 mgd of effluent for conveyance and discharge to the Lower Santa Fe River for recharge of the local aquifer. Similar to Alternative 3 in many ways, this alternative would not create a Living River in the downtown area. It also would not recharge any existing City wells, necessitating the implementation of new recovery wells at points along the Santa Fe River between Siler Road and the Paseo Real WRF discharge. These wells and the water rights they divert will require permit approvals, since it would comprise a new use of an existing aquifer. A map of this alternative is shown in Figure 5.4. The recovery quantities were subsequently revised as part of detailed analyses of this alternative, in light of newly-available results from spring 2016 seepage studies conducted by the City (as further described in Section 6.2).



ALTERNATIVE 4 - ASR VIA LOWER SANTA FE RIVER

FIGURE 5.4

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5.4.4.2 Treatment Goals and Gap Analysis

The analysis of treatment requirements for this alternative is identical to that proposed for Alternative 3: Enhanced Living River and Aquifer Storage and Recovery.

5.4.4.3 Description of Project Elements

The treatment processes proposed for the AWTF under this alternative are identical to those proposed for Alternative 3. Due to the closer discharge location, however, the conveyance infrastructure components of Alternative 4 are shorter than those of Alternative 3.

This alternative would require approximately 6.3 miles of nominal 14-inch diameter pipeline and one 310-HP pump station to convey a peak flow of 3.0 mgd along the alignment and to the discharge location shown in Figure 5.4. The discharge is conceptually located at the Siler Road crossing of the Santa Fe River.

Preliminary pipeline and pumping calculations assume 250-psi class ductile iron pipe, with the number of pump stations set to maintain pressures no higher than this. The pipeline would originate at the AWTF adjacent to the Paseo Real WRF and extend primarily along existing public right-of-way. Routing of the pipeline was conceptually planned to follow Alameda Street to Siler Road, to the bridge at the Santa Fe River. Ground elevations along the pipeline route increase from approximately 6313 feet MSL at the AWTF site up to a high point of 6767 before descending to the Santa Fe River discharge point with elevation of 6662, for a static pumping head of 454 feet. Total dynamic head was calculated based on estimated friction and minor losses at the maximum in-pipe velocity of 3.9 ft/sec.

Reclaimed water would be pumped to a point near Siler Road and discharged to the Santa Fe River to augment streamflow and recharge groundwater in Alternative 4.

Recovery wells would be installed in the upper aquifer at a point downstream of the discharge point, at a distance downstream to be determined after further analysis of hydrogeology and groundwater transport in the area. Percolation and recharge could potentially be enhanced by creating a distributary system (so discharged water does not become one single channel) and/or small low-head dams that would cause pooling in the Santa Fe River and enhance recharge. A US Army Corps of Engineers (USACE) 404 permit may be necessary for any modifications to the stream channel.

Depth to water in this area ranges between 100 and 170 feet below ground level (ft bgl; JSAI 2016). As determined from previous work by JSAI (1995), Koning and Read (2010), and Hawley (2014), the target geologic unit for recharge and recovery would be the Ancha Formation and Lithosome S of the Tesuque Formation. Average hydraulic conductivity is expected to be 15 feet per day (ft/day). The anticipated depth of recovery wells would be 300 ft bgl.

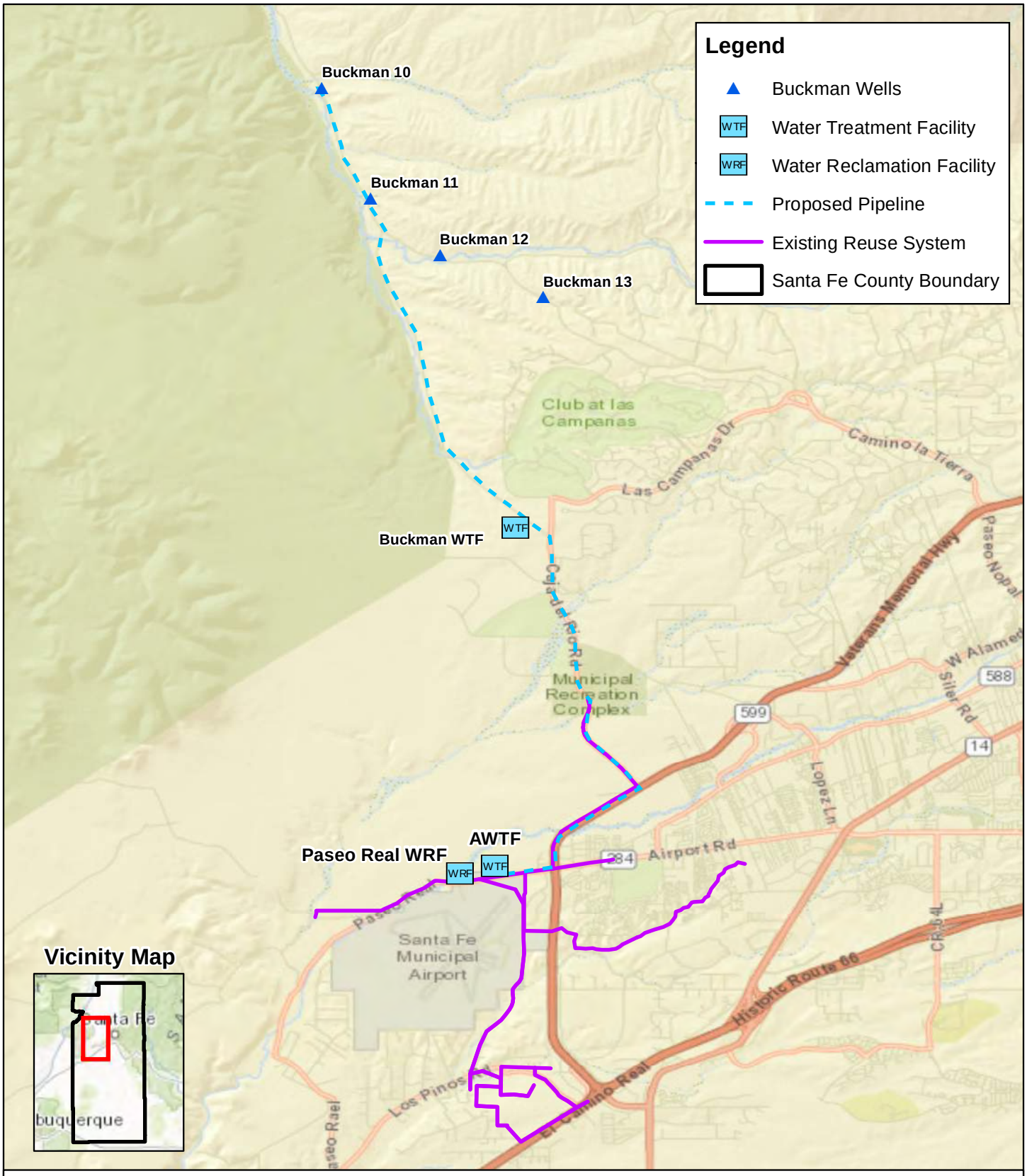
As with Alternative 3, a discharge permit from U.S. EPA Region 6 would be required for discharges to the stream channel and/or to groundwater. It may be possible to modify the existing discharge permit for the Paseo Real WRF (e.g., adding a new outfall).

The NMOSE would also require a water rights permit for recovery of stored water in the groundwater system. According to findings by John Shomaker and Associates developed under separate contract to the City, there are two possibilities for water rights permitting, 1) apply for new appropriation for recovery well and offset the diversion effects with discharge credits for storage of infiltrated effluent, and 2) apply for ASR permit. Either option will require some level of demonstration to prove that the water recovered is equal to or less than the water stored in the aquifer. Although ASR permits are required to pass the demonstration tests, the discharge credit plan may not require a demonstration project. A third option would be to use the recharge to enhance Santa Fe's existing local groundwater sources, without applying for a permit to increase groundwater diversions.

5.4.5 Alternative 5: Aquifer Storage and Recovery via Buckman Well Field

5.4.5.1 Overview

Alternative 5 involves advanced treatment of reclaimed water from the Paseo Real WRF, which is then conveyed northward to the Buckman Well Field, where is it injected into and withdrawn from existing wells. A map of this alternative is shown in Figure 5.5. Through radial flow model analysis, JSAI (2012) concluded that Buckman Wells 10 through 13 have significant recharge capability. It should also be noted that there are numerous domestic wells in the area that could pose a significant public acceptance challenge for Alternative 5.



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ALTERNATIVE 5 - ASR VIA BUCKMAN WELL FIELD

FIGURE 5.5

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5.4.5.2 Treatment Goals and Gap Analysis

This is a potable reuse alternative, and as such, requires additional treatment beyond what is being provided at the Paseo Real WRF. As discussed in Section 4.9.1, this alternative must achieve 12-log virus, 10-log *Giardia*, and 10-log *Cryptosporidium* treatment credit. Existing infrastructure includes the Paseo Real WRF, which provides 1.9-log virus, 0.8-log *Giardia*, and 1.2-log *Cryptosporidium* credit.

The entire treatment credit must be achieved before injection, because the injected water could be withdrawn directly from the well at any time and is used to supply the distribution system directly without further treatment (except addition of a disinfectant residual). No opportunity exists in this arrangement for SAT or other in situ treatment. As shown in Table 5.4, this means an AWTF for this alternative would have to meet *at minimum* 10.1-log virus, 9.2-log *Giardia*, and 8.8-log *Cryptosporidium* goals.

In Alternative 5, reclaimed water would be conveyed to the Buckman Well Field for injection into the aquifer and recovery with wells that include Buckman Well 13, shown here.

Table 5.4 Alternative 5 Gap Analysis Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County			
	LRV Credits		
	Virus	Giardia	Crypto
Goals	**12**	**10**	**10**
Existing Treatment Components			
Paseo Real WRF(1)	1.9	0.8	1.2
Treatment Needed at AWTF	**10.1**	**9.2**	**8.8**

Notes:

(1) The pathogen LRV credits assigned to the Paseo Real WRF are estimated based on taking the 10th percentile values observed in a study examining the removal in six different water reclamation facilities (Rose et al. 2005).

5.4.5.3 Description of Project Elements

The AWTF would consist of the fully augmented version of the treatment train laid out in Section 4.9.2, with all described treatment processes: O_3, BAF, UF, UV, and Cl_2. The UV system assumed in this treatment train provides the full 6-log virus removal credit and is capable of removing NDMA. As shown in Table 5.5, this train is intended to achieve 15-log virus, 10-log *Giardia*, and 10-log *Cryptosporidium* credit.

Table 5.5 Alternative 5 Treatment Log Removal Value Summary Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County			
	LRV Credits		
	Virus	Giardia	Crypto
Treatment Needed at AWTF	**10.1**	**9.2**	**8.8**
Advanced Treatment Processes			
Ozone	5	0	0
Biologically Active Filtration (BAF)	0	0	0
Ultrafiltration (UF)	0	4	4
Ultraviolet (UV) Disinfection	6	6	6
Chlorine (Cl_2)	4	0	0
Total Advanced Treatment LRVs	**15**	**10**	**10**

The advanced purified water would then be conveyed along the alignment and to injection into Buckman production wells, as shown in Figure 5.5. The initial analysis assumed conversion of production wells to two-way (injection and production) ASR wells using Baski InFlex™ Flow Control Valves or similar approaches.

Buckman Wells 10 through 13 have sufficient well design, specific capacity, aquifer storage capacity, and available drawdown to operate as ASR wells. JSAI (2012) used the geologic model and a calibrated numeric radial flow model to assess the feasibility of implementing ASR at Buckman Wells 10 through 13 to mitigate elevated arsenic concentrations in groundwater. Injected water would be stored around the well, so during recovery pumping the water quality would resemble that of the injected water. Some mixing occurs after removing approximately 80 percent of the volume injected (Finch 1997). Additional site-specific research would be needed to confirm recharge rates, blending rates, and water quality compatibility before implementing this alternative.

Buckman Wells 10, 11 and 13 can accept injection rates of approximately 500 gallons per minute (gpm) each for several years at a time or seasonally, and Buckman Well 12 is limited to 250 gpm. Recovery would remove injected water because the injected water displaces the natural groundwater away from the well with minimal effects of mixing. Injecting water with 5 parts per billion (ppb) arsenic would allow recovery of water with less than 7 ppb. The ASR cycles could be developed to work with availability of sources and demand during drought cycles. Modeled water levels during ASR would remain 100 feet below land surface.

This alternative would require approximately 12.2 miles of nominal 14-inch diameter pipeline and one 180-HP pump station to convey a peak flow of 3.0 mgd. As with Alternative 2, it was conservatively assumed for purposes of this Feasibility Study that Santa Fe would not have the ability to repurpose the existing 12-inch diameter non-potable reuse pipeline that serves the MRC and other users in the vicinity, since the City does not own that pipeline.

Preliminary pipeline and pumping calculations assume 250-psi class ductile iron pipe, with the number of pump stations set to maintain pressures no higher than this. The pipeline would originate at the AWTF adjacent to the Paseo Real WRF and extend primarily along existing public right-of-way and easements utilized for the BDD raw water transmission line (from the BDD diversion to BRWTF). Ground elevations along the pipeline route increase from approximately 6313 feet MSL at the AWTF up to a high point of 6537 before descending to the assumed well sites (Buckman Well 13 and surrounding wells), for a static pumping head of 224 feet. Total dynamic head was calculated based on estimated friction and minor losses at the maximum in-pipe velocity of 3.9 ft/sec.

5.4.6 Alternative 6: Augment Nichols Reservoir

5.4.6.1 Overview

Nichols Reservoir and its upstream counterpart, McClure Reservoir, are located in the Upper Santa Fe River watershed that is closed to public access and highly protected as a key source of water supply for Santa Fe. This alternative involves advanced purification of the effluent from Paseo Real WRF, which is then conveyed eastward to the Nichols Reservoir, where it is discharged to augment the surface water resources in the reservoir. Nichols Reservoir was selected for this alternative over McClure Reservoir because it requires less pipeline length and elevation gain, and should be capable of providing adequate mixing of reclaimed water and native water. The discharge point was conceptually located some distance away from the intake to better facilitate mixing. Blended water diverted through the existing reservoir intake would then be treated at the CRWTF, much as it is today. A map of this alternative is shown in Figure 5.6.

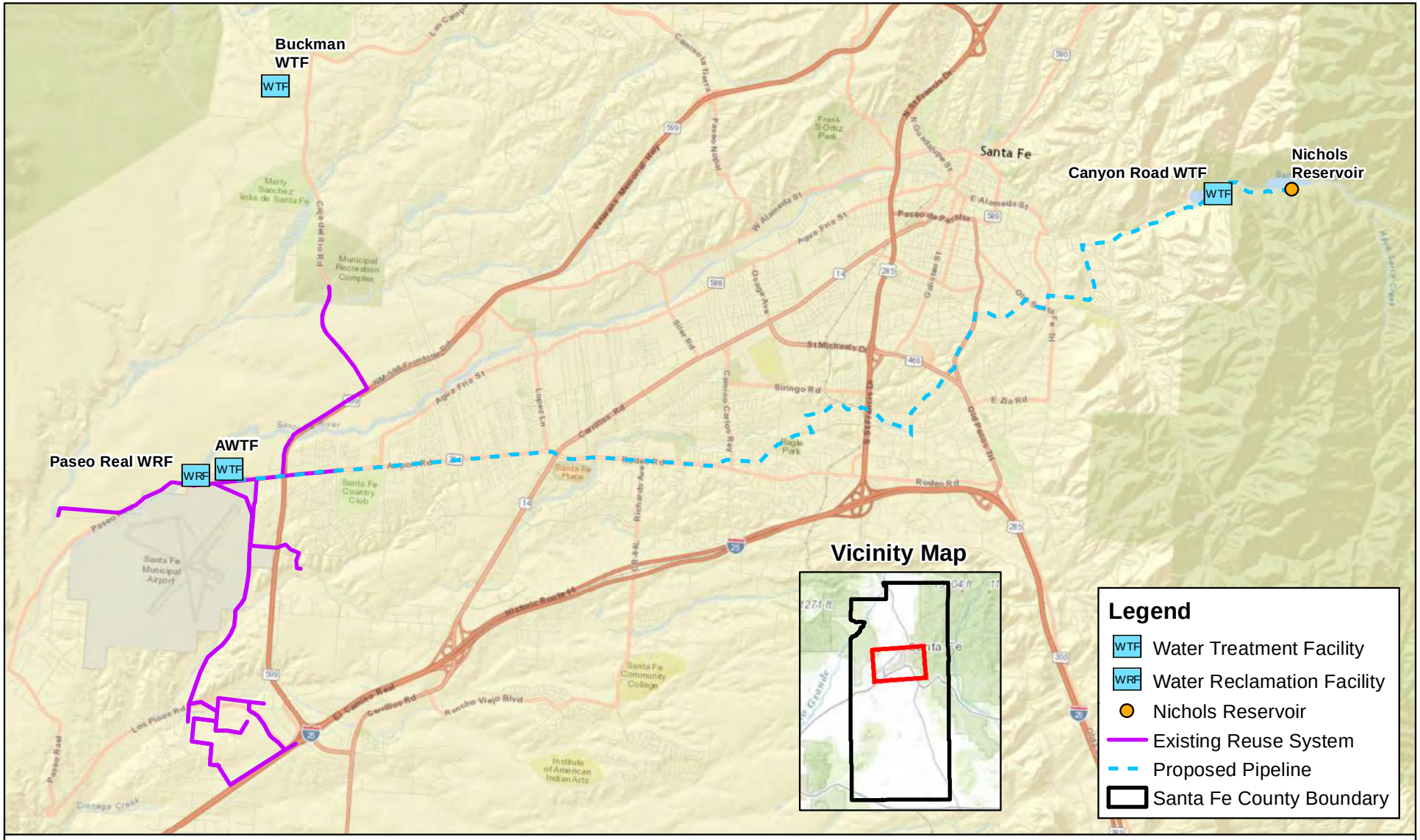
5.4.6.2 Treatment Goals and Gap Analysis

This is a potable reuse alternative, and as such, requires additional treatment beyond what is being provided at the Paseo Real WRF. As discussed in Section 4.9.1, this alternative must achieve 12-log virus, 10-log *Giardia*, and 10-log *Cryptosporidium* treatment credit. Existing infrastructure (Paseo Real WRF and the CRWTF) provide 5.9-log virus, 3.8-log *Giardia*, and 4.2-log *Cryptosporidium* credit.

As shown in Table 5.6, this means an AWTF for this alternative would have to meet *at minimum* 6.1-log virus, 6.2-log *Giardia*, and 5.8-log *Cryptosporidium* goals. In addition, this alternative would require a discharge permit from U.S. EPA. The discharge would have to meet more stringent requirements for nitrogen and phosphorous removal than the sole current Paseo Real WRF outfall, as well as other parameters such as metals (including aluminum), since the reservoir is designated for many of the most stringent use designations under the New Mexico Surface Water Quality Standards, such as high-quality coldwater aquatic life and public water supply.

Table 5.6 Alternative 6 Gap Analysis
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

	LRV Credits		
	Virus	**Giardia**	**Crypto**
Goals	**12**	**10**	**10**
Existing Treatment Components			
Paseo Real WRF	1.9	0.8	1.2
CRWTF	4	3	3
Treatment Needed at AWTF	**6.1**	**6.2**	**5.8**



ALTERNATIVE 6 - AUGMENT NICHOLS RESERVOIR

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0 1 2 Miles

FIGURE 5.6

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SANTA FE WATER REUSE FEASIBILITY STUDY

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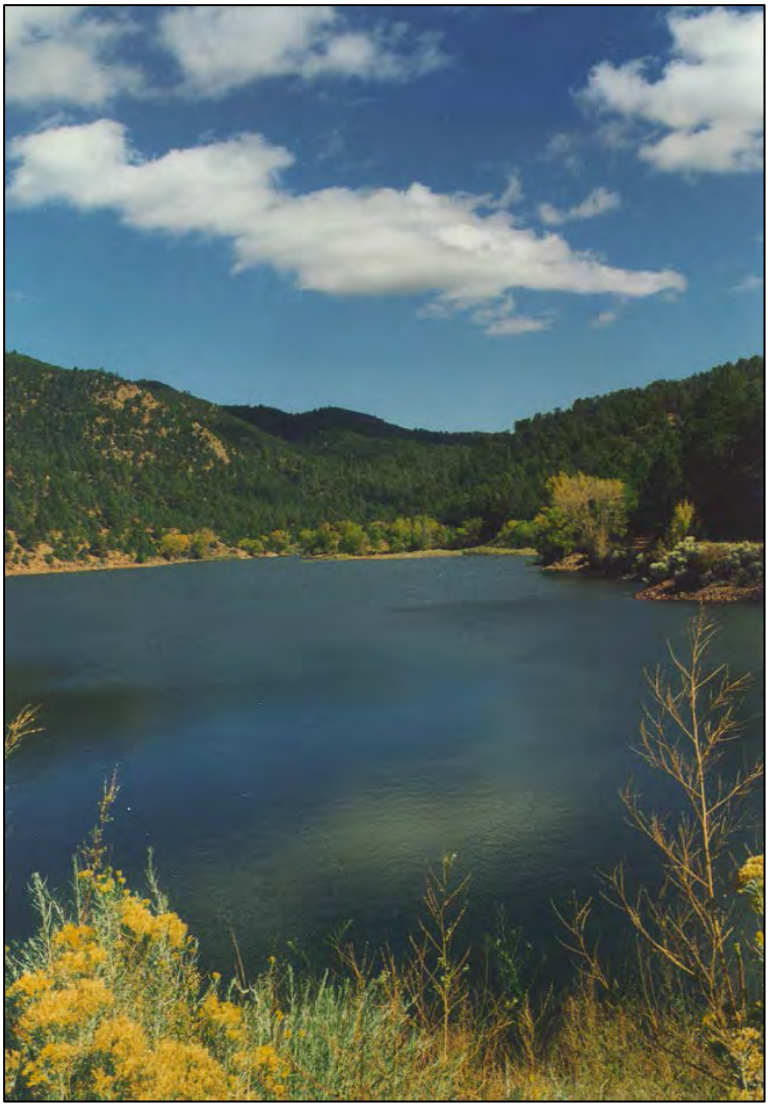
5.4.6.3 Description of Project Elements

The AWTF would consist of an augmented version of the treatment train laid out in Section 4.9.2, with: O_3, BAF, UF, and UV. The UV system is sized larger than necessary to achieve the minimum virus removal required by this alternative. This was done to acknowledge the pristine nature of the Nichols Reservoir surface water and the appropriately less stringent, though more than adequate, treatment that occurs at the CRWTF as compared to the BRWTF. The combination of UF and UV also provides a significant safety factor on the minimum requirements for protozoa.

As shown in Table 5.7, the AWTF described for this alternative would achieve a total of 11-log virus, and 10-log each *Giardia* and *Cryptosporidium* removal credit.



Under Alternative 6, reclaimed water would be pumped up to Nichols Reservoir to blend with and augment Santa Fe River supplies that are treated at the CRWTF.

