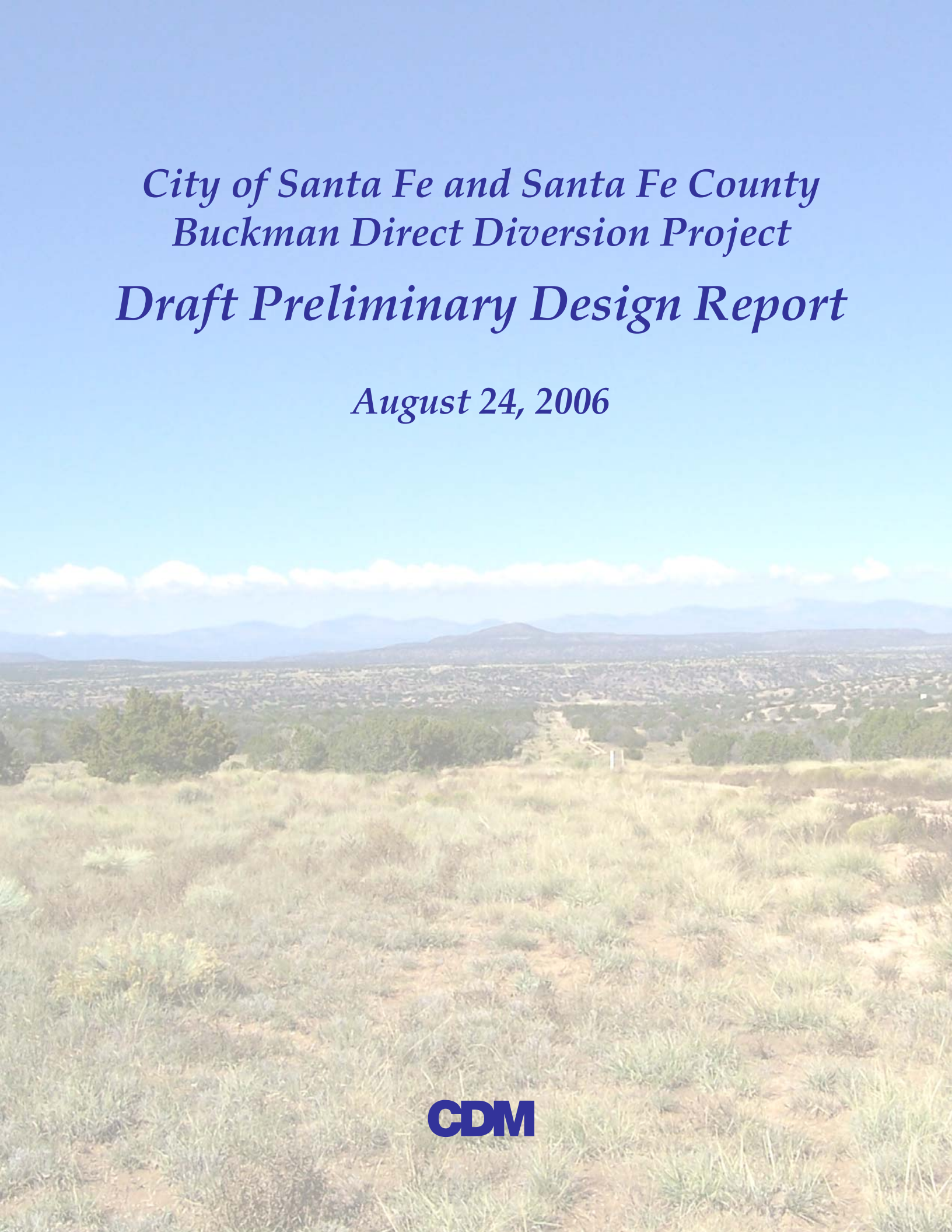
City of Santa Fe and Santa Fe County
Buckman Direct Diversion Project

Draft Preliminary Design Report

August 24, 2006



CDM

Overview

The Buckman Direct Diversion (BDD) Project is being implemented to address imminent needs to access surface water supplies for the City of Santa Fe, Santa Fe County, and Las Campanas Limited Partnership (LCLP). Collectively termed the project "Partners," these entities seek to divert, convey, treat, and distribute surface water from the Rio Grande by fall 2009. The two Owners, the City of Santa Fe and Santa Fe County, have jointly formed a BDD Board charged with overseeing the implementation of the Project. The Project is being implemented using a design-build approach.

The BDD Project is an extremely important Project. It will shift Santa Fe's core water supply from mined groundwater to a sustainable surface water supply while diversifying Santa Fe's water supply options. Planning, permitting and obtaining environmental approvals have been underway since 2001. The Partners expect successful completion of these efforts in 2006, groundbreaking in 2007, and initial operation of the BDD in 2009.

The Project includes design, construction and operation of key facilities (Figure ES-1):

- Diversion Structure with a 28 to 32 cubic feet per second (cfs) peak capacity, a raw water lift station (RWLS), new pipelines, sediment removal facility (SRF) and return pipeline
- Two high-head pump stations; Booster Station 1A (BS1A) with 18.4-mgd capacity and Booster Station 2A (BS2A) with 15.1-mgd capacity for the City and County and 3.25-mgd capacity for Las Campanas
- City/County Water Treatment Plant (C/CWTP) with 15-mgd capacity and two finished water booster stations (BS4A and BS5A)
- 28 miles of 12- to 30-inch diameter raw and treated water pipelines
- Realignment and upgrade of approximately 9.5 miles of Buckman Road and a quarter mile of an existing utility corridor road
- Ancillary works including a new electrical substation, upgrades to an existing substation, installation of electrical service facilities

This Preliminary Design Report serves as a reference that describes the technical analyses, alternatives considered and the Owners' Consultant's recommendations for the BDD Project facilities. It provides information on the background and basis for the Technical Requirements and the Preliminary Design Drawings. Whereas the Technical Requirements and Preliminary Design Drawings will be baseline requirements for the DB Proposers and the selected DB Contractor, this Report provides non-binding information and recommendations supporting those documents.

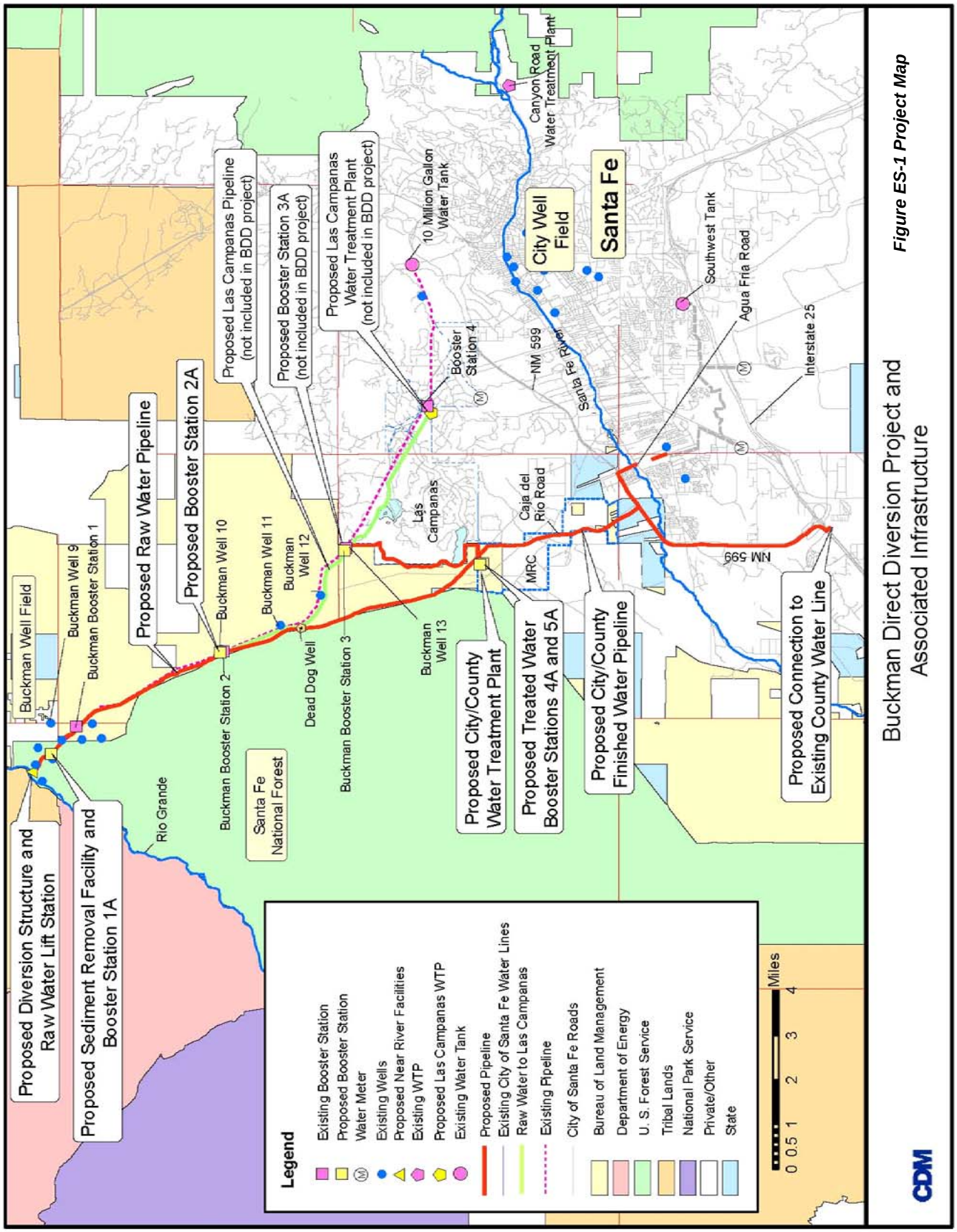


Figure ES-1 Project Map

Owners' Objectives

A Design Build (DB) method of project delivery was chosen by the Owners for the Project to accomplish a number of specific objectives not readily achievable with the traditional design-bid-build method of public works construction. The Owners engaged CDM as their OC to develop a comprehensive process and implementation plan for delivery of the Project. The first task in the OC scope of work, Task A1, was preparation of a detailed set of Project Delivery Objectives and Performance Measures to guide the Owners, OC, and the selected DB Contractor throughout all phases of project delivery.

The Owners have developed specific objectives for DB delivery of the Project in the OC's Request for Proposals (RFP) and other documents. The Owners' Objectives are an essential foundation of the BDD Project Delivery Process. These are objectives that will be referenced throughout the Project and used to guide development of project delivery strategies.

The four summary objectives, termed the "Owners' Objectives" are as follows:

Quality – Provide high-quality project facilities and equipment that meet performance requirements in order that the Owners can reliably operate the Project to produce high quality drinking water

Cost – Minimize the Owners' life-cycle cost of the Project

Schedule – Initially establish and maintain the project schedule in order to delivery the completed project in the shortest practicable time and eliminate (to the greatest extent achievable) future occurrences of material project completion delays

Risk – Minimize the risks of project delivery to all parties, maximize the clarity and acceptance by all parties of the risk allocation, and eliminate (to the greatest extent achievable) the Owners' risks – subsequent to award of the DB Contract – of increased costs and of the completed Project not meeting performance requirements

The OC is providing a Preliminary Design in order to realize the Owners' quality, cost, risks, and schedule objectives. The purpose of this Report is to document the decision making behind the design of the facilities.

As a part of the Preliminary Design objectives, the OC will complete the Preliminary Design of the different components to the various levels. The OC's comprehensive Preliminary Design of the Project advances the Owners' objectives for quality, cost, risk, and schedule as well as the Owners' operability and maintainability needs and preferences. The Preliminary Design provides detailed Technical Requirements (Volume III of the RFP). The DB Contractor will be required to verify, use and enhance where necessary the Preliminary Design in order to prepare the DB Contractors' final design, specifications, and documentation.

General Basis of Design

Capacity Goals

Capacity goals were set to meet the Partners' projected water demands being served by a set number of duty pumps or processes. The minimum and peak water demands are presented in Table ES-2.

Table ES-2 Partners' Water Demands

Water User	Peak Day Demand (mgd)	Peak Day Demand (cfs)	Low Flow Demand (mgd)	Low Flow Demand (cfs)
City of Santa Fe	11.3	17.5	0	0
Santa Fe County	3.7	5.7	0.32	0.5
Las Campanas	3.3	5.0	0.10	0.15
Total	18.3	28.2	0.42	0.65

cfs: cubic feet per second
mgd: million gallons per day

The intake and raw water pump station are designed for three duty and two standby units. These facilities are anticipated to need more maintenance because of the quantity and abrasiveness of solids in the raw water prior to the SRF. The raw water booster pump stations will be designed based upon three duty and one standby. The C/CWTP processes and equipment will be designed based on criteria allowing treatment goals to be met with one unit out-of-service. A summary of capacity goals for each facility is presented in Table ES-3.

Table ES-3 Buckman Direct Diversion Project Capacity Goals (mgd)

Project Components	Flow (mgd)		
	Minimum	Maximum w/ Duty Equipment	Maximum w/ Standby Equipment
Diversion Structure and Raw Water Lift Station	3.0(1)	20.8	34.7
Sediment Removal Facility	3.0(1)	20.8	26.7
Raw Water Booster Stations			
Booster Station 1A	3.0(1)	18.4	22.5
Booster Station 2A - City and County only	3.0(1)	15.1	20.3
Raw Water Pipeline (2)	3.0(1)	15.1	22.5
C/C WTP Raw Water with Plant Return Flow	3.0(1)	18.0	18.0
Finished Water Booster Stations			
Booster Station 4A	1.5	8.9	8.9 (3)
Booster Station 5A	2.0	10.0	13.3(4)

(1) Normal minimum flow will be higher to provide 4 fps velocity in raw water system prior to SRF and 2 fps in raw water system after SRF
(2) Capacity of the raw water pipeline could be significantly higher but with higher operating costs and higher pressure pumps
(3) Maximum capacity of existing Buckman BS3 and BS4 limit maximum capacity from BS4A to 8.9-mgd, BS4A and pipeline sized for future capacity of 15 mgd
(4) Capacity of BS5A pipeline could be significantly higher but with higher operating costs and higher pressure pumps

The raw water system must be designed to allow the City and County flexibility in how the facilities are operated. The flexibility is needed since the C/CWTP could be operated as a base-load plant, peaking plant, or with just intermittent use. The selection of which of these modes to operate will likely vary over time, as demands increase and changes are made in other components of the City and County's water supply systems. To provide this flexibility, specifically for the raw water supply, the C/CWTP includes 7.5 million gallons (MG) of raw water storage/equalization at the head end of the plant and 7.5-MG of finished water storage.

Las Campanas anticipates a minimum daily demand in 2009 of 0.1-mgd or 69 gpm depending on the amount of raw water storage Las Campanas utilizes. In the future, a peak demand of 3.25-mgd is anticipated. The BS2A wetwell will provide raw water for Las Campanas' system. With a wetwell sized at 50,000 gallons, if the City and County did not have any water needs from the BDD system, the raw water system supplying BS2A would need to be activated approximately twice a day to meet Las Campanas' minimum demand needs. Intermittent pump operation would meet Las Campanas' minimum daily needs while also maintaining the required 2 fps velocity in the

pipe. The raw water supply system would be run on a more continuous basis at maximum demands. Therefore, as long as the raw water supply system is operational, the BDD supply facilities would meet Las Campanas' raw water demands.

Raw Water Quality

The Rio Grande has a large watershed above the diversion location and exhibits highly variable water quality. A pilot study on the Rio Grande raw water quality was conducted to gather information required for process design of the new C/C WTP. The pilot plant was operated from April to late-October 2005 to evaluate water quality during the three major flow conditions observed in the river: spring runoff beginning in April through June, low summer flows with intermittent monsoon rains from July through mid-September, and low autumn and winter flows in September and October. Pilot study data and data collected by the United Stated Geologic Survey (USGS) at the Otowi gaging station were used to characterize the raw water quality for the BDD Project. The turbidity and suspended solids data and the CDM pilot study results indicate that the turbidity and suspended solids levels in the Rio Grande can reach high levels and that the levels can increase rapidly due to rainfall events (Figure ES-2). A limited amount of microbiological data is available for the Rio Grande water. The available data indicate the presence of both *Giardia* and *Cryptosporidium*. Bacteriological analyses revealed the presence of Escherichia coliform (E. coli.). These data indicate the contamination of the river water by fecal matter. The highest levels of TOC occur during spring runoff (snowmelt) with levels ranging from 4 to over 8 mg/L. An extensive discussion of the raw water quality is provided in the *Pilot Testing and Water Quality Report*. Table ES-4 presents proposed water treatment goals for the C/CWTP. To be in accordance with the Owner's overall goal to reliably produce high quality treated water, the plant will be designed to be able to respond to the different water quality challenges in a robust manner.

Figure ES-2 Rio Grande Looking South – Pilot Plant Sampling Point Submerged in Center of Photo

Table ES-4 Water Treatment Goals for C/CWTP

Water Quality Parameter	Unit	Regulation or Guideline	Goal[1]
Turbidity			
Settled Water	ntu	2 to 3	<2
Filtered Water, each filter	ntu	0.3 or less	<0.1
Reclaimed Washwater	ntu	2	<2
Pathogen Removal/Inactivation			
Viruses	logs	4-log	>5 logs
Giardia	logs	3-log	>3.5 logs & none detected
Cryptosporidium	logs	5-log[2]	>3.5 logs & none detected2
Disinfection By-Products			
Total Trihalomethanes	mg/L	0.08 or less	<0.06
Haloacetic Acids (HAA5)	mg/L	0.06 or less	<0.05

Table ES-4 Water Treatment Goals for C/CWTP

Water Quality Parameter	Unit	Regulation or Guideline	Goal[1]
Other			
Distribution System Chlorine Residual	mg/L	0.2	>0.2
Total Coliform Bacteria	cfu/100 ml	95% none detect	none detected
Synthetic Organic Chemicals	µg/L	varies	none detected
Pesticides and Herbicides	µg/L	varies	none detected
Color	pcu	15	<5
Odors	TON	3	<3
Tastes	---	none	non-objectionable
Calcium Carbonate Precipitation Potential	mg/L as CaCO3	none	0 to 10

Notes:
1. Goals apply to finished water unless otherwise indicated.
2. Depends on bin classification under the LT2ESWTR. Goal assumes Bin 3 classification.

Diversion Structure and Raw Water Lift Station

The Diversion Structure will be used to divert water from the Rio Grande to supply the Partners with surface water for treatment. The Diversion Structure will be an on-stream bankside intake structure with a low-profile design. The diversion structure will be constructed south of the termination of Buckman Road. The fish screens will be oriented parallel to the river flow to facilitate a cross-flow at the screen face and will screen out material 1.75-mm and larger while minimizing velocities to prevent fish capture. The intake structure will be designed with five individual intake cells, each associated with one raw water pump.

The RWLS will be used to pressurize the river water for conveyance to the Sediment Removal Facility. The RWLS will be located east of the Diversion Structure, above the 100-yr flood plain elevation. Although, the fish screens will remove sand and other suspended materials of size 1.75-mm and larger. The raw water pumps will need to reliably pump water, at times containing relatively large concentrations of abrasive sand and silt materials. The RWLS has been designed to mitigate impacts of views from White Rock Overlook and the Buckman Road area utilizing mounded soil and landscaping, as shown in Figure ES-3.

Figure ES-3 Simulated View of the Diversion Structure and Raw Water Lift Station on the Rio Grande Adjacent to Buckman Road

Sediment Removal Facility

The SRF will be used to remove sand with diameters of 0.1-mm and larger from the raw Rio Grande water. This sand, often referred to as grit, is abrasive to pumps, valves, and piping and its removal will reduce abrasive wear on the downstream facilities (i.e., BS1A, BS2A and the raw

water pipeline). The SRF will have to be designed to treat the peak raw water flow rate from the RWLS of 32.2 cfs. The facility should also be able to treat this peak flow when the river water contains high levels of suspended sediment (i.e., the 95th percentile level).

Based on limited water quality data, it is estimated that the 0.1-mm and larger fraction of the sediment will represent approximately 25 percent of the total sediment. It is anticipated that some amount of the smaller sized sediment (e.g., 5 percent) will be removed along with the larger sand. The sediment removal, dewatering, and conveying equipment will need to be sized to handle this amount of sediment. The remainder of the suspended sediment will be conveyed with the partially clarified raw water to the C/CWTP and Las Campanas facilities.

Raw Water Pipelines and Booster Stations

The raw water pipelines of this project consist of two systems. The first connects the RWLS to the SRF. Three parallel 20-inch high density polyethylene (HDPE) pipelines, just over one-half mile in length, will be installed at this location. The second system will employ a 30-inch pipeline to carry raw water from the SRF to the C/CWTP. Approximately 10.5 miles in length, this pipeline may be Ductile Iron (DIP), Steel Cement Mortar Lined and Coated Pipe (SCLC) or concrete cylinder pipe (CCP).

In general, the raw water pipelines will follow the existing alignment of Buckman Road and the existing 20-inch DIP water line. The alignment will deviate when the dirt roadway traverses too far off the general heading necessary to direct the pipelines to the C/CWTP. This alignment will traverse past existing Buckman BS1 and BS2 and many existing Buckman wells, which are adjacent to Buckman Road.

The raw water carried by these pipelines will be pumped by two new Booster Stations: BS1A which is located with the SRF, and BS2A which is to be constructed adjacent to existing BS2.

City/County Water Treatment Plant

As part of preliminary design, the OC was tasked with evaluation treatment alternatives and recommending a process train for the C/CWTP. A preliminary list of treatment alternatives was developed based on information obtained during the pilot testing period and on a survey of other facilities treating waters with similar or related water quality conditions. Fifteen alternatives were initially selected, which were considered to have a reasonable chance of meeting the project objectives of quality, risk, cost and schedule. An initial screening was conducted that narrowed the 15 alternatives down to three alternatives for further evaluation. The three short-listed alternatives were evaluated based on quality, risk and cost criteria from the Owners' objectives. Additionally, a relative capital, O&M, and life-cycle cost estimate was prepared for the three short-listed alternatives. Numerous workshops were held with the Owners to discuss the selection of the various alternatives.

The selected process is presented in Figure ES-4 and contains the following unit processes:

- Raw water equalization/presedimentation
- Chemical feed and coagulation (flash mixing)
- Flocculation
- Sedimentation

- Membrane filtration
- Ozonation
- GAC contact adsorbers

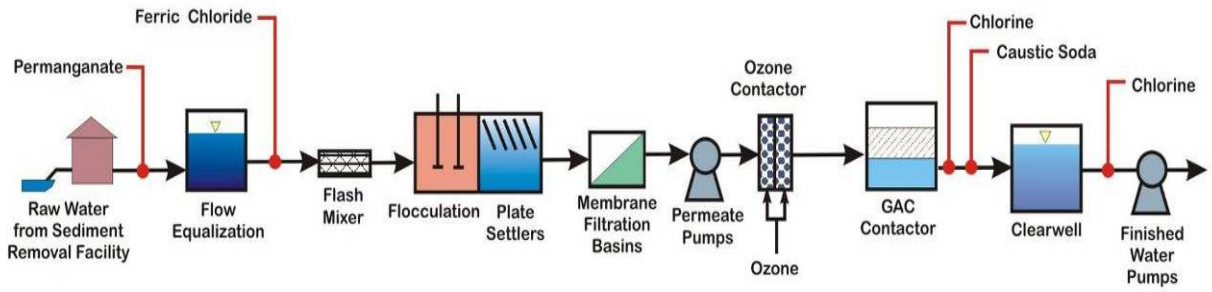


Figure ES-4 Selected Process Train for C/CWTP

A main treatment goal for the C/CWTP is 5.0-log inactivation of *Cryptosporidium* to meet the requirements of a Bin 3 classification of the Rio Grande source under the LT2ESWTR. The 5.0-log inactivation is met with presedimentation (flow equalization and coagulation/flocculation/sedimentation), low finished water turbidity (less than 0.15 NTU) and membrane filtration in the selected process train.

Preliminary design of the C/CWTP concentrated on selecting process technologies and outlining design criteria to meet the Owners' Objectives. Each process provides several advantages and benefits in regard to meeting the Owners' Objectives:

- Raw Water Presedimentation Basins: Provides equalization of pumped flow from BS2A, additional settling prior to treatment, and storage of 7.5-MG in case of a raw water supply interruption
- Flash Mixer: A counter-current jet mixing system to provide superior mixing while minimizing chemical usage
- Flocculation: Three process trains with 3-stage flocculation with variable speed mixer for varying water quality
- Sedimentation Basins: Compact high rate settling for additional removal of solids
- Membrane Filtration: State of the art water treatment process that provide a high degree of particle and microbial removal
- Ozonation: Oxidation of contaminants and organics for removal in the GAC contactors
- GAC Contactors: Provides removal of taste and odor causing compounds, removal of contaminates and biological breakdown and removal of organics minimizing disinfection by-products in the distribution system

The treatment plant will include a number of facilities. The architectural style for the buildings, as selected by the Owners, is based on a Territorial Style as shown in Figure ES-5. Building will be constructed of reinforced concrete, precast concrete panels or CMU masonry block with textured and colored stucco finishes.

The Operations and Maintenance Buildings will be designed and constructed by the DB Contractor to provide a LEED certification in accordance with requirements of the U.S. Green Building Council LEED Rating System. All facilities will be designed to meet the New Mexico Energy Conservation Code.

Figure ES-5 Operations Building at C/C WTP with Territorial Style

Finished Water Pipelines and Booster Stations

Approximately 14 miles of finished water pipelines are needed to convey treated water from the C/CWTP to the City and County distribution systems. The finished water pipelines of this project have been separated into four pipeline segments generally named for the roadway the pipeline follows as it traverses toward its destination.

The finished water pipelines will be constructed within roadways or the roadway ROW in all cases. The BS4A Potable Water Pipeline is a 4.3 mile long, 30-inch pipeline that begins at the C/CWTP and ends at existing BS3 being installed primarily within the Las Campanas Drive ROW. The Caja Del Rio Potable Water Pipeline is a 3.9 mile long, 24-inch pipeline that begins at the C/CWTP and ends at NM-599. This pipeline will be within the western road ROW. The South Meadows Road Potable Water Line begins at a tee provided in the Caja Del Rio Potable Water Pipeline at the intersection with NM-599. This pipeline is 24-inch diameter and traverses northerly within the frontage road ROW for NM-599 and south along South Meadows Road where approximately 1.2 miles where it connects to a planned 24-inch pipeline in South Meadows Road. The planned pipeline will be suspended from a planned bridge crossing the Santa Fe River along South Meadows Road. The NM-599 Potable Water Pipeline begins as a continuation of the Caja Del Rio pipeline at a 90-degree bend at the intersection of Caja del Rio Drive and NM-599. This pipeline is 16-inches and continues along the NM-599 western road ROW to Interstate 25 (4.8 miles) where it will be bored under I-25 and connected to an existing 16-inch County pipeline. Materials for the finished water pipelines may be DIP, CCP or SCLC.

The finished water will be pumped into the distribution systems via BS4A and BS5A, which will be located at the C/CWTP and pump directly from the finished water storage reservoirs. BS4A will serve the City of Santa Fe water demands from the C/CWTP of up to 15-mgd treated water will be conveyed to the suction side of existing BS3 and subsequently be conveyed to the City's 10-MG storage tank. BS4A will initially have a pumping capacity of 8.9-mgd with room for two additional future pumps to increase the capacity to 15-mgd. BS5A will serve the City and County of Santa Fe Water demands from the C/CWTP of up to 10-mgd. Treated water will be delivered for City demands by connecting directly into the existing distribution network at the southern extents. Treated water will be conveyed to the county by service to an existing reservoir. BS5A is required to deliver a total of 10-mgd. The alignments and lengths of the potable water pipelines associated with BS5A are still under study and may be revised.

Additional modeling work is currently being conducted that may require the extent of finished water piping and the location of connections to be changed in the final RFP.

SCADA and Telemetry

The project will include replacement of the existing Citect SCADA system with a new system based on the same software. The new system will have its master computers at the C/CWTP and will communicate with the existing RTUs using the existing MAS radio system. The SCADA LAN at the C/CWTP will be linked to the SCADA LAN at the Canyon Road WTP via new 5 GHz Ethernet radios with repeaters at Tesuque Peak and the San Mateo Office. These radios will replace the existing 960 MHz radios connecting the Canyon Road WTP to the San Mateo Office and Tesuque Peak.

The project will install fiber optic along the pipeline ROW between the C/CWTP and the other new BDD facilities. The fiber optic will be used to provide video surveillance of the remote BDD facilities, telephone extensions to the facilities, and other services as needed. Communications between the SCADA master computers at the C/CWTP and RTUs at the new facilities will also use the fiber optic system.

Buckman Road

Access to the raw water facilities will be provided via the existing County Road 77 (Buckman Road and Camino La Tierra), which also provides access from NM-599 to the Rio Grande and the City of Santa Fe Buckman Well Field. The majority of the information available for the existing Buckman Road was compiled by the Tierra-LopezGarcia Group in *"The Buckman Roadway Study for the Buckman Water Diversion Project, Santa Fe, New Mexico,"(Study)* prepared for the Sangre de Cristo Water Division in February 2004.

The *Study* includes a comprehensive evaluation of the Buckman Road area, proposed future development, the existing roadway conditions, the need for roadway improvement, a safety and risk analysis, a cost estimate of the road improvement alternatives, and conceptual roadway design drawings (both existing and proposed). Preliminary design work identified major portions of the road that will be improved to meet Santa Fe Code. In the event a permit to return sediment back to the Rio Grande is obtained, the design criteria for the Buckman Road Improvements will be less stringent as described in the Technical Requirements and the Preliminary Design Drawings as a Deduction Alternate.

Project Implementation

Implementation Schedule

An implementation schedule has been prepared based upon the goal of all BDD facilities being tested and operational by Fall 2009. However, the Project's Record of Decision may not be issued until December 2006 after the Design-Build Request for Proposals is currently scheduled for release. Therefore, this bar chart schedule shown in Figure ES-6 may need to be updated in the near future.

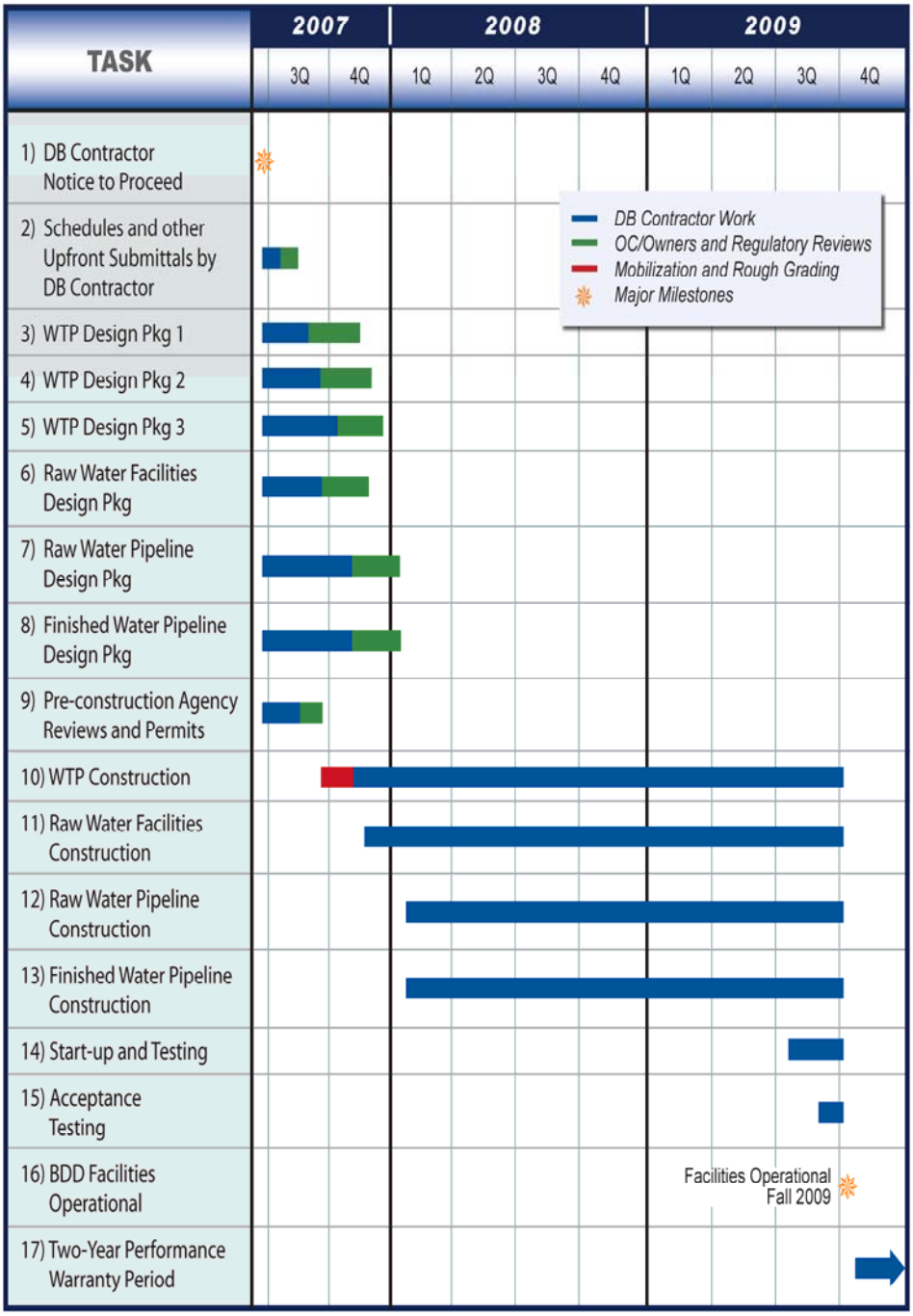


Figure ES-6 Implementation Schedule

Cost Estimates

A construction cost was prepared for all of the BDD facilities based upon the current processes and design criteria documented in this PDR. The total construction cost, escalated to the mid-point of construction (2008 dollars) is $129 million. The estimated Project Cost, which includes the construction cost as well as administrative, legal, engineering, electrical facilities and other costs, is approximately $159 million. Las Campanas' share of the Project Cost is approximately $7.5 million. The City and County are to split the remaining $151.5 million equally.

Annual O&M costs were estimated for six categories: personnel, chemicals, materials and supplies, electric use, solids transportation and disposal, replacement items and Buckman Road maintenance. The O&M cost, including amortized replacement items such as membranes, results in a total annual cost of approximately $6.77 million dollars in 2006 dollars. This equates to a cost of approximately $2.99 per 1,000 gallons produced.

Executive Summary

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Section 4 – Sediment Removal Facility

Section 5 – Raw Water Pipelines and Booster Pump Stations

Section 6 – Water Treatment Facilities

Section 7 – Finished Water Transmission

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Appendices

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1.1 Overview

The Buckman Direct Diversion (BDD) Project is being implemented to address imminent needs to access surface water supplies for the City of Santa Fe, Santa Fe County, and Las Campanas Limited Partnership. Collectively termed the project "Partners," these entities seek to divert, convey, treat, and distribute surface water from the Rio Grande by fall 2009. The two Owners, the City of Santa Fe and Santa Fe County, have jointly formed a BDD Board charged with overseeing the implementation of the Project. The Project is being implemented using a Design Build approach, as further described in Section 1.4.

The BDD Project is an extremely important Project because it will provide infrastructure to divert San Juan-Chama (SJC) Project water that is contracted to the Owners. It will shift Santa Fe's core water supply from mined groundwater to a sustainable surface water supply while diversifying Santa Fe's water supply options. Planning, permitting and obtaining environmental approvals have been underway since 2001. The Partners expect groundbreaking in 2007, and initial operation of the BDD in late 2009.

The Project includes design, construction and operation of key facilities (Figure 1.1-1):

- Diversion Structure with a 28 to 32 cubic feet per second (cfs) peak capacity, a Raw Water Lift Station (RWLS), new pipelines, Sediment Removal Facility (SRF) and sediment return pipeline
- Two high-head pump stations; Booster Station 1A (BS1A) with 18.25-mgd nominal capacity and Booster Station 2A (BS2A) with 15.0-mgd nominal capacity for the City and County and 3.25-mgd capacity for Las Campanas
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- 28 miles of 12- to 30-inch diameter raw and treated water pipelines
- Realignment and upgrade of approximately 9.5 miles of Buckman Road and a quarter mile of an existing utility corridor road
- Ancillary works including a new electrical substation, upgrades to an existing substation, and installation of electrical service facilities

CDM is serving as the Owners' Consultant (OC) for project delivery of the BDD Project. CDM is referred to as the Boards' Engineer in other Project documents. The OC's detailed scope of work is separated into five phases. The first phase of work, "Phase A: Conceptual Design of the Design Build (DB) Process" provided for the development of the scope of work for Phases B, C, D and E. Phase A work included pilot testing, permit planning, defining project objectives, planning for project completion and geotechnical and corrosion studies. Phase B work includes the Preliminary Design.

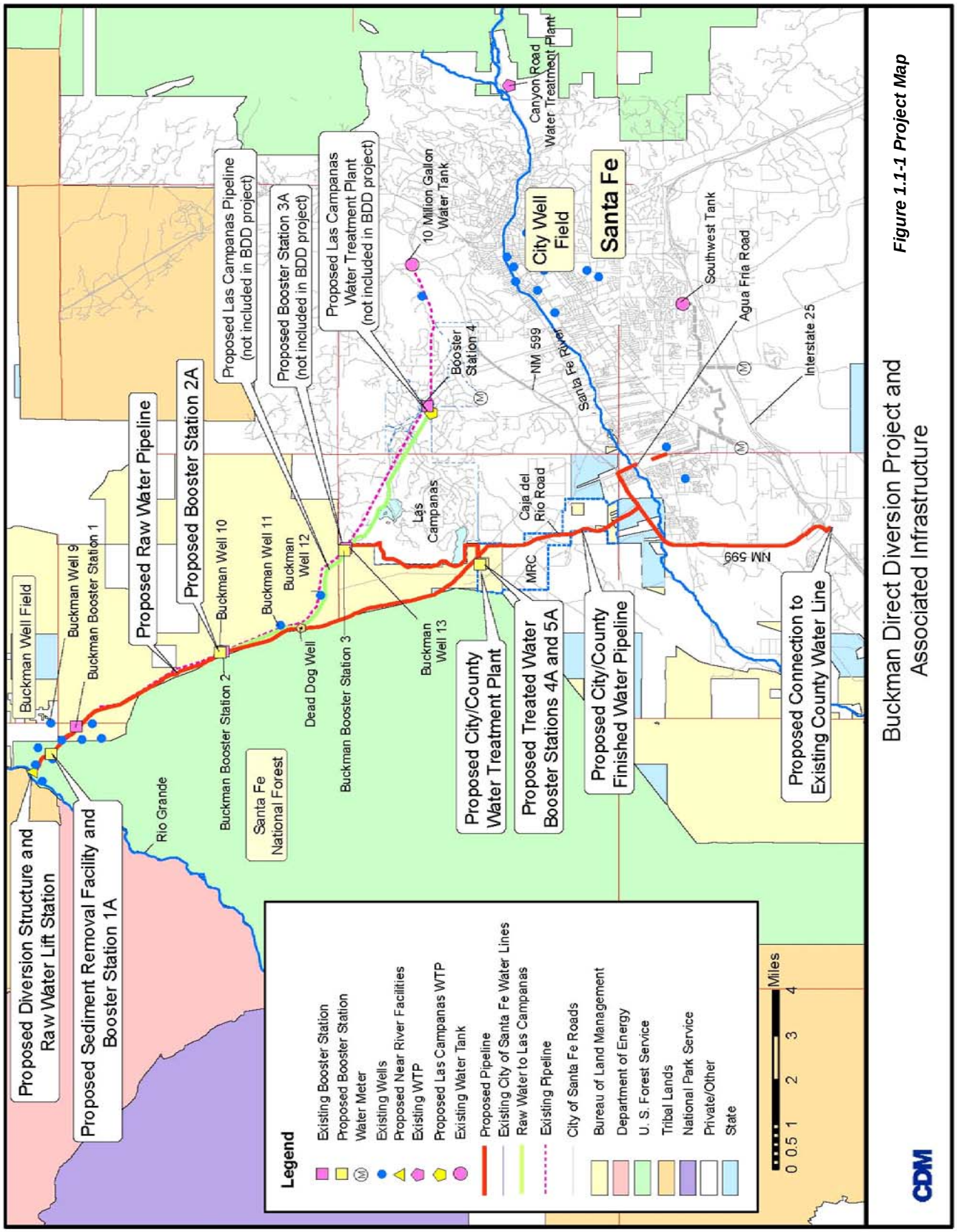


Figure 1.1-1 Project Map

This Preliminary Design Report (PDR) was prepared in accordance with the scope of work for Task B8. The PDR serves as a reference document that describes the technical analyses, alternatives considered, and recommendations of the OC for the BDD Project facilities. It provides information on the background and basis for the Technical Requirements and the Preliminary Design Drawings. Whereas the Technical Requirements and Preliminary Design Drawings will be baseline requirements for the DB Proposers and the selected DB Contractor, this PDR provides non-binding information and recommendations supporting those documents.

Additional information on the goals and role of this PDR is provided in Section 1.5. The organization of this report is described in Section 1.8.

1.2 Water Supply Background

Water in Santa Fe is obtained from multiple sources, forming a supply and deliver system that has evolved over time as the City's service base grew and constraints on local sources became more evident. The City's three primary sources of supply today include: surface water from the Santa Fe River watershed; groundwater from the City Well Field along the Santa Fe River; and groundwater from the Buckman Well Field near the Rio Grande. Figure 1.2-1 identifies the City's current water sources.

The Santa Fe River watershed is primarily runoff from the Sangre de Cristo Mountains. This water is stored in McClure and Nichols Reservoirs. Surface water in the reservoirs is treated with conventional treatment at the Canyon Road WTP, located below the reservoirs. Historically, surface water comprises 40 percent of the total City supply but the City typically relies completely on groundwater during winter months when water demand decreases. Currently, the sum of the three sources of water marginally meets the City's demands when conservation and drought management measures are in place. The City of Santa Fe is the primary water provider to Santa Fe County under a "wheeling" agreement.

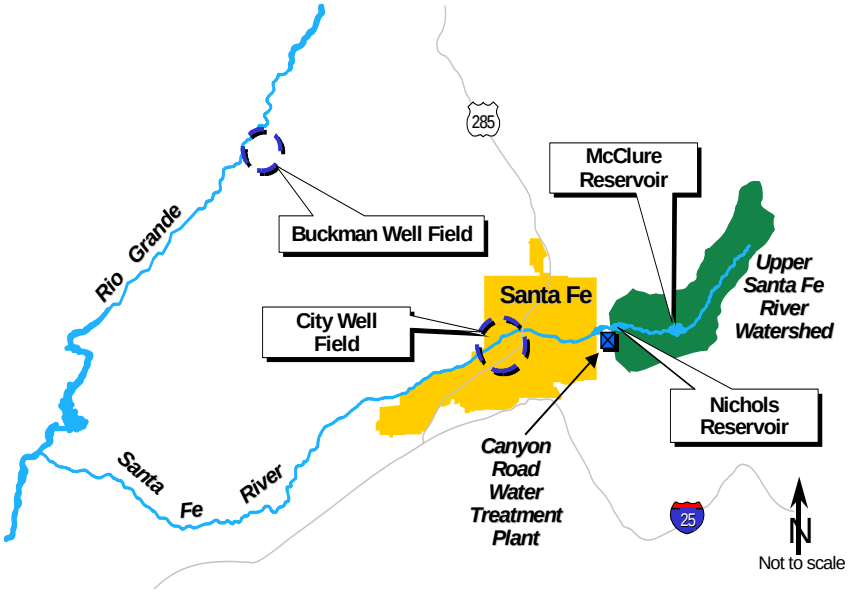


Figure 1.2-1 Santa Fe's Existing Sources of Water Supply

Although the City has three separate water sources, the prevalence of a drought and growth in the region has increased the City's reliance on groundwater. Increased drawdown levels and impacts on tributaries and other groundwater wells in the County are a growing concern. Several studies identifying additional water supply sources have been prepared over the past seven years. The focus of these studies has been to recommend the best means for the City and Santa Fe County to utilize their portion of SJC Project water. The City and County have a total SJC Project water right of 5,605 acre feet per year (AFY). SJC water is a result of a Bureau of Reclamation Project that

diverts water through tunnels from southern Colorado into the Rio Grande basin of New Mexico. The project water is stored in reservoirs in northern New Mexico. To date, the City has only used SJC water to offset the effects on the Rio Grande from pumping the Buckman Wells. Planning, design and construction of the BDD Project on the Rio Grande was ultimately recommended as a result of previous studies. This Project will provide a total of 6,930 AFY of drinking water for the City and County.

The Project consists of numerous components. Rio Grande water will be diverted through submerged, inclined screens constructed within the river and pumped via the RWLS to the SRF. High-rate mechanical solids separation equipment will be used to remove sand and grit to protect pumping equipment and reduce solids handling requirements at the C/CWTP. The partially clarified raw water will then be pumped via two new booster pump stations (BS1A and BS2A) to the C/CWTP. A portion of the diverted water (in addition to the 15-mgd) will be pumped from BS2A through a third booster station (BS3A) to Las Campanas. Figure 1.2-2 is a schematic of the existing Buckman system with the addition of the BDD Project. BS3A, the pipeline to Las Campanas and the Las Campanas WTP are not being designed or constructed as part of this Project. Refer to Figure 1.1-1 for the location of the proposed BDD facilities.

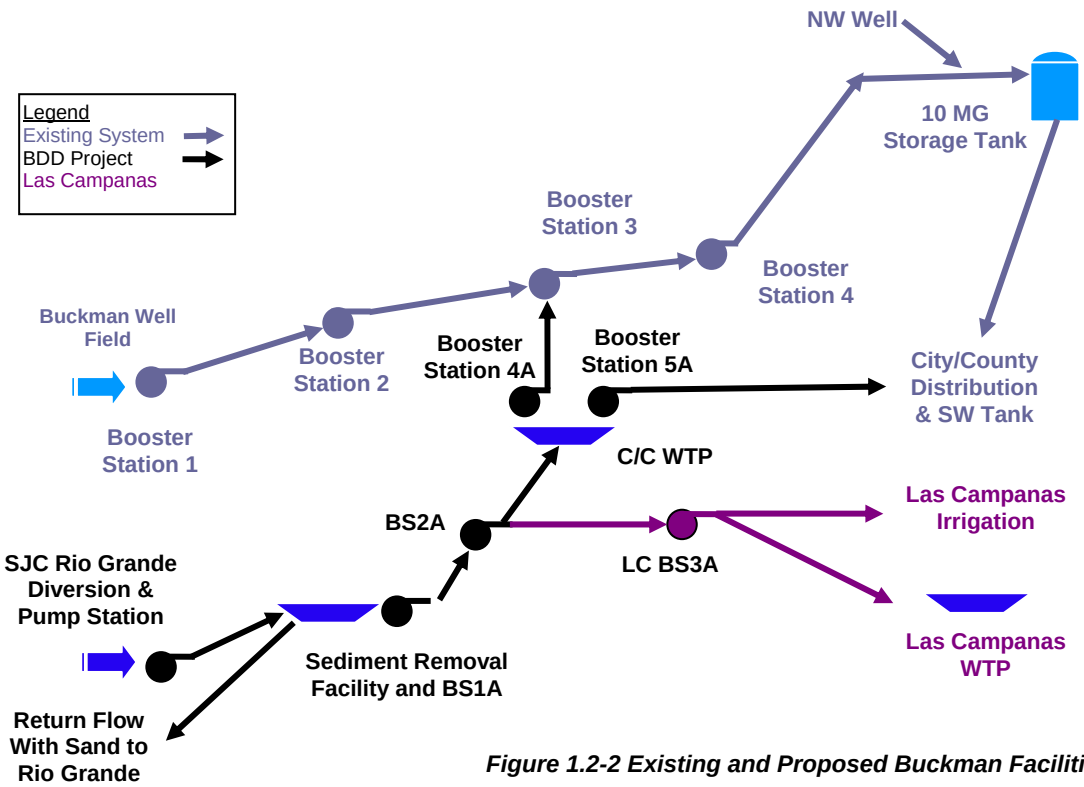


Figure 1.2-2 Existing and Proposed Buckman Facilities

1.3 Project Owners' Objectives and Performance Measures

1.3.1 Overview

A Design Build (DB) method of project delivery was chosen by the Owners for the Project to accomplish a number of specific objectives not readily achievable with the traditional design-bid-build method of public works construction. The Owners engaged CDM as their OC to develop a comprehensive process and implementation plan for delivery of the Project. The first task in the

OC scope of work, Task A1, was preparation of a detailed set of Project Delivery Objectives and Performance Measures to guide the Owners, OC, and the selected DB Contractor throughout all phases of project delivery.

The Owners developed specific objectives for the delivery of the Project in the OC's Request for Proposals (RFP) and other documents. The Owners' Objectives are an essential foundation of the BDD Project Delivery Process. These are objectives that will be referenced throughout the Project and were used to guide development of project delivery strategies. In addition, the Performance Measures developed alongside the objectives are to be used throughout the Project to measure how well the objectives are being met. These objectives and performance measures will guide project procurement and delivery activities of the Owners, the OC, and the DB Contractor.

1.3.2 Development of Owners' Objectives

The OC and the Owners collaboratively developed a list of delivery objectives and then prioritized, reviewed and finalized the objectives through a series of workshops and deliverables.

CDM held a workshop with operations and maintenance (O&M) staff on May 13, 2005 to further define the objectives, develop a ranking of the objectives, and receive important input on other project issues. A paired comparison exercise was used at the workshop to rank the objectives. Input into the objectives was obtained from both the City and County. In addition to the comparison and ranking of objectives, the O&M staff was also asked open-ended questions on: concerns with the new BDD facilities, concerns with the project delivery approach, operation and maintenance objectives for the facilities, perceived project risks, maintenance requirements, needed redundancy, and preferences for individual facilities.

A comprehensive list of 43 specific objectives, as expressed by the Owners for delivery of the Project, was then developed. The list was compiled from several sources, including the Owners' RFP for OC services, the DB White Paper submitted to City Council, the City's Purchasing Manual (Section 23.B for DB Projects), the Draft Environmental Impact Statement (DEIS), discussions between the Owners and the OC during contract negotiations for Phase A services, the O&M interview conducted by the OC on May 13, 2005, and existing knowledge of the OC regarding the Owners' goals and vision for the delivery of the Project. It was recognized that several of the objectives overlap, compete or conflict with one another; however, the list was not intended to resolve such conflicts or to indicate the relative importance of the objectives. These objectives are presented in the September 16, 2005 Technical Memorandum *Owners' Project Delivery Objectives and Performance Measures*.

An Objectives Workshop was held on May 25, 2005 and an Objective Statement was developed for five themes: Quality, Cost, Schedule, Risk and Management. The final objectives are discussed in the next section. Other objectives for the project (not specifically Owners' objectives) were developed from various documents and project requirements.

1.3.2.1 Environmental Objectives

Environmental objectives were compiled from the Project DEIS and the OC's existing knowledge of outside agency concerns and constraints, and the Owners' goals and vision for the Project. The list was not intended to resolve conflicts or to indicate the relative importance of the objectives.

1. Comply with all applicable regulations for avoiding and mitigating natural and cultural environmental impacts.
2. Understand and comply with all requirements and commitments in the DEIS and the Record of Decision.
3. Identify environmental compliance requirements and constraints early to minimize risk of additional costs to Owners.
4. Mitigate/minimize claims, change orders, and the risk of disputes and litigation in the project's environmental compliance.
5. Minimize costs of environmental compliance costs through combined expertise and cooperative efforts of all parties working together.

1.3.2.2 Project Considerations

This section summarizes the project considerations that impacted the finalization of the Owners' objectives and performance measures. As indicated earlier, it includes those expressed objectives of the Owners that are more appropriately listed as Project needs, constraints, preferences, requirements, or criteria. As with the objectives listed earlier, this compilation includes items that may overlap or conflict with one another, and no attempt is made at this point to prioritize or resolve such conflicts.

Project Needs

1. Obtain necessary expertise and labor resources, thereby reducing the Owners' workload in managing delivery of the project.
2. Provide early and thorough training of Owners' operations and maintenance staff for early take over of the Project.
3. Implement the phased hiring of new management and O&M staff by Owners.
4. Provide for the seamless transfer of responsibility for project operations from the DB Contractor to the Owners.
5. Provide for the careful monitoring of operation and maintenance of the completed project by the DB Contractor, including the preparation of documentation on downtime, water quality results, repairs, use of spare parts, and other activities, to ensure that accurate records are generated, unacceptable water quality is not delivered, and equipment and facilities are not "run down."
6. Identify environmental compliance requirements and constraints early to minimize risk of delay and additional costs.
7. Identify and plan for environmental compliance scheduling conflicts to establish and maintain a firm project delivery schedule and to minimize claims, change orders, and disputes.

Project Constraints

1. Minimize impact on the public through the use of expedited construction processes.
2. Provide for the continuation of reliable and compliant water utility operations by Owners during delivery of the project.
3. Recognize the wide range of variability in both quality and available quantities associated with the raw water source during the course of a given year and otherwise.

4. Comply with the requirements of applicable laws at the local, state, and federal levels, including regulations for avoiding and mitigating natural and cultural environmental impacts.
5. Understand and comply with all requirements and commitments set forth in the Environmental Impact Statement (EIS) and the Record of Decision (ROD).
6. Obtain all permits in a timely manner so the Project is not delayed.

Owners' Preferences

1. Provide innovation and creativity in design (including treatment processes) and construction.
2. Provide treatment processes similar to Canyon Road WTP for familiarity, consistency, and exchange of operating staff.
3. Provide extended operation by DB Contractor (2 or more years) to allow gradual buildup of Owners' O&M staff.
4. Provide maximum flexibility in unit treatment processes to meet finished water quality criteria under variable raw water conditions throughout the year.
5. Provide robust treatment processes to meet finished water quality criteria under variable raw water conditions throughout the year.

Project Requirements

1. Provide unit treatment processes that have been selected and sized to meet finished water quality requirements for taste and odor.
2. Provide a specified margin of safety between the completed project's capability to produce water quality and the applicable regulatory standards and requirements.
3. Ensure that selected water treatment processes are based upon the results of pilot testing to provide treatment that meets water quality goals, anticipated future regulations, possible arsenic removal from Buckman Wells, and that is expandable.
4. Incorporate maintenance considerations into the design of the project, including adequate accessibility, available parts, good parts storage, limited confined space, and expandable for future needs.
5. Provide a high degree of redundancy in the project (2 to 3 extra units in some cases), with good availability of spare parts and shelf-spares to provide a high degree of reliability.
6. Provide for equipment warranties that are well defined resulting in an adequately long coverage that ensures repairs and replacements are provided and no "lemons" are accepted.

1.3.3 Final Owners' Objectives

Table 1.3-1 summarizes the resulting objective statements developed by the Owners and the OC through the process and the series of meetings described above.

Table 1.3-1 Owners' Major and Specific Objectives

Objective Statement	Specific Objectives
QUALITY	Q1 – Very high level of reliability to meeting finished water quality criteria (including taste and odor) under variable raw water conditions. Q2 – High level of reliability in meeting other performance requirements (including the transmission of raw and finished water). Q3 – Meet Owners' standards of quality in all aspects of the completed project (design, construction, equipment, and materials). Q4 – Meet the specific project requirements and preferences of the Owners (including ease of operation).
COST	C1 – Establish total Design/Build cost with a high degree of certainty to Owners early in the delivery process. C2 – Determine costs of operations and maintenance early in the delivery process. C3 – Minimize the life-cycle cost of the project. C4 – Minimize the project's operational requirements (including energy consumption, O&M staffing, supplies, chemicals, and equipment renewal and replacement costs).
SCHEDULE	S1 – Establish schedule with a high degree of certainty early in the delivery process. S2 – Deliver the project in the shortest practicable time (not later than December 2009).
RISK	R1 – Shift all performance risks of the completed project to the Owners' contractors. R2 – Minimize the risk of disputes and litigation during delivery of the project. R3 – Minimize the risks of project delivery (costs and delay) to all parties. R4 – Provide for reasonable risk sharing among the parties to ensure a competitive DB procurement process and cost-effective bids.

From these objectives statements, four summary objectives and a mission statement were developed. The objectives presented in Table 1.3-1, and the other objectives discussed in Section 1.3.2, drive the decision-making, preparation of this Report and the development of the BDD Project.

The project mission statement developed at the Owners' Objectives Workshop was as follows: *To develop and implement a project delivery procurement process in a timely manner that provides the best value to the Owners based on the Owners' objectives for the Project.*

The four summary objectives, termed the "Owners' Objectives" are as follows:

Quality – Provide high-quality project facilities and equipment that meet performance requirements in order that the Owners can reliably operate the Project to produce high-quality drinking water

Cost – Minimize the Owners' life-cycle cost of the Project

Schedule – Initially establish and maintain the project schedule in order to delivery the completed Project in the shortest practicable time and eliminate (to the greatest extent achievable) future occurrences of material project completion delays

Risk – Minimize the risks of project delivery to all parties, maximize the clarity and acceptance by all parties of the risk allocation, and eliminate (to the greatest extent achievable) the Owners' risks – subsequent to award of the DB Contract – of increased costs and of the completed Project not meeting performance requirements

1.3.4 Performance Measures

To most effectively apply the Owners' Objectives toward successful project delivery, a complete set of quantitative or qualitative Performance Measures was produced for each major objective. The Performance Measures are to be used to periodically assess Project performance throughout the course of Project development and delivery.

At the May 25, 2005 O&M Objectives Workshop, the staff was asked "how would you measure success of this project." The responses were compiled a list of Performance Measures for the

delivery of the Project were developed for the five major themes. The Performance Measures are described in Table 1.3-2 below.

Table 1.3-2 Performance Measures

Objective	Project Delivery	Owners' Consultant	DB Contractor
Quality Measures	No significant (unexcused) violation of finished water quality criteria during first year of Owners' operation. No significant (unexcused) failure to deliver raw or finished water within operating capacities of facilities during the first year of Owners' operation. Unplanned and planned downtime is within stated ranges for specific facilities.	OC review of quality assurance/quality control (QA/QC) procedures required to be followed by DB Contractor identifies any major failure by DB Contractor to comply with design or construction quality requirements.	No significant (unexcused) violation of finished water quality criteria during two-year period of operation with DB Contractor assistance. No significant (unexcused) failure to deliver raw or finished water within operating capacities of facilities during two-year period of operation with DB Contractor assistance. Unplanned and planned downtime is within stated ranges for specific facilities during two-year period of operation with DB Contractor assistance.
Cost Measures	Life-cycle cost expressed as annualized cost for 25-year operations period with discount rate of 5 percent per annum. Annual revenue requirement for Owners' payment of capital and operating costs.	Change orders initiated by DB Contractor attributable to OC's preliminary design or technical requirements do not exceed 1 percent of DB price. Awarded DB contract prices are within 10 percent of OC's final cost estimate.	Operation and maintenance costs incurred during two-year period of operation with DB Contractor assistance are within Owners' budget.
Schedule Measures	Completion of all project delivery activities within the scheduled date for initial operations, except for excused delay.	Completion of all assigned activities that fall on the project's critical path within the scheduled dates. Timely updating of project schedule to reflect changing circumstances and to mitigate controllable delays. Review and comment on DB Contractor submittals within allowed time frame.	Compliance with contractual schedule for permitting, design, construction, and testing of the project.
Risk Management Measures	Additional costs for risks allocated to Owners are covered by risk contingency fund or insurance. No additional costs are incurred by Owners for risks allocated to other parties.	New risks are identified and mitigated in a timely manner through OC's ongoing risk management process. No major disputes are attributable to lack of clarity in risk allocation. The Owners and DB proposers accept the allocation of risks set forth in the final RFP at the time of proposal submission. Timely execution of permit plan.	Any disputes regarding risk allocation are resolved in timely manner. Acceptance testing is successfully completed without significant modifications to completed facilities.

1.4 Project Delivery Strategy

The procurement process for the DB Contract includes two basic steps as originally identified in the Owners' RFP for the OC.

Step 1 - Request for Qualifications: This first step of the procurement process started with the issuance of the Step 1 Request for Qualifications (RFQ) and concluded with the designation of a

short list consisting of three Respondents, or DB Proposers, that have been invited to submit proposals in the second step. The RFQ phase included a mandatory pre-Submittal conference. A short-list of DB teams by a City/County selection committee was completed in June 2006.

Step 2 - Request for Proposals: The second step of the procurement process began with the issuance of a draft Step 2 RFP to the Qualified Respondents for review and comment in August and September 2006. The final RFP is scheduled for issuance in October 2006 and approximately 90 days will be scheduled for proposal preparation. A pre-proposal conference for the Qualified Respondents will be held some 30 days after issuance of the final RFP. The RFP step will conclude with the evaluation of the Proposals by the Step 2 Selection Committee and the award of the DB Contract by the BDD Board.

Upon completion of the RFP process, contract negotiations will be initiated with the top-ranked Proposer. Following successful contract negotiations, a final DB Contract will be submitted to the BDD Board for award.

Figure 1.4-1 is a graphical representation of the relationship between the principal parties involved in the delivery of the Project. The Owners (Santa Fe County and the City of Santa Fe) have established a Joint Powers Agreement (JPA) for the BDD Project. The JPA establishes the BDD Board to enter into and oversee a number of contracts to implement the Project on behalf of the City and the County. Additionally, the County, City and LCLP will enter into a Facility Operating and Procedures Agreement (FOPA). The FOPA addresses issues such as ownership of Project facilities, capacity rights, cost sharing, transfer of water rights, and sharing of water shortages.

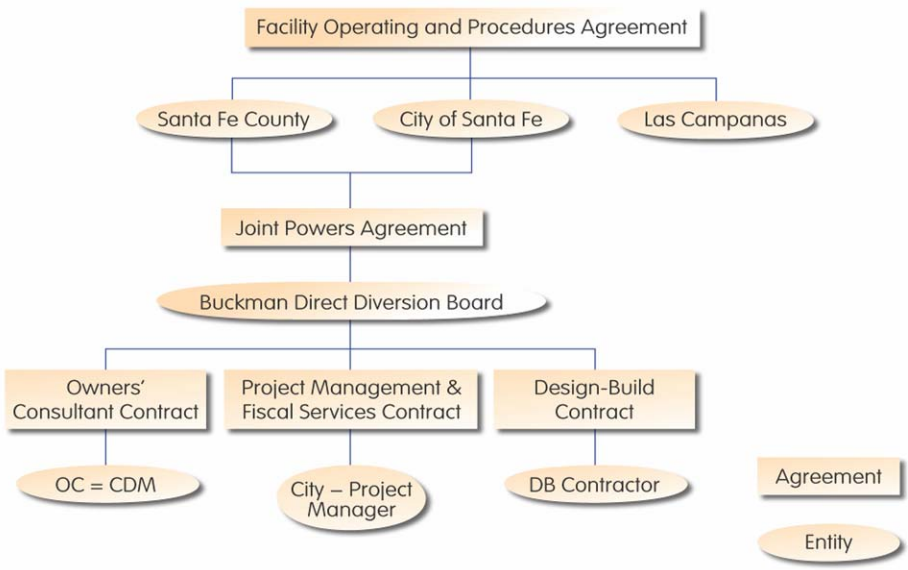


Figure 1.4-1 Relationship Between Principal Parties of BDD

The five-member BDD board of directors includes two members of the City of Santa Fe Council (City Council) appointed by the Mayor and approved by City Council, two members of the Board of Santa Fe County Commissioners appointed by the County Commissioners, and one at-large citizen member appointed by a majority vote of the other four members of the BDD Board. Each member of the board has one vote. The City will provide services to the BDD Board to support implementation of the Project. Under the proposed Project Management and Fiscal Services Contract (PMFS Contract), the City will act as Project Manager for delivery of the Project and will be responsible for day-to-day management and related fiscal activities. Upon completion of initial performance testing under the DB Contract, the City will also operate and maintain the new facilities under the FOPA and PMFS Contract. The BDD Board intends to engage the DB Contractor for the permitting, design, construction, acceptance testing and operations support services for the facilities.

Before procurement of the DB Contractor was initiated, the OC completed evaluations to guide the Owners' toward the Project Delivery Strategy that best met the Owners' Objectives. The purpose of the Project Delivery Strategy was to identify and analyze alternative contracting approaches. The Owners' detailed objectives, needs, constraints, preferences, requirements, and criteria documented in Section 1.3 served as the foundation for the development of the Project Delivery Alternatives, the analyses of the alternatives, and the OC's recommended Project Delivery Strategy.

The Recommended Project Delivery Strategy addressed key issues requiring early resolution for timely implementation and procurement of the Project. It answers the following questions:

- Operations and Maintenance by the DB Contractor?
- Format for the DB Contract?
- Preliminary Design by the Owners?
- Extent and Responsibilities for Site Investigations?
- Responsibilities for Archaeology Investigations and Cultural Data Recovery?
- Responsibilities for the Acquisition of Permits and Approvals?
- Alternatives for the DB Procurement Technical Proposal Process?
- Alternatives for the DB Procurement Pre-Qualification Process?

The following recommendations have been developed through the participation of representatives of the Owners and the Owners' Consultant at two workshops on project delivery alternatives (held on July 27 and August 12, 2005) and based on the analysis of alternatives by the Owners' Consultant as documented in two Draft Technical Memoranda (dated July 11 and August 9, 2005).

- As a condition of Substantial Completion, the DB Contractor will be required to operate the BDD facilities according to the Acceptance Test Plan for a period of approximately 30 days. During the two-year period subsequent to Substantial Completion, the Owners may conduct up to three additional tests according to the protocols and procedures in the Acceptance Test Plan. The DB Contractor is also required to provide operations and maintenance consulting services and training of the operations and maintenance staff during these first two years of operation.
- The City and County should support various steps and activities that must be completed, with assistance of the OC, to prepare for the complete ownership of O&M responsibilities for the Project, including the timely hiring and training of qualified staff and any necessary adjustments in wage scales.
- A lump sum compensation form of DB Contract should be utilized for obtaining the services of the DB Contractor
- A preliminary design, to various levels of completeness for different project components, should be prepared by the OC
- A relatively extensive program of site investigations should be conducted by the OC prior to issuance of the RFP to the short-listed DB Proposers
- Archaeology investigation and cultural data recovery for known sites should be performed prior to signing of the DB Contract; unknown sites should be addressed by the DB Contractor under a process that will be set forth in the RFP documents

- The acquisition of permits and approvals required for the Project should be shared by the OC/Owners and the DB Contractor, as appropriate for each permit
- The DB technical proposal process should include the preliminary design prepared by the Owners as a mandatory minimum requirement and allow alternative designs or innovation only in limited areas; the DB Proposers should be required to accept or enhance the preliminary design when proposals are submitted
- The DB pre-qualification process should specify a short-list of three firms, include some materials that would be included in the subsequent RFP (such as risk allocation summary), and set forth minimum criteria for pre-qualification as well as comparative evaluation criteria

The DB procurement process should be designed to require a single proposal, consisting of technical proposal and business proposal components, and that alternative design approaches be limited to areas specifically identified in the mandatory minimum preliminary design. Any such design alternatives would be considered by the DB Proposer and its best approach for each would be reflected in a single technical proposal (not in several alternative technical proposals).

The following strategies apply both to the DB pre-qualification process and to the RFP process:

- Size of the pre-qualified short list: It can range from a minimum of three under the City's Purchasing Procedures for DB Projects to a maximum of five under the State Procurement Code. Due to concerns in the DB industry, a maximum of three short-listed firms was recommended.
- Requirement for interviews: Interviews of DB firms seeking inclusion on the pre-qualified short list will not be required during the pre-qualification process, but may be required during the proposal evaluation process.
- Extent of RFP-related materials: The RFQ should incorporate, as a minimum, a general risk allocation matrix and overall procurement schedule.
- Minimum criteria and/or comparative rankings for pre-qualification short list: The process for selection of the pre-qualified short list will be developed once the Owners' legal counsel makes a final determination as to the applicable procurement law, but should include both minimum criteria for pre-qualification and comparative evaluation criteria to rank the most qualified firms for the short list.

1.5 Purpose and Objectives of Preliminary Design

The purpose and objectives of the preliminary design is for the OC to define and select the unit treatment processes, equipment, construction materials, and other project requirements. By providing a Preliminary Design, the OC is able to realize the Owners' quality, cost, risks, and schedule objectives. Additionally, during the Preliminary Design, the OC is able to begin permitting work to aid in early completion of the Project.

The purpose of the PDR is to document the design of the facilities, but will not be a part of the DB Contract.

As a part of the Preliminary Design objectives, the OC will complete the design of the various components to the various levels, as described below:

- Diversion Structure, Diversion Support Facilities Building and RWLS – moderate level (20 percent of full design)
- SRF and BS1A – low level (10 percent of full design level)
- BS2A – moderate level (20 percent of full design)
- Raw water pipeline – low level (10 percent of full design level)
- C/CWTP – high level (30 percent of full design)
- Finished water transmission pipelines – moderate level (20 percent of full design level)

To facilitate the design, the OC will utilize the results of a series of design activities, including the following:

- A screening of numerous process and facility alternatives to three acceptable alternatives and brought to the Owners in a workshop setting
- Evaluation of the screened alternatives to determine a recommended alternative brought to the Owners in workshops to provide an agreed upon alternative
- Tours of other agencies' facilities to better understand the design, operations and maintenance of the alternatives
- Reviews by the Owners at various stages of completeness
- A number of in-house technical reviews at each step of the Preliminary Design process
- A value-engineering session of this PDR and in-progress Preliminary Design to obtain expert opinions on how the Project cost can be decreased and/or value increased
- Based on the technical reviews, Owners' reviews, and value engineering session, the Preliminary Design, Project Development Requirements and PDR will be completed.

Components of the OC's Preliminary Design that require selection of technologies are based on a successive screening process. Alternative technologies for components are identified and described for review and discussion in workshops with the Owners. The goal of these Preliminary Design workshops was to select three viable alternative technologies for further consideration. The OC conducted detailed evaluations of the three alternatives and the resulting information along with the OC's recommendation was provided at follow-up workshops. The goal of the follow-up workshops was to select the technology and processes for the OC's Preliminary Design.

Other objectives of the OC's Preliminary Design include:

- **Finished Water Pipeline Modeling:** Utilize the City's existing distribution system model to determine the Project's finished water pipeline diameters.
- **Scour Study:** Conduct scour studies for the proposed two pipeline crossings of the Santa Fe River and two typical arroyo crossings. The scour study helped to determine the depth of the pipeline and protection measures.
- **Surge Analysis:** Perform a surge analysis of the raw water and finished water conveyance systems to provide Technical Requirements to mitigate surges in the systems.
- **Computational Fluid Dynamics Modeling:** Apply computational fluid dynamics (CFD) software to analyze the hydraulic performance of the diversion structure to verify that, at low flow, adequate velocities are realized in areas where debris may potentially settle and to evaluate the overall hydraulic conditions at the diversion structure.

- **Value Engineering (VE) Session:** Review the OC's Draft Preliminary Design for identifying measures that will add "value" and minimize construction and/or O&M costs.
- **Treatment Process Selection:** Evaluation of treatment processes, including possible pre-treatment and near-river sedimentation facilities, to determine water treatment processes utilized in the Preliminary Design and the minimum design and performance criteria. These criteria were based on the results of the pilot study, water quality regulations including anticipated future regulations, operational characteristics, ease of operation, maintenance requirements, flexibility to meet varying water quality, robustness of processes to handle the poorest of water quality, O&M costs, residual solids handling and disposal costs, chemical and power costs, staffing requirements, ease of maintenance, compatibility with existing staff skills, and local and regional equipment (service and parts) support.
- **Conveyance Facilities:** Develop and prepare the Preliminary Design for the facilities outside of the C/CWTP. These facilities include the near-river facilities (diversion structure and RWLS), SRF, booster stations, raw water pipelines and finished water pipelines.
- **Operation and Maintenance Cost Estimates:** Develop an O&M cost model to evaluate the various facility options. The O&M cost model was used to develop relative cost differences between the three process alternatives, as well as the near-river and conveyance facilities.
- **Construction Cost Estimate:** Provide relative construction cost estimating for the three viable process alternatives for the selection process. Based on the accepted results of the VE report, the technical reviews, and the Owners' review comments, a final construction cost estimate was prepared.
- **Life-Cycle Cost Model:** Develop a life-cycle cost model for the Project recommendations based upon the Owners' cost objective for minimizing the Project's life-cycle cost

Therefore, the OC's comprehensive Preliminary Design of the Project has the objective of best meeting the Owners quality, cost, risk, and schedule objectives as well as the Owners' operability and maintainability needs and preferences. The Preliminary Design provides detailed technical requirements and criteria. The DB Contractor will be required to verify, use and enhance the Preliminary Design in the preparation of the DB Contractors' final design, specifications, and documentation.

1.6 Summary of Project Development Requirements

The Project Development Requirements, otherwise known as the "Technical Requirements", are made an integral part of the RFP and ultimately the DB Contract. The Requirements provide the minimum technical, design, construction and performance requirements. The DB Contractor will be responsible for all aspects of the design, permitting, construction and performance of the Project facilities. Additional information on the use of the Requirements is provided in Section 10 – Project Implementation.

The Technical Requirements, provided as Volume III of the RFP, are organized as follows:

Section 1 – Introduction: provides a description of the Volume III components, organizational information, definition of terms, and the water quality and testing information for the Project.

Section 2 – Existing Site Conditions: provides an overview of existing utilities and other existing facilities that occur in the vicinity of the Project facilities.

Section 3 – Quality Management Requirements: describes the requirements for the DB Contractor's Quality Management Program.

Section 4 – Project Documents and Communications: provides the requirements for the DB Contractor for communications, quality management, submittals, design and construction documentation, and progress payments.

Section 5 – Performance Standards: provides the acceptance testing and operating performance standards for the DB Contractor's completed Project facilities.

Sections 6 through 19 - Project Development Requirements: these sections describe the requirements the DB Contractor must meet for the design, equipment selection, installation, testing, and startup of the Project facilities.

Section 20 – Startup and Testing: provides requirements for the DB Contractor for the startup, commissioning, and testing of the Project facilities.

Section 21 – Operations and Maintenance (O&M) Requirements: describes the requirements for operation and maintenance activities and products for all the BDD project facilities.

Section 22 – Construction Requirements and Constraints: provides the construction constraints and the requirements the DB Contractor must meet with respect to methods and techniques, the training and qualifications, and environmental and cultural protection.

Appendix A – Referenced Documents: The plans referenced in Section 22 (Construction Requirements and Constraints) and Section 3 (Quality Management Requirements) are provided in this Appendix.

Appendix B – Permit Applications: Copies of permit applications that have been submitted to the City and appropriate agencies are provided in this appendix.

Appendix C – Permits: Copies of permits that have been granted for the BDD Project to date are included in this appendix.

1.7 Meeting Owners' Objectives

In order to meet the Owners' Objectives (as presented in Section 1.3), the OC's Preliminary Design and procurement documents focused on four main criteria: minimizing risk, optimizing quality, controlling cost, and maintaining the Project schedule.

1.7.1 Risk

The most important tasks of the OC's Preliminary Design were to minimize the risk of Project delivery to all parties, maximize the clarity and acceptance by all parties of the risk allocation, and eliminate (to the greatest extent achievable) the Owners' risk (subsequent to the award of the DB

Contract) of increased costs and of the completed Project not meeting the performance requirements.

Most, if not all, portions of the OC's Preliminary Design include the minimization of risk. The key elements of the Preliminary Design that are critical to minimizing risk include, but are not limited to, the following:

- Evaluating the available Project facilities sites
- Performing pilot and bench-scale testing for characterizing and assessing treatment parameters for the raw water conditions and developing a range of conditions for the DB Contractor acceptance testing and operating performance standards
- Analyzing current, near-term, and foreseeable future water quality regulations
- Evaluating and preparing various permits, easements, and other regulatory requirements for the Project; including communicating with the associated agencies
- Providing archaeological and cultural data recovery investigations
- Providing a comprehensive Preliminary Design for the DB Proposers and Contractor
- Providing cost analyses, including O&M costs and life-cycle costs
- Providing Project-specific technical requirements for processes, equipment, and installation

1.7.2 Quality

The second most important task of the OC's Preliminary Design includes the objectives of optimizing the quality of the Project facilities and providing equipment that meets the performance requirements in order that the Owners can reliably operate the Project to produce high quality drinking water.

Similar to minimizing risk, most, if not all, portions of the OC's activities on this Project include the optimization of quality. The key elements of the Preliminary Design that are critical to this include, but are not limited to, the following:

- Providing archaeological and cultural data recovery investigations
- Performing pilot and bench-scale testing for characterizing and assessing treatment parameters for the raw water conditions and developing a range of conditions for the DB Contractor performance guarantees
- Providing a comprehensive Preliminary Design for the DB Proposers and Contractor
- Including redundant processes and/or equipment where viable
- Including process control and/or automation, where viable, to minimize operator error
- Performing a corrosion analysis for appropriate transmission line materials selection
- Performing various facilities modeling/studies, including Finished Water Pipeline Modeling, a Scour Study, a Surge Analysis, and CFD Modeling of the Diversion Structure
- Providing O&M flexibility for the facilities, including chemical selection and off-peak operation

- Providing a staffing analysis of the BDD facilities
- Providing a Draft RFP for review by short-list DB Proposers
- Performing multiple discipline-specific reviews on all aspects of the Preliminary Design

1.7.3 Cost

An essential component of the OC's Preliminary Design, includes the objectives of controlling the costs of the Project facilities to minimize the Owners' life-cycle cost of the Project. The key elements of the Preliminary Design that are critical to controlling the cost include, but are not limited to, the following:

- Initiating and establishing communications with regulatory agencies for permitting and easement acquisition activities
- Providing a comprehensive Preliminary Design for the DB Proposers and Contractor
- Providing high-efficiency equipment, including the Booster Station pumps and motors
- Performing various analyses of construction, O&M and life-cycle costs
- Providing O&M flexibility for the facilities, including chemical selection and off-peak operation
- Providing a staffing analysis of the new facilities
- Perform a value engineering review of the draft preliminary design to identify cost savings and value-added measures

1.7.4 Schedule

The fourth key component of the OC's Preliminary Design, includes the objectives of maintaining the Project schedule by establishing and upholding the Project schedule in order to deliver the completed Project in the shortest practicable time and eliminating (to the greatest extent achievable) future occurrences of delays to the Project completion.

Again, numerous, if not all, portions of the OC's activities on this Project include maintaining the Project schedule. The key elements of the Preliminary Design that are critical to this include, but are not limited to, the following:

- Performing a detailed RFQ process for selection of a competent and qualified DB Contractor
- Initiating and establishing communications with regulatory agencies for permitting and easement acquisition activities prior to the release of the DB Contract
- Initiation or completion of permit applications as early as possible
- Providing archaeological and cultural data recovery prior to construction
- Providing a comprehensive Preliminary Design for the DB Proposers and procurement of a DB Contractor
- Selecting non-proprietary equipment/processes for the Project facilities
- Allowing adequate flexibility so the DB Contractor can construct the facilities within the scheduled duration
- Performing numerous in-house technical reviews

- Providing a staffing hiring plan for early staffing buildup for training and "ownership" of the BDD Facilities
- Transferring electronic project files to the DB Contractor to minimize rework

Many of the items listed above are common to all four of the key Project principals. All of these items are reflected in the OC's Preliminary Design. The DB Contractor will be required to verify, use and enhance the Preliminary Design in the preparation of the final design, specifications, and documentation.

1.8 Report Organization

This Report is organized into ten sections. Section 2 provides the general basis for design including capacity goals and criteria, raw water quality, finished water quality goals and criteria and regulatory requirements.

Each of the following sections document the preliminary design analysis performed for the major facilities. Each section presents the performance and design criteria, the initial screening of alternatives, the selected alternatives for analysis, the evaluation and cost analysis of the alternatives and the recommendations.

- Section 3 - Diversion Structure and Raw Water Lift Station
- Section 4 - Sediment Removal Facility
- Section 5 - Raw Water Pipeline and Booster Pump Stations
- Section 6 - Water Treatment Facilities
- Section 7 - Finished Water Transmission
- Section 8 - SCADA and Telemetry
- Section 9 - Buckman Road Improvements

Section 10 discusses project implementation. This section describes how the Preliminary Design will be used by the DB Contractor, how the new facilities will be connected to existing facilities, a schedule for implementation, permitting and easements, staffing recommendations and construction, O&M and life-cycle cost estimates.

Numerous appendices are also included with this report. The contents of the appendices document the various studies, evaluation and drawings that were prepared during Phases A and B of the Project:

Appendix A - Geotechnical Investigations Report
Appendix B - Corrosion and Stray Current Analysis
Appendix C - Scour Study
Appendix D - Pipeline Analysis
Appendix E - Surge Analysis
Appendix F - Computation Fluid Dynamics Modeling of Diversion Structure
Appendix G - Solids Alternative Use Study
Appendix H - Detailed Construction Cost Estimate
Appendix I - Detailed O&M Cost Estimate

Appendix J – Permits and Easements Plan

In addition to the appendices, other documents are referenced extensively throughout the PDR. The Project Development Requirement (Technical Requirements) are referenced as Volume III of the RFP. The Preliminary Design Drawings are referenced as Volume IV of the RFP.

1.9 Acronyms and Abbreviations

The acronyms and abbreviations used throughout this report are defined below for reference.

AABC	Associated Air Balance Council
AASHTO	American Association of State Highway and Transportation Officials
AC	Air Changes
A/C	Air Conditioning
acfm	Actual Cubic Feet per Minute
ACH	Air Changes per Hour
ADA	American Disabilities Act
AF	Acre Feet
AFY	Acre-Feet per Year
AMCA	Air Moving and Conditioning Association
AMSL	Above Mean Sea Level
ANSI	American National Standards Institute
AOC	Assimilable Organic Carbon
AQB	Air Quality Bureau (of NMED)
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ATS	Automatic Transfer Switch
AVAR	Air Vacuum Air Release
AWG	American Wire Gauge
AWWA	American Water Works Association
BAC	Biological Activated Carbon
BDD	Buckman Direct Diversion
BER	Bit Error Rate
bps	Bits per Second
BS	Booster Station
C	Celsius
$CaCO_3$	Calcium Carbonate

CCP	Concrete Cylinder Pipe
CCTV	Closed-Circuit Television
C/CWTP	City/County WTP
CDM	The Owners' Consultant (OC) and the Boards' Engineer for the Project
CFD	Computational Fluid Dynamics
cfm	Cubic Foot per Minute
CFR	Code of Federal Regulations
cfs	Cubic Foot per Second
CFU	Colony Forming Units
CIP	Clean in Place
Cl2	Chlorine
CLSM	Controlled Low Strength Material
CMMS	Computerized Maintenance Management System
CPB	Construction Programs Bureau (of NMED)
CPU	Central Processing Unit
CSI	Cellular Specialties Inc.
CWA	Clean Water Act
db	Decibels
DB	Design Build
DBP	Disinfection By-Product
DBPR	Disinfection By-Products Rule
DEIS	Draft Environmental Impact Statement
DIP	Ductile Iron Pipe
DOC	Dissolved Organic Carbon
DWB	Drinking Water Bureau (of NMED)
EBCT	Empty Bed Contact Time
EPR	Ethylene Propylene Rubber
ES	Effective Size
F	Fahrenheit
FCC	Federal Communications Commission
FEP	Front End Processor
FIK	Flange Insulating Kit
FM	Factory Mutual
FOD	Field Operations Division (of NMED)
FOPA	Facility Operating and Procedures Agreement

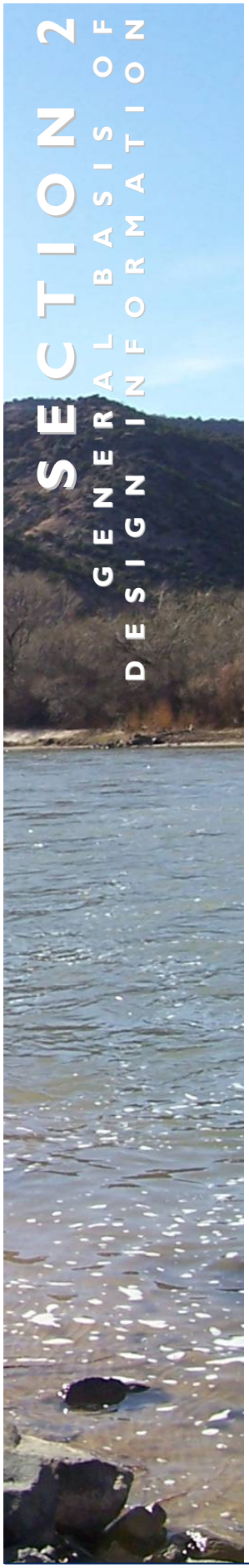
fps	Foot per Second
FRP	Fiberglass Reinforced Plastic
ft	Foot or Feet
GAC	Granular Activated Carbon
gal	Gallons
GFCI	Ground Fault Circuit Interrupter
gfd	Gallons per Square Foot per Day
GOX	Gaseous Oxygen
gpm	Gallons per Minute
GRSC	Galvanized Rigid Steel Conduit
GWQB	Ground Water Quality Bureau (of NMED)
HAA	Haloacetic Acids
HDPE	High Density Polyethylene
HEC-RAS	Hydraulic Engineering Center River Analysis System
HMI	Human Machine Interface
HP	Horsepower
hr	Hour
HRT	Hydraulic Retention Time
HVAC	Heating, Ventilation and Air Conditioning
ID	Internal Diameter
IEEE	Institute of Electrical and Electronics Engineers
IESWTR	Interim Enhanced Surface Water Treatment Rule
IFC	International Fire Code
IFGC	International Fuel Gas Code
in	Inch
I/O	Input Output
JPA	Joint Powers Agreement
kbps	kilobits per second
KSU	Key Service Unit
kv	kilovolts
KVA	kilovolt amps
LA	Laboratory of Anthropology
LAN	Local Area Network
L	Liter
LCLP	Las Campanas Limited Partnership

LCR	Lead and Copper Rule
LED	Light Emitting Diode
Leq	Equivalent Level
LOP	Layers of Protection
LOX	Liquid Oxygen
LRAA	Localized Running Annual Average
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
LUD	Land Use Department (of Santa Fe County)
m	meter
MAS	Multiple Address System
MAU	Make Up Air Unit
Mbps	Megabits per Second
MCC	Motor Control Center
MCL	Maximum Contaminant Level
MDS	Microwave Data System
MF	Membrane Filtration
MG	million gallons
mg	milligram
mgd	million gallons per day
MIEX	Magnetic Ion Exchange
mil	millimeters
min	minutes
mL	millileters
mm	millimeters
mph	miles per hour
MRC	Municipal Recreation Complex
MSL	Minimum Service Life
NEBB	National Environmental Balancing Bureau
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NHPA	National Historic Preservation Act
nm	nanometers
NMAC	New Mexico Administrative Code
NMCID	New Mexico Construction Industries Division

NMDCA	New Mexico Department of Cultural Affairs
NMDGF	New Mexico Department of Game and Fish
NMDOT	New Mexico Department of Transportation
NMED	New Mexico Environment Department
NMEIB	New Mexico Environmental Improvement Board
NMFA	New Mexico Finance Authority
NMSFD	New Mexico State Forestry Division
NMSLO	New Mexico State Land Office
NOI	Notice of Intent
NOM	Natural Organic Matter
NPDES	National Pollution Discharge Elimination System
NPSH	Net Positive Suction Head
NPT	National Pipe Tapered
NSF	National Sanitary Foundation
NTU	Nephelometric Turbidity Units
O&M	Operations and Maintenance
OC	Owners' Consultant
Otowi	Otowi Gaging Station
Owners	City of Santa Fe and Santa Fe County
OSHA	Occupational Safety and Health Administration
P&ID	Process & Instrumentation Diagrams
PA	Programmatic Agreement
PC	Personal Computer
PNM	Public Service Company of New Mexico
ppd	Pounds per Day
pcf	pounds per cubic foot
PCS	Process Control System
PDR	Preliminary Design Report
PFT	Paint Filter Test
PLC	Programmable Logic Controller
PMFS	Project Management and Fiscal Services
POD	Plan of Development
PRV	Pressure Regulating Valve
psf	pounds per square foot
psi	pounds per square inch

psig	pounds per square inch gauge
Pt Co	Platinum Cobalt Units
PVC	Polyvinyl Chloride
PVDF	Polyvinyl Difluoride
QA/QC	Quality Assurance/Quality Control
RF	Radio Frequency
RFP	Request for Proposals
RFQ	Request for Qualifications
RGSM	Rio Grande Silvery Minnow
ROD	Record of Decision
ROW	Right of Way
Rpm	Revolutions per Minute
RSSI	Received Signal Strength Indicator
RTU	Remote Terminal Unit
RWLS	Raw Water Lift Station
SCADA	Supervisory Control and Data Acquisition
scfm	Standard Cubic Feet per Minute
sec	seconds
sf	Square Foot
SFCWRD	Santa Fe County Water Resources Department
SFSWMA	Santa Fe Solid Waste Management Agency
SHPO	State Historic Preservation Officer
SJC	San Juan-Chama
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SOC	Synthetic Organic Compounds
SOR	Surface Overflow Rate
SLR	Surface Loading Rate
SRF	Sediment Removal Facility
sq	Square
SWQB	Surface Water Quality Bureau (of NMED)
SWPPP	Storm Water Pollution Prevention Plan
SWTR	Surface Water Treatment Rule
TCR	Total Coliform Rule
TDS	Total Dissolved Solids
THM	Total Trihalomethane

TOC	Total Organic Carbon
TON	Threshold Odor Number
TSS	Total Suspended Solids
UCMP	Unregulated Contaminant Monitoring Rule
UFAS	Uniform Federal Accessibility Standards
UL	Underwriters Laboratory
UPS	Uninterruptable Power Supply
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
UV	Ultraviolet
v	volt
vac	Vacuum
VE	Value Engineering
VFD	Variable Frequency Drive
VoIP	Voice over Internet Protocol
WTP	Water Treatment Plant
yr	year



This section provides a general design criteria overview for the proposed BDD Project facilities, which include: the diversion structure, the RWLS, the SRF, the raw water pipeline, the booster pump stations, the C/CWTP, and the finished water transmission system. Each of these facilities will be described further within subsequent sections of this report. This section provides general background information including:

- Goals and criteria for BDD Project capacities
- Water treatment regulatory framework
- Raw water quality information
- Finished water quality goals and criteria

2.1 Capacity Goals and Criteria

The proposed Project is designed to address the immediate need for a sustainable means of accessing water supplies for the Project Partners. Extensive new facilities must be designed and constructed to divert, convey, and treat river water from the Rio Grande and to deliver the finished drinking water to points of connection with existing City and County drinking water distribution pipelines.

In order to meet these requirements, various capacity goals have been established for each portion of the Project. The capacity goals were based upon the Owners' projected water demands being served by a set number of duty pumps and processes. "Duty" means the equipment or process trains that will be operational to meet peak flow requirements. There is additional hydraulic capacity at each of the facilities through the addition of standby pumps or processes. The standby pumps or processes would not operate routinely but only if other pumps or processes are off line for maintenance or if operation dictates their use.

The intake and raw water pump station are designed for three duty and two standby units (generally termed as N+2 with "N" as the number of duty units and 2 as the number of standby units). These facilities are anticipated to need more maintenance because of the quantity and abrasiveness of solids in the raw water prior to the SRF. The raw water booster pump stations will be designed based upon N+1 (three duty and one standby). The C/CWTP processes and equipment will be designed based on N+1, or N+0 with criteria allowing treatment goals to be met with one unit out-of-service. A summary of capacity goals for each facility is presented in Table 2.1-1.

Table 2.1-1 Buckman Direct Diversion Project Capacity Goals (mgd)

Project Components	Flow (mgd)		
	Minimum	Maximum w/ Duty Equipment	Maximum w/ Standby Equipment
1. Diversion Structure	3.0[1]	20.8	34.7
2. RWLS	3.0[1]	20.8	34.7
3. SRF	3.0[1]	20.8	26.7
4. Raw Water Booster Stations			
a. BS1A	3.0[1]	18.4	22.5
b. BS2A - City and County only	3.0[1]	15.1	20.3
5. Raw Water Pipeline [2]	3.0[1]	15.1	22.5
6. Raw Water Equalization Basin	3.0[1]	18.0	18.0
7. Flash Mix/Coagulation/Flocculation	3.0	18.0	18.0
8. Sedimentation	3.0	16.1	18.0
9. Membrane Filtration	3.0	15.3	20.0
10. Ozonation	3.0	15.3	22.5
11. GAC Contactors	3.0	15.1	18.0
12. Washwater Recovery Pump Station	0.5	2.9	4.1
13. Finished Water Booster Stations			
a. BS4A	1.5	8.9	8.9 [3]
b. BS5A	2.0	10.0	13.3[4]

[1] Normal minimum flow will be higher to provide 4 fps velocity in raw water system prior to SRF and 2 fps in raw water system after SRF

[2] Capacity of the raw water pipeline could be significantly higher but with higher operating costs and higher pressure pumps

[3] Maximum capacity of existing Buckman BS3 and BS4 limit maximum capacity from BS4A to 8.9-mgd, BS4A and pipeline sized for future capacity of 15 mgd

[4] Capacity of BS5A pipeline could be significantly higher but with higher operating costs and higher pressure pumps

2.1.1 Raw Water Facilities

2.1.1.1 Performance Criteria

Water will be diverted from the Rio Grande through a diversion structure with a 32.2-cfs (20.8 million gallons per day or mgd) peak duty capacity. This facility is designed based upon three diversion cells normally in use and two diversion cells in standby. Therefore, the hydraulic capacity of the facility is much higher than peak duty capacity, estimated to be approximately 35-mgd with all units in operation. The RWLS will pump water through new pipelines from the diversion structure to the SRF. The RWLS normal peak operating capacity will be 20.8-mgd (including about 2.6-mgd of sand return carriage water for returning sediment to the river) with a minimum operating capacity of 3-mgd. The hydraulic capacity (with the addition of the two standby units in operation) is 34.7-mgd.

If a workable discharge permit is approved by the United States Environmental Protection Agency (USEPA) and the New Mexico Environment Department (NMED), a sediment return pipeline will be constructed connecting the SRF to the river to return approximately 4 cubic feet per second (cfs) (2.6-mgd) of water containing settled sand or sediment back to the Rio Grande. If the discharge permit is not approved, sediment storage basins will be used to dry the sand to be hauled away for disposal or reuse.

2.1.1.2 Design Criteria

Two high-head pump stations, one located near the SRF (BS1A) and one adjacent to existing Buckman BS2 (BS2A) will convey raw water from the SRF to the C/CWTP and to Las Campanas' pumps and pipeline connection at BS2A. These facilities are designed for three duty units and one standby unit. The peak duty capacity of BS1A is 18.4-mgd with three pumps in operation. The peak duty capacity of BS2A is 15.1-mgd with three pumps in operation. The pumps in BS2A that pump to Las Campanas are not included in the peak duty capacities. The hydraulic capacity of both BS1A and BS2A is higher with the operation of the one spare pump at each facility. The peak hydraulic capacity of BS1A and BS2A is 22.5-mgd and 20.3-mgd, respectively.

Space for two pumps, and one future pump, will be provided at BS2A for Las Campanas. These pumps will convey water through a Las Campanas pipeline starting at BS2A and paralleling the raw water pipeline up to Dead Dog Well and then to Las Campanas' Booster Station 3A and water treatment plant. Other than the raw water facilities up through BS2A, the Las Campanas pumps, and related equipment, and pipelines are not included in the BDD Facilities or the design-build request for proposals. The pumps and pipeline up to Dead Dog Well have been shown in the preliminary design drawings for coordination purposes.

2.1.2 Water Treatment Facilities

2.1.2.1 Performance Criteria

Treatment of the diverted water will be accomplished through the C/CWTP with a finished water peak capacity of 15-mgd. Losses and return flows in the various treatment processes will require a feed water hydraulic capacity of 18.0-mgd from the raw water equalization basins, 16.1-mgd from the sedimentation basins, 15.3-mgd from the membrane filters and 15.1-mgd from the GAC contactors.

2.1.2.2 Design Criteria

Capacities of individual waste streams for sedimentation, membrane filtration, and GAC contactors will be discussed in Section 6 of this report; however, the capacity of the washwater recovery system will be1,900 gpm (2.9-mgd) to handle the waste streams from all of the treatment processes. The washwater recovery system will collect process washwater and decanted water from the solids handling facility for return to the raw water pipeline prior to chemical injection and presedimentation.

2.1.3 Finished Water Facilities

2.1.3.1 Performance Criteria

Two new booster stations (BS4A and BS5A) will be located at the C/CWTP. BS4A will have a pipeline hydraulic capacity of 15-mgd and a pump capacity of 8.9-mgd initially and 15-mgd in the future. BS4A will pump treated water to BS3 for distribution of treated water into the City's distribution system via the existing Buckman pipeline to the 10-MG tank. BS5A will convey up to 10-mgd of finished water to the southwest portion of the City of Santa Fe water system and will be connected to the City and County's distribution systems. The BS4A/BS5A pump station will also provide utility and potable water for the C/CWTP, backwash water for the GAC Contactors, and fire protection water.

2.1.3.2 Design Criteria

BS4A and BS5A are both designed for three duty units and one standby unit. BS4A will also have room for two additional future pumps. The initial peak duty capacity of BS4A will be 8.9-mgd with three pumps in operation. The peak duty capacity of BS5A will be 10-mgd with three pumps in operation. The backwash pump for the GAC Contactors will be sized to provide up to 6,750 gpm.

2.1.4 Raw Water Supply Operational and Maintenance Philosophy

The operation of the BDD raw water system and the C/CWTP must meet the water demands and operational needs of the Project's partners. Therefore, the BDD facilities have been designed by the OC with significant operational flexibility to meet planned demands.

2.1.4.1 Meeting the Water Demands of the Partners

Table 2.1-2 provides the peak day demand of the BDD Project. The C/CWTP will provide a peak finished water capacity of 15-mgd for the City and County and 3.25-mgd of raw water to Las Campanas via BS2A.

Table 2.1-2 Peak Day Water Demands

Water User	Peak Day Demand (mgd)	Peak Day Demand (cfs)
City of Santa Fe	11.3	17.5
Santa Fe County	3.7	5.7
Las Campanas	3.3	5.0
Total	18.3	28.2

cfs: cubic feet per second

In addition to meeting these peak day demands, the BDD facilities will meet near-term minimum daily (low flow) demands. Table 2.1-3 shows these "low flows" that the facilities will provide.

Table 2.1-3 Minimum Water Demands

Water User	Low Flow Demand (mgd)	Low Flow Demand (cfs)
City of Santa Fe	0	0
Santa Fe County	0.32	0.50
Las Campanas	0.10	0.15
Total	0.42	0.65

The minimum water demand for the City of Santa Fe is dependent upon the sources in operation. If other sources (well fields or Canyon Road WTP) can adequately meet the water demand (i.e., during low demand winter months), the raw water system and the C/CWTP may not be utilized to meet the City's water demands.

Meeting Santa Fe County Water Demands

The raw water system must be designed to allow the City and County flexibility in how the facilities are operated. The flexibility is needed since the C/CWTP could be operated as a base-load plant, peaking plant, or with just intermittent use. The selection of which of these modes to

operate will likely vary over time, as demands increase and changes are made in other components of the City and County's water supply systems. To provide this flexibility, specifically for the raw water supply, the C/CWTP includes 7.5 million gallons (MG) of raw water storage/equalization at the head end of the plant and 7.5-MG of usable finished water storage. These facilities will allow more intermittent use of the raw water system and C/CWTP to meet County water demands.

Meeting Las Campanas' Water Demands

Las Campanas anticipates a minimum daily demand in 2009 of 0.1-mgd or 69 gpm depending on the amount of raw water storage Las Campanas utilizes. In the future, a peak demand of 3.25-mgd is anticipated. The BS2A wetwell will provide raw water for Las Campanas' system. With a wetwell sized at 50,000 gallons, if the City and County did not have any water needs from the BDD system, the raw water system supplying BS2A would need to be activated approximately twice a day to meet Las Campanas' minimum demand needs. Intermittent pump operation would meet Las Campanas' minimum daily needs while also maintaining the required 2 fps velocity in the pipe. The raw water supply system would be operated on a more continuous basis at maximum demands. Therefore, as long as the raw water supply system is operational, the BDD supply facilities would meet Las Campanas' raw water demands.

The raw water supply facilities have been designed by the OC so that pumps can be removed without shutting down the system. Two standby pumps at the RWLS and two standby grit removal mechanisms at the SRF will be provided for system reliability in the portion that conveys and treats water with sand. After sand and sediment removal at the SRF, a single standby pump at both BS1A and BS2A will be used for system reliability.

The wetwell at BS2A will provide raw water storage for Las Campanas' pumps to draw from in supplying irrigation and raw water for treatment at the Las Campanas WTP (LCWTP). The pumps and related equipment at BS2A, the raw water pipeline to BS3A and the LCWTP are not included in this project.

2.1.4.2 Operation of the Raw Water System

Sediment Deposition in Facilities

The raw water conveyance facilities will pump raw water diverted from the Rio Grande to the C/CWTP and to Las Campanas' raw water pipeline connection at BS2A. The Rio Grande experiences a wide variation in water quality including the total suspended solids (TSS) concentration. Screens at the Diversion Structure will limit solids to 1.75 millimeters (mm) in diameter and smaller coming in from the river. The SRF will remove at least 98 percent of all sediment 0.075 millimeters and larger.

In general, velocities necessary to keep sediment in suspension are dependent upon the particle size. Larger particles require a higher velocity than smaller particles. The largest particle size expected in the system, upstream of the SRF, is 2-mm in diameter. After the SRF, the largest particle size expected is 0.1-mm in diameter.

Pipeline and Pump Station Operation

The raw water conveyance facilities are comprised of three distinct segments:

- Conveyance of the raw water from the Diversion Structure and RWLS to the SRF. This water is heavily sediment-laden. The overall capacity of these components is the highest (20.8-mgd plus carriage water for sediment return to the river if granted).

- Conveyance of 18.4-mgd between BS1A and BS2A. The sediment load is slightly less in this and the following reach as approximately 25 percent of the solids was removed at the SRF.
- Conveyance of 15.1-mgd between BS2A and the C/CWTP. Las Campanas' portion (3.25-mgd) will be pumped from BS2A through separate Las Campanas' pumps and pipeline which are not included in this project.

The pipeline between the RWLS and BS2A will operate at a peak flowrate of 18.4-mgd, which includes 3.25-mgd being provided to Las Campanas. These figures do not include an additional 2.6-mgd (4 cfs) at the Diversion Structure and RWLS for the proposed sediment return flow from the SRF if the sediment may be returned to the river. The raw water will include material less than 1.75-mm in diameter, such as sand.

To provide a high level of reliability, there will be three duty and two standby pumps, all with variable frequency drives (VFDs), at the RWLS. Three pipelines will convey sand-laden water from the RWLS to the SRF. To prevent solids deposition in these pipelines, the RWLS pumps will provide a startup velocity of 6 fps or more, and then maintain an operating velocity of 4 fps or more. As more water is needed at BS1A, additional RWLS pumps will be brought on-line. Low level sensors at BS1A's wetwell will activate the RWLS pumps.

After removal of sand (i.e., material greater than about 0.075 mm diameter) at the SRF, raw water will be stored in a wetwell at BS1A. The wetwell will have a capacity of 50,000 gallons. BS1A will include three duty pumps and one standby pump, each with VFDs, to convey raw water to BS2A. The capacity of BS1A will be 18.4-mgd when all three duty pumps are on-line. Similar to the RWLS controls, the pumps at BS1A will be activated by the wetwell water level at BS2A.

The wetwell at BS2A will have a capacity of 50,000 gallons. There will be three City/County duty pumps and one standby pump, each with VFDs, to convey raw water to the C/CWTP raw water presedimentation basins. The capacity of BS2A will be 15.1 mgd when all three City/County duty pumps are in operation. Similar to the other pump stations' controls, pumps at BS2A will be activated by the level of the raw water equalization basins and the need for water at the plant.

The wetwell at BS2A will also provide water for Las Campanas' pumps which will supply raw water to Las Campanas for irrigation and treatment (one duty, one standby and one future). The pumps, to be installed through Las Campanas, will provide 1,110 gpm each.

Pipeline Operation between BS1A and C/CWTP

For the pipelines between BS1A and BS2A, and BS2A and the C/CWTP, a minimum velocity of 2 fps is needed to prevent settling of sediment during operations. Although the particle size dictates only 1 fps is necessary, a higher 2 fps velocity will reduce sedimentation at bends and other pipeline appurtenances. However, sediment in the water remaining in the pipelines when the system is not in operation will settle so resuspension of settled materials will be needed when the pipeline is put back in operation. Startup of the pumps at both BS1A and BS2A will provide a minimum initial velocity of 3.5 fps or higher for resuspension of settled material.

To provide a straightforward and efficient operation of the supply facilities, the 2 fps velocity criterion will be met with only one pump in operation.

Therefore, for operation of the raw water system, the OC recommends:

- Maintaining a minimum velocity of 2 fps with one pump in operation
- Providing a high velocity greater than 3.5 fps when restarting the system for a duration of not less than 10 minutes
- Periodically, monthly or more often as needed, operate the pipeline at 5 fps or greater
- Minimizing the use of the diversion and raw water system, to the extent possible, during poor water quality conditions (turbidity greater than 1,000 NTU)
- Limiting operation of the diversion and raw water system during extremely poor water quality conditions (turbidity greater than 4,000 NTU)
- Utilizing an online turbidimeter and raw water sampling system at the RWLS to facilitate real-time, continuous monitoring of the river water quality

Operation of Facilities to Meet Variable Water Demands

Design of the raw water conveyance facilities and the C/CWTP considers the ability to deliver minimum flows to the Project partners. The conveyance facilities will be used to deliver flow to Las Campanas from the BS2A wetwell. The 50,000 gallon wetwell will allow periodic operation of the RWLS and BS1A to meet the minimum Las Campanas demands when the C/CWTP is not in operation. Similarly, the raw water system will deliver water to the C/CWTP raw water storage basin for minimal flow (3-mgd) through the plant.

2.1.4.3 Maintenance of the Raw Water System

Sedimentation within the pipeline will cause the system capacity to lessen over time by increasing head losses and increasing the amount of maintenance required. Periodically, monthly or more often, a cleansing velocity of at least 5 fps will be needed for the pipelines between BS1A and the C/CWTP.

As is standard practice, the pipeline segments will periodically need routine maintenance and inspection. Therefore, for maintenance of the raw water system, the OC recommends:

- Utilizing a high velocity, greater than 5 fps for approximately 2 to 3 hours depending on pipeline segment and diameter (amounting to one pipeline volume)
- Cleaning and inspection of the pipeline at least once per year initially
- Flushing of the lines via the blow off stations (refer to Section 5.1 – Raw Water Pipelines) during emergencies only
- Cleaning and inspection of air/vacuum relief valves (refer to Section 5.1 – Raw Water Pipelines)
- Performing routine inspection and maintenance on all raw water pumps (RLWS, BS1A and BS2A) as discussed in Section 5.2

2.1.5 Finished Water Supply Operational and Maintenance Philosophy

The operation of the C/CWTP must meet the water demands and operational needs of the Project's partners. Therefore, the BDD facilities have been designed by the OC with significant operational flexibility and robustness to meet planned demands.

2.1.5.1 Meeting the City and County Water Demands

The C/CWTP will provide a peak capacity of 15.0-mgd (23.2 cfs) to meet City and County water demands. Anticipated water demands for each entity, including Las Campanas, are shown in Table 2.1-4 and are based on the total acre-feet per year for each entity. The C/CWTP has been designed to meet the needs of the City and County over this entire range.

Table 2.1-4 Finished Water Demands

Water User	Year 2010 Demand (mgd)	Year 2015 Demand (mgd)	Year 2020 Demand (mgd)
City of Santa Fe	4.67	4.67	4.67
Santa Fe County	0.60	1.02	1.52
Las Campanas	0.55	0.58	0.66
Total	5.81	6.27	6.85

mgd: million gallons per day

BS4A at the C/CWTP will provide up to 15-mgd to the existing Buckman BS3. Initially, up to 8.9-mgd of finished water will be pumped from BS4A to BS3 through a new pipeline and from BS3 through the existing Buckman pipeline to the 10-MG Tank via existing BS3. BS5A, also at the C/CWTP, will provide up to 10-mgd to the City/County area to the south.

In addition to meeting these peak day demands, the BDD facilities have been designed by the OC to meet near-term minimum daily (low flow) demands. The "low flows" that the facilities have been designed to meet are 0-mgd (0 cfs) for the City and 0.32-mgd (0.50 cfs) for the County. The minimum low flow operating conditions for the C/CWTP assume the City requires no flow from the C/CWTP.

The minimum water demand for the City is dependent upon the sources in operation. If other sources (well fields or Canyon Road WTP) in operation can adequately meet the water demand (i.e., during low demand winter months), the C/CWTP may not be utilized for the City. Alternatively, the City could shut down operation of the Buckman Wells and the Canyon Road WTP and thus the minimum water demands would need to be met by the City Wells and C/CWTP. During this situation, the plant production would be considerably higher than the minimum County demand.

2.1.5.2 Operation of the Finished Water System

The OC's Preliminary Design of the conveyance facilities and the C/CWTP take into account the ability to deliver minimum flows to the Project partners. The conveyance facilities will be used to deliver flow for both the County and Las Campanas at very low demand periods. Similarly, the C/CWTP will treat and deliver a smaller quantity of water for just the County when the City is meeting minimum water demands from other water sources (i.e., the Buckman Wells, the City Wells or the Canyon Road WTP).

During the low flow periods, the finished water booster pumps (at BS4A and BS5A) can be turned down as dictated by the flow requirements. The upper limit of the turn down on the pumps, due to the limits of the VFDs, is typically 50 percent. Therefore, finished water storage is mandatory for each entity, including the Southwest (SW) Sector Tank and finished water storage tanks at the C/CWTP for the City (refer to Section 6.3.7 – Finished Water Storage). The Owners are evaluating the need and best location for additional storage with the distribution system. This additional storage may be necessary to meet future fire flow demands and to serve customers in areas

without nearby storage when the C/CWTP is not in operation. The new storage may include the City's planned La Tierra Tank in the proposed or alternate location.

The C/CWTP has been designed by the OC to allow the Owners flexibility in how the facilities are operated. The flexibility is needed since the plant could be operated as a base-load plant, peaking plant, or with just intermittent use. The selection of which of these modes to operate the plant in will likely vary over time, as demands increase and changes are made in other components of the City and County's water supply systems. To provide this flexibility, the plant includes:

- 7.5 MG of raw water storage within the presedimentation and storage basins
- Membrane filtration, which is much less sensitive than granular filtration to intermittent operation
- 7.5 MG of finished water storage through two reservoirs for BS4A and BS5A

The C/CWTP will have three parallel treatment trains with a combined firm treatment capacity of 15-mgd, based on reasonably conservative design criteria to provide a robust treatment process. Each of the three pretreatment process trains (flocculation and sedimentation) will be sized for a hydraulic capacity 9-mgd, allowing one train to be offline for emergency maintenance.

The County anticipates a peak day demand of 3.04-mgd in 2020. Should the City be utilizing other sources of water in lieu of the C/CWTP, the plant will need to be operated at its minimum flowrate or intermittently with startups approximately every four days to meet the County's needs. During low demand periods, the County anticipates a need for 0.32-mgd in 2009. Again, pumping from the two, 4-MG finished water storage tanks at the C/CWTP will accommodate this low demand. In this case, the plant should operate with only one half of the clearwell capacity (one tank) to reduce the age of the water.

2.1.5.3 Maintenance of the Finished Water System

As is standard practice, the pipeline segments will periodically need to be taken down for maintenance and inspection. Therefore, for maintenance of the finished water system, the OC recommends:

- Periodic inspection and cleaning of finished water reservoirs
- Inspection, flushing and other cleaning operations of pipeline segments at least once per year initially
- Inspection and cleaning of air/vacuum relief valves (refer to Section 7.2 – Finished Water Pipelines)
- Routine maintenance of all finished water booster pumps (BS4A and BS5A) as discussed in Section 7.3

Prior to the BDD Projecting coming on-line, it is recommended that the Owners perform a thorough unidirectional cleaning and flushing of all distribution pipelines. Water produced by the C/C WTP will have a different chemical makeup than the water that has typically been conveyed through the pipelines. Even with pH and alkalinity balancing, the difference could cause colored water or taste and odor complaints if cleaning of lines is not performed.

2.2 Regulatory Framework for the City/County Water Treatment Plant

The quality of drinking water is the purview of the New Mexico Environmental Improvement Board (NMEIB), which is responsible for environmental management and consumer protection. The role of the NMEIB is to promulgate rules and standards for drinking water, as well as for air quality, solid waste, and hazardous waste. The NMEIB has adopted the drinking water regulations found at New Mexico Administrative Code (NMAC) Title 20, Environmental Protection, Chapter 7, Wastewater and Water Supply Facilities, Part 10, Drinking Water (NMAC 20.7.10). NMAC 20.7.10 incorporates federal drinking water quality regulations found at 40 CFR Part 141 (National Primary Drinking Water Regulations) and Part 143 (National Secondary Drinking Water Regulations), as they were on September 13, 2002. A hearing was held on July 26, 2006, adopting the amendments to 40 CFR Parts 141 and 143 through July 1, 2005. The adoption of 40 CFR Part 141 through July 1, 2005, incorporates the following regulations by reference to the extent that they amend Part 141:

- Stage 2 Disinfectants and Disinfection Byproducts Rule, 71 Fed. Reg. 388 (Jan. 4, 2006)
- Long Term 2 Enhanced Surface Water Treatment Rule, 71 Fed. Reg. 654 (Jan. 5, 2006)

The NMED Drinking Water Bureau (DWB) is responsible for administering and enforcing the drinking water regulations. For construction or modification of drinking water supply systems, NMED DWB must review and approve the design prior to construction. The designed and constructed plant facilities must allow the Owners' to easily comply with all applicable regulations. Therefore, the proposed and anticipated regulations must be considered during design of the C/CWTP. Table 2.2-1 summarizes the provisions of each regulation that will affect the design of the C/CWTP.

Table 2.2-1 Summary of Provisions of Regulations Affecting Design of the C/CWTP

Regulation	Provisions
Total Coliform Rule (TCR)	1. Requires monthly sampling for total coliforms at designated sampling locations in the distribution system. Samples must be absent of total coliforms in 95 percent of all samples in the month or system in violation. Positive samples must be verified by testing *E. Coli* or fecal coliform and both must be absent or system in violation. 2. The plant must be designed to fully disinfect ambient fecal matter coliforms so it does not enter the distribution system, resulting in TCR violations.
Surface Water Treatment Rule (SWTR)	1. Treatment must achieve 3.0-log (99.9 percent) removal/inactivation for *Giardia lamblia*. Conventional treatment results in a 2.5-log credit requiring a 0.5-log credit from chemical disinfection. 2. Treatment must achieve a 4.0-log (99.99 percent) removal/inactivation for viruses. Conventional treatment results in a 2.0-log credit requiring a 2.0-log credit from chemical disinfection. 3. Combined filtered water turbidity ≤ 0.5 NTU in at least 95 percent of monthly samples and combined filtered water turbidity never to exceed 5 NTU. 4. Turbidity monitoring continuously or by grab samples every four hours. 5. Establishes chemical disinfection credit based upon the Ct value (disinfection residual concentration "C" multiplied by the disinfection contact time "t").
Lead and Copper Rule (LCR)	1. Requires periodic monitoring of designated locations in the distribution system for copper and lead concentrations. 2. Action levels for lead and copper of 0.015 mg/L and 1.3 mg/L, respectively. 3. Treatment to prevent corrosion or replacement of pipes may be necessary if action levels exceeded in more than 10 percent of the samples.
Interim Enhanced Surface Water Treatment Rule (IESWTR)	1. Added a 2.0-log removal/inactivation requirement for *Cryptosporidium*. Allowed conventional sedimentation/filtration treatment plants a 2.0-log credit if turbidity provisions are met. 2. Reduced turbidity requirements to the following: combined filtered water turbidity less than or equal to 0.3 NTU in at least 95 percent of monthly samples and combined filtered water turbidity never to exceed 1 NTU.

Table 2.2-1 Summary of Provisions of Regulations Affecting Design of the C/CWTP

Regulation	Provisions
Stage 1 Disinfectants / Disinfection By-Products Rule (DBPR)	1. Set Total Organic Carbon (TOC) removal requirement percentages dependent upon the source water alkalinity and TOC concentration. 2. Established DBP Maximum Contaminant Levels (MCLs) as follows: THM - 80 µg/L; HAA - 60 µg/L; bromate - 10 µg/L; and chlorite - 1.0 mg/L. 3. Required monitoring in the distribution system to verify compliance with the DBP MCLs.
Radionuclides Rule	1. Established MCL for uranium of 30 µg/L and retains MCLs for gross alpha particles, beta/proton emitters, and radium 226/228. 2. Initially requires four quarterly samples at entry points to distribution system to determine compliance with rule and to set continued monitoring schedule. 3. Management techniques or treatment will be necessary if uranium MCL is exceeded.
Arsenic Rule	1. Lowered the total arsenic MCL to 10 µg/L in drinking water.
Filter Backwash Recycling Rule	1. Designates that all recycled streams in the WTP are returned to the front of the plant so recycled water is treated through all plant processes.
Long Term 2 ESWTR (LT2ESWTR)	1. Requires systems to collect and analyze 24 monthly samples of surface water sources for *Cryptosporidium* and turbidity. 2. Monitoring results dictate if additional treatment of *Cryptosporidium* is required based upon the average concentration from the collected samples. The average concentration indicates which "Bin" the source water is classified. 3. Bin classification determines additional treatment requirements (none, 1.0-, 2.0- or 2.5-log) above the 2.0-log requirements in the IESWTR. 4. Established a toolbox of processes that can be used to meet the additional treatment requirements.
Stage 2 DBPR	1. Revises compliance based upon a locational running annual average (LRAA) at the highest concentration areas in the distribution system. MCLs same as Stage 1 DBPR: TTHM - 80 µg/L and HAA - 60 µg/L.

Of particular significance to the design of the C/CWTP is the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). The purpose of the LT2ESWTR is to reduce illness linked with the contaminant *Cryptosporidium* and other pathogenic microorganisms in drinking water. Under the LT2ESWTR, systems will monitor their water sources to determine treatment requirements. This monitoring includes an initial two years of monthly sampling for *Cryptosporidium*. To reduce monitoring costs, small filtered water systems will first monitor for *E. coli*—bacterium which is less expensive to analyze than *Cryptosporidium*—and will monitor for *Cryptosporidium* only if their *E. coli* results exceed specified concentration levels.

Monitoring starting dates are staggered by system size, with smaller systems beginning monitoring after larger systems. Systems must conduct a second round of monitoring six years after completing the initial round to determine if source water conditions have changed significantly. Systems may use (grandfather) previously collected data in lieu of conducting new monitoring, and systems are not required to monitor if they provide the maximum level of treatment required under the rule.

LT2ESWTR requirements for *Cryptosporidium* treatment is based on monitoring results in filtered water systems. The systems will be classified in one of four treatment categories (bins). The majority of systems will be classified in the lowest treatment bin, which carries no additional treatment requirements. Systems classified in higher treatment bins must provide 90 to 99.7 percent (1.0 to 2.5-log) additional treatment for *Cryptosporidium*. Systems will select from a wide range of treatment and management strategies in the "microbial toolbox" to meet their additional treatment requirements. All unfiltered water systems must provide at least 99 or 99.9 percent (2- or 3-log) inactivation of *Cryptosporidium*, depending on the results of their monitoring.

The NMED DWB requires an "Application for Approval of Construction or Modification of Existing Public Water System" as mandated by the federal Safe Drinking Water Act and the NM

Drinking Water Regulations. The DWB's approval of an application does not imply a guarantee of any type for the constructed project nor does it relieve the applicant from the responsibility for the overall integrity of the project, the adequacy of the project's design, or from the responsibility of complying with any of the provisions other applicable state and federal laws or regulations.

2.3 Raw Water Quality

The C/CWTP will treat water diverted from the Rio Grande approximately three miles downstream of the Otowi Bridge and Highway 502. This section provides a brief summary of the water quality data that have been compiled for the raw Rio Grande water. An extensive discussion of the raw water quality is provided in the Pilot Testing and Water Quality Report (CDM, March 2006).

2.3.1 Turbidity and Suspended Sediment

The sediment data available for the BDD project has been collected from several sources including daily suspended sediment samples from the United Stated Geological Survey (USGS) and the raw water evaluation study conducted by CDM in the summer of 2005.

The USGS has been collecting Suspended Sediment Concentration (SSC) data for over 50 years. This data is available for daily samples from 1955 to 1993 and (approximately) monthly samples are available for 1993 to 2004. This is the largest and most complete resource of sediment data available for the Rio Grande in this area. Additionally, the collection and analysis protocols are likely more consistent than other, smaller sampling ventures.

CDM conducted a 6-month pilot study and water quality evaluation (Pilot Testing Report, CDM, March 2006) from April to October 2005. During this study, weekly samples of Rio Grande water quality parameters, including Total Suspended Solids (TSS), were collected including three extreme weather rain events.

Figures 2.3-1 and 2.3-2 provide probability plots of the Rio Grande turbidity data based on samples collected by the USGS at the Otowi Gage upstream of the proposed diversion site and samples collected during CDM's pilot study in 2005. The USGS data presented was collected over the period July 1978 to September 2002. The median, average, 95th percentile, and maximum turbidity values are 25, 48, 180, and 950 NTU, respectively. During the CDM pilot study higher levels of turbidity were observed. Between April and October 2005, the median, average, 95th percentile, and maximum turbidity values recorded were 86; 261; 1,230; and 4,180 NTU, respectively.

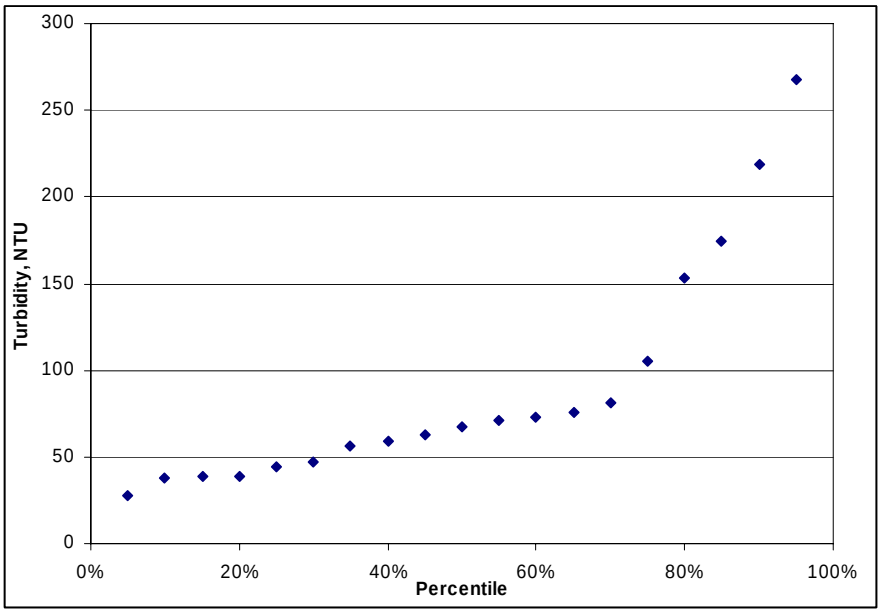


Figure 2.3-1 Probability Plot of Rio Grande Turbidity at Otowi (1970-2004)

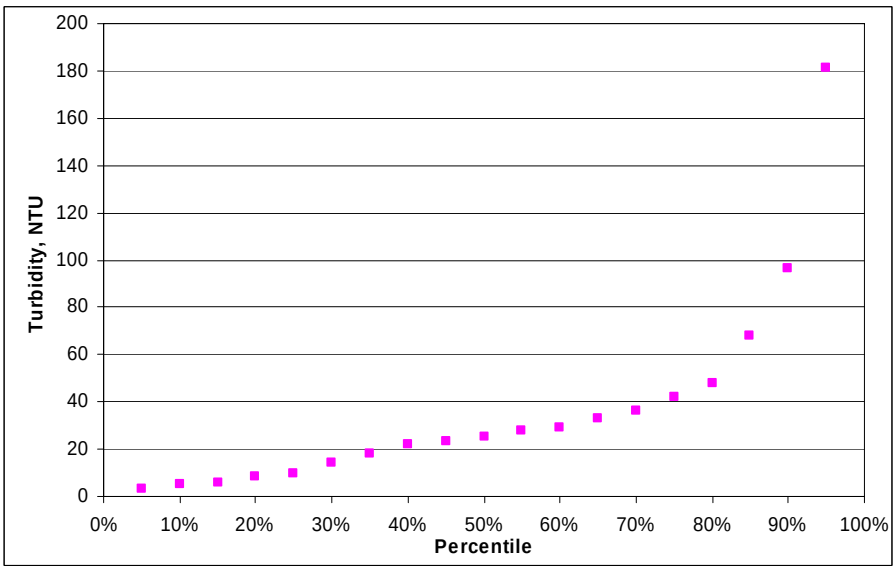


Figure 2.3-2 Probability Plot of Rio Grande Turbidity During Piloting

Figure 2.3-3 presents a probability plot of the Rio Grande SSC data based on samples collected at the Otowi Gage analyzed by the USGS. The data was collected between April 1971 and September 2004. The median, average, 95th percentile, and maximum levels recorded were 497; 1,985; 10,510; and 45,300 mg/L, respectively. A previous study[1] presented a detailed analysis of the suspended sediment concentrations collected by the USGS at the Otowi Gage versus the time of the year over a 45-year period (1955 to 2000). The analysis of the time series plots of these data indicated that there was "no overall seasonal pattern of [suspended sediment] concentration."

[1] Heggen, R.J. 2001 *Preliminary Las Campanas Intake Sediment Study*,

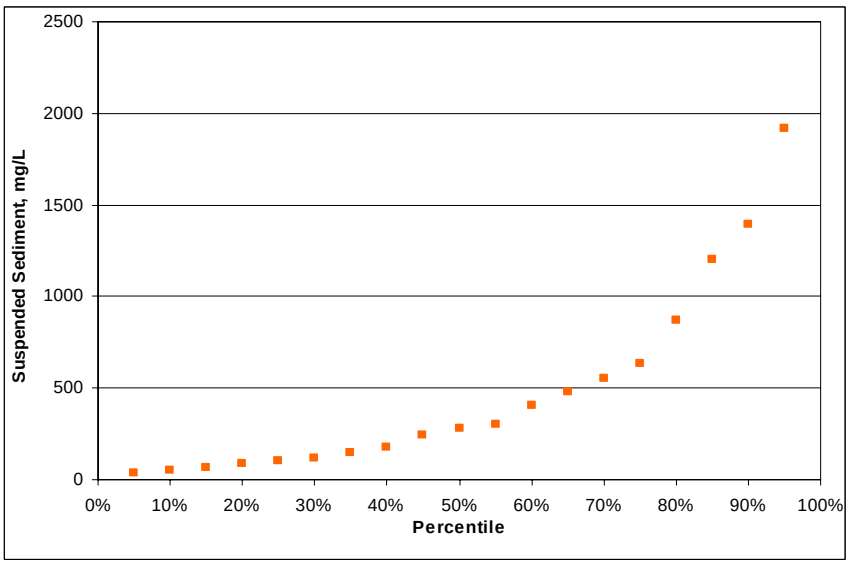


Figure 2.3-3 Probability Plot of Rio Grande Suspended Sediment at Otowi

Figure 2.3-4 presents a probability plot of the weekly TSS samples collected during the pilot study. This data was analyzed for Total Suspended Solids and may not be exactly comparable to the Otowi data for reasons discussed below.

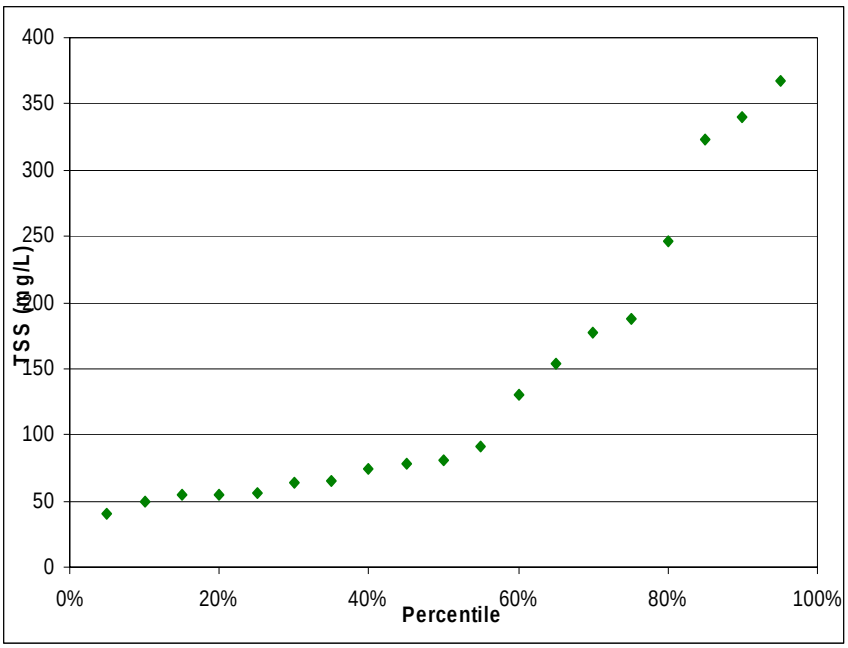


Figure 2.3-4 Probability Plot of Rio Grande TSS During Piloting

The turbidity and suspended solids data and the CDM pilot study results indicate that the turbidity and suspended solids levels in the Rio Grande do reach high levels and that the levels can increase rapidly due to rainfall events. Therefore, the design of C/CWTP, including the solids handling facilities, needs to account for these raw water conditions. In other words, a robust clarification system is required ahead of filtration. In addition, if turbidity levels over 1,000 NTU

are to be treated at the C/CWTP, then pre-sedimentation is required ahead of the clarification process. Moreover, the solids handling system at the C/CWTP must be designed to account for very high daily solids loadings. Figure 2.3-5 is a photograph of the Rio Grande near the diversion site when the turbidity was approximately 80 NTU and TSS was 40 mg/L. Figure 2.3-6 is a photograph of the same area while the turbidity is approximately 210 NTU and the TSS is 180 mg/L. These two photographs were taken three weeks apart. The red tint of the river in the second photograph indicates runoff originating in the Rio Chama watershed.

Figure 2.3-5 Rio Grande on August 1, 2005

Figure 2.3-6 Rio Grande on August 22, 2005

There is a difference between SSC and TSS that may affect the design criteria of the solids handling equipment in both the raw water facilities and at the C/CWTP. Gray et al. (2000)[2] report that SSC is a better representative of natural water conditions than TSS, is more reliable, especially when the sand concentration is about 25 percent of the dry sediment mass. From previous reports[3] on Rio Grande water composition and the evaluation of the particle classification data, the sand-size particles comprise about 25 percent of the suspended sediment composition. 20-25 percent sand in the total solids content is expected in the diverted water from the Rio Grande. SSC is reported to be a better indicator of suspended sediment content because even if the collection protocol for SSC and TSS samples are identical, the SSC analyzes the entire sample volume for solids content while the TSS only analyzes an aliquot of the original sample. The difference is that some of the larger sand-size particles may not be transferred into the TSS aliquot as a result of particle rejection by the transfer pipettes. The SSC method has also been standardized by the USGS National Sediment Laboratories while TSS analysis allows for some variability in protocol for analytical laboratories (Gray et al., 2000).

Historical data presented to date for the BDD project was of turbidity and suspended sediment, not TSS. SSC is typically higher than TSS concentration. Use of TSS data may underestimate the actual solids loadings. The sand fraction of total solids is often underestimated in the TSS analysis.

Alternative or surrogate measurements of suspended sediment such as turbidity and other optical/laser methods should be used with caution. Turbidity and SSC do follow a general positive

[2] Gray, J.R., D. Glysson, L.M. Turcios, and G.E. Schwarz. 2000. *Comparability of Suspended Sediment Concentration and Total Suspended Solids Data*. WRIR 00-4191. USGS, Reston, VA

[3] CH2M Hill. 2002. *Las Campanas Buckman Suspended Sediment Removal and Return.* Draft Report.
USGS. 2002 *Spatial and Temporal Variation s in Streamflow, Dissolved Solids, Nutrients, and Suspended Sediment in the Rio Grande Valley Study Unit, Colorado, New Mexico, and Texas, 1993-95.* WRIR 02-4224

trend; however, the relation is neither linear nor absolute. Gray et al. (2003)[4] prepared correlations of surrogate technologies to SSC and found that the demonstration technologies had to be calibrated to the specific source water and were not transferable to another site once calibrated. No correlation of turbidity to TSS or SSC values has been confirmed for the Middle Rio Grande.

2.3.2 Microbiological Parameters

A limited amount of microbiological data is available for the Rio Grande water. The available data indicate the presence of both *Giardia* and *Cryptosporidium*. Bacteriological analyses revealed the presence of Escherichia coliform (E. coli.). These data indicate the contamination of the river water by fecal matter. Therefore, the C/CWTP must be designed to provide effective barriers to prevent the passage of potentially pathogenic microorganisms into the potable water supplies of the City and County.

Table 2.3-1 summarizes the *Cryptosporidium* data for the Rio Grande in the area of the proposed Diversion Structure and suggests that the C/CWTP will fall into a Bin 1 or Bin 2 category under the LT2ESWTR. For this analysis, it is assumed that the C/CWTP will be designed to comply with a Bin 3 designation under the LT2ESWTR. This designation would normally be given to plants treating raw water with average *Cryptosporidium* levels of between 1 and 3 oocysts/L. Bin 3 requires treatment to achieve an overall *Cryptosporidium* removal/inactivation of at least 5 logarithmic units (log). Treatment plants using conventional treatment that are operated in compliance with the IESWTR receive a prescribed 3.0-log *Cryptosporidium* treatment credit, so for a Bin 3 designation, an additional 2-log of removal/inactivation must be provided. At least 1-log of this additional removal/inactivation treatment has to be achieved via ozone, chlorine dioxide, ultraviolet radiation, membranes, or bag filters. For membrane filtration plants, the primary agency determines the additional treatment requirements.

Table 2.3-1 Summary of *Cryptosporidium* Testing Results

Sample Date	Volume Tested (Liter)	Turbidity (NTU)	*Cryptosporidium*			River Flow (cfs)
			# Detected(1)	# Observed / L(2)	# Reported / L(3)	
5/24/2005	10	>165	0	0	<0.1	6480
7/18/2005	2.5	728	0	0	<0.4	1000
8/12/2005(4)	3	>1000	0	0	<0.3	1500
8/16/2005	10	35	0	0	<0.1	700
9/14/2005	10	78	0	0	<0.1	720
9/28/2005(4)	0.1	2350	0	0	<10	1400
10/11/2005(4)	3	164	1	0.3	0.3	600
Data from Previous Water Quality Evaluations(5)						
08/13/2003	7.0	150	0	0	<0.1	481
08/25/2003(4)	9.0	117	0	0	<0.1	966
09/11/2003	0.0984	2590	0	0	<10	774
10/09/2003	2.0	71.2	0	0	<0.5	372
11/06/2003	6.116	16.1	1	0.2	0.2	382
12/04/2003	5.0	25.3	0	0	<0.2	600
01/06/2004	10.0	7.8	0	0	<0.1	385

NTU = Nephelometric Turbidity Unit
cfs = Cubic Feet per Second
(1)Detected = Includes all oocysts and cysts of *Cryptosporidium* or *Giardia* observed, respectively, using EPA Test Method 1623
(2)Measured as # detected divided by the total volume tested in liters
(3)Laboratory presents *Cryptosporidium* concentration (#/L) as detection limit when the number detected is 0 (see laboratory report)
(4)Collected on a rain event
(5)Previously reported in Water Quality Evaluations Project Reports
(6)Laboratory results in report are rounded to the nearest 10

[4] Gray, J.R., et al. 2003. *USGS Research on Surrogate Measurements for Suspended Sediments.*

2.3.3 TOC and Disinfection By-Product Precursors

TOC analyses of the Rio Grande water samples collected at the Otowi Gage revealed minimum, median, average, 95th percentile, and maximum levels of 1.8, 5.0, 6.3, 10.9, and 91 mg/L, respectively. These statistics are based on 144 samples collected between July 1972 and December 2003. Dissolved organic carbon (DOC) analyses were also performed by the USGS on the Rio Grande water samples; 149 samples collected at the Otowi Gage between July 1975 and December 2003. The analyses revealed minimum, median, average, 95th percentile, and maximum DOC levels of 1.2, 3.3, 3.8, 6.2, and 26 mg/L, respectively.

Observations regarding the occurrence of TOC in the raw Rio Grande water were made during the CDM pilot study. The highest levels of TOC occur during spring runoff (snowmelt) with levels ranging from 4 to over 8 mg/L. The high springtime TOC levels coincide with low alkalinity levels resulting in the highest TOC removal requirements under the enhanced coagulation requirements of the Stage 1 Disinfectants and Disinfection Byproducts Rule (DBPR). Based on these data, compliance with the enhanced coagulation requirements would require different ranges of TOC removal during different periods of the year:

- February through June: 25 to 45 percent required TOC removal
- July through September: 15 to 45 percent required TOC removal
- October through January: 15 to 35 percent required TOC removal

Based on CDM pilot study results, it will be necessary to reduce the TOC level in the finished water to 2.0 mg/L or less to meet the total trihalomethane (TTHM) and haloacetic acid (HAA) goals of 60 and 40 µg/L, respectively. This assumes a 96-hour detention time in the City and County water distribution systems. However, CDM's pilot study showed that THMs and HAAs in the finished water did not significantly increase after 48-hours.

2.3.4 Water Temperature, pH, Conductivity, and Hardness

The USGS measures the water temperature of the Rio Grande at the Otowi Gage. Between January 1971 and September 2004, the USGS made 714 measurements. Figure 2.3-7 provides a probability plot of the water temperature data. The 5th percentile, 25th percentile, median, average, 95th percentile, and maximum water temperatures observed were 1.5, 7, 13, 13, 22, and 27 degrees Celsius (C), respectively.

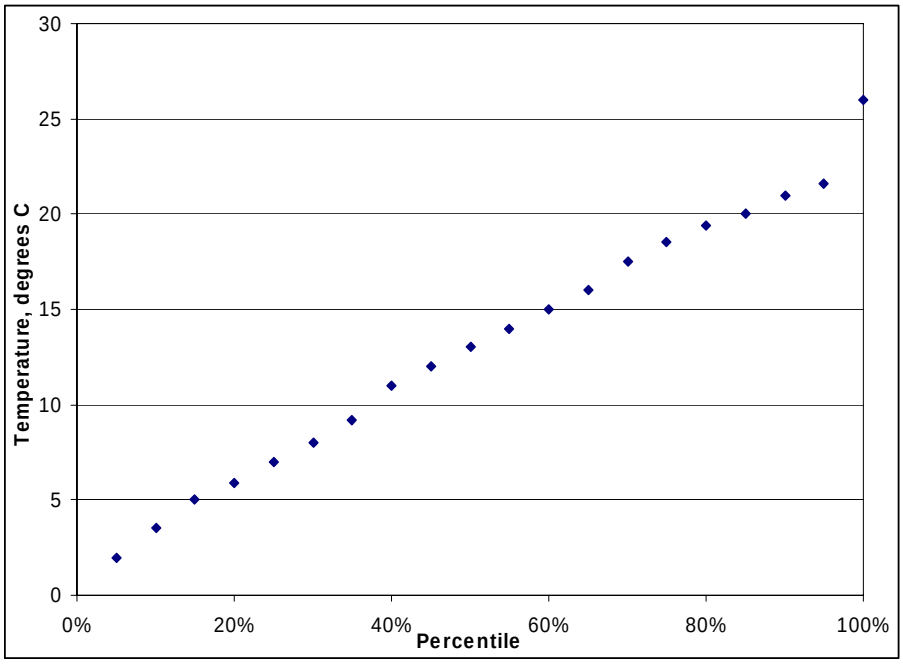


Figure 2.3-7 Probability Plot for Rio Grande Temperature at Otowi (1970-2004)

Figure 2.3-8 provides a probability plot of the Rio Grande water temperature observed at Otowi during the pilot study. The 5th percentile, 25th percentile, median, average, 95th percentile and maximum temperatures during this period were 12.2, 15.5, 18.7, 18.2, 23.5, 25.3 degrees C, respectively.