Table 5.7 Alternative 6 Treatment Log Removal Value Summary Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County			
	LRV Credits		
	Virus	Giardia	Crypto
Treatment Needed at AWTF	**6.1**	**6.2**	**5.8**
Advanced Treatment Processes			
Ozone	5	0	0
Biologically Active Filtration (BAF)	0	0	0
Ultrafiltration (UF)	0	4	4
Ultraviolet (UV) Disinfection	6	6	6
Total Advanced Treatment LRVs	**11**	**10**	**10**

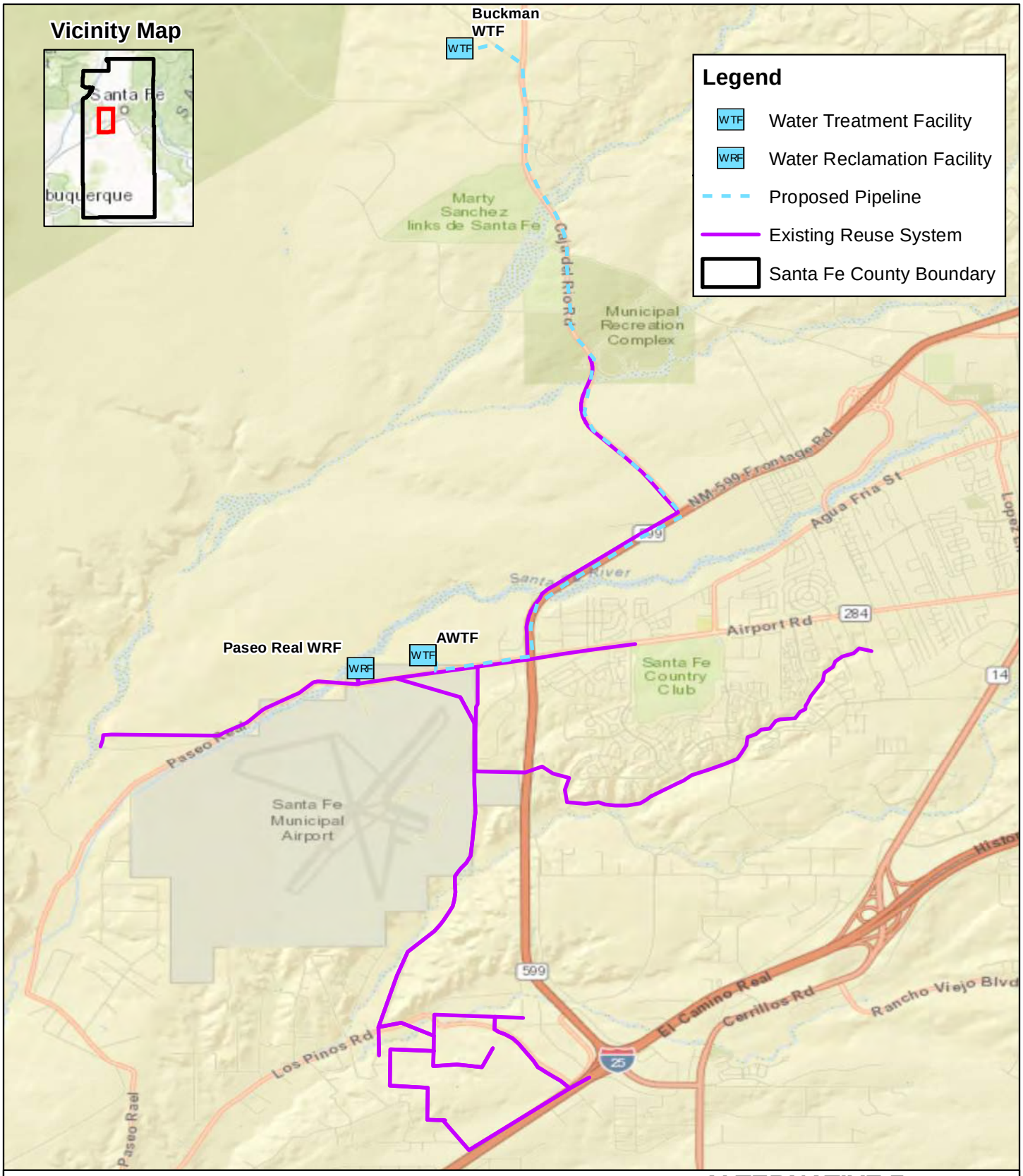
The advanced purified water would then be conveyed along the alignment and to a discharge location into Nichols Reservoir, as shown in Figure 5.6. Due to the significant elevation gain and length of pipeline, significant pumping power would be required for this alternative. In total, the alternative would require 14.7 miles of 14-inch diameter pipeline with three 270-HP pump stations to convey a peak flow of 3 mgd from the AWTF site to the discharge location at Nichols Reservoir.

Preliminary pipeline and pumping calculations assume 250-psi class ductile iron pipe, with the number of pump stations set to maintain pressures no higher than this. The pipeline would originate at the AWTF adjacent to the Paseo Real WRF and extend primarily along existing public right-of-way. Routing of the pipeline was conceptually developed to avoid the congested downtown area and potential sensitive cultural resource sites by tracking eastward along existing rights of way in south-central Santa Fe before moving northward to eventually follow Upper Canyon Road past the CRWTF and on up to the reservoir. Ground elevations along the pipeline route increase from approximately 6313 feet MSL at the AWTF site up to the reservoir discharge point with elevation of 7535, for a static pumping head of 1222 feet. Total dynamic head was calculated based on estimated friction and minor losses at the maximum in-pipe velocity of 3.9 ft/sec.

5.4.7 Alternative 7: Direct Potable Reuse

5.4.7.1 Overview

This alternative involves advanced purification of the effluent from Paseo Real WRF, which is then conveyed northward to the BRWTF site, where is it blended with raw water diverted from the Rio Grande via the BDD diversion and the blended water is treated at the WTP. A map of this alternative is shown in Figure 5.7.



ALTERNATIVE 7 - DIRECT POTABLE REUSE

Miles
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FIGURE 5.7

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5.4.7.2 Treatment Goals and Gap Analysis

This is a DPR alternative, and as such, requires additional treatment beyond what is being provided at the Paseo Real WRF. As discussed in Section 4.9.1, this alternative must achieve 12-log virus, 10-log *Giardia*, and 10-log *Cryptosporidium* treatment credit. Existing infrastructure (Paseo Real WRF and the BRWTF) together provide 5.9-log virus, 3.8-log *Giardia*, and 4.2-log *Cryptosporidium* credit. As shown in Table 5.8, this means an AWTF for this alternative would, at a minimum, have to meet 6.1-log virus, 6.2-log *Giardia*, and 5.8-log *Cryptosporidium* goals.

Table 5.8 Alternative 7 Gap Analysis
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

	LRV Credits		
	Virus	**Giardia**	**Crypto**
Goals	**12**	**10**	**10**
Existing Treatment Components			
Paseo Real WRF	1.9	0.8	1.2
BRWTF	4	3	3
Treatment Needed at AWTF	**6.1**	**6.2**	**5.8**

Reclaimed water from a new AWTF would be blended with Rio Grande water and treated at the BRWTF (shown here) under Alternative 7.

5.4.7.3 Description of Project Elements

The AWTF for this alternative would consist of a fully augmented version of the treatment train laid out in Section 4.9.2, with: O_3, BAF, UF, UV, and Cl_2. While not all of these treatment processes are needed to meet the minimum log removal treatment requirements, this alternative represents a DPR project, which does not include the potential benefits of an environmental buffer. To mitigate the higher risks associated with a project with minimal response retention time (RRT), such as reduced reaction time to respond to a process upset when compared to an IPR project, additional treatment redundancy is considered prudent.

The UV system in the current treatment concept is designed mainly for protozoa disinfection, providing full 6-log for those parameters, but only 1-log virus credit. As such, it would not be suitable for addressing any issues related to NDMA. The UF step is added to provide treatment redundancy for protozoa. The chlorine disinfection step is added as a relatively inexpensive way to take advantage of existing travel time in the pipeline from the Paseo Real WRF site to the BRWTF site, which simultaneously acts as an environmental storage buffer with a plug-flow hydraulic retention time of approximately 124 minutes at peak flow.

As shown in Table 5.9, the AWTF described for this alternative would achieve a total of 10 log each removal of virus, *Giardia* and *Cryptosporidium*, with the potential of additional virus removal credit through an increase in UV system sizing. The advanced purified water would then be conveyed along the alignment and to the blend point at the BRWTF (conceptually identified as blending in the raw water sedimentation ponds on the southeast side of the facility), as shown in Figure 5.7.

Table 5.9 Alternative 7 Treatment Log Removal Value Summary
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

	LRV Credits		
	Virus	**Giardia**	**Crypto**
Treatment Needed at AWTF	**6.1**	**6.2**	**5.8**
Advanced Treatment Processes			
Ozone	5	0	0
Biologically Active Filtration (BAF)	0	0	0
Ultrafiltration (UF)	0	4	4
Ultraviolet (UV) Disinfection	1	6	6
Engineered Storage Buffer (Cl_2)	4	0	0
Total Advanced Treatment LRVs	**10**	**10**	**10**

This would require approximately 6.1 miles of nominal 14-inch diameter pipeline and one 180-HP pump station to convey a peak flow of 3.0 mgd. As with Alternatives 2 and 5, it was conservatively assumed for purposes of this Feasibility Study that Santa Fe would not have the ability to repurpose the existing 12-inch diameter non-potable reuse pipeline that serves the Municipal Recreation Complex and other users in the vicinity, since the City does not own that pipeline.

Preliminary pipeline and pumping calculations assume 250-psi class ductile iron pipe, with the number of pump stations set to maintain pressures no higher than this. The pipeline would originate at the AWTF adjacent to the Paseo Real WRF and extend primarily along existing public right-of-way and easements utilized for the existing non-potable pipeline. Ground elevations along the pipeline route increase from approximately 6313 feet MSL at the AWTF up to a high point of 6537 before descending to the BRWTF elevation of 6519, for a static pumping head of 224 feet. Total dynamic head was calculated based on estimated friction and minor losses at the maximum in-pipe velocity of 3.9 ft/sec.

5.5 Summary of Conveyance Infrastructure for the Alternatives

A summary of the infrastructure required to pump and convey reclaimed water to the reuse sites under each alternative is summarized in Table 5.10. Pipeline routes were analyzed using desktop methods (no field survey) to delineate which portions would consist of urban construction (with traffic control, pavement removal and replacement, etc.), and which portions would be routed through relatively undeveloped or rural areas, as summarized in the table.

5.6 Net Water Yield of the Alternatives

Each of the alternatives was assumed to have access to up to 2,376 AFY of reclaimed water at the Paseo Real WRF, as detailed in Section 4.4. Alternative 1 (expanded non-potable reuse) was constrained not by the availability of reclaimed water, but by the level of non-potable water demand for the selected non-potable reuse sites.

Table 5.10 Conveyance Infrastructure Summary
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Alternative	Pipeline Distance (mi)	Rural Pipeline (mi)	Urban Pipeline (mi)	Peak Flow (mgd)	Max. Elevation Gain (ft)	Total Dynamic Head (ft)	Pipe Diameter (nominal in)	Max pipeline pressure (psi)	No. of Pump Stations	Pump Station Power (HP each)
1. Expand Non-Potable Reuse	8.5	0.0	8.5	1.0	632	825	8	179	2	70
2. Full Consumption of SJCP Water via Rio Grande Return Flow Credits	17.7	17.7	0.0	3.0	253	379	14	164	1	200
3. Enhanced Living River and Aquifer Storage and Recovery(1)	12.2	0.0	12.2	3.0	1006	1257	14	181	3	220
4. Aquifer Storage and Recovery via Lower Santa Fe River	6.3	6.3	0.0	3.0	454	583	14	253	1	310
5. Aquifer Storage and Recovery via Buckman Well Field	12.2	12.2	0.0	3.0	224	345	14	150	1	180
6. Augment Nichols Reservoir	14.7	0.0	14.7	3.0	1222	1525	14	220	3	270
7. Direct Potable Reuse	6.1	6.1	0.0	3.0	224	350	14	151	1	180

Notes:

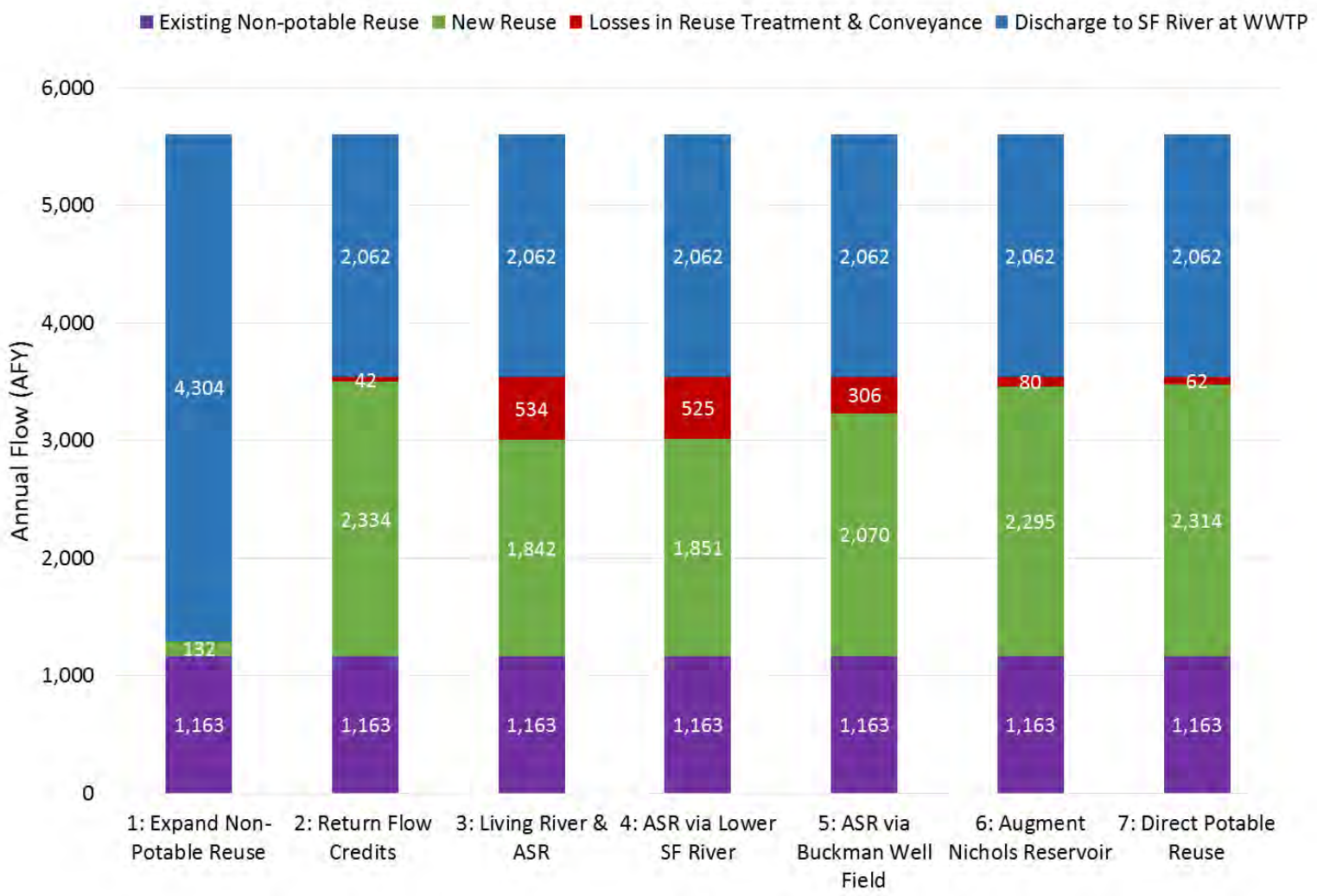
(1) Assuming discharge to Upper Santa Fe River near Monsignor Patrick Smith Park. Discharge location was revised in detailed analysis of this alternative (see Section 6.2).

The net reclaimed water yield of the alternatives was determined by considering the potential for losses between the end of the Paseo Real WRF treatment train and the point at which reclaimed water is ultimately recovered for use. This includes consideration of the following losses:

- Losses via conveyance piping leakage, assessed at an assumed 0.1 percent per mile of transmission pipe.
- Losses in Santa Fe River aquifer recharge, assuming 20 percent of water discharged to the Santa Fe River will either not seep into the alluvium by the time the discharged water travels to the site of recovery wells, or would not be recaptured by the recovery wells.
- Losses in Buckman well recharge, assuming 10 percent of water injected into ASR wells would not be recaptured by the Buckman wells.
- Losses in AWTF treatment, assuming 2 percent losses in total water treated associated with management of solids and residuals. This value would be significantly higher for RO-based treatment trains, which was one of several reasons non-RO trains were prioritized for consideration in this Feasibility Study.
- No losses in Nichols Reservoir, assuming no increase in additional evaporation in the reservoir because evaporation is a function of exposed surface area, and this alternative is not expected to modify reservoir levels appreciably.

Figure 5.8 presents the results of this analysis. Derivation of the total reclaimed water yield for each preliminary alternative included:

- Initiation with the entire 5 mgd, or about 5,600 AFY of reclaimed water produced at the Paseo Real WRF.
- Subtraction of the minimum 2 mgd (2,062 AFY) of downstream water discharges (assuming 5 mgd annual supply and maximum 3 mgd of existing and new reuse as described earlier, leaving minimum 2 mgd discharges year-round).
- Subtraction of the 1,163 AFY of existing non-potable water reuse contracts that are assumed to be operated in perpetuity (using 2014 actual reclaimed water demand)
- Subtraction of conveyance and treatment losses and well recovery inefficiencies, as applicable to each alternative as described above.



RECLAIMED WATER ALLOCATION FOR EACH ALTERNATIVE

FIGURE 5.8

Conveyance losses were highest for the Santa Fe River recharge alternatives (Alternatives 3 and 4), due to the length of transmission piping to convey water from the AWTF to the point of discharge in the river, AWTF treatment losses, and the assumed inability to recapture all flow discharged to the river through recovery wells. Total recovered water estimates for Alternatives 3 and 4 were updated as part of subsequent detailed analyses of these alternatives, in light of newly-available seepage study data from the City in mid-2016 (see Sections 5.8 and 6.2).

Losses were also relatively high for the Buckman Wells recharge alternative for similar reasons, but with higher recovery in the injection/ASR system than in riverbed percolation associated with the Santa Fe River recharge alternatives. Other alternatives' losses were minor, due to lack of AWTF treatment for the expansion of non-potable reuse and return flow credits/exchange alternatives and, in some cases, shorter transmission piping distances.

5.7 Waste Discharge Requirements

The alternatives considered in this evaluation do not involve significant generation of waste. Alternatives 1 and 2 involve no change in treatment technology, only construction of new conveyance infrastructure. As such, no additional waste products will be generated by these alternatives.

The remaining alternatives all involve advanced treatment processes for potable reuse, which can involve significant issues related to waste disposal. However, the treatment processes proposed herein were selected explicitly for their lack of waste products, specifically, the absence of an RO process means that the projects do not have to address issues related to concentrate disposal. The added benefit of this approach is that valuable water, often as much as a quarter of the original reclaimed water, that would have been part of the waste product in an RO-based treatment train, is recycled for additional potable water augmentation.

As far as specific waste streams at the AWTF, the O_3, UV, and Cl_2 treatment processes have no significant waste streams. The filters (BAF and UF) regularly produce a backwash water that may or may not contain cleaning chemicals. This waste stream will be routed to the headworks of the adjacent Paseo Real WRF and therefore recycled with the remaining wastewater.

An additional consideration for the DPR alternative (Alternative 7) is the potential need to dispose of treated water that under process upset conditions may not meet water quality specifications for blending with the raw water at the BRWTF. If the issue is identified prior to the purified water entering the pipeline from the Paseo Real WRF site, this water can be discharged into the Santa Fe River with the discharge that is planned to maintain environmental flows, or recycled to the headworks of the Paseo Real WRF, if it has sufficient capacity at that time. If the off-spec water enters the transmission pipeline, an additional disposal mechanism will be required at the site of use.

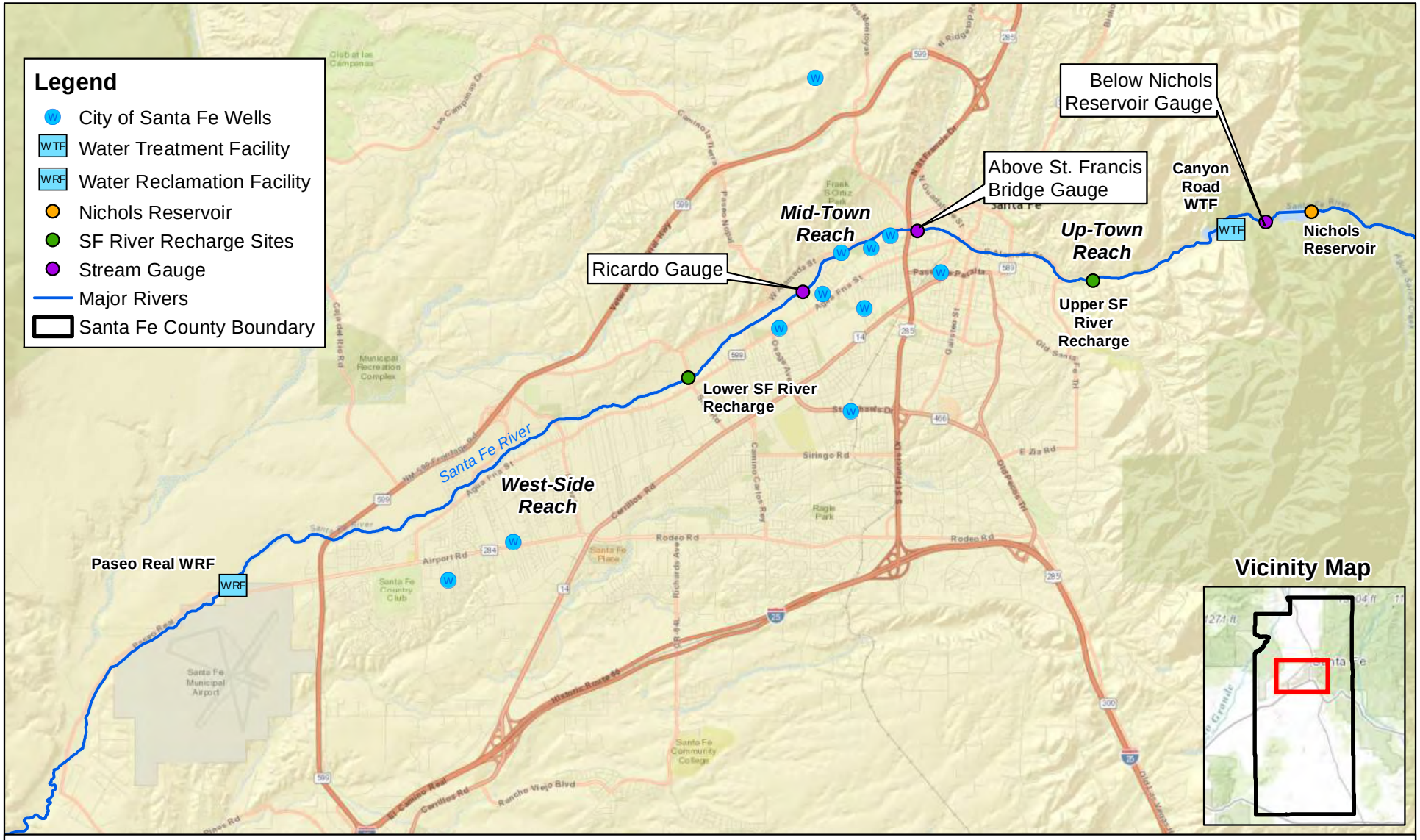
5.8 Assessment of Aquifer Infiltration and Recovery Options

The Santa Fe River recharge alternatives (Alternatives 3 and 4) are dependent upon the water released into the river infiltrating into the subsurface for later extraction. Any river water that flows past the groundwater well zone of extraction without recharging the aquifer will not be available as a water supply source for the City.

Lewis and Borchert (2009) summarized available data from several stream flow loss studies on the Santa Fe River from Nichols Reservoir to the Paseo Real WRF. The report evaluated seepage rates determined from both seepage investigations and gauge data, and provided estimates of seepage rate for the three separate reaches of the river shown in Figure 5.9.

In May 2016, the City of Santa Fe made three releases from Nichols Reservoir to measure seepage losses in the Santa Fe River channel downstream. Data from these three events indicate very little seepage loss in the reach between the potential Upper Santa Fe River delivery point for Alternative 3 and St. Francis Drive. The highest seepage rates occurred in the 3.9-mile reach downstream of St. Francis Drive to San Ysidro Crossing. Estimates of seepage rates from the 2016 studies were used in detailed analyses of Alternatives 3 and 4.

Using the entire available length of the river appears to provide the best chances for successfully infiltrating all of the available reuse water while also providing continuous flows in the upper reaches through the city. A series of wells, spaced along the river from St. Francis Drive to the Paseo Real WRF, could potentially recover the water, although the actual capture zone area of the wells would potentially be much smaller than the area affected by percolating water beneath the river.



SANTA FE RIVER STREAM GAUGES AND REACH LOCATIONS, ADAPTED FROM LEWIS AND BORCHERT (2009)

N

0 1 2 Miles

FIGURE 5.9

CITY OF SANTA FE / SANTA FE COUNTY
SANTA FE WATER REUSE FEASIBILITY STUDY

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5.9 National Examples of Potable Reuse

Non-potable water reuse systems are successfully operated in Santa Fe and nationally. Non-potable water reuse applications discussed in this report present nothing novel from a regulatory or treatment perspective. However, there are novel components of both IPR and DPR options within this report, particularly as they pertain to projects in New Mexico. A perspective on these projects can be obtained from four example IPR and DPR projects that are operating successfully in other places in the United States. For each of the referenced projects, a brief overview is provided below, followed by a discussion of similarities and differences with the various Santa Fe potable water reuse options.

5.9.1.1 Orange County Water District, California

The Orange County Water District's (OCWD) Groundwater Replenishment System (GWRS) is the world's largest potable water reuse project, with a daily production of 100 million gallons of purified water which is injected into the local groundwater basin. In over 30 years of operation, this project has injected more than 188 billion gallons of purified water into the groundwater basin, later to be extracted from the basin for potable water use. A photo of the OCWD's RO membranes is shown below.

As a point of comparison, Santa Fe Alternative 5 includes purification of reclaimed water and then injection of that reclaimed water into the Buckman Well Field.

Similarities:

- Advanced purification of reclaimed water meeting state and national water quality standards and guidance for both pathogens, regulated pollutants, and unregulated constituents.
- Injection of purified water into a groundwater basin.

Differences:

- The OCWD purifies secondary effluent prior to groundwater injection using MF, RO, and UV-AOP. For Santa Fe Alternative 5, the proposed treatment processes include O_3, biofiltration, UF, UV-AOP, and free chlorination.
- Injected water moves horizontally through the groundwater basin to down-gradient wells for extraction. For Santa Fe Alternative 5, the injected water would be extracted from the same well through which it was injected. This type of ASR concept is being implemented in Oxnard, California as part of a different potable water reuse project in Southern California.

5.9.1.2 Water Replenishment District/Los Angeles County Sanitation Districts California

The Water Replenishment District of Southern California (WRD) and the Los Angeles County Sanitation Districts (LACSD) are partners in the recharge of tertiary recycled water (secondary treated effluent that is then filtered and disinfected) into the local groundwater basin. Over more than 30 years, greater than 1.45 million acre-feet of reclaimed water has been placed into spreading basins and percolated down into the aquifer, later to be extracted for potable water use. A photo of the Rio Hondo spreading grounds is shown below.

As a point of comparison, Santa Fe Alternatives 3 and 4 would include placement of advance treated secondary effluent into the Santa Fe River, which would percolate into the underlying groundwater basin.

Similarities:

- Treatment of reclaimed water with tertiary processes, but not to potable water standards.
- Reliance upon the percolation process to improve water quality, through both biodegradation and filtration mechanisms.

OCWD RO membranes used to purify reclaimed water for potable water reuse

Differences:

- The WRD/LACSD projects have extensive treatment occurring within the first few feet of percolation, with literature documenting the pathogen removal and organics removal occurring through the "Soil Aquifer Treatment" process. The water is retained within the groundwater basin for months to years, providing further time for pathogens to die off due to time and temperature impacts.

- For the Santa Fe project, the treatment through percolation is not well defined. Further, the travel time from the Santa Fe River to extraction wells is anticipated to be short. To counter these two items, the project team proposes to add substantially more advanced treatment prior to delivering the water to the Santa Fe River. The proposed technologies are O_3, biofiltration, and UV disinfection.

Rio Hondo Spreading Grounds

5.9.1.3 Gwinnett County, Georgia

Gwinnett County, Georgia is responsible for the advanced treatment of wastewater prior to discharge into Lake Lanier. The latest treatment process modifications to the F. Wayne Hill Water Resources Center were completed in 2005, allowing the advanced treatment of secondary effluent at up to 150 mgd using MF, pre-ozone, biofiltration, and post ozone. Water from Lake Lanier is then treated at a conventional water treatment plant and distributed to customers throughout Gwinnett County.

As a point of comparison, Santa Fe Alternative 6 would include purification of secondary effluent followed by placement of the water into Nichols Reservoir, later to be treated at the CRWTF and then provided to Santa Fe residents.

Similarities:

- Advanced purification of secondary effluent to remove pathogens and organic pollutants.
- Mixing of the newly purified water with other raw water supplies prior to final polishing treatment at a water treatment plant.

Differences:

- Nichols Reservoir is a highly protected watershed, as opposed to Lake Lanier which is broadly used for recreational activities.
- For the Santa Fe project, treatment beyond that employed by Gwinnett County is recommended, using O_3, biofiltration, UF, and a UV advanced oxidation process (UV-AOP). This additional measure of treatment is intended to be consistent with the goal of continued protection of the pristine quality of Nichols Reservoir.

Lake Lanier, Georgia

5.9.1.4 Colorado River Municipal Water District, Texas

Extreme drought in Texas led the Colorado River Municipal Water District (CRMWD) to construct the Raw Water Production Facility (RWPF) in Big Spring, Texas. The RWPF utilizes the same advanced treatment processes as the OCWD, including MF, RO, and UV-AOP. After purification, the water from the RWPF is fed into a raw water supply line which blends with other raw water (up to 50 percent) and is then subjected to treatment at a standard water treatment plant (media filtration and chlorine disinfection).

As a point of comparison, Santa Fe Alternative 7 would include purification of secondary effluent followed by delivery of the purified water to the BRWTF. The BRWTF is a robust water treatment plant, including chemical addition, plate settling, pre-ozonation, biofiltration, MF, and chlorination.

Similarities:

- Advanced purification of secondary effluent to remove pathogens and organic pollutants.
- Mixing of the newly purified water with other raw water supplies prior to final polishing treatment at a water treatment plant.

Differences:

- The CRMWD uses RO as its core treatment process; whereas the proposed Santa Fe project uses O_3 with biofiltration as the core treatment process.
- The BRWTF is extremely robust compared to a conventional water treatment plant.

Colorado River Municipal Water District's Raw Water Production Facility in Big Spring, Texas

6.0 ECONOMIC AND NON-MONETARY ANALYSIS

6.1 Preliminary Screening

The seven water reuse alternatives were evaluated on the basis of four criteria and associated performance measures developed in consultation with City and County representatives. Criteria weights were assigned to reflect the relative importance of each criterion, and two weighting profiles were tested to assess the sensitivity of decision scores to the criteria weighting. The criteria, performance measures, and weighting profiles are summarized in Table 6.1.

Table 6.1 Alternatives Screening Criteria and Weighting
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

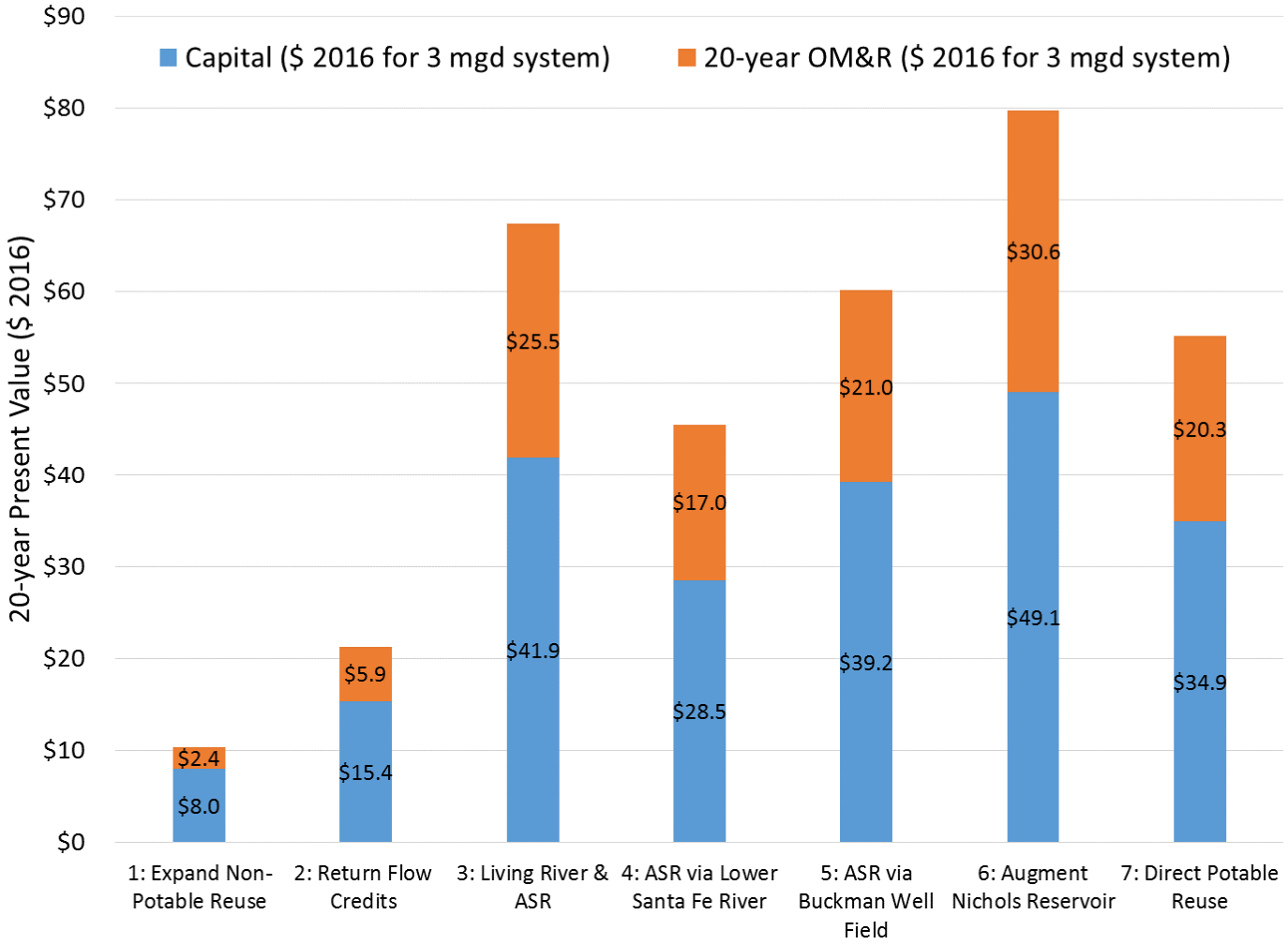
	Criteria Weights		
Criterion	**Profile 1**	**Profile 2**	**Performance Measures**
Cost Effectiveness	40%	30%	20-year net present value (NPV) cost per acre-foot (AF) of potable water offset ($/AF)
Public and Environmental Benefit	20%	20%	Increases beneficial use of local water resources Creates aesthetic, recreational, and/or economic flow benefits for Santa Fe River in town (tourism) Creates Santa Fe River aesthetic/rec flow benefits in town (residents) Increases reliable irrigated recreational facility areas Interim sale of excess water rights on Rio Grande Enhance sustainability of groundwater use
Public Acceptance	20%	20%	Already accepted by the public Additional outreach can improve public acceptability

Table 6.1	Alternatives Screening Criteria and Weighting Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County		
	Criteria Weights		
Criterion	**Profile 1**	**Profile 2**	**Performance Measures**
Project Risk Mitigation	20%	30%	Permitting system in place Water supply availability (e.g., water available in prolonged drought upstream of BDD diversion) Water quality impacts (e.g., remobilization of arsenic in Buckman wells) Does not create a long-term requirement/expectation for instream flow on the Santa Fe River

6.1.1 Screening Level Cost Evaluation

An initial screening-level evaluation of costs was developed for the seven alternatives, based on approximate pipeline distances, pumping requirements, and treatment costs scaled from other projects. The result of this analysis is shown in Figure 6.1.

To assess cost-effectiveness, the screening-level 20-year NPV cost of each alternative was divided by its estimated yield over 20 years of operation. Results of this analysis are provided in Table 6.2.



SCREENING-LEVEL CAPITAL AND OM&R COMPONENTS OF NPV COSTS FOR THE ALTERNATIVES

Note: Alternative 1 produces less than 3 mgd, limited to 1 mgd by non-potable system demands.

FIGURE 6.1

CITY OF SANTA FE / SANTA FE COUNTY
SANTA FE WATER REUSE FEASIBILITY STUDY

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Table 6.2 Alternatives Cost-Effectiveness Summary Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County			
Alternative	**20-Year NPV ($M)**	**Yield (AFY)**	**Cost-Effectiveness ($/AF)**
1. Expand Non-Potable Reuse	$10.4	133	$3,900
2. Full Consumption of SJCP Water via Rio Grande Return Flow Credits	$21.3	2,334	$500
3. Enhanced Living River and Aquifer Storage and Recovery	$67.4	1,842	$1,800
4. Aquifer Storage and Recovery via Lower Santa Fe River	$45.5	1,851	$1,200
5. Aquifer Storage and Recovery at Buckman Wells	$60.2	2,070	$1,500
6. Augment Nichols Reservoir	$79.7	2,294	$1,700
7. Direct Potable Reuse	$55.2	2,314	$1,200

Results of the cost-effectiveness analysis show a dramatic difference between the non-potable reuse alternative (Alternative 1) and the exchange-based and potable reuse alternatives. While Alternative 1 has the lowest NPV cost, it also provides a significantly lower yield. When considering the cost per yield provided, Alternative 1 is by far the least cost-effective alternative and does the least to address the projected Santa Fe water supply shortages. In contrast, Alternative 2 was found to be the most cost-effective approach in terms of supply economics, primarily due to its lower costs (no AWTF required). Other alternatives exhibited a range of cost-effectiveness, depending on treatment and conveyance requirements and the amount of water recovered for water supply.

The potential economic implications of not addressing Santa Fe's projected water supply shortages are enormous. Like any community, a reliable water supply is critical to public health and welfare, as well as maintaining a business-friendly community. But Santa Fe is unique in the degree to which it has already established one of the most progressive and successful water conservation programs, and the significant degree to which its economy is reliant on tourism. An analysis of tourism's importance to Santa Fe found that in 2011, 12.4 percent of employment in the County was related to tourism, some 9,426 jobs in the County were directly or indirectly related to tourism, and tourists spent nearly $700 million, generating $159.2 million in federal, state, and local tax revenue (Tourism Economics 2011).

6.1.2 Screening Analysis

For this screening analysis, the alternatives were characterized as to whether they did (indicated by a check mark) or did not (indicated by a blank cell) meet the qualitative performance measures under each of the criteria. For each criterion, the check marks were

tallied for each alternative to obtain a matrix indicating how well each alternative meets each criterion. Table 6.3 presents the unweighted scoring used to characterize the seven preliminary alternatives against these criteria.

Scores were assigned to the alternatives generally as described below for each performance measure.

- 20-year NPV cost per acre-foot (AF) of potable water offset ($/AF): Alternatives with higher $/AF were deemed to be less cost-effective. Calculated values were used in the weighted criteria decision model.
- Increases sustainable use of local water resources: All alternatives provide some degree of water supply benefit and increased water resource sustainability. Therefore, all alternatives were scored equally.
- Creates aesthetic, recreational, and/or economic flow benefits for Santa Fe River in town (tourism): Only Alternative 3 provides flow in the Santa Fe River through the central business and tourist areas. All others require the use of bypass flows from the Upper Santa Fe River reservoirs to maintain a Living River, which could instead be diverted for potable supply at the CRWTF.
- Creates Santa Fe River aesthetic/rec flow benefits in town (residents): Alternatives 3 and 4 both augment Santa Fe River flows that would have community benefits in portions of the watershed.
- Increases reliable irrigated recreational facility areas: Alternative 1 provides a benefit to the community in terms of increasing the reliability and sustainability of landscape irrigation for sites that would be irrigated with recycled water. The other alternatives do not directly provide this benefit.
- Interim sale of excess water rights on Rio Grande: Alternative 2 could potentially allow the interim sale or lease of water discharged above the rate needed for additional diversions via the BDD for public water supply, until such time as the entire flow is needed by Santa Fe for potable uses. The other alternatives do not offer this potential benefit.

Table 6.3 Alternatives Screening Matrix
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

	1: Expand Non-Potable Reuse	2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits	3: Enhanced Living River and Aquifer Storage and Recovery	4: Aquifer Storage and Recovery via Lower Santa Fe River	5: Aquifer Storage and Recovery via Buckman Well Field	6: Augment Nichols Reservoir	7: Direct Potable Reuse
Cost-Effectiveness							
20-Year NPV cost per AF of potable water offset ($/AF)	$3,900	$500	$1,800	$1,200	$1,500	$1,700	$1,200
Public and Environmental Benefit	*2*	*2*	*4*	*3*	*2*	*1*	*1*
Increases sustainable use of local water resources	✓	✓	✓	✓	✓	✓	✓
Creates SFR aesthetic/rec/economic flow benefits in town (tourism)			✓				
Creates SFR aesthetic/rec flow benefits in town (residents)			✓	✓			
Increases reliable irrigated recreational facility areas	✓						
Interim sale of excess water rights on Rio Grande		✓					
Enhance sustainability of groundwater use			✓	✓	✓		
Public Acceptance	*2*	*2*	*2*	*2*	*1*	*0*	*1*
Already acceptable to the public	✓	✓	✓	✓			
Additional outreach improves public acceptability	✓	✓	✓	✓	✓		✓

Table 6.3 Alternatives Screening Matrix
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

	1: Expand Non-Potable Reuse	2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits	3: Enhanced Living River and Aquifer Storage and Recovery	4: Aquifer Storage and Recovery via Lower Santa Fe River	5: Aquifer Storage and Recovery via Buckman Well Field	6: Augment Nichols Reservoir	7: Direct Potable Reuse
Project Risk Mitigation	*4*	*3*	*2*	*3*	*3*	*3*	*4*
Permitting system in place	✓	✓		✓	✓		✓
Water supply availability - no significant issues (e.g., water available in prolonged drought upstream of BDD diversion)	✓		✓	✓	✓	✓	✓
Water quality impacts - no significant issues (e.g., remobilization of arsenic in Buckman wells)	✓	✓	✓	✓		✓	✓
Does not create a long-term requirement/expectation for instream flow on the Santa Fe River	✓	✓			✓	✓	✓

Notes:

(1) All alternatives operating at up to 3 mgd, constrained by availability of water after existing non-potable uses and downstream discharges are satisfied (except Alternative 1, Expand Non-Potable Reuse, with peak demand of 1.0 mgd).

- Enhance sustainability of groundwater use: Alternatives that recharge groundwater (Alternatives 3, 4, and 5) can help enhance the sustainability of local groundwater use, either through offsetting increased pumping of these sources and/or by the losses from projected inefficiencies (i.e., recovery wells unable to capture 100 percent of water percolated or injected into the wells).

- Already accepted by the public: Non-potable reuse (Alternative 1) has been practiced in Santa Fe for over five decades and has been key to providing expanded recreational amenities to Santa Feans (e.g., irrigation of the MRC. Return flow credits (Alternative 2) indirectly reuses water and is expected to be publicly acceptable. Previous public meetings and other local venues have shown strong public support for the Santa Fe River recharge alternatives. All other alternatives are expected to require additional outreach to achieve broad public acceptance.

- Additional outreach can improve public acceptability: Experience in other western communities suggests that proactive public outreach efforts can help garner support for potable reuse projects (e.g., Alternatives 5 and 7). However, it is not anticipated that any amount of outreach could yield public support for augmenting the pristine Upper Santa Fe River watershed sources (Alternative 6). Alternatives already accepted by the public (see previous measure) were scored positively here, so that they would receive higher Public Acceptance scores.

- Permitting system in place: There is an established permitting process in New Mexico – although no guarantee of permitting success for Santa Fe projects – for Alternative 1 (non-potable reuse, e.g., Santa Fe's existing reuse system), Alternatives 3 and 4 (including aquifer recharge, similar to a precedent project in Albuquerque), and Alternative 7 (DPR, with the efforts undertaken by NMED to permit the Village of Cloudcroft DPR project). Permitting Alternative 3 will be complicated by ongoing work to demonstrate full usage of the City Well Field water rights. It is not anticipated that it would be feasible to permit discharges to the protected Upper Santa Fe River watershed under Alternative 6.

- Water supply availability (e.g., water available in prolonged drought upstream of BDD diversion): Alternative 2 is directly dependent on the availability of "wet water" at the BDD diversion. Prolonged droughts might affect this availability. The other alternatives are not directly dependent on this availability.

- Water quality impacts (e.g., remobilization of arsenic in Buckman wells): Recharging wells in the Buckman Well Field (Alternative 5) could have the potential to create water quality issues that are not otherwise present. The other alternatives do not exhibit this potential concern.

- Does not create a long-term requirement/expectation for instream flow on the Santa Fe River: The two alternatives (3 and 4) that discharge water to the Santa Fe River to create a Living River and augment underlying groundwater resources could pose a potential that the discharges be made permanent or guaranteed by a regulatory entity. The other alternatives do not share this potential concern.

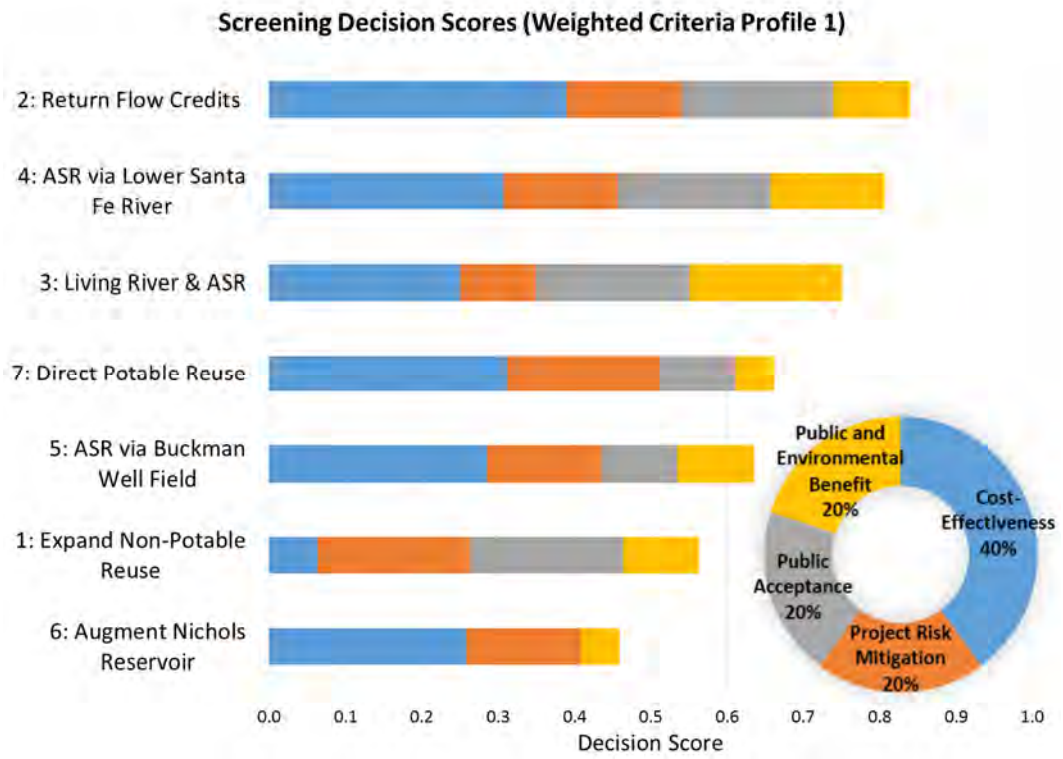
Weighted decision scores were developed to assess the product of criteria weightings and raw (unweighted) performance of the alternatives against the criteria. In this way, the alternatives that best address the most important criteria result in higher weighted decision scores, indicating they are more suitable for selection and implementation.

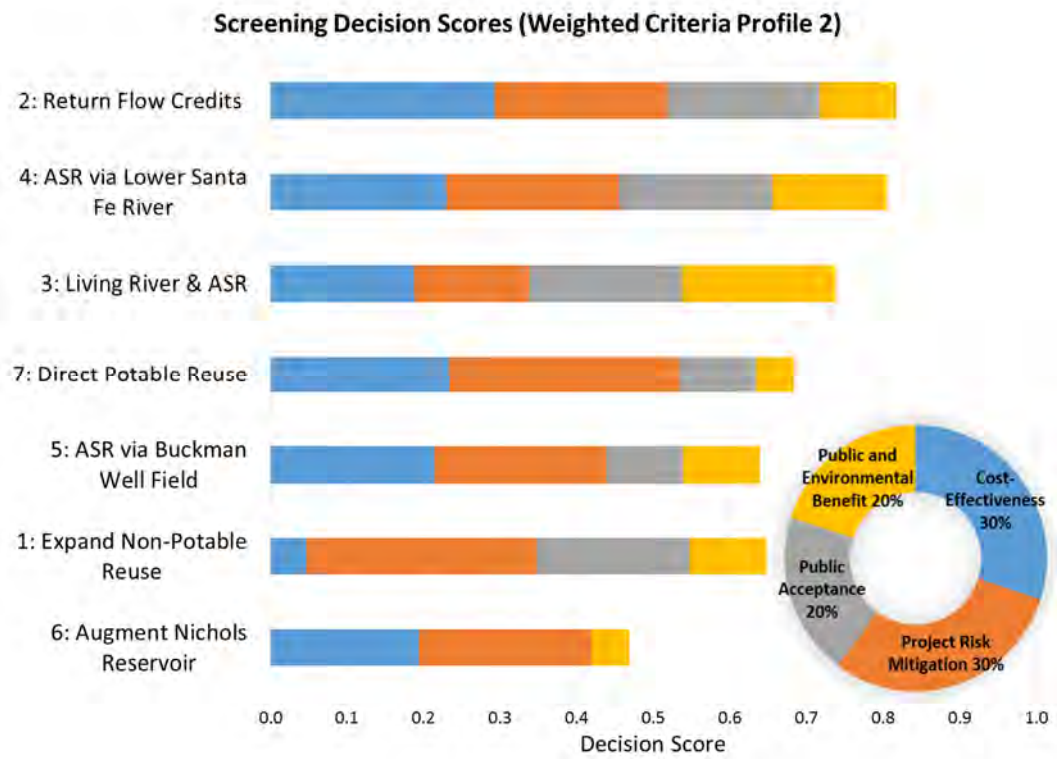
The weighted decision scores are charted in Figure 6.2, using the two different weighting profiles shown in Table 6.1. Either weighting profile results in the same four alternatives being ranked the highest, demonstrating a general consensus that those four alternatives most robustly satisfy the range of criteria and the range of importance that might be placed on each criterion. Further sensitivity analysis of the criteria weightings concluded that these four alternatives best meet the screening criteria under a wide range of potential priorities and weighting values.