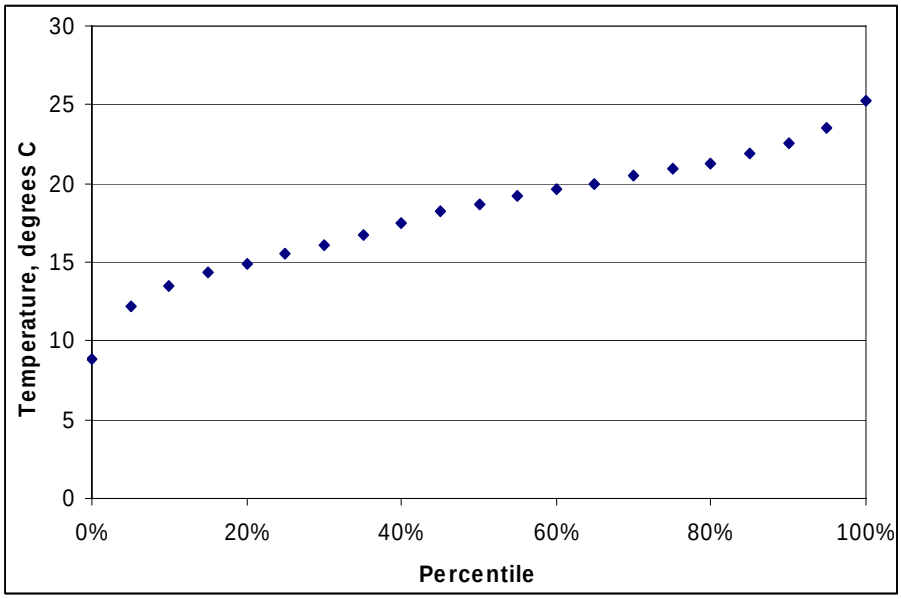


Figure 2.3-8 Probability Plot for Rio Grande Temperature During Pilot Study

2.3.5 Contaminants

Several primary constituents were measured at concentrations of 80 percent of the maximum containment level (MCL) in at least one sample during pilot testing or historically at Otowi: alpha particles, arsenic, beryllium, beta emitters, bis(2-ethylhexyl)phthalate, lead, radium 226/228 and turbidity. Additionally, the secondary constituents measured at or above 80 percent of the secondary standard included aluminum, color, iron, manganese, pH and TDS.

Many of these constituents were at elevated levels (80 percent of MCL or greater) only in samples collected during storm events. These include arsenic, beryllium, lead, and radium 226/228. Most of these constituents were present in dry weather samples but at significantly lower concentrations. Other constituents also were detected well below the MCL but at higher levels in the samples collected during storm events compared to the dry weather samples. These constituents are likely washing into the Rio Grande with stormwater runoff. The organic chemical bis(2-ethylhexyl) phthalate is not likely a contaminant in the river but an artifact of sampling or analysis. This is a constituent in the flexible tubing used at the pilot plant that was detected at a higher concentration in the treated water than the river or when none was detected in the river.

Per the 1996 Amendments to the Safe Drinking Water Act, on September 17, 1999, the Unregulated Contaminant Monitoring Program (UCMP) was revised to gather and generate data on unregulated contaminants which will be evaluated and prioritized for possible new drinking water standards. List 1 includes 12 chemical contaminants for which analytical methods exist. List 2 contains contaminants with newly developed laboratory methods. List 3 contains contaminants without established laboratory methods. One set of Rio Grande water samples was collected for analysis of the entire List 1 unregulated contaminants. These constituents were all below the laboratory detection limit and the following observations were made:

- No "unregulated contaminants" were detected for the UCMP List 1
- Strontium was not detected in the paired treated water sample which was collected when the strontium was elevated in the river sample.
- Tritium was observed in all samples at a consistently low concentration, the concentration remained low in the rain samples as is most likely attributable to background levels of tritium in the atmosphere.
- Plutonium 239/240 was measured at the very low detection limit in one raw water sample
- No isotopes were detected in the treated water sample

- Perchlorate was observed in all river samples and the concentration was higher in the samples collected during storm events
- Pharmaceuticals and personal care products were not detected in previous studies at the Buckman diversion site, indicating that they are either not entering the system, readily decompose or below detection level

No contaminants were noted as being present and unamenable to conventional treatment or more robust treatment processes. However, robust processes will provide multi-barriers for removal of contaminants should they appear in the future.

2.4 Finished Water Quality Goals and Criteria

2.4.1 Regulatory Requirements

Regulatory requirements were outlined in Table 2.2-1. Those regulations presented a guiding framework for the evaluation and preliminary design of the water treatment process.

In addition to using reasonably conservative design criteria, there will be redundant unit processes to address the different water quality parameters of concern. For instance, multiple barriers will be provided to minimize the likelihood of viable *Cryptosporidium* oocysts from passing into the potable water supplies of the Owners. Specifically, a *Cryptosporidium* removal/inactivation goal of 5-log is set that requires treatment to provide at least 2-log of inactivation credit for the conventional filtration alternatives and 1-log of inactivation credit through inactivation or removal beyond filtration.

2.4.2 Water Quality Goals and Criteria

The DB Contractor must design and construct the C/CWTP such that the finished water is in compliance with all applicable regulations; and specific performance parameters and compliance requirements outlined in Table 2.4-1. In general, the treatment goals for the C/CWTP will be a maximum of 80 percent of the MCL or action levels of all water quality regulations as specifically outlined in the performance requirements in Section 5 of RFP Volume III. Water quality regulations applicable to the C/CWTP include standards established by the NMED Drinking Water Quality Bureau and federal drinking water regulations promulgated by the USEPA. In addition, all treated water shall be in compliance with any water quality parameters set forth in Table 2.4-1 not otherwise established by the above regulatory agencies.

Table 2.4-1 describes specific performance requirements for finished water quality. Testing and compliance determination frequency, monitoring locations and the minimum performance standard are outlined for each parameter.

Table 2.4-1 Specific C/CWTP Performance Standards

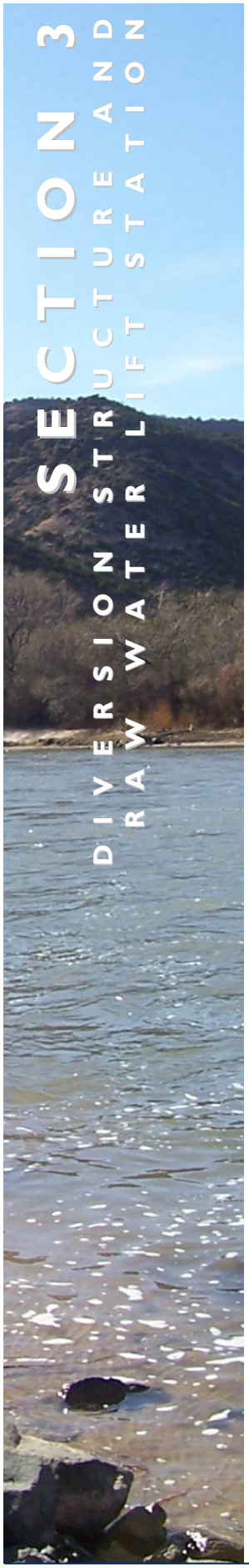
Parameter	Point of Compliance	Performance Standard
Turbidity	Membrane Filter Inlet	<2.0 NTU, 90 percent of each calendar month based upon continuous monitoring
	Combined GAC Contactor effluent	≤ 0.15 NTU, 95 percent of each calendar month based upon continuous monitoring
		≤ 0.20 NTU, 100 percent of each calendar month based upon continuous monitoring
Cryptosporidium removal/inactivation credit	Removal between Inlet Flow Distribution Box and Combined GAC Contactor Effluent	Daily demonstration (the average of twelve, 2-hour interval samples) of greater than or equal to 5.0-log removal of 3 to 5 micron particles between Inlet Flow Distribution Box and Combined GAC Contactor Effluent
Cryptosporidium	Combined GAC Contactor Effluent	Not detected in 100 percent of weekly samples
Giardia removal/inactivation credit	Removal between Inlet Flow Distribution Box and Combined GAC Contactor Effluent	Daily demonstration (the average of twelve, 2-hour interval samples) of greater than or equal to 4.0-log removal of 5 to 10 micron particles between Inlet Flow Distribution Box and Combined GAC Contactor Effluent
Giardia	Combined GAC Contactor Effluent	Not detected 100 percent of weekly samples
Viruses removal/inactivation credit	Finished Water Storage Effluent to Distribution	4.0-log removal demonstrated as follows: 2.0-log from compliance with turbidity performance standards and 2.0-log from virus CT requirements for primary and/or secondary disinfectants
Total Coliform	Finished Water Storage Effluent to Distribution	Not detected 100 percent of time based on daily grab sample
Fecal Coliform	Finished Water Storage Effluent to Distribution	Not detected 100 percent of time based on daily grab sample
Heterotrophic Plate Count	Finished Water Storage Effluent to Distribution	<25 colony forming units 100 percent of time on daily grab sample
TOC Removal	Removal between Inlet Flow Distribution Box and Combined GAC Contactor Effluent	Most stringent of two determination methods: 1) regulatory removal requirement percentage (determined from TOC and alkalinity at Inlet Flow Distribution Box) and 2) less than 2 mg/L at the Combined GAC Contactor Effluent. TOC measurements at both compliance points at minimum of once per every two hours averaged for each day to calculate removal and TOC concentration for both determination methods.
Total THM and HAA Formation	Finished Water Storage Effluent to Distribution	THMs < 60 µg/L on running average based upon on simulated distribution test performed twice weekly[1]
		HAAs < 40 µg/L on running average based upon on simulated distribution test performed twice weekly[1]
Free Chlorine Residual	Finished Water Storage Effluent to Distribution	0.2 mg/L to 0.5 mg/L 100 percent of time as determined at conclusion of simulated distribution test performed twice weekly[1]
Bromate	Finished Water Storage Effluent to Distribution	<10 µg/L 100 percent of time, based upon twice weekly grab sample
pH	Finished Water Storage Effluent to Distribution	Between 7.5 and 7.8 100 percent of the time based upon continuous monitoring
Iron	Finished Water Storage Effluent to Distribution	≤0.01 mg/L 100 percent of time based upon daily grab samples
Manganese	Finished Water Storage Effluent to Distribution	≤0.04 mg/L100 percent of time based upon daily grab samples
Aluminum	Finished Water Storage Effluent to Distribution	≤40 µg/L 100 percent of time based upon daily grab samples
Lead	Finished Water Storage Effluent to Distribution	≤0.012 mg/L in all samples based upon jar test methodology[2]
Copper	Finished Water Storage Effluent to Distribution	≤0.1 mg/L in all samples based upon jar test methodology[2]
True Color	Finished Water Storage Effluent to Distribution	≤5 pt-Co units 100 percent of time, based upon daily grab samples
Fluoride	Finished Water Storage Effluent to Distribution	1.0 ± 0.05 mg/L 100 percent of time based upon continuous monitoring
Taste and Odor	Finished Water Storage Effluent to Distribution	100 percent of all biweekly tests shall meet the following: - Geosmin ≤5 ng/L - Methylisoborneol (MIB) ≤5 ng/L - Threshold Odor Number (TON) <1
Primary and Secondary Standards	Finished Water Storage Effluent to Distribution	All primary and secondary standards shall be <80 percent of their respective MCL in all samples based upon biweekly samples unless performance standard for that constituent identified previously

1 Simulated distribution test parameters as follows: no additional pH adjustment after plant finished water pH adjustment; free chlorine residual at end of test equal to 0.2 mg/L minimum; temperature +/- 3 degrees C from collected sample temperature; and test period of 96 hours +/- 2 hours. Running average based upon computation of running average of all completed tests during the current and all previous performance testing periods and are not separate averages for each performance testing periods

2 Two jar tests shall be conducted for a period of four weeks with weekly water exchange. One sample jar shall contain a copper sample coupon and the other sample jar shall contain a lead/tin solder coated copper sample coupon. Approximately 900 mL of finished water shall be placed in the 1-L sample jar and exposed to the coupons in the dark at room temperature for one week. A sample of the exposed water shall be collected from each jar for analysis of lead (or copper depending on jar), pH and chlorine residual weekly and the water then replaced with fresh sample from the finished water distribution outlet. The samples shall be unaltered and simulate water in the distribution system.

Finished water from the C/CWTP will at times be blended with water from the Buckman Wells, the City Wells and County Wells. Also, there is a potential for the C/CWTP finished water to blend with water from the City's Canyon Road WTP. Lead and copper corrosion control testing was completed during the pilot testing activities and it appears that adjustment of the finished water pH to match the other blended water pH, along with the addition of a sequestering agent such as zinc orthophosphate, will be adequate to minimize problems associated with blending. The potential for corrosion and other water quality impacts between the different waters needs to be evaluated on a continuous basis during operation of the facilities.

Corrosion control optimization study and testing is required once facilities are constructed. Adjustments may be required for corrosion control at each major change in the quality of water feeding the distribution system - such as when the Canyon Road WTP or the Buckman Wells are seasonally turned on and off.



This section provides design criteria, alternatives analysis, and preliminary design details for the Diversion Structure and RWLS to meet the capacity goals and criteria outlined in Section 2.

3.1 Diversion Structure

A number of design considerations were evaluated in selecting the appropriate screening technology including aesthetics, security, cleaning/ maintenance requirements and reliability. To minimize maintenance requirements and improve the reliability of the Diversion Structure, a "passive" intake screen (an intake screen with no moving parts) was preferred. This section presents the evaluation of Diversion Structure alternatives that was completed during preliminary design.

3.1.1 Performance and Design Criteria

The performance and design criteria for the Diversion Structure and the cleaning system are outlined in Table 3.1-1.

Table 3.1-1 Diversion Structure and Cleaning System Design Criteria

Design Parameter	Value
Diversion Structure	
Type	Bankside Raw Water Diversion and Screening Structure
Number of Intake Cells	5 (three duty and two standby)
Design Capacity (3 of 5 intake cells in service)	20.8-mgd
Screen Design	
Type	Wedge-Shaped Wire Screen
Individual Screen Capacity	6.9-mgd
Maximum Through Slot Velocity	0.5 fps
Maximum screen slot size	0.069-inches (1.75-mm)
Cleaning System (screen and intake cell floor)	
Type	Air Backwash
Minimum Air Backwash Capacity	25 cfm per sf of screen 50 cfm per sf of horizontal floor
Minimum Air Delivery Nozzles	1.4 per sf of screen 2 per sf of floor
Minimum Air Compressor Capacity	32 acfm and 175 psig
Minimum Air Receiver Capacity	660 gallons
Minimum Air Receiver Recharge Rate	20 to 100 psig in 15 minutes

3.1.2 Initial Screening of Alternatives

A feasibility study was previously conducted for Las Campanas to evaluate several water withdrawal alternatives; including wells, infiltration galleries, and surface water Diversion Structures. This study concluded that a surface water Diversion Structure was the preferred alternative. The conclusions of the feasibility study are presented in the report entitled *Las Campanas Water Supply Project Feasibility Study* dated October 2001. As part of that study, a river geomorphology and hydraulics evaluation was completed for use in selecting and designing a surface water diversion.

The OC reviewed the original study and evaluated new data to verify previous recommendations. The previous study and the verification are discussed below.

3.1.2.1 River Geomorphology and Hydraulics

The Rio Grande near Buckman Road has historically had a somewhat mobile channel. A discussion of the historic river conditions and the morphology of the area are presented in a document dated April 30, 2001, developed by Dr. Richard Heggen for CH2M-Hill. As indicated in that document, the river channel has stabilized in the last 40 years since completion of the Abiquiu Reservoir (1963) upstream from Buckman on the Rio Chama. Since completion of the reservoir, the range of flows in the Buckman reach has moderated. Prior to construction of the reservoir, typical low flows at the Otowi Bridge gaging station (approximately 3 miles upstream from Buckman) were often below 200 cfs and peak flows were up to 20,000 cfs. Following completion of the reservoir, the low flows have generally been above 200 cfs and peak flows are generally less than 10,000 cfs. Although a wide range of flows still occur, the low flows are generally higher than historic flows and the high flows are lower. This moderation in the typical range of flows is illustrated in Figures 3.1-1 (daily flow prior to Abiquiu) and 3.1-2 (daily flow post Abiquiu). Figure 3.1-3 shows the annual peak flows recorded at the Otowi gage from 1895 to 2005.

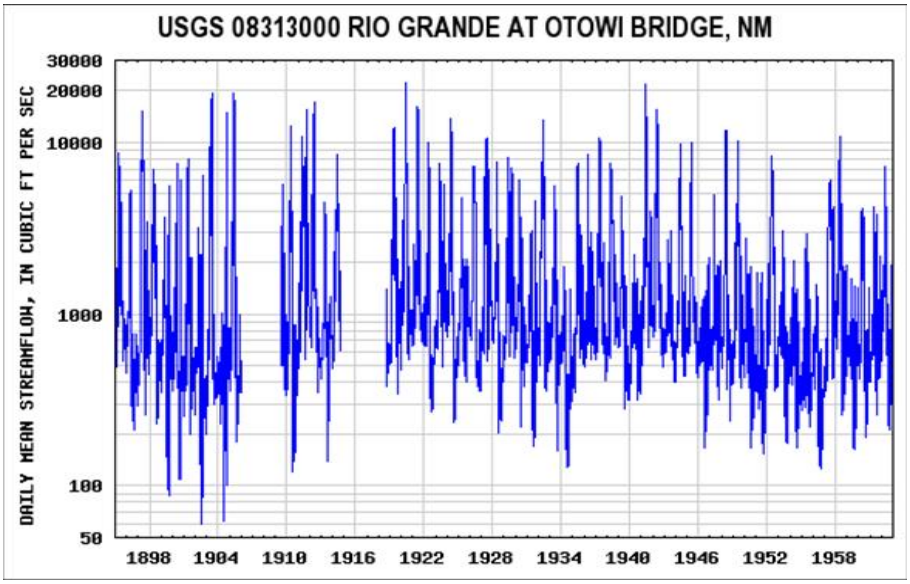


Figure 3.1-1 Daily Flow at Otowi Bridge Gaging Station 1895-1962

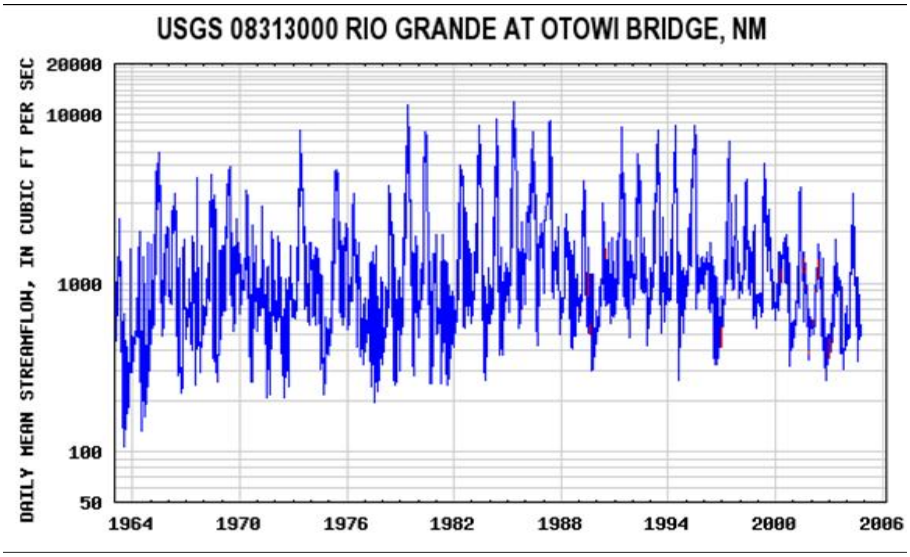


Figure 3.1-2 Daily Flow at Otowi Bridge Gaging Station 1963-2005

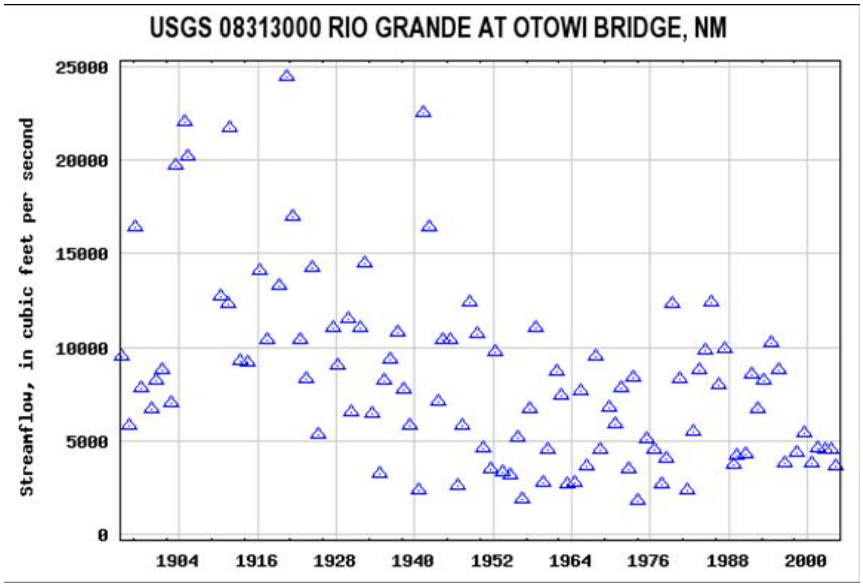


Figure 3.1-3 Peak Annual Flow at Otowi Bridge Gaging Station 1895-2005

The effects of this peak flow reduction are evident through review of the aerial photographs and observations at the site. The photographs indicate that the river channel has stabilized since reduction of the peak flows has occurred with vegetation becoming established through the series of aerial photographs. Observations on the ground reveal that the river banks are armored with cobbles in the reach near the Diversion Structure site and confirm that the vegetation is well established, further indicating stabilization of the channel.

The selected site for the Diversion Structure is located just downstream from a bend in the river. This is frequently a favorable location for an intake because of the scouring action that occurs as a result of the secondary currents generated at the bend. The secondary currents are a spiraling of the flow that tends to sweep bed-load sediment toward the inside of the bend and creates a scour hole on the outside of the bend. A survey of the channel bottom in the vicinity of the proposed Diversion Structure was conducted and verified that the deepest portion of the channel is located immediately in front of the proposed Diversion Structure. Figure 3.1-4 shows the proposed Diversion Structure location and the contours of the river bottom.

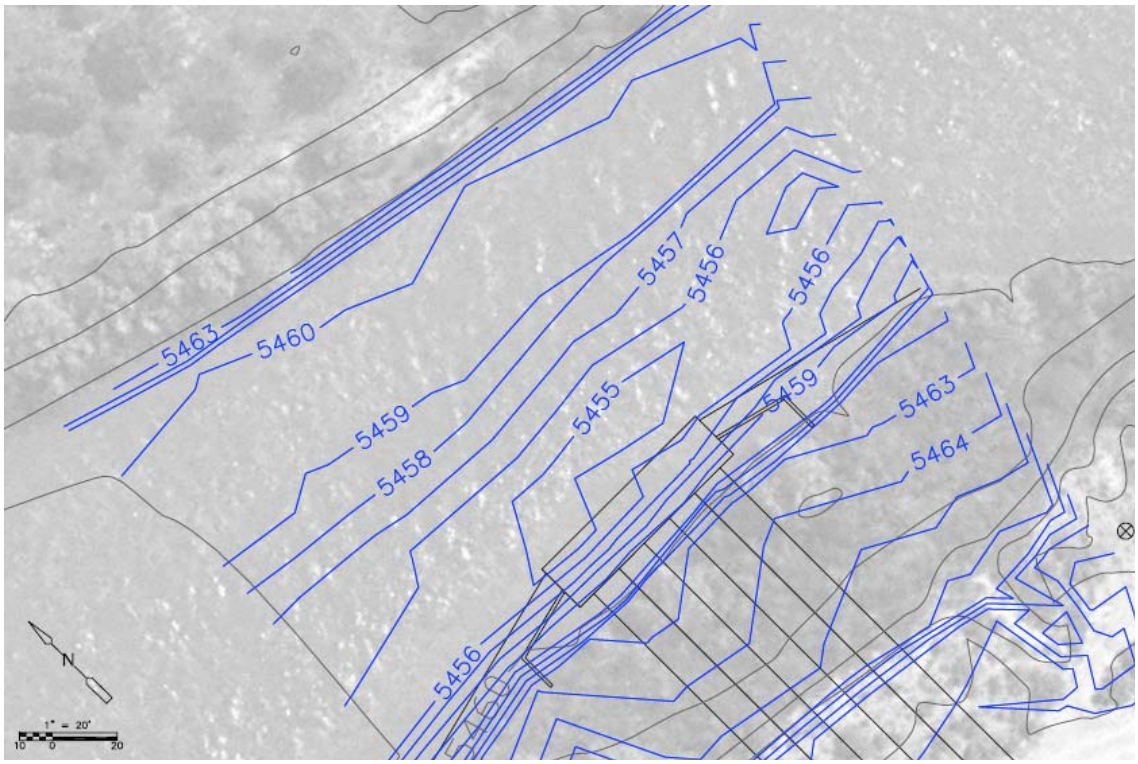


Figure 3.1-4 Diversion Structure Location and River Bed Elevation Contours

Hydraulic modeling, using Hydraulic Engineering Center River Analysis System (HEC-RAS) software, was conducted in 2001 by Dr. Richard Heggen. The modeling resulted in a prediction that the water depth at the Diversion Structure will be approximately 3-ft deep at minimum flows, increasing to approximately 4-ft at 700 cfs and up to 8-ft deep at flood stage. During the site survey on March 21, 2006, the water surface elevation was measured to be elevation 5459.96-ft above mean sea level (amsl) or approximately 5-ft deep at the Diversion Structure site when the Otowi Gaging station indicated a river flow of 730 cfs. This indicates that the HEC-RAS model may predict a lower water surface elevation at the Diversion Structure than was measured. Based on this information, the Diversion Structure will be designed such that the screens will remain

completely submerged when the water surface elevation drops as low as elevation 5458.5-ft amsl, which will correspond to approximately 200 cfs.

3.1.2.2 Initial Screening Recommendations

A number of design considerations were evaluated in selecting the appropriate surface diversion technology including aesthetics, security, cleaning / maintenance requirements and reliability. To minimize maintenance requirements and improve the reliability of the Diversion Structure, a "passive" intake screen (an intake screen with no moving parts) was preferred.

3.1.3 Diversion Alternatives

Several "passive" Diversion Structure design alternatives were considered:

- Alternative 1 - Submerged tee or drum screens in the river channel
- Alternative 2 -Bankside flat panel intake screens in the river channel
- Alternative 3 - Side channel intake (with panel, tee or drum screens)
- Alternative 4 - Diversion dam (with panel, tee or drum screens)

Each of these technologies is appropriate for certain application. The following section provides a summary of the considerations for each of these alternatives.

3.1.4 Evaluation and Cost Analysis

The following presents the evaluation of the four intake diversion alternatives.

3.1.4.1 Evaluation of Alternatives

Alternative 1 - Submerged Tee or Drum Screens in the River Channel

Tee and drum screens are an effective passive screening technology that consist of cylindrically shaped screens with closely spaced bars. An example of a tee screen is shown in Figure 3.1-5. Water passes through the screen slots while aquatic life remains in the river. The intake screens can be piped directly to the pump inlets. The intake can be equipped with an air backwash system to remove debris that accumulates on the screens.

Figure 3.1-5 Tee Screen

The primary design challenge presented by the tee or drum screen design for the Buckman Diversion structure is the depth required for the screens to function properly. There is only approximately 3- to 4-ft of depth in the river for the Diversion Structure and the tee screens require a minimum total depth of 2 times the screen diameter to function properly. Based on this design requirement, the maximum diameter screen that could possibly be used is a 24-inch screen and it would be necessary to install more than 20 intake screens to meet the capacity requirements. Other concerns with the tee and drum screen designs are that they can cause scouring of the river bed, especially in fast moving rivers. There is also a concern with the deposition of solids downstream from the screens that can alter the river hydraulics.

Tee or drum screens in the river channel were not recommended for further consideration based on the shallow depth available for the installation.

Alternative 2 - Bankside Flat Panel Intake Screens in the River Channel

Bankside flat panel screens are a common configuration for surface water Diversion Structures. The screens consist of an array of screen panels, each with closely spaced bars. Figure 3.1-6 shows two available screen bar configurations. The bars are spaced such that they allow water to pass through the screen slots while aquatic life remains in the river. This screen designs provide a robust screen panel that is resistant to impact damage by floating debris. To further protect the screens from floating debris, a log boom (for low cross-flow installations) or coarse bar racks can be incorporated; however, bar racks can increase maintenance requirements for removal of stringy materials. This screen design is rigid and generally does not require additional protection to prevent damage. The screens can be mounted on to a concrete structure designed to direct screened water to the pump suction piping. To remove debris that may accumulate on the screens, an air backwash system can be incorporated.

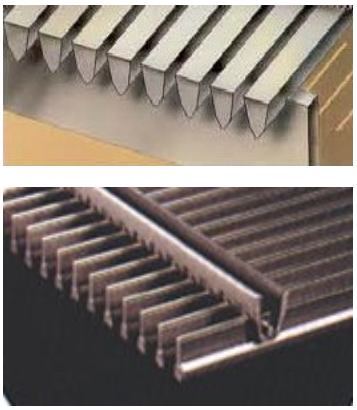


Figure 3.1-6 Wedge Wire Screen (top) and Profile Bar Screen (bottom)

The bankside intake screen is effective for use in installations where there is a moderate or high cross-flow velocity. The cross-flow prevents debris from collecting on the screens and sediment from accumulating in front of the screens. Care must be taken in the design of the interior of the Diversion Structure just downstream of the screens to minimize potential for accumulation of sediment. The bankside intake screen is effective for shallow installations and can be oriented on an angle to increase the square footage of the screens, thereby reducing the screen through slot velocity.

A bankside intake along the river channel was found to be a feasible design approach that can meet the design criteria. This design is recommended for further consideration based on the shallow depth available at the Buckman Diversion Structure site.

Alternatives 3 and 4 - Side Channel or Diversion Dam Intake with Panel, Tee, or Drum Screens

A side channel off from the main river channel is commonly used with various types of intake screens and is effective for many installations. This type of structure, however, is not conducive for use on the reach of the Rio Grande near Buckman due to the high suspended sediment load. In a side channel configuration, the velocity of the flow would slow from the relatively high velocity in the main channel, resulting in the deposition of solids. This arrangement would result in a great deal of dredging maintenance to prevent plugging of the intake screens.

A diversion dam intake design is often used with a side channel intake structure or can be used with a bankside type intake. This concept is effective for many applications, but again, will result in the slowing of the flow in the main river channel and consequently significant solids deposition. Although the diversion dam concept can be designed to provide a means to sluice the intake structure to reduce solids deposition in the immediate vicinity of the screens, there remains a concern about severe deposition in the main river channel which could disrupt the river channel characteristics and hydraulics.

Side channel or diversion dam type intakes were not recommended for further consideration based on expected complications with property ownership issues (native American tribe owns other side of river), DEIS impacts, as well as the potential for significant solids deposition problems with both design concepts.

A cost evaluation was not performed because only one of the four alternatives was determined technically feasible.

3.1.5 Recommended Diversion Structure Facilities

3.1.5.1 Diversion Structure Hydraulics

The Diversion Structure will be an on-stream bankside intake structure (Alternative 2) with a low-profile design. The fish screens will be oriented parallel to the river flow to facilitate a cross-flow at the screen face. The cross-flow velocity at the intake site during typical flow conditions is on the order of 3 to 5 fps and will facilitate natural passive cleaning because it is significantly higher than the maximum screen through velocity of 0.5 fps. The structure will be designed with a smooth transition from the bankline and river bottom to the intake structure face to prevent the occurrence of eddies and in front of and downstream from the structure. The bottom of the intake screens will be at least 6-inches above the deepest portion of the scour hole located in the river at the intake site and the toe of the screens will extend outward from the banks to the scour hole.

The top of the intake screens will be below the normal low water level in the river to prevent floating debris from impacting the screen or becoming impinged. The intake structure will be designed with five individual intake cells, each associated with one raw water pump. This design will facilitate maximum velocities in the intake structure by only utilizing the intake cell associated with operating pump, thereby minimizing solids deposition in the intake. The interior geometry of the intake cells will have sloped walls and minimal flat surfaces to reduce the potential for solids accumulation in the intake. Drawing 1M-1 in the Raw Water Facility Preliminary Design Drawings presents the preliminary Diversion Structure drawings.

Computational Fluid Dynamics (CFD) modeling of the Diversion Structure was performed to evaluate the hydraulic conditions within the individual intake cells. One of the primary hydraulic concerns is deposition of solids in the intake cells. The CFD modeling, see Figure 3.1-7, facilitated evaluation of intake modifications to identify appropriate methods of maximizing the floor currents, thereby limiting solids deposition. The CFD modeling technical memorandum is included in Appendix F.

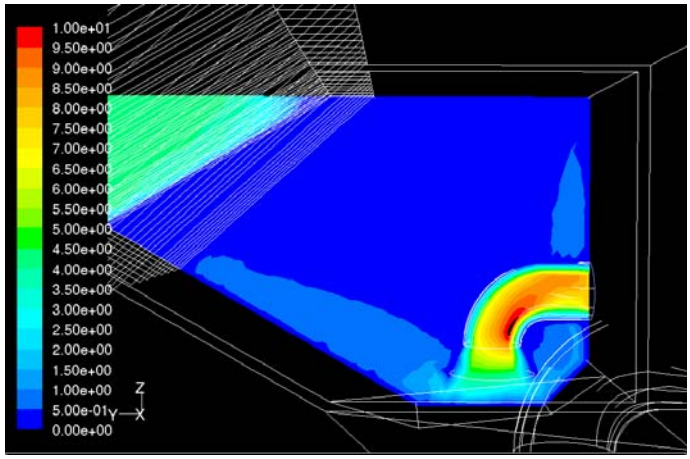


Figure 3.1-7 Velocity contours of Diversion Structure CFD model with blue at 0.5 fps and red at 10 fps

3.1.5.2 Process and Mechanical

The intake screens will be flat panel stainless steel wedge-shaped wire-type screens properly sized to pass the flow of one raw water pump. The screens will be designed to prevent fish and other aquatic biota from entering or becoming impinged upon the intake structure. The Diversion Structure design criteria were presented in Table 3.1-1.

The top of the screen will be below the typical low water level in the river providing approximately 3-ft of river depth that can be screened. To increase the effective screen area and stay within the velocity criteria, the screen will be inclined at an angle of 30 degrees. With this configuration, each intake cell will be equipped with 10-ft wide and 6-ft long screen panels to meet

the maximum through screen velocity criteria. This configuration will also provide a 20 percent safety factor to compensate for potential screen fouling.

Each intake cell will have two air backwash systems; one for screen cleaning and one to re-suspend settled sediment prior to startup of the raw water pumps. The air backwash equipment will consist of a process logic controller (PLC), air compressor, and air receiver tank in the RWLS and two air distribution manifolds per intake cell and associated valves within the Diversion Structure. The air backwash system design criteria were presented in Table 3.1-1.

The air backwash system for the screens will be initiated by a timer based on the run time for the corresponding pump. The screen will be backwashed every 4 hours of run time, but the frequency of backwashing can be changed based on operating experience. The air backwash system for the screen will also be initiated if it is detected that the through screen velocities are approaching maximum acceptable levels as a result of screen plugging. Screen fouling will be indicated based on the water level differential across the screens as measured by pressure transducers.

The Diversion Structure floor backwash system will be initiated prior to start-up of each pump. When a pump is called to start, the air backwash system will release air for 15 seconds and upon stopping, the pump will be immediately started. It is anticipated that air will become entrapped in the turned down pump inlet. To reduce the amount of air trapped in the pump suction piping, an air vent should be installed on top of the pump inlet to release excess air. At each pump start, the pump should be ramped up to obtain a pipeline velocity of at least 6 fps for resuspension of material that may have settled. After a short operational period the pump will be operated to obtain a velocity of 4 fps or more to keep material in suspension. Operation of pumps will be rotated to clear Diversion Structure cells and pipelines of settled material.

Locking access hatches will be provided for each intake cell. Although it is not expected that it will be necessary to enter the intake cells on a regular basis, provisions will be provided to isolate each intake with water tight panels that will cover the intake screens. After installation of the panels, a portable submersible pump can be used to pump down the Diversion Structure. The intake screens and air backwash manifolds are to be designed so that they can be removed from the Diversion Structure. The screens' air backwash manifolds will be designed such that they can be dismantled into sections that are no more than 4-ft wide and less than 125 pounds. A portable jib crane will be provided that can be moved to each intake cell for removal of the screens and air backwash manifolds as necessary.

3.1.5.3 Civil Site Work

The Diversion Structure site will be returned to the existing conditions with similar site topography. Rip rap will be placed along the river bank both up and downstream from the Diversion Structure and will provide a smooth transition from the river bank to the face of the Diversion Structure. Drainage will be away from the Diversion Structure and the ground surface will be generally returned to pre-construction contours where possible. Civil site work also includes a facility access road from Buckman Road. The access road will be similar to Buckman Road with a gravel base course surface and a 16-ft wide driving width for two-way traffic.

3.1.5.4 Landscaping/Revegetation

Any area disturbed through the construction of the Diversion Structure must be revegetated in accordance to requirements and guidelines of the United States Forest Service (USFS).

All disturbed areas at the Diversion Structure must be revegetated by planting indigenous riparian plants. Successful stabilization of the river bank will depend upon the rapid establishment of riparian plants and cannot be gained by seeding. This work should be performed by a riparian specialist. Table 3.1-2 presents a list of suggested plant species, however, opinions may vary between wetland specialists and the final list of species will be approved by the USFS.

Table 3.1-2 Suggested Plant Species for Riparian Revegetation at the Diversion Structure

Plant Name	Plant Name
Carex emoryi	Scirpus olneyi
Eleocharis palustris	Scirpus pungens
Juncus balticus	Scirpus validus
Scirpus acutus	Salix exigua

3.1.5.5 Structural

The structural requirements provide minimum design criteria and will be used as a guide in the design and construction of the Diversion Structure.

The general types of construction at the Diversion Structure include cast-in-place concrete or prestressed concrete for liquid containing basins or reservoirs.

Foundations of structures will be designed in accordance with the conclusions and recommendations of the project geotechnical report (Appendix A). In general, the type of foundation for the Diversion Structure is a mat foundations or continuous spread footings along the walls with slab-on-grade at the center portions for the liquid containing basins or reservoirs.

3.1.5.6 Architectural Design for Diversion Structure

Design Standards

All buildings for the Buckman project will be designed to meet the 2004 New Mexico General Construction Building Codes (Title 14 NMAC – Chapters 5 and 7). The buildings must also comply with the requirements of the BLM and USFS where the buildings lie on those respective properties.

Space Planning and Architectural Style

This structure is essentially a large concrete inlet box on the bank of the river and is not a building. Therefore there are no architectural space planning or style considerations.

Architectural Construction Requirements

The structure's size, shape and configuration will be designed by the project structural and hydraulic engineers. Therefore there are no architectural materials or construction systems to be considered.

3.1.5.7 Operations

The Diversion Structure will be designed and constructed to allow reliable, continuous, un-staffed operation. The screens will be a passive design and will not require regular operator interface. A regular part of operations at the intake will be screen cleaning and intake cell cleaning with the air backwash system. Pressure transducers will detect a hydraulic differential across the screen of an operating intake cell and will initiate the air backwash screen cleaning system when the head loss across the screen exceeds a designated value. The air backwash will also be initiated on regular time intervals regardless of differential water levels. In addition to the screen air backwash system, there will be an intake cell floor air backwash system. This system will be initiated prior to

startup of a pump to re-suspend sediment that has settled on the flat portion of the Diversion Structure floor. The sediment will then be removed from the intake cell by pumping through the raw water pumps. Both air backwash systems will be fully automated and will not require operator interface to initiate.

3.1.5.8 Maintenance

The Diversion Structure is designed minimize maintenance requirements. The intake will have few flat surfaces where sediment can collect and the flat surfaces that do exist are located near the pump inlet where the fluid velocities will be the greatest. This arrangement will facilitate re-suspension of settled sediment to minimize maintenance. Regular maintenance inspections of the intake should be conducted to monitor sediment accumulation inside the intake cells as well as outside the structure. The wide range of flows and dynamic river characteristics could periodically result in sediment accumulation or scour outside the intake structure. Although the Diversion Structure is designed to prevent accumulation of sediment in front of the screens, periodic excavation of sediments could be required and the river geomorphology should be monitored to document any changes over time.

Maintenance of the intake screens could be periodically required. The design does not include provisions for trash racks and there is a possibility that the screens could be damaged by large floating debris. The structure is to be designed such that screens can be removed and cells hydraulically isolated with panels installed on the outside of the structure. A slotted guide is envisioned for installing the panels along the river side of the intake cells. The isolation panel will be sufficiently water tight to allow the intake cell to be pumped dry for access. The intake screens and associated air backwash equipment will be designed such that they can be removed from the intake cells to facilitate maintenance of the screens.

The Diversion Structure and associated equipment will require little routine maintenance. The screens are a passive design and free from moving parts. The air backwash system will be equipped with an air compressor, located at the RWLS, which will require regular maintenance typical of this type of equipment. The required maintenance will primarily be associated with monitoring of sedimentation and scour at the river and solids accumulation within the intake cells.

3.2 Raw Water Lift Station

The RWLS will be used to pressurize the raw Rio Grande water for conveyance from the Diversion Structure to the SRF. In addition to the raw water pumps, the lift station houses support equipment (e.g., the air backwash system) for the Diversion Structure.

3.2.1 Performance and Design Criteria

The RWLS will pump raw Rio Grande river water after it passes through the fish screens at the Diversion Structure. The fish screens will remove sand and other suspended materials of size 1.75-mm and larger. As a result, the raw water pumps will have to be able to reliably pump water at times containing relatively large concentrations of abrasive sand and silt materials.

The Rio Grande river water has very variable water quality characteristics, especially regarding suspended solids levels. Following rain storms, the watershed and various tributaries to the Rio Grande contribute considerable soil and other debris to the water. The USGS collects water quality and other data at the Otowi Gage, which is approximately 3 miles upstream from the proposed Buckman diversion site. Based on these data, the 95th percentile suspended sediment

concentration is approximately 10,500 mg/L. The average suspended sediment level is approximately 2,000 mg/L. This relatively high suspended solids level could result in high levels of abrasion of typical pumping equipment materials. Therefore, appropriate material selection will be required to provide reliable, long-life equipment.

Figure 3.2-1 shows the relationship between the hardness of common materials found in nature and common pump material metal alloys. As shown on the bottom scale, the Brinell hardness of silica sand is approximately 570. Most common metal alloys for fabricating pump casings and impellors (e.g., cast iron) have lower Brinell hardness values. In other words, these materials are vulnerable to erosion from pumping sand laden waters, such as the Rio Grande. Using materials with Brinell hardnesses above 570 (e.g., high chrome cast iron) would provide protection from erosion. Sometimes, pumps with normal cast iron casings are fitted with wear plates of metal of high hardness in the areas most prone to erosion.

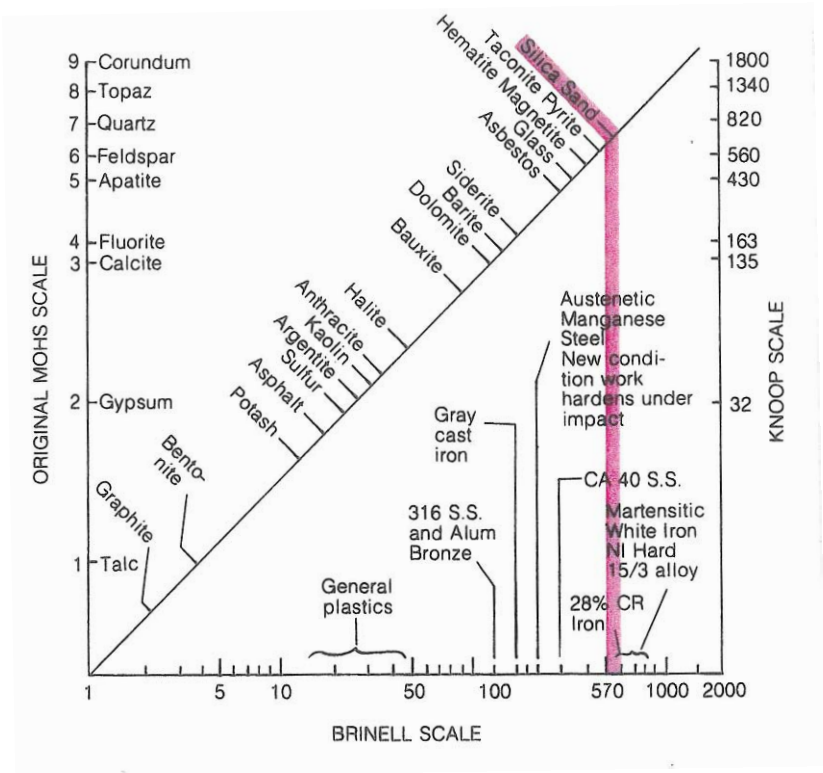


Figure 3.2-1 Mineral Versus Metal Alloy Hardness

A second important issue with the high suspended solids levels in the raw water is deposition of sand and silt in pipelines and other locations. It will be important that provisions be made to prevent low velocities in piping and to allow for re-suspension of sand and silt if settling does occur.

Other design issues relate to the remote location of the RWLS. The pumping station is to be designed to not require continuous staffing. Automation and other features need to be included in the design so daily visits to the facility by operation and maintenance staff are not required. Also, the remote location and normally unstaffed condition of the facility will make it more susceptible to vandalism. The facility must be designed to include security features to minimize and prevent access and damage to the equipment. This will include multiple levels of protection such as walls and fences, and security cameras and intrusion alarms.

Table 3.2.1 lists the performance and design criteria for evaluating the RWLS alternatives. There will be five pumps (three duty, two standby). Each pump will have a capacity of approximately 4,820 gpm (6.9-mgd), with a total pump station capacity of 20.8-mgd. This flow capacity includes an additional 1,800 gpm (4 cfs) for carrier water to return sand removed from the raw water at the SRF back to the Rio Grande. If the USEPA does not permit return of the sediment to the Rio Grande, then the capacity of the raw water pumps can be lowered to 18.2-mgd.

Table 3.2-1 Raw Water Lift Station Design Criteria

Description	Value
Number of Pumps	5 (three duty, two standby)
Capacity, Each Pump	4,820 gpm
Capacity, Total	14,460 gpm
Total Dynamic Head @ Capacity	235-ft

3.2.2 Initial Screening of Alternatives

Several pump station configurations and pump types were evaluated for use at the RWLS, including the following:

- Alternative 1 - Vertical non-clog pumps in a dry pit
- Alternative 2 - Horizontal end-suction slurry pump
- Alternative 3 - Submersible pumps located at the Diversion Structure
- Alternative 4 - Submersible pumps located at a remote wet well
- Alternative 5 - Vertical turbine pumps drawing from a wet well

Vertical turbine pumps were screened out due to concerns over high maintenance from the abrasive solids in the river water. Maintenance on the submerged bearings, impellers, and other pump components would require the use of a crane to lift the pumps from the wet well.

3.2.3 Pumping Alternatives

The initial screening resulted in three pump types for further evaluation: vertical non-clog (Alternative 1), horizontal end-suction slurry pumps (Alternative 2) and submersible (Alternatives 3 and 4). The evaluation included a comparative cost analysis on the three configurations as well as an assessment of non-economic factors.

Figure 3.2-2 shows a typical vertical non-clog type pump installation. The pumps would be placed in a dry pit with individual pump suction connections to the pipes originating at the Diversion Structure. The dry pit would be accessed by a set of stairs from the upper level of the pumping station. One option with this configuration would be to locate the electric motor at the upper level with an extended shaft to the pump. This would provide protection of the motor from water damage in case the dry pit floods. Another option would be to place the non-clog pump in a horizontal orientation.

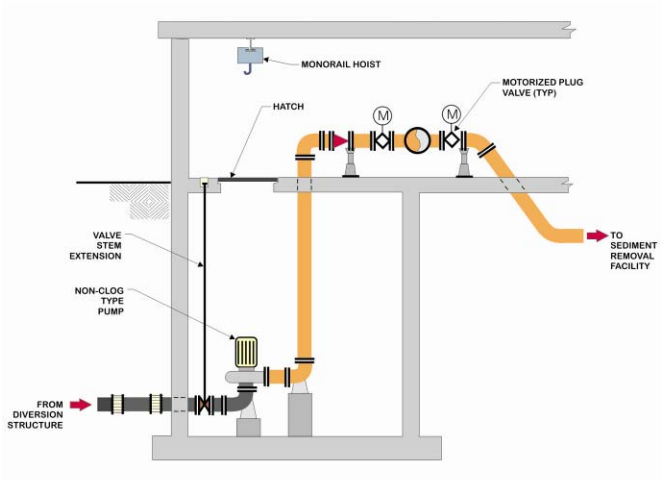


Figure 3.2-2 Alternative 1 - Vertical Non-Clog Pump Installation

Figure 3.2-3 shows a typical horizontal end suction slurry type pump installation in a dry pit. The suction flange of each pump would be aligned with one of the pipelines extending from the Diversion Structure. Valves and other equipment would be located at the upper level of the pumping station

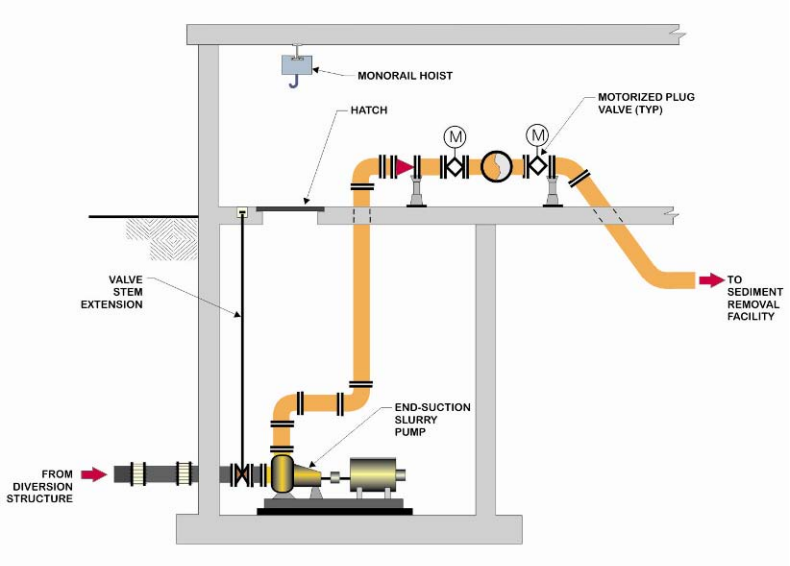


Figure 3.2-3 Alternative 2 - Horizontal End Suction Slurry Pump Installation

Figure 3.2-4 shows a typical submersible pump installation. The pumps would be placed in a wetwell receiving water from the Diversion Structure. A hatch would be available to withdraw the pumps. The discharge valves could be placed in an at grade vault, as shown. Alternatively, the valves could be located in the building used to house the electrical equipment and other equipment. Submersible-type pumps can also be placed in a dry pit. This configuration may require a water jacket cooling system for the motor.

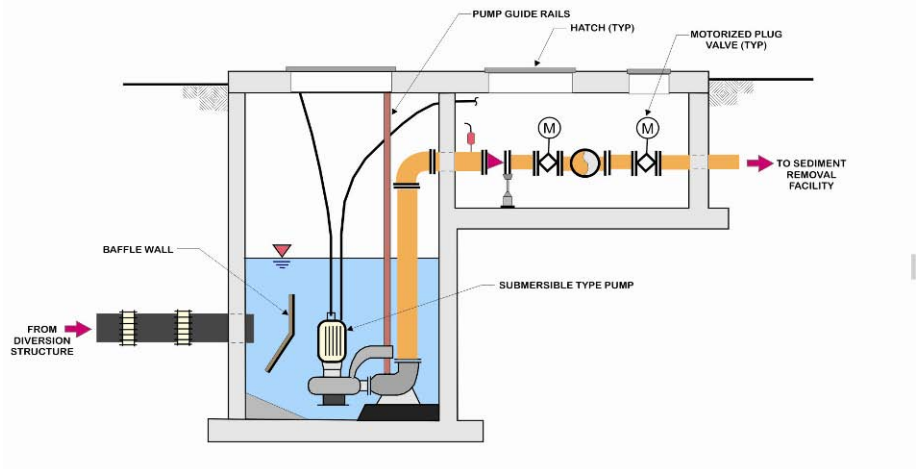


Figure 3.2-4 Alternatives 3 and 4 - Submersible Pump Installation

3.2.4 Evaluation and Cost Analysis

An evaluation was performed on the three alternatives for the pump type and pumping station configuration for the RWLS. The overall objectives for the Project are as follows:

Quality – Provide high-quality project facilities and equipment that meet performance requirements in order that the Owners can reliably operate the Project to produce high-quality drinking water

Cost – Minimize the Owners' life-cycle cost of the Project

Schedule – Initially establish and maintain the project schedule in order to delivery the completed Project in the shortest practicable time and eliminate (to the greatest extent achievable) future occurrences of material project completion delays

Risk – Minimize the risks of project delivery to all parties, maximize the clarity and acceptance by all parties of the risk allocation, and eliminate (to the greatest extent achievable) the Owners' risks – subsequent to award of the DB Contract – of increased costs and of the completed Project not meeting performance requirements

3.2.4.1 Evaluation of Alternatives

Each of the different pump type and pumping station alternatives has advantages and disadvantages. Among the categories included in evaluation of the alternatives were the following:

- Construction cost
- Operation and maintenance cost
- Life-cycle cost
- Availability in materials with Brinell hardness of 600
- Specialized design features for pumping sand/silt slurries
- Efficiency of pumps
- Ease of maintenance
- Anticipated frequency of maintenance
- Vulnerable to flooding
- Site space requirements

3.2.4.2 Construction, O&M and Life-Cycle Cost Analysis

Table 3.2-2 shows the results of an economic analysis of the three alternative pump type/pump station configurations. Except for Alternative 3, Submersibles at Diversion Structure in Wet Wells, it was assumed that the lift station pumps would be located approximately 250-ft east of the Diversion Structure. This is a reconnaissance-grade cost analysis using a similar basis for comparing among the alternatives. The accuracy of the estimate is considered to be +50 percent/-30 percent in 2006 dollars.

Table 3.2-2 RWLS Pumping Station Alternatives Cost Comparison

	Cost[1] ($-million)				
	Vertical Non-Clog in Dry Pit (Alt. 1)	End-Suction Slurry in Dry Pit (Alt. 2)	Submersibles at Diversion Structure in Wet Wells (Alt 3)	Submersibles in Wet Wells (Alt 4)	Submersibles in Dry Pit (Alt 5)
Construction Cost	4.4	4.8	4.6	4.4	4.5
Annual O&M Cost	0.41	0.38	0.40	0.40	0.41
Total Annual Cost	0.74	0.73	0.74	0.73	0.74
Unit Cost ($/ac-ft)	85	84	85	84	85

Notes:
1. This is a comparative cost estimate for selecting between alternatives. The costs are considered to have an accuracy of +50 percent/-30 percent in 2006 dollars.
2. Total annual costs assume construction costs are amortized over 25 years at 5.5 percent.
3. Unit cost is based on an assumed annual pumping volume of 8,730 AFY.

As indicated in the table, the construction cost is similar for the different alternatives. The submersible and vertical non-clog pumping station configurations have lower construction costs than the end suction slurry pump alternative due to the reduced footprint of the wet well and dry pit, respectively. The assumed horizontal orientation of the end suction pump requires a larger area for the dry pit. The submersible pumps had higher annual O&M costs due to the less efficient pumps and motors resulting in higher annual electrical energy costs. The vertical non-clog and end-suction pumps were assumed to have similar efficiencies. To develop total annual costs, the construction costs were amortized over 25 years at an interest rate of 5.5 percent and the results added to the annual O&M costs.

The pumping station configuration using end suction slurry pumps (Alternative 2) and submersible pumps in wet wells (Alternative 4) had the lowest total annual costs, but the cost difference between the alternatives was negligible. Similarly, the unit costs were essentially the same for the different alternatives. The unit costs were each based on pumping 8,730 AFY, which is the combined annual raw water demand from the BDD Project for the three Partners as noted in the DEIS.

3.2.4.3 Ranking of Alternatives

Table 3.2-3 provides a summary of an evaluation of the different RWLS alternatives. The evaluation included both cost and non-economic factors. The different alternatives have been scored for each of the different factors. Total scores are computed for each factor category and an overall total score and ranking are computed for each alternative. The total scores are computed by taking the individual factor scores and multiplying by the assigned "weight" of each factor and then summing the products.

Table 3.2-3 Evaluation Matrix for Raw Water Pumping Station Alternatives

Raw Water Lift Station Alternatives	Quality Factors					Risk and Aesthetic Factors							Cost Factors			Total Overall Score	Overall Ranking
	Abrasion Resistant Materials	Specialized Design for Sediment	Ease of Maintenance	Frequency of Maintenance	Quality Score	Proprietary (sole source vendor)	Minimizes Confined Space Entry	Application History	Space Requirements	Accessible During High River Flows	Low Profile	Risk/Aesthetics Score	Construction Cost	O&M Cost	Cost Score		
Weight:	20	20	20	20	80	8.3	8.3	8.3	8.3	8.3	50	50	20	30	50	180	
1. Vertical Non-Clog Pumps in Dry Pit	4	4	4	4	320	5	3	3	3	5	3	183	3.5	3.5	175	678	
2. End-Suction Slurry Pumps in Dry Pit	5	5	5	5	400	5	3	5	2	5	3	192	3	5	210	802	1
3. Submersibles in Wet Well at Diversion Structure	5	4	2	4	300	5	5	4	4	1	5	200	4	4.5	215	715	
4. Submersibles in Wet Well	5	4	3	4	320	5	5	4	4	5	4	225	5	4.5	235	780	2
5. Submersible Pumps in Dry Pit	5	4	4	4	340	5	3	4	3	5	3	192	4.5	4	210	742	3

Notes
1. Scores range from 1 to 5 with 5 being the highest most desirable score possible.

For this analysis, the "quality factors" were assigned an overall weighting of 80, or 44 percent, of the overall weighting of 180. The "risk and aesthetic factors" and the "cost factors" were each assigned a weighting of 50, or 28 percent overall. The weights assigned to each factor and factor category indicate the assumed importance of that factor. The last column of the matrix ranks the different alternatives.

The end suction slurry pumps scored highest in the "Quality" category. These pumps are specifically designed to handle water containing high levels of sand. They include design features and are available in hard materials that increase their durability for this service. Submersible pumps set in wet wells scored highest in the "Risk and Aesthetics" category. This was due to scoring high in several of the factors of this category. Submersible pumps in wet wells would eliminate the need to enter a below-grade dry pit for routine inspection and maintenance of the pumps. Eliminating the dry pit would also reduce the space requirements within a building and could reduce the overall profile of the pumping station, assuming that it was acceptable to use a portable crane or boom truck for removing the pumps.

The submersible pumps in wet wells and vertical non-clog pumps in a dry pit scored highest for the construction cost factor. This is related to the reduced size of the pumping station structure. The end-suction slurry pumps scored highest for the operation and maintenance cost factor. This is attributed to the higher pump efficiency of these pumps as well as the expected reduced maintenance requirements due to their specific design for pumping sand laden water.

The total overall scoring identified the end-suction slurry pumps as having the highest score. The submersible pumps set in wet wells and submersible pumps set in a dry pit scored second and third highest, respectively. Based on this analysis it is recommended that end-suction slurry pumps be the basis of the design of the RWLS.

3.2.5 Recommended Raw Water Lift Station Facilities

The recommended features of the RWLS are detailed in the following sections.

3.2.5.1 Process and Mechanical

Raw Water Lift Station Pumps

It is recommended that the RWLS include five end-suction type pumps specifically designed for pumping sand-laden water. Each pump would have a flow capacity of approximately 4,820 gpm, which is equivalent to one-third of the Diversion Structure Capacity of 32.2 cfs (14,450 gpm). Therefore, between one and three pumps would be placed in-service to meet the demands of the City, County, and Las Campanas. The other pumps would be in standby mode. Note: If the sand removed at the SRF is disallowed by the USEPA to be returned to the Rio Grande, then the flow capacity of the raw water pumps could be reduced to approximately 4,220 gpm each.

With a total of five pumps at the RWLS, as many as two pumps can be taken out of service for maintenance while allowing the lift station to be able to pump its full capacity. This standby capacity is recommended due to the severe raw water quality conditions periodically posed by the Rio Grande.

The wetted portions of the pumps are to be fabricated of hard metal with a Brinell hardness of at least 600 to limit abrasion by the sand laden raw water. The pumps should also include design features to minimize maintenance requirements on the seals and other components due to this service.

The pumps are to be located in a dry pit with access using standard stairs. This will facilitate observation and maintenance by the O&M staff. The pumps should be fitted with either "immersible" or "submersible" motors. This will avoid damage to the pump motors in the case the dry pit floods. The dry pit shall include a duplex sump pumping unit for removing water in the dry pit due to minor leaks or wash down. The discharge from the sump pumps shall be to an on-site infiltration field.

The five pumps will be equipped with variable frequency drives (VFDs). This will allow the pumps to be operated at rates closely matching the water demands by the City, County, and Las Campanas, without having to cycle the pumps on and off too frequently.

A bridge crane will be included at the RWLS for lifting and moving the raw water pumps within the dry pit. The bridge crane should be supported from the dry pit ceiling and designed to lift a pump or motor and move it to a location where the unit can then be raised through a hatch in the ceiling of the dry pit.

Raw Water Lift Station Piping and Valves

The piping for conveying the raw water within the pumping station should be rubber-lined steel (RLS). This type of piping is specifically designed to handle water containing abrasive solids. All piping beneath structures should be concrete encased.

Gate valves are to be used for isolation purposes. Control valves should be eccentric plug valves. The plug valves should be oriented so that the plug is positioned at the top of the valve when opened. Each raw water pump should be fitted with cushioned swing check valves with hydraulic dash pots. All valves should be placed in horizontal runs of pipe.

The buried piping for conveying raw water to and from the RWLS is recommended to be high density polyethylene (HDPE) to minimize the effects of abrasion caused by sediment.

Raw Water Pipeline Control Valves

The discharge of each of the five raw water pumps will be connected to a common discharge manifold. The manifold will also include the connections to the three raw water pipelines for conveying the water to the SRF. Each of the pipeline connections should include a motorized control valve. Similar to the operation of the pumps, one or more of the valves will be opened to bring a pipeline into service based on the water demand requirements of the City, County, and Las Campanas.

Hydropneumatic Tank

A hydropneumatic tank should be included to control water hammer surges. The hydropneumatic tank would be connected to the pump discharge manifold. The DB contractor will be responsible for conducting a surge analysis of the final design system to mitigate surges.

Electrical and Mechanical Building

Electrical equipment (e.g., motor control centers and variable frequency drives) and mechanical equipment will be housed in a building with a floor slab elevation at least 6-ft above the 100-year flood stage of the Rio Grande. Sumps and sump pumps will be provided to mitigate water intrusion. This building will house the fish screen cleaning system for the Diversion Structure.

PNM Electrical Yard

Transformers, switch gear, and meters for the electrical service from the Public Service Company of New Mexico (PNM) will be placed in a walled area near the Electrical and Mechanical Building. The electrical service will be double-ended to increase the reliability of the facility. The yard should include solid masonry or concrete walls to protect the electrical gear from bullets. Also, the yard should include solid steel vehicle access gates. Figure 3.2-5 shows a similar PNM Electrical Yard at Booster Station 1.

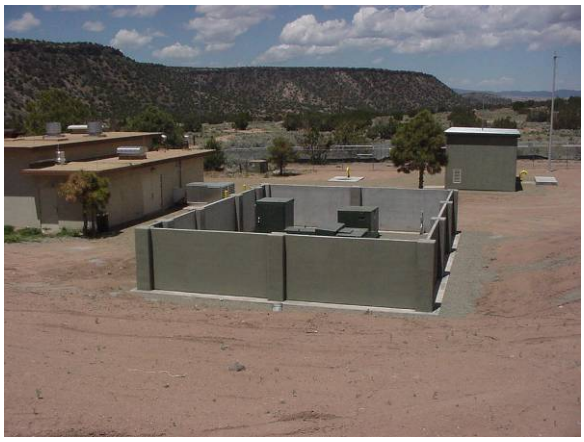


Figure 3.2-5 PNM Electrical Yard at Booster Station 1

3.2.5.2 Civil Site Work

Sheet 1C-4 of the Raw Water Pipeline and Facilities Preliminary Design Drawings shows a preliminary site plan for the RWLS. The entire mechanical/electrical building is partially buried with the soil sloped up the western and southern side and over the building roof. A retaining wall will be constructed on the southern side for access into the building. The PNM electrical yard will be located east of the RWLS Building.

The RWLS building (pump dry pit) is also buried to reduce visual impacts. An above-grade stairway entrance will provide access to the dry pit. A hatch will be provided to allow removal of the pumps and motors using a boom truck or crane. Soil will cover the RWLS building, similar to the mechanical/electrical building.

A set of 16-ft wide graveled roads will provide vehicle access to the different facilities. The access road would include a manual gate with pad lock. The entire site would be surrounded with a chain link fence including concertina wire.

The site should be graded to promote drainage away from the facilities. The drainage should be designed to work with the existing drainage patterns in the area.

3.2.5.3 Landscaping/Revegetation

Design criteria for landscaping and revegetation of the RWLS includes reclamation seeding of specially selected seed mix and planting of indigenous trees. The area of interest is out of the river channel and can thus be seeded with a reclamation seed mix approved by the USFS (see Table 3.2-4).

Table 3.2-4 Reclamation Seed Mix at the Raw Water Lift Station

Name (% of Total)	Name (% of Total)
Blue Grama (23%)	Indian Ricegrass (11%)
Western Wheatgrass (23%)	Sand Dropseed (11%)
Little Blue Stem (11%)	Sideoats Grama (6%)
Fourwing Saltbush (3%)	Sand Sage (11%)

In addition, in the interest of screening the facilities from view, trees will be planted around the site.

The trees may be transplanted trees from elsewhere on site or nursery stock, or a combination thereof. In order to ensure establishment of the trees, they will require watering by an on-site irrigation system. Recommended trees for this landscape are Populus deltoids (Rio Grande Cottonwood), Juniperus monosperma (One-seeded Juniper), and Forestiera neomexicana (New Mexico Olive). Container plantings will also be used to screen the facilities. Container plantings will be installed over each building roof area. Container plants will include the trees listed above and two additional plants - fourwing saltbush and sand sage. The landscape plan for the RLWS is presented on Sheet L-7 of the Raw Water Pipeline and Facilities Preliminary Design Drawings.

Figure 3.2-6 View from White Rock Overlook of RWLS

To minimize visual impacts from White Rock Overlook at the Buckman Road, the RWLS has been integrated into the site with landscaping to be strategically planted around the facilities. Figure 3.2-6 shows the view of the RWLS from White Rock Overlook and Figure 3.2-7 shows the view from Buckman Road. The images include a computer-generated 3D image of the designed facilities.

Figure 3.2-7 View from Buckman Road of RWLS

3.2.5.4 Structural

These structural requirements provide minimum design criteria and will be used as a guide in the design and construction of the RWLS facilities.

The general types of construction at the RWLS will include cast-in-place concrete for liquid containing basins. Below-grade structures, including roof slabs, will receive a waterproofing system.

Foundations of structures will be designed in accordance with the data presented in the project geotechnical report (Appendix A) and the recommendations of the DB Contractor's geotechnical engineer. In general, the type of foundation for the RWLS structures may be mat foundations or continuous spread footings along the walls with slab-on-grade at the center portions for the liquid containing basins or reservoirs and continuous spread footings along the walls for masonry buildings.

3.2.5.5 Architectural

Design Standards

All buildings for the Buckman project will be designed to meet the 2004 New Mexico General Construction Building Codes (Title 14 NMAC – Chapters 5 and 7). The buildings must also comply with the requirements of the BLM and the USFS where the buildings lie on those respective properties.

Space Planning

The interior space planning for this facility was performed by the process engineers and will be completed by the DB Contractor's design staff. The building size, shape and vertical height will be determined by the RWLS equipment to be housed.

Architectural Style

Meetings were held with the USFS regarding architectural style. The RWLS is to be compatible with its surroundings by constructing the pump building below grade and covered over with soil and native plant materials. The mechanical and electrical equipment building will be above grade with two sides and the roof buried below soil and plantings. The exposed concrete building walls will be on the side facing away from White Rock Overlook and the river. With this approach, all visual issues should be mitigated.

3.2.5.6 Operations

The RWLS will be designed and constructed to minimize operator intervention. The RWLS will be highly automated with PLC controls of the pumping systems and other equipment. The RWLS will be connected to the Owners' SCADA system to allow remote monitoring and control.

The pumps, valves, and piping will be designed to provide reliable service while handling the raw Rio Grande water. Redundant pumps and other equipment units will be provided to increase the stations reliability.

3.2.5.7 Maintenance

The RWLS will be designed and constructed to minimize operator intervention. The RWLS will be automated with PLC controls of the pumping systems and other equipment. The RWLS will be connected to the Owners' SCADA system to allow remote monitoring and control.

The pumps, valves, and piping will be designed to provide reliable service while handling the raw Rio Grande water. Redundant pumps and other equipment units will be provided to increase the stations reliability.

3.3 Diversion Structure and Raw Water Lift Station General Requirements

3.3.1 Geotechnical

Alluvium and various members of the Santa Fe Group underlie the majority of the Project facilities. The Santa Fe Group is a series of unconsolidated Quaternary age sedimentary units. The lithology and cementation of the units composing the Santa Fe Group range widely, from claystone and siltstone to sandstones and gravel/conglomerates. Most of the visible units within the Project area and records of previous nearby investigations indicate that the bedrock units within the area are generally weakly-cemented, and generally pose little difficulty to excavate using conventional drilling and earthwork equipment. Occasional cobbles and boulders will probably be encountered.

For the Diversion Structure and RWLS, groundwater will most likely be encountered at the Rio Grande River depending upon season of the year and precipitation levels. The complete description of the site is provided in Appendix A – Geotechnical Investigations Report.

For the diversion site facilities, the structures may be supported on conventional spread and strip footings bearing on a minimum of 3-ft of structural fill. The structural fill should extend a minimum of 2-ft laterally beyond the edge of all footings. The foundations may be designed to allow a bearing pressure of 1,500 pounds per square foot (psf).

The base of the exterior footings should be embedded a minimum of 24-inches below the lowest adjacent grade. The base of the footings should be embedded a minimum of 12-inches below the finished pad grade. The spread and strip footings should be a minimum of 24- and 18-inches wide, respectively.

Lateral foundation loads will be resisted by a combination of passive soil pressure against the sides of the footings and friction along the base. A passive soil resistance of 300 pounds per cubic foot (pcf) should be utilized for the DB Contractor's design.