While any of the alternatives could be used to offset a portion of the projected water supply shortages, three alternatives were rejected because they did not meet Santa Fe's prioritized criteria and values as well as the others:

- Alternative 1: Expand Non-Potable Reuse. This alternative faces significant challenges in that there is little or no reclaimed water supply available for meeting peak summer demands, due to existing commitments of reclaimed water for non-potable reuse from the Paseo Real WRF. This alternative also performed particularly poorly in terms of cost-effectively offsetting water demands, as it yields roughly 5 percent of the water yielded by potable reuse alternatives and scored far worse than any other alternative in terms of cost-effectiveness.

- Alternative 5: Aquifer Storage and Recovery at Buckman Wells. This alternative did not score well relative to other alternatives for public acceptance or public and environmental benefit, as reflected in the weighted-criteria decision scores. Moreover, there are significant questions about the feasibility of obtaining permits and approvals for this approach, questions about the degree to which recharged water could be recaptured in the wells, uncertainty in the ability of existing wells to recharge water at adequate rates, concerns about remobilizing constituents in the aquifer (e.g., arsenic), and anticipated high power costs associated with pumping water back out of the deep wells and over the hill to Santa Fe.





WEIGHTED DECISION SCORES FOR TWO WEIGHTING PROFILES

FIGURE 6.2

- Alternative 6: Augment Nichols Reservoir. Given that the reservoir is part of the protected and pristine Upper Santa Fe River watershed, there would be significant challenges in terms of both permitting and public acceptance of this alternative. This alternative scored the worst of any alternative relative to the weighted screening criteria.

The following four alternatives were carried forward for further evaluation:

- Alternative 2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits
- Alternative 3: Enhanced Living River and Aquifer Storage and Recovery
- Alternative 4: Aquifer Storage and Recovery via Lower Santa Fe River
- Alternative 7: Direct Potable Reuse

In addition, the Non-Title XVI Alternative (purchasing additional water rights on the Rio Grande for diversion and treatment through the BDD system) was also carried forward.

6.2 Potential for the Project Alternatives to Meet Future Demands

The projected water supply yield from each of the alternatives is discussed in detail in Section 5.6. The net yields for Alternatives 3 and 4 were re-evaluated after preliminary analyses, in light of newly-available results from spring 2016 seepage studies conducted by the City (JSAI 2016a).

Alternative 3 was modified in two ways based on the newly-available information:

- The point of discharge into the Upper Santa Fe River was changed from its original assumed point near Monsignor Patrick Smith Park to a point further upstream, just upstream of site of the former Two Mile Reservoir. This change was made so that the discharge could help augment flows in environmental features in this area, while continuing to provide the Living River benefit through central Santa Fe. The revised conveyance infrastructure includes a 13.7-mile pipeline and three 230-HP pump stations to deliver up to 3 mgd of water to the Two Mile Reservoir site.
- The method of recovery was modified to include the construction of new recovery wells in the lower Santa Fe River (in the same reach using the same methods as Alternative 4) instead of assuming recovery via rehabilitated City Wells (Alto and Torreon wells). This change was made in light of newly-available seepage studies using data collected during mid-2016 Living River bypasses from the Canyon Reservoirs (McClure and Nichols), which found that minimal seepage would occur via the streambed above the City Well field. The JSAI (2016a) seepage study indicated that most of the Living River releases infiltrated downstream of the City Well Field, and that City Well Field wells are likely too deep to be candidates for a Living River ASR project. Potential future ASR projects should focus on the part of the aquifer downstream of Ricardo Road.

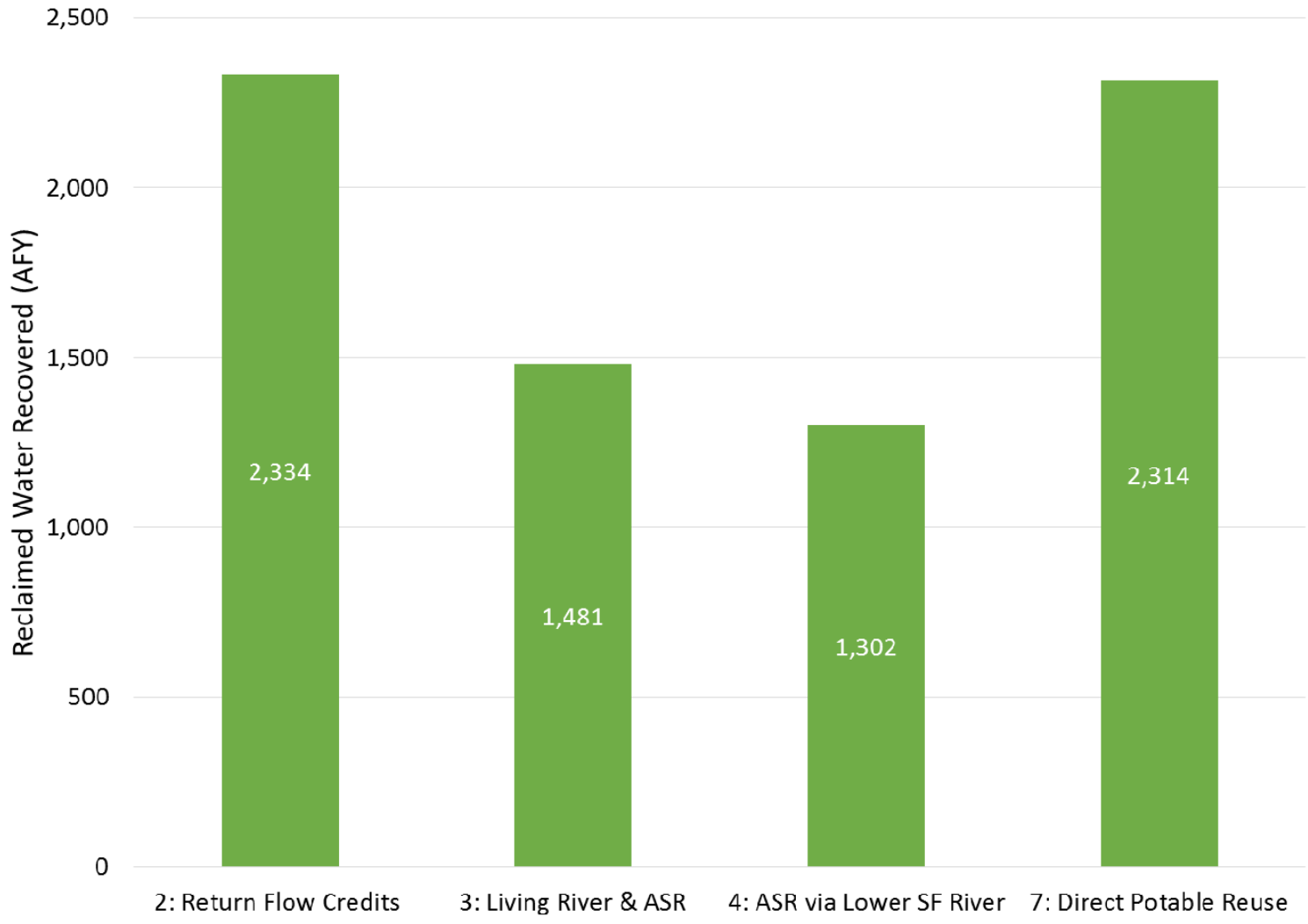
The 2016 seepage studies also found that only approximately 2.15 mgd of total seepage capacity exists in the Santa Fe River between the revised point of discharge for Alternative 3 (Two Mile Reservoir) and recovery wells along the lower Santa Fe River. The studies also estimate that about 10 percent of any flow delivered to the upper or lower Santa Fe River would be lost to evaporation and other instream losses before percolating into the aquifer.

This resulted in a reduction in the amount of water that could be recovered from the alternative annually, as preliminary calculations assumed that up to 3 mgd of reclaimed water discharged to the river (when seasonally available) under this alternative could percolate into the aquifer. The net water that can be recovered under Alternative 3, after treatment and conveyance losses, instream evaporation losses, seepage rate capacity limitations, and inefficiencies in recovery through new Lower Santa Fe River wells, is approximately 1,481 AFY, 361 AFY less than originally predicted.

As with Alternative 3, the amount of water that can be recovered under Alternative 4 was also revised as part of detailed analyses. The net water that can be recovered under Alternative 4, after treatment and conveyance losses, instream evaporation losses, seepage rate capacity limitations, and inefficiencies in recovery through new Lower Santa Fe River wells, is approximately 1,302 AFY, 549 AFY less than originally predicted.

Figure 6.3 summarizes the revised yields for the alternatives. Any of these alternatives could provide a significant benefit toward avoiding the projected water supply shortages in Santa Fe. Differences in the yields of these four alternatives is primarily driven by projected inefficiencies in recapturing flows discharged to the Santa Fe River through groundwater wells, as reflected in the lower yields for Alternatives 3 and 4.

The Santa Fe WaterMAPS model was used to characterize the effectiveness of the alternatives on reducing the probability and magnitude of future water supply shortages and the ability of the city to meet months of peak demand. The WaterMAPS model is a systems dynamics model in the STELLA software platform that is used by the City for water supply planning and operational decision support. The model simulates water sources, demands, supplies and water rights for the City's water supply system, and was upgraded in 2013 to include County demands and rights as well. The model has two planning modes and one operational mode, and it includes historical hydrology in addition to climate change impacted hydrology. The model is extensively documented in previous planning documents, including the City's 2008 Long Range Water Supply Plan and the 2015 Basin Study.



NET YIELD OF THE ALTERNATIVES

FIGURE 6.3

CITY OF SANTA FE / SANTA FE COUNTY
SANTA FE WATER REUSE FEASIBILITY STUDY

carollo

For the current Water Reuse Feasibility Study, a range of scenarios in the planning mode of the model (planning year simulated under all hydrology types) was considered with and without the proposed water reuse alternatives. This process was used to discern the likelihood and degree of future supply deficits as well as the degree to which each alternative could be used to offset those deficits. The scenarios varied in the year simulated and in the type of climate change conditions assumed. The scenarios included a near-term analysis (2022 conditions) and projected 2055 conditions (matching the Basin Study's long-range planning horizon). The scenarios are:

- Baseline (no additional water reuse) in 2022
- All reuse alternatives in 2022 (one simulation for each water reuse alternative)
- Baseline (no additional water reuse) in 2055
- All reuse alternatives in 2055 (one simulation for each alternative) without climate change
- Baseline (no additional water reuse) in 2055 under climate change (worst case scenario within the climate change Basin Study climate change scenarios, also described as “Hot and Dry” in the Basin Study report)

As anticipated, the most significant deficits would occur in the 2055 under a “hot and dry” climate change scenario. Results of that simulation are presented in Table 6.4 and Figure 6.4. The table and figure include results for the following model runs:

- 2055 climate change hot and dry with no additional water reuse
- 2055 climate change hot and dry – Alternative 2 (Full Consumption of SJCP Water via Rio Grande Return Flow Credits)
- 2055 climate change hot and dry – Alternative 4 (Aquifer Storage and Recovery via Lower Santa Fe River)
- 2055 climate change hot and dry – Alternative 7 (Direct Potable Reuse)

Alternative 3 (Enhanced Living River and Aquifer Storage and Recovery) was not modeled in WaterMAPS, since it is similar to Alternative 4 in all ways, except Alternative 4 recovers slightly less water (due to seepage rate capacity limits in the reach of the river receiving reclaimed water flows) and thus provides a slightly more conservative analysis of the potential for mitigating water supply shortages.

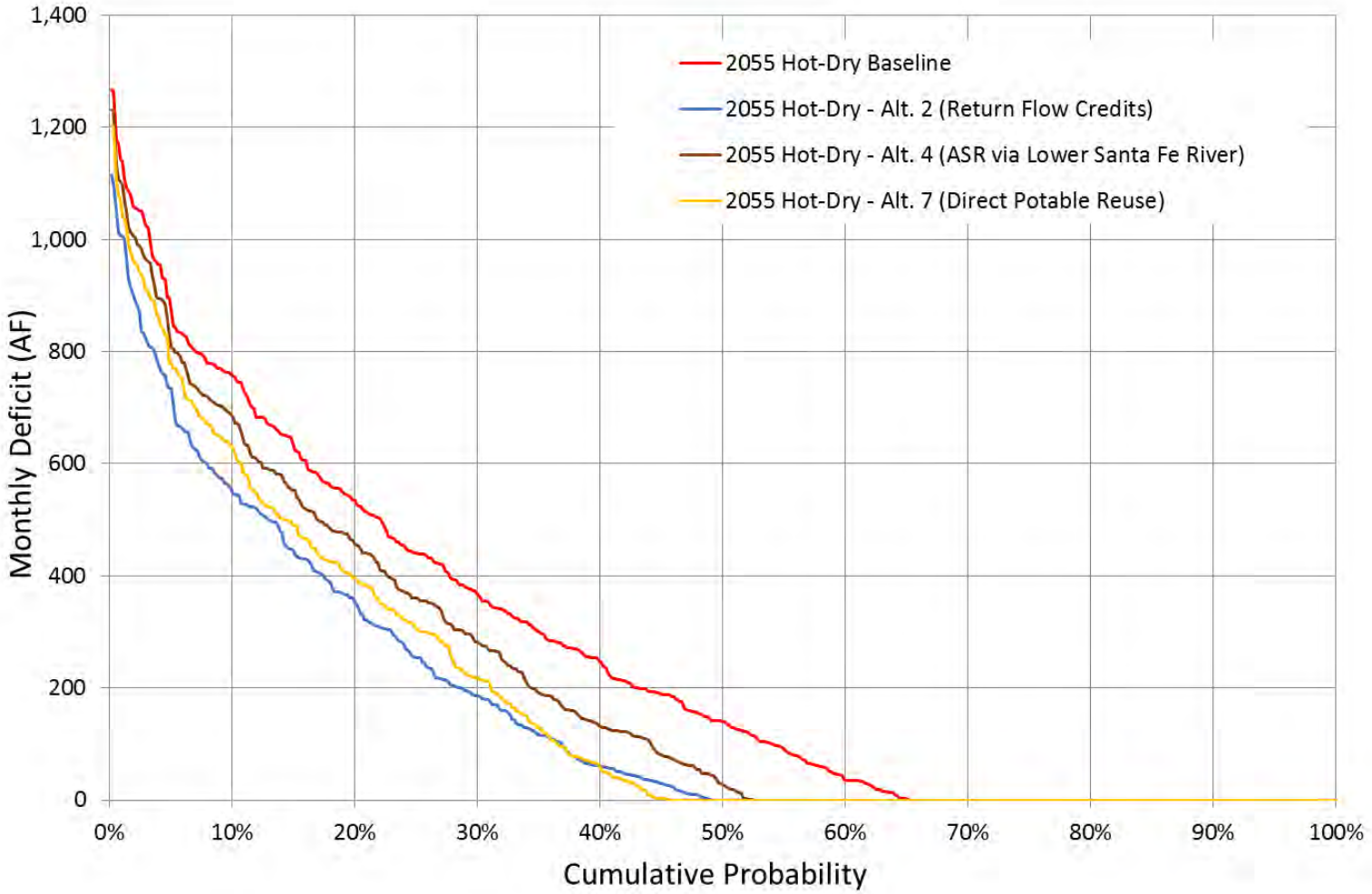
Table 6.4	Magnitude and Frequency of Monthly Deficits under Baseline Condition and Reuse Alternatives Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County		
	Average Annual Deficit (AFY)	**Max Monthly Deficit (AF per month)**	**Number of Months with a Deficit(1)**
Baseline (No Additional Water Reuse) in 2055 Under No Climate Change	680	800	183
Baseline (No Additional Water Reuse) in 2055 with Climate Change	3,090	1,270	375
Alternative 2 (Full Consumption of SJCP Water via Rio Grande Return Flow Credits) in 2055 with Climate Change	1,920	1,120	283
Alternative 4 (Aquifer Storage and Recovery via Lower Santa Fe River) in 2055 with Climate Change	2,480	1,230	302
Alternative 7 (Direct Potable Reuse) in 2055 with Climate Change	2,110	1,200	262

Notes:

(1) Number of months out of all hydrology sequences analyzed for the planning year (2055). Refer to Figure 6.4 for probabilities of shortages.

The results from the WaterMAPS monthly analysis are presented in terms of the magnitude and frequency of monthly deficits. The monthly deficits were plotted in an exceedance probability curve to illustrate the benefits of the alternatives in terms of reducing deficits. Alternative 2 (Return Flow Credits from the Rio Grande) proved most robust, as the timing of the use of the water was not tied to availability of reclaimed water for additional reuse (due to annual accounting of supplies on the Rio Grande), allowing for greater flexibility of use of the increased supply from reclaimed water. If the timing and rate of withdrawals were instead required to coincide with the timing and rate of return flows, the supply benefit of Alternative 2 would be lessened. Under the other alternatives, reclaimed water availability for additional reuse was assumed to be linked to the immediate demand for the water due to a lack of storage in Alternative 7 (Direct Potable Reuse) and conservative assumptions regarding the amount of storage provided in the alluvial aquifer and related permit conditions for Alternative 4 (Aquifer Storage and Recovery via Lower Santa Fe River).

Figure 6.4 shows the exceedance probability curves for the WaterMAPS monthly deficit output. The graphic shows that all the alternatives clearly improve the reliability in extreme long-term conditions. The probability of deficits is reduced by each of the alternatives, and the magnitude of the maximum deficit is also reduced. Alternative 2 (Return Flow Credits from the Rio Grande) shows the largest benefit in terms of reducing deficits, in magnitude and frequency, followed by Alternative 7 (Direct Potable Reuse).



EXCEEDANCE PROBABILITY CURVES FOR MONTHLY DEFICITS UNDER BASELINE CONDITION AND REUSE ALTERNATIVES

FIGURE 6.4

6.3 Economic Analysis

For the four alternatives, capital costs and operation, maintenance, and replacement (OM&R) costs were estimated and used to develop cost summaries, NPVs, and unit costs to compare alternatives. Costs were revised for the four remaining alternatives using more detailed analyses and information than were used for the preliminary screening of alternatives.

6.3.1 Capital Costs

Capital costs for the alternatives were developed for three primary components, as applicable to each alternative:

- AWTF
- Pumping and conveyance
- Recovery wells

Costs were developed at an alternatives analysis / planning level of detail, consistent with an AACE Class 4 estimate suitable for study or feasibility analyses, with an expected planning level accuracy of +50/-30 percent. Cost estimates are typically refined as projects move into preliminary and final design, with increasing levels of accuracy associated with the greater level of detail available for use in estimating.

Capital costs for AWTF process components were adapted from recent engineering estimates of unit process costs for similar facilities, drawing in part on bid costs. The various unit process costs for ozone, BAF, UF, UV, and chlorine were included or subtracted out of the AWTF cost depending on the treatment train for the given alternative. Cost components included a metal building, tanks, earthwork, advanced treatment, miscellaneous equipment, and process piping, with multipliers for electrical/instrumentation and controls and for general conditions. The scale of operations method was used to adjust these costs from recent engineering estimates of differently sized facilities to the proposed 3 mgd AWTF. Multipliers for unidentified project elements were added to the total direct cost, including 15 percent on the advanced treatment system and 30 percent on all other components, reflecting greater uncertainty in linear infrastructure as compared to defined treatment needs. General contractor overhead, profit, and risk costs of 20 percent of capital, and then engineering, legal, and administrative fees of 15 percent of the subtotal were applied to arrive at the total estimated AWTF project capital costs.

Pumping costs were developed by trending costs of recent pump station bid costs for a range of pump station capacities, updating those costs to 2016 dollars, and assigning a cost curve to fit those costs as a function of pump station capacity. Pipeline costs for rural and urban construction were determined using detailed cost estimating software and converting those costs to an estimated unit cost of $8 per inch diameter per linear foot of pipeline for rural construction and $12 per inch diameter per linear foot of pipeline for urban construction, inclusive of a 30 percent estimating contingency. General contractor overhead, profit, and risk costs of 20 percent of capital, and then engineering, legal, and administrative fees of 15 percent of the subtotal were applied to arrive at the total estimated conveyance capital costs.

Capital costs for construction of new 300-foot deep recovery wells in the lower Santa Fe River alluvium (Alternatives 3 and 4) were adapted from costs provided in support of this project (JSAI 2016). Contingency equal to 30 percent of construction costs; general contractor overhead, profit, and risk costs of 20 percent of the subtotal; and then engineering, legal, and administrative fees of 15 percent of the subtotal were applied to arrive at the total estimated recovery well capital costs.

6.3.2 Operation, Maintenance, and Replacement Cost Assumptions

OM&R costs were tracked for the alternatives in support of estimating the life-cycle cost associated with implementation and long-term operation of each alternative. OM&R costs for the alternatives were based on the following unit factors and assumptions, drawing on engineering experience and data provided by the City:

- Average power cost of $0.096 per kilowatt-hour, based on a weighted average of the City's current rate structure (assuming equal use of power in the peak 8:00 a.m. to 8:00 p.m. period and the off-peak 8:00 p.m. to 8:00 a.m. period, and seasonal weighting based on the amount of reclaimed water available for additional use, which reduces the average rate because more reclaimed water is available for additional reuse in the less-expensive months outside summer).
- Conveyance
  - 70 percent wire-to-water electrical efficiency for pumping equipment
  - OM&R at 2.5 percent of capital cost per year for pump stations and related equipment
  - OM&R at 1 percent of capital cost per year for pipelines and related equipment

- Advanced water treatment facilities
  - Chemical usage
  - Power
  - Operation staff
  - Equipment replacement
  - Miscellaneous facilities upkeep

6.3.3 Cost Summary, Net Present Value, and Unit Cost of Alternatives

A summary of capital, OM&R, and 20-year NPV costs for the four alternatives is presented in Table 6.5 and summarized in Figure 6.5. NPV costs conservatively assume that inflation and discount rates are equal. Line item breakdowns for each cost estimate are presented in Appendix B.

6.4 Evaluation of Other Benefits

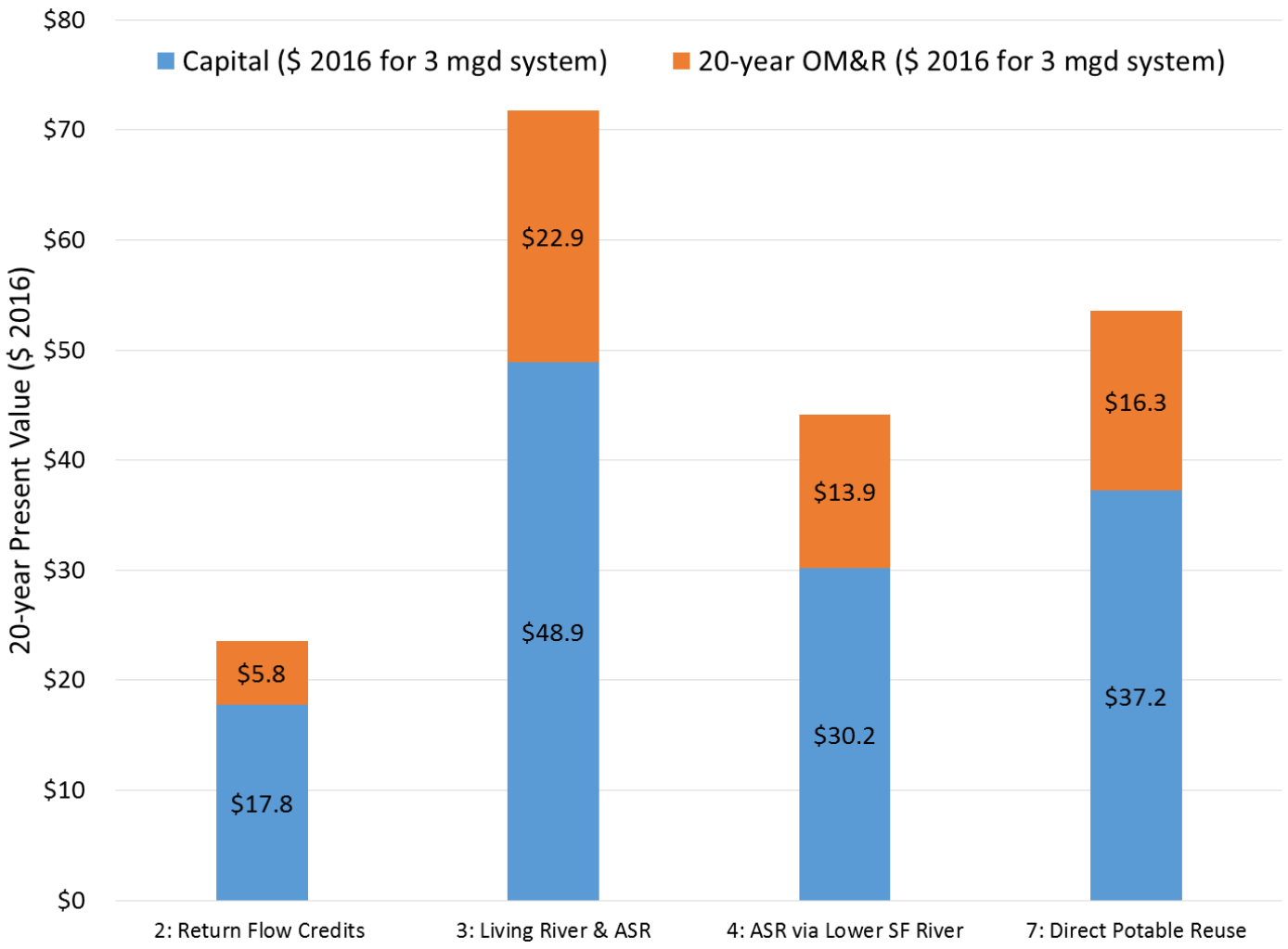
The key benefits of the seven preliminary alternatives were summarized in the alternatives screening matrix, presented above as Table 6.3 and discussed further in Section 6.1. The four remaining alternatives are considered in further detail, both in terms of their potential benefits and their anticipated implementation challenges, in Sections 7 through 10.