Prior to fill placement and following footing excavation, the natural soils should be scarified to a depth of 8-inches and moistened to a near optimum moisture content (±3 percent). The exposed soils should then be compacted to a minimum of 95 percent of maximum density. Prior to pouring concrete, footing excavations should be cleaned of any slough, loose soil, or debris. Additional compaction information can be found in the attached report. However, it is important to note that backfill compaction adjacent to walls should be performed using relatively light, hand-operated equipment to prevent overstressing the wall and excessive lateral deflections.

Foundations designed and constructed by the DB Contractor are not anticipated to settle more than 1-inch. The DB Contractor's design will be required to prevent excessive settlement. Vibratory equipment, including pumps, will require mounting on isolated equipment pads to minimize settling. The wet well of the RWLS will be supported on a structural slab to provide resistance against hydrostatic forces.

The final structural requirements are to be developed by the DB Contractor's geotechnical engineer.

3.3.2 Electrical

3.3.2.1 Electrical Design Approach Overview

The electrical design for the common facilities at the Diversion Structure and RWLS will provide an electrical system that is the heavy-duty, industrial type incorporating quality, reliability, redundancy, energy efficiency, maintainability, safety, and Owners' requests. Design and construction for this facility will be similar to requirements and methods normally applied to municipal water and wastewater treatment plants.

Redundancy and Versatility Criteria

The electrical system will be designed for redundancy, reliability and versatility. The design will ensure that if any one piece of the equipment or one set of the cables fails or is de-energized for maintenance, it will not shut down the entire facility. The following guidelines will be used:

- Dual incoming PNM 12.47kv services each with its own primary metering and secondary selective distribution circuit arrangement
- Dual full capacity 12.47kv-480/277v transformers
- Dual bussed low voltage (480-volt) main switchgear with two main and a tie circuit breaker
- Dual motor control centers (MCCs), one for the powering or controlling duty equipment and one for the equivalent standby equipment, one set of process trains on one MCC and the other set on the second MCC.

Commonality of Systems

All facilities associated with this project will have the same design and construction approach and criteria, so the electrical distribution system for each facility will be similar. All pieces of similar equipment, e.g., switchgears, MCCs, VFDs, etc., will be furnished by the same manufacturers.

Electrical Equipment Criteria

Pieces of equipment for this facility will be sized for power handling capacity to accommodate initial and known future loads plus a minimum reserve capacity of 25 percent. Main oil-filled transformers will have an additional 12 percent capacity when they are operated at 65 degree C rise, instead of at 55 degrees. By adding fans to the transformers, they can provide about an additional 13 percent capacity for a total of 25 percent. Pieces of equipment will be required to be de-rated for the facility elevation of 5,470-ft amsl so that they will be over-sized to provide the required capacity and/or rating.

The electrical system design will incorporate the use of copper conductors, busses, terminals, windings and splices. The use of aluminum conductors, lugs, etc., will not be permitted because they have reduced reliability and increased maintenance requirements.

Pieces of equipment will be designed, built and tested to applicable NEMA, ANSI/IEEE, and UL standards.

Space Requirements

Electrical pieces of equipment will be provided with working spaces as required by the code. In addition, for free-standing type, at least 24-inches more than the minimum clearance required by the codes or by the manufacturer, whichever is greater will be provided for the 15-kv and low-voltage switchgears and at least 18-inches more for 480-volt MCCs and VFDs.

Clear space will be provided adjacent to the two 480-volt MCCs for future addition of at least two vertical sections. Electrical equipment will have provisions to accommodate additions of sections.

3.3.2.2 Facility Loads

The loads at this facility will be rated either at 480, 208, or 120 volts as indicated the electrical load listing (Table 3.3-1). Since the largest motor is rated at 400 HP, a 480-volt, 3-phase system was selected for the main utilization voltage.

Table 3.3-1 Electric Load List for Diversion Structure and Raw Water Lift Station

Item	Estimated Connected HP or KW	Comments
Pump No. 1	400	480 VAC
Pump No. 2	400	480 VAC
Pump No. 3	400	480 VAC
Pump No. 4	400	480 VAC (Standby Unit)
Pump No. 5	400	480 VAC (Standby Unit)
Sump Pump 1	3.0	480 VAC
Sump Pump 2	3.0	480 VAC
UW Pump 1	2.0	480 VAC
UW Pump 2	2.0	480 VAC
Sample Pump	0.75	480 VAC
Monorail Hoist	2.0	480 VAC
Monorail Trolley	0.5	480 VAC
Diversion Screen Cleaning System	*15*	480 VAC
Electrical Room AC	*8.0*	
Exhaust Fans	*3.0*	480 VAC
Electric Unit Heaters	*15 KW*	
Lights	*2 KW*	
Miscellaneous Other Loads	*10 KW*	Instrumentation, tools, etc.

3.3.2.3 Main Services

The electrical services for the Diversion Structure and RWLS Facility will be a dual 12.47kv 3-phase primary from separate PNM underground feeders for redundancy and reliability. One service will be connected to the existing Buckman Feeder No. 12 and the other will be connected to the new Buckman Feeder No. 13. Each will be separately metered at 12.47kv. If one PNM feeder fails, the facility will have the capability to be served by the other. The PNM switchgears and meter cabinets and the facility main substation will be located within an outdoor area with a wall barrier for protection from vandalism.

Services are obtained at the primary voltage so that the Owners can benefit from a more favorable rate schedule known as Rate No. 11B - Water and Sewage Pumping Service -- Time-of-Use Rate.

3.3.2.4 Power Distribution

Double-ended Substation

Each service will feed a double-ended substation with fully rated 2,500 KVA 12.47kv-480/277 v outdoor pad-mounted, oil-filled transformers protected by vacuum circuit breakers located in an adjacent weatherproof housing. The transformer secondary at 480/277 volts will feed each side or bus of the low voltage main switchgear.

Low Voltage Switchgear

The double-ended substation will feed an indoor 480-volt (low voltage) switchgear with cables in conduits. The switchgear will be furnished with two main circuit breakers, a tie circuit breaker and feeder circuit breakers for the MCCs. The switchgear main, tie and feeder circuit breakers will be the draw-out, electrically operated power air type. The main and tie circuit breakers will be controlled by an automatic transfer system to provide automatic switch over of power in case there is a power failure on the upstream side of one of the switchgear main circuit breakers. Of the three breakers, consisting of two mains and a tie, only two will be allowed to be closed at any one time by an interlock system. Under normal conditions, the two main breakers will be closed and the tie open, which is the PNM required arrangement. The low voltage switchgear will be located in the RWLS electrical room.

Motor Control Centers

The two switchgear feeder circuit breakers will provide a radial feeder connection to the two MCCs located in the RWLS electrical room. The two MCCs will be connected together via the tie circuit breaker. The two MCC main circuit breakers and the tie circuit breaker will be provided with a keyed interlocked system so that only any two breakers can be closed at any one time.

MCCs will house combination breaker-motor starters and feeder circuit breakers for the VFDs, package process equipment and 480-208/120 and 480-240/120 volt dry-type transformers for panelboards. Breakers and starters for the multiple process equipment and pumps of each type will be located in different MCCs so that the failure of one MCC will not shut down the lift station.

Automatic Transfer Switches

Each automatic transfer switch (ATS) will provide 480-volt power from either MCC A or MCC B to the dry-type transformer. The normal source will be designated as the power from MCC A and the standby source as from MCC B. If the power from MCC A fails, the ATS will automatically switch to the MCC B power, if available, after a time delay.

Panelboards

Because of the ATSs, the 208/120-volt, 3-phase, 4-wire panelboard for miscellaneous loads, lights, and receptacles and the 240/120-volt, single phase, 4-wire panelboard for instrument loads will be fed from either the A or B source for reliability. The dry-type transformer for the instrument panelboard will be the noise isolation type to provide clean power to the instruments.

3.3.2.5 Standby Power

Standby power such as an engine-generator set for this facility will not be provided. Emergency light fixtures and exit fixtures with back-up battery packs will provide illumination for safety and egress when there is a power outage condition on both A and B sources.

3.3.2.6 Variable Frequency Drives

VFDs for the pumps will be the 480-volt, 18-pulse clean power type in packaged free-standing NEMA 1 enclosures each with an incoming circuit breaker. The 18-pulse VFDs will be used to mitigate their harmonics generation since they comprise almost all of the connected loads at this facility and will allow compliance more easily with PNM and IEEE 519 Standards requirements as well as minimize harmful effects on the facility distribution system such as overheating of equipment and introducing interference to sensitive electronic equipment.

VFDs will be furnished with an output filtering system to minimize the damaging effects on the cables and motor insulation due to overvoltage and dv/dt conditions. Acceptable VFD manufacturers have been limited in the Technical Requirements due to problems encountered with certain manufacturers' equipment.

3.3.2.7 Underground Conduit System

Underground conduit systems will be a minimum 2-inch diameter, Schedule 40 polyvinyl chloride (PVC) conduits encased in concrete. All ductbanks, except those for area lighting, will have steel reinforcement. Concrete handholes will be provided as necessary for ductbank entrance for entry into buildings and structures and for change in direction.

All conduits originating from buildings and structures and terminating in handholes and all conduits terminating in outdoor electrical enclosures will be sealed with conduit sealing bushings to prevent moisture transmission, rodents and snakes entering into enclosures, panels, buildings and structures. For PVC endbell sealing and where the sealing bushing is impractical, conduit openings will be sealed with rodent-resistant, foam duct sealant as shown in Figure 3.3-1.

Figure 3.3-1 Application of Foam Duct Sealant

3.3.2.8 Exposed Conduit Systems

Exposed conduits inside and outside will be the hot-dipped galvanized rigid steel (GRSC) type. Conduits located over water and in contact with the soil will be the PVC bonded GRSC type.

3.3.2.9 Wires and Cables

Low Voltage (600-Volt) Wires and Cables

600-volt cables for control and power, No. 8 AWG and smaller, will have Type XHHW insulation. Power cables No. 6 AWG and larger, will have Type RHW-USE insulation. Conductors will be the stranded copper type.

Minimum size conductor for 120 volt or greater power circuits will be No. 12 AWG. Minimum size 120 volt or greater conductors within control panels and switchboards will be No. 14 AWG.

Terminations for power wires and cables will be made with color-coded wrought copper compression type connectors with lug hole(s) using the tool and die as recommended by the connector manufacturer.

Stranded control conductors will be lugged at terminations except where terminations are made on devices available only with box terminals. Lugs will be the locking spade type. Terminals blocks will be the strap-screw type.

High Voltage (15kv) Cables

15kv cables will be the annealed tinned copper, Class B concentric lay, 133 percent shielded, MV-105 type, insulated with a thermosetting ethylene propylene rubber (EPR) compound over an extruded, non-conducting high dielectric stress control layer, with a semi-conducting shield applied directly over the primary insulation.

All material used in terminating and splicing high voltage cables will be as recommended by the cable manufacturer. Cables will be terminated and spliced in accordance with the kit supplier's drawings.

Outdoor cable terminations for outdoor locations will be made with a single conductor shielded cable type with one piece, track resistant silicone rubber with top seal, rain skirt and ground strap assemblies.

Rodent-Resistant Cable Coating

In handholes and exposed locations, rodent and fire-resistant coating will be applied to the entire exposed cable and wire surfaces. Cable coating will be required to have been tested successfully for rodent resistance. The specified manufacturer Hy-Tech has a product in which multiple lab studies conducted at New Mexico Tech have verified that the rodents always avoided the treated cable insulation. See Figure 3.3-2.

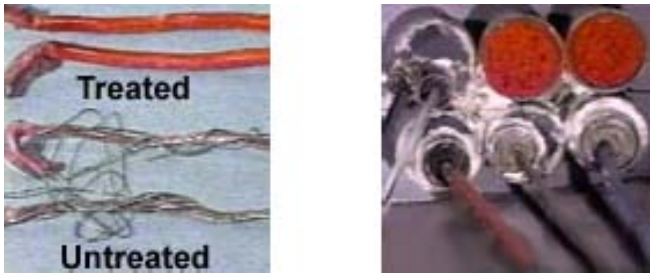


Figure 3.3-2 Success of Treating Cable Insulation

The bottom wires shown as "Untreated" were removed after 24 hours and have hardly any insulation material left. The top wires shown as "Treated" remained in the cage with the animals for 4 months.

3.3.2.10 Motor Control

Each 480-volt motor starter and VFD will be provided with an individual control power transformer. The following control scheme will be provided:

- Emergency stop pushbuttons (red mushroom, maintained push-pull type) at the motor and starter or VFD
- "Hand-Off- Auto" maintained three-position selector switch for each driven equipment at starter or VFD
  - In hand, controlled by "Start" and "Stop" momentary pushbuttons with a seal-in contact (three-wire). For VFD, motor speed controlled manually with the speed adjustment on the VFD HMI. Bypasses the PLC control.
  - In auto, controlled by the PLC
- Indicating lights
  - White - "Control power on"
  - Green - "Off"
  - Red - "Run"
  - Red - shutdown alarm conditions each, e.g., high pressure, motor failure, etc.
  - Amber - Status alerts
- Equipment and personal safety detection switches and contacts
  - Hardwired in the control circuit
  - Shut down and lock out the motor until the abnormal condition is cleared and the "Reset" pushbutton is depressed.
  - Alarms inputted to the PLC

3.3.2.11 Lighting

Light fixtures within buildings and structures will be the fluorescent type with energy-efficient F32T8 tubes and electronic ballasts. LED type exit fixtures with batteries will be provided over doors leading to the outside. Also, emergency lighting fixtures with batteries will be provided for egress during power outages.

Light fixtures located outside will have bullet-proof shields and will be the cut-off type for compliance with the New Mexico Night Sky Protection Act. Light fixtures for illuminating water surface within open structures will be the watertight stainless steel fluorescent type (Figure 3.3-3) controlled by locally mounted switches. All fixtures will be suitable for 120 vac power.

Figure 3.3-3 Stainless Steel Fluorescent Light

All lamps will be the green end cap type which has low mercury content for qualifying as non-hazardous by the NMED Hazardous Waste Bureau. The NMED has adopted the Federal Universal Waste Rule and allows lamps to be disposed as normal standard solid waste if the mercury content of each lamp is below the Toxicity Characteristic Leaching Procedure (TCLP) limit of 0.2 mg/L. Each lamp will be required to have a certification showing it has passed successfully the third party test for the TCLP limit for Mercury

in accordance with EPA Method 1311 of Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-8.

3.3.2.12 Receptacles

Convenience (115 volt) receptacles will be spaced at least every 30-ft in all enclosed areas and at least every 40-ft in open structure areas with mechanical pieces of equipment. All convenience receptacles will be the GFCI type and also will have the weatherproof covers outdoors and in areas subject to hose-downs. All convenience receptacles will be identified with labels indicating the originating panelboard and circuit designations.

3.3.2.13 Lightning Protection System

Buildings, superstructures, etc., will be protected by lightning protection systems which will be bonded together and to the facility grounding system.

3.3.2.14 Discussions with Electrical Utility

Discussions, correspondences and meetings have been held with PNM regarding the upcoming project and the required electrical services for this facility. PNM has the preliminary single line diagram, site location, and electrical load data for this facility and is in the process of developing an agreement for this project.

PNM will be upgrading their existing Buckman No. 12 underground 12.47kv feeder system and will be installing a new Buckman No. 13 underground 12.47kv feeder system to accommodate the RWLS and BS1A.

3.3.3 Instrumentation and Control

3.3.3.1 Control Descriptions for Facilities

The RWLS will start-up automatically in response to a LOW water level signal from the wet-well at BS1A. Five variable speed pumps will pump raw water from the Diversion Structure to the SRF. Depending upon the flows required, one to three of these pumps will be operating at any given time. The other pumps will be in stand-by mode. The discharge pipe of each pump is equipped with a motorized plug valve.

The RWLS pumps flow to the RWLS Discharge Manifold. The RWLS Discharge Manifold controls the flow into the first reach of the raw water pipeline. The first reach of pipeline is actually three parallel 20-inch diameter pipelines. Each of the three pipelines is equipped with a motorized plug valve at the RWLS Discharge Manifold. Opening and closing of these valves controls flow in the raw water pipelines. Adequate flow velocity must be maintained in the pipelines to prevent sand from settling in the pipelines.

3.3.3.2 Instrumentation and Monitoring

All equipment and process parameters shall be monitored for safe and efficient operation. Control commands received from the C/CWTP shall be received by the local PLC processor and executed by the programming within the unit. All parameters pertinent to determining process and equipment readiness for the command and confirmation that the command has been properly carried out shall be provided and reported to the C/CWTP PCS.

3.3.3.3 Transmission of Information and Control

Due to the multiple data needs of this site and the coincide construction of the pipeline from this site to the C/CWTP and associated facilities en-route, the installation of fiber optic media is the optimal means to provide sufficient data carrying capacity for the control system needs, and would also support the demands of remote video surveillance and inter-facility telecommunications. Therefore, the PLC equipment at this site will be configured as part of the Ethernet Network of the C/CWTP control system. The PLC interface will operate at 100 Mbps. This approach will allow the remote PLC to be incorporated into the polling sequence of the plant PLC system in the same manner as any of the on-plant PLC installations. Consistency and speed are two of the benefits to such an approach.

3.3.4 SCADA/Telemetry

The Process LAN from the C/CWTP shall be extended to the RWLS via fiber optic cable. Process control for the RWLS shall consist of PLCs on the process LAN communicating with the SCADA Master at the C/CWTP and other PLCs on the process LAN. Detailed information on the SCADA system is included in Section 8.

3.3.5 HVAC, Plumbing and Fire Protection

3.3.5.1 Heating, Ventilation and Air Conditioning (HVAC)

The HVAC system in the RWLS will consist of systems necessary to meet the numerous functions.

Systems will provide comfortable conditions in buildings and areas intended for human occupancy. In wet areas or areas with potential for condensation, maintain a low relative humidity (RH) to minimize or eliminate condensation and corrosion. Where outside air is required for ventilation, the outdoor air will be treated by heating and filtering as required.

Electrical rooms will be provided with mechanical cooling for heat removal and reduction in potential corrosion in the electrical room. A minimum of two units will be provided.

Operation spaces will be provided with ventilation where they will be occupied spaces. In addition spaces that may be entered by plant personnel will be ventilated in accordance with applicable codes and good engineering practices.

Ventilation will use multiple supply fans in each space with relief dampers. Supply fans will have both outdoor and return dampers to provide a minimum supply temperature during cold weather.

HVAC Codes and Standards

Design of the HVAC system at the RWLS is to comply with the applicable portions of the following codes and standards:

- 2003 New Mexico Commercial Building Code
- 2003 New Mexico Mechanical Code
- 2003 New Mexico Energy Conservation Code
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- National Fire Protection Association (NFPA) standards

Design Criteria

The design will be based on outdoor design conditions of 10 degrees F DB (dry bulb) during the winter and 96 degrees F DB, with a 60 degrees F MWB (mean wet bulb) during the summer. Air density will be based on an elevation of 5,470-ft amsl. Selection of condensers for air-conditioning units will be based on 106 degrees F deg.

The design of cooling and heating systems for specific spaces will be based on the indoor conditions shown in Table 3.3-2.

Table 3.3-2 Raw Water Lift Station Indoor Design Temperatures and Ventilation Rates

Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Pipe space	Ambient + 10/55		• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation • Unit heater
Lower Pipe space	Ambient + 10/55		• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation. • Unit heater
Pump space	Ambient + 10/55		• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation. • Unit heater
Truck way and access to lower levels	Ambient + 10/55		• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation. • Unit heater
Electrical room	85/55	0.25 CFM/sf	• Provide mechanical cooling with separate unit • Provide continuous ventilation

Additional information on systems and zoning of units and number of required units has been provided in the Technical Requirements and Preliminary Design Drawings.

3.3.5.2 Plumbing Systems

This plumbing in the RWLS will consist of systems necessary to meet the following functions:

- Drain systems with vents for sanitary, process rain water, equipment and HVAC condensation drain systems
- Sump pumps and discharge piping systems
- Water systems including utility water (non-potable) for process use and sample water systems

Plumbing Codes and Standards

Design of the plumbing systems at the RWLS shall comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Plumbing Code
- 2003 International Fuel Gas Code (IFGC)
- American Society of Plumbing Engineers (ASPE) design guides
- ANSI Z358.1: Emergency Eyewash and Shower Equipment, 1998
- AWWA
- NMED Title 20 Chapter 7 Part 3: Liquid Waste Disposal and Treatment Requirements

Description of Recommended Systems

Each water system will have its own backflow prevention device to eliminate cross-contamination of the facility's potable water system. All backflow devices will be protected against freezing and to facilitate maintenance.

The potable water system will include cold water for drinking water fountains, janitor's mop sink, and exterior hose bibs and hot water for janitor's mop sink. The sanitary system will include floor drains and Drinking fountain drains. The Process Drain system will be independent of the sanitary sewer and will include Floor drains in process areas. Rainwater Leaders will be based on a Rainfall rate of 2.0 inches per hour (0.021 gpm per square foot) for on a 100-year. This is the 1 hour rainfall rate per 1997 UPC.

Plumbing Fixtures

All hose bibs will be provided with individual vacuum breakers. Emergency Safety showers/eye wash drains – Exterior units and indoor units subject to freezing will be the freeze-resistant type with electric heat trace.

3.3.5.3 Fire Protection

Fire protection systems are not required for the RWLS. However, the DB Contractor will be responsible for determining the need for a fire protection system based on its design of the facilities.

3.3.6 Security

Security and personnel protection measures to protect the Project facilities during construction, start-up, and initial operation will be provided. During construction, temporary security measures will be provided as necessary to protect the facilities, equipment, and personnel.

3.3.6.1 Security Objectives

Security and personnel protection systems must be included for each facility to reduce risk to the integrity of these facilities and to protect the public water supply. The following security and personnel protection issues, at a minimum, will be addressed:

- Threats to the source water and water treatment facilities
- Threats to the pump stations
- Threats to the distribution systems/booster stations
- Threats to the Supervisory Control and Data Acquisition (SCADA)/telemetry system
- Fire detection and notification
- Communications

Threats may be in the form of one or more of the following: vandalism, criminal acts, sabotage/terrorism, or deliberate/malevolent acts by employees (either present or former).

The designed and installed security system will be compatible with the City of Santa Fe's existing security system at Canyon Road WTP and will be expandable to other City and County water facilities.

3.3.6.2 Recommended Security Systems

The following sections outline the physical security and personnel protection requirements for the Diversion Structure and RWLS. Because water systems cannot be made immune to all possible threats, the design of the facilities will address issues of critical asset redundancy, monitoring, response, and recovery to minimize risk.

For all of the Project facilities, basic physical security and personnel protection measures will be considered during design, including locks for access ladders, hatches, buildings, gates, and doors; bollards to prevent vehicle damage; back-up generators or battery supply for emergency power of alarms, security systems, fire alarm systems, communications and life safety devices; and appropriate signage and lighting.

For all of the remote facilities, including the Diversion Structure and RWLS, the design will also incorporate tamper-resistant hinges and security pins for each doorway. Windows and louvers will be provided with expanded metal grating on the interior side (i.e., provide grating with openings too narrow for bolt cutters to grip and too narrow to acquire handhold or toehold). Glass windows will incorporate glass-break sensors and magnetic alarm contacts for detection of penetration. Employee-activated and duress switches will be required at the remote facilities for notification of emergency situations.

Each Project facility will include Layers of Protection (LOP), built on the "protection in depth" principal, which requires a defeat of several protective barriers or security layers before a facility/component is compromised.

- Site Perimeter LOP includes perimeter fencing with concertina wire, access gate(s), landscaping barriers, vehicle barriers, and signage
- Inner Perimeter LOP includes site lighting, closed-circuit television (CCTV) cameras, and appropriate standoff distances between the facility and the perimeter fencing (also advantageous for preventing acts of vandalism by graffiti)
- Building LOP includes access card readers, windows, door alarms, and interior intrusion alarms.

For all outdoor PNM and facility distribution electrical equipment such as switchgears, transformers, etc., a concrete or concrete block wall(s) will surround each piece or group of equipment on four sides (open top) to provide an additional LOP. A set of bullet-resistant double doors will be provided to allow access and installation/removal of the equipment.

For the ventilation louvers at the facility buildings, similar construction of a three-sided (open top) concrete block wall will be required. A bullet-resistant door will be provided for personnel access.

For all facilities, Level 4 bullet-proof rated equipment will be required and conform to the UL rating 752-HPR 30.06.

Diversion Structure

The design will incorporate the following provisions to protect the water supply and the Diversion Structure:

- Shackled-protected locks to prevent breach with a bolt cutter
- Video surveillance of this site will be via cameras located at the RWLS

Raw Water Lift Station

The design will incorporate the following provisions to protect the RWLS:

- Perimeter vinyl-coated chain-link fencing with concertina wire around the individual facilities with bullet-proof rated warning signage for deterrence and protection
- Shackled-protected locks to prevent breach with a bolt cutter or fire arm
- Bullet-proof rated restricted access signage
- Bullet-proof rated restricted vehicle access signage
- Video surveillance via CCTV cameras (triggered by motion sensors) will be provided. Cameras and lenses will be installed in bullet-resistant metal enclosures. Cameras will be pole-mounted and provide redundant coverage of the entire perimeter of the site, as well as, coverage of each building entrance. Additionally, continuous video surveillance of the Diversion Structure will be provided from this site. Pole mounted cameras and long range lenses installed in bullet resistant enclosures will be provided. A minimum of two cameras will be provided to monitor the Diversion Structure. The complete CCTV system at this site will include: pole mounted cameras, lenses, infrared illuminators and bullet resistant enclosures; digital video recorder and accessories; power supplies; fiber optic interface components; mounting hardware; and, enclosures. The CCTV system will transmit video to and receive control from the C/CWTP via the fiber optic infrastructure.
- Perimeter protection utilizing volumetric microwave technology will be provided. The perimeter protection system will be integrated into the CCTV system and provide control to camera presets and recording functions.
- Card access/security system will be provided complete with multiplexer(s) and alarm panel(s); card reader, electric strike, request to exit device, magnetic door alarm contact and motion sensor at or in the immediate vicinity of each entrance door; glass break sensors in the immediate vicinity of all windows; magnetic window alarm contacts; alarm arming and disarming keypad; power supplies; fiber optic interface components. The card access / security system will transmit data and alarms to and receive data from the C/CWTP via the fiber optic infrastructure.
- Fire alarm system for structures
- Voice over Internet Protocol (VoIP) phone service will be provided to the RWLS as an extension of the C/CWTP's phone system. The fiber optic infrastructure will be utilized to extend service to the RWLS
- Adequate lighting, equipped with bullet-resistant bulb shields, to increase visibility of suspicious activity. Lighting will be motion sensor controlled with manual switch override.
- Bullet-resistant doors with handles and lock covers
- Kevlar curtain on roll-up doors to prevent bullets from passing into the building interior
- Any ladders will have pad locked anti-climb barriers

This section provides design criteria, alternatives analysis, and preliminary design details for the proposed Sediment Removal Facility.

4.1 Sediment Removal Facilities Objectives

The SRF will be used to remove sand with diameters of 0.1-mm and larger from the raw Rio Grande water. This sand, often referred to as grit, is abrasive to pumps, valves, and piping and its removal will reduce abrasive wear on the downstream facilities (i.e., BS1A, BS2A and the raw water pipeline).

The sediment loading rates used for design of the SRF and other solids handling facilities are discussed in detail in Appendix G - Solids Alternative Use Study.

4.2 Alternatives and Evaluation

Several alternative grit removal technologies were evaluated for use at the SRF. The technologies included those that rely upon gravity to settle the sediment and those that use centrifugal forces to separate the larger sand particles from the water. This subsection provides a description and findings of the evaluation of the different technologies.

4.2.1 Performance and Design Criteria

The SRF will remove grit from the raw Rio Grande river water after it passes through the Diversion Structure screens and is pressurized by the RWLS. The screens will remove sand and other suspended materials 1.75-mm and larger. The SRF will be designed to remove sand of 0.1-mm and larger or sand particles of size between 0.1-mm and 1.75-mm. Actual criteria for the equipment will be for 98 percent removal of material 0.075-mm and larger. Nominally this is referred to as "0.1-mm and larger."

4.2.1.1 Design Issues

The Rio Grande river water has highly variable water quality characteristics, especially regarding suspended solids levels. Following rain storms, the watershed and various tributaries to the Rio Grande contribute considerable soil and other debris to the water. The USGS collects water quality and other data at the Otowi Gage, which is approximately 3 miles upstream from the proposed Diversion Structure site. Based on these data, the average suspended sediment concentration (SSC) is approximately 2,000 mg/L; the 95th percentile SSC is approximately 10,500 mg/L; and the 25th percentile SSC is approximately 200 mg/L. Therefore, the grit removal technology selected will have to be able to effectively and treat a range of water quality.

The SRF will have to be designed to treat the peak raw water flow rate from the RWLS of 32.2 cfs. The facility should also be able to treat this peak flow when the river water contains high levels of suspended sediment (i.e., the 95th percentile level). When the suspended sediment

levels are this high or higher, it is anticipated that the diversion will be stopped temporarily or reduced in flow rate so as to reduce the costs of treatment. The C/CWTP design will include both raw and finished water storage to allow temporary shut-down of the raw water facilities, if necessary. It is anticipated that Las Campanas will also include storage to allow temporary shut-down of the raw water facilities. A small amount of storage will also be available in the wet wells of the BS1A and BS2A. Each of these wet wells will have approximately 50,000 gallons of operational water volume.

Based on the water quality data available, it is estimated that the 0.075-mm and larger fraction of the sediment will represent approximately 25 percent of the total sediment. It is anticipated that some amount of the smaller sized sediment (e.g., 5 percent) will be removed along with the larger sand. The sediment removal, dewatering, and conveying equipment will need to be sized to handle this amount of sediment. The remainder of the suspended sediment will be conveyed with the partially clarified raw water to the C/CWTP and Las Campanas facilities (only as far as BS2A under this project).

As with the Diversion Structure and the RWLS, the SRF is to be designed to not require continuous staffing. The facility will include automation and other features to reduce the need for daily visits to the facility by operation and maintenance staff.

Also, the remote location and normally unstaffed condition of the facility will make it more susceptible to vandalism. The facility must be designed to include security features to minimize and prevent access and damage to the equipment. This will include physical barriers such as walls and fences but also security cameras and intrusion alarms.

Table 4.2-1 lists the design criteria for evaluating the SRF alternatives. Due to the importance of this facility and the abrasiveness of the raw water, it will be important to have redundant treatment equipment and/or systems. A minimum of four sediment removal units (e.g., grit basins) were assumed; three duty and one standby. For the centrifugal separator technologies, where approximately seven duty units would be required for treating the maximum raw water flow, two standby units were assumed. In either case, the assumed standby capacity equals approximately 30 percent of the total duty capacity. It was assumed that approximately 30 percent of the influent suspended solids would be removed from the raw water. The total solids capacity assumed a limit of treating the peak hydraulic influent with the 95th percentile suspended solids concentration.

Table 4.2-1 Sediment Removal Facility Design Criteria

Design Parameter	Value
Number of Treatment Units	4 (three duty, one standby) for grit basins 9 (seven duty, two standby) for centrifugal separators
Hydraulic Treatment Capacity	14,460 gpm [a]
Removed Solids Capacity	185 cy/day [b]

[a] If Discharge Permit to return sediment to Rio Grande not obtained, the capacity of the SRF can be lowered to 19,600 gpm

[b] Assumes 30 percent SSC removal and a dried unit weight of 110 lbs

4.2.2 Initial Screening of Alternatives

Two general categories of treatment technology were evaluated, including (1) technologies that depend on gravity settling of the sand and (2) technologies that use centrifugal force to assist in separating the sand from the water. The different technologies evaluated are listed below.

Technologies depending solely on gravity for settling:

- Rectangular horizontal flow grit basins
- Circular horizontal flow degritter basins
- Lamella plate settlers
- Headcell™ grit removal system

Technologies using centrifugal forces for separating:

- Centrifugal solids separators
- Teacup™ type grit removal systems
- Vortex grit removal systems

The initial screening resulted in three grit removal technologies for further evaluation: circular horizontal flow de-gritter basins, lamella plate settlers, and centrifugal solids separators. Proprietary Teacup type grit removal systems were also kept in the evaluation since this technology is similar to the centrifugal solids separators.

4.2.3 Sediment Removal System Alternatives

The following list identifies the SRF alternatives that will be evaluated further.

Alternative 1 - Circular Horizontal Flow Degritter Basins
Alternative 2 - Lamella Plate Settlers
Alternative 3 - Centrifugal Solids Separators
Alternative 4 - Teacup Type Grit Removal Systems

Each alternative is described below.

4.2.3.1 Alternative 1 - Circular Horizontal Flow Degritter Basins

Figure 4.2-1 shows a circular horizontal flow degritter basin. This technology has been used for removing grit at the head of wastewater treatment facilities. Water is directed across a relatively shallow (approximately 3-ft deep) basin. A set of flow deflectors are used to distribute the influent across the basin width. The basin dimensions are set by the flow rate and the time required to settle the target size sand particle (e.g., 0.1-mm). At flows lower than the design influent rate, settling of smaller sized particles will also occur. A sediment scraper suspended from a bridge supported drive mechanism is used to move the settled sediment to a hopper. A conveyor or set of pumps can be used to move the sediment from the hopper to the grit dewatering system.

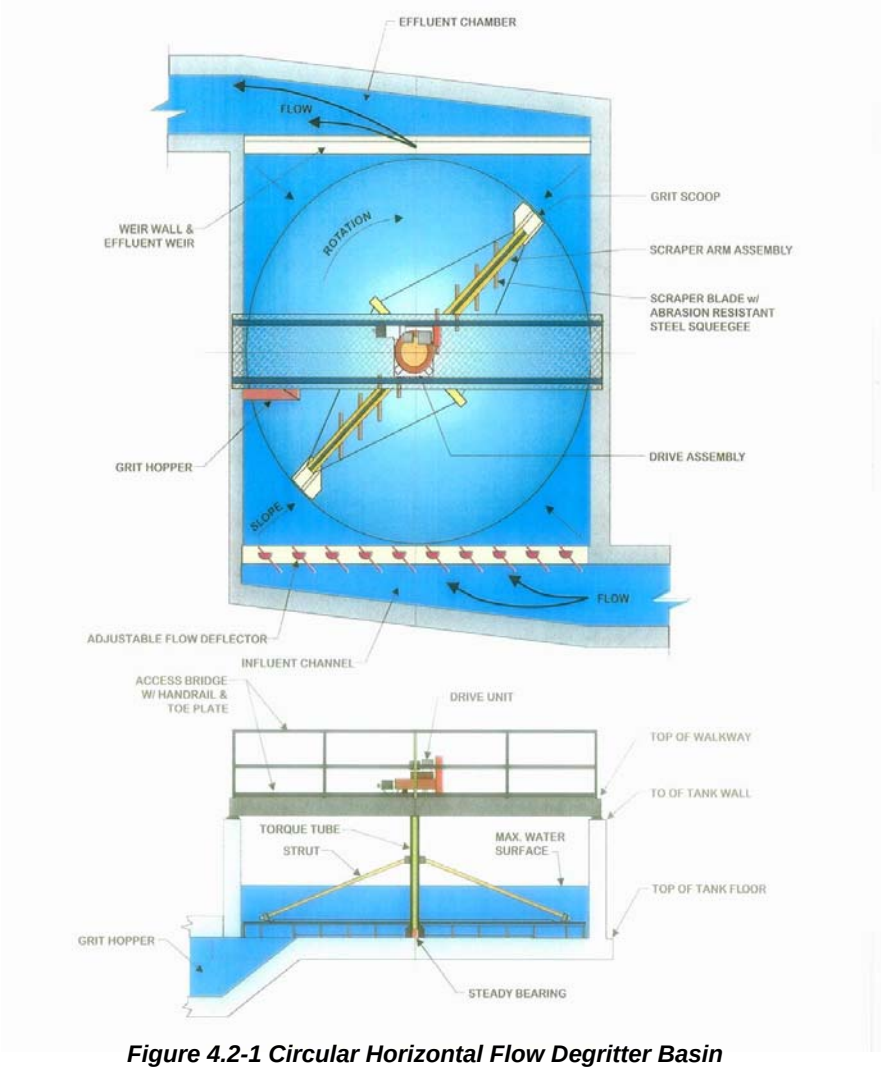


Figure 4.2-1 Circular Horizontal Flow Degritter Basin

4.2.3.2 Alternative 2 - Lamella Plate Settlers

Figure 4.2-2 shows a set of lamella plates set in a concrete settling basin. As with the degritter basins, lamella plate settlers rely upon gravity to remove suspended solids. Lamella plates consist of a set of flat plates set at a steep angle (approximately 55 degrees from horizontal). The plates are set in a row with 2- to 3-inches of clearance between each plate. The influent is directed upwards between the plates. The sediment settles onto the plates and then slides down to the bottom of basin. Typically, a chain-in-flight type solids collection system is used to rake the sediment to a hopper. A chain-in-flight cross collector or

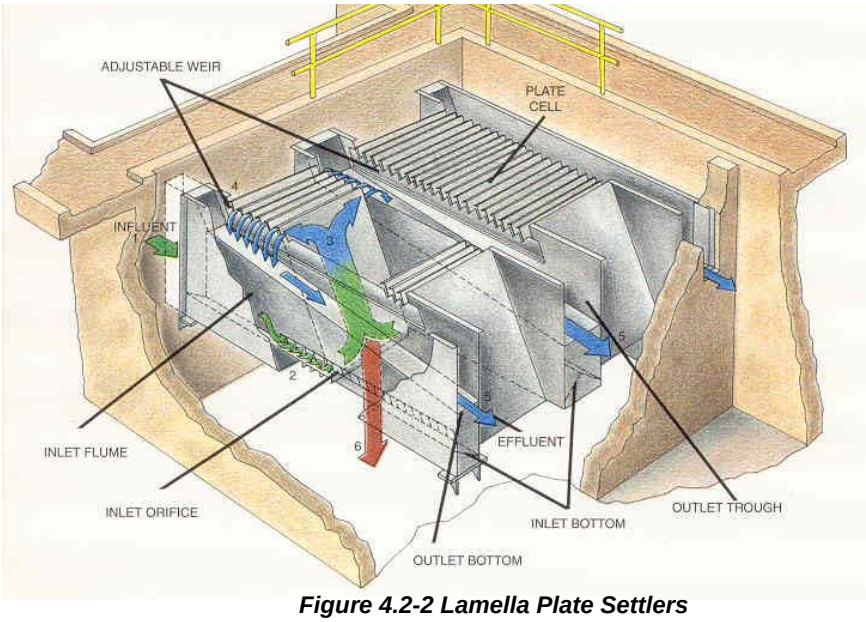


Figure 4.2-2 Lamella Plate Settlers

auger is used to move the solids to a drain or conveyor system that moves the sediment to the dewatering system.

4.2.3.3 Alternative 3 - Centrifugal Solids Separators

Figure 4.2-3 shows a schematic representation of a centrifugal solids separator sometimes referred to as a hydrocyclone. This technology uses centrifugal force to separate the sediment from the water. The separators are essentially hollow cylinders. Influent enters near the top of the separator tangentially to the cylinder wall. The water takes on a vortex flow pattern that exerts centrifugal force. The heavier solids are forced to the inner wall of the separator and slide down the wall to the bottom of the unit. The partially clarified water exits at the top of the unit. The sediment is either continuously or periodically removed from the bottom using a purge valve. The sediment slurry flows to the dewatering system.

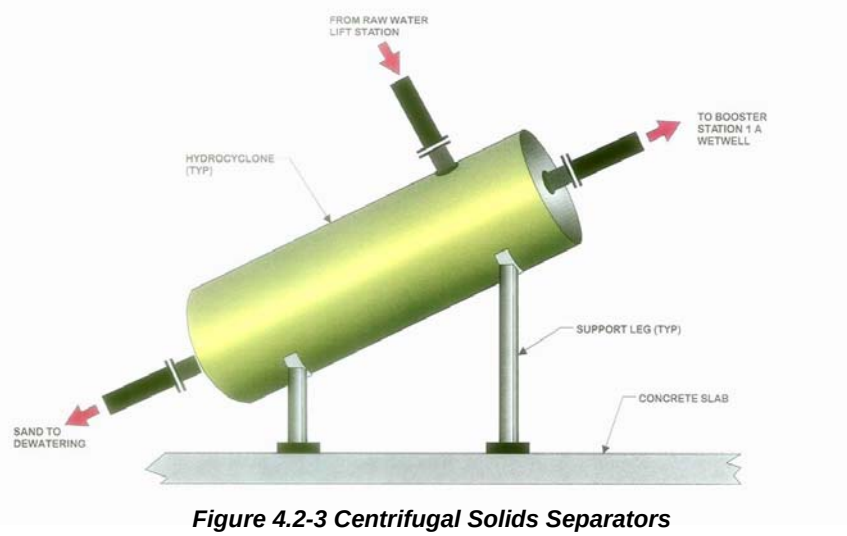


Figure 4.2-3 Centrifugal Solids Separators

4.2.3.4 Alternative 4 - Teacup Type Grit Removal Systems

Figure 4.2-4 shows a Teacup™-type separator. Two different manufacturers market this technology primarily to the wastewater industry. As with the centrifugal solids separators, centrifugal forces are used to separate the sediment from the water. The inside of the units also include baffles that assist in optimizing the removal process.

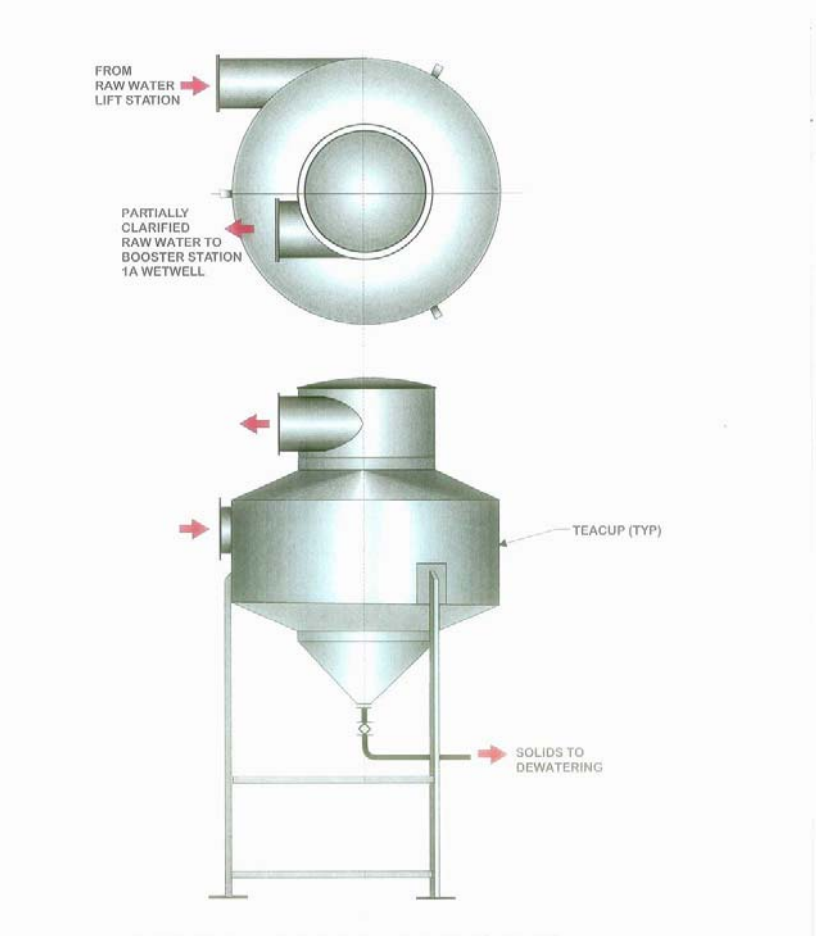


Figure 4.2-4 Teacup™-Type Sediment Removal System

4.2.4 Evaluation and Cost Analysis

An evaluation was performed on the four alternatives. The evaluation included a comparative cost analysis of different technologies as well as an assessment of non-economic factors.

4.2.4.1 Evaluation of Alternatives

Each of the four SRF alternatives has advantages and disadvantages. The evaluation was completed for the numerous factors identified below:

- **Quality Factors** - Reliability in removing 0.1 mm and larger grit, accommodate flow rate variances, mechanically simple, maintenance requirements and familiar technology
- **Risk and Aesthetic Factors** - Proprietary technology, safety, process history, site space requirements and low profile
- **Cost Factors** - Construction and O&M costs

The evaluation matrix is presented in Section 4.2.4.3.

4.2.4.2 Construction, O&M and Life-Cycle Cost Analysis

Table 4.2-2 shows the results of an economic analysis of the different alternatives. This is a reconnaissance-grade cost analysis using a similar basis for comparing among the alternatives. The accuracy of the estimate is considered to be +50 percent/-30 percent in early 2006 dollars.

Table 4.2-2 SRF Alternatives Cost Comparison

Cost Category	Cost (Million $)		
	Circular Horizontal Flow Degritter Basins (Alt 1)	Lamella Plate Settlers (Alt 2)	Centrifugal Solids Separators (Alt 3)
Construction Cost	5.7	5.4	4.8
Annual O&M Cost	0.17	0.16	0.21
Total Annual Cost	0.59	0.56	0.57
Unit Cost ($/ac-ft)	68	64	65

Each of the construction costs include costs associated with the SRF equipment, the associated piping and concrete basins if applicable. The systems were assumed to be housed within a building. Also, in the building would be a set of grit classifiers for dewatering the removed sediment and a screw conveyor system for loading the dewatered sediment into a set of roll-off containers.

The annual O&M costs include estimated costs for energy, labor, general facility/equipment maintenance and replacement, plus the costs for trucking and disposal of the solids at a regional landfill. For the centrifugal solids separator alternative, the additional RWLS pumping energy cost due to the higher influent pressure requirement was included. The total annual cost adds the estimated annual O&M costs to annualized construction costs amortized at 5.5 percent over 25 years. The unit cost assumes a total annual water volume of 8,730 ac-ft.

The centrifugal solids separator alternative (Alternative 3) was estimated to have the lowest construction cost. This is due to the relatively simple technology and the compact footprint. The other two alternatives require the construction of concrete basins and would require more building space. However, Alternative 3 had the highest O&M costs due to the additional energy cost associated with pumping at a higher head from the RWLS. The centrifugal solids separator technology requires additional pressure at the influent to the units to create the centrifugal force for separating the sediment from the water.

The total annual and unit costs for the centrifugal solids separators (Alternative 3) and the plate settlers (alternative 2) were estimated to be similar. At this level of analysis, the life-cycle costs for these two alternatives are judged to be essentially the same.

4.2.4.3 Ranking of Alternatives

Table 4.2-3 presents the evaluation summary for the SRF alternatives. The evaluation included both cost and non-economic factors. The different alternatives have been scored for each of the different factors. Total scores are computed for each factor category and an overall total score and ranking are computed for each alternative. The total scores are computed by taking the individual factor scores and multiplying by the assigned "weight" of each factor and then summing the products.

Table 4.2-3 Evaluation Matrix for SRF Alternatives

Sediment Removal Facility Alternatives	Quality Factors					Risk and Aesthetic Factors							Cost Factors			Total Overall Score	Overall Ranking
	Reliably Removes 0.1-mm Sand	Accommodates Flow Rate Variances	Mechanically Simple	Maintenance Requirements	Familiar Technology	Quality Score	Proprietary (sole source vendor)	Safety	Process History	Space Requirements	Low Profile	Risk/Aesthetics Score	Construction Cost	O&M Cost	Cost Score		
Weight:	16	16	16	16	16	80	10	10	10	10	10	50	20	30	50	180	
1. Circular Horizontal Flow Grit Basins	5	5	3	4	5	352	5	3	5	2	5	200	2	4	160	712	1st
2. Lamella Plate Settlers	5	3	3	4	4	304	5	4	4	3	5	210	3	5	210	724	3rd
3. Centrifugal Solids Separators	5	4	5	5	5	384	5	5	5	4	4	230	5	5	250	864	1st
4. Teacup-Type Grit Chambers	4	3	4	4	5	320	4	5	4	5	3	210	4	5	230	760	2nd

1. Scores range from 1 to 5 with 5 being the highest score possible and the more desirable.

For this analysis, the "quality factors" were assigned an overall weighting of 80 or 44 percent of the overall weighting of 180. The "risk and aesthetic factors" and the "cost factors" were each assigned a weighting of 50 or 28 percent overall. The weights assigned to each factor and factor category indicate the assumed importance of that factor. The last column of the matrix ranks the different alternatives.

Alternative 3 - centrifugal solids separators scored highest in the "Quality" category. This technology is mechanically simple and reliable for removing sand from water. It should not require as much operation and maintenance staff intervention and the Owners' O&M staff is familiar with this technology. The use of multiple units will allow for flow rate variations as well as provide redundancy.

The centrifugal solids separators also scored highest in the "Risk and Aesthetic" category. These treatment units are compact and will require less site and building space. Also, the units will not require an unusually tall building or a below grade vault to house. The lack of open basins and exposed moving parts increases the safety to the O&M staff. This technology has an established history and there are multiple manufacturers.

The centrifugal solids separators scored highest in the overall "Cost" category. As discussed above, the centrifugal solids separators are estimated to have the lowest construction cost. Also, the O&M costs for this technology is lower than the circular degritter basins and comparable to the lamella plate settlers.

The total overall scoring identified the centrifugal solids separators (Alternative 3) as having the highest score. Based on this analysis it is recommended that centrifugal solids separators are used for the basis of the design of the SRF. The Owners may want to consider the Teacup™-type technology as an allowable alternative technology.

4.2.5 Recommended Facilities without Sediment Return to River

The recommended features of the SRF in the event an NPDES discharge permit is not obtained from the USEPA are described in this section.

4.2.5.1 Process and Mechanical

Influent Flow Meters and Monitoring

It is recommended that a set of three flow meters be included to measure the raw water flow in each of the three pipelines from the RWLS. The signals from these meters would be used to control the operation of the centrifugal solids separators. To achieve reliable removal of the targeted sand, it is important that the flow through each of the separators be within the prescribed range. With changes in raw water flow rate, a different number of separators will be placed in operation. The TSS in the raw water will be monitored by a set of TSS analyzers. This will assist in determining the timing between sand slurry purges from the on-line centrifugal solids separators. It will also assist in determining the frequency of roll-off bin delivery and removal.

Centrifugal Solids Separators

It is recommended that the SRF include nine centrifugal solids separators. Each separator would have a flow range of approximately 1,160 to 2,150 gpm. Two of the nine units shall be standby units. The separators should be designed to remove 98 percent of the sand particles of 0.075-mm and larger. Each of the units should have motorized inlet, outlet, and purge valves.

A PLC-based control system should be provided by the separator manufacturer to control the operation of the units. This system should monitor the raw water flow rate and automatically open or close the inlet and outlet valves to bring the correct number of separators into service. Also, the control system should operate the purge valves to direct the collected sand slurry to the Grit Pumping Station.

Grit Pumps

A set of five grit pumps should be included to pump the sand slurry from the centrifugal separators to the sand dewatering system. The grit pumps should be specifically designed to handle abrasive grit so as to increase their reliability and minimize maintenance and replacement requirements. It is recommended that the grit pumps be cantilever style recessed impeller pumps with the motors located above the submerged pumps. Three of the pumps should be duty, with the other two pumps for standby.

Dewatering System

A set of four solids classifiers should be installed to dewater the removed sand. Three of the classifiers should be duty, with the other one as standby. The classifiers should include integral clarifier sections sized for the flow and to allow the sand to settle to the bottom of the units. The

clarifier water will flow to the wet well for BS1A. A belt conveyor system will remove the settled sand and allow water to drain back into the clarifier section.

The belt conveyors will deliver the dewatered sand to a set of screw conveyors that will automatically load a set of three 20-cy roll-off containers. A PLC-based control system will be provided to control the dewatering system. A set of ultrasonic level probes positioned above each of the roll-off containers will automatically control the reversing screw conveyors and chute gates to evenly distribute the dewatered sand into the roll-off containers.

Depending on the raw water flow rate and suspended solids concentration, between one and ten roll-off containers would be filled with dewatered sand each day. Under high solids production conditions, it would be useful to have a backup grit dewatering and storage system, so that trucks do not have to be delivering and removing roll-off containers outside of working hours.

Backup Grit Basins

A set of backup grit basins should be provided for use if the sand dewatering system is not in operation. For instance, if for some reason trucks are not able to remove the filled roll-off containers and replace them with empty units, then a backup dewatering and sand storage system would be necessary. This would allow uninterrupted operation of the SRF and the downstream BS1A and BS2A.

It is recommended that three backup grit basins be provided each sized to treat the maximum sand slurry flow (approximately 1,900 gpm) from the centrifugal solids separators. Three basins would allow one to be in operation, a second to be draining, while the dewatered sand in the third basin was being removed.

The basins should be rectangular with a horizontal flow pattern. A minimum length to with ratio of 5:1 should be used to reduce short circuiting. A weir at the end of each basin would be used to decant the clarified water. Each basin should have a solids storage capacity of approximately 160 cy of sand. This volume is equivalent to four to five days of sand storage when the raw water system is operating at maximum flow capacity with the estimated average suspended solids concentration in the Rio Grande. The inlet ends of the basins should be sloped to allow access by a front-end loader for removing the dried solids.

Decanted water from the backup grit basins will flow by gravity to an adjacent decant return pumping station. It is recommended that a set of submersible pumps be used to pump the decant to the wet well of BS1A. A set of vertically stacked 10-ft diameter reinforced concrete pipe sections could be used to create the wet well.

Sediment Removal Facility Piping and Valves

It is recommended that the piping for conveying the raw water within the pumping station be rubber-lined steel (RLS). This type of piping is specifically designed to handle water containing abrasive solids. All piping beneath structures should be concrete encased.

It is recommended that gate valves be used for isolation purposes. Control valves should be eccentric plug valves. The plug valves should be oriented so that the plug is positioned at the top of the valve when opened. All valves should be placed in horizontal runs of pipe.

The buried piping for conveying grit slurry is recommended to be HDPE.

PNM Electrical Yard

It is recommended that the transformers, switch gear, and meters for the electrical service from the Public Service Company of New Mexico (PNM) be placed in a walled area near adjacent to BS1A and the SRF building. The electrical service should be double-ended to increase the reliability of the facility. The yard should include a solid masonry or concrete wall to protect the electrical gear from bullets. Also, the yard should include solid steel vehicle access gates.

4.2.5.2 Operation and Maintenance of Facilities

The SRF will be designed to include a high level of automation so that it can normally be operated un-staffed. However, it is anticipated that the facility will be visited most days to verify proper operation. Routine maintenance will be required to keep the facility equipment in proper working order. The centrifugal solids separators will not require a great deal of daily maintenance due to their simple design. The grit dewatering system is more mechanized and will require greasing of bearings and other maintenance.

The process piping and equipment will be designed to provide reliable service while treating and handling the abrasive sand. The process instrument and control system shall send signals to the SCADA system to allow the process to be monitored remotely from the C/CWTP.

4.2.5.3 Civil Site Work

Sheet 2C-2 of the Raw Water Pipeline and Facilities Preliminary Design Drawings shows a preliminary site grading plan for the SRF/BS1A. The PNM electrical yard would be located to the east of the SRF/BS1A building.

The existing access road to Buckman Well 2A will be upgraded to a 16-ft wide gravel road. A 16-ft wide gravel road around the building would provide vehicle access to the different access points in the facility. The access road would include a manual gate with pad lock. The entire site would be surrounded with an 8-ft high chain link fence including concertina wire.

The site should be graded to promote drainage away from the facilities. The drainage should be designed to work with the existing drainage patterns in the area. The temporary use areas around the facility will be returned to their original contours prior to revegetation.

4.2.5.4 Landscaping/Revegetation

Disturbance due to construction of the SRF shall be as minimal as possible and in all cases must be within the environmental survey limits and the temporary use areas permitted by the agencies. Reclamation of the SRF surroundings will include reclamation seeding of any disturbed area with a specially selected seed mix for Pinon-Juniper Areas approved by the USFS. The stockpiled topsoil will be replaced over areas to be revegetated prior to the seeding operations. A seed mixture was shown in Table 3.2-4 (Section 3).

4.2.6 Recommended Facilities with Sediment Return to River

The USEPA may allow the sand removed from the raw water at the SRF to be returned to the Rio Grande. This would allow certain elements at the SRF to be modified or omitted.

4.2.6.1 Differences in Recommended Facilities

If the USEPA allows the removed sediment to be returned to the Rio Grande, then the sand dewatering system can be omitted from the SRF. The elements that could be omitted include the

grit dewatering classifiers and the dewatered grit conveyer system. These omissions would allow the building to be reduced in sized by approximately 3,200 sf.

It is recommended that at least two of the three the Standby Grit Basins be retained so that if under certain circumstances sand return to the river is not allowed, the SRF could continue to operate. For instance, there may be restrictions on sand return if the Rio Grande flow rate is below a certain level.

4.2.6.2 Changes in Operation and Maintenance of Facilities

The elimination of the grit dewatering and conveyance system would reduce the required operation and maintenance staff time and cost for the SRF. The grit dewatering and dewatered sand conveyance system is mechanically intensive and requires routine maintenance. Returning the removed sand to the river would also eliminate or at least minimize the number of roll-off containers delivery trucks traversing Buckman Road. Returning the removed sand to the river would provide substantial cost savings.

4.2.6.3 Process and Mechanical

As mentioned above, elimination of the grit dewatering and conveyance system would significantly reduce the complexity for the treatment processes at the SRF. The grit dewatering and dried sand conveyance system is mechanically intensive and its elimination would simplify this facility.

4.2.6.4 Civil Site Work and Landscaping

Eliminating the grit dewatering and conveyance system would reduce the site footprint for the SRF. The access road and amount of landscaping could be reduced. Other civil and landscaping features would still be required.

4.3 General Recommendations for SRF

4.3.1 Geotechnical

Geotechnical data was collected as part of a field investigation. The complete description of the field investigation is provided in Attachment A – Geotechnical Investigations Report.

For the SRF, the structures may be supported on conventional spread and strip footings bearing on a minimum of 3-ft of structural fill. The structural fill should extend a minimum of 2-ft laterally beyond the edge of all footings. The foundations may be designed to allow a bearing pressure of 1,500 psf.

The base of the exterior footings should be embedded a minimum of 24-inches below the lowest adjacent grade. The base of the footings should be embedded a minimum of 12-inches below the finished pad grade. The spread and strip footings should be a minimum of 24 and 18-inches wide, respectively.

Foundations designed and constructed by the DB Contractor are not anticipated to settle more than one-inch. Therefore, the DB Contractor will be required to design and construct the foundations to tolerate this settlement level. Vibratory equipment, including the cyclones, will require mounting on isolated equipment pads to minimize settling.

The DB Contractor's geotechnical engineer is responsible for developing structural recommendations for these and all other BDD facilities.

4.3.2 Structural

The structural requirements provide minimum design criteria and will be used as a guide in the design and construction of all facilities.

The general types of construction will be as follows:

- Cast-in-place concrete or prestressed concrete for liquid containing basins or reservoirs.
- Masonry walls with steel roof for buildings.

Foundations of structures will be designed in accordance with the data provide in the project geotechnical report. The DB Contractor's geotechnical engineer is responsible for developing recommendations and criteria for structures. In general, the type of foundation for structures will be as follows:

- Mat foundations or continuous spread footings along the walls with slab-on-grade at the center portions for the liquid containing basins or reservoirs.
- Continuous spread footings along the walls for masonry buildings.

4.3.3 Architectural Design for Sediment Removal Facility

4.3.3.1 Design Standards

All buildings for the Buckman project will be designed to meet the 2004 New Mexico General Construction Building Codes (Title 14 NMAC – Chapters 5 and 7). The buildings must also comply with the requirements of the BLM and the USFS where the buildings lie on those respective properties.

4.3.3.2 Space Planning

The space planning for this facility was done by the process engineers and did not involve the project architect. The building size, shape and vertical height are determined by the sediment removal equipment to be housed.

4.3.3.3 Architectural Style

The architectural style for all buildings along the raw water pipeline (SRF, BS1A and BS2A) will be concrete or CMU block walls with a textured stucco finish and no fenestration except for entry doors and ventilation louvers. The walls will be capped with flat removable concrete roof slabs. The only architectural style considerations will be to provide exterior wall and roof edge colors to meet the approval of BLM and USFS.

4.3.3.4 Architectural Construction Requirements

In the process of designing the buildings for the BDD Project and establishing the Technical Requirements, the project architect in collaboration with the process design engineers proposed general requirements for the enclosing shell (including vandalism resistance) and the interior finishes and furnishings for the buildings in the project.

4.3.4 Electrical

4.3.4.1 Power Distribution

All pieces of equipment with motors and requiring power will be fed from MCC A and MCC B located in the BS1A electrical room. Multiple pieces of equipment will be fed and controlled from different MCCs, i.e., odd numbered from MCC A and even numbered from MCC B. Conduits from BS1A to the SRF will be underground in concrete ductbanks.

At each piece of 480-volt equipment, a power disconnect switch will be provided to allow maintenance personnel to open the switch to de-energize the power and lock it out for safety. The disconnect switch will be provided with an auxiliary contact to open the control circuit of starters, VFDs, etc., to shut down the motor before opening the power switch blades.

4.3.4.2 Facility Loads

The loads at the SRF will be rated either at 480, 208, or 120 volts. A electric load list for SRF and BS1A are shown in Table 4.3-1. Since the largest motor is rated at 900 hp, a 480-volt, 3-phase system was selected for the main utilization voltage.

Table 4.3-1 Electric Load List for Sediment Removal Facility and Booster Station 1A

Item	Estimated Connected HP or KW	Comments
Sediment Removal Facility		
Grit Pump No. 1	15	480 VAC
Grit Pump No. 2	15	480 VAC
Grit Pump No. 3	15	480 VAC
Grit Pump No. 4	15	480 VAC (Standby Unit)
Grit Pump No. 5	15	480 VAC (Standby Unit)
Grit Classifier No. 1	2	480 VAC
Grit Classifier No. 2	2	480 VAC
Grit Classifier No. 3	2	480 VAC
Grit Classifier No. 4	2	480 VAC (Standby Unit)
Decant/Return Pump No. 1	15	480 VAC
Decant/Return Pump No. 2	15	480 VAC
Decant/Return Pump No. 3	15	480 VAC (Standby Unit)
Screw Conveyor No. 1	3	Main Grit Conveyor
Screw Conveyor No. 2	3	Bin Loading Conveyor 1
Screw Conveyor No. 3	3	Bin Loading Conveyor 2
Screw Conveyor No. 4	3	Bin Loading Conveyor 3
Misc. Motor Controls	9	Valves
Inlet Flow Meters	*0.6 KW*	Hydropneumatic Tank
BS1A Facilities		
Booster Pump No. 1	900	480 VAC
Booster Pump No. 2	900	480 VAC
Booster Pump No. 3	900	480 VAC
Booster Pump No. 4	900	480 VAC (Standby Unit)
UW Pump 1	2.0	480 VAC
UW Pump 2	2.0	480 VAC (Standby Unit)
Seal Water Flush Booster 1	3.0	480 VAC
Seal Water Flush Booster 2	3.0	480 VAC (Standby Unit)
Air Compressor No. 1	10	Hydropneumatic Tank
Air Compressor No. 2	10	Hydropneumatic Tank (Standby Unit)
Sample Pump	*0.6 KW*	480 VAC
Electrical Room AC	8.0	
Exhaust Fans	2.0	480 VAC
Electric Unit Heaters	*10 KW*	
Indoor Lighting	*5.5 KW*	Pump and Electrical Room
Outdoor Lighting	*5 KW*	Facility Security
Miscellaneous Other Loads	*10 KW*	Instrumentation, tools, etc.
Total	*3789 hp + 31.7 KW*	

4.3.5 Instrumentation and Control

4.3.5.1 Control Descriptions for Facilities

The raw water flow rate to the SRF will be measured by a set of three flow meters located in below-grade vaults. Each of the flow meters measures the flow in one of the three raw water pipelines from the RWLS. The signals from each of the flow meters will be combined to determine the total flow into the SRF.

The larger sand particles (i.e., 0.1-mm and above) will be targeted for removal through a set of centrifugal solids separators. This larger sand (grit) can be particularly abrasive to pumps, valves, and piping. The number of separators in-service will depend on the raw water flow rate. Each separator has a flow range of approximately 1,160 to 2,150 gpm. The number of separators in-service must be such that the flow through each separator falls in this operating range. There will be nine separators; as many as seven of these units will be in-service at a time. At least two separators will be in standby mode.

The partially clarified raw water will flow on to the wet well of BS1A. The sand removed by the separators will fall to the bottom of each unit. A purge valve will periodically open to release the sand slurry, which will flow by gravity to the wet well of the grit pumps.

The grit pumps will pump the sand slurry to a set of the sand dewatering system. There will be five grit pumps. Normally, as many as three grit pumps will be in-service with the other units in standby mode. The grit pumps will be equipped with variable frequency drives. The grit pumps will turn on and off as well as ramp up and down in speed to maintain the slurry level in the wet well within its operating band. Alarms and automatic shutdown will be programmed into the facility control system in case of a high-high slurry level and incipient overflow of the wet well.

The sand dewatering system consists of a set of four grit classifiers, a system of screw conveyors, and roll-off bin loading chutes and gates. The sand slurry is pumped to the clarifier sections of the in-service grit classifiers. At least one of the classifiers will be in standby mode. The sand settles in the bottom of the clarifier sections and the decant flows by gravity to the wet well of BS1A. The settled sand is conveyed out of each clarifier section using a belt conveyor. The belt conveyors feed a set of screw conveyors that convey the sand to above a set of three roll-off containers. The bin loading conveyer use reversing screws to deliver the sand to one of three chutes positioned over the roll-off containers. The conveyer system using signals from a set of ultrasonic probes to measure the sand levels in the different roll-off containers. The reversing screws operate to evenly distribute the sand in each bin. Trucks periodically come to the facility to drop-off an empty bin and collect a full bin. The sand will likely be taken to the regional landfill for use as cover.

The SRF will include a set of Backup Grit Basins. These basins will be used in the mechanical sand dewatering system is not in service or all of the available roll-off containers are full. Three grit basins will be provided; each with the capacity to accept the maximum slurry flow from the centrifugal sand separators (approximately 1,900 gpm). Each of the grit basins is rectangular with a length to width ratio of approximately 5.5:1. As the sand slurry flows horizontally down the length of a basin, the sand will settle to the bottom. The clarified water is decanted over an end weir into a common effluent channel for the three basins. The clarified water then flows by gravity to the Decant Pumping Station. Once a basin becomes full of sand, it will be taken off-line and drained by raising a slide gate in the weir wall. The sand in the basin will be allowed fully drain and partially dry prior to removing the sand. The dewatered sand will be removed using a front-end loader that will be used to load the sand into dump trucks, which will transport the sand to the landfill or some other appropriate disposal site.

The clarified water from the Backup Grit Basins will be pumped from the Decant Pumping Station to the wet well for BS1A. The pumping station will include three submersible-type pumps. The pumps will have variable frequency drives and will be controlled to maintain the water level in the Decant Pumping Station within the operating band.

4.3.5.2 Instrumentation and Monitoring

All equipment and process parameters will be monitored for safe and efficient operation through SCADA. Control commands received from the C/CWTP will be received by the local PLC processor and executed by the programming within the unit. All parameters pertinent to determining process and equipment readiness for the command and confirmation that the command has been properly carried out shall be provided and reported to the C/CWTP SCADA system.

4.3.5.3 Transmission of Information and Control

Due to the multiple data needs of this site and the construction of the pipeline from this site to the C/CWTP and associated facilities en-route, the installation of fiber optic media is the optimal means to provide sufficient data carrying capacity for the control system needs, and could also support the demands of remote video surveillance and inter-facility telecommunications. Therefore, the PLC equipment at this site will be configured as part of the Ethernet Network of the C/CWTP control system. The PLC interface will operate at 100 Mbps. This approach will allow the remote PLC to be incorporated into the polling sequence of the plant PLC system in the same manner as any of the on-plant PLC installations. Consistency and speed are two of the benefits to such an approach

4.3.6 SCADA and Telemetry

The Process LAN from the C/CWTP will be extended to the SRF/BS1A via fiber optic cable. Process control for the SRF shall consist of PLCs on the process LAN communicating with the SCADA Master at the C/CWTP and other PLCs on the process LAN. Detailed information on the SCADA system is included in Section 8.

4.3.7 HVAC, Plumbing and Fire Protection

4.3.7.1 HVAC

The HVAC system in the SRF, BS1A and BS2A will consist of systems necessary to meet the numerous functions.

Systems will provide comfortable conditions in buildings and areas intended for staff occupancy. In wet areas or areas with potential for condensation, maintain a low RH to minimize or eliminate condensation and corrosion. Where outside air is required for ventilation, the outdoor air will be treated by heating and filtering.

Electrical rooms will be provided with mechanical cooling for heat removal and reduction in potential corrosion in the electrical room.

Operation spaces will be provided with ventilation where they will be occupied spaces. In addition spaces that may be entered by plant personnel will be ventilated in accordance with applicable codes and good engineering practices

Ventilation will use multiple supply fans in each space with relief dampers. Supply fans will have both outdoor and return dampers to provide a minimum supply temperature during cold weather.

HVAC Codes and Standards

Design of the SRF and BS1A will comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Commercial Building Code
- 2003 New Mexico Mechanical Code
- 2003 New Mexico Energy Conservation Code
- New Mexico Boiler Code
- ASHRAE
- NFPA standards
- SMACNA standards

Design Criteria

The design will be based on outdoor design conditions of 10 degrees F dry bulb during the winter and 96 degrees F dry bulb, with a 60 degrees F MWB (mean wet bulb) during the summer. Air density will be based on an elevation of 6,560-ft amsl (SRF and BS1A) and an elevation of 6,043-ft amsl (BS2). Selection of condensers for air-conditioning units will be based on 106 degrees F.

The design of cooling and heating systems for specific spaces will be based on the indoor conditions shown in Tables 4.3-2 and 4.3-3.

Table 4.3-2 SRF & BS1A Indoor Design Temperatures and Ventilation Rates

Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Equipment Room	Ambient + 10/55		• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation • Unit heater
Pump Room	Ambient + 10/55		• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation • Unit heater
Electrical room	85/55	0.25 CFM/sf	▪ Provide mechanical cooling with separate unit ▪ Provide continuous ventilation

Table 4.3-3 BS2A Indoor Design Temperatures and Ventilation Rates

Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Pump Room	Ambient + 10/55		• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation • Unit heater
Electrical room	85/55	0.25 CFM/sf	▪ Provide mechanical cooling with separate unit ▪ Provide continuous ventilation

Refer to system diagrams for additional information on systems and zoning of units and number of units required.

4.3.7.2 Plumbing Systems

The plumbing in the SRF, BS1A and BS2A will consist of systems necessary to meet the numerous functions.

Drain systems with vents where required for sanitary, process rain water, equipment and HVAC condensation drain systems. Sump pumps and discharge piping systems. Water systems including utility water (non-potable) for process use and sample water systems

Plumbing Codes and Standards

Design of the plumbing systems at the SRF, BS1A and BS2A shall comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Plumbing Code
- 2003 IFGC
- NMED Title 20 Chapter 7 Part 3: Liquid Waste Disposal and Treatment Requirements

Description of Recommended Systems

The Process Drain system will be independent of the sanitary sewer and will include floor drains in process areas.

Rainwater Leaders will be based on a Rainfall rate of 2.0 inches per hour (0.021 gpm per square foot) for a 100-year storm. This is the 1 hour rainfall rate per 1997 UPC.

4.3.7.3 Fire Protection

There are no fire protection systems anticipated for the SRF and BS1A facilities. The DB Contractor is to work with the authorities on any required fire protection systems based on its final design of the facilities.

4.3.8 Security

Security and personnel protection measures to protect the Project facilities during construction, start-up, and initial operation will be provided. During construction, temporary security measures will be provided as necessary to protect the facilities, equipment, and personnel.

4.3.8.1 Security Objectives

Security and personnel protection systems must be included for each facility to reduce risk to the integrity of these facilities and to protect the public water supply. The following security and personnel protection issues, at a minimum, will be addressed:

- Threats to the source water and water treatment facilities
- Threats to the pump stations
- Threats to the distribution systems/booster stations
- Threats to the Supervisory Control and Data Acquisition (SCADA)/telemetry system
- Fire detection and notification
- Communications

Threats may be in the form of one or more of the following: vandalism, criminal acts, sabotage/terrorism, or deliberate/malevolent acts by employees (either present or former).

The designed and installed security system will be compatible with the City of Santa Fe's existing security system at Canyon Road WTP and will be expandable to other City and County water facilities.

4.3.8.2 Recommended Security Systems

The following sections outline the physical security and personnel protection requirements for the SRF. Because water systems cannot be made immune to all possible threats, the design of the facilities will address issues of critical asset redundancy, monitoring, response, and recovery to minimize risk.

For all of the Project facilities, basic physical security and personnel protection measures will be considered during design, including locks for access ladders, hatches, buildings, gates, and doors; bollards to prevent vehicle damage; back-up generators or battery supply for emergency power of alarms, security systems, fire alarm systems, communications and life safety devices; and appropriate signage and lighting.

For all of the remote facilities, including the SRF, the design will also incorporate tamper-resistant hinges and security pins for each doorway. Louvers will be provided with expanded metal grating on the interior side (i.e., provide grating with openings too narrow for bolt cutters to grip and too narrow to acquire handhold or toehold). Glass windows will incorporate glass-break sensors and magnetic alarm contacts for detection of penetration. Employee-activated switches will be required at the remote facilities for notification of emergency situations.

Each Project facility will include a level of protection (LOP), built on the "protection in depth" principal, which requires a defeat of several protective barriers or security layers before a facility/component is compromised.

- Site Perimeter LOP includes perimeter fencing topped with concertina wire ad with access gate(s), landscaping barriers, vehicle barriers, and signage
- Inner Perimeter LOP includes site lighting, CCTV cameras, and appropriate standoff distances between the facility and the perimeter fencing (also advantageous for preventing acts of vandalism by graffiti)
- Building LOP includes access card readers, windows, door alarms, and interior intrusion alarms.

For all outdoor PNM and facility distribution electrical equipment such as switchgears, transformers, etc., concrete or concrete block walls will surround each group of equipment on four sides (open top) to provide an additional LOP. A set of bullet-resistant double doors will be provided to allow access and installation/removal of the equipment.

For the ventilation louvers at the facility buildings, similar construction of a three-sided (open top) concrete block wall will be required. A bullet-resistant door will be provided for personnel access.

For all facilities, Level 4 bullet-proof rated equipment will be required and conform to the UL rating 752-HPR 30.06.

Sediment Removal Facility

The design will incorporate the following provisions to protect the water supply and the SRF:

- 8-foot high perimeter colored vinyl-coated chain-link fencing with concertina wire around the individual facilities with bullet-proof rated warning signage for deterrence and protection
- Shackled-protected locks to prevent breach with a bolt cutter
- Bullet-proof rated restricted access signage, including signage restricting access to the control room to authorized personnel only
- Bullet-proof rated restricted vehicle access signage
- Video surveillance via CCTV cameras (triggered by motion sensors) will be provided. Cameras and lenses will be installed in bullet-resistant metal enclosures. Cameras will be pole-mounted and provide redundant coverage of the entire perimeter of the site, as well as, coverage of each building entrance. The complete CCTV system at this site will include: pole-mounted cameras, lenses, infrared illuminators and bullet resistant enclosures; digital video recorder and accessories; power supplies; fiber optic interface components; mounting hardware; and, enclosures. The CCTV system will transmit video to and receive control from the C/CWTP via the fiber optic infrastructure.
- Perimeter protection will be provided utilizing volumetric microwave technology will be provided. The perimeter protection system will be integrated into the CCTV system and provide control to camera presets and recording functions.
- Card access/security system will be provided complete with multiplexer(s) and alarm panel(s); card reader, electric strike, request to exit device, magnetic door alarm contact and motion sensor at or in the immediate vicinity of each entrance door; glass break sensors in the immediate vicinity of all windows; magnetic window alarm contacts; alarm arming and disarming keypad; power supplies; fiber optic interface components. The card access / security system will transmit data to and receive data from the C/CWTP via the fiber optic infrastructure.
- Fire alarm system within structures
- Voice over Internet Protocol (VoIP) phone service will be provided to the SRF as an extension of the C/CWTP's phone system. The fiber optic infrastructure will be utilized to extend service between the two sites.
- Adequate lighting, equipped with bullet-resistant bulb shields, to increase visibility of suspicious activity. Lighting will be motion sensor controlled with manual switch override.
- Bullet-resistant doors with handles and lock covers
- Kevlar curtain on roll-up doors to prevent bullets from passing into the building interior
- Bolts/Hardware that require a special wrench (where generally available screw-drivers and wrenches would not work) to unlock access hatches and valve vaults
- Pad locked anti-climb barriers

4.4 Disposal of Solids from River

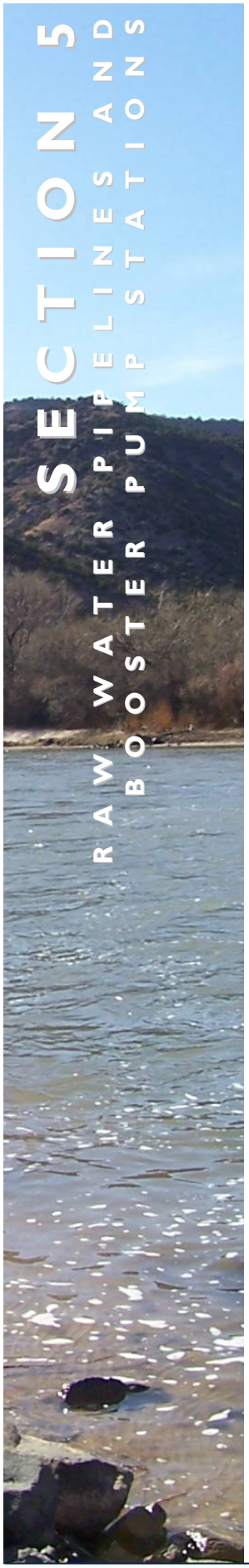
4.4.1 Trucking of Solids

Settling ponds will be provided at the SRF as a backup to the river sediment return system. If sediment return to the Rio Grande is not permitted or is temporarily out of service, at average flow conditions 52 wet tons/day at 25 percent solids will be removed through the SRF.

The least expensive and most stable beneficial reuse for the river sediment (if return to the Rio Grande is disallowed) is their use as daily and intermediate landfill cover at the Caja del Rio Landfill in Santa Fe. The test results completed during the pilot testing indicate that use of these materials as landfill cover is allowable under the current regulations. The existing landfill permit will have to be modified to include the use of these materials as daily and intermediate cover. The approximate distance form the SRF to the landfill is 20 miles. Under the average flow conditions, 62 cy per day of river sediment will be generated at the SRF. This would require a little over three trucks trips per day with a 20 cy dump trailer.

4.4.2 Return of Solids to River

An NPDES Discharge Permit has been submitted by the City to EPA. If granted, the NPDES discharge permit will allow the return of river sediment collected at the SRF back to the Rio Grande downstream of the raw water diversion structure. Sediment removed at the SRF will be returned to the Rio Grande through a 16-inch pipeline. The 16-inch pipeline will be buried parallel to the raw water pipelines between the RWLS and the SRF. The sand would be returned as a slurry to the Rio Grande for dispersion into the river downstream of the Diversion Structure.



5.1 Raw Water Pipelines

The raw water pipelines consist of two distinct reaches: from the RWLS at the Rio Grande to the SRF approximately one mile to the south; and from the SRF to the C/CWTP approximately ten miles further south. The following are general design criteria covering the pipelines and their installation.

5.1.1 Pipe Alignments

5.1.1.1 Pipe Route and Cover

In general, the raw water pipelines will follow the existing alignment of Buckman Road and the existing 20-inch ductile iron water line. The alignment will deviate when the unimproved (dirt) roadway traverses too far off the general heading necessary to direct the pipelines to the C/CWTP. This alignment will traverse past existing Buckman BS1 and BS2 and the related existing Buckman wells, which are adjacent to Buckman Road. The raw water carried by these pipelines will be pumped by two new Booster Stations: 1) BS1A which is located with the SRF and 2) BS2A which is to be constructed adjacent to existing BS2.

Pipe cover for the raw water pipelines will generally be 4-ft in minimum. Additional depth will be necessary where the pipelines cross arroyos and the pipe will be concrete encased and located 2-ft below the anticipated scour depth for several arroyo crossings.

5.1.1.2 Air Relief Valves and Other Appurtenances

Shut-off or control valves will not be required on raw water pipelines, however, air/vacuum relief valves will be installed on the pipeline at locations determined through the DB Contractor's surge modeling. Recommendations from the OC's surge modeling conducted during preliminary design are presented in Appendix E and summarized in Section 5.1.5.

5.1.1.3 Impacted Utilities

The raw water pipelines will be laid across, under or adjacent to existing buried and overhead utilities including steel high pressure gas lines with impressed current for corrosion protection. Other existing utilities include three-phase underground electric, 20-inch ductile iron water, fiber optic communication lines and overhead electric.

5.1.2 Pipe Sizes, Material and Length

The BDD raw water pipelines consist of two systems. The first connects the RWLS to the SRF. Three parallel 20-inch HDPE pipelines, just over one-half mile in length will be installed at this location. The second system will consist of a 30-inch pipeline to carry raw water from the SRF to the C/C WTP. Approximately 10.5 miles in length, this pipeline may be Steel

Cement Mortar Lined and Coated Pipe (SCLC), Ductile Iron (DIP) or Concrete Cylinder Pipe (CCP).

Selected pipe materials will be adequate for the maximum operating pressures (with all duty and standby pumps in operation) at BS1A and BS2A plus the surge pressure designated under the appropriate pipe material ASTM or AWWA standard. As an option, the DB Contractor should consider pipeline materials with lower pressure ratings at higher reaches of each pipeline segment as pressures decrease. Pipeline diameters were selected to optimize the pipeline capacity, electric costs due to friction losses and velocity requirements.

Various pipe materials were evaluated for use in the BDD Project. Pipe materials were evaluated for their ease of construction, cost, reliability, availability at design diameter and operating pressures and compatability with site soils.

HDPE pipe has been selected for the raw water pipelines between the RWLS and the SRF because of its resistance to abrasive material and ease of fabrication and installation in the field. This type of pipeline may be heat fused at the joints, resulting in a continuous conduit essentially without joints, thus leak-proof. Because of its flexibility, the HDPE pipeline can be installed in curved trenches eliminating, in many instances, the need for elbows. HPDE pipe is inert plastic, immune to corrosion and highly resistant to chemical interactions. However, HPDE is limited to lower pressure applications at bigger pipe diameters and is therefore not recommended for the raw water pipeline segments between BS1A and the C/CWTP.

SCLC, DIP and CCP pipe have been selected as acceptable material materials for the raw water pipelines between BS1A and the C/CWTP because of their long record of success in this application. Local and nation-wide pipeline contractors have extensive experience with these materials, and no special equipment is required for their installation. Pipelines made of these materials are available across the southwest in many sizes and with many lining and coating materials, making their repair with an identical product a routine matter. These materials are available at the design pressure ratings and diameters. The existing Buckman pipeline is a 20-inch DIP that has been in service since the early 1970s. Corrosion control measures will be necessary for non-plastic pipelines used for the BDD Project as discussed elsewhere in this Report and the Technical Requirements.

5.1.3 Geotechnical

A draft geotechnical report dated March 10, 2006 for the entire BDD Project has been prepared and includes recommendations for pipeline construction. This information can be found in Appendix A. The geotechnical report indicates that native material will be suitable for inclusion in the installation of the various pipelines being constructed for this project. However, it will be the DB Contractor's responsibility to identify useable material to meet its' final pipeline design.

5.1.3.1 Pipeline Bedding and Backfill

Bedding and Backfill for C303 Concrete Cylinder Pipe

Bedding for CCP will likely be a Controlled Low Strength Material (CLSM) composed of water, Portland cement, native trench material and fly ash. CLSM will exhibit an ultimate compressive strength of between 150 and 200 psi. Slump during placement will be approximately 10-inches.

The bedding material will be placed to the following dimensions:

Below the pipe: 4-inches
Atop the pipe: 12-inches
Each side of the pipe to the undisturbed sides of the trench

Backfill for CCP will be native trench material placed above the CLSM for the entire width of the trench, compacted to 85 percent maximum density in off-road undeveloped areas, 90 percent beneath dirt roadways and 95 percent adjacent to or beneath paved roads.

Bedding and Backfill for Ductile Iron and SCLC Pipe

Bedding material for DIP and SCLC pipe will be sand, gravel or crushed stone to a depth of 1/8 of the pipe diameter or 4-inches minimum.

Backfill will be native trench material free of rock larger than 3-inches in any direction 12-inches from the pipe, free of any rock larger than 12-inches in any direction and free of frozen or organic material. Compaction will be 85 percent in off road, undeveloped areas, 90 percent beneath dirt roadways and 95 percent adjacent to or beneath paved roads.

Bedding and Backfill for HDPE Pipe

To protect the near-river pipelines from damage due to river flooding, bedding and pipe zone backfill for HDPE pipelines will be a Controlled Low Strength Material (CLSM) composed of water, portland cement, native trench material and fly ash. CLSM will exhibit an minimum 28-day compressive strength of 150 psi.

Backfill above the pipe zone will be native trench material free of rock larger than 12-inches in any direction, containing no organic or frozen material. Compaction will be 85 percent in off-road undeveloped areas, 90 percent beneath dirt roads and 95 percent adjacent to or beneath paved roadways. Plastic pipe backfill will include the placement of a continuous 4-inch wide detectable marking tape with the word "WATER" marked on the tape for its entire length. The tape will be placed during backfilling 18-inches above the top of the pipeline.

5.1.4 Corrosion Analysis

A corrosion and stray current analysis was completed for the raw water pipeline alignment. The report documenting the methodology, results and recommendations are included in Appendix B. The following paragraphs summarize the recommendations for the raw water pipeline:

The soils along the raw water pipeline corridor are corrosive based on low resistivity and high chloride concentration. Chlorides are generally corrosive to iron and steel and high chloride concentrations typically coincide with a low resistivity. Several corrosion control measures are required for the raw water pipeline based on the collected data, previous work and the observations regarding the natural gas pipeline that parallels and crosses the raw water pipeline. The recommendations are based upon a 100-yr service life, vary with the pipe material and are presented by material.

5.1.4.1 Corrosion Requirements for DIP

If the DB Contractor selects DIP for the raw water pipeline, the corrosion protection measures shall consist of polyethylene encasement, electrical continuity bonding with test stations, and life extension cathodic protection. The DB Contractor will be required to evaluate the need for

additional stray current and corrosion control measures once the pipeline alignment and profile are finalized and details of the natural gas pipeline proximity and depth are field verified.

5.1.4.2 Corrosion Requirements for CCP

The high chloride in the soil will contribute to soil side corrosion of CCP. If the DB Contractor selects CCP for the raw water pipeline, the corrosion protection measures shall consist of electrical continuity bonding (isolated from foreign structures using dielectric isolation fittings) with test stations and have cathodic protection in accordance with NACE RP-0169-2002 criteria.

5.1.4.3 Corrosion Requirements for HDPE

HDPE pipe is typically not susceptible to corrosion. The pipeline supplier must demonstrate the pipe material meet the 100-yr service life requirements in high chloride soils if the DB Contractor selects the use of plastic pipe for any portions of the raw water pipeline.

5.1.4.4 Corrosion Requirements for Steel Pipe

If the DB Contractor selects Steel Piping for any portion of the raw water pipelines, the corrosion protection measures shall consist of electrical continuity bonding (isolated from foreign and above ground structures using dielectric isolation fittings), test stations, a dielectric coating, and cathodic protection in accordance with NACE RP-0169-2002 criteria. The DB Contractor will be required to evaluate the need for additional stray current and corrosion control measures once the pipeline alignment and profile are finalized and details of the natural gas pipeline proximity and depth are field verified.

5.1.5 Surge Protection

A surge analysis was completed for the raw water conveyance system. The surge analysis was completed using H2OSurge software, developed by the University of Kentucky in conjunction with MWHSoft. The raw water conveyance system surge analysis is documented in a memorandum included in Appendix E.

For the raw water system, the worst-case scenario was judged to be power failure, when the system is operating at its peak design flow. A pump station power failure with pump stations operating at their planned peak design flow of 20.8-mgd for the RWLS, 18.2-mgd for BS1A and 16.0-mgd for BS2A was evaluated. Information on maximum pressure rise or drop through the system following failure of the pumps was then compiled. Based on the model results, the OC developed recommended mitigation measures for the raw water system.

Worst-case pressure transients result when a power failure occurs with the system operating at its peak design flow. With no mitigation, pressure drops throughout the pipeline, with most of the pipeline reaching full vacuum conditions. Hydropneumatic surge tanks are required at each of the three pump stations in the raw water system, to protect the system from downsurge. Hydropneumatic surge tanks should be sized for each facility as follows:

- RWLS: 2,000-gallon surge tank, with 30 percent air/70 percent water ratio (steady-state operating pressure of 77 psi, at 5,470-ft amsl elevation)
- BS1A: 7,000-gallon surge tank, 50 percent air/50 percent water ratio (steady-state operating pressure of 243 psi, at 5,560-ft amsl elevation)
- BS2A: 6,000-gallon surge tank, 40 percent air/60 percent water ratio (steady-state operating pressure of 242 psi at 6,043-ft amsl elevation)

Vacuum relief valves will need to be provided at several locations along the pipeline, at local high spots, and upper reaches of the pipeline alignment (i.e. just before reaching the next booster pump station). For valves at locations where significant quantities of air may be drawn into the pipeline, valves should be equipped with a slow closing feature to avoid rapid expulsion of air from the system, which could cause a secondary high-pressure transient upon closure of the air valve. Options include APCO S-1500C, Vento-Mat RBX series, or combination valves with surge check feature. Valves at other locations can be standard combination valves. Recommended vacuum relief valve locations and sizes are shown in Table 5.1-1. Refer to the pipeline plan drawings in the Raw Water Pipeline and Facilities Preliminary Design Drawing for station locations.

Table 5.1-1 Preliminary Locations and Sizes of Vacuum Relief Valves[1]

Location	Size	Notes
RWLS Suction Pipelines	2-inch	Valve on each line
Station 32+30	2-inch	Three valves (one on each parallel pipeline)
Station 36+50	2-inch	Three valves (one on each parallel pipeline)
Station 42+75	4-inch	Three valves (one on each parallel pipeline) Slow-venting valve
Station 140+60	4-inch	
Station 145+30	2-inch	Slow-venting valve
Station 231+00	1-inch	
Station 242+50	1-inch	
Station 248+00	1-inch	
Station 250+70	1-inch	
Station 252+70	2-inch	
Station 256+00	2-inch	
Station 262+50	8-inch	Slow-venting valve

[1]Stationing based on preliminary design drawings dated March 21, 2006

The DB Contractor will be responsible for completing its' own surge protection system analysis during final design based upon its final pipeline alignments, pipeline materials and selected pumping equipment.

5.1.6 Scour Studies

A scour study was performed to estimate scour depth at locations where the raw water pipeline crosses several arroyos. The scour study is included as Appendix C. This section summarizes the results and recommendations from the scour study.

Topographical cross sections were collected for one wide and one deep arroyo and the depth of scour was estimated using various computational methodologies. The minimum scour depth was determined to be essentially zero feet. However, for protection of the pipe, the normal pipeline cover under roadways (4-ft) was increased by a 50 percent safety margin to 6-ft cover. All arroyo crossings along the raw water pipeline alignment will be similar. Arroyo crossing details, other than cover depth, are not discussed in the scour study report. However, the preliminary design drawings include typical arroyo crossing and specific arroyo crossing details. In general, the pipeline cover depth is 6-ft and a 12-inch thick concrete cutoff wall will be constructed downstream of the arroyo crossing. Three crossings (Calabasa Arroyo, Alamo Creek and Canada Ancha) will also require concrete encasement of the pipeline.

5.1.7 Archaeological Sites

The raw water pipelines and/or Buckman Road will traverse through six identified archaeological sites. Table 5.1-2 identifies the significant archaeological sites along the raw water pipeline

and/orBuckman Road by Laboratory of Anthropology (LA) Number. The sites include the Buckman Townsite (LA 15222) at the beginning of the construction project, near the Rio Grande; and a prehistoric site (LA 137068) located between Buckman Road and the raw water pipeline to the southeast of the beginning of the Project. Also affected by the Project are the remnants of the historic Chili Line Railroad (LA 128580), which is crossed several times by Buckman Road and the raw water pipelines. Preconstruction treatment is planned for two sites. These two sites and all others in the table will be fenced and monitored during initial ground disturbing activities.

Table 5.1-2 Significant Archaeological Sites Along the Raw Water Pipeline and Buckman Road

LA	Pipeline Station Location	Site Name	Adverse Affect	Preconstruction Treatment	Construction Treatment
117262	121+00 to 123+00		Effects avoided by constructing in disturbed areas	None	Fence and monitor
137070	220-ft right of the station line near 146+00		Effects avoided by constructing in disturbed areas	None	Monitor
137072	275-ft right of the station line near 152+00		Effects avoided by constructing in disturbed areas	None	Monitor
128580	Various	Chili Line	- Adverse effect to Chili line at several crossings by pipeline - Near Buckman Townsite effects avoided by constructing in disturbed areas	Data recovery at pipeline crossings	Fence and monitor near Buckman Townsite
137068	74+00 to 76+00		- Buckman Road improvements will affect the site - Avoid effects from pipeline and electric by construction in disturbed areas	Data recovery	Fence and monitor
15222	18+00 to 33+00	Buckman Townsite	Effects avoided by constructing in disturbed areas	None	Fence and monitor

5.1.7.1 Construction Oversight and Monitoring

Compliance with Section 106 of National Historic Preservation Act (NHPA) (16 U.S.C. § 470) is required for the Project. The OC has received State Historic Preservation Officer (SHPO) concurrence that Project effects have been mitigated for the known sites. The OC will provide a qualified archaeologist to monitor initial ground disturbing activities throughout the project. Employees and sub-contractors of the DB Contractor will be trained on archaeology site avoidance procedures, the need to identify potential cultural resources, and the procedures to follow if resources are observed during construction. If any unidentified cultural resources are encountered during construction, construction activities in the vicinity of the discovery will cease and the archaeologist and Owners will be immediately notified.

5.1.7.2 Inadvertent Damage to Cultural or Natural Resources

If natural or cultural resources are inadvertently damaged, the immediate area will be secured to prevent further impacts. The DB Contractor will notify the OC environmental coordinator as quickly as is reasonable. The OC will develop a plan to mitigate the inadvertent damage in consultation with the appropriate agencies.

5.1.8 Rights-of-Way

The raw water pipelines will be installed within permanent right of ways (ROWs) dedicated for the installation of water pipelines. In addition, temporary construction easements (temporary use areas) have also been established as working areas and to store material and supplies as well as construction equipment. All work must be done within the environmental survey limits identified on the Preliminary Design Drawings. Both BLM and USFS will issue ROWs for the permanent

areas and the temporary use areas as outlined in the permitting discussion in Section 10.6. The OC prepared legal descriptions for the ROWs identified in the Preliminary Design Drawings. The DB Contractor will have to revise the legal descriptions if there are any revisions to either the permanent ROW or the temporary use areas.

5.1.9 Revegetation

Disturbance due to construction of the pipeline shall be as minimal as possible and in all cases must be within the environmental survey limits and the temporary use areas permitted by the agencies. Reclamation of the Raw Water Pipeline will include reclamation seeding of any disturbed area with a specially selected seed mix for Pinon-Juniper Areas approved by the USFS and BLM. The stockpiled topsoil will be replaced over the pipeline prior to the seeding operations. A seed mixture was shown in Table 3.2-4 (Section 3).

5.2 Booster Stations 1A and 2A

5.2.1 Performance and Design Criteria

The pumps for BS1A and BS2A will be vertical turbine type pumps with barrels set in a set of wetwells. The pumps will be suitable for pumping raw river water containing abrasive suspended materials.

The pump construction will conform to the ANSI/AWWA E101 for "Vertical Turbine Pumps, Line Shaft Type." Pump testing will be in accordance with ANSI/HI 2.6. Pump construction will comply with all local and state sanitary and safety regulations.

BS1A will include four pumps, three operating and one standby. The pumps will be suitable for long-term operation under the following conditions:

- Continuous Duty
- Variable Frequency Drives
- Raw Rio Grande water with sediment 0.1-mm and smaller
- 5,560-ft amsl Project Site Elevation

BS1A pump performance requirements are listed in Table 5.2-1.

Table 5.2-1 BS1A Pump Performance Requirements

Description	Pump Performance Requirements
Minimum Shutoff Head	1,000-ft
Design Flow Capacity, Each	4,225 gpm
Design Flow Pump Head (TDH)	575-ft
Design Flow Minimum Bowl Efficiency	84 percent
Maximum Flow Capacity at Max Speed	5,800 gpm
Maximum Flow Pump Head (TDH)	400-ft
Maximum Flow Minimum Bowl Efficiency	76 percent
Maximum Pump Speed	1,780 rpm
Maximum Motor Speed	1,800 rpm
Minimum Motor Size	900 hp

BS2A will include six pumps, three operating and one standby for pumping to the C/CWTP and space for one duty, one standby and one future pump for pumping to Las Campanas, which are

not included in this Project. The wetwell of BS2A will be designed with sufficient space for the installation of all three Las Campanas pumps and related equipment.

The raw water pumps for the pumping to the C/CWTP will be suitable for long-term operation under conditions similar to BS1A except the project elevation is 6,043-ft amsl. BS2A pump performance requirements are listed in Table 5.2-2.

Table 5.2-2 BS2A Pump Performance Requirements

Description	Pump Performance Requirements
Minimum Shutoff Head	950-ft
Design Flow Capacity, Each	3,560 gpm
Design Flow Pump Head (TDH)	590-ft
Design Flow Minimum Bowl Efficiency	84 percent
Maximum Flow Capacity at Max Speed	4,200 gpm
Maximum Flow Pump Head (TDH)	600-ft
Maximum Flow Minimum Bowl Efficiency	76 percent
Maximum Pump Speed	1,780 rpm
Maximum Motor Speed	1,800 rpm
Minimum Motor Size	700 hp

Design Criteria

The pumps and booster station facilities will be designed to comply with Hydraulic Institute Standards and the pump manufacturer's written requirements. The pumps will be located so as to provide adequate net positive suction head (NPSH). Adequate NPSH will be defined as the pump manufacturer's recommended minimum required NPSH (NPSHreq) at the pumps maximum flow capacity at maximum speed plus 5-ft. The available NPSH will account for head losses in the suction lines to the pumps. In no case will the pump impeller be located above the low water level in the suction wetwell. Vacuum pumps, check valves, or other mechanical devices are not allowed on the suction piping.

The booster station will have a wetwell to provide for operational storage of water. The wetwells will have a minimum usable operating volume of 50,000 gallons. The interior walls and ceiling of the pump house will have sound attenuation so that the sound level does not exceed 48.6 decibels (db) Leq measured 300-ft from the structure in any direction, with the pumping station operating at full capacity.

Each pump will be configured and valved to allow the pump to be isolated from the other pumps to allow maintenance and removal, while allowing continuous operation of the other pumps. Packing drainage will be collected and disposed of using an on-site drain field with an upstream vault to allow sediments to settle for periodic removal using a vacuum truck.

The booster stations will be designed to maintain a minimum velocity of 2 fps in the raw water pipe. The booster stations (and SRF) will have the ability to maintain a water level in the wetwells of the booster pump stations without short cycling of pumps (start-stop operation of the lead or any other pump less than 30 minutes, or less if required by the pump or other equipment manufacturer). The wetwell's sediment cleaning system will automatically maintain a wetwell free of sediment buildup.

The booster pump stations will operate continuously without intervention of the Owners' operating and maintenance staff performing repairs on the facilities, equipment and systems.

Valves

The discharge connection from each pump will be provided with a combination air vacuum air release (AVAR) valve with an isolation eccentric plug valve

The discharge connection from each pump will be provided with a check valve, a motorized ball valve and manually operated isolation gate valve downstream of the ball valve. The check valves will be swing type and have hydraulic dampening systems to prevent slamming. The motorized ball valves will be designed to slowly open upon pump start-up and slowly close prior to pump shut-down.

An air release valve will also be provided downstream of the isolation gate valve on each pump discharge. All valves will have ductile iron bodies with interiors coated with epoxy that is NSF-61 approved for potable water contact and will be pressure rated for ANSI B16.34 Class 300 or higher

Manholes and Structures

The pump houses will have reinforced concrete slabs and walls constructed per the architectural requirements herein. A roll-up door (10-ft wide by 12-ft tall, minimum) will be provided to allow access into the pump house by a service vehicle. The pump house roofs will have removable hatches to allow removal of the vertical turbine pumps and motors

Pump wetwells will be constructed with reinforced concrete floors, walls, and roofs. A minimum of two access hatches (3-ft by 4-ft, minimum) will be provided in each wetwell roof.

Manholes and/or vaults will be constructed of reinforced concrete. Pre-cast vaults may be used in-lieu of cast-in-place.

Thrust Restraints

All piping will be anchored and restrained. Restraining harnesses will be used on all couplings (e.g., sleeve, mechanical, etc). Pressurized pipes leaving or entering structures/buildings will have wall flanges designed to restrain the piping. Concrete thrust restraints will not be used in conjunction with mechanical restraints.

Surge/Waterhammer Control

Each booster pumping station will be provided with a surge control system using surge anticipation valves. Refer to the Surge Analysis, Appendix E. However, the DB Contractor will be responsible for the design of the surge system based on the final design of facilities and the equipment to be supplied.

Utility Water System (BS2A only)

A utility water system will be designed and constructed for the BS2A. The utility water system will provide clean non-potable water for pump seal water flushing and general utility water uses. The source water for the utility water system will be raw Rio Grande water withdrawn from wetwell of BS2A. The utility water system will include pumps, strainers, and filters necessary to remove sand, silt, and other suspended material in the raw water and provide water at a flow of 25 gpm and a pressure of 50 psig. The system will include a minimum of two pumps, each able to produce the required flow and pressure. The system will include four 100 percent or greater capacity automatic backwash strainers consisting of two sets of strainers in-series. The initial strainers will be fitted with #60 mesh (0.25-mm) screens and the final set with #200 mesh (0.075-mm) screens. The system will be designed and constructed to allow one set of strainers to be taken out of service, while continuing to produce the required water quantity and quality. As required

by the Pump Manufacturer, additional pressurization and filtration equipment will be provided for supplying seal flush water. A 500-gallon capacity bladder type hydropneumatic tank to store the sieved utility water will also be provided. The tank will be designed and constructed to ASME code and stamped for a 125 psi working pressure. The utility water system will include a fully functional local control panel to automatically control all of the pumps, strainers, filters, valves, and other devices. The LCP will provide inputs and outputs from/to the SCADA system as indicated on the contract process and instrumentation diagrams (P&IDs).

5.2.2 Initial Screening of Alternatives

The initial screen of alternatives for BS1A and BS2A focused on obtaining pumps and pumping systems which are capable of pumping the required design capacity and head, have high pumping efficiency over a broad range of operation, have a successful history of booster station operation, are readily available from several manufacturers, required minimum maintenance and are suitable for pumping raw river water containing abrasive suspended materials.

Removing the 0.1-mm and larger sediment by the SRF will reduce the abrasiveness of the raw water to be pumped by the BS1A pumps and the other downstream booster station pumps. The relatively high TDH requirements for the booster pumps limits the types of pumps for use in this application. The pump types that best fit these criteria include the following:

- Horizontal split case
- Horizontal end suction
- Vertical turbine

These pumps were considered acceptable for use in BS1A and BS2A.

5.2.3 Pump Station Alternatives

The hydraulics associated with the SRF favors the use of a below grade wetwell at BS1A. To maintain a reasonably low profile building to house the sediment removal equipment, this equipment will likely have to be set with its bases attached to concrete slabs on-grade. Therefore, to allow gravity flow of the partially clarified water to the pump wetwell, the wetwell will have a high water level near grade. Moreover, to allow gravity flow of the sediment slurry to a dewatering basin, the dewatering basins will need to have a high water level near grade. To allow the decant from the dewatering basins to flow by gravity into the pump wetwell, the wetwell will have to have a high water level near grade.

With a below grade wetwell, vertical turbine booster pumps could be placed on top of the wetwell. Alternatively, a below-grade dry pit could be constructed adjacent to the wetwell to allow use of horizontal type pumps. Potentially, horizontal pumps with a vacuum-assist on the suctions could be used to allow at-grade pumps. This would reduce confined space access issues compared to using a dry pit. The wetwell would be constructed of reinforced concrete.

The wetwell should include feature to minimize the accumulation of solids. Any inside corners of the tank should be filleted with a minimum slope of 1:1 and slope towards the suction pipe(s) to prevent the accumulation of solids. Valving and piping should be provided to periodically allow the discharge from the booster station pumps to be directed to a set of tank eductor nozzles at the bottom of the wetwell tank to provide a jetting action. This feature would include motorized valves and controls to allow automated tank agitation at an operator set frequency.

The wetwell at BS2A could either be a below-grade or above grade tank. Using a below-grade tank would facilitate the use of vertical turbine type pumps mounted on the top of the tank or an attached wetwell. In this manner, the pumps would be at grade. Vertical turbine pumps could mounted in pressurized cans with the can tops at grade, which would allow the use of an above-grade tank for the wetwell. In this case, isolation valves on the suction connections would be required to allow a pump to be withdrawn from its can, while allowing continued operation of the other pumps. For using horizontal-style pumps, an above grade tank would be preferable to eliminate the confined space created by a dry-pit. Potentially, horizontal pumps with a vacuum-assist on the suctions could be used to allow at-grade pumps and eliminate the dry-pit.

5.2.4 Evaluation of Alternatives

5.2.4.1 Evaluation of Alternatives

The advantages and disadvantages of the possible alternative configuration were discussed with City and County staff at the process selection workshops. Two alternative pump configurations were selected for further evaluation; Alternative 1 – Horizontal Split Case Pumps in a Dry Pit shown in Figure 5.2-1 and Alternative 2 – Vertical Turbine pumps in Below – Grade Suction Wetwell shown in Figure 5.2-2.

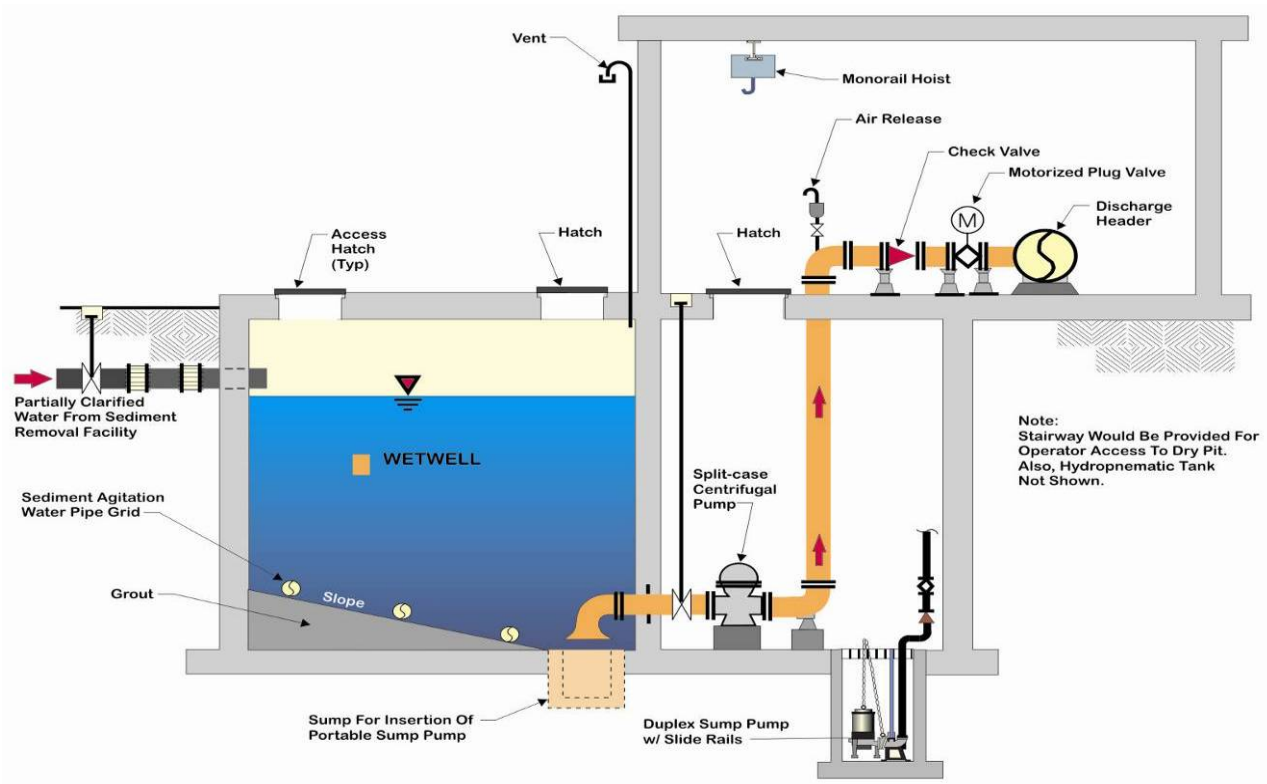


Figure 5.2-1 Booster Pump Alternative 1 – Horizontal Split Case Pumps in a Dry Pit

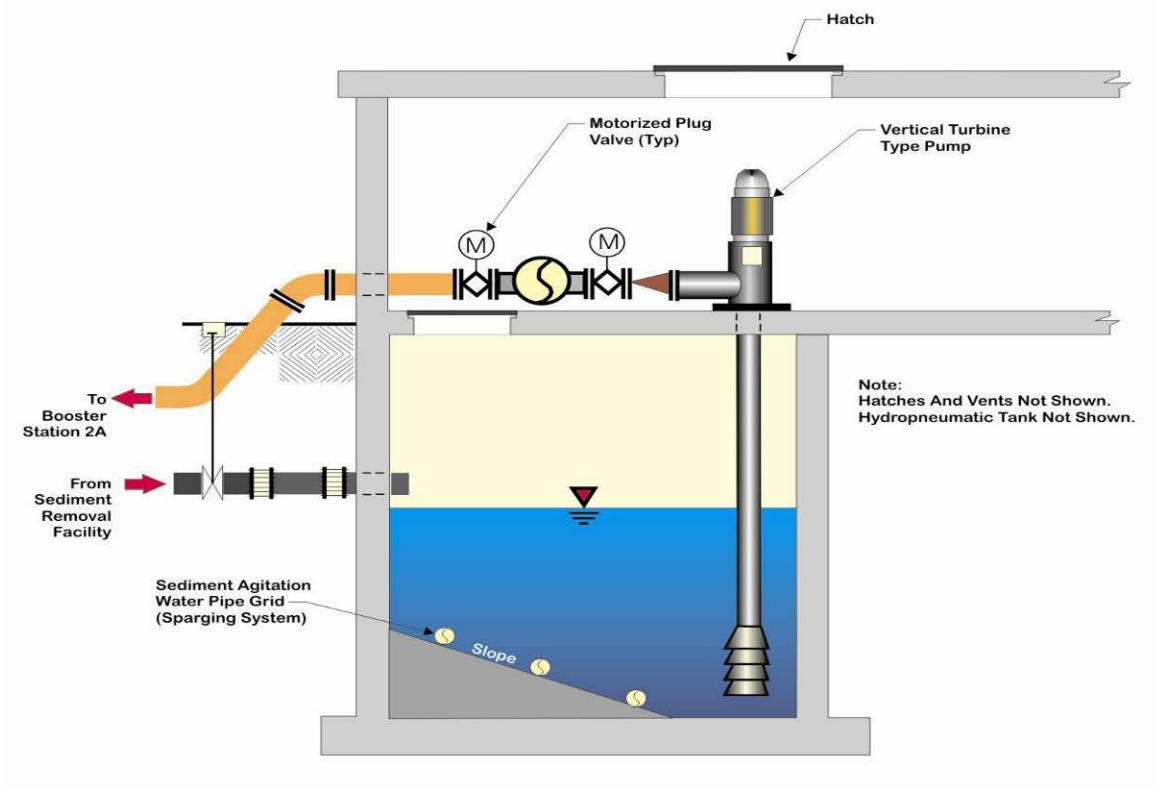


Figure 5.2-2 Booster Pump Alternative 2 – Vertical Turbine Pumps in a Below Grade Wetwell

5.2.4.2 Construction, O&M and Life-Cycle Cost Analysis

As shown in Table 5.2-3, a preliminary construction cost, O&M and life-cycle cost analysis were prepared for Alternative 1 and 2 for BS1A. The costs were planning level cost estimates for comparison of the different alternatives.

Table 5.2-3 BS1A Construction, O&M and Life-Cycle Cost Analysis

Description	Total Cost ($-Millions)	
	Alternative 1 Horizontal Split Case Pumps	Alternative 2 Vertical Turbine Pumps
Construction Cost	6.0	5.1
Annual O&M Cost	0.82	0.80
Total Annual Cost	1.3	1.2
Unit Cost ($/AF)	145	135

Table 5.2-4 indicates the preliminary construction cost, O&M and life-cycle cost analysis prepared for Alternative 1 and 2 for BS2A.

Table 5.2-4 BS2A Construction, O&M and Life-Cycle Cost Analysis

Description	Total Cost ($-Millions)	
	Alternative 1 Horizontal Split Case Pumps	Alternative 2 Vertical Turbine Pumps
Construction Cost	6.0	4.9
Annual O&M Cost	0.67	0.63
Total Annual Cost	1.1	1.0
Unit Cost ($/AF)	162	144

5.2.4.3 Ranking of Alternatives

The results of the construction cost, O&M and life-cycle cost analysis indicate vertical turbine pumps will have a lower initial construction cost, lower annual O&M cost and therefore the lowest annualized life-cycle cost.

Vertical turbine pumps are more efficient than horizontal split case pumps (approximately 84 to 85 percent efficient versus 80 to 83 percent efficiency for horizontal split case pumps). Vertical turbines have steeper pump curves and can be obtained at lower speeds. Vertical turbine pumps are more readily available from more pump manufacturers in materials suitable for pumping raw water containing abrasive suspended materials. Split case pumps are not readily available at the required discharge head at the booster stations.

Therefore, vertical turbine pumps were recommended for the booster pump stations.

5.2.5 Recommended Facility

The recommended facility arrangement for BS1A and BS2A will be vertical turbine type pumps with barrels set in wetwells. BS1A will include four pumps, three duty and one standby. BS2A will include six pumps, three duty and one standby for pumping to the C/CWTP and one duty and one standby for pumping to Las Campanas (under a separate project). The wetwell for BS2A will be designed with sufficient space for the installation of the Las Campanas pumps.

5.2.5.1 Description of Facility

The booster stations will be designed and constructed to be able to operate continuously (i.e., 24 hours per day, 365 days per year) at full capacity under all raw water quality conditions. These facilities will be designed and constructed to provide reliable, continuous, un-staffed operation. BS1A will be designed with redundant equipment and features to allow the facility to operate at full capacity with one of the four pumps out-of-service in standby mode and/or undergoing maintenance.

BS2A will be designed with redundant equipment and features to allow the facility to operate at full capacity with one of the four pumps out-of-service in standby mode and/or undergoing maintenance.

5.2.5.2 Operation of Facility

The booster pump stations will be fully automatic and designed to operate unmanned. BS2A will receive a level signal from the Raw Water Equalization Basins at the C/CWTP. As the level in the Raw Water Equalization Basins at the C/CWTP lowers, it will send a signal to start a pump in BS2A. The pump will start up in a preprogrammed operating mode and adjust pumping speed to keep the Raw Water Equalization Basins at a predetermined level. If the water level in the basins continues to drop after a set time interval, a second pump will start and the two operating pumps will operate to maintain a fixed water level in the basin. If the water level in the basins continues to drop after a set time interval, a third pump will start and the three operating pumps will operate to maintain a fixed water level in the basin. As the level in the basins rises above a fixed level the same procedure will be used to turn pumps off.

BS1A will receive a level signal from BS2A. As the level in the BS2A wetwell lowers, it will send a signal to start a pump in BS1A. The pump will start up in a preprogrammed operating mode and

adjust pumping speed to keep the wetwell in BS2A at a predetermined level. If the water level in the wetwell of BS2A continues to drop after a set time interval, a second BS1A pump will start and the two operating pumps will operate to maintain a fixed water level in the wetwell of BS2A. If the water level in the basins continues to drop after a set time interval, a third pump will start and the three operating pumps will operate to maintain a fixed water level in the wetwell of BS2A. As the level in the wetwell of BS2A rises above a fixed level the same procedure will be used to turn BS1A pumps off.

5.2.5.3 Control Description

Booster Station 1A

The degritted raw water from the SRF flows by gravity to the adjacent wetwell for BS1A. BS1A pressurizes the raw water for conveyance to the next Booster Station (i.e., BS2A).

BS1A includes four vertical turbine pumps. Normally, between one and three pumps are to be operated, with the other pump(s) in standby mode. Each pump is equipped with a VFD and has a flow range of between approximately 3.0 to 6.1-mgd, depending on the pump speed. Three pumps operating together provide the booster station with a flow capacity of 18.4-mgd.

Local control of each pump is performed by using the LOCAL/ REMOTE selector switch and the START and STOP pushbuttons located at each pump. When the L/R switch is placed in LOCAL and the START pushbutton is pressed, the motor starter controls start the pump. Once started in local control mode, the pump operates until the STOP pushbutton is pressed or the L/R switch is placed in REMOTE.

Automatic Start-up and Shut-down Sequence

A pump at BS1A will start-up automatically in response to a LOW water level signal from the wetwell at BS2A. The pump with the lowest cumulative run time will start first, except if this pump has been in operation within the previous 30 minutes in which case the pump with the second lowest cumulative run time will start, except if this pump has been in operation within the previous 30 minutes, etc.

The pumps will start against its associated closed discharge valve. The discharge valve begins to open once the pump reaches full speed. A second pump will start if the water level in the wetwell at BS2A is still at or below the LOW set point after an adjustable time period after startup of the previous pump. A third pump will start-up similarly in response to the LOW water level signal at BS2A. Initial pump startup will provide a pipeline velocity of 3.5 fps to resuspend settled material. After resuspension of material, the flow will be reduced to the desired flowrate, though no lower than the flow corresponding to a pipeline velocity of 2 fps to keep material from settling.

Once the water level at BS2A reaches the HIGH set point, the speed(s) of the on-duty pump(s) at BS1A ramp down to maintain the water level at the BS2A wetwell between the LOW and HIGH set points. A pump at BS1A shuts-down when the water level is above the HIGH set point at the BS2A wetwell for an adjustable time period.

A low flow switch on the pump discharge for each pump transmits a permissive to the MCC/VFD. On loss of flow, after a set period of time, the pump will shutdown. A Lockout-Stop button is provided near each pump for maintenance purposes.

A high pressure switch on the pump discharge for each pump transmits a permissive to the MCC/VFD serves to protect the pumps in all modes of operation. When the pressure switch is tripped for a set period of time, the pump will be shutdown.

Run status of each pump is transmitted to the control system for indication and run time totalization. A pump FAIL alarm (tripped motor overload) and a READY status are also transmitted to the control system. The control system will also generate a pump FAIL alarm if a pump is called to run and no pump run status is received within 30 seconds. When the LOCAL/REMOTE switch at the pump is in REMOTE, the control system receives a REMOTE status input from the MCC.

Booster Station 2A

BS2A pressurizes the raw water for conveyance to the C/CWTP. BS2A includes four 5.1-mgd vertical turbine pumps (three duty; one standby) for conveying water to the C/CWTP and two 3.0-mgd vertical turbines (one duty; one standby) for conveying water to Las Campanas. Each pump is equipped with a VFD to allow for an approximate 50 percent turndown.

Local control of each pump is performed by using the LOCAL/ REMOTE selector switch and the START and STOP pushbuttons located at each pump. When the L/R switch is placed in LOCAL and the START pushbutton is pressed, the motor starter controls start the pump. Once started in local control mode, the pump operates until the STOP pushbutton is pressed or the L/R switch is placed in REMOTE.

Automatic Start-up and Shut-down Sequence

For the C/CWTP supply pumps, the C/CWTP plant operator will key in the desired flow rate for the pumps that correspond with the desired plant production rate. The pump(s) will start/stop sequentially to provide this flow rate. The pump with the lowest cumulative run time will start first, except if this pump has been in operation within the previous 30 minutes in which case the pump with the second lowest cumulative run time will start, except if this pump has been in operation within the previous 30 minutes, etc. Initial pump startup will provide a pipeline velocity of 3.5 fps to resuspend settled material. After resuspension of material, the flow will be reduced to the desired flowrate, though no lower than the flow corresponding to a pipeline velocity of 2 fps to keep material from settling.

For the Las Campanas Pumps, a pump at BS2A will start-up automatically in response to a LOW water level signal from the wetwell at BS3A (a separate Las Campanas project). The pump with the lowest cumulative run time will start first.

The pumps will start against its associated closed discharge valve. The discharge valve begins to open once the pump reaches full speed. The associated discharge valve on the pump shuts prior to the pump shutting down.

A low flow switch on the pump discharge for each pump transmits a permissive to the MCC/VFD. On loss of flow, after a set period of time, the pump will shutdown. A Lockout-Stop button is provided near each pump for maintenance purposes.

A high pressure switch on the pump discharge for each pump transmits a permissive to the MCC/VFD serves to protect the pumps in all modes of operation. When the pressure switch is tripped for a set period of time, the pump will be shutdown.

Run status of each pump is transmitted to the control system for indication and run time totalization. A pump FAIL alarm (tripped motor overload) and a READY status are also transmitted to the control system. The control system will also generate a pump FAIL alarm if a pump is called to run and no pump run status is received within 30 seconds. When the

LOCAL/REMOTE switch at the pump is in REMOTE, the control system receives a REMOTE status input from the MCC.

5.2.5.4 Maintenance of Facility

The construction of the pumps, position and number of column pipe flanges will be such that the pumps can be readily installed and removed for repairs within the head room limitations of the building using normal methods of operation and handling without undue difficulties. If required, the entire pump and motor assembly can be pulled out through the roof hatch located directly above each pump.

To minimize maintenance and repair for the life of the booster stations, major mechanical equipment will have a minimum service life (MSL) equal or greater than 25 years. The booster station structures will be designed for a minimum service life of 50 years. Pump impellers and other wear parts will be designed to not require replacement or resurfacing more than once every five years. Pump bearings will have a minimum B-10 life of 100,000 hours. Pump casings and other components will have an MSL equal or greater than 25 years. Electrical motors, motor control centers, and associated metering will have an MSL equal or greater than 25 years.

Extreme sediment loading of pump stations and pipelines can create excessive maintenance. It is recommended that the operation of the raw water system be limited when the river water turbidity is greater than 1,000 NTU. When the turbidity is above 4,000 NTU, the raw water system should be shut down. This will help minimize facility maintenance, solids disposal costs and help limit high contaminant loading of the system and the C/C WTP.

5.3 Recommended Booster Station Facilities General Requirements

5.3.1 Civil Site Work

Sheet 2C-2 of the Raw Water Pipeline and Facilities Preliminary Design Drawings shows a preliminary site grading plan for the SRF/BS1A facility. A site plan for BS2A is included on Sheet 3C-1 of the same drawing set. The PNM electrical yard would be located to the east of the SRF/BS1A building and to the north of the BS2A building.

The existing access road to Buckman Well 2A will be upgraded to a 16-ft wide gravel road for access to the SRF/BS1A. A new 16-ft wide gravel road will be constructed from Buckman Road into the BS2A site through an area previously disturbed for the construction of Buckman Well 10. A 16-ft wide gravel road around each building would provide vehicle access to the different access points in each facility. The access roads would include a manual gate with pad lock. The entire site would be surrounded with an 8-ft high chain link fence including concertina wire.

The sites should be graded to promote drainage away from the facilities. The drainage should be designed to work with the existing drainage patterns in the area. The temporary use areas around each facility will be returned to their original contours prior to revegetation.

5.3.2 Landscaping/Revegetation

Disturbance due to construction of the booster stations shall be as minimal as possible and in all cases must be within the environmental survey limits and the temporary use areas permitted by the agencies. Reclamation of the booster station surroundings will include reclamation seeding of any disturbed area with a specially selected seed mix for Pinon-Juniper Areas approved by the

USFS and BLM. The stockpiled topsoil will be replaced over areas to be revegetated prior to the seeding operations. A seed mixture was shown in Table 3.2-4 (Section 3).

5.3.3 Geotechnical

The geotechnical recommendations for the BS1A facilities are provided under Section 4.3.5 and are similar for the BS2A facilities. The DB Contractor's geotechnical engineer is responsible for developing structural criteria. The OC's geotechnical investigation report is provided in Appendix A.

5.3.4 Structural

These requirements provide minimum design criteria and will be used as a guide in the design and construction of the booster station facilities. The general types of construction will consist of cast-in-place reinforced concrete or prestressed concrete for liquid containing basins or reservoirs, and masonry walls, reinforced concrete or precast concrete walls with steel roof for buildings.

Foundations of structures will be designed in accordance with of the data provided in the OC's project geotechnical report and the DB Contractor's geotechnical engineer's recommendations. In general, the type of foundation for the booster station structures will be mat foundations or continuous spread footings along the walls with slab-on-grade at the center portions for the liquid containing basins or reservoirs; and continuous spread footings along the walls for masonry buildings.

5.3.5 Architectural Design for Raw Water Booster Stations

5.3.5.1 Design Standards

All buildings for the Buckman project will be designed to meet the 2004 New Mexico General Construction Building Codes (Title 14 NMAC – Chapters 5 and 7). The buildings must also comply with the requirements of the BLM and the USFS.

5.3.5.2 Space Planning

The space planning for this facility was performed by the process engineers based on the equipment and functions of the building. The building size, shape and vertical height are determined by the raw water booster pump equipment to be housed.

5.3.5.3 Architectural Style

The architectural style for the Booster Station buildings will be concrete walls or CMU block wall with textured stucco finish and with no fenestration except for entry doors and ventilation louvers. The walls will be capped with flat removable concrete roof slabs. The only architectural style considerations will be to provide exterior wall and roof edge colors to meet the approval of BLM and USFS. Construction requirements for buildings are included in the Technical Requirements.

5.3.6 Electrical

5.3.6.1 Service

The electrical services for BS1A and BS2A will be a dual 12.47kv, 3-phase primary from separate PNM underground feeders for redundancy and reliability. One service will be connected to the existing Buckman Feeder No. 12 and the other will be connected to the new Buckman Feeder No.

13. Each will be separately metered at 12.47kv. If one PNM feeder fails, the facility will have the ability to be served by the other.

5.3.6.2 Facility Loads

The loads at the booster station facilities will be rated either at 480, 208, or 120 volts. An electric load list for BS1A is shown in Table 4.3-1. Even though the largest motor is rated at 900 hp at BS1A, a 480-volt, 3-phase system was selected over a 4,160-volt, 3-phase system for the main utilization voltage since 480-volt VFDs and 460-volt motors are available beyond the 900 hp rating and are preferred by the Owners.

Table 5.3-1 Electric Load List for Booster Station 2A

Item	Estimated Connected HP or KW	Comments
Pump No. 1	700	480 VAC
Pump No. 2	700	480 VAC
Pump No. 3	700	480 VAC
Pump No. 4	700	480 VAC (Standby Unit)
UW Pump 1	2.0	480 VAC
UW Pump 2	2.0	480 VAC (Standby Unit)
Seal Water Flush Booster 1	3.0	480 VAC
Seal Water Flush Booster 2	3.0	480 VAC (Standby Unit)
Las Campanas Pump 1	200	480 VAC
Las Campanas Pump 2	200	480 VAC (Standby Unit)
Electrical Room AC	*8.0*	
Exhaust Fans	*2.0*	480 VAC
Electric Unit Heaters	*10 KW*	
Lights	*1 KW*	
Miscellaneous Other Loads	*10 KW*	Instrumentation, tools, etc.
Total	*3,620 hp + 21 KW*	

5.3.6.3 Power Distribution

Double-Ended Main Substation

Each service will feed a double-ended main substation with fully rated 3,750 KVA 12.47kv-480/277v pad-mounted oil-filled transformers protected by vacuum circuit breakers located in an adjacent weatherproof housing. The transformer secondary at 480/277v will feed each side or bus of the low voltage metal-enclosed switchgear. The PNM switchgears and meter cabinets and the facility main substation will be located within an outdoor area with a wall barrier for vandalism protection.

Low Voltage Switchgear

The double-ended main substation will feed an indoor 480v (low voltage) switchgear with busways. The switchgear will be furnished with two main circuit breakers, a tie circuit breaker and feeder circuit breakers for the low voltage (LV) VFDs and two MCCs.

The LV switchgear main, tie and pump VFD circuit breakers will be the draw-out, electrically operated power type. The main and tie circuit breakers will be controlled by an automatic transfer system to provide automatic switch over of power in case there is a power failure on the upstream side of one of the switchgear main circuit breakers. Of the three breakers, consisting of two mains and a tie, only two will be allowed to be closed at any one time by an interlock system. Under a normal condition, the two main breakers will be closed and the tie open which is the PNM

required arrangement. The feeder breakers will be the draw-out, electrically operated power type. The LV switchgear will be located in the BS1A Building.

Motor Control Centers

MCC A and MCC B will house main circuit breakers, combination breaker-motor starters, and feeder circuit breakers for the package process equipment and 480-208/120 and 480-240/120 volt dry-type transformers for panelboards. Breakers and starters for the multiple process equipment and pumps of each type will be located in different MCCs so that the failure of one MCC will not shut down the entire booster station facility.

Automatic Transfer Switches

Each automatic transfer switch (ATS) will provide 480-volt power from either MCC A or MCC B to the dry-type transformer. The normal source will be designated as the power from MCC A and the standby source as from MCC B. If the power from MCC A fails, the ATS will automatically switch to the MCC B power, if available, after a time delay.

Panelboards

Because of the ATSs, the 208/120-volt, 3-phase, 4-wire panelboard for miscellaneous loads, lights, and receptacles and the 240/120-volt, single phase, 4-wire panelboard for instrument loads will be fed from either A or B source for reliability. The dry-type transformer for the instrument panelboard will be the noise isolation type to provide clean power to the instruments.

5.3.6.4 Standby Power

Standby power for BS1A and BS2A will not be provided. Emergency light fixtures and exit fixtures with back-up battery packs will provide illumination for safety and egress when there is a power outage condition on both A and B sources.

5.3.6.5 Variable Frequency Drives

480v Variable Frequency Drives

VFDs for the booster pumps will be either the active front-end or the 18-pulse type, in packaged free-standing NEMA 1 enclosures each with an incoming circuit breaker. Either of these two types of VFDs will be used to mitigate their harmonics generation since they comprise almost all of the connected loads at these two facilities and will allow compliance more easily with PNM and IEEE 519 Standards requirements.

VFDs will be furnished with an output filtering system to minimize the damaging effects on the cables and motor insulation due to over-voltage and dv/dt conditions.

For the larger 700 and 900 HP motors, the 480-volt or LV VFDs were selected over the 4.16kv or medium voltage (MV) type for these reasons:

- Currently, the City does not have any MV VFDs or motors and prefers LV over MV
- MV VFDs have higher capital costs than LV VFDs
- MV VFDs are more complicated and harder to maintain requiring specially-trained service personnel who may not be locally available and may have to be flown in from another city

- MV VFDs are less reliable than LV VFDs. Recently, MV VFD reliability has improved because of the advancement in power electronic devices. The MV VFDs have lower mean time between failures (MTBF) than the LV type. Table 5.3-2 presents a comparison between the two types of VFDs (as compared by ABB).

Table 5.3-2 Comparison of LV and MV VFDs

Manuf. & Model	900 HP VFD		
	VFD Type	MTBF	Cost
ABB ACS800ULH	480v (LV)	15.0 yrs.	$106,000
ABB ACS1000i	4.16kv (MV)	6.1 yrs.	$120,000

- LV VFDs up to around 2,000 HP are available from some manufacturers.
- GE makes the 460-volt inverter duty (suitable for VFD application) motors up to 2,000 HP and US Motors up to 1,000 HP as listed in their catalogs.
- MV motors cost about $5,000 to $7,000 more than the LV motors.
- MV pieces of equipment, cables, etc., require special training and instruments for maintenance.

At BS2A there are additional benefits with the LV VFDs:

- Two 4.16kv-480v unit substations not required
- Double-ended 5kv switchgear not required to feed the VFDs. Instead, cheaper LV switchgear will feed them
- Foregoing bullet items will reduce the floor space requirement

Some of the disadvantages of the LV VFDs compared to the MV VFDs are as follows:

- Higher heat loss due to the higher current of the 460-volt motors
- Higher air conditioning load
- Larger cables and more conduits required for the motors

5.3.6.6 Underground Conduit System

Underground conduit systems will be a minimum 2-inch diameter, Schedule 40 PVC conduits encased in concrete. All ductbanks, except those for area lighting, will have steel reinforcement. Concrete handholes will be provided as necessary for ductbank entry into buildings and structures and for change of direction.

All conduits originating from buildings and structures and terminating in handholes and all conduits terminating in outdoor electrical enclosures will be sealed with conduit sealing bushings to prevent moisture transmission, rodents and snakes entering into enclosures, panels, buildings and structures.

5.3.6.7 Exposed Conduit Systems

Exposed conduits inside and outside will be the hot-dipped GRSC type. Conduits located over water and in contact with the soil will be the PVC bonded GRSC type.

5.3.6.8 Wires and Cables

Low Voltage (600-Volt) Wires and Cables

600-volt cables for control and power, No. 8 AWG and smaller, will have Type XHHW insulation. Power cables No. 6 AWG and larger, will have Type RHW-USE insulation. Conductors will be the stranded copper type.

Minimum size conductor for 120 volt or greater power circuits will be No. 12 AWG. Minimum size 120 volt or greater conductors within control panels and switchboards will be No. 14 AWG.

Terminations for power wires and cables will be made with color-coded wrought copper compression type connectors with lug hole(s) using the tool and die as recommended by the connector manufacturer.

Stranded control conductors will be lugged at terminations except where terminations are made on devices available only with box terminals. Lugs will be the locking spade type. Terminal blocks will be the strap-screw type.

High Voltage (15kv) Cables

15kv cables will be the annealed tinned copper, Class B concentric lay, 133 percent shielded, MV-105 type, insulated with a thermosetting EPR compound over an extruded, non-conducting high dielectric stress control layer, with a semi-conducting shield applied directly over the primary insulation.

All material used in terminating and splicing high voltage cables will be as recommended by the cable manufacturer. Cables will be terminated and spliced in accordance with the kit supplier's drawings.

Rodent-Resistant Cable Coating

In handholes and exposed locations, rodent and fire-resistant coating will be applied to the entire exposed cable and wire surfaces. Cable coating will be required to have been tested successfully for rodent resistance. Refer to Section 3 for additional information.

5.3.6.9 Lighting

Light fixtures within buildings and structures will be the fluorescent type with energy-efficient F32T8 tubes and electronic ballasts. LED type exit fixtures with batteries will be provided over doors leading to the outside. Also, emergency lighting fixtures with batteries will be provided for egress during power outages.

Light fixtures located outside will have bullet-proof shields and will be the cut-off type for compliance with the New Mexico Night Sky Protection Act. Light fixtures for illuminating water surfaces within open structures will be the watertight stainless steel fluorescent type, similar to that shown in Section 3, controlled by switches. All lamps will be the green end cap type which has low mercury content as described and shown in Section 3. All fixtures will be suitable for 120 vac power.

5.3.6.10 Receptacles

Convenience (115 volt) receptacles will be spaced at least every 30-ft in all enclosed areas and at least every 40-ft in open structure areas with mechanical pieces of equipment.

All convenience receptacles will be the GFCI type and also will have the weatherproof covers outdoors and in areas subject to hose-downs. Receptacles will be identified with labels indicating the originating panelboard and circuit designations.

5.3.6.11 Lightning Protection System

Buildings, superstructures, etc. will be protected by lightning protection systems which will be bonded together and to the facility grounding system.

5.3.7 Instrumentation and Control

5.3.7.1 Control Descriptions for Facilities

A pump at BS1A will start-up automatically in response to a LOW water level signal from the wet-well at BS2A. The de-gritted raw water from the SRF flows by gravity to the adjacent wet-well for BS1A. BS1A pressurizes the raw water for conveyance to the next Booster Station (i.e., BS2A).

BS1A includes four vertical turbine pumps. Normally, between one and three pumps are to be operated, with the other pump(s) in standby mode. Each pump is equipped with a VFD and has a flow range of between approximately 3.0- to 6.1-mgd, depending on the pump speed. Three pumps operating together provide the booster station with a flow capacity of 18.2-mgd.

For the C/CWTP supply pumps, the C/CWTP plant operator will key in the desired flow rate for the pumps that correspond with the desired plant production rate. The pump(s) will start/stop sequentially to provide this flow rate. BS2A pressurizes the raw water for conveyance to the C/CWTP and the Las Campanas facilities.

BS2A includes four 5.1-mgd vertical turbine pumps (three duty; one standby) for conveying water to the C/CWTP. Two 3.0-mgd vertical turbines (one duty; one standby) will be installed under another project for conveying water to Las Campanas. Pumps will be equipped with a VFD to allow for an approximate 50 percent turndown.

5.3.7.2 Instrumentation and Monitoring

All equipment and process parameters shall be monitored for safe and efficient operation. Control commands received from the C/CWTP shall be received by the local PLC processor and executed by the programming within the unit. All parameters pertinent to determining process and equipment readiness for the command and confirmation that the command has been properly carried out shall be provided and reported to the C/CWTP SCADA system.

5.3.7.3 Transmission of Information and Control

Due to the multiple data needs of this site and the coincide construction of the pipeline from this site to the C/CWTP and associated facilities en-route, the installation of fiber optic media is the optimal means to provide sufficient data carrying capacity for the control system needs, and could also support the demands of remote video surveillance and inter-facility telecommunications. Therefore, the PLC equipment at this site will be configured as part of the Ethernet Network of the C/CWTP control system. The PLC interface will operate at 100 Mbps. This approach will allow the remote PLC to be incorporated into the polling sequence of the plant PLC system in the same manner as any of the on-plant PLC installations. Consistency and speed are two of the benefits to such an approach, as well as significant expansion capacity.

5.3.8 SCADA and Telemetry

The Process LAN from the C/CWTP will be extended to BS1A and BS2A via fiber optic cable. Process control for the booster stations will consist of PLCs on the process LAN communicating with the SCADA Master at the C/CWTP and other PLCs on the process LAN.

5.3.9 HVAC, Plumbing and Fire Protection

5.3.9.1 HVAC

The HVAC system in BS1A and BS2A will consist of systems necessary to meet the numerous functions.

Systems will provide comfortable conditions in buildings and areas intended for human occupancy. In wet areas or areas with potential for condensation, maintain a low relative humidity (RH) to minimize or eliminate condensation and corrosion. Where outside air is required for ventilation, the outdoor air will be treated by heating and filtering as required.

Operation spaces will be provided with ventilation where they will be occupied spaces. In addition spaces that may be entered by plant personnel will be ventilated in accordance with applicable codes and good engineering practices

Ventilation will use multiple supply fans in each space with relief dampers. Supply fans will have both outdoor and return dampers to provide a minimum supply temperature during cold weather.

HVAC Codes and Standards

Design of BS1A and BS2A HVAC system will comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Commercial Building Code
- 2003 New Mexico Mechanical Code
- 2003 New Mexico Energy Conservation Code
- ASHRAE
- NFPA standards
- SMACNA standards

Design Criteria

The design will be based on outdoor design conditions of 10 degrees F dry bulb during the winter and 96 degrees F dry bulb, with a 60 degrees F MWB (mean wet bulb) during the summer. Air density will be based on an elevation of 6,043-ft amsl. Selection of condensers for air-conditioning units will be based on 106 degrees F.

Indoor Design Conditions

The design of cooling and heating systems for specific spaces will be based on the indoor conditions shown in Table 5.3-3.

Table 5.3-3 BS1A and BS2A Indoor Design Temperatures and Ventilation Rates

Area	Temp (°F) Summer / Winter	Design Features
Pump Room	Ambient + 10/55	• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation • Unit heater
Lower Pump Room	Ambient + 10/55	• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation • Unit heater

Refer to system diagrams in the Preliminary Design Drawings and the Technical Requirements for additional information on systems and zoning of units and the number of units required

5.3.9.2 Plumbing Systems

The plumbing in BS1A and BS2A will consist of systems necessary to meet the numerous functions.

Drain systems with vents where required for sanitary, process rain water, and equipment. Sump pumps and discharge piping systems. Water systems will include utility water (non-potable) for process use.

Plumbing Codes and Standards

Design of BS1A and BS2A shall comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Plumbing Code
- 2003 IFGC
- ASPE design guides
- AWWA
- NMED Title 20 Chapter 7 Part 3: Liquid Waste Disposal and Treatment Requirements

Description of Recommended Systems

The process drain system will include floor drains in process areas and the use of dry wells.