Table 6.5 Feasibility Level Cost Estimates for Alternatives
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

	2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits	3: Enhanced Living River and Aquifer Storage and Recovery	4: Aquifer Storage and Recovery via Lower Santa Fe River	7: Direct Potable Reuse
TOTAL CAPITAL (2016 $M)	**$17.8**	**$48.9**	**$30.2**	**$37.2**
Cost Components: Capital ($ 2016 for 3 mgd system)				
Conveyance Costs	$17.8	$26.7	$8.4	$8.3
Recovery Well Costs		$2.5	$2.1	
Treatment Costs	$0.0	$19.7	$19.7	$28.9
TOTAL OM&R (2016 $M/YEAR)	**$0.29**	**$1.14**	**$0.70**	**$0.82**
Cost Components: OM&R ($M/yr in 2016 for 3 mgd system)				
Conveyance Variable OM&R	$0.13	$0.44	$0.19	$0.11
Conveyance Fixed OM&R	$0.16	$0.30	$0.10	$0.10
Treatment Variable OM&R	$0.00	$0.26	$0.26	$0.46
Treatment Fixed OM&R	$0.00	$0.15	$0.15	$0.15
20-YEAR PRESENT VALUE (2016 $M)	**$23.6**	**$71.8**	**$44.1**	**$53.6**

Notes:

(1) OM&R costs for all alternatives assume operation at up to 3 mgd, constrained by availability of water after existing non-potable uses and downstream discharges are satisfied.



DETAILED SCREENING-LEVEL CAPITAL AND OM&R COMPONENTS OF NPV COSTS FOR THE FOUR ALTERNATIVES

FIGURE 6.5

7.0 SELECTION OF THE TITLE XVI PROJECT

7.1 Evaluation of Potential Challenges

Each of the alternatives carried forward for detailed evaluation is associated with a number of implementation and operational challenges that can be broadly grouped into four categories: technical, permitting, outreach, and others. Below, these issues are identified and potential solutions are proposed.

7.1.1 Challenges with Alternative 2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits

7.1.1.1 Technical Challenges

Because water rights on the Rio Grande are managed on an annual accounting basis, this alternative could provide significant flexibility in terms of the "virtual storage" of the water discharged to the Rio Grande, allowing additional water to be diverted from the Rio Grande using the BDD system during times of peak demand. This is particularly valuable for expanding water reuse in Santa Fe, since the availability of reclaimed water from the Paseo Real WRF is at its lowest in summer due to non-potable reuse, when both demands for both potable water and non-potable reuse are highest.

That said, this alternative relies on the availability of "wet water" upstream of the BDD diversion to divert in exchange for return flows piped to the Rio Grande, and would increase the utilization of the BDD diversion, conveyance, and treatment system without increasing its capacity. Under this scenario, the system's capacity will be utilized more fully, and utilization of the system in winter, spring, and fall may increase relative to current plans in order to divert the total acre-feet of water afforded by the return flow credit. At times when system-wide demands exceed the capacity of the BDD, the City and County can use other surface and groundwater supplies to provide peaking capacity.

Because this alternative uses the BDD system to divert water, it would also be subject to operating rules and protocol of the existing system. BDD operational protocol calls for voluntary suspension of diversions from the Rio Grande when turbidity in the river exceeds 600 nephelometric turbidity units (NTU). The BDD also has agreed to suspend diversions from the river anytime flow in Los Alamos Canyon exceeds 5 cfs. These two conditions can coincide but oftentimes do not. BDD staff report that the suspension of diversions for either reason rarely lasts for more than a half-day to a full day. Storage of water in the BRWTF presedimentation basins provides a buffer against temporary supply interruptions.

7.1.1.2 Permitting Challenges

Potential permitting challenges for this alternative include:

- **Uncertainties in the NMOSE / Interstate Stream Commission requirements for the water exchange**. The Albuquerque Bernalillo County Water Utility Authority has established a precedent for this type of exchange on the Rio Grande. The permit conditions for that exchange include numerous stipulations and constraints on the operation of the exchange. However, the distance between diversion and return flows in Albuquerque's system is around 10 miles and includes Critical Habitat for the endangered Silvery Minnow, whereas Santa Fe's distance could be on the order of 100 yards or less. Other considerations include potential limitations on the amount of water that can be returned and exchanged to the Rio Grande, which NMOSE may link to the source of supply that generated the return flow.

- **Rio Grande NPDES discharge permit requirements**. City staff anticipates that the discharge permit requirements for an alternate point of discharge to the Rio Grande from the Paseo Real WRF would be equal to or less stringent than the discharge requirements to the Santa Fe River. Designated uses per New Mexico water quality standards are similar for the Santa Fe River and the Rio Grande (per Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code [NMAC]), except the Rio Grande at Buckman is designated as marginal coldwater aquatic life and warmwater aquatic life instead of the Santa Fe River's coolwater aquatic life designation. The coolwater aquatic life designation drives significant requirements in the existing Paseo Real WRF discharge permit. The Rio Grande at Buckman is designated as public water supply, whereas the Santa Fe River below the WRF does not carry this designation. However, it is expected that the current Paseo Real WRF facilities could meet the nitrogen limits and other parameters that would accompany this designation.

- **The potential that any additional work on the BDD corridor would require supplemental environmental analyses and/or re-open existing Bureau of Land Management (BLM) and U.S. Forest Service (USFS) permits for the BDD project along the BDD pipeline corridor**. Construction in the same utility corridors as the existing non-potable piping system from the Paseo Real WRF to the Municipal Recreation Complex and from the BRWTF to the Rio Grande will help minimize environmental disturbances, and similar mitigation measures can be used as in those pipelines' original construction.

If Santa Fe makes operational decisions to divert the return flow credit water at rates not matching the discharge rates (i.e., utilizing "virtual storage"), or is not authorized to do so, additional analyses may be required to demonstrate that there is no negative impact of increased or decreased stream flows in the reach of river between diversion and discharge. Minimizing the distance between these two features will also minimize the potential for such issues.

7.1.1.3 Outreach Challenges

All of the proposed alternatives, by definition, divert reclaimed water that would have otherwise been discharged into the lower Santa Fe River. Therefore, downstream users may voice some concerns over any reuse project. Each of the four alternatives diverts a similar amount of water, although recovery rates for potable supply differ between the alternatives. Therefore, the concerns associated with downstream Santa Fe River impacts are anticipated to be identical for all four alternatives. Minimum discharges to the Santa Fe River at the Paseo Real WRF, while voluntary, are contemplated in this Feasibility Study (see Section 4.2) in order to provide water in the river for downstream environmental benefit and to help meet historical downstream consumptive uses.

No additional outreach challenges are anticipated with this alternative, particularly because it reuses water indirectly by exchange, with no reclaimed water being used to directly blend with and augment other potable water supply sources.

7.1.1.4 Other Considerations

Santa Fe already depends to a large degree on water from the BDD, and this alternative would increase that dependence. However, Santa Fe also has a broad diversity of supplies in the Upper Santa Fe River reservoirs, the Buckman Well Field, the City Well Field, and the County's wells. Therefore, increasing reliance on surface water from the Rio Grande is not a significant risk. The simplicity of the system, with no new treatment, a single new pump station, conveyance that follows existing rights-of-way and easements, and use of existing infrastructure provides an elegance to the system not found in the other alternatives. This simplicity can help increase reliability relative to more complex systems.

Currently, Santa Fe does not need all the water that could be diverted through the BDD in exchange for discharges to the Rio Grande under normal water supply and operational conditions. Therefore, until all the water is needed, there is the potential to manage the return flows in ways that could provide water storage benefits, economic benefits, and/or environmental benefits.

7.1.2 Challenges with Alternative 3: Enhanced Living River and Aquifer Storage and Recovery

7.1.2.1 Technical Challenges

Seepage and recovery rates constrain the ability of this alternative to provide a water supply benefit. Seepage rates could potentially be increased using one of several approaches, as detailed in Appendix C (JSAI 2016b). Santa Fe is not currently considering in-channel approaches, in light of anticipated permitting challenges and potential environmental effects. Alternatively, percolation basins could be constructed adjacent to the lower Santa Fe River to increase the recharge and recovery of water through a new lower Santa Fe River well field. Although this approach would increase the water supply benefit, it would eliminate the instream flow or Living River benefits of Alternatives 3 and 4. An alternate site for potential recharge was identified in the Arroyo de los Chamisos adjacent to Villa Linda Park, underlain by saturated Ancha Formation (JSAI 2016). This recharge site could be used instead of or in addition to Santa Fe River recharge or constructed percolation basins, but would not provide the Living River benefit in the Santa Fe River.

For purposes of this alternative, it was assumed that up to 3 mgd (limited by seasonal reclaimed water availability) would continue to be discharged to the river at Two Mile Reservoir to provide the Living River benefits. However, it is important to acknowledge that bypasses from McClure and Nichols Reservoirs would still be required under this alternative to supplement the Living River flows. The availability of reclaimed water is at its lowest point in summer (due to existing non-potable reuse demands), which coincides with when the Living River flows are most valuable in terms of aligning with natural (pre-reservoir) streamflow patterns and providing public benefits. On peak summer non-potable reuse demand days, no reclaimed water would be available for pumping to the Upper Santa Fe River, and the entire Living River flow would need be supplied by McClure and Nichols bypasses (much as it is today). Depending on water rights accounting, this alternative could potentially help to preserve some of the water in the reservoirs for treatment at the CRWTF (i.e., water that would otherwise be bypassed to provide Living River flows), but it would not eliminate the need for those bypasses.

Moreover, reclaimed water discharges to the Upper Santa Fe River under this alternative will greatly modify the streamflow patterns in the Santa Fe River. Today, Living River ordinance requires that flows be released in spring and early summer, with any winter releases not counting towards Living River requirements. Under Alternative 3, flows would be at their highest in winter due to the availability of reclaimed water for this use, and would be lowest in summer when target Living River flows would be accomplished through a combination of reclaimed water discharges and McClure and Nichols Reservoirs' bypass flows. There may also be challenges with maintaining a discharge on colder winter days due to freezing conditions, and/or with maintaining the full 2.15 mgd of seepage along the riverbed between Two Mile Reservoir and lower Santa Fe River recovery wells for similar reasons.

As with all of the potable reuse alternatives (i.e., Alternatives 3, 4, and 7), one technical challenge is the design of the AWTF. While the treatment processes are well understood, the complexity of advanced treatment requires a detailed understanding of the site-specific source water quality and monitoring requirements. These can and should be determined through demonstration-scale testing.

While it provides a high level of treatment for the purposes of potable reuse, the treatment process evaluated for this alternative is not specifically designed to remove nutrients. The Paseo Real WRF already produces low-nutrient reclaimed water, minimizing the need for additional nutrient removal. Further evaluation of the assimilative capacity of the Santa Fe River between Nichols Reservoir and the Paseo Real WRF for nitrogen and phosphorus should be conducted prior to the implementation of this alternative, in order to determine the suitability of the proposed treatment for discharge to the river.

This alternative also relies in part on soil aquifer treatment that occurs during percolation of the water from the riverbed into the underlying aquifer. Though existing literature suggests that this treatment is sufficient to provide the LRV credits assigned in Section 5, column studies with the native soil should be conducted to confirm the literature values and provide additional certainty.

Finally, the proposed pipeline for this alternative is routed through urbanized areas of Santa Fe, making construction of the pipeline challenging. Significant traffic control and public outreach will be needed during construction to mitigate impacts on the community and address public concerns.

While the first pump station required for this alternative would be located onsite at the AWTF, the other two pump stations would need to be sited at suitable points on the hydraulic gradeline. Property would need to be acquired for these two pump stations, potentially at significant cost, unless suitably-located sites in the public right of way could be identified.

7.1.2.2 Permitting Challenges

Similar to the treatment challenges, demonstration-scale testing can be used to support the permitting process for NMED to approve the project from the perspective of augmenting Santa Fe's drinking water supplies through IPR.

Obtaining rights/permits for additional groundwater from new wells, based on the percolation of water discharged into the Santa Fe River and subsequently recharging the underlying aquifer, does not have a direct analog in New Mexico. Dialogue and negotiations with NMOSE would be required to obtain credit for recharging the aquifer and the approval to recover and divert that water through new well fields. NMOSE has established procedures for consideration and approval of an Underground Storage and Recovery (USR) permit, which includes detailed requirements for a pilot/demonstration study and subsequent engineering analysis and reporting (as detailed at NMAC Title 19 Chapter 25 Part 8). The Albuquerque Bernalillo County Water Utility Authority Bear Canyon USR

project provides an example for the permitting process, although the source of water for that project differed significantly from what is considered in this Alternative 3. Rather than pursue USR permit approvals, the City may instead elect to use a discharge credit or pumping offset approach. Further analysis of permitting options would be needed, in consultation with NMOSE, as part of implementing this alternative.

Similar to the technical challenge, the water quality necessary for discharge into the Upper Santa Fe River, particularly for nutrients (nitrogen and phosphorous), is currently unknown. The reach of the Santa Fe River between Nichols Reservoir and Guadalupe Street has State designated uses that include coolwater aquatic life, wildlife habitat, primary contact, livestock watering, and irrigation. This is identical to the designated uses for the reach below the Paseo Real WRF, which currently drive discharge permit conditions. However, it is possible that the intentional use of the Upper Santa Fe River discharge for augmenting groundwater supplies could lead the state to modify the designated use categories for this reach of the river. Permitting this discharge therefore represents some uncertainty and a potential challenge.

7.1.2.3 Outreach Challenges

In addition to the downstream users' concerns with any additional reuse, the public may also have concerns about water quality impacts of reclaimed water discharges into the Santa Fe River or the concept of a potable reuse project. Of the potable reuse alternatives, the Santa Fe River alternatives are less likely to encounter public opposition to the concept of potable reuse as it is *indirect*: the water is allowed to mingle with surface water in the Santa Fe River (when available) and then percolate into the ground before being withdrawn through wells. These concerns may be offset somewhat by public support for more robust and reliable Living River flows. Dating back at least as far as the 1998 TEMP and in implementing the City's Living River Ordinance, strong public support for Living River flows has been evident.

7.1.2.4 Other Considerations

As detailed in Section 7.1.2.1, discharging into the Santa Fe River at the upstream location proposed under this alternative will allow the City to reduce the bypass flows from the upstream reservoirs for the purposes of creating a Living River within the city. However, this effect is marginal, as water will not be available for this purpose during the peak summer non-potable reuse demand periods.

7.1.3 Challenges with Alternative 4: Aquifer Storage and Recovery via Lower Santa Fe River

Challenges for this alternative will be similar in many ways to those of Alternative 3. These include the same list of permitting, outreach, and other challenges listed above. The only distinction between these alternatives is the location of the discharge to the Santa Fe River, which affects a few of the challenges associated with this pair of alternatives.

The proposed discharge location is further downstream in this alternative, resulting in

- A shorter pipeline route that does not have to traverse central Santa Fe and upper Canyon Road, which in turn would make construction easier in terms of traffic control and would reduce the impact of construction on the community.
- A shorter reach of river in which the water can percolate, reducing the amount that can be infiltrated to an estimated 1.74 mgd based on the City's 2016 seepage studies.
- Less stringent designated uses for the stream, which are identical to the reach above Guadalupe Street (i.e., the Alternative 3 discharge reach) except that the coolwater aquatic life designation is replaced with limited aquatic life; this should result in less stringent discharge requirements than Alternative 3.

Because this alternative does not discharge water to the Upper Santa Fe River, the full Living River benefit could not be achieved. Therefore, it is anticipated that Living River bypasses from McClure and Nichols Reservoirs would still be needed to maintain the Living River through central Santa Fe, similar to bypasses made in current operations, reducing the water supply benefit of this alternative relative to Alternative 3.

Alternative 4 recovers less water than Alternative 3 because of the lower seepage capacity associated with a shorter reach of riverbed in which to accomplish the seepage (i.e., 2.15 mgd under Alternative 3 versus 1.74 mgd under Alternative 4).

Seepage studies conducted by the City in 2016 confirmed that the riverbed is much more conducive to recharge in the lower broader alluvial portions of the river than in the more channelized rock bed of the Upper Santa Fe River.

7.1.4 Challenges with Alternative 7: Direct Potable Reuse

7.1.4.1 Technical Challenges

As a DPR project, the main technical challenge with Alternative 7 is associated with providing a final water quality protective of human health. This begins with source control measures in the raw wastewater and the community of dischargers to sewers tributary to the Paseo Real WRF in the facility's service area, where additional pretreatment requirements would have to be implemented in order to prevent unforeseen constituents from entering the DPR loop.

Similar to Alternatives 3 and 4, the individual treatment processes proposed for the AWTF under this alternative are well understood. However, by combining even more unit processes together to form the DPR treatment train, the complexity exceeds that of the preceding alternatives. If this alternative is pursued, demonstration-scale testing should be utilized to provide the necessary engineering, regulatory, and public confidence in the treatment process.

An additional challenge is the treatment redundancy between the proposed advanced treatment facility and the existing treatment at BRWTF. Both facilities employ ozone and biofiltration as major treatment steps. The current analysis assumes that the BRWTF is only provided the LRV credits it is currently required to achieve (4-log virus, 3-log *Giardia* and *Cryptosporidium*), which is equal to the conventional treatment provided at the CRWTF. Further consideration may be warranted if the City determines it would like to rely more heavily on the robust treatment already provided at BRWTF to reduce the level of treatment proposed for the AWTF.

An additional technical challenge that must be considered is what effects blending this new water with the existing surface water from the BDD will have on the operation of the BRWTF. This blending component should be incorporated into the demonstration testing if this alternative is selected for further study.

7.1.4.2 Permitting Challenges

The two major permitting challenges for this alternative were discussed above. First, a pipeline from the new AWTF to the BRWTF has the potential to re-open supplemental environmental analyses and/or re-open existing BLM permits for the BDD project in the vicinity of the BRWTF. The pipeline for this alternative is about one-third the length of the pipeline under Alternative 2, and unlike Alternative 2, it does not extend further into BLM land beyond the BRWTF.

The second challenge is associated with permitting a DPR project with NMED. The Cloudcroft DPR project provides a precedent but is not yet fully approved. More recently, NMED has developed draft guidelines for DPR projects which, when finalized, will clarify the permitting process for this alternative. Initial dialogue with NMED regarding this alternative conducted as part of this Feasibility Study suggested that NMED would work in partnership with Santa Fe to implement and permit a DPR project, if that alternative were to be selected for implementation.

7.1.4.3 Outreach Challenges

The main outreach challenge with this alternative is the potential public opposition that could accompany the concept of a DPR project. To address this anticipated opposition, the proposed demonstration test would be constructed as a public education facility where community leaders and the public at large would be able to see and taste the water and gain a deeper understanding of the multiple-barrier protections and advanced monitoring used at the facility.

7.1.4.4 Other Considerations

This alternative could be implemented as a future second phase to the return flow credits and exchange alternative (Alternative 2). In this scenario, the Alternative 2 pipeline would be constructed to deliver the treated effluent to a point of discharge on the Rio Grande immediately downstream of the BDD diversion in exchange for the right to divert additional flows through the BDD system. If future supply conditions warrant, the new pipeline, which would run immediately adjacent to the BRWTF, could be repurposed to deliver water for a DPR project on either a temporary or permanent basis.

7.2 Multi-Criteria Analysis of the Alternatives

The four alternatives were compared in further detail using a multi-criteria decision support process. The multi-criteria evaluation used an enhanced triple bottom line approach (considering economic, social, and environmental aspects) that also considered technical aspects related to timely implementability and operability and project risk mitigation.

The matrix shown in Table 7.1 summarizes the following aspects of the multi-criteria evaluation of the four alternatives:

- The criteria, sub-criteria, and performance measures used in the evaluation,
- The relative importance or "weighting" assigned to the criteria through dialogue with the Feasibility Study planning team,
- The scores assigned to each alternative for each of the performance measures, and
- A brief description of the basis for scoring in the "notes" column.

Table 7.1 Multi-Criteria Analysis of the Four Alternatives
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Water Reuse Feasibility Study Criteria with Objective	Performance Measures	Weight of Criterion/ Perf. Measure	2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits	3: Enhanced Living River and Aquifer Storage and Recovery	4: Aquifer Storage Recovery via Lower Santa Fe River	7: DPR	NOTES
ECONOMIC: Cost-Effective Supply Augmentation		***45%***					
Minimize NPV unit cost ($/AF)	20-year net present value (NPV) cost per acre-foot of potable water offset ($/AF)	60%	$505	$2,421	$1,692	$1,157	Unit costs updated from preliminary screening based on 2016 seepage study recovery rates for Alts. 3 and 4.
Maximize outside funding opportunities	Potential for outside funding (qualitative score)	20%	3	4	4	2	More funding opportunity for environmental benefit projects and water management opportunities through RFC. Public acceptance affects DPR.
Phasing potential	Potential to defer capital and expand system as needed (qualitative score)	10%	1	3	3	5	Infrastructure-intensive alternatives score low (1 or 3). DPR can be phased (mostly treatment; 5).
Potential for supplemental revenue generation	Ability to lease unused reclaimed water until needed (qualitative score)	10%	5	2	2	2	Possible with RFC on Rio Grande (5). Difficult on SF River (2).
SOCIAL: Public Benefit and Social Acceptability		***25%***					
Provide Living River in town and habitat benefits	Living River location and flow (qualitative score)	20%	3	5	4	3	Status quo with bypass flows from reservoirs provides Living River under all alternatives. Additional flow under Alts. 3 and 4 improves score.
Public acceptance of reuse strategy (exchange, IPR, DPR)	Public acceptance (qualitative score)	50%	2	4	3	1	Downstream Santa Fe River concerns expected under any alternative. Potential concerns about DPR acceptability unless/until severe supply shortage.
Availability of flow for downstream uses	Flow discharged to Santa Fe River at WRF at full reuse capacity (qualitative score)	30%	2	4	4	4	Potable reuse alts are all the same in this regard and exceed minimums; RFC could reduce flows sooner under potential interim management strategies.
ENVIRONMENTAL: Protect and Sustain the Environment		***10%***					
Minimize environmental impacts and permitting requirements during construction	Environmental impacts and permitting requirements (qualitative score)	50%	2	2	3	4	Primarily scored based on length of pipeline; permitting for any ASR is challenging; Upper Santa Fe River recovery particularly challenging.
Minimize greenhouse gas emissions of operations	Power use for pumping and AWTF treatment per AF of water reused (kWh/AF)	50%	562	4,043	2,648	1,715	No treatment for RFC reduces power consumption. Less pumping for end discharge/use that is closer to Paseo Real WRF.

Table 7.1 Multi-Criteria Analysis of the Four Alternatives
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

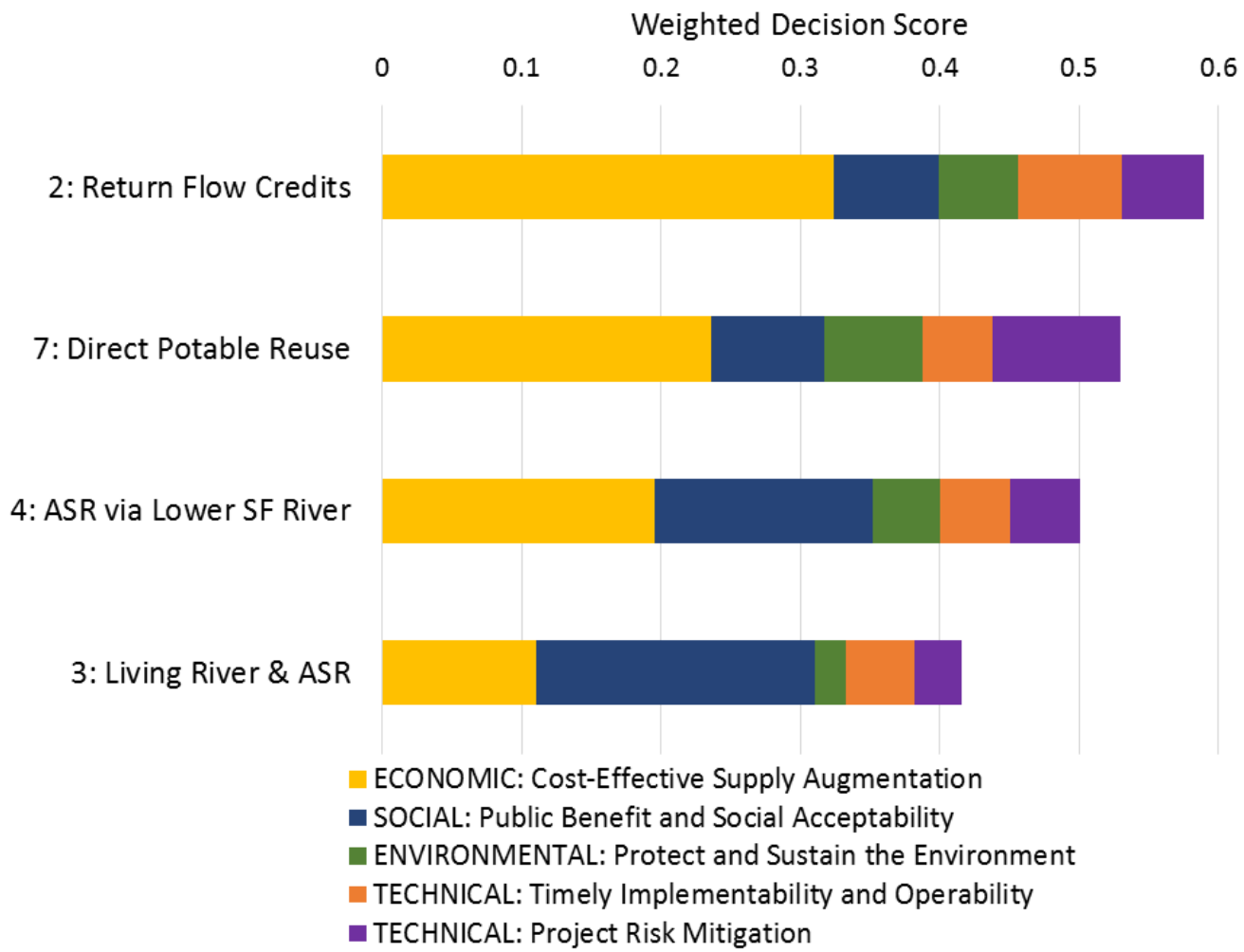
Water Reuse Feasibility Study Criteria with Objective	Performance Measures	Weight of Criterion/ Perf. Measure	2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits	3: Enhanced Living River and Aquifer Storage and Recovery	4: Aquifer Storage Recovery via Lower Santa Fe River	7: DPR	NOTES
TECHNICAL / OTHER: Timely Implementability and Operability		*10%*					
Ensure alternative can be implemented by the time the water is needed	Ability to implement by time the water is needed (qualitative score)	50%	3	3	3	3	All have potential permitting hurdles; no known constructability challenges that would delay implementation.
Use technology appropriate for Santa Fe resources	Treatment and monitoring technology complexity (qualitative score)	50%	5	3	3	3	RFC has no treatment; others require AWTF and critical control point monitoring.
TECHNICAL / OTHER: Project Risk Mitigation		*10%*					
Reduce permitting complexity	Permitting complexity score (qualitative score)	33%	3	2	2	4	Clear path for DPR; RFC is complex; Aquifer recharge/recovery very complex.
Ensure supply availability in times of extreme drought	Reliance on Rio Grande physical supply availability during extreme drought (qualitative score)	33%	2	4	4	5	RFC depends on Rio Grande flow and water quality; Recharge depends on hydrology; DPR is max supply.
Operational flexibility	Potential for long-term requirement to maintain discharges to upper Santa Fe River (qualitative score)	33%	5	1	3	5	Santa Fe River discharges could potentially trigger a mandate, particularly upper Santa Fe River.

Notes:
(1) Operating at up to 3 mgd, constrained by availability of water after existing non-potable uses are satisfied
(2) Upper and Lower Santa Fe River alternatives would discharge 3 mgd for instream flow benefits but anticipated seepage is limited to 2.15 mgd (Alternative 3) and 1.74 mgd (Alternative 4).

The weighted decision scores for the four alternatives using the scores and criteria weights from Table 7.1 are presented in Figure 7.1. The results show that Alternative 2, Full Consumption of SJCP Water via Rio Grande Return Flow Credits, is the highest-ranked alternative for this weighting profile. Alternative 7, DPR, was the second highest-ranked alternative.

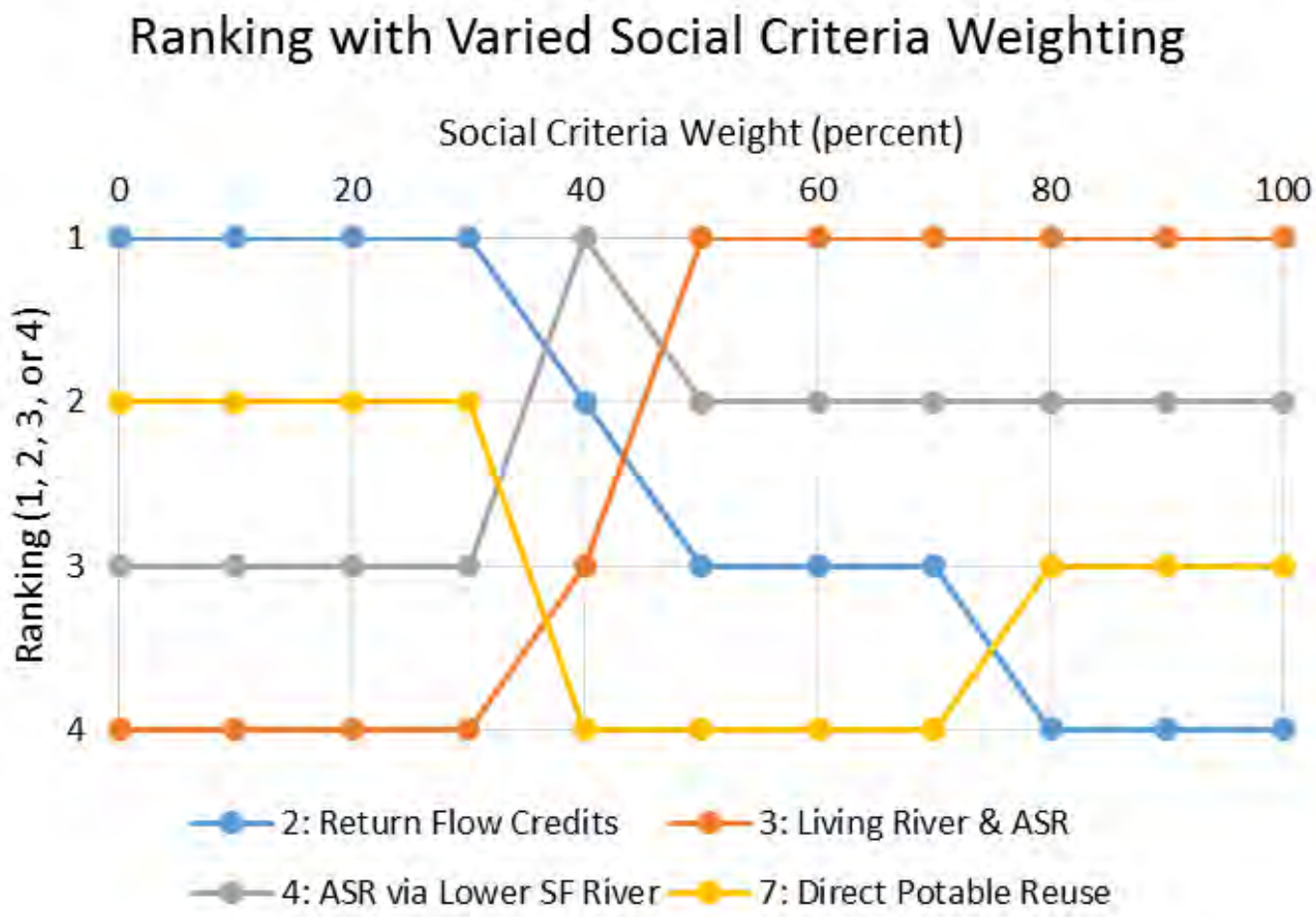
Recognizing that different individuals and groups will have different priorities (as defined here as the criteria weightings), a sensitivity analysis was conducted to assess how the alternatives would be ranked (1 through 4, with 1 indicating the highest-ranked alternative) under a range of weights for each of the five major criteria. The results are shown in Figures 7.2 through 7.6, where the weight of each major criterion was varied over a range from 0 to 100 percent, with the other four criteria sharing the remainder of the 100 percentage points (pro-rated among the four criteria based on their baseline weights). The sensitivity analyses show that the highest-ranked alternative changes from Alternative 2 under the following conditions:

- At very high social criteria weights, Alternative 3 (Enhanced Living River and Aquifer Storage and Recovery) would be highest-ranked.
- At technical (project risk mitigation) weights above about 25 percent, Alternative 7 (DPR) would be highest-ranked.
- Weighted decision scores are insensitive to technical (timely implementability and operability) scores, with Alternative 2 (Full Consumption of SJCP Water via Rio Grande Return Flow Credits) always ranked highest.
- At economic criteria weights below about 25 percent, Alternative 4 (Aquifer Storage and Recovery via Lower Santa Fe River) would be highest-ranked.
- At environmental criteria weights above about 35 percent, Alternative 7 (DPR) would be highest-ranked.



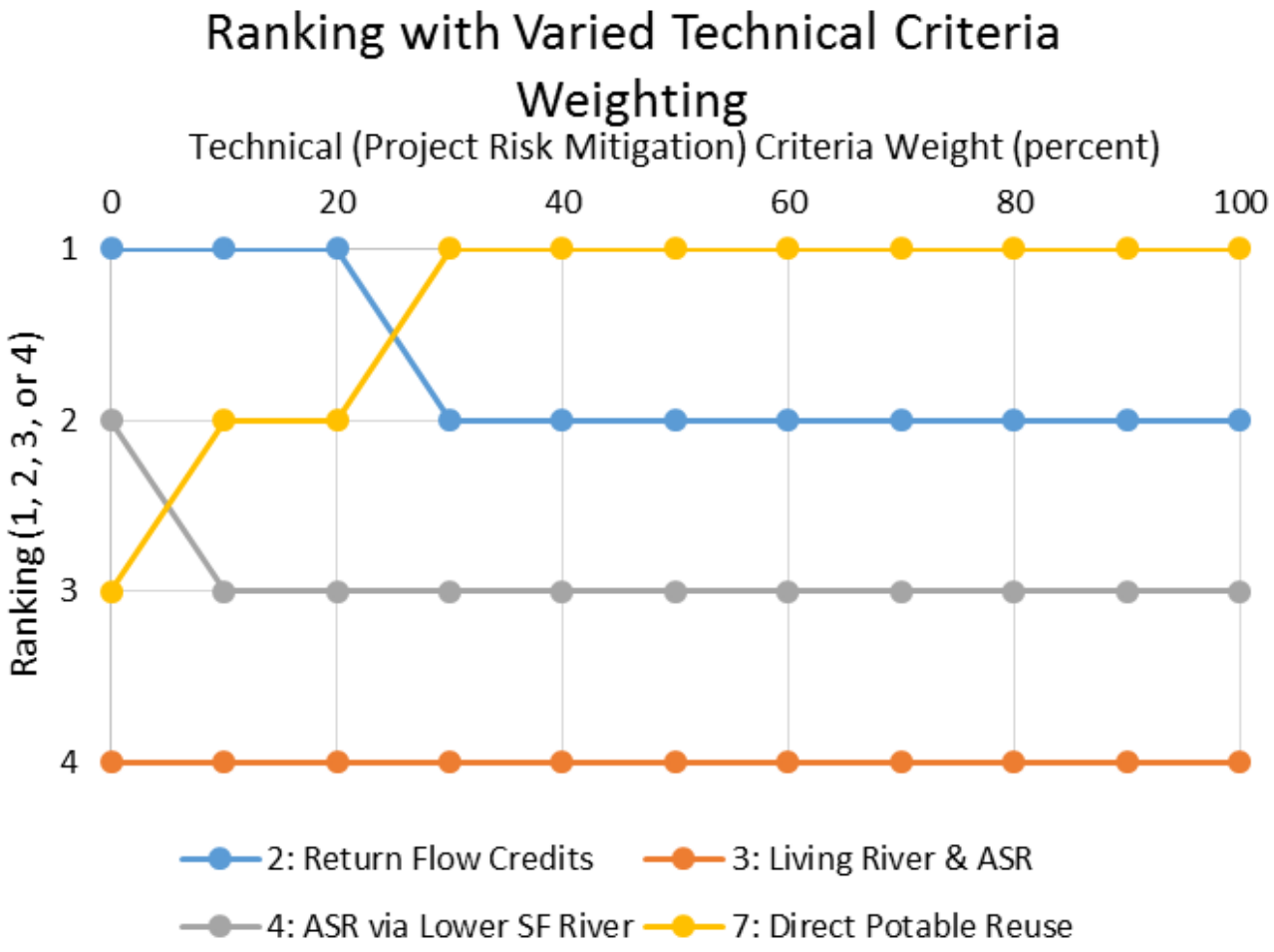
WEIGHTED DECISION SCORES FOR THE DETAILED ANALYSIS OF FOUR ALTERNATIVES

FIGURE 7.1



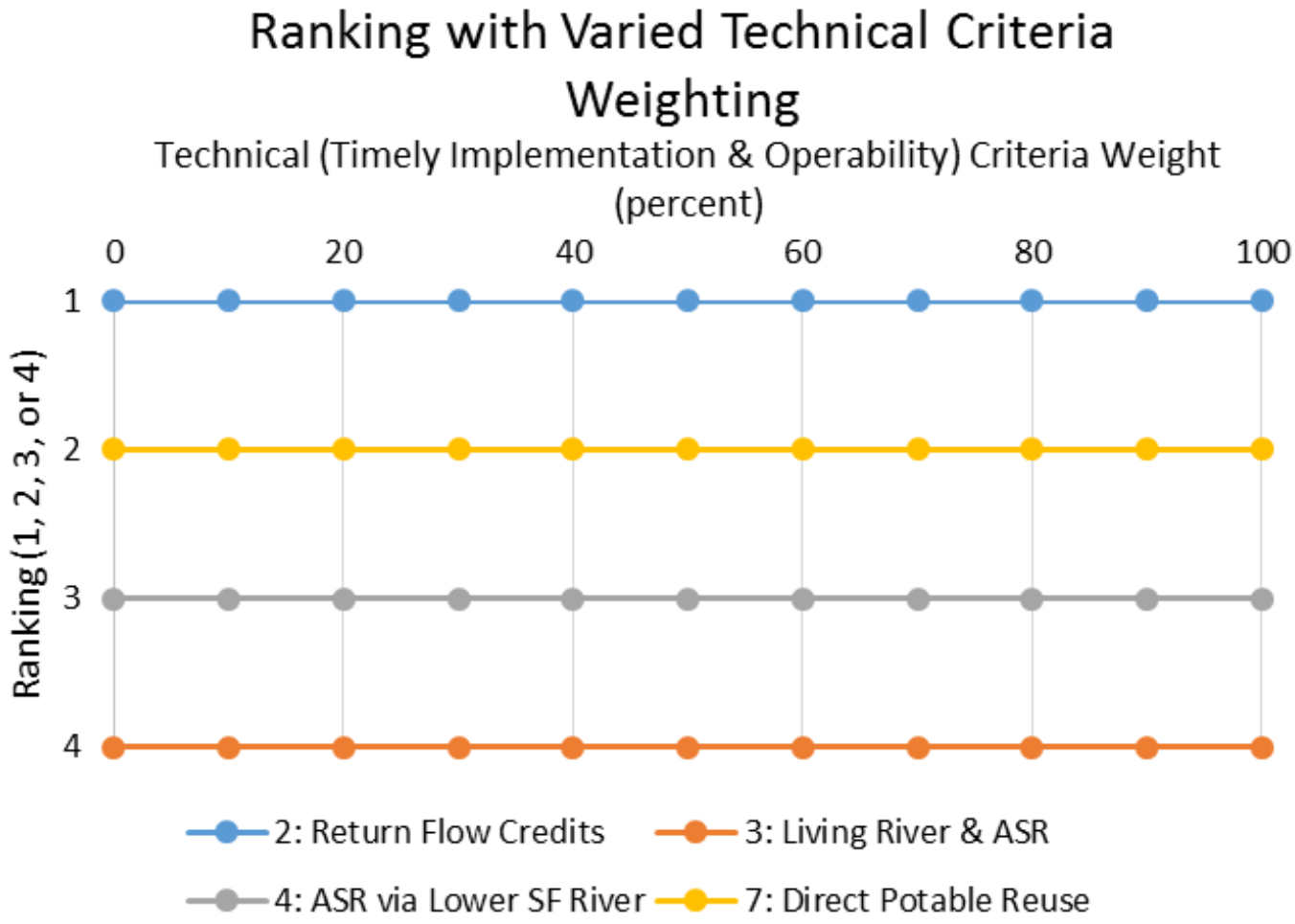
SENSITIVITY ANALYSIS FOR SOCIAL CRITERIA WEIGHTING

FIGURE 7.2



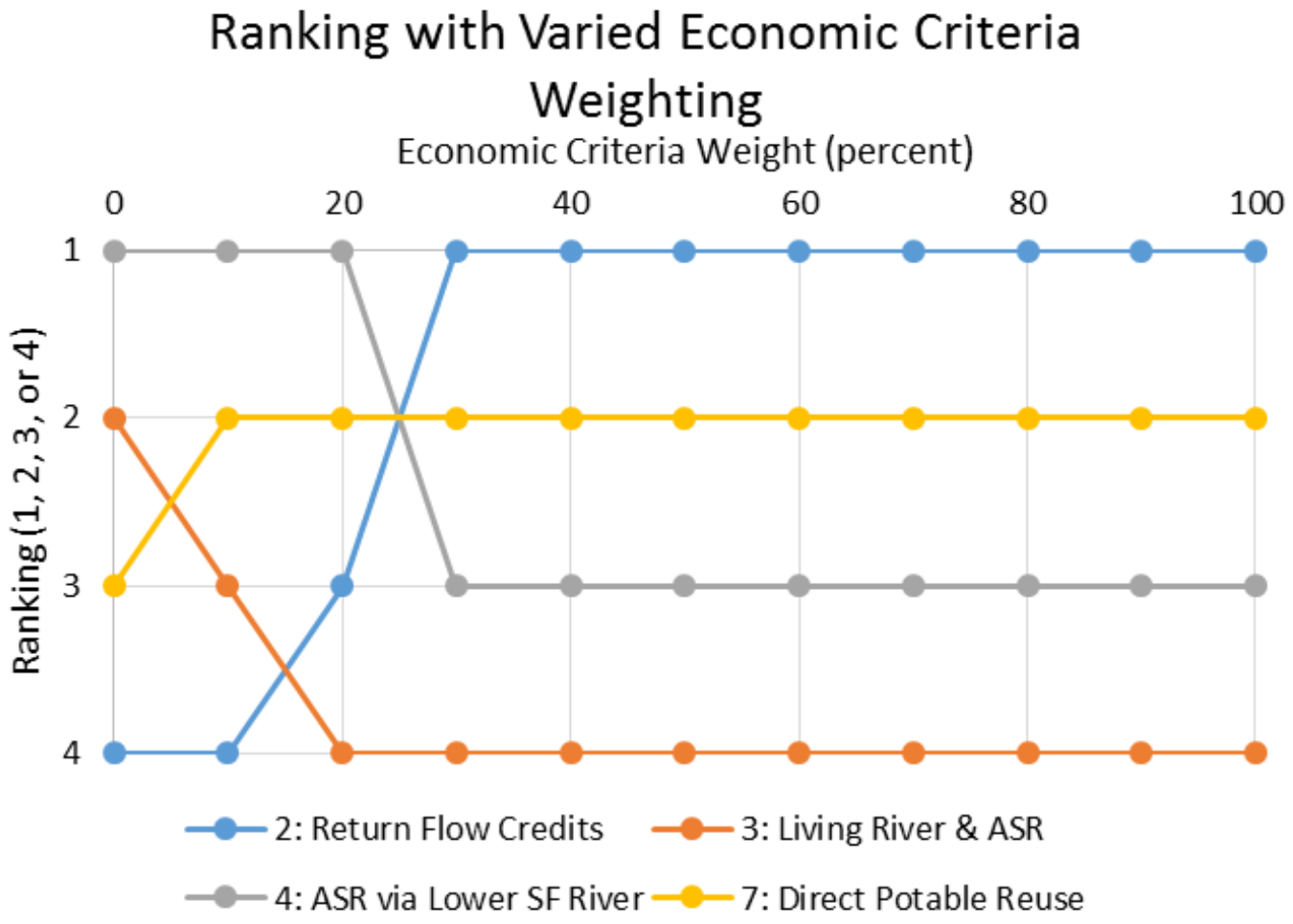
SENSITIVITY ANALYSIS FOR TECHNICAL (PROJECT RISK MITIGATION) CRITERIA WEIGHTING

FIGURE 7.3



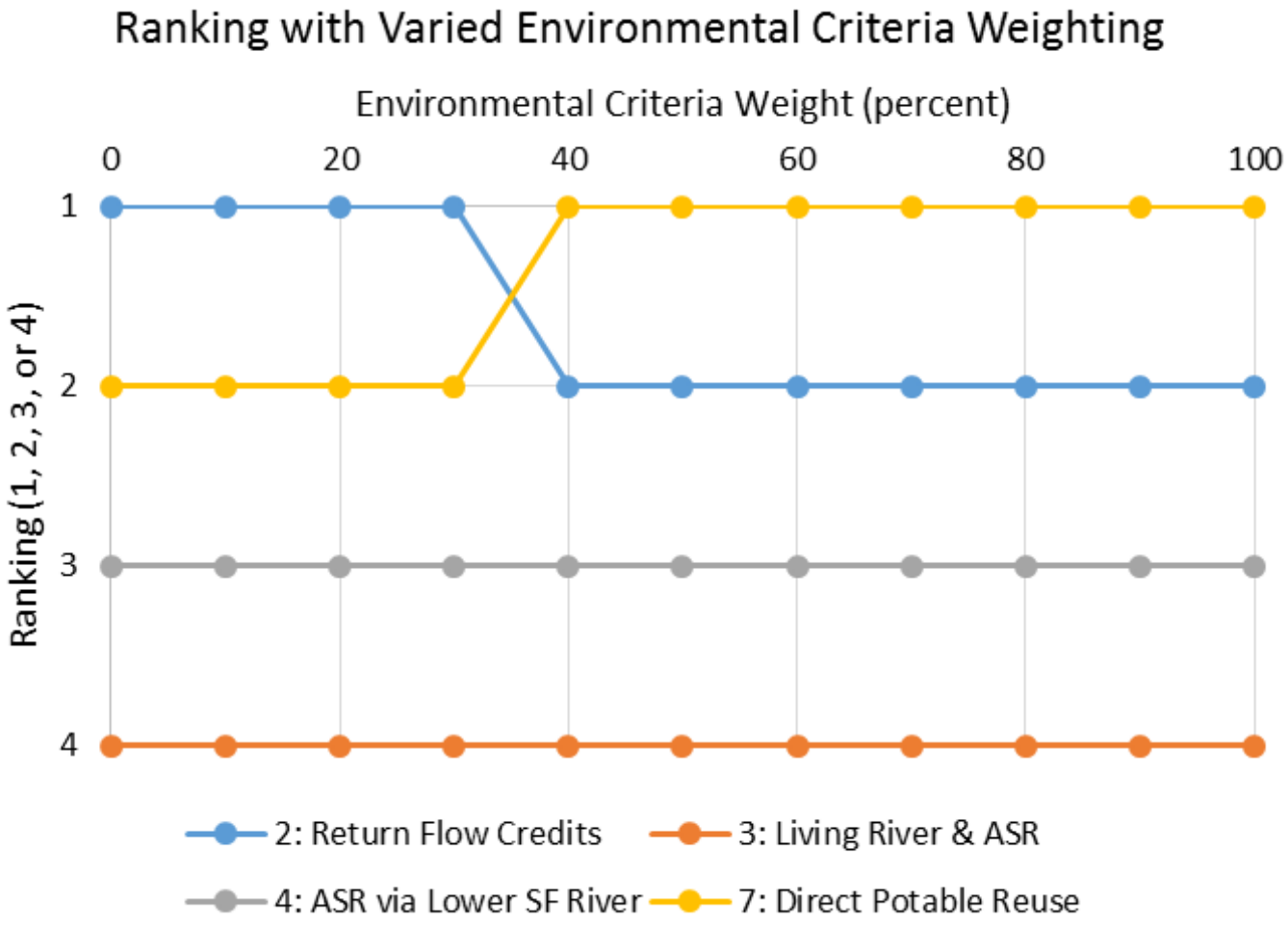
SENSITIVITY ANALYSIS FOR TECHNICAL (TIMELY IMPLEMENTATION AND OPERABILITY) CRITERIA WEIGHTING

FIGURE 7.4



SENSITIVITY ANALYSIS FOR ECONOMIC CRITERIA WEIGHTING

FIGURE 7.5



SENSITIVITY ANALYSIS FOR ENVIRONMENTAL CRITERIA WEIGHTING

FIGURE 7.6

7.3 Comparison of Alternative 2 to the Non-Title XVI Project Alternative

The Non-Title XVI Alternative (no additional water reuse) has aspects that are similar to the highest-ranked Title XVI Alternative (Alternative 2, Full Consumption of SJCP Water via Rio Grande Return Flow Credits), in that it would involve diversions of additional water from the Rio Grande through using existing capacity in the BDD system for diversion, conveyance, and treatment. The two alternatives differ in the source of the water. Under the Non-Title XVI Alternative, as described in Section 5.1, approximately $71 million in water rights would need to be acquired to provide the same yield as the highest-ranked alternative. Minimal OM&R costs would be expected for the purchase of water rights under the Non-Title XVI Alternative, as it simply involves purchase of water rights to be diverted through the BDD system. OM&R costs for the BDD system were excluded under all alternatives.