Rainwater Leaders will be based on a Rainfall rate of 2.0 inches per hour (0.021 gpm per square foot) for a 100-year storm. This is the 1 hour rainfall rate per 1997 UPC.

5.3.9.3 Fire Protection

No fire protection systems are currently anticipated for BS1A and BS2A. However, the DB Contractor will need to investigate the need for a fire suppression system based on its design and the materials of construction.

5.3.10 Security

Security and personnel protection measures to protect the Project facilities during construction, start-up, and initial operation will be provided. During construction, temporary security measures will be provided as necessary to protect the facilities, equipment, and personnel.

5.3.10.1 Security Objectives

Security and personnel protection systems must be included for each facility to reduce risk to the integrity of these facilities and to protect the public water supply. The following security and personnel protection issues, at a minimum, will be addressed:

- Threats to the source water and water treatment facilities
- Threats to the pump stations
- Threats to the distribution systems/booster stations
- Threats to the SCADA/telemetry system
- Fire detection and notification
- Communications

Threats may be in the form of one or more of the following: vandalism, criminal acts, sabotage/terrorism, or deliberate/malevolent acts by employees (either present or former). The designed and installed security system will be compatible with the City of Santa Fe's existing security system at Canyon Road WTP.

5.3.10.2 Recommended Security Systems

The following sections outline the physical security and personnel protection requirements for the Raw Water Pipeline, BS1A and BS2A. Because water systems cannot be made immune to all possible threats, the design of the facilities will address issues of critical asset redundancy, monitoring, response, and recovery to minimize risk.

For all of the Project facilities, basic physical security and personnel protection measures will be considered during design, including locks for access ladders, hatches, buildings, gates, and doors; bollards to prevent vehicle damage; battery supply for emergency power of alarms, security systems, fire alarm systems, communications and life safety devices; and appropriate signage and lighting.

For all of the remote facilities, including BS1A and BS2A, the design will also incorporate tamper-resistant hinges and security pins for each doorway. Windows and louvers will be provided with expanded metal grating on the interior side (i.e., provide grating with openings too narrow for bolt cutters to grip and too narrow to acquire handhold or toehold). Glass windows will incorporate glass-break sensors and magnetic alarm contacts for detection of penetration. Employee-activated duress switches will be required at the remote facilities for notification of emergency situations.

Each Project facility will include LOPs, built on the "protection in depth" principal, which requires a defeat of several protective barriers or security layers before a facility/component is compromised.

- Site Perimeter LOP includes perimeter fencing with concertina wire, access gate(s), landscaping barriers, vehicle barriers, and signage

- Inner Perimeter LOP includes site lighting, CCTV cameras, and appropriate standoff distances between the facility and the perimeter fencing (also advantageous for preventing acts of vandalism by graffiti)
- Building LOP includes access card readers, windows, door alarms, and interior intrusion alarms.

For all outdoor PNM and facility distribution electrical equipment such as switchgears, transformers, etc., a concrete or concrete block walls will surround each group of equipment on four sides (open top) to provide an additional LOP. A set of bullet-resistant double doors will be provided to allow access and installation/removal of the equipment.

For the ventilation louvers at the facility buildings, similar construction of a three-sided (open top) concrete block wall will be required. A bullet-resistant door will be provided for personnel access.

For all facilities, Level 4 bullet-proof rated equipment will be required and conform to the UL rating 752-HPR 30.06.

Booster Station 1A

Because this station is contiguous with the SRF the design to protect the water supply and BS1A will follow the criteria established for the SRF.

Booster Station 2A

The design will incorporate provisions similar to those used at the SRF and BS1A. Refer to Section 4 of this Report.

Raw Water Pipeline and Appurtenances

The design will incorporate the following provisions to protect the Raw Water Pipeline and appurtenances:

- The area of aboveground exposure for the pipelines and appurtenances will be minimized
- Back-flow prevention devices will be used at all appropriate connections
- Bolts/hardware that require a special wrench (where generally available screw-drivers and wrenches would not work) to unlock access hatches and valve vaults
- Pad-locked protective cages over aboveground appurtenances, such as backflow preventors, to restrict access. These cages shall be constructed ½-inch, #13 gage diamond patter flat rolled expanded steel with all welded construction. The cages shall be of Type 304 stainless steel or protective coated carbon steel with a 2-mil minimum thickness polyester powder coating.
- Locking covers

5.4 Las Campanas Requirements for BS2A

BS2A will eventually be equipped with equipment dedicated to delivering raw water to Las Campanas through a separate 12-inch pipeline. Las Campanas will provide details on surge mitigation measures for the 12-inch pipeline, and additional information on pump equipment and telemetry equipment.

BS2A will provide space to include two pumps for Las Campanas with space for a third future pump. It is envisioned that each pump will be equipped with a VFD.

Each Las Campanas pump VFD feeder breaker compartment at the low voltage switchgear will be furnished with a microprocessor power monitoring module with a Modbus communication port for connection to the BS2A PLC for keeping track of power consumption for the Las Campanas system. Flow is to be metered separately through the use of a flow meter on the 12-inch discharge pipeline.

A conduit is also to be installed with the 12-inch pipeline with pull boxes. The conduit will be used for pulling of fiber optic cable for communications between BS3A and BS2A. A Qwest Bridge System will be used by Las Campanas for data transfer. A Landstar and Microstar system will be installed by Las Campanas at BS2A. Las Campanas will also be responsible for the SCADA system functionality which will include status and control of the Las Campanas pumps, wet well level, and water quality information from the RWLS. The CCTV or intrusion alarms signals will not be sent to Las Campanas.

This section provides a general design criteria overview for the C/CWTP. The section also presents evaluation and process design criteria used in evaluating candidate process train alternatives for the proposed C/CWTP. These criteria were used in the selection process of the final treatment process train for the plant, including the development of construction, operation and maintenance, and life-cycle costs.

6.1 Water Treatment Plant Objectives

The C/CWTP will serve as the primary component of the BDD Project for removing pathogens and other undesirable constituents from the source water, producing finished water which is safe, reliable, and acceptable to the public while complying with all State and Federal water quality regulations. Water quality and quantity objectives which must be met by the C/CWTP were described previously in Section 2 of this report. The plant must be capable of producing 15-mgd of finished (potable) water on a daily basis. The C/CWTP must also be capable of low flow operations (3-mgd). Additionally, with the exception of the septic tank-leachfield system, the C/CWTP must be capable of operation as a zero liquid waste discharge facility.

6.2 Water Treatment Alternatives and Screening

Development and screening of the process alternatives for the water treatment facilities was performed over a six-month period with a workshop approach with the following five steps:

1. Development and evaluation of the 15 preliminary process alternatives
2. Process Screening Workshop to identify three short-listed alternatives
3. Development of life-cycle cost estimates for short-listed alternatives
4. Process Selection Workshop for identifying selected treatment alternative
5. Process development for selected alternative and development of a preliminary opinion of cost

Throughout the evaluation and development of the treatment processes, quality assurance and control activities were performed, including: reviews by a Technical Review Committee at various stages, evaluation by an independently lead Value Engineering Committee, and discipline and process specific technical expert reviews at various stages of development.

The conclusions and recommendations from this development and screening process are presented within this subsection of the Report.

6.2.1 Evaluation Criteria

Evaluation criteria for short-listing and selection of treatment alternatives were based on the Project's primary goals of quality, risk, cost, and

schedule. No significant differences were seen between the alternatives in terms of schedule and implementation, so these factors were not specifically identified in the evaluation matrix. However, it should be noted that potential schedule impacts were considered in both the selection of the preliminary process alternatives and in the overall evaluation process.

Table 6.2-1 lists the individual criteria used to evaluate the various alternatives. These criteria were first used in developing three short-listed alternatives during a Process Screening Workshop held on December 20, 2005, and then for the final recommendation of a single selected alternative. Weighting factors for each criteria used in the evaluation were developed during the Process Screening Workshop based on scoring from City and County staff.

Table 6.2-1 Treatment Process Screening Evaluation Criteria

Criteria	Details	Weight
Quality		80
Always meets turbidity goal	Is the process train able to meet the finished water turbidity goal of 0.1 NTU at all times, regardless of feed water conditions or other operating variables?	10
Always meets pathogen goals	Is the process train able to meet 5-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal at all times, regardless of feed water conditions or other operating variables?	10
Always meets DBP goals	Is the process train able to meet the goal of finished water TOC < 2.0 mg/L, regardless of feed water conditions or other operating variables?	10
Always meets aesthetic goals	Is the process train able to meet the goal of finished water free from taste, odor, and color at all times, regardless of feed water conditions or other operating variables?	10
Addresses future regulations	Does the process train provide protection against future regulations and emerging contaminants, such as pharmaceuticals, personal care products, and radiological constituents?	10
Ease of operation	Does the process train maximize ease of operation?	11
Minimizes maintenance	Does the process train minimize routine and periodic maintenance?	11
Minimizes residuals	Does the process train minimize production, handling, and disposal of residuals?	8
Risk		50
Demonstrated process history	Does this process or unit process components have a proven history of operability and reliability for addressing the water quality issues of concern?	10
Risk of out-of-spec water	Does this process train minimize the risk of the plant producing out-of-spec water at any point after start-up?	10
Staff and public safety risk (hazardous chemicals)	Does this process train minimize the safety risk to staff and public through minimizing use of hazardous chemicals and hazardous working conditions?	10
Simplicity of process	Does this process train minimize complexity to the extent possible? Does it minimize variable components, number of subsystems, and is the process functionality easily understood?	10
Environmental impacts (energy, land, air quality)	Does the process train minimize environmental impacts, such as energy use, land requirements, and air quality impacts?	10
Cost		50
Life- cycle	Relative to the other alternatives, does this have a low life-cycle cost?	40
Operations and Maintenance	Relative to the other alternatives, does this have a low operations and maintenance cost?	10

The selected weighting factors gave the eight quality criteria a total weight of 80. The five risk criteria were given a total weight of 50, as were the two cost criteria. In regards to the cost criteria, life-cycle cost was the primary criteria considered with a weight four times the weight of O&M costs. O&M costs were still considered independently of lifecycle cost, because such recurring costs can often carry economic and logistical impacts beyond what is included in the life-cycle cost.

6.2.2 Initial Screening of Alternatives

A preliminary list of treatment alternatives was developed based on information obtained during the pilot testing period and on a survey of other facilities treating waters with similar or related water quality conditions. Fifteen alternatives were initially selected, which were considered to have a reasonable chance of meeting the project objectives of quality, risk, cost and schedule. The fifteen candidate alternative process trains are as follows:

Alternative 1: Plate settlers with media filters

1A Clarification with Plate Settlers + Ozone + Granular Activated Carbon (GAC)/Sand Filtrain + Ultraviolet (UV) Disinfection
1B Clarification with Plate Settlers + Chlorine Dioxide + GAC/Sand Filtration + UV
1C Clarification with Plate Settlers + GAC/Sand Filtration + UV + Chlorine (Cl_2) Contact
1D MIEX® + Clarification with Plate Settlers + GAC/Sand Filtration + UV + Cl_2 Contact
1E MIEX® + Clarification with Plate Settlers + Ozone + GAC/Sand Filtration

Alternative 2: High-rate clarification with media filters

2A High-rate Clarification + Ozone + GAC/Sand Filtration + UV
2B High-rate Clarification + Chlorine Dioxide + GAC/Sand Filtration + UV
2C High-rate Clarification + GAC/Sand Filtration + UV + Cl_2 Contact
2D MIEX® + High-rate Clarification + GAC/Sand Filtration + UV + Cl_2 Contact
2E MIEX® + High-rate Clarification + Ozone + GAC/Sand Filtration

Alternative 3: Plate settlers with membrane filtration

3A Clarification with Plate Settlers + Membrane Filtration (MF) + Ozone + GAC Contactors
3B Clarification with Plate Settlers + Ozone + GAC Contactors + MF
3C Clarification with Plate Settlers + MF + GAC Contactors + Cl_2 Contact
3D MIEX® + Clarification with Plate Settlers + MF + Ozone

3E MIEX® + Clarification with Plate Settlers + MF + GAC Contactors + Cl_2 Contact

These 15 alternatives include various combinations of ten separate unit processes, each providing unique contributions to improve finished water quality. These unit processes are described briefly below. A full evaluation of each alternative is not included as part of this Report, however, additional information can be found in the meeting minutes from the December 20, 2005 Process Screening Workshop.

6.2.2.1 Clarification with Plate Settlers

This process includes the use of plate settlers following a coagulation and flocculation step for the removal of settleable solids, including both organic and inorganic constituents. This portion of the process would remove the bulk of the suspended matter and settleable solids, but cannot remove these to the trace levels required for acceptable finished water quality. The clarification process is therefore included for bulk removal of broad contaminants to reduce the level of loading on the downstream process, which focus more on polishing the finished water. The effectiveness of the clarification processes is highly dependent on the ability of plant operators to match coagulant doses with varying water quality conditions, producing optimal floc which settles well within the plate settlers. A non-optimized process or a clarification process which is overloaded with high solids concentrations could result in excessive carryover onto the downstream treatment processes, possibly impacting their performance or efficiency.

6.2.2.2 High Rate Clarification

High rate clarification is a term sometimes used to refer to proprietary processes such as those manufactured by Actiflo® and Densedeg®. In the Actiflo process, microsand is used to enhance the conventional flocculation and settling process. Microsand and polymer are mixed with coagulated water. The microsand acts as a ballast and provides a larger contact area to which suspended solids can bind. The settling of floc is accelerated because the microsand particles add to the floc size. This process employs very high surface loading rates requiring less than one-fifth the area of a traditional plate settler surface area. The process is also less sensitive to changes in the raw water quality and is capable of effective operation with much higher solids loading rates.

Employing high rate clarification may result in settled water turbidities roughly half the level of turbidities after traditional clarification with plate settlers.

6.2.2.3 MIEX®

MIEX® is a relatively new process that utilizes a magnetized anion exchange resin developed specifically for the removal of dissolved organic carbon (DOC). The process involves continuous feed of the magnetized anion exchange resin to a mixing tank where the water to be treated is introduced. The effluent from the mixing tank passes through a gravity settler where the resin is recovered. The settled resin is pumped back to the contactor as a concentrated slurry with a fraction (5 to 10 percent) continuously removed for regeneration and replaced with regenerated resin. The resin is regenerated in a batch process using a brine solution. MIEX® is typically installed as a pretreatment process since a small amount of resin carries over to the subsequent processes. It does not replace the coagulation/sedimentation process but can reduce the necessary coagulant dose. Operations require disposal of the waste brine regenerant and replacement of lost resin. MIEX® has been in full-scale operation at two plants in Australia since 2001, but has limited full-scale use in the United States. The MIEX® process was piloted by the OC to evaluate its effectiveness for the BDD Project. Figure 6.2-1 is a photograph of the MIEX® pilot testing equipment used by the OC during pilot testing at the Rio Grande.

Figure 6.2-1 MIEX® Pilot Testing Equipment

6.2.2.4 Media Filtration

Media filtration is a process utilizing sand, anthracite, granular activated carbon (GAC), or a combination of these media, to remove suspended matter from the water, typically after a sedimentation process. The efficiency of a media filter in removing contaminants and particles is highly dependent on an effective coagulation/flocculation process and a relatively stable raw water quality. The coagulation/flocculation process mixes chemical coagulants to create floc that is composed of organic and inorganic contaminants bound together with particles that settle in the sedimentation process and are filtered through media filtration. If the majority of the floc is not removed in the sedimentation process, the media filters will be quickly overloaded creating excessive headloss and breakthrough of contaminants and turbidity through the filters. Media filters are typically backwashed every one to three days, and must include a filter-to-waste period after backwashing to reduce the level of contaminant breakthrough. The entire process of coagulation, flocculation, sedimentation, and media filtration is commonly referred to as Conventional Treatment, and when meeting minimum operating and performance requirements is given 3.0–log removal credits for *Cryptosporidium* under the LT2SWTR and 2.5-log removal of *Giardia*. An additional 0.5- to 1.0-log *Cryptosporidium* removal credits can also be granted based on specific performance for exceptional filter performance and operation.

6.2.2.5 Granular Activated Carbon

GAC can be used either as part of the media filtration process or as a stand-alone step for organics removal. GAC, particularly when used in conjunction with ozone, provides an exceptional method for removal of TOC, synthetic organic compounds (SOCs), taste and odor, and other trace organics and emerging contaminants. When used as a media filter, GAC will experience the same operating issues related to headloss, breakthrough, and sensitivity to feed water quality as identified above for media filters. GAC may also be used downstream of either media or

membrane filters as a final polishing step for organics. Under such a scenario, backwashing could be reduced to once every 30 to 90 days, greatly simplifying the operating process and extending the life of the media.

6.2.2.6 Membrane Filtration

Membrane filtration (MF) typically refers to either microfiltration or ultrafiltration, and is a process in which semi-permeable membranes, typically in the form of hollow fibers, are used to remove suspended solids and biological constituents from the water. The removal effectiveness of membranes is not impacted by upstream processes, such as coagulation or sedimentation, by operating pressures, or by flowrate, since the membranes act as a near absolute barrier against contaminants larger than the membrane pores, which are on the order of 0.02 to 0.1-µm. The vast majority of organic compounds in natural waters are smaller than most microfiltration and ultrafiltration pores, and are not significantly removed by the MF process. As such, additional processes, such as coagulation, sedimentation, and GAC adsorption are necessary to enhance removal of these contaminants.

The LT2ESWTR designates *Cryptosporidium* credits for MF to be equivalent to the level which can be demonstrated in a direct challenge test and can be confirmed during operation by both direct and indirect integrity monitoring. Based on previous challenge tests reported for quality MF systems, this log removal credit should fall between 4.0- and 5.0-log units, however, credits as high as 6.0-log units may be possible, based on the new challenge test procedures outlined in the LT2ESWTR. Removal credits for *Giardia* are based on the maximum required by existing regulations, and are typically set at 3.0-log units.

6.2.2.7 Ozone

Ozone is a strong oxidant used both for the destruction of SOCs and the inactivation of *Giardia*, *Cryptosporidium*, viruses and other biological constituents at significantly high doses, particularly when the formation of chlorinated disinfection byproducts (DBPs) is a concern. While ozone does not contribute to the formation of trihalomethanes and haloacetic acids, one possible byproduct of ozonation is the formation of bromate. Bromate is a DBP that forms when high concentrations of bromide and ozone are present at neutral or higher pH. The risk of bromate formation, where bromide is present in the raw water, can be controlled by limiting ozone dose, through pH depression, or through a combination of these approaches.

Because of the strong oxidizing power of ozone, it is a popular process for reduction of SOCs, including many emerging contaminants, the reduction of taste and odor concerns, and for the reduction of high molecular weight TOC into low molecular weight assimilable organic carbon (AOCs), which can be more easily adsorbed by GAC or consumed by a biological layer on the surface of GAC. The process which uses a combination of ozone and GAC to create a biological treatment layer is commonly referred to as biologically activated carbon (BAC).

6.2.2.8 UV Disinfection

UV disinfection is a process where ultraviolet light is used to inactivate *Giardia*, *Cryptosporidium* and other bacteria in the water. UV disinfection works best on filtered water, since suspended solids in the water will interfere with the inactivation. While UV has little or no impact on organic compounds, taste and odor, or most viruses, it is considerably less expensive to construct and operate than ozone or chlorine dioxide, while providing similar levels of bacteria inactivation. UV is included in eight of the treatment alternatives, either to reduce the size of a more expensive ozone or chlorine dioxide system, or to replace it.

6.2.2.9 Chlorine Dioxide

Chlorine dioxide is a disinfection process used when the formation of chlorinated DBPs is a concern or when a stronger oxidant than chlorine is required for *Cryptosporidium* inactivation or more effective *Giardia* inactivation. Chlorine dioxide is less effective than ozone at breaking down of SOCs, emerging contaminants, and removal of taste and odor, but is a strong oxidant which is easier to handle and less hazardous than ozone. Chlorine dioxide is typically generated onsite using a mixture of sodium chlorite and one to two other chemicals. Chlorine dioxide can cause chlorite or chlorate residuals if over dosed, which generally limits the maximum dose of chlorine dioxide to around 1.0 mg/L.

6.2.2.10 Chlorine Contact Basin

Chlorine contact basins would be required to provide a redundant barrier to viruses for alternatives that do not include either ozone or chlorine dioxide. All 15 alternatives would employ chlorine or hypochlorite for secondary disinfection to maintain a residual in the distribution system. However, the six alternatives that rely on UV for primary disinfection would also require a baffled chlorine contact area to achieve the required levels of virus inactivation.

6.2.3 Short-Listed Treatment Alternatives

The preliminary list of fifteen process train alternatives was presented at a Process Screening Workshop on December 20, 2005 that included participation by representatives of the C/CWTP owners: City of Santa Fe and Santa Fe County, as well as NMED. The purpose of this workshop was to evaluate the process alternatives based on the established performance criteria through evaluation matrix methodology, and the selection of three viable alternatives for further analysis and final recommendation. It should be noted that the cost evaluation for this initial screening was based on relative costs between the alternatives rather than absolute costs of facilities. These included broad comparisons based on similar projects and general unit cost information.

Three alternatives were selected for further evaluation as agreed to at the workshop: Alternatives 1A, 2A, and 3A. The three alternative process trains are as follows:

Alternative 1 – Conventional Treatment with Plate Settler Clarification plus Ozone, BAC Filter Adsorbers, and UV disinfection

Alternative 2 – Conventional Treatment with High Rate Clarification (e.g., Actiflo) plus Ozone, BAC Filter Adsorbers, and UV disinfection

Alternative 3 – MF with Plate Settler Clarification plus Ozone and BAC Contactor Adsorbers

The following paragraphs provide a more detailed description and general design criteria for each short-listed alternative. The design criteria were used for developing construction and O&M cost information to allow a life-cycle cost comparison for the three alternatives.

6.2.3.1 Alternative 1 – Plate Settlers with Media Filters

The process flow diagram for Alternative 1 is shown in Figure 6.2-2**.** This alternative includes the following unit processes:

- Raw water equalization/presedimentation
- Chemical feed and coagulation (flash mixing)

- Flocculation
- Sedimentation using plate settlers
- Ozonation
- Dual media GAC filtration/adsorption
- UV disinfection

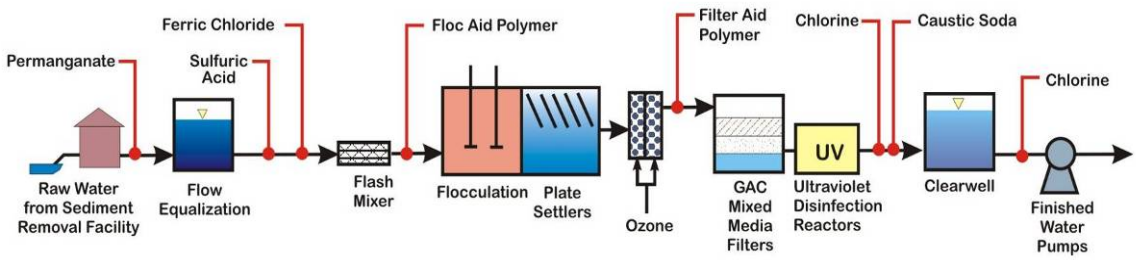


Figure 6.2-2 Alternative 1 - Plate Settlers with Media Filters

Raw Water Equalization/Presedimentation

Each of the three alternatives includes a set of Raw Water Equalization/Presedimentation Basins. These basins will be identical for all three alternatives and are described more fully in Section 6.3. The basins provide several functions including:

- Raw water storage to allow the C/CWTP to continue operating in the event of a temporary disruption in the raw water supply system (e.g., power loss at one of the raw water booster pumping stations).
- Raw water quality dampening to reduce the impact on plant processes of sudden changes in water quality in the Rio Grande (e.g., turbidity spikes following a rain storm).
- Preliminary sedimentation to reduce the raw water turbidity of the water entering the plant. This would be especially beneficial when the raw water turbidity exceeds 1,000 NTU so as not to overload the plant clarification systems. There will be the ability to feed ferric chloride ahead of the basins to assist in coagulating and settling the suspended material and improve turbidity removal in the Raw Water Equalization/Pre-Sedimentation Basins.
- The raw water storage capacity will also allow the Owners to take advantage of reduced electrical energy costs from PNM during off-peak periods (typically 8:00 pm to 8:00 am weekdays and all weekend).
- These basins will provide reaction time for oxidizing dissolved metals (iron, manganese and aluminum) with sodium permanganate fed at the inlet.
- When operated with a small coagulant dose and achieving 0.5-log (68.4 percent) reduction in total suspended solids, these basins can be used with granular filtration to receive up to 0.5-log *Cryptosporidium* removal credits under the IESWTR. Such credits may be needed to comply with treatment goals for Alternatives 1 and 2. However, Alternative 3 would receive these same credits for the flocculation/sedimentation process and would not require additional credits from the presedimentation process.

Flash Mix and Chemical Feed

Each of the three alternatives includes a Flash Mix Facility after the raw water basins to effectively diffuse ferric chloride and other treatment chemicals into the raw water. The flash mix will be identical for all three alternatives and is described more fully in Section 6.3. Alternative 1 includes the addition of ferric chloride at two separate feed points, flocculation aid polymer, filter aid polymer, and the option to feed sulfuric acid (spare chemical system) for enhanced coagulation.

Flocculation

Both Alternative 1 and Alternative 3 assume the use of rectangular, horizontal flow flocculation and sedimentation basins while Alternative 2 assumes the use of high rate clarification. The Alternative 1 flocculation basins are described more fully in Section 6.3. The proposed flocculation system for this alternative will use vertical shaft flocculators with Hydrofoil-type impellers with an option to substitute horizontal paddlewheel flocculators with submerged chains and fiberglass reinforced plastic flights. An N+0 level of redundancy is assumed with a hydraulic retention time of 40 minutes at a design flow rate of 6.0 -mgd per basin.

Sedimentation

Alternative 1 assumes the use of lamella plate settlers. Similar to the flocculation, the sedimentation basins will be identical for Alternatives 1 and 3, but will vary for Alternative 2. The Alternative 1 sedimentation system is described more fully in Section 6.3. For Alternative 1, a relatively low effective hydraulic loading rate of 0.4 gpm/sf were used to size the plate packs. This loading rate has been recommended by one of the plate pack manufacturers and appears to be consistent with other water treatment plants treating cold water. The goal of the sedimentation system under Alternative 1 is to be able to consistently produce settled water with a turbidity of 2 NTU or less.

Ozone Generation and Contacting

Alternative 1 assumes the use of settled water ozonation for disinfection and other purposes. An ozone system is assumed for all three alternatives and is described more fully in Section 6.3. It should be noted, however, that the ozone system required for Alternatives 1 and 2 will be required to achieve 1-log inactivation of *Cryptosporidium* while the Alternative 3 will be sized primarily for TOC reduction, oxidation of SOCs, and mitigation of taste and odor concerns.

Filtration/Adsorption

Alternative 1 assumes a set of concrete, gravity-flow filter adsorbers will be used to remove particulate matter through filtration of the settled/ozonated water. The filter adsorbers will also adsorb dissolved compounds in this water, including TOC, algal odor agents, and trace SOCs. The filter adsorbers will be operated in a biologically active mode to allow for the removal of Assimilable Organic Carbon (AOC) and to assist in regeneration of the adsorptive capacity of the GAC media.

The media would be periodically cleaned using air scour and water backwash. The waste backwash water would be conveyed to a Waste Washwater Equalization Basin. A duplicate Filter-to-Waste Equalization Basin would also be required. These basins would be piped to allow one filter to be taken out of service, while allowing the plant to continue backwashing and filter-to-waste operations using the remaining on-line basin. Each basin would be equipped with a set of three pumps to return the water to the head of the plant.

It is anticipated that the GAC media would be used as a medium for supporting biofilms to remove AOC produced by ozonation of the settled water and would not require frequent

replacement. For this analysis, the GAC replacement frequency is set at 1-year intervals, however, replacement intervals could extend as far as 3 to 5 years, depending on the TOC removal necessary and the level of degradation of the GAC media.

Ultraviolet Disinfection

Under Alternative 1, the filtered water would flow to the UV Disinfection Facility. This facility would include a set of four parallel UV reactors. Normally, three reactors would be in-service during peak plant flows, with the fourth reactor in standby mode. The reactors would be sized to allow for 1.0-log inactivation of *Cryptosporidium* at the maximum plant flow rate, providing the final log removal requirements necessary to comply with a Bin 3 classification under the LT2ESWTR.

6.2.3.2 Alternative 2 - High-rate Clarification

The process flow diagram for Alternative 2 is shown in Figure 6.2-3. This alternative includes the following unit processes:

- Raw water equalization/presedimentation
- Chemical feed and coagulation (flash mixing)
- Actiflo® reaction chamber
- High rate clarification using plate settlers
- Ozonation
- Dual media GAC filtration/adsorption
- UV disinfection

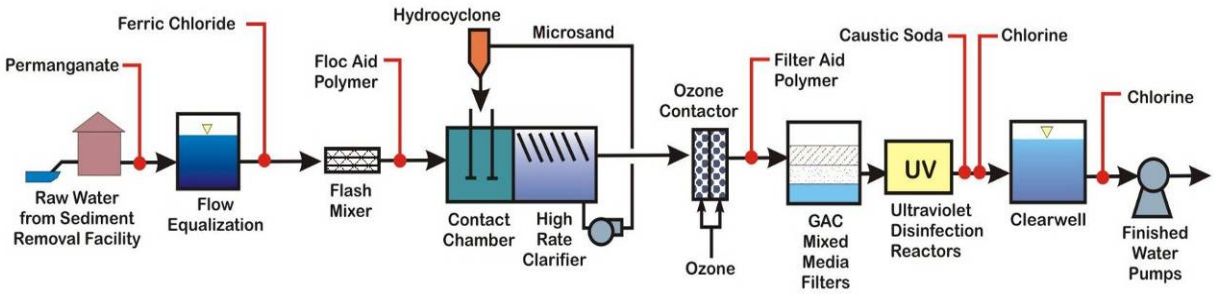


Figure 6.2-3 Alternative 2 - High-Rate Clarification

Raw Water Equalization/Pre-Sedimentation Basins

This facility would be the same as Alternative 1. See description above.

Flash Mix

This system would be the same as for Alternative 1.

Actiflo® Reaction Chamber and High-Rate Clarification

Under Alternative 2, a proprietary high-rate clarification system would be used. The two systems that may be suitable candidates are the Actiflo® process by Veolia/Kruger and the DensaDeg® process by Infilco Degremont Inc. (IDI). For this analysis, it is assumed that the Actiflo process is used. Four parallel Actiflo basins would be constructed, each with an influent capacity of 5.25-mgd. The clarifier sections would be sized for a hydraulic loading rate of 25 gpm/sq ft.

Ozone Generation and Contacting

These systems would be the same as for Alternative 1.

Filtration/Adsorption

These would be the same as for Alternative 1.

Ultraviolet Disinfection

This system would be the same as for Alternative 1.

6.2.3.3 Alternative 3 – Membrane Filtration

The process flow diagram for Alternative 3 is shown in Figure 6.2-4. This alternative includes the following unit processes:

- Raw water equalization/presedimentation
- Chemical feed and coagulation (flash mixing)
- Flocculation
- Sedimentation with Plate Settlers
- Membrane filtration
- Ozonation
- GAC contact adsorbers

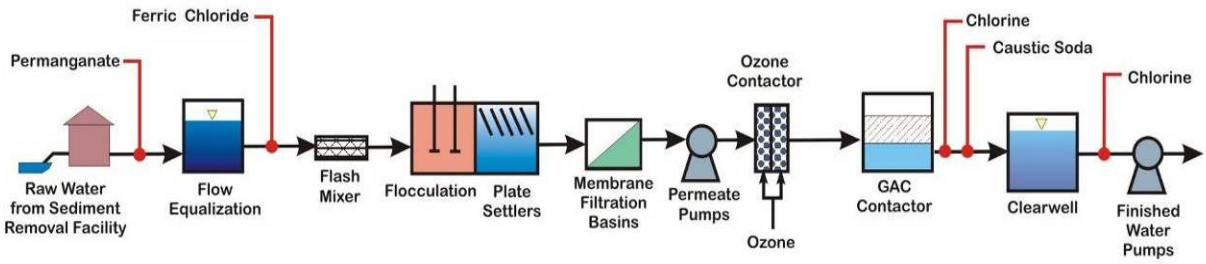


Figure 6.2-4 Alternative 3 - Membrane Filtration

Raw Water Equalization/Pre-Sedimentation Basins

This facility would be the same as Alternatives 1 and 2. However, the presedimentation system would not be relied on for Cryptosporidium removal/inactivation credits under the LT2 ESWTR and would therefore only require the use of coagulant during periods of extreme turbidity events to reduce the loading on the flocculation and sedimentation processes.

Flash Mix

This system would be similar to Alternative 1, however, no polymers would be used in the primary treatment process, simplifying the chemical feed and mixing requirements. Polymers can be damaging to efficient membrane operation and do not provide the same value with membranes as for conventional filtration. With MF non-settleable pinpoint floc is removed with the same level of efficiency as larger floc, reducing the need for polymers.

Flocculation

This facility would be the same as for Alternative 1.

Sedimentation

The Sedimentation Basins would be similar to Alternative 1, with the only difference the use of a higher effective surface loading rate for the plate settlers. For Alternative 3, an effective loading rate of 0.4 gpm/sf is assumed, however maintaining a settled water turbidity of 2 NTU or less is not as critical with MF as with granular media filtration.

Membrane Filtration

Alternative 3 assumes the use of MF. Either submerged or pressurized microfiltration could be used, using either microfiltration or ultrafiltration. The nominal membrane pore size would be between 0.02- and 0.1-µm. Given the high elevation of the facility, a relatively low flux rate for submerged systems would limit transmembrane pressure to around 8 psi vacuum. Low wintertime water temperatures will also limit the flux for both submerged and pressurized MF facilities. For the current comparison of the three process train alternatives, the design criteria assumptions are as follows:

- Use of pressure membranes with space for at least 15 percent additional membrane modules on each membrane skid
- Use of eight 2.5-mgd skids (six duty and two standby units)
- A minimum water temperature of 0.5 degrees C
- A design flux rate of 44 gfd
- At least 95 percent recovery
- Membrane waste backflush water would be collected in the Washwater Recovery Equalization Basins

Ozone Generation and Contacting

These systems would be similar to the systems for Alternatives 1 and 2; however, the system would be designed to achieve a 2.0-log virus inactivation rather than 1.0-log *Cryptosporidium* inactivation required for Alternatives 1 and 2.

GAC Adsorption

It was assumed that the GAC Adsorption Facility would be similar in design to the Filter Adsorbers for Alternatives 1 and 2. The media would consist of a 96-inch layer of 1.3-mm GAC, but there would be no sand layer beneath the GAC. The contact basins would be constructed of concrete and would be gravity flow with open top beds. Six contactor beds would be provided and sized for a surface loading rate of 6 gpm/sf with one bed off-line and one-bed in backwash mode. This would provide a minimum Empty Bed Contact Time (EBCT) of 10 minutes at a plant production rate of 15-mgd. The GAC Adsorption Facility would include both air scour and water backwash media cleaning systems similar to those for the Filter Adsorbers for Alternatives 1 and 2. It is anticipated that the beds would be cleaned approximately once per week. Waste washwater would be collected in a set of two 100,000-gal Washwater Recovery Equalization Basins. These basins would also be used to collect the washwater from the Membrane Filters. Similar to the Filter Adsorbers for Alternatives 1 and 2, it is assumed that the GAC would not be replaced/regenerated on a frequent basis. The media would provide a medium for sustaining biofilms for AOC removal. For this analysis, it was assumed that the media would be replaced every three years.

6.2.4 Evaluation and Costs Analysis

Final evaluation of the short-listed alternatives was based on the quality, risk and cost criteria identified in Table 6.2-1. Rankings for each alternative were given on a scale of 1 to 5, with 5 being the best and 1 the least desirable. Weightings were given for each individual criterion, as described in Section 6.2.1, based on weighting factors developed during the Process Screening Workshop. The overall weighting for the three evaluation categories were as follows: Quality 80, Risk 50, Cost 50. As stated previously, all evaluated alternatives provided equivalent opportunities for meeting the required schedule. Schedule was therefore not specifically included as one of the evaluation categories.

The following paragraphs discuss the evaluation and ranking of the various quality, risk, and cost factors considered in determining the recommended treatment approach.

6.2.4.1 Evaluation of Alternatives Quality and Risk Factors

Alternative 1 – Plate Settlers with Media Filtration

Quality Factors

While the process described as Alternative 1 is capable of producing exceptional quality water under most operating circumstances, the effectiveness of the process would be somewhat dependent on the ability of the operators to react effectively to changes in raw water quality conditions. The process may also be overwhelmed with extremely high turbidity events if the solids handling facility and presedimentation basins were unable to reduce solids to low enough levels for the sedimentation/filtration process to work effectively.

In terms of the quality evaluation factors listed in Table 6.2-1, Alternative 1 was rated moderate (3) in the ability to always meet turbidity goals and was rated moderately high (4) in the ability to always meet pathogen, DBP, and aesthetic goals, which could also be exceeded during periods where the process was overwhelmed by high turbidity or high TOC events, or when operators are unable to react effectively to raw water quality changes. The process was ranked moderately high (4) in its ability to meet future regulations, including unregulated contaminants, pharmaceuticals and personal care products.

The process was ranked moderately low (2) in ease of operation, due to the moderately high operator attention required to maintain the effectiveness of the process and to produce water that would consistently be in compliance with water quality regulations and treatment plant goals. The process was also ranked moderate to moderately high (3.5) in its ability to minimize maintenance and was rated moderate (3) in its ability to minimize residuals. All of these rankings will be summarized in Section 6.2.4.3 of this Report.

Risk Factors

Alternative 1 involves unit processes with the longest track record of operation compared with the other alternatives; however, its effectiveness also depends more than the others on operator attention and acceptable feedwater quality. The alternative therefore comes with a moderate amount of risk of producing out-of-compliance water. The process also involves the greatest number of chemicals onsite and highest ozone usage, due to the higher turbidities in the pre-ozonated water. This creates additional risks and complexity to the treatment process. Finally the higher ozone dose, GAC backwashing, and media replacement frequency associated with this alternative, along with the greater overall footprint and higher chemical usage create a moderate level of environmental impact. This alternative was rated high (5) for demonstrated process

history and moderate (3) for risk of out-of-compliance water, staff and public safety, simplicity of process, and environmental impacts.

Alternative 2 - High-Rate Clarification

Quality Factors

The process identified as Alternative 2 is better able to adjust to high turbidity event and changing raw water quality conditions than Alternative 1, but still depends on the chemistry of the coagulation process for removal of suspended solids and turbidity reduction. Breakthrough of turbidity will subsequently have an impact on pathogen removal and other water quality parameters. Alternative 2 was ranked as moderate to moderately high (3.5) in its ability to always meet turbidity goals, and moderately high (4) in its ability to always meet pathogen, DBP, and aesthetic goals. It was also ranked moderately high to high (4.5) in its ability to meet future regulations (slightly higher than alternative 1), since the lower turbidities in the settled water for this alternative are less likely to cause interference with the ozone and GAC removal of emerging and unregulated contaminants.

The process was ranked moderately low (2) in ease of operation, the same as Alternative 1. Although it is less dependent than Alternative 1 on high operator attention to changing raw water quality, it also involves the addition of a new unit process with the microsand feed, separation, and recycling systems required for the Actiflo system. The alternative was ranked moderate to moderately high (3.5) for minimizing maintenance and moderate (3) on minimizing residuals. Both were the same rankings given to Alternative 1.

Risk Factors

Alternative 2 involves a proprietary sedimentation process with a shorter process history than traditional plate settlers; however, all the processes involved with this alternative have been used extensively throughout the country and have a proven record of performance. The alternative was therefore rated high (5) in terms of demonstrated process history. The alternative has a lower risk of producing out-of-compliance water than Alternative 1 and a slightly lower risk to staff and public safety. With the ability of the process to minimize these risks it was rated moderately high (4) for producing out-of-scope water and moderate to moderately high (3.5) for staff and public safety. The simplicity of the process was rated moderately low (2.5), because it involves the most number of unit processes compared with the other alternatives. The environmental impact rated moderately high (4), due to its smaller footprint and low energy usage compared with Alternative 1.

Alternative 3 - Membrane Filtration

Quality Factors

The process identified as Alternative 3 involves highly automated systems with finished water that will remain consistently free of suspended solids and pathogens regardless of the feed water quality and with less dependence on chemical doses and efficient operations upstream of the membranes. Upsets in system operation caused by spikes in raw water turbidity may impact the efficiency of the MF operation, but will not cause breakthrough of solids to the finished water. Alternative 3 was therefore ranked highest (5) in its ability to always meet turbidity and pathogen goals. It was also ranked moderately high to high (4.5) in its ability to always meet DBP and Aesthetic goals and its ability to meet future regulations, since the elimination of all suspended solids prior to ozone and GAC will allow the downstream processes to be more efficient at removing TOC and trace organics, as well as many emerging and unregulated contaminants.

The process was ranked moderately high (4) for ease of operation and minimizing maintenance, due to the high level of automation, reliance on instrumentation rather than direct operator involvement, and the elimination of the UV disinfection system. It was also ranked moderately high on minimizing residuals, since the membranes will not require the filter-to-waste period needed for conventional filters and will likely operate at a slightly higher recovery rate than Alternatives 1 and 2.

Risk Factors

Alternative 3 has a slightly longer process history than Alternative 2, but considerably shorter than Alternative 1. As stated previously, all three alternatives have a strong record of proven performance throughout the country and were rated high (5) on demonstrated process history. Alternative 3 was also rated high (5) on the ability to reduce the risk of out-of-compliance water and was rated moderately high (4) in terms of reducing risks to staff and public safety. It is considered the safest alternative of the three evaluated, but still requires the use of a number of chemicals as well as generation of ozone, all of which create some level of risk to operators and the public. Alternative 3 was rated moderately high (4) on simplicity of process, given the reduced number of chemicals, the purely physical separation process offered by the membranes, and the elimination of UV disinfection from the treatment train. There is a potential risk for membrane fouling associated with the alternative. However, membrane fouling is difficult to predict and adjustments in chemicals can be made.

This alternative would involve the lowest ozone dose and GAC replacement, since all suspended solids would be removed by the membranes prior to the ozone/GAC process. The ozone dose and contact time for this alternative would be set only to achieve TOC removal rather than the *Cryptosporidium* inactivation required by the other two alternatives, significantly reducing the required ozone usage and associated energy demands. The alternative was therefore rated moderately high (4) in terms of overall environmental impact.

6.2.4.2 Construction, O&M and Life-Cycle Cost Analysis

The cost evaluation between these three alternatives was based on conceptual level construction and O&M cost estimates developed for each alternative. General basis of design criteria assumed in development of these costs were presented previously in Section 6.2.3. These costs were developed for comparative purposes only. The costs were developed based on experience with previous projects, typical unit cost information, and vendor quotes from some major equipment suppliers. All costs listed for this analysis should be considered to have a level of accuracy in a range of 50 percent above the listed cost to 30 percent below. A more detailed cost estimate was developed for the recommended alternative and is included in Section 10 of this report. The following assumptions were used in the development of conceptual costs for the three treatment alternatives:

- Treatment Facility Capital Cost refers to the cost of the process equipment provided by the manufacturer, installation, start-up, and all construction associated with the new facility (including ancillary facilities, on-site piping, site work, etc.)
- Percentage based estimates were used for several components of the capital cost estimate, including: Electrical (10 percent), Instrumentation (3 percent), Mobilization and General Conditions (2 percent), Site Work (4 percent), and Yard Piping (5 percent)
- Engineering costs are not included in the estimates
- Contingencies have been estimated at 30 percent of the capital cost

- Capital Cost Amortization is based on a 25-year municipal bond sale at the current interest of 5.5 percent
- The capital cost includes a 10 percent allowance for unlisted equipment and New Mexico Gross Receipts Tax of 7.56 percent on all equipment and materials
- Operations and Maintenance Cost varies depending on the treatment facility used; it includes energy (kwh), labor, chemicals, routine maintenance and replacements, and spare parts
- Membrane and media replacement costs are considered part of the Operations and Maintenance and were annualized based on the estimated replacement year and the current interest rate of 5.5 percent
- Total Annual Cost includes the capital cost amortization to build the treatment facility and operations and maintenance cost
- Total Production Cost per MG is based on the total product water produced and the total annual cost of the facilities.
- Life-Cycle Cost was calculated as the present value of the Total Annual Cost, assuming a 25-year period and a 5.5 percent interest rate

Costs for Short-Listed Alternatives

Table 6.2-2 details the relative capital, O&M, and life-cycle costs for the three short-listed alternatives.

Table 6.2-2 Conceptual Level Costs for Short-Listed Treatment Alternatives

Description	Cost		
	Alt 1 – Plate Settlers + Media Filtration	Alt 2 – High Rate Clarification	Alt 3 – Membrane Filtration
Total Construction Cost w/o contingency	51,400,000	50,900,000	60,100,000
Contingency @ 30 percent	15,420,000	15,270,000	18,030,000
Total Construction Cost with Contingency	66,820,000	66,170,000	78,130,000**
Annualized Construction Cost	4,980,000	4,930,000	5,820,000
Total Annual O&M Cost	3,210,000	3,410,000	3,180,000
Total Annual Cost	8,190,000	8,340,000	9,000,000
Annual Treated Water Production (mil gal/yr)	2,894	2,947	3,180
Unit Cost of Water ($/mil gal)	943	960	1,036
Unit Cost of Water ($/ac-ft)	2,894	2,947	3,180
Life-cycle Cost	109,910,000	111,940,000	120,810,000**

* See Section 6.2.4.2 for assumptions used in calculating conceptual level costs

** Revisions made later in the project, as recommended by Value Engineering and Technical Review committees substantially lowered the construction of this alternative

Based on these relative costs, relative rankings were given for life-cycle and O&M affordability in the Alternatives evaluation. It should be noted that the lowest price was given the highest affordability ranking, and that the ranking then decreased as cost increased. The following rankings were given to each of the three alternatives:

- Alternative 1 was ranked moderately high to high (4.5) on both life-cycle and O&M affordability

- Alternative 2 was ranked moderately high to high (4.5) on life-cycle and moderately high (4) on O&M affordability
- Alternative 3 was ranked moderate (3) on life-cycle and moderately high to high (4.5) on O&M affordability

6.2.4.3 Ranking of Alternatives

Table 6.2-3 presents the evaluation matrix used to determine final ranking of the three short-listed alternatives. This analysis indicates that Alternative 3 received the highest ranking in terms of Quality and Risk, but a slightly poorer ranking in terms of cost. Overall, Alternative 3 ranked the highest, with an overall score of 740 compared with a score of 650 for Alternative 2 and 630 for Alternative 1. The results of this analysis were discussed at the Process Workshop held January 19, 2006.

Table 6.2-3 Ranking of Short-Listed Treatment Alternatives

	Weight	Alt 1 – Plate Settlers + Media Filtration	Alt 2 – High Rate Clarification	Alt 3 – Membrane Filtration
Quality Factors				
Always meet turbidity goal	10	3	3.5	5
Always meet pathogen goals	10	4	4	5
Always meet DBP goals	10	4	4	4.5
Always meet aesthetic goals	10	4	4	4.5
Addresses future regs	10	4	4.5	4.5
Ease of Operation	11	2	2	4
Minimizes maintenance	11	3.5	3.5	4
Minimizes residuals	8	3	3	4
Quality Score	80	235	240	355
Risk Factors				
Demonstrated process history	10	5	5	5
Risk of out-or-spec water	10	3	4	5
Staff & public safety risk	10	3	3.5	4
Simplicity of process	10	3	2.5	4
Environmental impact	10	3	4	4
Risk Score	50	170	190	220
Cost Factors				
Life-cycle Cost	40	4.5	4.5	3
O&M Cost	10	4.5	4	4.5
Cost Score	50	225	220	165
Total Overall Score		630	650	740

6.2.5 Recommended Water Treatment Facilities

The results of the alternatives ranking were presented and discussed at the January 19, 2006 Process Workshop. Based on the recommendation of the meeting attendees and on the results of the matrix evaluation, Alternative 3 was selected as the treatment process for the C/CWTP. The selected process is presented in Figure 6.2-4 and contains raw water presedimentation, coagulation, flocculation, sedimentation, membrane filtration, ozonation and GAC contactors.

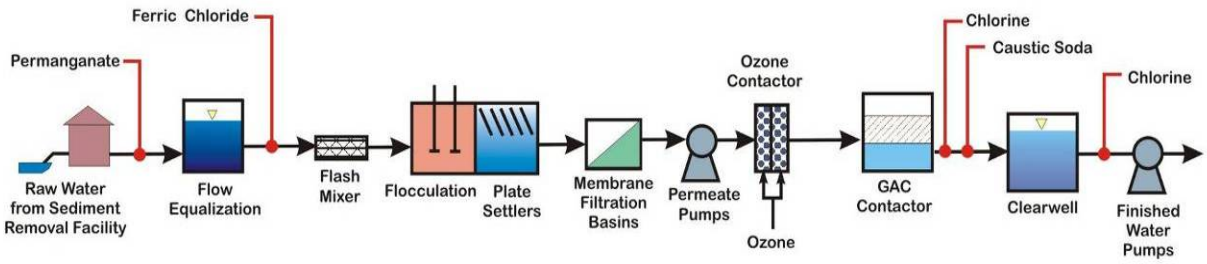


Figure 6.2-4 Alternative 3 - Membrane Filtration

The recommended processes are described more fully in Section 6.3, which identifies detailed design criteria for each component of the water treatment facility.

6.3 Unit Process Option Evaluation

Section 6.2 presented a screening fifteen and evaluation three water treatment alternative process trains and selected a recommended process train for the C/CWTP. However, several alternative technologies or configurations exist for most of the recommended unit processes. This section presents an evaluation of the best configuration or technology for the following unit processes:

- Raw Water Equalization and Presedimentation Basins
- Raw Water Metering
- Chemical Injection and Coagulation (Flash Mixing)
- GAC Contactors
- Solids Handling
- Washwater Equalization
- Finished Water Storage

Recommendations from this unit process evaluation and recommendations for all other processes (flocculation, sedimentation, membrane filtration, ozone, chemical feed systems and finished water booster stations) are discussed in the next section - Section 6.4.

6.3.1 Raw Water Equalization and Presedimentation Basins

6.3.1.1 Performance and Design Criteria

The C/CWTP will have presedimentation and equalization basins to remove settleable solids from the process water that are not removed at the SRF. In addition to removing settleable solids, the raw water equalization (RWEQ) facility will provide a total of 7.5 MG of storage in the event that the raw water system is out of service. The minimum detention time at peak flow (15-mgd) is 12 hours and extended detention times are possible at lower flow rates. The RWEQ facility will be configured so that a first stage, consisting of two rectangular basins, will provide sedimentation, equalization, and some storage while a third, second-stage basin will be used exclusively for raw water storage. The first-stage basins will be referred to as presedimentation basins. The second-stage basin will be referred to as the raw water storage basin. The two presedimentation basins will be oversized to allow 3-ft of sludge and sediment accumulation before cleaning is required. Each presedimentation basin can be taken out of service for drying, cleaning or maintenance. Each basin will be sized to provide 2.25 MG of storage and the raw water storage basin will be sized to

provide 3.0 MG of raw water storage. The total storage capacity of all basins is 7.5 MG. Plan and section drawings of the RWEQ facilities are shown on Sheets C-9 and 1M-1 in the C/CWTP preliminary design drawings.

A two-stage RWEQ facility is recommended because it allows for the removal of suspended sediment as the primary function of the first stage basins and raw water storage in the second-stage basin. This configuration allows for easier, more frequent cleaning of the two presedimentation basins that will receive more sediment-laden raw water while ample storage is provided in the raw water storage basin, which will require less frequent cleaning.

The design of the RWEQ facility shall be conducted such that the facility is not considered a jurisdictional dam subject to restrictions set forth by the State Engineer's office. A jurisdictional dam is defined as either a vertical elevation change of greater than 10-feet between the toe-of-slope ground surface elevation to the top of the spillway crest or an impoundment of greater than 10 acre-feet (AF) of water. The current design of the RWEQ basins incorporates a spillway from presedimentation basins 1 and 2 into the raw water storage basin and another spillway over the constructed embankment diverted into the storm water catchment pond on the west side of the site.

Design Criteria for the Raw Water Equalization Basins are as shown in Table 6.3-1:

Table 6.3-1 Raw Water Equalization Facility Design and Performance Criteria

Design Parameter	Value
Type	Two-Stage Equalization, Sedimentation and Storage Facility
Total Storage Capacity	7.5-MG
Overflow Rate	18-mgd
First Stage: Presedimentation Basins	
Type	Reinforced Concrete or Earthen Basins
Total Capacity	5.5-MG
No. of Basins	Two
Capacity of Each Basin	2.75-MG
Maximum Basin Depth	17.5-feet
Anticipated Maximum Sludge Depth	3.1-feet
Storage Capacity per Basin	2.25-MG
Sludge Storage Capacity per Basin	0.4-MG
Second Stage: Raw Water Storage	
Type	Earthen Basin or Prestressed Concrete
Total Capacity	3-MG
No. of Basins	One
Maximum Depth	17.5-feet

6.3.1.2 Initial Screening of Alternatives

The following seven alternatives were considered for configuration of the RWEQ:

Alternative 1 - Two rectangular sedimentation basins and pre-stressed concrete storage tank
Alternative 2 - Three large rectangular sedimentation basins and no additional storage tank
Alternative 3 - Two large rectangular sedimentation basins and no additional storage
Alternative 4 - Large rectangular sedimentation basins and lined earthen basins storage facility
Alternative 5 - Four concrete-lined earthen basins
Alternative 6 - Two-stage lined earthen basins for presedimentation and storage
Alternative 7 - Mechanical sedimentation system

A discussion of the initial screening of the alternatives is presented in the following paragraphs.

Alternative 1 - Two rectangular sedimentation basins and prestressed concrete storage tank

This facility consists of two rectangular engineered basins and one open-top DYK prestressed concrete reservoir. The majority of the sedimentation process will occur in the rectangular basins, which will be specifically designed to remove target particles under anticipated flow conditions. There will be access ramps in the rectangular basins for cleaning of collected sediments using a front-end loader, cleaning of the storage reservoir will use a set of "monitor"-type water cannons and drainage into the wash-water equalization basins via a separate drainage pipe at the apex of the sloped conical bottom. The re-suspended sediment will gravity flow to the waste wash-water equalization basins then pumped to the RWEQ basins for sediment removal. The rectangular basins will provide some storage capacity, however, the round DYK tank will be sized and designed to provide most of the raw water storage required. Equalization of return flows and mixing with raw water will occur in the rectangular basins. A bypass line will divert flow from the rectangular sedimentation tanks directly to the flash mix facility in the event the raw water storage tank is out of service for cleaning.

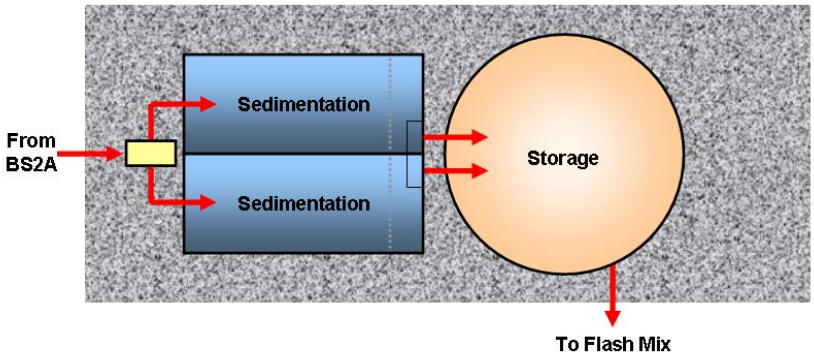


Figure 6.3-1 Alternative 1 with Rectangular Sedimentation Basins and Prestressed Concrete Storage Tank

Alternative 2 - Three large rectangular sedimentation basins and no additional storage tank

For this alternative, the RWEQ will be comprised of three rectangular reinforced concrete sedimentation basins designed to remove sediment and provide raw water storage in the same basins. The basins will be sized for each of three basins providing 33 percent of the required storage. Whenever a basin is taken off-line for maintenance or cleaning, the total available storage volume will be reduced by one-third. An access ramp will be provided in each basin to allow a front-end loader or similar equipment to access the basin to remove the collected sediment.

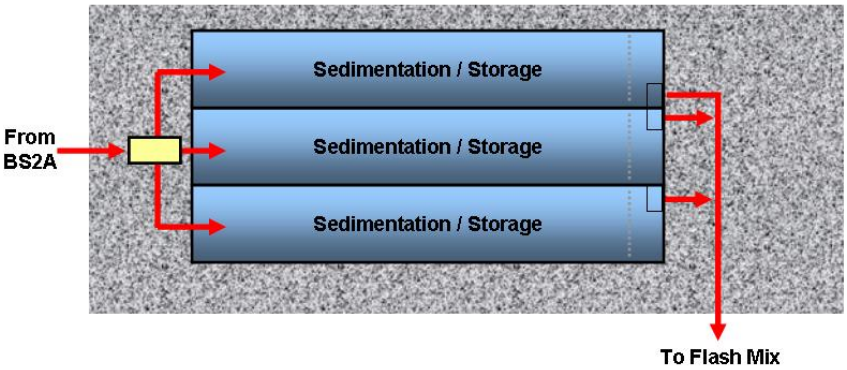


Figure 6.3-2 Alternative 2 with Three Rectangular Sedimentation Basins and No Additional Storage

Alternative 3 - Two large rectangular sedimentation basins and no additional storage

This alternative is similar to alternative 2 except only two basins will be provided with each basin sized for 50 percent of the required storage volume. The basins will be designed to provide sedimentation and storage in one facility. Operation and cleaning will be the same as described in Alternative 2. However, only 50 percent of the storage volume will be available when one basin is taken off-line.

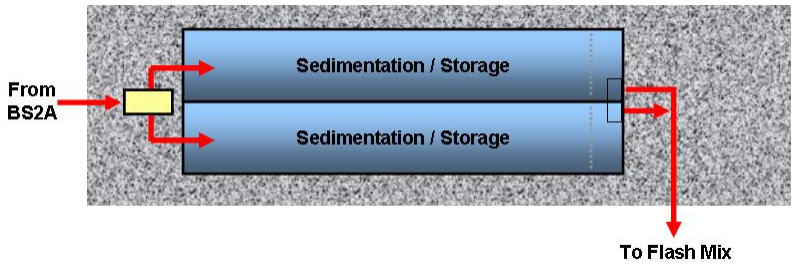


Figure 6.3-3 Alternative 3 with Two Rectangular Sedimentation Basins and No Additional Storage

Alternative 4 - Large rectangular sedimentation basins and lined earthen basin storage facilities

Alternative 4 is similar to alternative 1 except a lined earthen basin would be used for raw water storage instead of the pre-stressed concrete DYK tank. Access to and cleaning of the rectangular basins would be the same as described for Alternative 1. The rectangular basins will be sized slightly larger than in Alternative 1 so that the volume of the second stage basin is no greater than 10 AF and is not considered a jurisdictional dam.

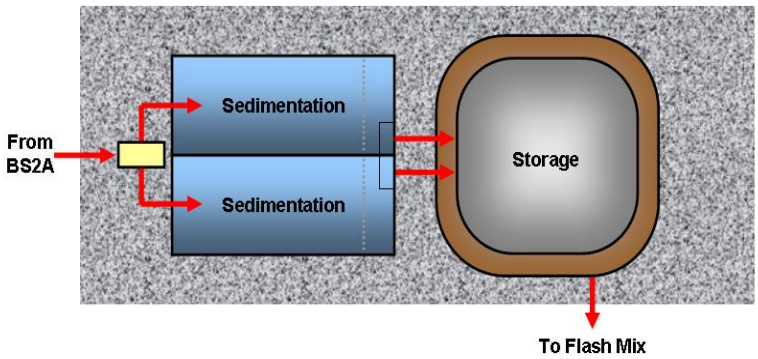


Figure 6.3-4 Alternative 4 with Rectangular Sedimentation

Basins and Lined Earthen Storage

Alternative 5 - Four concrete-lined earthen basins

This alternative is similar to the RWEQ facility proposed earlier in the design process. There would be four gunite lined earthen basins with sloped sides and each basin will have a dedicated decant facility to convey water to the C/CWTP. This alternative requires the greatest land area because the sloped sides consume land area without adding volume. Each of these basins would have a storage capacity of approximately one third of the storage volume required by the Owners so that one basin can be taken out of service for cleaning.

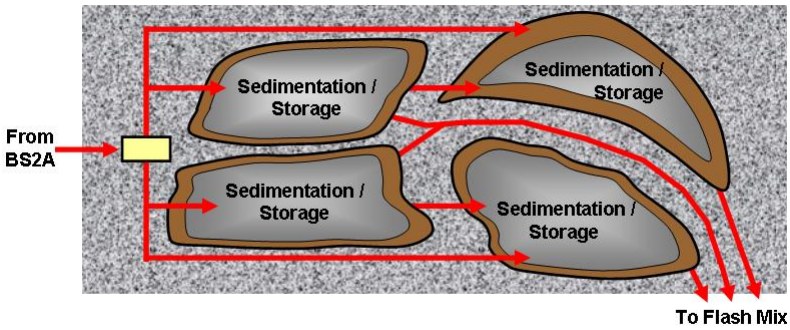


Figure 6.3-5 Alternative 5 with Four Concrete-Lined Earthen Basins

Alternative 6 - Two-stage lined earthen basins for presedimentation and storage

Alternative 6 is similar to Alternatives 1, 4, and 5 and provides two-stage operation like Alternatives 1 and 4 and the earthen basin construction like Alternative 5. Each of the two first-stage earthen basins would provide storage capacity and presedimentation capabilities to remove settleable solids from the incoming raw water. The second stage basin would provide raw water storage only. The total raw water storage volume would be exactly the quantity required by the Owners. Alternative 6 has a lower construction cost than Alternatives 1 through 5 because there are no reinforced concrete walls to construct and there are fewer earthen basins.

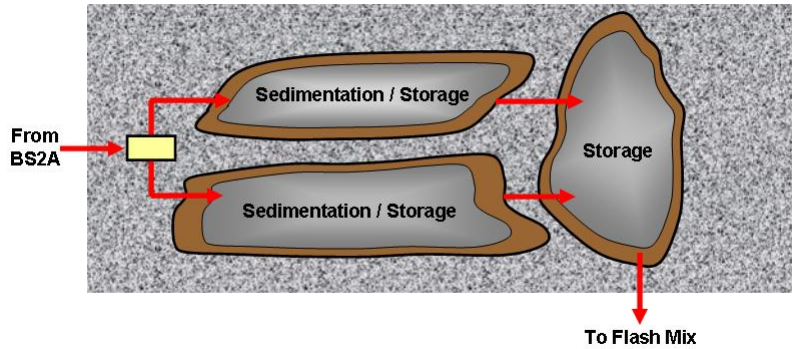


Figure 6.3-6 Alternative 6 with Two-Stage Lined Earthen Basins

Alternative 7 - Mechanical Sedimentation Facility

Alternative 7 is a mechanical sedimentation facilities that includes plate and tube settling systems, hydrocyclones, drum screens, mechanical clarifiers, etc. Mechanical sedimentation facilities would be appropriate if there were site limitations and gravity sedimentation facilities were not practical. This alternative provides no raw water storage, equalization of flows or blending of water quality.

Summary of RWEQ Alternative Advantages and Disadvantages

The advantages and disadvantages of each alternative are summarized in Table 6.3-2.

Table 6.3-2 Initial Screening of RWEQ Alternatives

	Advantages	Disadvantages
Alternative 1 - Two rectangular sedimentation basins and pre-stressed concrete storage tank	Separate sedimentation and storage facility Engineered storage basin No dam permit required	Increased capital cost for pre-stressed tank Extra pumping for clean-out of tank
Alternative 2 - Three rectangular sedimentation basins and no additional storage tank	Completely redundant basin	Higher capital cost for reinforced concrete
Alternative 3 - Two rectangular sedimentation basins and no additional storage	Smallest footprint of gravity sedimentation basins	50 percent of storage capacity off-line during cleaning
Alternative 4 - Large rectangular sedimentation basins and lined earthen basin storage facility	Lower capital cost than Alternative 1	May require dam permit for basin Larger area required than Alternative 1
Alternative 5 - Four concrete-lined earthen basins	Operational flexibility Lower capital cost	May require dam permit Large area required Could be complex to operate
Alternative 6 - Two-Stage Lined Earthen Basins for Presedimentation and Storage	Low capital cost Separate storage and sedimentation facility	May require dam permit Larger area required than Alternative 4
Alternative 7-Mechanical sedimentation system	Smallest footprint of all alternatives	Highest capital cost No storage, equalization or blending

Alternatives 2 and 3 were eliminated during the initial screening based upon the expense of the large, reinforced concrete basins. Alternative 7 was also eliminated because it was the highest cost alternative and did not provide necessary storage, equalization or blending.

Four alternatives remained after the initial screening: Alternatives 1, 4, 5 and 6.

6.3.1.3 Alternatives for Evaluation

Alternative 5 - Concrete-Lined Earthen Basins, was initially selected for the preliminary design but the remaining alternatives (1, 4 and 6) were re-visited after technical review and value engineering because these alternatives provide storage and sedimentation in a more flexible and perhaps more cost and space-effective configuration. Alternative 5 was initially selected because of the perceived lower construction cost. However, Alternative 5 requires the most land and the configuration may require a jurisdictional dam permit from the OSE.

Alternative 1 - Three rectangular Sedimentation Basins and a pre-stressed concrete tank, may be the most expensive of the remaining alternatives. This alternative could prove feasible since all elements are engineered, reinforced concrete basins and construction and design innovation will not be restricted by the jurisdictional dam regulations imposed on earthen embankments.

Alternative 4 - Large Rectangular Sedimentation Basins and Lined Earthen Basin Storage Facility, is similar to Alternative 1 except that the raw water storage reservoir is of earthen basin design and may be subject to jurisdictional dam regulations if the basins cannot be partially excavated.

Alternative 6 - Two-Stage Lined Earthen Basins for Presedimentation and Storage, is similar to Alternative 4 and 5 but requires less area and operation than both and is limited to the two-stage configuration with available bypass lines. This alternative would be the least expensive to construct because there are no reinforced vertical concrete structures to design and construct. Storage volume is maintained in the second stage basin and each of the basins are less than 10 AF each and embankments are no greater than 10-feet above existing ground surface, such that the basins would not subject to jurisdictional dam requirements.

Based upon the evaluation of the four short-listed alternatives for cost and feasibility, the two-stage presedimentation-raw water storage configuration (Alternatives 1, 4, or 6) is recommended. This recommendation provides for operational flexibility and substantial raw water storage. Cost savings are considerable when compared with reinforced concrete basins and prestressed concrete tanks and this cost savings allowed the earthen basin design throughout the raw water storage facility to prevail. Therefore, Alternative 6 was selected for the raw water presedimentation and storage facility.

6.3.1.4 Evaluation and Cost Analysis

A process evaluation is presented in Table 6.3-3 with a summary of the scoring criteria used to select the recommended alternative.

Table 6.3.3 RWEQ Process Evaluation

Alternative No.		Solids Removal	Storage	Land Use	Permitting	Life-Cycle Cost	O&M Cost	TOTAL Score
	Possible Score	*10*	*10*	*10*	*10*	*20*	*10*	*70*
1	2-Stage all reinforced	7	10	6	10	2	5	40
2	3 reinforced concrete basins	7	7	6	10	2	5	37
3	2 reinforced concrete basins	6	6	6	10	3	5	36
4	2-stage w/ earthen basin storage	7	10	5	6	10	6	44
5	4 earthen basins	8	10	2	4	14	7	45
6	2-stage w/ all earthen basins	8	10	4	5	15	8	50
7	Mechanical system	10	0	10	10	1	6	37

6.3.1.5 Recommendations

Alternative 6 - Two-stage earthen basins scored the highest and is recommended for design and construction at the C/CWTP. Additional recommendations for design and operation are discussed in Section 6.4.1.

6.3.2 Raw Water Metering

6.3.2.1 Performance and Design Criteria

The inlet flow meter measures the effluent flow from the RWEQ basins. In conjunction with the valves and water level at the RWEQ basins, the valves at the inlet flow meter will control the amount of water flowing through the C/CWTP.

The inlet flow meter is a 24-inch diameter ultrasonic type meter that will be connected to the monitoring equipment at the operations control center. In addition, a single, modulating control valve will be associated with the flow meter. The control valve will be located a minimum of 20-ft downstream of the meter in provide a laminar flow condition in the pipe. The control valve will operate within the range of 30 to 100 percent open to allow for control under the range of minimum to peak flow conditions. A wetted-type ultrasonic flow meter with two sensor packages was selected to provide the required accuracy from the system. Care must be taken in final instrument selection because particles and air bubbles present in the raw water can interfere with flow measurement. The appropriate meter must be designed and specified to mitigate this interference.

Design Criteria for the Raw Water Metering Facility are shown in Table 6.3-4.

Table 6.3-4 Raw Water Metering Facility Performance and Design Criteria

Design Parameter	Value
Overall System Performance	
Maximum Allowable Error	+/- 2 percent of Flow for Total System
Raw Water Flow Meter	
Type	Wetted Ultrasonic Transit-Time
Maximum Allowable Error	+/- 0.5 percent of Reading
Range	3 to 18 –mgd
Minimum Velocity	1.0 fps
Pipeline Diameter	24-inches
Alternative Configurations	Noninvasive Parallel Band Ultrasonic Meter
Flow Control Valve	
Type	Motor Operated Modulating Butterfly Valve
Number of Valves	1
Control Range	3 to 18 -mgd
Alternative Configurations	Two, Motor Operated Modulating Butterfly Valves, Installed in Parallel

6.3.2.2 Initial Screening of Alternatives

The raw water metering facility is a standard water treatment plant metering system comprised of a flow meter and control valves. Variations of this general design fall under two categories: variation of the meter type and variation of the control valve type and configuration.

Alternative 1: Flow Meter Type Selection

Flow meter types considered include the venturi meter, orifice meter, mag meter, propeller meter, and the ultrasonic flow meter.

Alternative 2: Valve Configuration

Butterfly and plug valves were both considered as alternative valve types for raw water metering. Butterfly valves cost less but gate valves offer a wider operational range. One plug valve or butterfly valve could be used in the place of two butterfly valves in parallel

One or two control valves were considered. In the case of two butterfly valves, valves of different sizes are mounted in parallel along the process flow stream and provide the maximum control of process water. The parallel valve scheme also has the benefit of allowing one valve to be taken out of service with no interruption in plant flow, although controllability is limited. However, the parallel configuration adds significant complexity and cost.