As detailed in Section 6, the 20-year NPV of Alternative 2 is slightly more than $20 million. With an NPV about 3.5 times the NPV of Alternative 2, the Non-Title XVI Alternative is not economically attractive. As described in Section 6 and the 2015 Basin Study, purchasing additional native water rights on the Rio Grande carries significant uncertainties regarding the availability of rights to be purchased, and has numerous other downsides as Santa Fe strives to be a good steward of regional water resources and cultural traditions.

In light of the economic and non-economic advantages of the highest-ranked alternative relative to the Non-Title XVI Alternative, the Non-Title XVI Alternative was eliminated from further consideration for this Feasibility Study. To the degree that future shortages exceed the supply that the Title XVI Alternative can provide, the purchase of additional native Rio Grande water rights may be reconsidered in the future to address the remaining gap.

7.4 Conclusions and Recommendations

The highest-ranked alternative, Full Consumption of SJCP Water via Rio Grande Return Flow Credits, best satisfies the evaluation criteria used to compare the alternatives in detail. When considering repeated cycles of returns, this alternative could increase the amount of consumable water that could be pulled from the BDD diversion by 150 percent without additional water rights, for an overall multiplier of 2.5 times the original consumable water right. Furthermore, there may be an opportunity to reduce treatment investments and operating costs at the Paseo Real WRF if discharge permit requirements are less stringent for the portion of the flow discharged to the Rio Grande.

The actual water supply benefit of the Full Consumption of SJCP Water via Rio Grande Return Flow Credits project would be limited by physical water supply availability at the Paseo Real WRF. Existing commitments to non-potable reuse and minimum target releases to the Santa Fe River from the Paseo Real WRF constrain the supply available for return flow credits at 2,334 AFY under the scenarios contemplated in this Feasibility Study. Increasing the capacity of the return flow credit pipeline for increased wintertime use and implementing additional conservation measures at non-potable reuse sites could increase the amount of water available for exchange under this alternative.

The Santa Fe Water Reuse Feasibility Study determined that this alternative is the highest-ranked water reuse approach, considering that it offers the lowest cost, provides the greatest water supply benefit through drought-resistant recycled water supplies, requires no additional treatment requirements, and leverages Santa Fe's existing investments and available capacity in the BDD diversion, conveyance, and treatment systems.

This alternative also offers unique flexibility for future adaptation. The Return Flow Credit pipeline would convey water along a route from the Paseo Real to the Rio Grande that passes immediately by the BRWTF. Should demands or water management conditions change in the future, this pipeline could easily be adapted to convey reclaimed water to the BRWTF for treatment as part of a Direct Potable Reuse system. Additional treatment may be warranted in this scenario, as described for Alternative 7 (Direct Potable Reuse).

Implementation steps recommended from this Feasibility Study include confirming that this alternative best meets the community's needs through further public outreach, followed by preliminary design, permitting, and project funding analyses to support implementation of the required infrastructure.

8.0 POTENTIAL ENVIRONMENTAL IMPACTS

Environmental impacts, including some benefits, would result from the construction of the alternatives. This analysis focuses on Alternative 2, Full Consumption of SJCP Water via Rio Grande Return Flow Credits, since it was the highest-ranked alternative. Most of the potential environmental impacts of Alternative 2 are associated with the pipeline corridor.

8.1 Environmental Benefits

The main purpose of the proposed project is to expand water reuse in Santa Fe to mitigate projected water supply shortages. As such, the reclaimed water itself is not intended to provide environmental benefits. However, relative to the Non-Title XVI alternative of purchasing and diverting additional native Rio Grande water rights, the reduction in withdrawals from the Rio Grande provides benefits to this watershed as described below.

In addition, the successful implementation of a cost-effective expansion of water reuse in the Rio Grande watershed will provide leadership for other neighboring utilities to pursue this alternative instead of continuing to rely on the dwindling water resources of the Rio Grande.

8.1.1 Reduced Withdrawals from Rio Grande

Santa Fe's primary renewable water supply is SJCP water delivered via the Rio Grande and diverted with the BDD system. Flow in the Rio Grande downstream of the Buckman diversion is available to serve the environmental flow requirements of the river, meeting a critical environmental need (especially during drought conditions), as flow travels downstream to meet additional consumptive and non-consumptive uses. Management of

flows in the Rio Grande are particularly critical for the federally-endangered Rio Grande Silvery Minnow, which is known to be present downstream of Cochiti Reservoir. Cochiti Reservoir is downstream of both the BDD and the proposed return flow pipeline discharge under Alternative 2. The highest-ranked alternative has no net impact on flows in the Rio Grande, with a proposed one-for-one exchange of water discharged and diverted. Water quality will be maintained in compliance with the terms of the discharge permit associated with the discharge.

Alternatively, if implemented, Alternatives 3 and 4 could have the potential to allow reduced withdrawals from the Santa Fe River while providing increased river flow. This could potentially be counted by the Interstate Stream Commission as "volumes (flows)" released from McClure and Nichols Reservoirs.

8.1.2 Energy Usage

The energy required to operate an AWTF is significant. Because it is an indirect reuse (water rights exchange) approach, the highest-ranked alternative eliminates the need for advanced water treatment, utilizing existing facilities and processes at the Paseo Real WRF to provide the necessary treatment. The highest-ranked alternative does incur new pumping energy usage and costs associated with conveying water from the Paseo Real WRF to the Rio Grande some 17.7 miles away. However, there is only about 200 feet of static head necessary for pumping up and over a ridge before flow to the Rio Grande discharge could continue by gravity. Given this and the lack of AWTF facilities needed for the exchange, this alternative had by far the lowest energy use per acre-foot of water recovered of the four alternatives considered in detail. Impacts on greenhouse gas emissions will thus be the lowest for this alternative relative to the others studied.

8.2 Environmental Concerns

In anticipation of potential implementation of the highest-ranked Title XVI alternative, a preliminary screening of potential environmental impacts during both construction and operation of the project was performed. The screening included the following environmental concerns: wildlife – especially threatened and endangered species, water resources, air quality, noise, vegetation, aesthetics, land use, transportation, historic and cultural resources, geology and soils, environmental justice, hazardous material, and climate change. In summary, minimal short-term and no long-term impacts are expected from the proposed project.

8.2.1 Reduced Outflow to the Santa Fe River

All of the alternatives would result in reduced Santa Fe River flow below Paseo Real WRF. The assumed minimum discharges to the Santa Fe River from the Paseo Real WRF of 0.5 mgd in winter months and 2.0 mgd during the irrigation season will help to support downstream ecological resources and communities according to analyses conducted by the City outside this Feasibility Study. The highest-ranked alternative was analyzed using an

assumed maximum combined water reuse (existing non-potable reuse and new Return Flow Credits from the Rio Grande) of 3 mgd, leaving about 2 mgd available for discharge from the Paseo Real WRF to the Lower Santa Fe River year-round.

8.2.2 Proposed Conveyance Infrastructure

The highest-ranked alternative would require piping reclaimed water from the existing Paseo Real WRF to a point of discharge immediately downstream of the current submerged BDD water intake through approximately 17.7 miles of nominal 14-inch diameter pipeline. The pipeline would originate at a new 200-HP pump station that would draw water from the Paseo Real WRF reuse channel, then parallel existing reclaimed water piping to a point near the site of the BRWTF. It would then extend along existing public right-of-way and easements of the Buckman Road utility corridor utilized for the BDD raw water transmission line. This utility corridor passes through BLM land along the unpaved Buckman Road.

Environmental studies would be required for pipeline construction. The Final EIS for the Buckman Water Diversion Project covers similar issues to what would be anticipated with the construction of this pipeline. Some minor impacts to air quality on a very localized area (dust), noise, and traffic are to be expected during construction. A Stormwater Pollution Prevention Plan (SWPPP) would be prepared to ensure that proper erosion control measures are taken during construction. Alternative routes or flagmen would be used along with signage to ensure public safety and allow the continued use of Buckman Road. Construction activities such as digging pipeline trenches in the existing right-of-way could disrupt normal facility maintenance, but are not expected to affect existing utility operations. Land disturbance associated with temporary construction easements could also have a short-term effect on grazing in the area. Since most construction would occur along existing utility corridors, long-term disturbances to land use would be minimal. The pump station would be constructed onsite at the Paseo Real WRF with no anticipated environmental or third-party implications.

Steps would be taken to mitigate the effects of pipeline construction on biological resources. Areas where vegetation is removed during construction will be replanted with native seeds of species common to the Buckman area. The revegetation program would include efforts to identify and reduce the spread of nonnative species in the construction area. To comply with the Migratory Bird Treaty Act, a survey of protected avian fauna at the outfall and pipeline routes would take place prior to construction. Wildlife would be taken into consideration by construction practices, including escape ramps for trenches left open overnight and slash piles for habitat.

The outfall to the Rio Grande would be constructed to avoid interfering with the historic Buckman townsite as much as possible. No significant environmental concerns associated with aesthetics, environmental justice, or hazardous materials are anticipated.

9.0 LEGAL AND INSTITUTIONAL REQUIREMENTS

9.1 Water Rights

Santa Fe has evaluated its legal right to reuse reclaimed water from the Paseo Real WRF, and has concluded that it has the water rights necessary to implement any of the water reuse alternatives considered in this Feasibility Study. Water rights considerations are documented in Section 4.2.

9.2 Institutional and Legal Requirements

Institutional and legal requirements associated with the highest-ranked alternative are described in Section 7.1.1, primarily consisting of permitting requirements. Santa Fe's ability to implement the highest-ranked alternative is not limited by any other known institutional or legal requirements, and the flexibility afforded by returning flow directly to the Rio Grande could help Santa Fe, Reclamation, and regional water supply partners better meet water management goals and requirements on the Rio Grande system.

Precedent for this type of approach has been established in New Mexico by the Albuquerque Bernalillo County Water Utility Authority, serving as a full-scale "proof of concept" in terms of both the technical and permitting aspects of such an exchange. The Authority is thereby fully diverting and utilizing its SJCP water. Similarly, this approach would allow Santa Fe to make full consumptive use of its imported water supplies, while potentially avoiding Rio Grande Compact and Rio Grande Environmental Impact Study concerns.

9.3 Multi-Jurisdictional and Interagency Considerations

Under the highest-ranked alternative, the City and County's jointly-owned and operated BDD facilities (diversion, conveyance, and treatment) would be more heavily used. The use of the BDD system is governed by agreements between the City and County, which would continue to govern the expanded use of the facilities. It is not anticipated that the diversion of additional flows via the return flow credit exchange would be constrained by any element of these agreements.

In addition, the County could opt to introduce additional reclaimed water into the regional City/County water supply system using reclaimed water from the County's Quill WRF, as described in Section 4.5.4. Depending on how the Quill reclaimed water were to be used, additional agreements for managing these water supplies may be needed between the City and the County.

9.4 Permitting Requirements

Permitting requirements are detailed for Alternative 2, the highest-ranked alternative, in Section 7.1.1.2 of this Feasibility Study report and again in Section 9.2 above.

9.5 Evaluation of Other Unresolved Issues

Other issues associated with implementation and operation of Alternative 2 are described in Section 7.1.

10.0 FINANCIAL CAPABILITY OF SPONSOR

The City and County each operate their water utilities as enterprise funds, with revenues from user fees and rates that pay for costs incurred for capital projects, administration, and ongoing OM&R of the two systems' facilities.

The schedule for implementation is likely to be contingent on the availability of Title XVI funds. Growth in the City and County's service area populations, even with Santa Fe's national leadership in water conservation programs, will be exacerbated by the onset of climate change conditions, stressing the ability of the utilities to sustainably meet demands. Already, drought conditions significantly impair Santa Fe's ability to sustainably meet demands without reliance on unsustainable groundwater pumping, requiring much heavier use of the City Well Field and Buckman Well Field to make up for reductions in Santa Fe River and/or SJCP supplies. Implementation of the Title XVI project will help Santa Fe maintain a drought-resilient and sustainable supply portfolio immediately upon its commissioning and startup.

The City and County are fully committed to paying their share of capital costs and paying the full OM&R costs for the Title XVI project. Rates and fees can be increased, within the reasonable bounds of public acceptance and support, to provide the necessary local cost share.

These rates and fees would be used to support a local 75 percent cost share for project costs. If necessary, bonds may be issued to support capital expenditures. If the highest-ranked alternative (Alternative 2, Full Consumption of SJCP Water via Rio Grande Return Flow Credits) is implemented and authorized for construction under the Title XVI program, the cost share of the overall $17.8 million capital cost (in 2016 dollars) at a 75/25 local/federal cost share would be about $13.4 million local (in 2016 dollars) and $4.4 million federal (in 2016 dollars).

11.0 EVALUATION OF RESEARCH NEEDS

The highest-ranked alternative, Full Consumption of SJCP Water via Rio Grande Return Flow Credits, is elegant in the simplicity of the solution offered. While there are implementation challenges associated with this alternative, there is little if any lack of scientific understanding associated with the discharge of reclaimed water to the Rio Grande for exchange against additional diversions from the Rio Grande. Confirmation of the reliability of wet water above the BDD diversion, and a deeper understanding of the NMOSE permitting requirements – particularly if Santa Fe is to discharge at different times or rates than the diversion of exchanged water – will be developed as project implementation progresses.

If other alternatives were to be implemented, additional research may be warranted. For example, IPR and DPR projects contemplated herein as Alternatives 3, 4, and 7 would each benefit from demonstration testing of the necessary AWTF process train for confirming and enhancing the engineering, permitting, and public acceptance aspects of treatment. For Alternatives 3 and 4, the degree to which soil aquifer treatment processes could provide log removals of pathogens and reductions in CEC concentrations would need to be studied using soil column matrices from the Santa Fe River alluvium.

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APPENDIX A – POTABLE REUSE REGULATORY REQUIREMENTS IN NEW MEXICO

CITY OF SANTA FE / SANTA FE COUNTY

SANTA FE WATER REUSE FEASIBILITY STUDY

APPENDIX A

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A-1.0 POTABLE REUSE REGULATORY REQUIREMENTS IN NEW MEXICO

A-1.1 Pathogen Removal Goals

The State of Texas was the first regulatory body to approve DPR in the United States, with both the Colorado River Municipal Water District (CRMWD) Raw Water Production Facility (RWPF) in Big Spring, Texas and the Wichita Falls Direct Potable Reuse Project (currently not in operation) approved by the Texas Commission on Environmental Quality (TCEQ). These two projects were approved on a case-by-case basis in accordance with the innovative/alternative treatment clause in 30 TAC 290 that allows “any treatment process that does not have specific design requirements” listed in that chapter to still be permitted. The RWPF uses three barriers: MF, RO, and ultraviolet light (UV) advanced oxidation with hydrogen peroxide (H_2O_2) addition, resulting in a UV advanced oxidation process (UV-AOP). The water from the RWPF is blended with other raw water supplies and is subsequently treated at a conventional water treatment plant. TCEQ's approach is to understand the pathogen concentrations in the feed to the AWTF and to then require multiple barrier treatment to provide the necessary pathogen reduction to meet acceptable risk standards. TCEQ, NWRI (2013) and the California Department of Public Health (CDPH) (2014) agree on the same risk standard, based on achieving a goal of a lower than 1 in 10,000 annual risk of infection with each examined pathogen group (originating from Regli et al. 1991). This risk standard was also applied to the control of *Cryptosporidium* oocysts as part of the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2) (U.S. EPA 2006a) and *Giardia* goal concentrations on the basis of a 1 in 10,000 annual risk of illness (EPA 1989). Drinking water pathogen goal concentrations are shown in Table A-1.1. With a clear understanding of potable water treatment goals and the concentration of pathogens in the source water, the amount of reduction (log reduction, with 1-log being 90 percent reduction) can be determined. As it applies to DPR projects in Texas, the AWTF ends up providing approximately 8 to 9 log reduction of virus and 6 to 7 log reduction of protozoa, as well as higher levels of bacteria removal.

Table A-1.1 Drinking Water Pathogen Goal Concentrations Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County		
Pathogen	**Drinking Water Goal**	**Reference**
Giardia	< 6.8 x 10^{-6} cysts/L	Regli et al. (1991)
Cryptosporidium	< 3.0 x 10^{-5} oocysts/L	Haas et al. (1996)
Enteric virus	< 2.2 x 10^{-7} MPN/L(1)	Regli et al. (1991)

Notes:

(1) MPN/L = most probable number per liter. The 10^{-4} risk level concentrations for a number of enteric viruses are provided by Regli et al. (1991). The most conservative value listed in this reference is for rotavirus (at 2.22 x 10^{-7} MPN/L).

NWRI convened an expert panel as part of a larger effort for a grant from the WateReuse Research Foundation (WRRF) to investigate the *Equivalency of Advanced Treatment Trains for Potable Reuse* (WRRF 11-02). The expert panel recommended pathogen control that achieves at minimum 12-log reduction of virus, 10-log reduction of protozoa (i.e., *Giardia and Cryptosporidium*), and 9-log reduction or inactivation of total coliform (NWRI 2013). The key difference between NWRI (2013) and the TCEQ examples above is the starting point of treatment, with NWRI (2013) focusing on the conversion of raw wastewater to potable water, and thus needing greater required pathogen reduction. State of California DDW, formerly the CDPH, regulates IPR projects based upon 12-log virus removal, 10-log *Cryptosporidium* removal, and 10-log *Giardia* removal, from the point of raw wastewater to the point of potable water consumption (CDPH 2014). The safety of the aforementioned log reduction approaches has been documented by the National Research Council report on *Water Reuse* (NRC 2012).

As it pertains to Santa Fe and potable reuse projects in New Mexico, the risk based approach defined here is expected to be the governing requirement, and treatment processes and log reduction requirements can be selected based upon starting with raw wastewater or starting with secondary effluent. Without information on secondary effluent pathogen levels, the prudent approach is to start the treatment process with raw wastewater and use the 12-log virus and 10-log protozoa removal values specified by DDW (CDPH 2014) and NWRI (2013).

A-1.2 Pollutant Removal Goals

The State of New Mexico enforces U.S. EPA requirements, and includes additional state-specific requirements for potable water quality. Table A-1.2 through Table A-1.6 are lists of recommended sampling for constituents with U.S. EPA-mandated MCLs and secondary MCLs (SMCLs), as well as specific compounds with Drinking Water Health Advisory values (U.S. EPA 2012).

Table A-1.2 Inorganics with Primary MCLs (from NWRI 2015a)
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Constituents	Primary MCL (mg/L)	Constituents	Primary MCL (mg/L)
Antimony	0.006	Fluoride	4
Arsenic	0.010	Lead	0.015(3)
Asbestos	7 (MFL)(1)	Mercury	0.002
Barium	2	Nitrate (as N)	10
Beryllium	0.004	Nitrite (as N)	1
Cadmium	0.005	Total Nitrate/Nitrite (as N)	10
Total Chromium	0.1	Selenium	0.05
Copper	1.3(2)	Thallium	0.002
Cyanide	0.2		

Notes:
(1) MFL = Million fibers per liter, with fiber lengths of >10 microns.
(2) Regulatory Action Level; if system exceeds, it must take certain actions, such as additional monitoring, corrosion control studies and treatment, and for lead, a public education program; replaces MCL.
(3) The MCL for lead was rescinded with the adoption of the Regulatory Action Level.

Table A-1.3 Constituents/Parameters with Secondary MCLs (from NWRI 2015a)
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Constituents	SMCL (mg/L)	Constituents	SMCL (mg/L)
Aluminum	0.2	Total dissolved solids (TDS)	500
Color	15 (units)	Fluoride	2.0
Copper	1.0	Chloride	250
Foaming Agents (MBAS)	0.5	Sulfate	250
Iron	0.3	pH	6.5 – 8.5
Manganese	0.05	Silver	0.1
Odor Threshold	3 (units)	Zinc	5

Table A-1.4 Radioactivity (from NWRI 2015a) Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County			
Constituent	**MCL**	**Constituent**	**MCL**
Uranium	0.030 mg/L	Gross Beta Particle Activity	4 millirem per year
Combined Radium-226 and 228	5 pCi/L	Radon	300 pCi/L
Gross Alpha Particle Activity	15 pCi/L		

Table A-1.5 Regulated Organics (from NWRI 2015a) Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County			
Constituent	**MCL (mg/L)**	**Constituent**	**MCL (mg/L)**
Volatile Organic Compounds			
Benzene	0.005	Monochlorobenzene	0.1
Carbon Tetrachloride	0.005	Styrene	0.1
1,2-Dichlorobenzene	0.6	1,1,2,2-Tetrachloroethane	0.001
1,4-Dichlorobenzene	0.075	Tetrachloroethylene	0.005
1,1-Dichloroethane	0.005	Toluene	1
1,2-Dichloroethane	0.005	1,2,4 Trichlorobenzene	0.07
1,1-Dichloroethylene	0.007	1,1,1-Trichloroethane	0.2
Cis-1,2-Dichloroethylene	0.07	1,1,2-Trichloroethane	0.005
Trans-1,2-Dichloroethylene	0.1	Trichloroethylene	0.005
Dichloromethane	0.005	Vinyl chloride	0.002
1,2-Dichloropropane	0.005	Xylenes	10
Ethylbenzene	0.7		
Semi-Volatile Organic Compounds (SVOCs)			
Alachlor	0.002	Heptachlor Epoxide	0.0002
Atrazine	0.003	Hexachlorobenzene	0.001
Bentazon	0.018	Hexachlorocyclopentadiene	0.05
Benzo(a)pyrene	0.0002	Lindane	0.0002
Carbofuran	0.04	Methoxychlor	0.04

Table A-1.5 Regulated Organics (from NWRI 2015a) Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County			
Constituent	**MCL (mg/L)**	**Constituent**	**MCL (mg/L)**
Chlordane	0.002	Molinate	0.02
Dalapon	0.2	Oxamyl	0.2
Dibromochloropropane	0.0002	Pentachlorophenol	0.001
Di(2-ethylhexyl)adipate	0.4	Picloram	0.5
Di(2-ethylhexyl)phthalate	0.006	Polychlorinated Biphenyls	0.0005
2,4-D	0.07	Pentachlorophenol	0.001
Dinoseb	0.007	Picloram	0.5
Diquat	0.03	Polychlorinated Biphenyls	0.0005
Endothall	0.1	Simazine	0.004
Endrin	0.002	Toxaphene	0.003
Ethylene Dibromide	0.00005	2,3,7,8-TCDD (Dioxin)	3×10^{-8}
Glyphosate	0.7	2,4,5-TP (Silvex)	0.05
Heptachlor	0.0004		

Table A-1.6 Disinfection Byproducts (from NWRI 2015a) Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County			
Constituent	**MCL (mg/L)**	**Constituent**	**MCL (mg/L)**
Total Trihalomethanes	0.080	Bromate	0.010
Total Haloacetic Acids	0.060	Chlorite	1.0

CECs should be considered in potable reuse projects because pharmaceuticals, personal care products, and hormonally active agents are present in wastewater effluents. Some are difficult to remove by conventional and advanced water treatment processes. The selection of which CECs to analyze is subjective, and there are a number of “lists” that could be followed. NWRI (2013) recommended a list (Table A-1.7) of CECs to be considered in DPR projects based on criteria including (in order of decreasing preference, with the U.S. EPA MCL the most preferred) the U.S. EPA MCL, World Health Organization Drinking Water Advisory Level, State MCL, State provisional level (e.g., California NL), *de minimus* concentration, *de minimus* dose, medical benchmark, and *de minimus* benchmark from secondary source. NWRI (2015a) recommended the use of the CECs found in Table A-1.7.

Table A-1.7 CECs to Consider for DPR Projects (NWRI 2013) Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County	
CEC	**Description**
Chemicals of potential interest, if present in wastewater	Perfluorooctanoic acid (PFOA) Perfluorooctane sulfonic acid (PFOS) Perchlorate 1,4-dioxane
Steroid hormones	Ethinyl estradiol 17β-estradiol
Chemicals useful for evaluating the effectiveness of organic chemical removal by treatment trains	Pharmaceuticals: Meprobamate/atenolol Primidone/dilantin Carbamazepine Estrone Other chemicals (chemicals of interest): Cotinine Sucralose TCEP DEET Triclosan
Bromate and bromide	

A-1.3 NMED Potable Reuse Guidance

The project team engaged NMED regarding the different potential potable water reuse project options, providing the first "test case" to compare NMED perspectives with the NWRI (2015a) and NWRI (2016) efforts. The meeting was held on June 24, 2016 at the NMED offices in Santa Fe. Attendees included:

- **NMED:** Danielle Shuryn, Joe Martinez, Peter Nathanson;
- **Santa Fe:** Bill Schneider, Alex Puglisi;
- **NWRI Expert Panel:** Jeff Mosher, Bruce Thomson; and
- **Carollo:** John Rehring, Andy Salveson.

A-1.3.1 Guidance for Santa Fe

The goal for engaging NMED in June 2016 was to provide a summary of potential Santa Fe water reuse projects, provide technical information, discuss issues of concern, and gain NMED input on the projects, allowing for an adjustment to the projects detailed within this feasibility study. This meeting arrived at the following general conclusions:

- The treatment and monitoring approaches proposed for the various potable water reuse projects were in agreement with the NMED efforts with NWRI (NWRI 2015a, NWRI 2016).
- Critical control point (CCP) monitoring, source control, operator training, and financial responsibility are all important components to successful potable water reuse projects.
- Before moving ahead with a particular potable water reuse project, NMED would want to have confidence that other reasonable options for water supply have been examined.
- A better understanding of groundwater movement (and travel time) will be needed if a groundwater recharge project is proposed for implementation.

In general, NMED expressed support for the various approaches to potable water reuse proposed for Santa Fe in this Feasibility Study.

A-1.3.2 NMED DPR Work Plan

NMED shared its Draft "Direct Potable Reuse Preliminary Assistance Work Plan" with the project team. This work plan lists key work efforts needed for a successful DPR project. Many of these recommended work efforts are equally useful for IPR projects.

- Recommended Work Efforts to Increase Water Supply
  - Emergency Response Plan
  - Operations and Maintenance Plan
  - Source Water Protection Plan
  - Water Loss Control Program
  - Asset Management Plan
  - Rate Study
- Required Items for Planning a DPR Project
  - Best Available Source of New Water
  - Public Education and Outreach Program
  - Engineering Design Summary
  - Application for Construction or Modification to NMED

  - Rationale for Configuration of Different Water Supplies
  - Accurate and Comprehensive O&M Costs
  - Demonstration Scale Verification of Process Performance
  - Operations and Maintenance Plan
  - Sewer Shed Protection Plan

- Required Items for Operating a DPR Project
  - Employment of Qualified Operators
  - Demonstration Scale Verification of Process Performance (repeated from above, likely redundant)
  - Refine Operations and Maintenance Plan
  - Refine Sewer Shed Protection Plan

Development of the Feasibility Study, as documented in this report, was consistent with applicable provisions of the NMED guidance. Several provisions of the guidance are actionable as part of implementation of a DPR project. All aspects of this guidance (once finalized) will be complied with, as applicable to the selected reuse project(s).

A-2.0 SALINITY MANAGEMENT CALCULATIONS

Salinity management is an important consideration in any potable water reuse system. Calculations of salinity levels for potable reuse were conducted as part of this Feasibility Study to assess whether additional steps or alternate treatment processes would be required for salinity removal.

The addition of salinity (TDS_{ADD}) from municipal use can range widely, from 150 mg/L to 380 mg/L (Asano et al. 2007; Table 3-11). A mass balance on the current system without DPR provides the following equation:

$$TDS_{ADD} = TDS_{EFF} - TDS_{S}$$

The 95th percentile of TDS effluent for the Paseo Real WRF from 2011-2016 was 465 mg/L, and the average blended source water TDS under typical source of supply ratios is 229 mg/L. The blended source water TDS was calculated based on annual fraction of supply of the BDD (via the BRWTF), CRWTF, City Wells, and Buckman Wells. Subtracting this source TDS from the effluent TDS yields a conservative 236 mg/L of additional TDS due to municipal use.

The effects of a DPR approach without salinity removal on steady-state potable water salinity can be estimated using a simple mass balance approach, which is graphically represented in Figure 4.4.

The mass balance equations that can be derived from Figure 4.4 include:

$Q_S*TDS_S + M_{ADD} = Q_L*TDS_{WW}$ (1)

$M_{ADD} = TDS_{ADD}*Q_{IN}$ (2)

$Q_{IN} = Q_S + Q_{DPR}$ (3)

$Q_L = Q_{L1} + Q_{L2} + Q_{L3}$ (4)

$Q_L = Q_S$ (5)

$TDS_{WW} = TDS_{EFF}$ (6)

$TDS_{EFF} = TDS_{DPR}$ (7)

Where Q = flow in mgd, TDS = total dissolved solids in mg/L, and M_{ADD} = mass loading rate of TDS added by municipal use in kg/day. The subscripts denote flows as follows:
S = supply from external potable source (wells and surface water), IN = combined potable water supplies to customers, L = combined losses to system through leaks and effluent discharge, WW = wastewater, EFF = treated effluent, and DPR = advanced-purified water from DPR.

The objective of this calculation is to define both TDS_{DPR} and TDS_{IN}. If TDS_{DPR} is below the water quality goal (500 mg/L), no additional blending with existing source water is necessary to maintain overall water salinity at acceptable levels and no desalination is needed.

If TDS_{DPR} is above the water quality goal, then an evaluation of TDS_{IN} is needed. If TDS_{IN} is below the water quality goal, then careful consideration of blending with existing water supplies is needed to remain below the water quality goal in all parts of the distribution system if desalination is to be avoided. If TDS_{IN} is above the water quality goal, then either desalination is needed or additional lower-TDS water is needed for blending.

Based on the substitution into and rearrangement of equation (1) above,

$Q_S*TDS_S + M_{ADD} = Q_S*TDS_{DPR}$

$M_{ADD} = Q_S(TDS_{DPR} - TDS_S)$ (8)

If one assumes a given fraction of the water supply to be constituted by the water produced from DPR (X_{DPR}), one can substitute $X_{DPR} = Q_{DPR}/Q_{IN}$ along with $Q_{IN} = Q_S + Q_{DPR}$ into equation (8) and obtain the following:

$M_{ADD} = Q_{IN}(1-X_{DPR})(TDS_{DPR} - TDS_S)$

$TDS_{ADD} = (1-X_{DPR})(TDS_{DPR} - TDS_S)$

$TDS_{DPR} = TDS_{ADD}/(1-X_{DPR}) + TDS_S$ (9)

APPENDIX B – COST ESTIMATING DETAILS

CITY OF SANTA FE / SANTA FE COUNTY

SANTA FE WATER REUSE FEASIBILITY STUDY

APPENDIX B

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B-1.0 Summary Tables for Elements Included in the Reclamation Project

Table B-1.1	**Alternative 2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits Capital Costs Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County**		
Description			**Total ($ million)**
Conveyance			
Pipeline (17.7 mi., 14 in.)			$10.47
Pump Stations (1 x 200 HP)			$2.41
	Direct Cost[(1)]		**$12.88**
General Contractor Overhead, Profit, and Risk		20%	$2.57
	Subtotal		**$15.45**
Engineering, Legal, and Administrative Fees		15%	$2.32
	CONVEYANCE CAPITAL COST		**$17.76**
	TREATMENT CAPITAL COST		**$0**
	TOTAL ESTIMATED CAPITAL COST		**$17.76**

Note:
(1) Includes 30% contingency

Table B-1.2 Alternative 3: Enhanced Living River and Aquifer Storage and Recovery Capital Costs Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County		
Description		**Total ($ million)**
Conveyance		
Pipeline (13.7 mi., 14 in.)		$12.15
Pump Stations (3 x 230 HP)		$7.22
Direct Cost[(1)]		**$19.37**
General Contractor Overhead, Profit, and Risk	20%	$3.87
Subtotal		**$23.24**
Engineering, Legal, and Administrative Fees	15%	$3.49
CONVEYANCE CAPITAL COST		**$26.73**
Recovery Wells		
Well Construction (five 300 ft wells)		$1.13
Direct Cost		**$1.13**
Contingency	30%	$0.34
Subtotal		**$1.46**
General Contractor Overhead, Profit, and Risk	20%	$0.29
Subtotal		**$1.76**
Engineering, Legal, and Administrative Fees	15%	$0.26
Subtotal		**$2.02**
Permitting		$0.50
RECOVERY WELLS CAPITAL COST		**$2.52**
Treatment		
Advanced Treatment Facilities (Ozone, BAF, UV)		$12.39
Direct Cost		**$12.39**
Unidentified Project Elements	15%	$1.86
Subtotal		**$14.25**
General Contractor Overhead, Profit, and Risk	20%	$2.85
Subtotal		**$17.10**
Engineering, Legal, and Administrative Fees	15%	$2.57
TREATMENT CAPITAL COST		**$19.67**
TOTAL ESTIMATED CAPITAL COST		**$48.92**

Note:
(1) Includes 30% contingency

Table B-1.3	**Alternative 4: Aquifer Storage and Recovery via Lower Santa Fe River Capital Costs Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County**	
Description		**Total ($ million)**
Conveyance		
Pipeline (6.3 mi., 14 in.)		$3.71
Pump Stations (1 x 310 HP)		$2.41
Direct Cost[(1)]		**$6.12**
General Contractor Overhead, Profit, and Risk	20%	$1.22
Subtotal		**$7.34**
Engineering, Legal, and Administrative Fees	15%	$1.10
CONVEYANCE CAPITAL COST		**$8.44**
Recovery Wells		
Well Construction (four 300 ft wells)		$0.90
Direct Cost		**$0.90**
Contingency	30%	$0.27
Subtotal		**$1.17**
General Contractor Overhead, Profit, and Risk	20%	$0.23
Subtotal		**$1.40**
Engineering, Legal, and Administrative Fees	15%	$0.21
Subtotal		**$1.61**
Permitting		$0.50
RECOVERY WELLS CAPITAL COST		**$2.11**
Treatment		
Advanced Treatment Facilities (Ozone, BAF, UV)		$12.39
Direct Cost		**$12.39**
Unidentified Project Elements	15%	$1.86
Subtotal		**$14.25**
General Contractor Overhead, Profit, and Risk	20%	$2.85
Subtotal		**$17.10**
Engineering, Legal, and Administrative Fees	15%	$2.57
TREATMENT CAPITAL COST		**$19.67**
TOTAL ESTIMATED CAPITAL COST		**$30.22**

Note:
(1) Includes 30% contingency

Table B-1.4 Alternative 7: Direct Potable Reuse Capital Costs Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County		
Description		**Total ($ million)**
Conveyance		
Pipeline (6.1 mi., 14 in.)		$3.61
Pump Stations (1 x 180 HP)		$2.41
Direct Cost[(1)]		**$6.02**
General Contractor Overhead, Profit, and Risk	20%	$1.20
Subtotal		**$7.22**
Engineering, Legal, and Administrative Fees	15%	$1.08
CONVEYANCE CAPITAL COST		**$8.30**
Treatment		
Advanced Treatment Facilities (Ozone, BAF, UF, UV, Cl_2)		$17.91
Engineered Storage Buffer (0.5 MG)		$0.28
Direct Cost		**$18.18**
Unidentified Project Elements - All but Advanced Treatment System	30%	$0.08
Unidentified Project Elements - Advanced Treatment System	15%	$2.69
Subtotal		**$20.95**
General Contractor Overhead, Profit, and Risk	20%	$4.19
Subtotal		**$25.14**
Engineering, Legal, and Administrative Fees	15%	$3.77
TREATMENT CAPITAL COST		**$28.91**
TOTAL ESTIMATED CAPITAL COST		**$37.21**

Note:
(1) Includes 30% contingency

Table B-1.5	**Alternative 2: Full Consumption of SJCP Water via Rio Grande Return Flow Credits Annual Operation, Maintenance and Replacement (OM&R) Costs** **Santa Fe Water Reuse Feasibility Study** **City of Santa Fe / Santa Fe County**
Description	**Total ($/year)**
Conveyance	
Power(1)	$126,000
Pump Station OM&R(2)	$60,000
Pipeline OM&R(3)	$105,000
CONVEYANCE OM&R COST	**$291,000**
TREATMENT OM&R COST	**$0**
TOTAL ESTIMATED ANNUAL OM&R COST	**$291,000**

Note:

(1) Average rate of $0.096/kW-hr. Excludes power cost of pumping water out of alluvial or bedrock wells.
(2) 2.5% of direct capital cost, includes labor & maintenance costs
(3) 1% of direct capital cost, includes labor & maintenance costs

Table B-1.6 Alternative 3: Enhanced Living River and Aquifer Storage and Recovery Annual Operation, Maintenance and Replacement (OM&R) Costs
Santa Fe Water Reuse Feasibility Study
City of Santa Fe / Santa Fe County

Description	Total ($/year)
Conveyance	
Power[1]	$435,000
Pump Station OM&R[2]	$180,000
Pipeline OM&R[3]	$122,000
CONVEYANCE OM&R COST	**$737,000**
Treatment (Ozone, BAF, UV)	
Chemicals[4]	$92,000
Process Power[5]	$140,000
Inter-process Pumping Power	$4,000
Replacement Equipment	$13,000
Advanced Treatment Operation Staff[6]	$146,000
Miscellaneous Upkeep[7]	$22,000
TREATMENT OM&R COST	**$407,000**
TOTAL ESTIMATED ANNUAL OM&R COST	**$1,144,000**

Note:
(1) Average rate of $0.096/kW-hr. Excludes power cost of pumping water out of alluvial or bedrock wells.
(2) 2.5% of direct capital cost, includes labor & maintenance costs
(3) 1% of direct capital cost, includes labor & maintenance costs
(4) Chemicals for disinfection: liquid ammonium sulfate and sodium hypochlorite
(5) Electricity for ozone production, BAF, and UV at average rate of $0.096/kW-hr
(6) Staffing assumed at an average of $50/hour (burdened rate), times 8 hours per day, 7 days per week
(7) 5% of facilities OM&R cost

Table B-1.7	**Alternative 4: Aquifer Storage and Recovery via Lower Santa Fe River Annual Operation, Maintenance and Replacement (OM&R) Costs Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County**
Description	**Total ($/year)**
Conveyance	
Power[1]	$191,000
Pump Station OM&R[2]	$60,000
Pipeline OM&R[3]	$37,000
CONVEYANCE OM&R COST	**$288,000**
Treatment (Ozone, BAF, UV)	
Chemicals[4]	$92,000
Process Power[5]	$140,000
Inter-process Pumping Power	$4,000
Replacement Equipment	$13,000
Advanced Treatment Operation Staff[6]	$146,000
Miscellaneous Upkeep[7]	$22,000
TREATMENT OM&R COST	**$407,000**
TOTAL ESTIMATED ANNUAL OM&R COST	**$695,000**

Note:

(1) Average rate of $0.096/kW-hr. Excludes power cost of pumping water out of alluvial or bedrock wells.
(2) 2.5% of direct capital cost, includes labor & maintenance costs
(3) 1% of direct capital cost, includes labor & maintenance costs
(4) Chemicals for disinfection: liquid ammonium sulfate and sodium hypochlorite
(5) Electricity for ozone production, BAF, and UV at average rate of $0.096/kW-hr
(6) Staffing assumed at an average of $50/hour (burdened rate), times 8 hours per day, 7 days per week
(7) 5% of facilities OM&R cost

Table B-1.8	**Alternative 7: Direct Potable Reuse Annual Operation, Maintenance and Replacement (OM&R) Costs Santa Fe Water Reuse Feasibility Study City of Santa Fe / Santa Fe County**
Description	**Total ($/year)**
Conveyance	
Power(1)	$114,000
Pump Station OM&R(2)	$60,000
Pipeline OM&R(3)	$36,000
CONVEYANCE OM&R COST	**$210,000**
Treatment (Ozone, BAF, UF, UV, Cl_2)	
Chemicals(4)	$156,000
Process Power(5)	$265,000
Inter-process Pumping Power	$4,000
Replacement Equipment	$13,000
Advanced Treatment Operation Staff(6)	$146,000
Miscellaneous Upkeep(7)	$22,000
TREATMENT OM&R COST	**$607,000**
TOTAL ESTIMATED ANNUAL OM&R COST	**$817,000**

Note:

(1) Average rate of $0.096/kW-hr. Excludes power cost of pumping water out of alluvial or bedrock wells.
(2) 2.5% of direct capital cost, includes labor & maintenance costs
(3) 1% of direct capital cost, includes labor & maintenance costs
(4) Caustic soda, sodium hypochlorite, hydrochloric acid, citric acid, and, for disinfection, liquid ammonium sulfate and additional sodium hypochlorite
(5) Electricity for ozone production, BAF, UF membranes, and UV at average rate of $0.096/kW-hr
(6) Staffing assumed at an average of $50/hour (burdened rate), times 8 hours per day, 7 days per week
(7) 5% of facilities OM&R cost

APPENDIX C – POTENTIAL METHODS FOR ENHANCING AQUIFER RECHARGE RATES ALONG THE SANTA FE RIVER

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TECHNICAL MEMORANDUM

To: John Rehring, Carollo Engineering
William H. Schneider, City of Santa Fe

From: Steve Finch, Principal Hydrogeologist-Geochemist

Date: September 5, 2016

Subject: Recommendations for infiltration basins or other mechanisms for conveying treated effluent to the aquifer along Santa Fe River for ASR

Alternatives 3 and 4 in draft report prepared by Carollo Engineering titled *Santa Fe Water Reuse Feasibility Study* (August, 2016) consider discharge of treated effluent to the Santa Fe River channel for natural infiltration, and recovery of infiltrated water using shallow wells. Alternative 3 involves discharge of treated effluent below Two Mile Reservoir, and Alternative 4 involves discharge of treated effluent below Siler Road crossing. JSAI (2016) recommended the recovery wells for either Alternative be located below Siler Road where hydrogeologic conditions are favorable; as defined by JSAI (1995), Koning and Read (2010), and Hawley (2014).

An evaluation of seepage rates along the Santa Fe River by JSAI (2016a) indicate the infiltration capacity for the natural river channel is less than the desired 3 MGD project considered for Alternatives 3 and 4. Other options for increasing infiltration capacity along the Santa Fe River upstream of the Wastewater Treatment Plant include the following:

1. Create in-channel distributary system (recommended by JSAI (2016))
2. Construct infiltration basin along Santa Fe River
3. ASR wells designed to inject water in the winter and recover in the summer.
4. Vadose-zone infiltration galleries parallel to Santa Fe River channel

Each of these options are briefly discussed below.

1. Distributary System

The discharge system is designed to spread water across the river channel. One issue with this approach is the limited channel width along the Santa Fe River. Below Siler Road, the channel width is about 35 ft with sections that open up to a width of about 60 ft. The crossing at San Yisdro Road already has erosion control features that act as a distributary system (see attached Fig. 1).

The discharge system at Siler Road crossing could be composed of two perforated pipes, on either side of the river channel, installed parallel to the channel (see attached Fig. 2).

2. Infiltration Basin

Infiltration basins would likely require City owned lands with some appreciable acreage. Based on the understanding of local geology and some familiarity with City owned lands, the two best locations for potential infiltration basins would be Frenchy's Field and Villa Linda Parks.

Frenchy's Field is located along south side of Santa Fe River approximately 1 mile upstream of Siler Road crossing. This park is about 16.5 acres and encompasses open natural space along the river. A small infiltration basin with enhanced infiltration facilities such as sub-surface leach-field type system or vadose-zone infiltration galleries completed in the Ancha Formation. The only downside is that Frenchy's Field Park is located a little farther upstream from the proposed location of recovery wells than desired.

The proposed pipeline route for Alternative 3 is along Rodeo Rd directly north of Villa Linda Park. Villa Linda Park consists of 6.6 acres adjacent to Arroyo de los Chamisos, and was identified by JSAI (2016) as a favorable location for ASR. A portion of the effluent could be discharged and infiltrated at Villa Linda Park, and the remainder could be sent to the Santa Fe River Alternative 3 discharge location. To implement this option would require two separate ASR systems. Example of Villa Linda Park system is illustrated on Figure 3 (attached).

3. ASR Wells

This option could be applied to Alternative 3 or 4. The basic principal is to take a portion of the available effluent that will not infiltrate along the Santa Fe River channel and inject it directly into the recovery wells described in JSAI (2016). Additional components would include effluent piping to the recovery wells, and educator pipes. The anticipated well diameter of 18 inches described in JSAI (2016) should be able to accommodate this option.

4. Vadose-Zone Infiltration Galleries

JSAI has evaluated this option for other clients, and has performed one successful pilot test. The general principal includes augering large diameter holes, backfilling them with clean gravel. These infiltration galleries can be installed in the bottom of an infiltration basin so the infiltration rate is maximized while minimizing the footprint of the basin, or separately with piping for

conveyance of effluent. The infiltration galleries are low cost and easy to replace. Anticipated depth would be about 40 ft, and estimated construction cost is about $5,000 per gallery. Tested infiltration capacities ranged from 100 to 200 gpm at a location consisting of Santa Fe Group sediments along the lower Rio Grande Valley near T or C, New Mexico.

Two options exists for these infiltration galleries: a) installed along the Siler Road crossing to increase infiltration of discharged water and work conjunctively with discharge to river channel, and b) installed in infiltration basins to reduce footprint of basin.

References Cited

[JSAI] John Shomaker & Associates, Inc., 1995, Recommendations for well-field rehabilitation, City of Santa Fe, New Mexico: draft consultant's report prepared for PNM Water Services, 15 p. plus figures.

Hawley, J.W., 2014, Hydrogeologic framework of the Public Service Company of New Mexico Santa Fe Generating Station site and surrounding parts of Santa Fe, New Mexico – with emphasis on hydrogeologic controls on contaminant transport in the vadose and saturated zones: consultant's report prepared for Public Service Company of New Mexico, 114 p. plus figures and appendices.

JSAI, 2016, Technical memorandum regarding initial hydrogeologic evaluation of using treated effluent for Aquifer Storage and Recovery within City of Santa Fe: prepared by Steven T. Finch, John Shomaker & Associates, Inc. for Carollo and City of Santa Fe.

JSAI, 2016a, Santa Fe River 2016 Monitoring Report: Consultant's report prepared by Annie McCoy and Steve Finch of John Shomaker & Associates, Inc. for City of Santa Fe, 30 p., plus appendices

Koning, D.J., and Read, A.S., 2010, Geologic map of the Southern Española Basin, Santa Fe County, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Report 531, 1:48,000 scale.

Figure 1. Aerial photograph showing San Ysidro Rd crossing the Santa Fe River. Erosion control features are identified by red circles.

Figure 2. Aerial photograph showing Siler Rd crossing the Santa Fe River. Conceptualized piping that distributes discharged water are shown as blue bars. Conceptualized bank of infiltration galleries is shown as green markers.

Figure 3. Aerial photograph showing Villa Linda Park and Arroyo de los Chamisos. Conceptualized bank of infiltration galleries is shown as green markers. Conceptualized recovery wells are shown as blue markers.