6.3.2.3 Alternatives for Evaluation

Ultrasonic flow meters offer numerous advantages over other flow meter types. These advantages include lower capital cost than most meter types, noninvasive installation with the band sensors, no additional headloss through the meter, and electronic calibration. The primary disadvantage of the ultrasonic meter is that air bubbles and particulates in the flow stream can interfere with the measurement. Several manufacturers claim to have technology in place to minimize this interference. No flow meter operates well at very low velocities with the ultrasonic meter being no exception. A minimum velocity of 1 fps is typically required to keep the flow accuracy within 1 percent of flow.

The evaluation of alternative valve types included both butterfly valves and plug valves. The advantages of butterfly valves are their low cost and compact design. The advantages of gate valves are wider operating range and lower cavitation potential.

6.3.2.4 Evaluation and Cost Analysis

An evaluation table was prepared to assist in evaluation of the Raw Water Metering Facility. This evaluation is shown in Table 6.3-5.

Table 6.3.5 Raw Water Metering Facility Process Evaluation

Alternative No.		Uninterrupted Operation	Accuracy	Flow Range	Life-cycle Costs	O&M Costs	TOTAL Score
	Possible Score	*10*	*10*	*10*	*10*	*10*	*50*
Raw Water Meter							
1	Ultrasonic	8	7	8	8	5	36
2	Venturi	5	5	5	6	5	26
3	Magnetic	7	7	8	6	5	34
4	Propeller	0	2	2	6	4	15
Flow Control Valve							
1	Parallel Butterfly	10	8	9	5	3	35
2	Single Butterfly	0	8	8	10	10	36
3	Parallel Plug	10	10	9	2	3	34
4	Single Plug	0	9	7	8	8	32

6.3.2.5 Recommendations

Based upon this worksheet, the ultrasonic meter paired with the single butterfly control valve configuration is the recommended system for the C/CWTP. This system was selected because it offers adequate plant flow rate control at a low cost.

The ultrasonic meter's advantages over the magnetic meter include a lower cost and simplified maintenance. The ultrasonic sensors can be removed and replaced as needed with the meter assembly remaining attached to the process pipeline. Venturi and propeller meters are not appropriate for this application.

The evaluation of alternative valve types included both butterfly valves and plug valves. The advantages of butterfly valves are their low cost and compact design. The advantages of plug valves are wider operating range and lower cavitation potential.

Additional recommendations for design and operation are discussed in Section 6.4.2.

6.3.3 Coagulation

6.3.3.1 Performance and Design Criteria

The flash mix facility (or coagulation process) is the primary chemical injection location at the C/CWTP. Coagulants, preoxidants, pH adjustment chemicals, and polymers (if required) are all typically dosed at the flash mix facility. The chemicals dosed at the flash mix facility for the C/CWTP will include ferric chloride as the primary coagulant and sodium hypochlorite as an oxidant. Additional injection ports will be provided for future expansion of chemical needs. The flash mix equipment will be housed in the Flocculation/Sedimentation Building.

The principle of the pumped injection flash mix facility is that a sidestream of process water is collected and pumped to increase the hydraulic energy of this sidestream. The chemicals are injected into the main process water line as the water is mixed by a wide-angle nozzle pointing upstream towards the process water flow and chemical injection points.

The design criteria for the coagulation facility are presented in Table 6.3-6.

Table 6.3-6 Coagulation Facility Performance and Design Criteria

Design Parameter	Value
Type	In-Line Pumped-Diffusion
Peak Flow Capacity	18 -mgd
Number of Injection Pumping Systems (N+1)	2
Minimum Pump Flow Rate	350 gpm
Pump Motor Minimum Power	7.5 hp
Mixing Energy	1,000 sec^{-1}
Discharge Velocity	40 fps
Nozzle Type	95 Full-Cone
Nozzle Diameter	4-inches
Number of Injection Pipelines	2
Mixing Zone (minimum)	1.5 pipe diameters
Minimum Water Temperature	0.5 degrees C
Number of Chemical Injection Ports	10 (2 Planned, 2 Future per system)

6.3.3.2 Initial Screening of Alternatives

The following alternatives were selected for evaluation:

Alternative 1 - Pumped-Diffusion Injection System
Alternative 2 - Rapid Mix Tank
Alternative 3 - Static Mixer

These alternatives are discussed in the following paragraphs.

Alternative 1 - Pumped-Diffusion Injection System

This alternative consists of applying mixing energy to a sidestream of process water with a pump and then re-injecting this sidestream just downstream of the chemical dosing ports. This provides consistent mixing under all flow conditions.

Alternative 2 - Rapid Mix Tank

This alternative applies mixing energy through a paddle mixer at high speed which distributes chemicals injected into the flow stream in a mixing cell.

Alternative 3 - Static Mixer

This alternative uses headloss energy from obstructions in the flow stream to mix chemicals into the process water. Mixing energy is dependent on the process flow rate and therefore less mixing is provided at lower flows. The City's operations staff is familiar with static mixers since these are used at the Canyon Road WTP.

Evaluation and Cost Analysis

An evaluation of the coagulation facility alternatives was conducted. Table 6.3-7 summarizes the results of the evaluation.

Table 6.3.7 Coagulation Facility Alternative Evaluation

Alternative No.		Energy Loss	Mixing Efficiency	Coagulant Use	Life-Cycle Cost	O&M Cost	TOTAL Score
	Possible Score	*10*	*10*	*10*	*20*	*10*	*60*
1	Pumped Diffusion	8	10	9	15	9	51
2	Rapid Mix Tank	6	7	7	12	8	40
3	Static Mix	1	4	5	18	9	37

6.3.3.3 Recommendations

Alternative 1 was selected as the best alternative. Pumped-Diffusion Injection, also termed as counter-current jet mixing, is state-of-the-art in the coagulation process because it provides consistent mixing under all flow conditions, no back mixing and provides efficient mixing of coagulation chemicals minimizing chemical costs.

While the static mixer (alternative 3) itself uses no energy, the energy required to pump or flow through the static mixer is significant. Additionally, mixing energy decreases at lower flow rates through the static mixer resulting in inadequate mixing of the coagulant.

Stirred-tank mixing requires at least as much energy as the pumped injection system and results in efficient disperse of chemicals into the process stream and back mixing requiring more chemical usage.

Operating costs for the two mechanized coagulation alternatives (1 and 2) are very similar, pumped-diffusion injection was selected because of the superior mixing characteristics of this system and corresponding reduction in chemical consumption.

Construction costs for the pumped-diffusion injection system (Alternative 1) are less than the rapid mix tank (Alternative 2) because no additional basins are required, the chemical mixing system occurs in the process pipeline.

Maintenance costs for the pumped-diffusion system are expected to be very low consisting only of routine motor and valve maintenance and annual inspection of the diffuser nozzle.

Additional recommendations for design and operation are discussed in Section 6.4.3.

6.3.4 Granular Activated Carbon Contactors

6.3.4.1 Performance & Design Criteria

The GAC Contactors at the C/CWTP will provide a final polishing step after oxidation with ozone and before conveyance to the finished water storage tanks. GAC Contactors will be horizontal pressure vessels. The design criteria for GAC Contactors are presented in Table 6.3-8.

Table 6.3-8 GAC Contactor Performance and Design Criteria

Design Parameter	Value
Type	Horizontal Pressure Vessels
Number of Contactors	5
Diameter, each contactor	12-ft
Length, each contactor	40-ft
Media Area, each contactor	450 sf
Empty Bed Contact Time (EBCT)	10 minutes
Media Effective Size	1.4-mm
Uniformity Coefficient	≤1.4
Minimum Media Depth	6-ft
Hydraulic Capacity, each contactor	3.5 -mgd
Process Capacity, each contactor	3.1 -mgd
Total Hydraulic Capacity	18.5-mgd
Total Process Capacity	15.3-mgd
Alternative Configuration	Vertical Pressure or Gravity Flow Contactors
Contactor Backwash Pumps	
Backwash Rate	15 gpm/sf
Backwash Duration	10 minutes
Backwash Frequency, each contactor	10 days
Number of Pumps	1
Pump Capacity, minimum	6750 gpm
TDH Required	60-ft

The GAC Contactor preliminary design drawings can be found on Sheets 6M-1 and 6M-2 of the Water Treatment Plant Preliminary Design Drawings.

6.3.4.2 Initial Screening of Alternatives

Four GAC Contactor alternatives were initially evaluated:

- Alternative 1 - Six gravity contactor beds
- Alternative 2 - Four gravity contactor beds
- Alternative 3 - Horizontal pressure contactors
- Alternative 4 - Vertical pressure contactors

Each alternative is discussed below.

Alternative 1 - Six Gravity Contactor Beds

Alternative 1 is comprised of six gravity contactors, designed as filter beds, in a 3 by 2 arrangement. The contactors would be constructed of reinforced concrete and a finished water pipe gallery would be constructed for conveyance of the contacted water to the finished water storage tanks. Each contactor bed would be approximately 450 sf, allowing for less backwash volume per contactor and a lower pumping rate than other alternatives. However, there would be more concrete required to construct the extra contactors and more valves and appurtenances.

Figure 6.3-7 Typical Conventional or GAC Gravity Contactors

Gravity GAC contactors look like conventional filter beds, as shown in Figure 6.3-7 but are operated to provide contact time with the GAC media, not as particle filters.

Alternative 2 - Four Gravity Contactor Beds

Alternative 2 consists of four gravity contactors, designed as conventional media filter beds, in a 2 by 2 arrangement. The contactors would be constructed of reinforced concrete and a finished water pipe gallery would be required to convey the contacted water to the finished water storage tanks. Each contactor bed would be approximately 550 sf, larger than those in Alternative 1 and would require more backwash volume per contactor and a higher pumping rate. Less concrete and fewer valves and appurtenances are required for this alternative than in Alternative 1.

Alternative 3 - Horizontal Pressure Contactors

Alternative 3 includes carbon-steel pressure contactors in a horizontal configuration. Each contactor would be approximately 40-feet long and 12-feet in diameter. The contactors would be housed inside, adjacent to the ozone generation facility. The pressure vessels would be supplied by a vendor as a complete package that includes the contactors, overdrain, underdrain, and a specified set of valves and control equipment such that the system is essentially turn-key. The pressurized contactor system would operate in tandem with the ozone pipeline contactor to maintain a pressurized system from the membrane equipment into the finished water storage tanks allowing the tanks to be situated above grade eliminating the need for expensive excavation. Six contactors were initially proposed, however five contactors were later determined to be adequate to meet the objectives of this system.

Alternative 4 - Vertical Pressure Contactors

Alternative 4 consists of carbon-steel pressure contactors in a vertical configuration. Each contactor would be approximately 20-feet tall and 12-feet in diameter. The contactors would be housed inside and adjacent to the ozone generation facility. The pressure vessels would be supplied by a vendor in one complete package that includes the contactors, overdrain, underdrain, and a specified set of valves and control equipment such that the system is essentially turn-key. The pressurized contactor system would operate in

Figure 6.3-8 Vertical GAC Contactors

tandem with the ozone pipeline contactor to maintain a pressurized system from the membrane equipment into the finished water storage tanks. A photograph of vertical GAC contactors is shown in Figure 6.3-8.

6.3.4.3 Alternatives for Evaluation

Gravity contactor systems were selected early in the preliminary design process and the conventional "filter" design was prepared. Minimal consideration of a pressurized system was given. Following the technical review and value engineering sessions, the concept of a fully pressurized system from membrane to finished water storage was developed for the investigation.

Alternatives 1 and 2 were eliminated after it was determined that significant cost savings in both construction and operations could be realized utilizing a pressure system.

Alternative 4 was eliminated because the extra contactors also required additional valves, instrumentation, and controls. Alternative 3 - Horizontal Pressure Contactors was selected because it achieved the objective of a pressurized GAC contactor system and minimized the number of vessels required to achieve the design objectives of 15.3-mgd at a 10 minute EBCT.

Evaluation and Cost Analysis

Cost comparison of the gravity GAC contactor system and the pressure GAC contactor system showed only marginal cost benefit for the pressurized system. The pressurized system maintains a pressure head throughout the system and this offers operational advantages and allows for an above ground storage tank. An evaluation worksheet is presented in Table 6.3-9 for the GAC Contactor alternatives.

Table 6.3-9 GAC Contactor Alternative Evaluation

Alternative No.		Reduction of DBPs and T/O	Observation of Bed Possible	Maintains Pressure Head	Life-Cycle Cost	O&M Cost	TOTAL Score
	Possible Score	*10*	*10*	*10*	*20*	*10*	*60*
1	6 Gravity Contactors	10	10	0	15	7	42
2	4 Gravity Contactors	10	10	0	14	5	39
3	Horizontal Pressure Contactors	10	0	10	16	7	43
4	Vertical Pressure Contactors	10	0	10	11	8	39

6.3.4.4 Recommendations

The pressure contactor system is recommended for the GAC contactor facility at the C/CWTP. This system will achieve the treatment and operations objectives at a low cost and provide a robust and simplified system to operate. Additional details and recommendations are presented in 6.4.8.

Horizontal pressure contactors are the recommended GAC contactor configuration, however, vertical pressure contactors will also be acceptable as well as gravity contactors, provided that these alternatives meet other objectives including no additional intermediate pumping.

6.3.5 Solids Handling

The design and performance criteria, short-list of alternatives, the evaluation of alternatives and recommendations for the solids handling system at the C/CWTP are presented in this section.

6.3.5.1 Performance and Design Criteria

In order to estimate the amount of solids entering the plant, the removal of solids within the presedimentation basins must be estimated. This estimation is often difficult for several reasons:

- Settling characteristics of the suspended solids is unique to every water source and is dependent upon the sediment size analysis
- Agitation of the water from wind blowing across the surface affects the settling of solids
- Currents created by the settling of solids sometimes carry along the basin floor and resuspends settled solids
- Solids loading and characteristics may vary seasonally

To determine the percent removal of solids in the presedimentation basins, the OC reviewed several references. One reference stated that it has been documented in the Mississippi and some of its tributaries and in some rivers in the Southwest that turbidities frequently, but temporarily, reach 10,000 mg/L and sometimes 40,000 mg/L. This data is consistent with the USGS Otowi gage data for the Rio Grande which indicates the 95th percentile solids concentration of 10,500 mg/L and a maximum concentration of 45,300 mg/L (See Section 4.1). The reference further stated that presedimentation basins under these conditions with detention times of 3 to 8 hours will reduce the TSS to not more than 1,000 mg/L.

The assumption that the TSS will be reduced to 1,000 mg/L for the 95th percentile solids data (10,500 mg/L) was used as the basis for estimating the removal efficiency of the presedimentation basins. Initially, solids will be removed at the SRF to be constructed near the river intake. The facility will be designed to remove 98 percent of sand with a diameter of 0.075-mm and larger, approximately 25 percent of the TSS. The 95th percentile peak TSS leaving the SRF will be approximately 7,900 mg/L.

Raw water will be conveyed from the SRF to presedimentation basins located at the C/CWTP site. Assuming 1,000 mg/L TSS leaving the presedimentation basins, the solids removal efficiency in the presedimentation basins is calculated as follows:

$$\begin{aligned} \text{\% solids removal} &= (\text{solids removed} / \text{solids in}) * 100 \\ &= (6{,}900 \text{ mg/L} / 7{,}900 \text{ mg/L}) * 100 \\ &= 87 \text{ percent} \end{aligned}$$

A survey was conducted of ten WTPs that utilize presedimentation basins. The results of the survey are as follows:

- The volume of presedimentation basins varies significantly among WTPs
- TSS values into and out of presedimentation basins are not often determined
- NTU values are commonly reported
- NTU reduction greater than 95 percent were frequently reported

Given the results of the survey, the estimated 87 percent removal of TSS in the presedimentation basins appears reasonable.

Although the 95th percentile data was used to estimate the percent solids removal in the presedimentation basins, the 90th percentile TSS condition (4,795 mg/L) will be used as the basis of design for the peak solids handling condition. Assuming 4,795 mg/L TSS will enter the SRF and 25 percent TSS removed, the solids concentration entering the presedimentation basins will be 3,600 mg/L. With 87 percent solids removed, the TSS concentration leaving the presedimentation basins will be approximately 500 mg/L. The presedimentation basin design will include the ability to add a coagulant to the head of the basins to aid in the settling of solids.

A sanitary sewer system does not exist for disposing of solids. Instead, de-watered solids will ultimately be disposed in a landfill or by other means. The minimum solids concentration for acceptance of dewatered solids from a landfill is based on the Paint Filter Test or typically 18 to 20 percent solids.

For calculating average solids production, the average TSS condition (1,985 mg/L) will be used as the basis of design. The SRF is expected to remove 25 percent of the TSS, leaving 1,500 mg/L TSS to be conveyed to the presedimentation basins. Assuming 87 percent removal of the TSS in the presedimentation basins, 200 mg/L is expected to enter the C/C WTP.

6.3.5.2 Initial Screening of Alternatives

Through the assessment of numerous storage and processing options, five solids handling alternatives were short-listed for further consideration. These alternatives were considered to be the most cost effective and proven methods of processing residuals given the project specific conditions. All five alternatives include the use of a gravity thickener in front of the dewatering process. The short-listed storage and processing options are as follows:

Alternative 1 – Lagoons
Alternative 2 – Drying Beds
Alternative 3 – Plate and Frame
Alternative 4 – Belt Filter Press
Alternative 5 – Centrifuges

Process flow schematics for each solids handling alternative is shown in Figures 6.3-9 to 6.3-13.

6.3.5.3 Evaluation and Cost Analysis

The alternative system packages were evaluated with respect to planning level construction and O&M costs and six non-monetary criteria. A general discussion of the advantages and disadvantages of each solids handling process is provided below.

Gravity Thickeners Common to All Alternatives

General Description

Gravity thickening is the most common method employed to thicken water treatment sludge prior to dewatering. Gravity thickeners are typically conical-based, concrete basins that rely on gravitational forces to settle the residual solids. A rake arm in the base of the tank draws the settled solids to a discharge point in the bottom of the thickener. Gravity thickeners provide some solids storage in addition to thickening. It is preferred over mechanical thickening for the following reasons:

- Typically operated with little operator attention
- Polymers are not needed for most operating conditions

- Thickener tanks can be used as storage/equalization prior to downstream dewatering processes
- Plant staff can control the feed rate from gravity thickeners, providing operational flexibility

Processing Capabilities of Gravity Thickeners

Metal hydroxide residuals from water treatment plants typically concentrate to approximately 1 to 3 percent, assuming a typical loading of 4.0 lb/day/sf. The addition of polymers enhance thickening and/or allow increased loading rates. The amount of thickening is generally dependent on the hydroxide to TSS ratio with lower ratios thickening better.

Equalization tanks are sometimes provided ahead of gravity thickeners to minimize surges of flow into the units. Another option to minimize surges is to oversize them by decreasing the surface overflow rate. Because of the potential high volume of solids that may be processed at the C/CWTP, the thickeners will be designed to handle an unusually high peak solids loading. During a peak event, a consistent flow of solids will be conveyed to the thickeners, preventing surging. During average conditions, the thickeners will operate at a low surface overflow rate, minimizing surging.

Gravity thickeners alone are not adequate to treat the residuals to meet landfill requirements. Thus, it must be combined with another process option for further dewatering.

Operation and Maintenance Requirements

Gravity thickeners can generally operate unattended. There is little mechanical equipment which limits the amount of maintenance required.

Design Criteria

The design criteria for the gravity thickener are shown in Table 6.3-10.

Table 6.3-10 Gravity Thickener Design Criteria

Design Criteria	Value
Flow and solids into thickener	1.9-mgd @ 0.5 percent solids
Solids into thickener	79,200 ppd
Number of thickeners	Two
Thickener diameter	80-ft
Surface overflow rate (SOR) for two thickeners in operation	190 gal/day/sf
Solids loading rate for two thickeners in operation	7.9 ppd/sf
SOR for one thickener in operation	380 gal/day/sf
Solids loading rate for one thickener in operation	15.8 lb/day/ sf
Flow and solids out of thickener	0.5-mgd @ 2 percent solids
Solids capture rate	95 percent

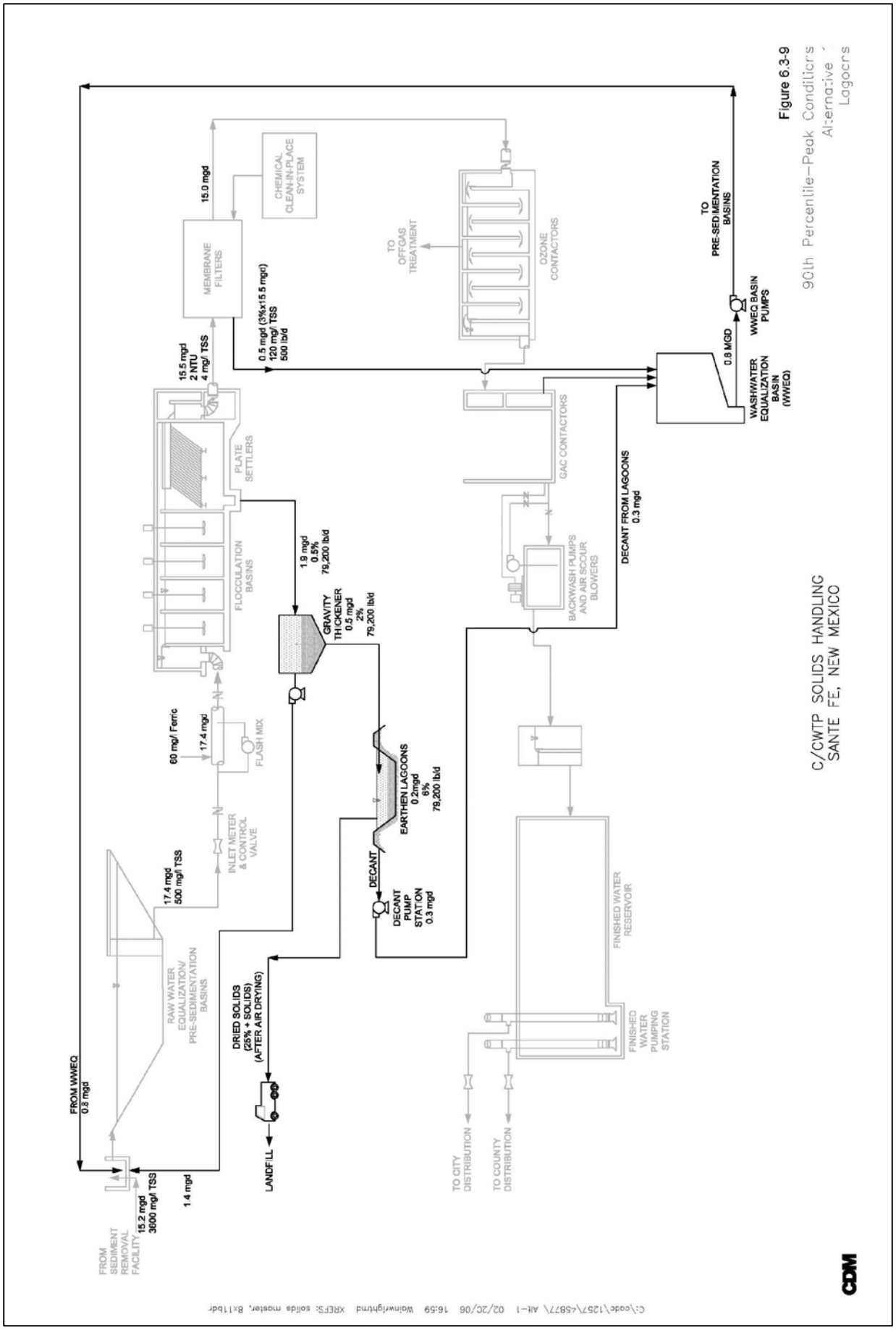


Figure 6.3-9
90th Percentile–Peak Conditions
Alternative 1
Lagoons

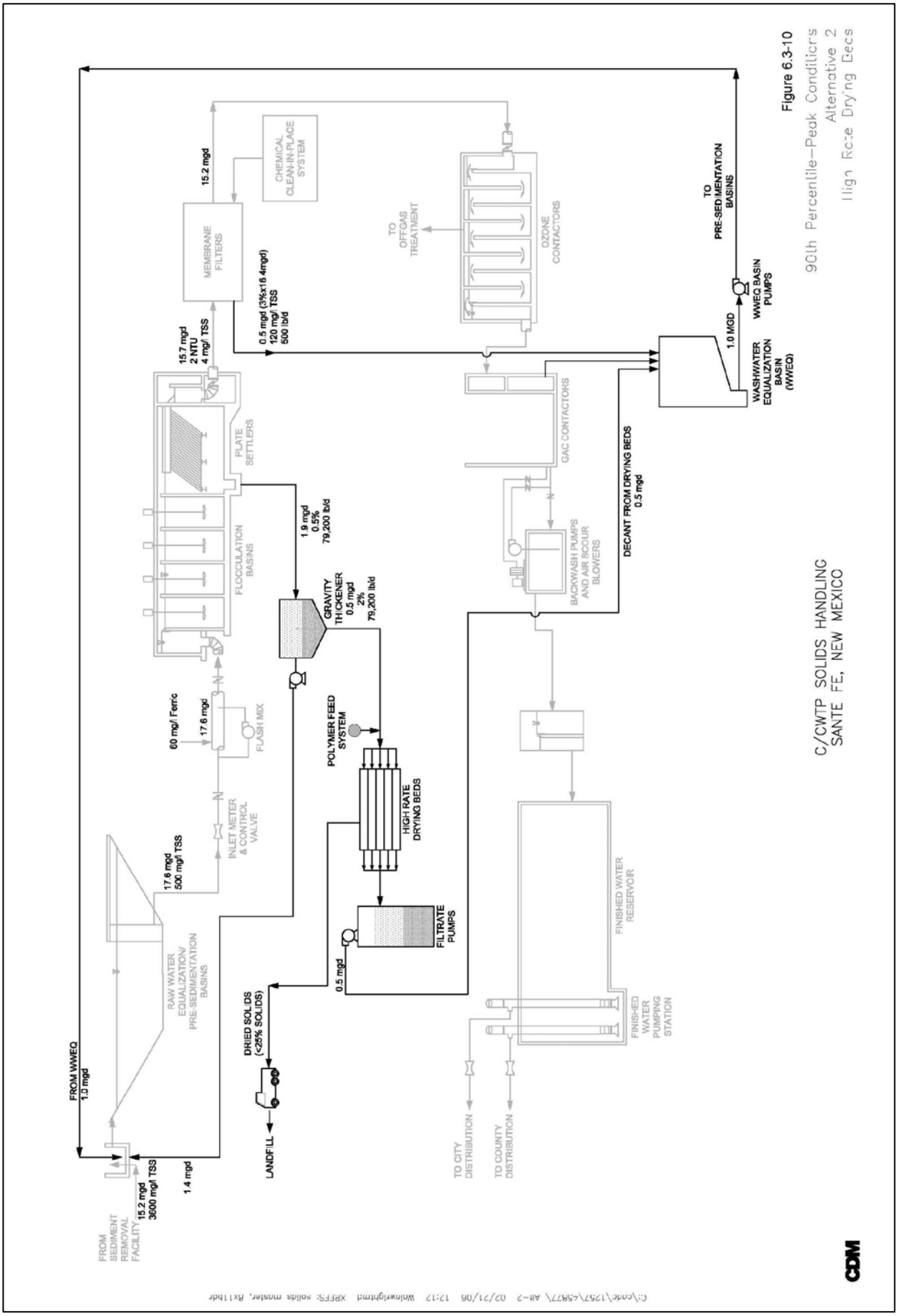


Figure 6.3-10
90th Percentile–Peak Conditions
Alternative 2
High Rate Drying Beds

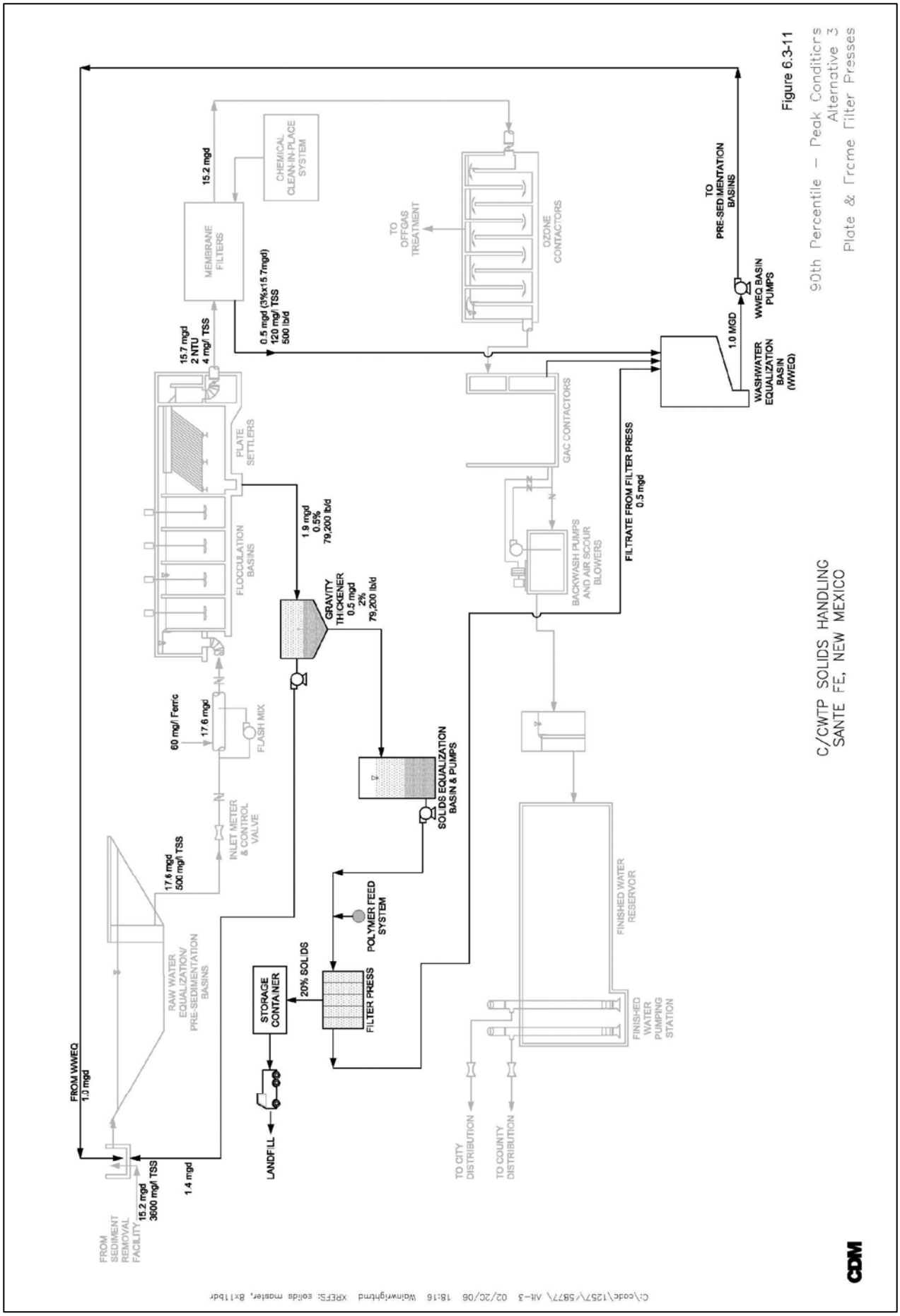


Figure 6.3-11
90th Percentile – Peak Conditions
Alternative 3
Plate & Frame Filter Presses
C/CWTP SOLIDS HANDLING
SANTE FE, NEW MEXICO
FROM WWEQ
1.0 mgd
FROM SEDIMENT REMOVAL FACILITY
15.2 mgd
3600 mg/l TSS
1.4 mgd
RAW WATER EQUALIZATION/ PRE-SEDIMENTATION BASINS
17.6 mgd
500 mg/l TSS
INLET METER & CONTROL VALVE
60 mg/l Ferric
17.6 mgd
FLASH MIX
FLOCCULATION BASINS
PLATE SETTLERS
15.7 mgd
2 NTU
4 mg/l TSS
MEMBRANE FILTERS
15.2 mgd
CHEMICAL CLEAN-IN-PLACE SYSTEM
0.5 mgd (3%x15.7mgd)
120 mg/l TSS
500 lb/d
1.9 mgd
0.5%
79,200 lb/d
GRAVITY THICKENER
0.5 mgd
2%
79,200 lb/d
SOLIDS EQUALIZATION BASIN & PUMPS
POLYMER FEED SYSTEM
FILTER PRESS
20% SOLIDS
STORAGE CONTAINER
LANDFILL
TO OFFGAS TREATMENT
OZONE CONTACTORS
GAC CONTACTORS
BACKWASH PUMPS AND AIR SCOUR BLOWERS
FILTRATE FROM FILTER PRESS
0.5 mgd
TO PRE-SEDIMENTATION BASINS
WWEQ BASIN PUMPS
1.0 MGD
WASHWATER EQUALIZATION BASIN (WWEQ)
FINISHED WATER RESERVOIR
FINISHED WATER PUMPING STATION
TO CITY DISTRIBUTION
TO COUNTY DISTRIBUTION
CDM

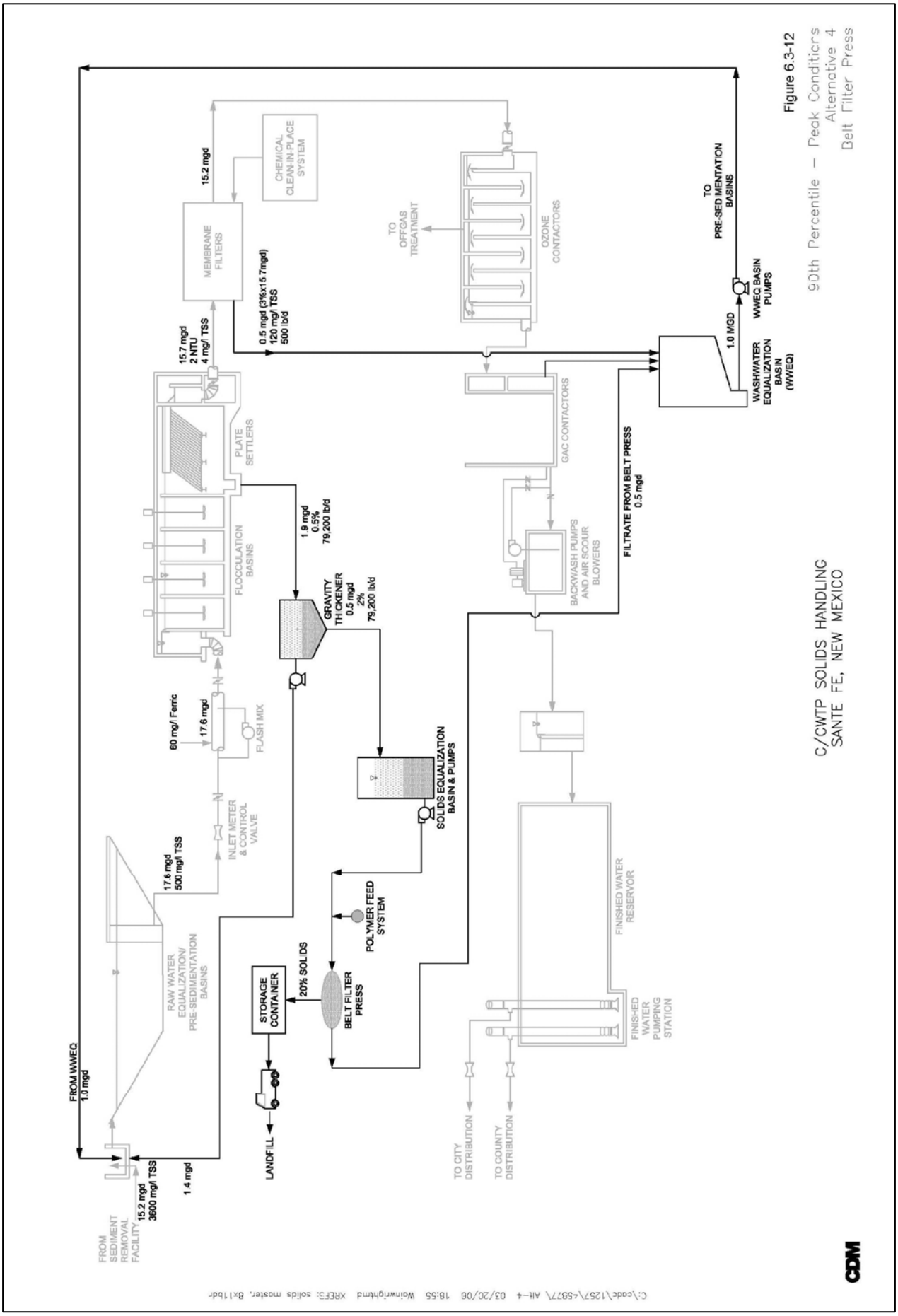

C/CWTP SOLIDS HANDLING
SANTE FE, NEW MEXICO
90th Percentile – Peak Conditions
Alternative 4
Belt Filter Press
FROM WWEQ
1.0 mgd
FROM SEDIMENT REMOVAL FACILITY
15.2 mgd
3600 mg/l TSS
1.4 mgd
RAW WATER EQUALIZATION/ PRE-SEDIMENTATION BASINS
17.6 mgd
500 mg/l TSS
INLET METER & CONTROL VALVE
60 mg/l Ferric
17.6 mgd
FLASH MIX
FLOCCULATION BASINS
PLATE SETTLERS
15.7 mgd
2 NTU
4 mg/l TSS
MEMBRANE FILTERS
15.2 mgd
CHEMICAL CLEAN-IN-PLACE SYSTEM
0.5 mgd (3%x15.7mgd)
120 mg/l TSS
500 lb/d
TO OFFGAS TREATMENT
OZONE CONTACTORS
GAC CONTACTORS
TO PRE-SEDIMENTATION BASINS
WWEQ BASIN PUMPS
1.0 MGD
WASHWATER EQUALIZATION BASIN (WWEQ)
FILTRATE FROM BELT PRESS
0.5 mgd
BACKWASH PUMPS AND AIR SCOUR BLOWERS
1.9 mgd
0.5%
79,200 lb/d
GRAVITY THICKENER
0.5 mgd
2%
79,200 lb/d
SOLIDS EQUALIZATION BASIN & PUMPS
POLYMER FEED SYSTEM
BELT FILTER PRESS
20% SOLIDS
STORAGE CONTAINER
LANDFILL
FINISHED WATER RESERVOIR
FINISHED WATER PUMPING STATION
TO CITY DISTRIBUTION
TO COUNTY DISTRIBUTION
CDM

Figure 6.3-12

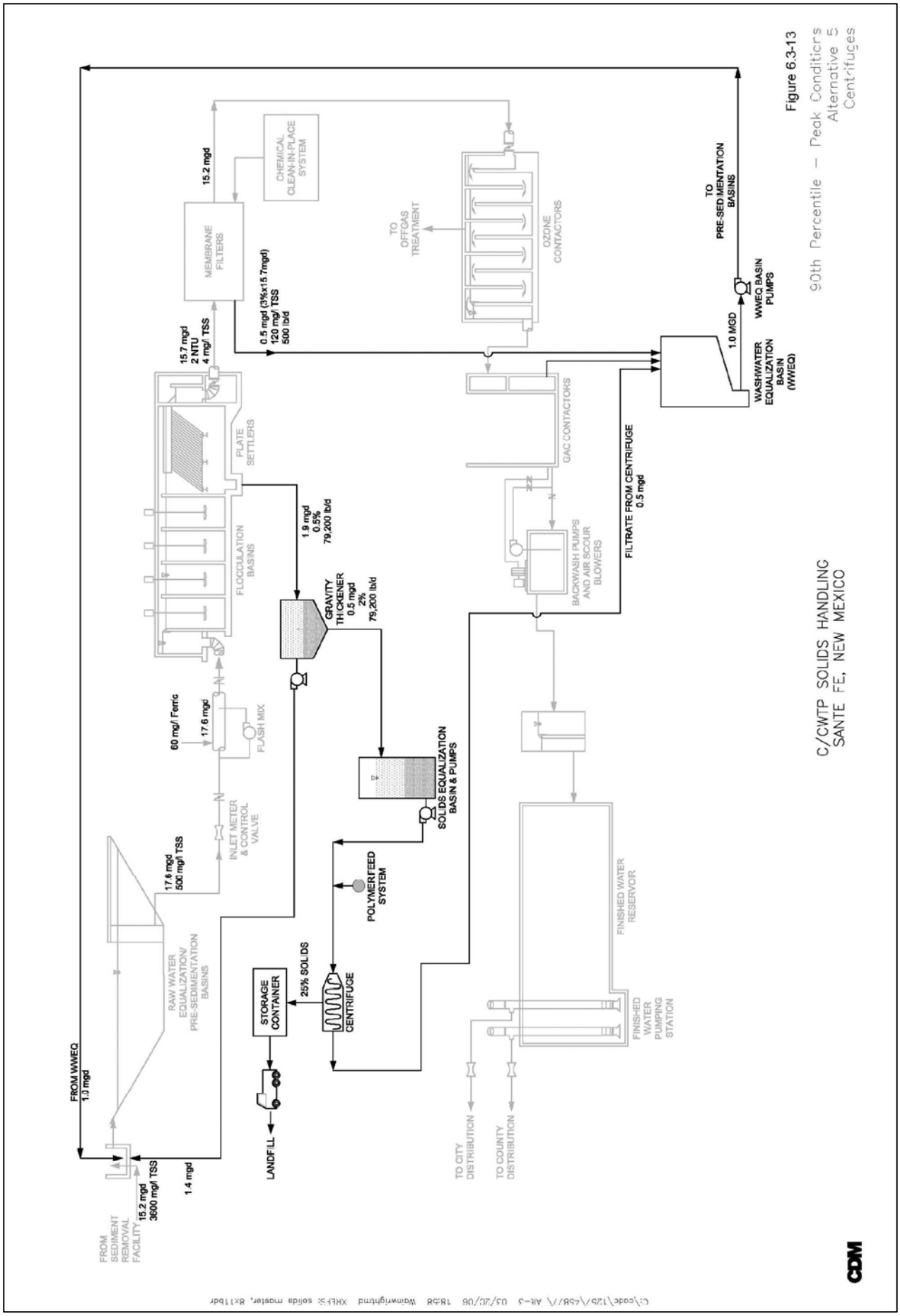


Figure 6.3-13
90th Percentile – Peak Conditions
Alternative 5
Centrifuges

Alternative 1 - Lagoons

General Description

Lagoons are man-made basins for storage, thickening, dewatering and sometimes drying of residuals. Lagoons are usually made of earthen materials with a low permeability. Storage and attenuation of the residual flows is provided by the large volume in the lagoons. Thickening occurs via sedimentation as the lagoons have a long detention time. Storage for the thickened sludge is provided in the bottom portion of the lagoon. Lagoons are operated on a relatively long term batch basis where the lagoon is either in a filling mode, dewatering mode, or drying mode of operation. Dewatering is accomplished by stopping inflows and decanting excess water and allowing evaporation to take place. Drying of water treatment residuals occurs after excess water is decanted from the lagoons. Residuals are allowed to air dry in the lagoon for an extended period of time that can vary significantly based upon solids characteristics and climate conditions.

After the desired thickness is achieved, mechanical equipment must be used to remove the solids. Removal and disposal of the solids may be performed by an outside contractor because of the labor and equipment involved and because it is performed on an intermittent basis.

Processing Capabilities of Lagoons

Dewatering of solids in lagoons is a very common method of residuals processing and is considered a reliable storage and processing option. Lagoons can be used for a variety of raw solids residual sidestreams and, depending upon land available, can be sized to operate without an upstream thickening step. Lagoons provide good storage and peak flow attenuation of the sidestreams.

The solids thickening capability of a lagoon depends on the method of operation and the length of time the residuals are in the lagoon. Dewatering and drying are also affected by climatic conditions. Hot dry weather will improve performance while cold climates or locations with high precipitation can be detrimental to performance by slowing the drying process. Freezing and thaw cycles can be beneficial for drying/dewatering but these climatic conditions can constrain lagoon operations during the filling and decanting stages of operation.

Metal hydroxide sludge under the water column will typically thicken to 6 to 10 percent solids. For the Santa Fe area, the drying period is estimated to take from four to six months. Typically, when left to air dry, a crust will develop on the top of the sludge layer after the supernatant has evaporated. This crust can become quite dry (solids > 50 percent), but the sludge beneath this crust layer will often remain at 10 percent or less solids unless tilling/mixing is provided to allow air drying of the lower layers.

To reach the more than 20 to 25 percent solids content required for landfill disposal, mixing and tilling of the dewatered solids would be required. While site specific data is not available, it is estimated that the drying period would require four to six months, with six months recommended for design in absence of pilot or other data.

Land Requirements

Lagoons require a relatively large amount of land and the area required is primarily influenced by the desired final solids concentration and climatic conditions. Even with the favorable climatic conditions in the Santa Fe area, the land requirement for the design conditions is considered unfavorable relative to the amount of land available.

Operation and Maintenance Requirements

On a daily basis, lagoons require very little operator attention because of their process simplicity and their minimal use of mechanical equipment. The periodic maintenance and repair of the lagoon sidewalls and berms is a consideration unless concrete lagoons are used. However, the sludge drying and removal steps are more difficult and labor intensive than other alternatives. Lagoons require additional considerations related to site safety and security measures to minimize the risks associated with having a large open water body on the plant site. Overall, lagoons are considered favorable from an O&M perspective if solids removal is performed by an outside contractor.

Environmental/Aesthetic Concerns

Lagoons can have aesthetic concerns primarily in relation to visual and odor impacts, especially where located near residential areas. Environmental impacts can be minimized by installing a liner. Overall, lagoons are rated as neutral to slightly unfavorable for environmental and aesthetic concerns.

Assessment of Alternative

The discussion presented above is summarized into the assessment summary table shown as Table 6.3-11. The summary presents the advantages and disadvantages of the drying lagoon alternative.

Table 6.3-11 Assessment Summary for Drying Lagoons

Advantages	Disadvantages
Able to easily handle variations in solids/sludge production	High land requirement – approximately 26-acres for design condition
Long term storage requires fewer cleanings per year (relative to drying beds)	Sludge removal is labor intensive
Less complex than mechanical dewatering systems – highly skilled operators not required	Aesthetic concerns associated with visual and odor issues
Low day-to-day maintenance costs	Tilling of drained sludge required to obtain 20 to 25 percent plus solids desired
	Performance is generally more variable than other dewatering methods

Design Criteria

Table 6.3-12 presents the design criteria for the drying lagoons.

Table 6.3-12 Drying Lagoons Design Criteria

Design Criteria	Value
Sludge applied	0.8-mgd @ 2 percent solids
Solids applied	138,000 ppd
Drying and cleaning cycle	4-6 months
Sludge storage volume	35 acre-feet @ 6 percent solids
Sludge storage depth	4-ft
Lagoon depth	10-ft (incl 2-ft freeboard)
Lagoon area (including berms)	6.3 acres per lagoon
Number of lagoons required	6
Total lagoon area required	38 acres

Capital Cost

Initial capital costs for lagoons include land, earthwork, piping, decanting and drainage facilities, and in many cases a basin liner. With increased regulatory requirements and heightened concerns over groundwater contamination, it is becoming more common to construct lagoons with an impermeable liner. The use of a liner can significantly increase the cost of the lagoon. Unlined lagoons can be cost effective where land is readily available. For this project, it is assumed that a liner would be utilized. As a result, lagoons are considered neutral from a capital cost perspective.

The estimated capital cost for the lagoon system described above is $2.25 million for an unlined lagoon and $3 million for a lined lagoon.

Alternative 2 - Sand Drying Beds

General Description

Sand drying beds are similar to lagoons except that they have the added feature of a sand drainage layer at the bottom and the liquid depth is considerably less (the liquid depth is usually maintained at 24- to 36-inches as opposed to 6 to 10-ft in a lagoon). The operation of a sand drying bed is similar to a filter. Residuals are applied on the top of the sand bed and water moves through the sand layer and is removed by a gravel underdrain system. Decanting can be used to remove excess water on the top of the sand drying beds. Evaporation will provide further dewatering of the residuals when discharge to the bed is halted.

Proprietary, high rate drying bed systems such as the Deskins System are available and claim more reliable and better performance than a traditional drying bed system. For purposes of this evaluation, it was assumed that a high rate system such as a Deskins System would be used. Figure 6.3-14 is a photograph of a Deskin System in operation in Clovis, California.

Figure 6.3-14 Deskins System in Operation

Processing Capabilities of Sand Drying Beds

Like lagoons, sand drying beds can accept a wide range of residual sidestream flows. Assuming sufficient bed area and number of beds are provided, they can provide good storage and peak flow attenuation. While they have been used most extensively for sewage sludge, sand drying beds have a reasonably long process history and are considered a reliable dewatering and drying method.

Sand drying beds can achieve percent solids in the same range as lagoons by with less mechanical effort (tilling and mixing often is not required). Sand beds will typically achieve thickening faster than a lagoon because of the underdrain system employed. However, depending upon the design, the sand layer can become plugged with fines from the sludge, causing the bed to act like a shallow lagoon.

Sand drying beds processing ferric sludges in a Santa Fe area climate could be loaded at 3 to 4 psf of bed area. A 5 to 7-day cycle would be required for application, drying, and solids removal. For the Santa Fe climatic conditions, it is expected that sand drying beds can reach more than the 20 to 25 percent solids content required for landfill disposal.

Land Requirements

Sand beds require a relatively large amount of land and the area required is primarily influenced by the solids loading rate. A 3 psf loading rate would be recommended until pilot testing or other data confirms a higher rate. However, even at a loading rate of 4 psf and the favorable climatic conditions in the Santa Fe area, the land required for sand drying beds is considered unfavorable relative to the amount of land available.

Operation and Maintenance Requirements

Operation and maintenance requirements of sand drying beds are greater than lagoons. The cycle times are more frequent and thus bed preparation and cleaning operations need to be carried out daily rather than every 4 to 6 months. A small portion of the sand layer will get mixed with and removed with the dried sludge and will require periodic replacement. The sand can also cause additional wear and tear on sludge removal equipment. Overall, this option is rated neutral to slightly unfavorable in terms of O&M.

Environmental/Aesthetic Concerns

Sand drying beds have similar aesthetic concerns as lagoons, which are primarily visual and odor concerns. Overall, drying beds are rated as slightly unfavorable for environmental and aesthetic concerns.

Assessment of Alternative

The discussion presented above is summarized into the assessment summary table shown as Table 6.3-13. The summary presents the advantages and disadvantages of the sand drying bed alternative.

Table 6.3-13 Assessment Summary for Sand Drying Beds

Advantages	Disadvantages
High solids concentration: 20 to 25 percent or more	High land requirement – approximately 9-acres for design condition
High percentage of filtrate recovered	Labor intensive relative to mechanical systems and lagoons – requires daily solids removal & handling
Low maintenance costs	Sand drainage layer can become plugged and requires periodic replacement of sand lost during sludge removal
Less complex than mechanical dewatering systems – highly skilled operators not required	Performance impacted by weather / climate
	Minimal competition among suppliers of proprietary high rate systems

Design Criteria

Table 6.3-14 presents the design criteria for the sand drying beds.

Table 6.3-14 Sand Drying Bed Design Criteria

Design Criteria	Value
Sludge applied	0.5-mgd @ 2 percent solids
Solids applied	79,200 ppd
Drying Bed loading rate	3 lbs solids / sf
Bed area required per day	26,400 sf
Drying/sludge removal cycle time	7 days
Total bed area required	211,000 sf (~5 acres)
Solids conc. in dried cake	20 to 50 percent

Capital Cost

Initial capital costs for sand drying beds are similar to but slightly less than lagoons. Primary cost items include land, earthwork, concrete work, underdrain piping, and decanting facilities. Overall, capital costs are rated as favorable.

The estimated capital cost for a proprietary high rate sand drying system such as a Deskins System is $2.5 million.

Alternate 3 - Plate and Frame Filter Press

General Description

The last three dewatering alternatives (Alternative 3, 4 and 5) involve the use of mechanical equipment. The success of mechanical dewatering is dependent upon the turbidity of the water, the size of the solids particle removed in the treatment process, the amount of coagulant used to aid in the settling and the amount of polymer used upstream of the dewatering equipment.

The variability of these factors makes the performance of dewatering equipment unique for every plant and difficult to predict. For example, sludges from high turbidity water are easier to dewater than those from a low turbidity water. The incoming turbidity to the C/CWTP will vary greatly throughout the year depending on the river conditions, making predictions of performance of dewatering equipment difficult. Equipment manufactures were contacted in order to estimate performance. The estimated dewatered solids concentration percentages provided below is based on typical values seen at similar plants.

A plate and frame filter press consists of a series of porous plates with a recessed chamber and filter fabrics which are placed against each plate. Residuals are pumped into the cavity between plates. Solids are retained on the filter fabric while the filtrate water that passes through the fabric is removed from the press. In some models, the incoming feed pressure is gradually increased to 100 to 225 psi, and then the press is opened and the solids cake removed. In the other models, there is a diaphragm between the filter fabric and the plate. After the initial low-pressure pumping of the residual into the press, the diaphragm is inflated which increases the pressure up to approximately 250 psi. The press is then opened and the cake is removed.

Plate and frame filter presses typically require more building space than most other mechanical dewatering equipment. The equipment is also much heavier, adding additional costs for the structure.

Processing Capabilities of Plate and Frame Presses

Filter presses generally produce higher cake solids concentrations than either belt presses or centrifuges. However, equipment manufactures expect a final solids concentration of just 25 percent for the ferric hydroxide sludge to be generated at the C/CWTP, which is not significantly better performance than the other mechanical dewatering devices.

Operation and Maintenance Requirements

Plate and frame filter presses operate in a batch mode and intermittent operator supervision is often needed during the feed, discharge and wash intervals. Compared to other mechanical dewatering equipment, these units are larger and have more components that require additional maintenance. Constant operator attention is needed since the dried cake does not always release from the plates.

Assessment of Alternative

The discussion presented above is summarized into the assessment summary table shown as Table 6.3-15.

Table 6.3-15 Assessment Summary for Plate and Frame Press

Advantages	Disadvantages
Solids capture is highest among mechanical dewatering	Larger number of units (6) require more operator attention; greater attention
Good mechanical reliability	More building space required
	Equipment is heavy requiring additional capital costs for structure
	Equipment costs approximately 4 times greater than other alternatives

Design Criteria

Table 6.3-16 presents general design criteria assumed in the analysis.

Table 6.3-16 Plate and Frame Press Design Criteria

Design Criteria	Value
Sludge applied	0.5-mgd @ 2 percent solids
Solids applied	79,200 ppd
Dewatered solids concentration	20 percent solids
No. of dewatering cycles/day	4 cycles
Volume of solids per cycle	500 cf/cycle
No. of units required	4 (includes 1 spare)

Capital Costs

The capital costs for the equipment is generally higher than other mechanical dewatering equipment. These additional costs are sometimes offset by the production of a higher solids concentrated sludge, decreasing solids handling and hauling costs. But as mentioned above, significantly higher solids concentration is not expected for the C/CWTP ferric hydroxide sludge to offset the high equipment costs.

The estimated capital cost for dewatering via plate and frame presses including the building and sludge load-out facility is $11.4 million.

Alternative 4 - Belt Filter Press

General Description

Belt filter press dewatering employs filter fabrics (belts) and a series of rollers to apply increasing pressure to the residual slurry. The residuals are first conditioned with a polymer which is essential for effective dewatering. A typical belt-filter press has three dewatering stages. The first stage allows for gravity drainage through the lower belt. In the second stage, a second belt sandwiches the residuals to form a cake between the two belts. In the third stage, a series of rollers subject the residuals to increasing pressure. Finally, the dewatered residuals are scraped off the belt for transportation and final disposal.

Processing Capabilities of Belt Filter Presses

Equipment manufactures have estimated that the ferric hydroxide sludge produced at the C/CWTP will dewater to approximately 20 percent solids. Belt filter presses are more sensitive to changes in the concentration or composition of the sludge and typically require higher polymer doses than used for centrifuges.

Operation and Maintenance Requirements

Operator attention would likely be required at all times during the hours of operation, because filter presses are sensitive to input changes and polymer dosages. They also have more daily maintenance than most other mechanical dewatering options. An advantage over centrifuges is operator can witness the dewatering when the equipment is in operation. However, careful operational safety procedures are needed because of the open machinery.

Assessment of Alternative

Table 6.3-17 presents an assessment summary for sand plate and frame filter presses.

Table 6.3-17 Assessment Summary for Belt Filter Press

Advantages	Disadvantages
Less power needed	Adjustments for varying solids concentration is not automated
Less polymer needed	Equipment wash down is not automated
Operator can witness dewatering when equipment is in operation	Constant water feed is needed to clean belt
	More clean-up is required since dewatering operation is exposed

Design Criteria

Table 6.3-18 presents general design criteria assumed in the analysis.

Table 6.3-18 Belt Filter Press Design Criteria

Design Criteria	Value
Sludge applied	0.5-mgd @ 2 percent solids
Solids applied	79,200 ppd
Dewatered solids concentration	20 percent solids
Solids loading	600-750 lbs/hr/meter
Belt width	2.8 meters
No. of units required	3 (two duty, one standby)

Capital Cost

The capital cost of belt filter presses is less than that of centrifuges but operating costs are higher. The estimated capital cost for dewatering with belt presses including the building and sludge load-out facility is approximately $3.7 million.

Alternative 5 - Centrifuge

General Description

Centrifuge dewatering employs centrifugal forces developed by high-speed rotation to facilitate liquid-solid separation. The most effective type of centrifuge for dewatering water treatment residuals is the solid-bowl centrifuge. After the residual enters the centrifuge, it is forced against the interior walls of the bowl and separates into a solid layer and liquid centrate. A helical screw conveyor inside the bowl moves the solids to a tapered end on the bowl where solids come up out of the liquid layer where they are dewatered and then discharged. As the centrate liquid is separated from the solid residuals, it accumulates in the middle of the centrifuge bowl and eventually flows over a weir at the opposite end of the centrifuge. Most centrifuge operations use polymers to improve the separation process and increase the capacity of the centrifuge.

Processing Capabilities of Centrifuges

Equipment manufactures have estimated that the ferric hydroxide sludge produced at the C/CWTP will dewater to approximately 20 to 25 percent solids. The addition of polymer is usually necessary to improve centrate clarity, increasing capacity, improving conveying characteristics of the solids and increasing cake dryness.

Operation and Maintenance Requirements

As is the case with all mechanical dewatering equipment, moderate amounts of operator attention during operation are required. An advantage of centrifuges is that they automatically adjust for changes in solids concentration. They also are self-cleaning and have less spillage as compared to a belt press. A disadvantage to some operators is the inability to witness the liquid-solid separation taking place.

Assessment of Alternative

Table 6.3-19 presents an assessment summary for sand plate and frame filter presses.

Table 6.3-19 Assessment Summary for Centrifuges

Advantages	Disadvantages
Highest mechanical dewatering efficiency	Higher power consumption (250 hp motors)
Automatically adjust for varying solids concentration	Operators are not able to witness the dewatering taking place
Continuous wash water not needed	Higher capital costs
Less clean-up needed since dewatering is not exposed	
Lowest operator attention including automated shutdown/cleaning	

Design Criteria

Table 6.3-20 presents general design criteria assumed in the analysis.

Table 6.3-20 Centrifuge Design Criteria

Design Criteria	Value
Sludge applied	0.5-mgd @ 2 percent solids
Solids applied	79,200 ppd
Dewatered solids concentration	20-25 percent solids
Solids loading	3,000 lbs/hr/unit
No. of units required	2 (1 duty and 1 spare)

Capital Cost

The capital costs for centrifuges are higher than for belt presses. Operational costs are also higher since larger motors are needed to operate the equipment.

The estimated capital cost for dewatering via centrifuges including the building and sludge container facility is $5.4 million. (Note: the actual cost of the facilities was reduced by almost 50 percent based on revisions to the equipment sizes and systems.)

Summary of Evaluation

The solids handling processes were evaluated with respect to planning level construction and O&M costs and six non-monetary criteria. The selection matrix is presented in Table 6.3-21. The matrix indicates that belt filter presses and centrifuges have similar scores with centrifuges shown as slightly more favorable. For this reason, centrifuges were selected for solids dewatering. The proposed processes for the Solids Handling Facility are discussed below.

Table 6.3-21 Selection Matrix

Scoring = 0 to 5 (0 being least favorable, 5 being the most favorable)	Process History / Extent of Use in US	Processing Capabilities/Reliability	Land Requirements	Ease of Operation & Maintenance	Construction Cost	O&M Cost	Environmentally Friendly	Aesthetic Impacts	Total Weighted Score
Process Weight	10	15	5	20	10	20	5	10	
Processing Options	Evaluation Rating								
Non-Mechanical Dewatering									
Earthen Lagoons	5	2	0	4	3	5	3	1	315
Rapid Rate Drying Beds (Proprietary System Such As Deskins)	4	4	2	3	4	3	4	2	310
Mechanical Dewatering									
Centrifuges	4	4	5	3	3	3	5	5	350
Belt Filter Presses	4	4	5	2	4	3	5	5	340
Plate and Frame Filter Presses	4	3	4	1	1	1	5	5	230

6.3.5.4 Recommendations

Alternative 5 - Gravity thickeners combined with centrifuges is recommended for the C/CWTP. Design and operation recommendations are presented in Section 6.4.10.

6.3.6 Washwater Equalization

6.3.6.1 Performance and Design Criteria

The Waste Washwater Equalization facility (WWEQ) is a separate solids handling facility to convey plant return flows back to the C/CWTP inlet flow distribution box at the RWEQ facility. The WWEQ facility is comprised of two equalization basins to collect return flows and a pump station to convey this water to the head of the plant at a steady rate. Return flows include membrane backwash and clean-in-place water, GAC Contactor backwash, decant and centrate from the solids handling facility, and return water from the lagoons.

The design criteria for the WWEQ facility are presented in Table 6.3-22.

Table 6.3-22 WWEQ Facility Performance and Design Criteria

Design Parameter	Value
Washwater Equalization Basins	
Type	Reinforced Concrete with Conical Bottom
Number of Basins	Two
Volume per Basin	100,000 gal
Total Volume	200,000 gal
Minimum Basin Depth	11-ft
Waste Washwater Return Pump Station	
Type	Vertical Turbine Pumps in a Wetwell
Number of Pumps	Three (two duty, one standby)
Maximum Flow Rate Per Pump	950 gpm
TDH required	60-ft
Pump Control	VFD
Process Return Flows	Membrane CIP and Backwash, GAC Contactor Backwash, Thickener and Lagoon Decant, Process Overflow, Centrifuge Centrate

6.3.6.2 Initial Screening of Alternatives

The following alternatives were considered for the WWEQ facility:

Alternative 1 – WWEQ Basins and Pump Station - 2 high duty/2 low duty return pumps

Alternative 2 - WWEQ Basins and Pump Station- 3 medium duty pumps

Each alternative is discussed below.

Alternative 1 - WWEQ Basins and Pump Station only- 2 high duty/2 low duty return pumps

Alternative 1 includes two WWEQ basins and the WWEQ pump station for return flows and no additional clarifiers. In this alternative, the pump station is configured with a total of four pumps including two low duty return pumps (450 gpm max) and two higher duty return pumps (1,250 gpm max). The pump station was configured to allow for one duty and one standby pump for each of the two sizes, however, more than one of each pump could be operated at one time, if operators desired. This configuration allows for maximum pumping flexibility and keeps low service pumps in a more efficient operating range than throttling down to achieve a low flow rate.

Alternative 2– WWEQ Basins and Pump Station only- 3 medium duty pumps

Alternative 2 is similar to alternative 2. The pump station in this alternative is comprised of three medium duty (950 gpm) pumps such that two pumps are capable of handling peak flows and one is available for standby. The pump capacity was selected to allow for turndown of 50% to accommodate minimum flow conditions such that a nearly steady state flow could be maintained out of the pump station

The advantages and disadvantages of each alternative are summarized in Table 6.3-23.

Table 6.3-23 Initial Screening of WWEQ Alternatives

	Advantages	Disadvantages
Alternative 1	Process flexibility May not require VFD operators	Four pumps required
Alternative 2	Fewer, more uniform pumps	Pumps require VFD Operators to achieve flexibility

6.3.6.3 Evaluation and Cost Analysis

Table 6.3-24 presents a decision Evaluation to assist in evaluation of the WWEQ Facility.

Table 6.3-24 Decision Worksheet for WWEQ Facility

Alternative No.		Flow Range Flexibility	Equalization Capacity	Solids Removal Capacity	Life-Cycle Cost	O&M Cost	TOTAL Score
	Possible Score	*10*	*10*	*10*	*20*	*10*	*60*
1	WWEQ w/ 4 pumps	10	8	1	10	7	36
2	WWEQ w/3 pumps	8	8	1	18	10	45

6.3.6.4 Recommendations

Alternative 1 was eliminated because the added cost of four pumps in a waste washwater equalization facility would not provide a significant benefit to operations efficiency at this facility. Alternative 2 is the recommended option. Additional recommendations are presented in Section 6.4.

6.3.7 Finished Water Storage

6.3.7.1 Performance and Design Criteria

The Finished Water Storage facility at the C/CWTP will provide storage on site for 12 hours of peak demand in the event that the plant is out of operation. Additionally, backwash water for the GAC contactors will be provided from the finished water storage tanks via the BS4A and BS5A facility. The Finished Water storage facility is comprised of two 4-MG tanks and a distribution manifold to provide flow to the booster station pumps. Of the total 8-MG volume, 0.5-MG is reserved for plant needs (fire, utility, potable, GAC Backwash). Information for BS4A and BS5A is found in Section 7.3. The GAC Contactor facility is discussed in Section 6.3.4.

Design Criteria for the Finished Water Storage Tanks are as shown in Table 6.3-25.

Table 6.3-25 Finished Water Storage Tanks Design and Performance Criteria

Design Parameter	Value
Type	Above Grade Welded Steel Tanks
Number of Tanks	2
Volume per Tank	4-MG
Total Volume	8-MG
Useable Storage Volume	7.5-MG, 0.5-MG Reserved for Plant Needs
Maximum Height Above Grade	32-ft
Minimum Diameter	150-ft
Alternative Types	Prestressed Concrete Tanks or Reinforced Concrete Basins

6.3.7.2 Initial Screening of Alternatives

The following three alternatives were considered for configuration of the Finished Water Storage Tanks:

Alternative 1 – Two above-ground prestressed concrete tanks

Alternative 2 – One below-grade reinforced concrete reservoir divided into two sections

Alternative 3 – Two above-ground welded steel tanks

Alternative 1 - Two above-ground prestressed concrete tanks

This alternative consists of two prestressed concrete tanks each with a capacity of 4-MG. These tanks can be constructed at grade or partially below grade. Each of these alternatives includes the necessary appurtenances for operation of the finished water storage facility.

Alternative 2 - One below-grade reinforced concrete reservoir divided into two sections

Thsi alternative consists of a rectangular reservoir constructed predominantly below ground with a divider wall to provide two basins each with a capacity of 4-MG. This reservoir would be constructed entirely of reinforced concrete with a concrete roof.

Alternative 3 - Two above-ground welded steel tanks

This alternative is similar to Alternative 1 with two 4-MG above-ground welded steel tanks. The steel tank alternative would be constructed entirely above grade.

The advantages and disadvantages of each alternative are summarized in Table 6.3-26.

Table 6.3-26 Initial Screening of Finished Water Storage Alternatives

Alternative	Advantages	Disadvantages
Alternative 1 - Prestressed Concrete	Long Life Minimal Maintenance Provided and erected by manufacturer	Expensive Tall tank requiring attention to design to mitigate sight line
Alternative 2 - Submerged Reservoir	Long Life Minimal Maintenance Submerged basin out of sight line Gravity flow to reservoir possible	Requires Design by DB Contractor Expensive Buried reservoir requires additional excavation
Alternative 3 –Welded Steel Tanks	Low capital cost Flexible design and reasonably long life expectancy Provided and erected by manufacturer	Requires re-epoxy every 20 years Tall tank requiring attention to design to mitigate sight line

Alternatives for Evaluation

The prestressed concrete tanks (Alternative 1) were retained for further evaluation because the prestressed concrete tanks require little maintenance and have a long life. One disadvantage of this alternative is the visibility of the tanks requiring attention during design to the sight line.

The submerged reservoir (Alternative 2) was the original finished storage preliminary design option selected. Two main advantages of this alternative are the ability to flow from the GAC facility via gravity into the finished water storage and no visual impact because most or all of the facility is below grade. However, this alternative is the most expensive requiring extensive excavation and large quantities of concrete.

Welded steel finished water storage tanks were selected for preliminary design because steel tanks provide long life and can be configured for nearly any height or diameter required. Maintenance of the steel tanks is more extensive than other options; however, the life-cycle cost of the steel tank is less due to a lower capital cost.

6.3.7.3 Evaluation and Cost Analysis

The evaluation of the finished water storage alternatives is presented in Table 6.3-27.

Table 6.3-27 Finished Water Storage Tanks Alternative Evaluation

Alternative No.	Criteria	Custom Design Required	Sight Line	Installation Provided	Life-Cycle Cost	O&M Cost	TOTAL Score
	Maximum Score	*10*	*10*	*10*	*20*	*10*	*60*
1	Prestressed Concrete	10	2	10	5	8	35
2	Submerged Reservoir	0	9	0	1	8	18
3	Welded Steel Tanks	10	2	10	10	5	37

6.3.7.4 Recommendations

Two welded steel finished water storage tanks are recommended for the C/CWTP. Each tank will have a capacity of 4-MG and configured so that each tank can be operated individually if necessary. A passive mixing system would provide a well mixed contents.

The interior of each tank will be lined with a NSF 61 certified, potable water approved, interior primer and epoxy coating following erection of the tank. Exterior surfaces will be epoxy coated and a urethane topcoat will be provided in a color specified by the Owners. The exterior epoxy will be NSF 61 certified at interfaces with the interior of the tank.

The water distribution manifold following the finished water storage tanks will convey contacted water from the tanks to the BS4A/BS5A Pump Station. This manifold will have pipe connections for all of the finished water pumps, both planned and future, and the backwash pump and fire sprinkler pumps.

6.4 Recommendations for C/CWTP Processes

This section presents the recommended performance and design criteria and design considerations for all treatment processes at the C/CWTP. To aid the final decision making, City and County staff conducted a tour of treatment plant facilities in California from March 2 through 4, 2006, to obtain insight into the operation and maintenance of various equipment and processes. The group visited: Clovis WTP, South San Joaquin WTP, Alameda County Water District's WTP No. 2, Union Sanitation WWTP, San Francisco's Sunol WTP and the Benicia WTP. The knowledge obtained from the tour of these plants has been incorporated into the Preliminary Design as discussed in the following material.

6.4.1 Raw Water Equalization and Presedimentation Basins

6.4.1.1 RWEQ Facility Design

Two reinforced concrete- and gunite-lined earthen basin reservoirs will comprise the first stage basins which will be used for both presedimentation of settleable solids and for raw water storage. Each of the first-stage basins will have a raw water storage capacity of 2.25-MG; however the total capacity of each basin will be approximately 2.5-MG to allow for flow equalization and sediment accumulation of approximately 3-feet in each basin.

The second-stage raw water storage basin will be concrete- and gunite- lined earthen basin design. The total capacity of this facility will provide for 3-MG of raw water storage. This second stage is not anticipated to have appreciable sediment accumulation so no additional volume is provided for sludge storage.

For earthen basin design, the side-slope of the inside of the basins will be between 1.5:1 and 2:1 V:H ratio and the bottom of the basins will be at a 100:1 slope to provide drainage and settling to the outlet end of the basins. The exterior wall impoundments, mostly on the west side of the ponds, will also be between 1.5:1 and 2:1 slope. The maximum water depth of each pond is 17.5-ft and a minimum of 2-ft of freeboard is allowed. The top of the embankment is at an elevation of 6515-ft amsl and the maximum water level is 6513.5-ft amsl. A concrete open-cut spillway connecting each presedimentation basin with the raw water storage basin and a third open-cut spillway overflowing to the storm water catchment is proposed in the preliminary design drawings. The spillways allow for the construction of the embankment to approach the OSE height restriction of 10 feet without classification as a jurisdictional dam, as this restriction is measured

from existing ground at the toe of slope to the spillway crest. The spillway crest is currently at an elevation of 6513.5-ft amsl, at the proposed maximum water surface level.

The basins will be lined with steel-reinforced gunite on the sidewalls and the floors will be constructed of reinforced concrete. An access ramp constructed of steel reinforced concrete to the bottom of each of the three basins will be required for a front-loader to periodically remove the settled, mostly dried, solids from the basin floor. Hose-down monitor water cannons will be required on the second stage raw water storage basin for periodic rinsing of solids residue. The gunite side walls will be dyed a shade of brown to match the surrounding environment. A 12-ft wide gravel roadway will be constructed around the entire perimeter to provide truck and front-loader access. All site gravel will be selected to blend in with surrounding soil colors.

Inlet and outlet structures at the first-stage presedimentation basins will be designed to minimize short circuiting and allow for maximum sedimentation of solids from the raw and reclaimed water. The second-stage basin will drain directly to the raw water metering and flash mix facility. A bypass line will be required to allow raw water past one or both stages of the RWEQ Facility. Drains have been included to convey water with high level of solids to the lagoons. Overflow spillways will be needed in all three basins and the overflow will drain to the stormwater catchment basin.

6.4.1.2 Presedimentation Process Operation

The raw water pipeline will enter from the northeast corner of the C/CWTP site and turn south to the RWEQ facility. A chemical injection port will be located upstream of the splitter box for chemical dosing. Raw water pipelines convey water from the flow splitter box to each of the two presedimentation basins, with a by-pass pipeline to the raw water storage basin.

At the flow splitter box, flow control to each basin will be via a motor-controlled sluice gate. An overflow will be provided in the flow splitter box in the event that all basins are full and the raw water pipeline is still in operation. A flow sensor alarm will indicate flow in the overflow pipeline, which will drain to the solids lagoons at the solids handling facility. Inlet flow to each basin will be dispersed onto energy dissipaters in each of the basins. The discharge elevation will be at the approximately five feet above the floor level in each presedimentation basin (approximately 6501-ft amsl).

The outlet structure of each of the first-stage basins will be a concrete decant structure with self-contained downward opening weir gates to maintain the basin high water level. In addition, two motor-operated gate valves will be installed below the lowest travel of the weir gate and at the low water level elevations. These valves will allow the basins to gradually drain as conditions require. The decant structure will be located at the center of the far downstream end of each of the two presedimentation basins at the low point of the basin floor. Outlet piping will be installed at the low water level and connect to the raw water storage basin. From the second-stage raw water storage basin, raw water will flow directly into the conveyance pipeline to the raw water metering facility, no decant structure will be required. The outlet piping from the presedimentation and raw water storage ponds to the inlet meter/flash mix facility will be 36-inch pipe to minimize headloss to upstream of the Raw Water Flow Meter when the conveyance will reduce to a 24-inch line to increase velocity at the meter. A steel man-way bridge with handrails will be installed to provide access to the decant structure from the edge of each of the two presedimentation ponds.

Coatings for the valves, weir gates and exposed piping shall be provided on both the interior and exterior of the appurtenances to prevent corrosion of the intermittently submerged surfaces.

6.4.2 Raw Water Metering

A 36-inch pipeline from the presedimentation facility will convey raw water through a control valve and flow meter, and into the flash mix facility. In order to increase flow velocity through the meter, which improves measurement accuracy, the pipe will be reduced to 24-inches upstream of the flow meter. The velocity through the meter will be 8.8 fps at 18-mgd (peak flow) and 1.5 fps at 3.0-mgd (minimum flow). A minimum of 20-ft length (greater than 10 pipe diameters) of 24-inch pipe will be installed upstream and 10-ft length downstream (greater than 5 pipe diameters) of the flow meter to provide fully developed laminar flow at the metering location. A minimum flow velocity of 1 fps is needed to achieve an accuracy of ±0.5 percent of flow. A single modulating high-performance butterfly valve will be used to control the raw water flow into the treatment processes.

The piping conveying raw water to the inlet meter is largely underground. A ten foot square vault containing the meter and the meter control equipment is required for maintenance and calibration access. A control valve vault will be located adjacent to the flash mix facility. This vault contains both the main flow control valves, motors, and actuators as well as the isolation valves required to allow for removal of the control valve for maintenance or replacement. The isolation valves will be gate valves to provide uninterrupted flow during the normally open position.

6.4.3 Coagulation (Flash Mix)

The Flash Mix facility consists of pumps injecting water upstream (counter current) into the raw water and added chemicals. Pump power and nozzle size are the most significant elements of the flash mix design. The required energy to provide complete mixing of the primary coagulant (ferric chloride) with the raw water is a velocity gradient of 1,000/second. At a plant flow rate of 18 - MGD, a minimum water temperature of 0.5 degrees C, and a discharge velocity of 40 fps, the pump power required is 4.9 hp and mixing water flow rate is 350 gpm. A 7.5 hp pump capable of delivering 400 gpm was selected. Two 100 percent injection systems (1 duty and 1 standby) will be installed to provide a redundant flash mix system. These systems will have valve configurations to operate individually or in series as required.

The nozzle selected for preliminary analysis is a 4-inch diameter stainless steel flange mounted device with a 95 degree full-cone spray pattern, manufactured by Spraying Systems, Inc. A 4-inch pipe was selected to minimize head losses conveying the pumped injection water. The velocity of the water in the injector stream is 4.0 fps, assuming 350 gpm sidestream flow.

Chemical injection ports are placed on the main 36-inch process water pipe just upstream of the flash mix nozzle. The injection ports will be attached using bulkhead fittings fabricated onto the mainline. Specific types and sizes of chemical injection feed ports and pipelines have not been selected as chemical feed line sizing is correlated to chemical stock concentration, dosing requirements, and feed rate. Estimated chemical feed line sizes and pipe materials are shown in the preliminary design drawings. There will be five chemical feed ports for each injection system: two for currently planned chemicals, 1 for a spare chemical and two to accommodate future requirements. The currently planned chemicals are ferric chloride and sodium hypochlorite. The primary coagulant injector nozzle will be a full-length, single orifice type fabricated from ½-inch titanium pipe to provide a durable injector resistant to the corrosive effects of the coagulant.

Chemical feed lines will enter the flash mix building through two chemical line carrier pipes which the individual chemical feed lines will be placed. The carrier pipes will provide secondary containment in the event a leak in the pipeline. Two chemical line carrier pipes are required to

prevent chemical reactions if more than one chemical leaks; incompatible chemicals will be delivered through separate carrier pipes. These carrier pipes will slope downward one percent to the chemical feed building to convey any leaking chemical to the spill containment areas or to low-point leak sensors.

Adequate walking space must be provided around all of the equipment in the flash mix area for maintenance and inspection. Access to the overhead monorail hoist installed in the adjacent sludge pump area will be provided for removal of the injector pumps. The flash mix are of the Flocculation /Sedimentation Building will have water quality instrumentation to measure pH, temperature, and turbidity in the raw water. Additionally, a sample monitoring point will be installed at the flocculation basin inlet channel to measure pH and streaming current of the coagulated water. A pumped sample line will be installed at both of these locations to convey water samples to the plant laboratory for additional water quality monitoring.

6.4.4 Flocculation

The flocculation process will be carried out in rectangular, horizontal flow reinforced concrete basins ahead of the sedimentation basins. The basins will be constructed of reinforced concrete using a silica fume mix to protect the concrete from low pH water conditions. The established design criteria require an N+0 level of redundancy and a plant turn-down ratio of 5:1. Therefore, three 6.0-mgd parallel process trains will be used; three duty with no standby. The additional capacity per basin allows for up to five percent water loss due to filter backwashing and solids slurry removal from the sedimentation basins. As will be discussed in the next subsection, sedimentation basins will be fitted with plate settlers. Flocculation design criteria is presented in Table 6.4-1.

Table 6.4-1 Flocculation Design Criteria

Design Criteria	Value
No. Parallel Basins	3
No. of Stages per Basin	3
Design Flow Rate per Basin	6.0-mgd
Retention Time per Stage	10 min
Basin Width	25-ft

The proposed flocculation system will use vertical shaft flocculators with Hydrofoil-type impellers. The flocculators will each have VFDs to allow adjustments in the mixing energies. The proposed flocculation basins will include three stages of flocculation with concrete baffle walls between each stage to reduce short circuiting. The flocculation basins will be sized to provide a total hydraulic retention time (HRT) of 40 minutes at the design flow rate (i.e., 6.0 -mgd per basin). The flocculation basins will be housed in a building with the flash mix facilities and the sedimentation basins. Refer to the plan and sections shown Sheets 3M-1 and 3M-3 of the Water Treatment Plant Preliminary Drawings for additional information.

As an alternative to the use of vertical shaft flocculators, the DB Contractor has the option to provide horizontal paddlewheel flocculators with submerged chains and fiberglass reinforced plastic flights. The flocculators will each have VFDs to allow adjustments in the mixing energies. This option will still include three stages of flocculation with concrete baffle walls between each stage to reduce short circuiting. The basins will still be sized to provide a total hydraulic retention time of 40 minutes at a design flow rate of 6.0 -mgd. For this option, all of the east-west concrete

walkways shown on drawing 3M-1 will be eliminated, the overall flocculation basin length will increase by approximately 7 feet and the depth will decrease by approximately 3 feet.

Based on the raw water quality data and the pilot study results, it is anticipated that a ferric chloride dose in the range of 40 to 60 mg/L will be required to meet the settled water turbidity and finished water TOC goals of 2 NTU and 2.0 mg/L, respectively. The average ferric chloride dose is estimated to be approximately 45 mg/L. The data indicates that at times, it may be necessary to practice enhanced coagulation to achieve the settled water TOC goal. Enhanced coagulation may be accomplished by feeding higher doses of ferric chloride to suppress the pH of the coagulated water to 6.0 or lower. Alternatively, a sulfuric acid feed system may be provided in the future to suppress the pH of the coagulated water independently of the ferric chloride dose.

6.4.5 Sedimentation

Sedimentation will occur within reinforced concrete basins with lamella plate settlers and sludge collection equipment. The plates will be installed as plate packs and will be fabricated of fiberglass reinforced plastic. An effective hydraulic loading rate of 0.4 gpm/sf will be used to size the plate packs. This loading rate appears to be consistent with other water treatment plants treating cold water. The goal of the sedimentation system is to be able to consistently produce a settled water with a turbidity of 2 NTU or less. The solids collection system will be either a cable driven vacuum system (i.e., US Filter's Trac-Vac) or a scraper system such as Prakson's Superscrapers. Cross collection for the Superscrapers would be via a cross scraper system to a sump for solid withdrawal using sluice gates or telescoping valves and gravity flow to the sludge pump facility adjacent to the front of the flocculation basins. The design criteria for the sedimentation basins are summarized in Table 6.4-2.

Table 6.4-2 Sedimentation Basin Design Criteria

Design Criteria	Value
No. Parallel Basins	3
Design Flow Rate per Basin	6.0-mgd
Freeboard at Design Flow	2-ft, 6-in
Effective Loading Rate at Design Flow	0.4 gpm/sf
No. Rows of Plate Packs per Basin	3
No. of Plate Packs per Row	3

Four sludge pumps will be provided to convey the settled and collected sludge to the solids thickener facility. The preliminary design criteria for the solids transfer pumps are shown in Table 6.4-3.

Table 6.4-3 Solids Transfer Pumps Design Criteria

Design Criteria	Value
No. Pumps	4 (3 duty, 1 Standby)
Design Floe Capacity, each	440 gpm
Design Flow Pump Head	50-ft
Design Flow Minimum Pump Efficiency	60 percent
Minimum Shutoff Head	60-ft
Maximum Pump Speed	1150 rpm
Maximum Motor Speed	1200 rpm
Minimum Motor Size	10 hp

The solids transfer pump facility will be designed complete with flow metering equipment, a level controlled pump startup and shutdown sequence, discharge control, and a monorail hoist and guide rails as discussed in the Technical Requirements.

6.4.6 Membrane Filtration

The membrane filtration (MF) system will be primarily responsible for removal of suspended solids, biological constituents, and floc carry-over from the sedimentation basins. The system will provide near absolute rejection of all *Giardia*, *Cryptosporidium*, bacteria, protozoa, and suspended solids from the supply water by filtering water through sub-micron size pores in the walls of the hollow fiber membranes. As stated previously, the effectiveness of the membranes at removing these contaminants will not be impacted by the feedwater quality, flow rate, or the effectiveness of the upstream treatment. Membrane filtration will have little impact, however, on dissolved constituents, such as inorganic and organic compounds. Removal of such contaminants will depend on the coagulation process and downstream treatment processes.

During the preliminary design period, the City and County visited a number of treatment facilities to evaluate the different short-listed and selected process alternatives. Based on these visits and on a concern with operating a submerged MF system at elevations exceeding 6500 feet, it was decided by the Owners that submerged membrane systems would not be incorporated into the preliminary design or the DB procurement documents.

Hollow fiber microfiltration membranes may be employed in the pressurized operating mode. The system will consist of thousands of membrane fibers bound together in a standard size membrane module, with modules piped together within a pressurized skid. Figure 6.4-1 shows an example of a pressure microfiltration skid. The membrane modules can be seen mounted vertically in this photo.

Figure 6.4-1 Pressurized Microfiltration Skid (from Pall Corporation)

The membrane filtration system will be purchased as a proprietary system package, with many specifics of the system design dependent on the particular membrane manufacturer chosen. The following subsystems will be included as part of the membrane system package:

- Membrane modules
- Membrane skids
- Feed pumps
- Pre-membrane strainers
- Backwash system
- Chemical clean-in-place system
- Compressed air system
- Instrumentation and controls

Each of these subsystems is described briefly below, with general design criteria given for major system components.

6.4.6.1 Membrane Modules

Membrane modules will contain microfiltration hollow fiber membranes manufactured from polyvinyl difluoride (PVDF) material. Other materials are available and used commonly in the municipal water treatment industry, however, PVDF was selected for this facility due to its superior chemical resistance, low fouling properties, and record of performance and fiber integrity at currently operating systems employing this material. The membranes supplied will be compatible with one of the following systems:

- Memcor CMF-L as manufactured by Siemens
- Microza Microfiltration system as manufactured by Pall Corporation

Table 6.4-4 lists membrane characteristics for each of the proposed manufacturer's systems.

Table 6.4-4 Microfiltration/Ultrafiltration Membrane Characteristics

	Membrane System	
	Memcor CMF-L	Microza MF
Classification	Microfiltration	Microfiltration
Nominal Pore Size (µm)	0.1	0.1
Material	PVDF	PVDF
Flow Direction	Outside-in	Outside-in
Configuration	Pressure	Pressure
Module Dimensions (inches)	Dia = 4.7 L = 46	Dia = 6.0 L = 80
Membrane Area (sf)*	319	538
Number of fibers per module	14,500	8,000

* Based on fiber outside diameter

6.4.6.2 Membrane Skids

Membrane modules will be connected hydraulically and arranged into pressurized membrane skids. Each skid will contain groups of modules oriented vertically with all required piping, valves, and supports for independent skid operation contained within the skid. Modules will be easily removable and will be capable of hydraulic isolation from the other modules in the skid. Water will be forced through these membranes under pressure using VFD driven feed pumps, with flow controlled for each skid using either feed or permeate backpressure valves. Feed pressure to the skids will be set at a constant value and controlled by the feed pump VFDs. The maximum allowable feed pressure for each system will be established based on the recommendation of the selected membrane system supplier.

The production rate for each unit of membrane area is commonly referred to as membrane flux, and is defined as the daily production from the membranes per unit of membrane surface area in gallons per square foot per day (gfd). The allowable flux is dependent on feed water temperature and is inversely proportional to the viscosity of the water. In order to normalize membrane flux for changing temperature and pressure conditions, specific flux can be used and is calculated by first normalizing the membrane flux to 20 degrees C and then dividing it by the transmembrane pressure.

Maximum allowable design specific fluxes have been established for each membrane system, which will dictate the minimum size of each membrane skid for each manufacturer. These

maximum specific fluxes were established based on previous certification testing completed for each membrane system and through discussions with the membrane system suppliers. While the design criteria identified in this document will establish the minimum flow required from each membrane skid, the actual design flux proposed by the selected membrane system supplier will dictate the final number of membrane modules in each skid.

Each membrane cell will be designed with 15 percent additional slots to add future modules. Table 6.4-5 presents general design criteria for each pre-approved membrane system.

Table 6.4-5 Membrane System Design Criteria

	Membrane System	
	Memcor CMF-L	Microza MF
Configuration	Pressure	Pressure
Number of Skids	8	8
Net Capacity per Cell/Rack at 5 degrees C (mgd)	1.9	1.9
Net Capacity per Cell/Rack at 10 degrees C (mgd)	2.5	2.5
Max Design Sp. Flux (gfd/psi)	1.7	1.7
Max Design Transmembrane Pressure (psi)	26	40
Minimum Recovery (percent)	95	95
Max Cleaning Frequency (each cell/skid)	1/month	1/month

6.4.6.3 Pre-Membrane Strainers

Each membrane system will contain automatically backflushing strainers upstream of the membranes to prevent debris from entering the membrane system and damaging membrane fibers. The mesh size for the strainer will be based on the recommendation of the selected membrane system supplier, however strains will be 500-µm mesh size or smaller. Between two and four automatically backwashing strainers will be required, as proposed by the membrane system supplier, with the strainers capable of operating at full plant flow with one strainer out of service. The pressure drop across the strainers will not exceed 1.0 psi when clean. Strainers will be placed in-line after the membrane feed pumps and will backflush automatically either with backwash pumps or using line pressure within the feed piping.

6.4.6.4 Feed or Permeate Pumps

Membrane systems will be fed by four VFD driven feed pumps each capable of delivering 3,500 gpm of flow. Total dynamic head against which pump must operate will be determined by actual pressurized system being proposed. The feed pumps will be vertical turbine pumps with all wetted metallic parts manufactured from 316 stainless steel.

6.4.6.5 Backwash System

Backwash cycles will be initiated automatically through the control system using totalized volume, trans-membrane pressure, or time, as selected by the operator. The backwash processes will be carried out automatically through the control system. Backwashing frequency and duration will be as recommended by the membrane system supplier. Backwashing volumes will be limited by the requirement to maintain 95 percent plant recovery at flow rates greater than 10-mgd.

Firm on-line backwash pumping capability will be provided such that backwash requirements can be met with any one backwash pump off-line. Backwash water will be pumped using dedicated horizontal end suction pumps, unless backwash blowers and compressors are used in place of pumps.

Spent backwash water exiting the skids will be discharged in a controlled manner and routed to a backwash recovery system. The backwash system will be designed such that no more than one skid can be backwashing at any time.

6.4.6.6 Compressed Air System

The membrane system will include a compressed air system for the following applications:

- Operation of the pneumatic actuated valves on the MF skid
- Operation of the membrane integrity test system
- Operation of all miscellaneous appurtenances, as applicable by the proposed MF system
- MF system backwash, if proposed by the membrane system supplier

Firm on-line standby capacity will be provided for the systems listed above. The system will include a complete compressed air system consisting of compressors, ASME-rate receiver refrigerated air dryer, controls, pressure relief valves, manual shutoff valves, pressure gauges, vibration mounts and all mounting hardware, inlet filter silencer, air regulator assemblies and air filters. Separate pneumatic tanks will be provided for the control air and process air.

6.4.6.7 Clean-In-Place System

The cleaning system will include chemical feed pumps, clean-in-place (CIP) make-up water heating system, CIP make-up water transfer pumps, chemical solution recirculation/drain pumps, valves, instrumentation, controls and appurtenances needed for a fully functional and operational CIP system and maintenance wash system. The cleaning system will include systems for cleaning and neutralization chemicals including muriatic acid, sodium hypochlorite, sodium hydroxide, sodium bisulfite, and other chemicals as recommended by the membrane system supplier. The membrane system will be sized to prevent CIP cleaning frequency from exceeding once per month.

The MF system will include integral, automatic, membrane CIP systems designed to maintain system performance by reducing the transmembrane pressure at a given flow and water temperature to within the pre-defined normal operating limits. The cleaning system will operate automatically upon operator initiation of the cycle. CIP chemicals will be injected into the CIP transfer piping, downstream of the CIP Make-up Water Transfer Pumps. The CIP system will be designed such that no more than one skid can be undergoing a CIP at any time.

Disinfection cleanings will be done using a sodium hypochlorite solution with concentrations not to exceed 500 mg/L or the maximum concentration recommended by the membrane system supplier, whichever is lower. Low pH cleanings will be done using muriatic acid solution at pH 2.0 or higher, as recommended by the membrane system supplier. Tank heaters will be used to maintain cleaning solution temperatures up to 100 degrees F. While some membrane systems employ chemically enhanced backwashes or "mini-cleans" to extend the CIP duration, such cleanings would significantly increase chemical waste flows and could adversely impact plant performance. Chemically enhanced backwashes will therefore not be employed at this facility, and chemical concentrations in the backwash water will not exceed the levels in the plant finished water.

Membrane CIP chemical feed systems will be included for each of the cleaning and neutralization chemicals required for the system. Each membrane clean-in-place chemical feed system will include duty and stand-by chemical metering pumps, valves, flow meters, pressure gauges and switches, flow confirmation switches and controls.

The system will include CIP Make-up Water Transfer Pumps which transfer water from the CIP storage tank to the MF skids. Firm on-line CIP Make-up Water pumping capability will be provided such that CIP requirements can be met with any one CIP Make-up Water Transfer pump off-line. CIP Make-up Water Transfer pumps will be of horizontal end suction type. Casings and impellers will be Type 316 stainless steel.

6.4.7 Ozone

6.4.7.1 Introduction and Basis of Design

Ozone treatment will be used at the C/CWTP to reduce the formation potential of certain disinfection byproducts (DBPs) such as total trihalomethanes (TTHMs) and halo-acetic acids (HAAs) and to oxidize contaminants and assist with the control of taste and odors. The ozone will react with natural organic matter (NOM) in the water, including taste and odor causing compounds and DBP precursors, to form biodegradable compounds, which can be effectively removed by the biologically active GAC contactors.

Ozone will be added to the treatment process following the membrane filtration process and before the GAC contactors.

Ozone Demand and Decay Kinetics

The sizing of ozone treatment systems will be influenced by the ozone demand and decay kinetics of the water. Ozone demand of water is the amount of ozone consumed by substances in the water and by autocatalytic decomposition of ozone instantaneously upon contact. The ozone demand is typically measured as the transferred ozone dose minus the ozone residual after 60 seconds. Initial ozone demand is dependent on various water quality parameters, such as temperature, pH, turbidity, TOC, alkalinity, and chlorine residual.

Ozone decay is the decrease of ozone residual over time due to decomposition and reaction with other constituents in the water. Ozone decomposition is a complex process that often involves chain-radical reactions and may be initiated by several types of constituents in water such as hydroxide ion (i.e., higher pH values), natural organics (e.g., humic materials), soluble metals, and other reducing compounds. Other water quality parameters that may affect ozone decay include temperature, turbidity, TOC, alkalinity, and chlorine content.

Ozone demand and ozone decay rates can be determined experimentally in bench-scale or pilot plant studies as a function of ozone dose. Bench-scale testing of ozone demand and decay kinetics was conducted in June 2003 on Rio Grande water as part of the 2003 MRC Water Quality Studies and Evaluations Project. Pilot-scale testing on Rio Grande water was conducted in 2005 as part of the BDD Pilot Testing Program.

During the bench-scale testing, raw Rio Grande water was treated using 1 mg/L potassium permanganate, 35 mg/L ferric chloride, 1.5 mg/L cationic polymer, 0.25 mg/L non-ionic polymer, 30 minutes coagulation/flocculation, and 30 minutes settling. The chemical treatment conditions used in this bench testing are similar to the conditions proposed for the C/CWTP. The major difference between the bench-scale testing and the full-scale water treatment plant is the proposed

implementation of MF ahead of the ozone system. Following treatment of the raw water, various ozone doses were applied to evaluate the impacts of ozone dose on demand and decay kinetics.

An empirical relationship between 60 Second Ozone Residual and applied ozone dose is shown on Figure 6.4-2. The relationship between ozone demand and applied ozone dose can be calculated by: Ozone Demand = Applied Ozone Dose – 60 Second Ozone Residual

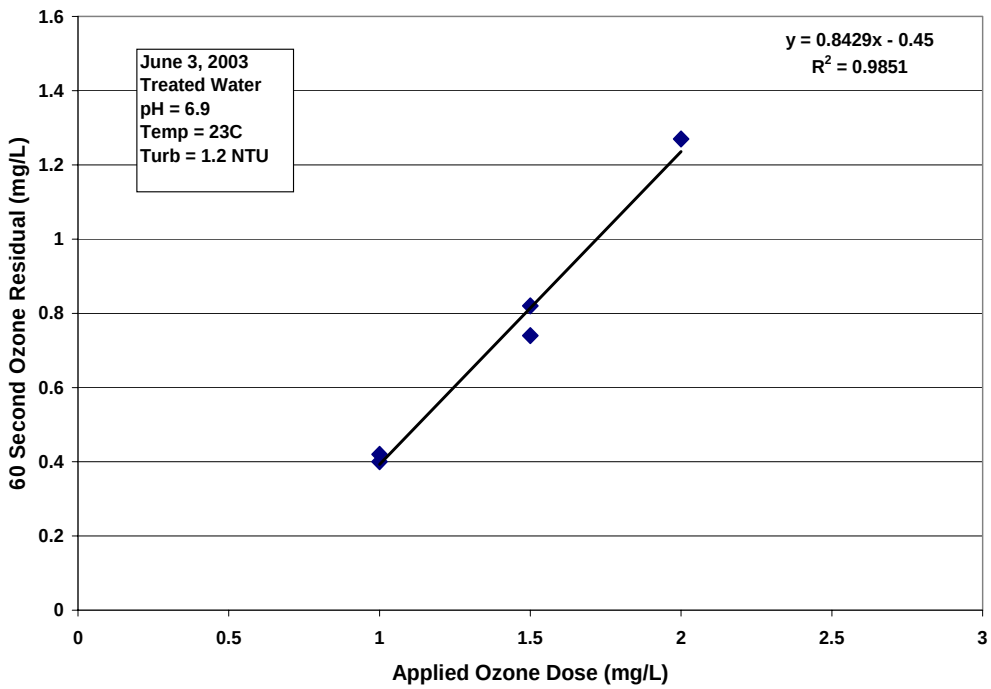


Figure 6.4-2 60 Second Ozone Demand of Treated Rio Grande Water

Based upon the empirical results, calculated estimates for ozone demand of treated Rio Grande water are shown in Table 6.4-6.

Table 6.4-6 Calculated Ozone Demands

Ozone Dose (mg/L)	60 Second Residual (mg/L)	Ozone Demand (mg/L)
1.0	0.4	0.6
2.0	1.2	0.8
3.0	2.1	0.9
4.0	2.9	1.1
5.0	3.8	1.2

The water temperature during this bench-scale investigation was approximately 23 degrees C, which is close to the maximum anticipated Rio Grande water temperature. Since ozone demand typically increases with increasing water temperature, the relationship between ozone demand and applied ozone dose measured in the bench-scale testing is expected to be a conservative prediction for ozone demand at other temperatures. The additional treatment step of MF ahead of the ozone system in the full-scale installation should also result in the bench-scale testing being a conservative estimate of full-scale ozone demand.

An empirical relationship between ozone half-life and applied ozone dose is shown on Figure 6.4-3. The relationship between ozone decay and applied ozone dose can be calculated by: Ozone Decay Coefficient = ln(0.5) / Ozone Half-Life

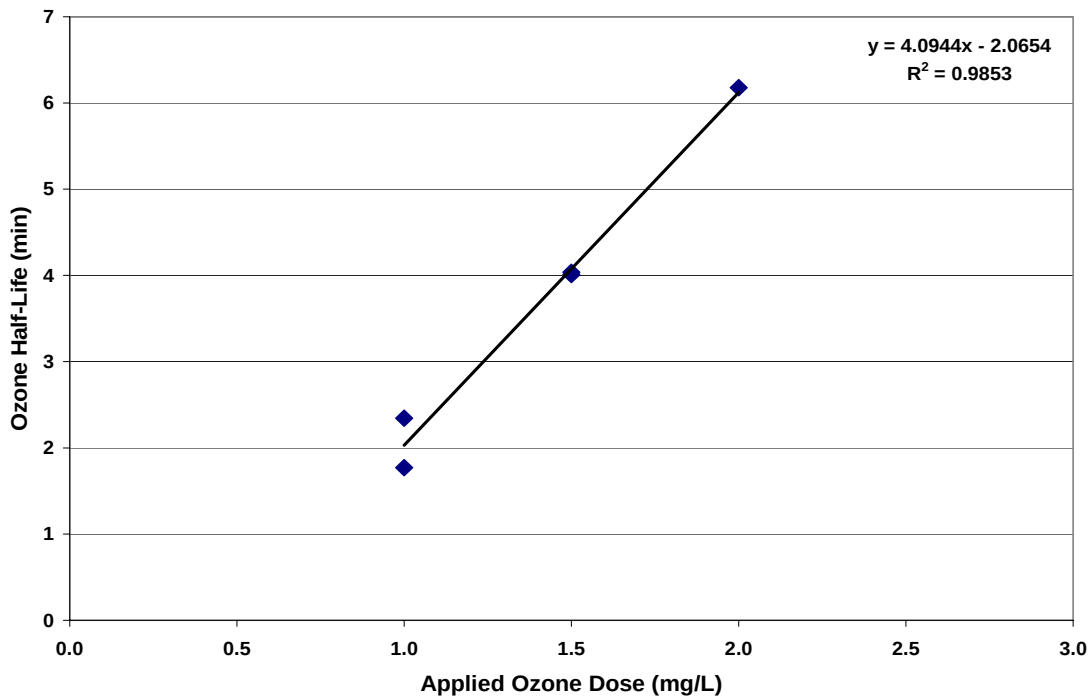


Figure 6.4-3 Ozone Half-Life of Treated Rio Grande Water

Based upon the empirical results, calculated estimates for ozone decay of treated Rio Grande water are shown in Table 6.4-7.

Table 6.4-7 Calculated Ozone Decay

Ozone Dose (mg/L)	Ozone Half-life (min)	Ozone Decay (1/min)
1.0	2.0	0.34
2.0	6.1	0.11
3.0	10.2	0.07
4.0	14.3	0.05
5.0	18.4	0.04

The relationship between ozone decay and ozone dose found in the bench-scale testing is expected to be a conservative estimate of the relationship for the full-scale installation at the C/CWTP as discussed previously.

The pilot-scale testing demonstrated slightly higher ozone demand for Rio Grande water following treatment that included chemical coagulation followed by sedimentation, and in some cases, filtration. The pilot-scale ozone demand results ranged from 1 to 2 mg/L. Filtered water TOC levels ranged from approximately 1.5 to 3 mg/L during the pilot testing. The testing also demonstrated that an ozone dose of approximately 1 mg/L was sufficient to significantly reduce 96 hour TTHM and HAA formation potential to values approximately half of the Stage 2 TTHM and HAA limits of 80 and 60 µg/L.

Basis of Design

The design of the ozone system to provide control of taste and odor causing compounds and disinfection byproduct precursors is be based upon an applied ozone dose of 0.5 to 2.0 mg/L, with an anticipated average dose of 0.5 to 1.0 mg/L. This provides a maximum ozone-to-TOC ratio of

0.7 to 1.3 mg ozone/mg TOC under maximum flow design conditions. The design ozone contact time will be 5 minutes under maximum flow conditions.

6.4.7.2 Design Criteria

Proposed design criteria for the ozone system is listed in Table 6.4-8.

Table 6.4-8 Ozone System Proposed Design Criteria

Design Parameter	Value
Maximum Day Flow	15.3-mgd
Average Day Flow	6.2-mgd
Minimum Day Flow	3.0-mgd
Maximum Applied Ozone Dose	2.0-mg/L
Average Applied Ozone Dose	0.5 to 1.0 mg/L
Ozone Application Point	Following Membrane Filtration System
Bulk Water Temperature Range	33 to 78 degrees F
Ozone Generation Design	
Type	LOX Fed, Medium Frequency
Number of Ozone Generators	2 (one Duty, one Standby)
Minimum Ozone Generator Capacity	255 ppd (each)
Ozone in Oxygen Concentration	8 to 12 percent
Supplemental Nitrogen System	Duty an standby supplemental nitrogen system with dewpoint analyzer and automatic flow throttling
Guaranteed Maximum Ozone System Power Consumption	6.0 kWh/lb ozone produced
Ozone Dissolution System Design	
Type	Sidestream Injection System with Degas Separator
Number	Minimum 2 systems (one duty, one standby) to provide system redundancy
Guaranteed Minimum Ozone Transfer Efficiency	95 percent
Ozone Contactor Design	
Ozone Contactor Sizing	5 minutes at Maximum Day Flow
Number of Ozone Contactors	1
Type	Pipeline Contactor, 72-inch diameter, mortar-lined steel or PCCP
Liquid Oxygen (LOX) Facilities Design	
LOX Storage Tanks Description	6,000 gallons, vertical
Number of LOX Storage Tanks	1
LOX Tank Storage Duration	22 days under maximum design conditions 110 days under average design conditions
LOX Vaporizers Description	Ambient vaporizers
Number of LOX Vaporizers	3 (one duty, one defrost, one standby)
Ozone Destruct Facilities Design	
Ozone Destruct Description	Catalyst destruct with preheater and blowers
Number of Ozone Destruct Systems	2 (one duty, one standby)

Ozone Generation Facilities

The ozone generation system will include two pure oxygen fed, medium frequency / constant voltage type ozone generators (one duty, one standby) to produce ozone gas at a concentration of between 8 to 12 percent. Full redundancy shall be provided for the ozone generation system and each of the duty and standby generators will have adequate capacity to supply the maximum design applied ozone dose of 2.0 mg/L at the maximum design plant flow rate of 15.3-mgd. The minimum capacity of ozone generators shall be 255 ppd each. The guaranteed maximum power requirements of the ozone generators shall be less than 6.0 kWh/ppd of ozone produced.

A supplemental nitrogen system with dewpoint analyzer and automatic flow throttling will be included with the ozone generation system. The ozone generators would be housed inside the ozone building in a room suitably designed for the hazardous gases.

Ozone Dissolution Facilities

A sidestream injection system shall be used to dissolve the ozone gas into a sidestream from the bulk water flow. The sidestream injection system will include booster pumps, venturi eductor system and mixing system and degas separator. Full redundancy will be provided for the sidestream injection system such that the maximum design condition can be met with one sidestream injection unit out of service.

The ozonated sidestream flow will be mixed into the bulk water stream pipeline at the entrance to the ozone contactors using nozzles and a 316 stainless steel flash mix reactor. The sidestream injection system will be as manufactured by Mazzei Injection Corporation, or approved equal.

Ozone Contactor Facilities

The ozone facilities include an ozone pipeline contactor that will provide 5 minutes of ozone contact time at a flow of 15.3-mgd. The contactor will be sized to hydraulically accommodate a flow of 22.5-mgd. The ozone contactor will include a feed point for calcium thiosulfate to quench the ozone-in-water at the end of the contactor. A static mixer will be provided to ensure complete ozone quenching.

The preliminary design of the ozone system is based on the implementation of one 72-inch diameter pipeline contactor approximately 250-ft in length. The pipeline contactor will be designed of 316 SS at the point of ozone injection and mortar-lined and coated steel pipe (SCLC) along the buried portion of the pipeline contactor. All wetted surfaces of the pipeline contactor will be made of materials suitable for use with ozonated water. No rubber gaskets will be used with the ozone contactor. In addition, there shall be no carbon steel exposed to the ozonated water. Maximum working pressure for the pipeline contactor will be approximately 50 psi. Alternative diameters will be allowed for the pipeline contactor provided that the design contact time of 5 minutes under maximum design flow is maintained.

As an alternative to the pipeline ozone contactor, the DB Contractor may propose implementation of a baffled, cast-in-place concrete ozone contactor basin. To be acceptable, the ozone contactor basin shall be well baffled with a baffling factor of T_{10}/HRT of 0.7 or greater. The contactor would provide 5 minutes of ozone contact time at a flow of 15.3-mgd and sized to hydraulically accommodate a flow of 22.5-mgd. The contactor basin design would need to be implemented without additional intermediate pumping.

Liquid Oxygen (LOX) Facilities

The ozone will be produced using pure gaseous oxygen (GOX) as the feed gas. Liquid oxygen (LOX) will be delivered to the site and stored in one 6,000 gallon vertical tank, capable of providing approximately 22 days storage under peak design conditions and 110 days under average design conditions. When empty, the LOX tank will be capable of accepting a full 4,500 gallon LOX bulk truck delivery. The LOX tank will be located outside adjacent to the ozone building in a concrete containment area. Three ambient vaporizers will be provided to convert the LOX to GOX. Each vaporizer will be sized to provide 100 percent of the maximum design GOX demands for the system. Under normal operational conditions one vaporizer will be in duty mode, one vaporizer will be in defrost mode, and one vaporizer will be in standby mode.

Ozone Destruct Facilities

An ozone destruct system will be installed to collect off-gas from the sidestream injection system, and if necessary, from the ozone contactor to comply with local permit requirements. Discharge concentrations of ozone will be reduced to comply with local permit requirements prior to discharge. The ozone destruct system shall employ induced draft blowers to maintain a negative pressure within the off-gas collectors, and shall employ both a preheater and catalyst vessel for removal of ozone. Two ozone destruct units will provided, each designed for 100 percent of the capacity demands for the system.

6.4.8 GAC Contactors

6.4.8.1 GAC Contactor Configuration

The GAC contactor system recommended is comprised of five, 40-ft long and 12-ft diameter pressure vessels aligned in a single row. The contactors are located in the main process building adjacent to the ozone generation and injection facility.

There are two pipe connections on the end of each pressure vessel, one at the top and one at the bottom. The top connection is for process feed of the ozonated feed water and outlet of the waste wash water line. The lower pipe connection is for the contacted water outlet and the feed backwash water line. A tee at each connection will allow for appropriate plumbing of the system. On the outlet contacted water lines, each contactor will be connected to instrumentation for monitoring water quality and quantity. The GAC pressure contactor system shall be furnished complete with the contactor vessels, underdrain system, overdrain system with distribution laterals, four motor operated control valves per contactor, and a local control system compatible with the C/CWTP PLC system. The GAC media will be domestic GAC. Two additional ports will be provided to facilitate the removal and replacement of GAC media. The GAC removal ports will be equipped with manually operated valves for the GAC slurry.

Design Criteria for the GAC Contactor Facility is presented in Table 6.4-9.

Table 6.4-9 GAC Contactor Performance and Design Criteria

Design Parameter	Value
Type	Horizontal Pressure Vessels
Number of Contactors	5
Diameter, each contactor	12-ft
Length, each contactor	40-ft
Media Area, each contactor	450 sf
Empty Bed Contact Time (EBCT)	10 minutes
Media Effective Size	1.4-mm
Uniformity Coefficient	≤1.4
Minimum Media Depth	6-ft
Approximate Bed Volume	2750 cubic feet
Hydraulic Capacity, each contactor	3.5 -mgd
Process Capacity, each contactor	3.1 -mgd
Total Hydraulic Capacity	18.5-mgd
Total Process Capacity	15.3-mgd
Alternative Configuration	Vertical Pressure or Gravity Flow Contactors
Contactor Backwash Pumps	
Backwash Rate	15 gpm/sf
Backwash Duration	10 minutes
Backwash Frequency, each contactor	10 days
Number of Pumps	1
Pump Capacity, minimum	6750 gpm
TDH Required	60-ft

6.4.8.2 Backwash System

Lower than typical backwash rates are proposed for the backwash system because it will not be necessary to fluidize the contactor bed as aggressively as required in a conventional media filter. Inlet process water is already of very high quality and essentially no particle filtration will occur in the Contactor. The operating conditions proposed for the backwash system are as follows:

Backwash rate: 15 gpm/SF

Backwash duration: 10 min or less until backwash water turbidity is between 15-20 NTU

Backwash water will be supplied from the finished water distribution manifold. Backwash frequency is estimated for approximately once every ten days per contactor. Such infrequent backwashing should not require the use of sodium thiosulfate to remove residual chlorine, which is typically detrimental to the BAC action in the contactors.

The backwash water pump will be vertical turbine type with variable speed drive. The backwash pump will operate assuming 60-ft of head required and 6,750 gpm backwash flow rate. The pumps will include 480 volt 150 hp premium efficiency electric motors.

Once a contactor is determined ready for backwash, either from high headloss, turbidity, TOC or other indication, a backwash sequence will be initiated. The backwash rate and bed expansion will be determined during final design to minimize GAC media loss during backwashing.

6.4.8.3 Contactor Operation

The GAC contactors will be operated to provide equal usage during lower demand periods and be able to maintain even flow distribution during peak demands. Ozonated process water will enter the contactor building following the ozone pipeline contactor and the removal of residual ozone in the process water with calcium thiosulfate. The inlet control valve at each contactor will control if that contactor is in operation. The outlet control valve will be a modulating type and will be designed to control the rate of flow out of each contactor.

The contactors will operate in parallel and individual contactors will be taken off-line for backwashing or maintenance as required. It is estimated that GAC replacement will be necessary every 3 to 5 years, though operation may indicate more or less frequent replacement requirements. During low demand periods, only one contactor will be required to provide the 3.0 -mgd service required at an EBCT of 10 minutes, however, two contactors could be operated at a longer EBCT if improved treatment is required. During high demand periods all five contactors will be operated to provide, at a minimum, the design EBCT of 10 minutes at maximum plant capacity. Four contactors will be capable of providing a slightly shorter EBCT (8.6 minutes) at the peak demand of 15.3 -mgd. Fewer contractor may be used during operational periods when a low TOC removal rate is needed.

6.4.9 Chemical Feed Systems

This section provides criteria for chemical storage and feed systems, excluding liquid oxygen (LOX) for ozonation. The LOX system is addressed in other sections of this Report.

6.4.9.1 Design Criteria

The chemical tanks and feed pumps have been sized for preliminary design purposes based on the dosage criteria shown in Table 6.4-10.

Table 6.4-10 Chemical System Design Criteria

Chemical	Dosage (mg/L)			Application Design Flow			
	Min.	Avg.	Max.	Units	Min.	Avg.	Max.
Ferric Chloride	25.0	50.0	70.0	mgd	2.37	6.3	15.5
Sodium Permanganate	1.0	2.5	4.0	mgd	2.37	6.3	15.5
Sodium Hydroxide (caustic)	30.0	50.0	70.0	mgd	2.37	6.3	15.5
Membrane CIP Acid	0.01	0.03	0.05	mgd	n/a	n/a	n/a
Non-Ionic Polymer	0.50	1.25	2.00	mgd	0.1	0.3	1.9
Sodium Hypochlorite	2.0	3.5	5.0	mgd	2.37	6.3	15.5
Calcium Thiosulfate	0.3	0.5	2.1	mgd	2.37	6.3	15.5
Zinc Orthophosphate	1.0	3.0	6.0	mgd	2.37	6.3	15.5
Fluorosilicic Acid	1.0	1.0	1.0	mgd	2.37	6.3	15.5

All design flows cited above include ~3% for process waste.

6.4.9.2 Design Considerations

Unless otherwise noted, all liquid and emulsion storage systems shall be bulk storage tank systems. When given the choice between a dry and liquid chemical, the Owners and the design team opted for the liquid chemical in the interest of facilitating operator handling and general plant housekeeping. When given the choice between emulsion and more dilute mannich polymers, the design team recommends emulsion, in the interest of minimizing storage volume requirements. The majority of the project's chemicals will be stored in fiberglass reinforced plastic tanks set within secondary containment dikes. Polymer and membrane CIP acid will be stored in smaller, disposable or reusable containers. Typical storage and feed systems are shown in the photograph included as Figure 6.4-4. Specific chemical system design considerations are described below.

Figure 6.4-4 Typical Chemical Storage and Feed System

Pre-Oxidant

Oxidizing the raw water aids in controlling algae, manganese, iron, taste, odor, and (to some extent) TOC. To achieve these goals, liquid sodium permanganate (20 percent solution) was chosen over granular potassium permanganate to promote simplified operations. The sodium permanganate will be dosed at a point upstream of the raw water presedimentation basins.

Primary Coagulant

Pilot testing revealed that ferric chloride tended to yield more favorable results than other coagulants tested. The design will be based on the use of acidified ferric chloride, in an effort to avoid the need for a dedicated acidifying system, such as a sulfuric acid system. Flexibility will be provided to facilitate a change in primary coagulant (if determined to be necessary in the future) through equipment materials of construction selection being versatile enough to handle aluminum sulfate (alum), acidified alum, or polyaluminum chloride. Further, while maximum ferric chloride dosage is established based on the pilot study, extra pumping capacity is provided by allowing the option to activate a second feed pump to augment the first. The three pumps provided in the design include a duty, standby, and spare pump. During extraordinary high turbidity events, the plant would to be able to feed nearly twice the maximum dosage reported in the pilot study. The ferric chloride would be dosed at points in either the first or second flash mixing chambers and possibly prior to the presedimentation basins.

Membrane Clean-In-Place (CIP) Chemicals

Phosphoric, sulfuric, citric, and muriatic acids were contemplated for membrane clean-in-place. The design will allow the acid selection to be determined by the membrane system vendor. Chemical delivery and storage will utilize 55-gallon drums in lieu of bulk storage tanks.

Ozone Quenching

Calcium thiosulfate will be used to quench ozone as it exits the ozone contactor pipeline. It will also be used to dechlorinate backwash water for the GAC contactors. While available in disposable containers, bulk deliveries to a storage tanks are planned due to a reduced cost per gallon.

pH Adjustment

While the chemical cost of lime is considerably less than that of 50 percent caustic soda, the latter is proposed for use in pH and alkalinity adjustment. Lime was eliminated from further consideration due to its inherent operational challenges, the local construction limitations precluding the use of tall lime storage silos, and the potential need to continuously mix (i.e., high energy consumption) the lime slurry. Caustic soda may be fed at the flash mix chamber, up-and down-stream of the GAC contactors, at the upstream end of the finished water reservoir, and at a point to neutralize spent CIP solution.

Corrosion Control

A zinc orthophosphate storage and feed system has been provided for corrosion control. The chemical will be fed into the finished water pipeline downstream of the finished water pumps. Separate injection points have been provided for BS4A and BS5A to provide flexibility in corrosion control.

Fluoridation

The raw water fluoride concentration is reported to range from non-detect to 0.5 mg/L. Fluoridation is currently a City requirement. This is the only system proposed to have a day tank, to prevent over feeding of the chemical. The hydrofluorosilicic acid will be stored and fed from a segregated room due to the corrosive nature of the chemical. Injection into the finished water will be provided at both BS4A and BS5A since Buckman well water is fluoridated at the 10-MG Tank.

Oxidation and Secondary Disinfection

Sodium hypochlorite will provide secondary disinfection (chlorination) within the Finished Water Reservoirs and finished water pipelines. This chemical may also be fed periodically upstream of the presedimentation basins for should shock chlorination be needed for controlling algae and at the flash mix chamber for algae control within the process basins. Hypochlorite will regularly be used for the membrane clean-in-place process.

Due to this chemical's tendency to degrade, particularly in warm weather, provisions are in place (i.e., tank volumes, chemical feeders, etc.) to allow dilution from 12.5 percent to 6 percent if deemed necessary. A mixing and recirculation pump is also provided in the design for dilution of the tank contents.

Polymer System for Solids Handling

An emulsion polymer system will be provided within the solids dewatering system. Chemical delivery and storage in 55-gallon drums will be provided for, with redundant polymer blending units provided to activate the polymer and convey it into the process stream. Dosages on the order of 0 to 3 mg/L will be allowed for, with flexibility for adjustment based on startup and operational experience. Based on experience at other facilities, the preliminary design assumes the use of a 25 percent solution of nonionic to slightly anionic emulsion polymer.

Spare Chemical System

A complete spare chemical system has been included in the Preliminary Design. The system will include a single 6,000 gallon storage tank and two metering pumps with piping to all of the major chemical injection points. This system may be used for a variety of chemicals for optimization of the treatment system or for plant-scale testing of various treatment chemicals. It may also be used as a substitute for other chemical systems should a system's duty and standby units both be out of service.

Chemical Building Features

The layout of the storage, feed, and chemical receiving facilities will accommodate streamlined deliveries, operations, and maintenance. The arrangement features bases stored separately from acids and all items segregated into separate containment areas. A corridor will be situated between the two rows of chemical systems. Local control panels and chemical distribution panels will be located off the center corridor above the chemical containment areas to provide safe access to control features.

Truck loading stations will be arranged on each side of the building with depressed reinforced concrete containment areas to capture and contain any spillage. Each truck unloading containment area is piped to a common sump that will normally convey stormwater to the catchment area. When delivering a chemical, a valve downstream of the common sump will close so a spill will be captured before it enters the stormwater system. The spill containment system will then need to be pumped out and washed before accepting other deliveries.

Emergency show and eyewash stations will be located within chemical equipment areas as well as at the truck offloading areas. Flow switches in the shower stations will alert the plant operators to the use of a station and a possible emergency.

Chemical System Control Descriptions

The individual control descriptions are included in the Technical Requirements and detail the methods of chemical flow pacing for each of the systems. In general, flow rate signals will pace the pre-oxidant, coagulant, fluoridation, pH/alkalinity adjustment, ozone quenching, secondary disinfection, and corrosion control systems. Analytical instrument signals (e.g., fluoride concentration, ozone residual, pH, chlorine residual) will "trim" the chemical feed rate by adjusting the metering pumps' stroke length. All of the chemical metering pumps will be able to be operated in a totally manual mode if desired.

6.4.10 Solids Handling

Solids will flow by gravity from the sedimentation basins to either of two circular gravity thickeners, each 80-feet in diameter. The concentration of solids into the gravity thickeners will be approximately 0.5 percent and the concentration of solids leaving the thickeners will be about 2 percent. From the elevated gravity thickeners, the thickened stream will flow by gravity to a 500,000 gallon solids equalization tank. The tank will hold one-day storage of solids for the 90th percentile peak condition or five days storage for average conditions. This will allow intermittent use of centrifuges to minimize overtime labor at the plant. Additional solids storage is available within the gravity thickeners.

From the solids equalization tank, solids will be pumped to two centrifuges (one duty and one standby) utilizing three (two duty and one standby) progressive cavity pumps in the Solids Equalization Basin pump room. The room will also house a solids equalization tank recirculation pump to keep the basin's contents well mixed.

The centrifuges will dewater the sludge to approximately 20 to 25 percent dry solids. The centrate from the centrifuges will flow by gravity to the washwater equalization basins and pumped to the head of the plant. The solids will be conveyed to roll-off containers (one container per centrifuge) for disposal.

Two 600,000 gallon earthen lagoons have been provided in the preliminary design for a variety of situations. The lagoons may receive the following flow streams:

- Drainage from the raw water presedimentation/storage basins
- Solids from the sedimentation basins
- Solids from the solids equalization basin via the centrifuge feed pumps
- Overflow from the raw water inlet structure, the sedimentation basins, the waste washwater equalization basins and the solids thickeners

The lagoons will have outlet facilities that can be drained to the waste washwater pump station to return to the presedimentation basins, or the basins can be used to just contain the particular stream. Solids will need to be removed with a front-end loader after being drained and dried.

6.4.11 Washwater Equalization

6.4.11.1 Design Considerations

The Waste Washwater Equalization (WWEQ) Facility is intended to contain process return flows and certain overflow streams. This facility is comprised of two 100,000 gallon equalization basins and a pump station with three, 950 gpm vertical turbine pumps (two duty and one standby pump) to return flow to the raw water pipeline prior to the presedimentation facility.

Operations Scheme

For the design and operation of the plant, the following models were developed to illustrate the flows in and out and the total volume in the basins under different flow conditions. Two peak flow scenarios and one low flow scenario are shown.

The first scenario (Figure 6.4-5) illustrates a peak flow condition where reclaimed water is returned to the presedimentation facility at a low, but steady, rate. In this figure, there is a 10 minute GAC backwash cycle at the beginning of the scenario and constant membrane backwash and reclaimed water from the solids handling facility. Ten minutes before the GAC backwash cycle begins, two pumps operate at 100 percent to convey the washwater to the presedimentation facility at a flow rate of 1,900 gpm. In this scenario the basin volume never exceeds 60,000 gal and the basin is at a volume of 30,000 gal within 6 hours. The basins were sized at 100,000 gal each to provide storage volume in extreme events that would require several GAC backwash cycles in one day or other increased return flow scenarios.

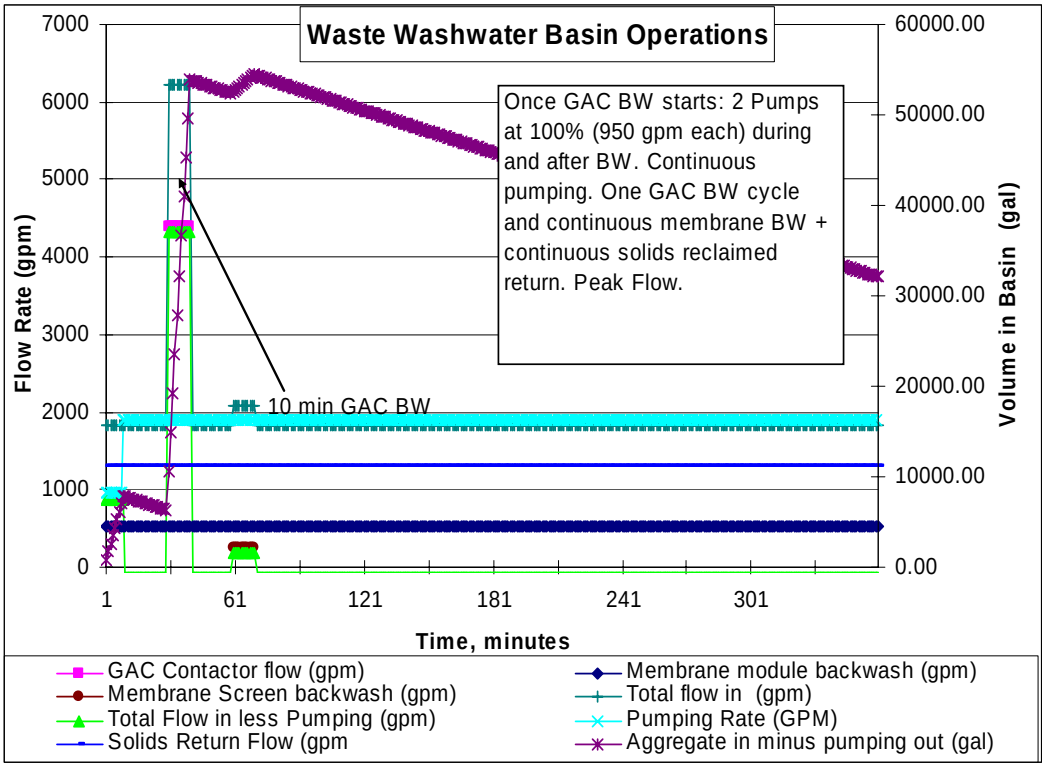


Figure 6.4-5 Peak Flow WWEQ Scenario Using 2 Pumps

In the following scenario (Figure 6.4-6), three return pumps are operated at 100% duty to rapidly drain the washwater equalization basins. The return flows from the membrane, GAC, and solids facility are the same as in the previous scenario. Three pumps are operated for approximately 30 minutes, which drains the WWEQ basins to a volume of 25,000 gal. Following this, two pumps operate at 100 percent to bring the basin volume to below 5,000 gal within 6 hours. The volume in the WWEQ basin exceeds 60,000 gal only in the first minutes of backwash. This scenario illustrates a rapid draining of the WWEQ basins which may be required if the raw water has elevated solids concentrations causing the sedimentation basins and membranes to generate extreme solids streams.

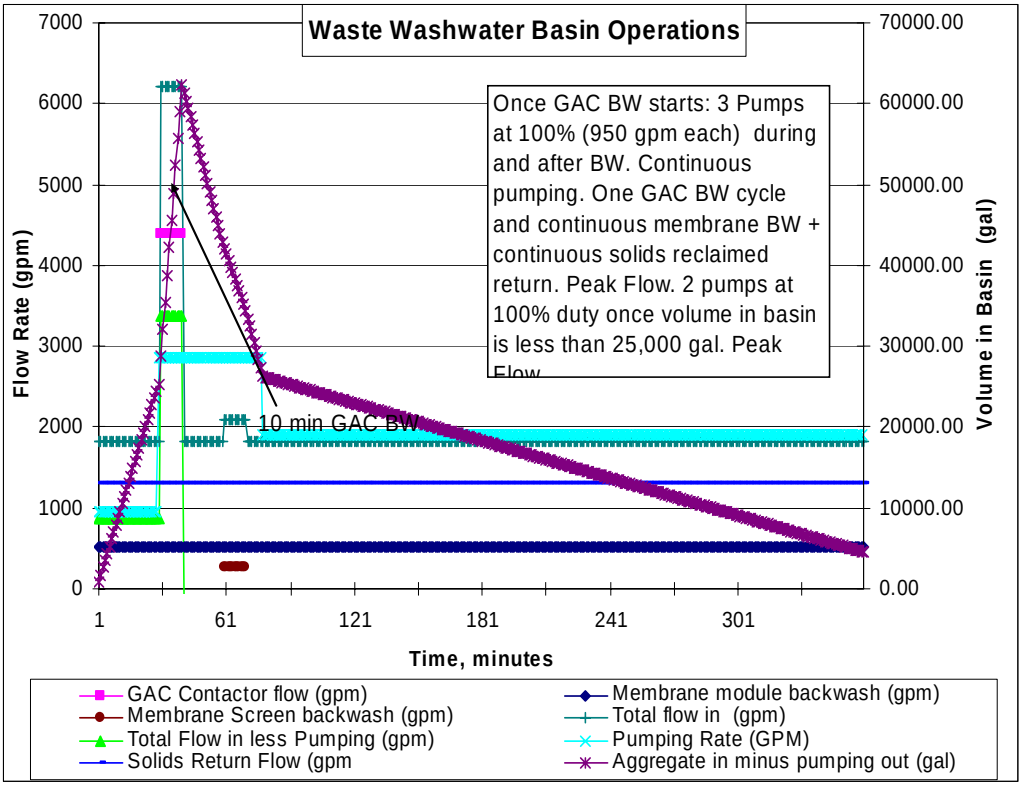


Figure 6.4.6 Peak Flow Scenario Using Three Pumps

The final scenario, shown in Figure 6.4-7, displays return flow conditions when the C/CWTP is operating at minimum demand requirements. In this scenario, the constant return flows from membrane backwash and the solids facility are approximately one-third of the peak demand flows and one GAC backwash is performed. When the GAC backwash is initialized, one return pump starts and operates at 100 percent for approximately 1 hour to bring the basin volume below 25,000 gal. Following this, the pump is turned down to 50 percent and within 4-1/2 hours the basin is nearly empty.

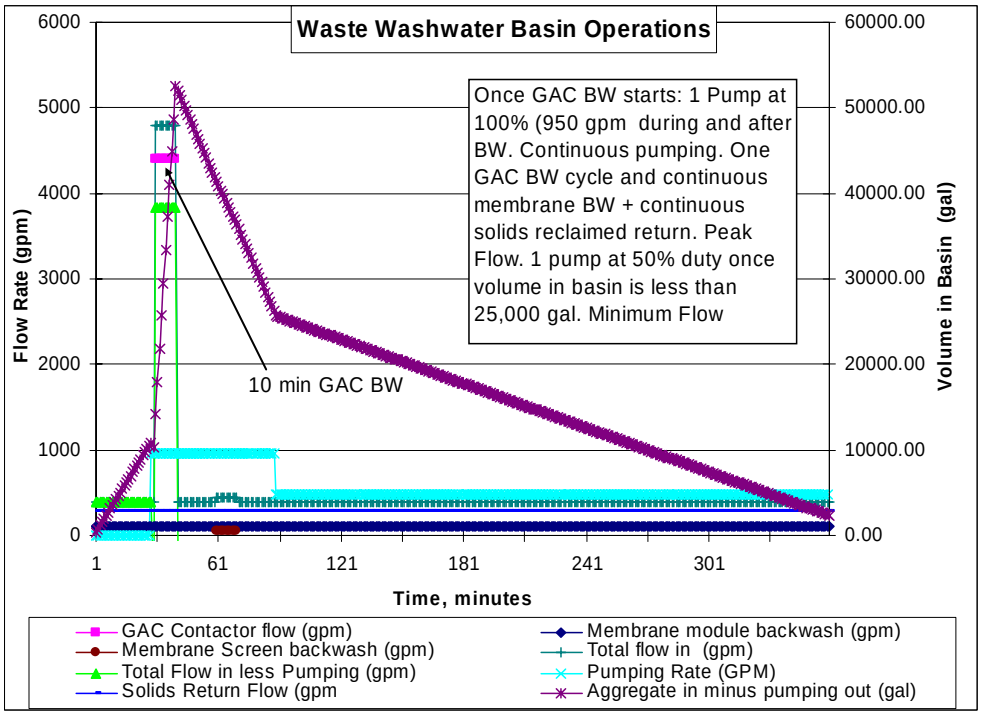


Figure 6.4-7 Minimum Flow Scenario Using One Pump

The scenarios presented in Figure 6.4-6 through 6.4-8 are examples of operations of the WWEQ facility. Actual operation will differ depending on water quality conditions and operations preferences.

Facility Design

The WWEQ basins will be constructed of reinforced concrete with steep sloped conical bottoms. Solids handling facility site layout will be such that decant from the solids thickeners and centrate can flow by gravity into the WWEQ basins and the basins can overflow into the solids lagoons as needed. The pump station and wetwell will be enclosed while the basins will be outdoors.

Inlet flows to the WWEQ facility all flow via gravity to the basins. Basins will be configured so that each can be operated independently for maintenance or cleaning. Manually operated slide gates at the inlet to the wetwell will allow for isolation of the individual basins.

Inlet to the basins will create a passive mixing system to reduce solids buildup in the basins. The bottom of each WWEQ basin will be sloped (approximately 30 percent) to provide complete drainage of solids from the basins for conveyance to the raw water equalization facility via the WWEQ pump facility. If the basins are constructed using a conical bottom, the pipe section to the wetwell will have adequate slope to allow for complete drainage of solids under all flow conditions. Monitor-type water cannons will be provided for each basin to facilitate the cleaning of basins as needed.

6.4.12 Finished Water Storage

The finished water storage facility will be comprised of two 4-MG welded steel storage tanks, a distribution manifold to BS4A and BS5A, and the related piping and appurtenances required for operation of the facility. Space will be provided for a third future 4-MG tank in the same area.

6.4.12.1 Storage Tank Design

Based upon the hydraulic grade developed for the C/CWTP, the floor elevation for the finished water storage tanks is approximately 6480 feet, if a 28-foot water depth in each tank is used.

The welded steel tank will be fabricated on site according to the Technical Requirements and the DB Contractor's design. The minimum steel plate thickness will be 1/4 inch. Each tank will have a fail-safe vent system to prevent rapid draining causing damage to the tanks.

Each tank will have a minimum of two access manways at locations appropriate for maintenance at ground level and one access hatch on the roof for inspection. Hatches and manways will be a minimum of 30 inches square.

Level elements will be provided in each of the tanks for inventory, alarm and control of equipment. Sodium hypochlorite and sodium hydroxide will be injected upstream of the tanks for disinfection and pH adjustment. Downstream of the tanks will be analyzers for indication and control of the feed systems.

The Technical Requirements also provide allowable alternatives for the DB Contractor's design of the storage tanks. These alternatives include a prestressed design and a reinforced concrete design.

6.4.12.2 Storage Tank Performance

Storage tanks will have a service life equal to all other major facilities at the C/CWTP with a epoxy re-coating frequency of approximately 20 years. Exterior urethane topcoats will provide UV protection for approximately 5 to 10 years, at which time the Owners may elect to re-coat for aesthetic purposes.

Upon completion of tank construction and following coating, the DB contractor will demonstrate that the finished water storage tanks exhibit no detectable leakage.

6.4.12.3 Water Distribution Manifold

The water distribution manifold will have connections for all current and future booster station pumps, chemical injection booster pump lines, and water quality sampling ports. The manifold will convey finished water to Booster Station 4A/5A which is an enclosed pump station with booster pumps, sprinkler pumps, membrane backwash pump, and connections for the utility water, potable water and yard hydrant systems. Design criteria for the booster station are included in Section 7.4

6.5 Recommended C/CWTP General Requirements

6.5.1 Civil and Site Work

6.5.1.1 Site Layout

Description of Site

The C/CWTP will receive greater traffic and heavier loads than the other sites and the civil requirements reflect the increased stresses on the facility.

To provide for potential future facilities, the Preliminary Design Drawings include site drawings with the preliminary arrangement of the treatment plant facilities. The plant process basins will be arranged to allow for the potential future addition of process units. Through discussions with the Owners, it is not anticipated that there will be a significant increase of the plant's capacity in the near future. However, future unanticipated regulations may require the additional of different processes or chemicals. The plant yard piping will be laid-out to accommodate the addition of future processes.

The plant site has been laid out in the Preliminary Design Drawings with the following features:

- A single entrance point into the site that can be monitored
- Asphaltic paved roadways throughout the plant with gravel roads around the perimeter, where not serviced by paved roads, and gravel roadways around the presedimentation basins
- Secondary access gates for staff and deliveries to keep the general public from entering the process and chemical handling areas within the site
- Layout of the process from east to west, following the downhill gradient of the site, to utilize gravity flow as much as possible
- Stormwater catchment ponds, solids lagoons and finished water reservoirs on the downhill side of the site

- Finished Water Reservoirs on the west side of the site where the taller tanks will not impact sight lines
- Operations Building adjacent to the major process buildings for ease of access to accommodate frequent staff rounds
- Chemical Building central to the process areas for dispersion of chemicals and monitoring of chemical deliveries
- Maintenance Building located on the south side of the site, away from the Operations Building to allow adequate spare for vehicle and equipment maintenance and parking

Access to Facilities

Entrance to the C/CWTP will be provided via an access road off of Caja del Rio. To enter the site, a motorized access gate with a card reader, intercom and camera, will provide a greater level of security and monitoring capability. The existing utility corridor road modified for the plant access. The plant access road will be of the heavy-duty type with a 24-ft wide paved surface suitable for two-way traffic. Other access roads within the C/CWTP will be of the medium-duty type suitable for two-way traffic.

The plant roadways will have curb and gutters in the process area and chemical area that direct rainwater to numerous drainage inlets for conveyance to an on-site storm water catchment basin. Other roadways will be sloped to drainage ways to convey flows to the catchment basin. The paving and grading plan for the C/CWTP is included on Sheets C-4 through C-8 of the Water Treatment Plant Preliminary Design Drawings.

Site sidewalks will comply with the ADA and UFAS and will have the least possible slope. The maximum slope will be 1:12 and the maximum rise for any run will be 30-inches. The maximum cross-slope will be 1:50. Parking areas will be as indicated on the Preliminary Design Drawings for this site. A minimum of two parking spots for the disabled will be provided in accordance with the ADA and UFAS.

Relation of Facilities

Utility services required at the C/CWTP include electricity, gas, water, and telecommunications. A standby/emergency generator will be provided to power lights, instrumentation, and controls as well as allow a controlled shut-down of the facility. The C/CWTP will have a system for using natural gas provided by PNM at this site for heating and hot water services. A standby/emergency generator will also be provided to power a fire protection pump for the sprinkler systems in the event of fire during a power outage.

Traffic and Security

The site roads, sidewalks, parking and traffic circulation at the C/CWTP will be medium-duty type and for two-way usage, except for one-way roads in lesser traveled areas of the plant. The existing utility corridor road will be upgraded between Caja del Rio Road and the C/CWTP. The plant access road for use by chemical delivery trucks will be of the heavy-duty type and wide enough for two-way usage. Motorized access gates will be provided at the site. Additional security details are included in Section 6.5.11. Public access to the site will be restricted and controlled by gates at the plant access point and within the plant.

6.5.1.2 Yard Piping

Piping at the C/CWTP will convey process water, finished water and chemicals between the various process units. All piping in contact with water will be constructed of NSF-61 approved materials. Welded steel pipe with mortar coating and mortar lining will make up most of the yard piping, though ductile iron piping and other types will be used as necessary for the processes. Hazardous chemical pipes will be secondarily contained within containment piping. Backflow prevention valves will be installed on all connections to the finished water and potable water pipelines.

6.5.1.3 Stormwater

The C/CWTP includes a sizable amount of impermeable surfaces. Storm drainage will be collected and detained in storm water detention basins located on the downhill side of the site. The storm water detention basins will be designed to hold the 100-year rainfall event with 3-ft of freeboard and shall be sized in accordance with the Santa Fe County LUD development requirements to limit site run-off to pre-development flow rates. The DB Contractor will be responsible for the design of the stormwater system based on its plant layout.

On each side of the Chemical Building, sloped concrete pads with grating will be used to capture chemicals in the event of a spill during off-loading of chemicals. The off-loading pads will drain to a containment vault with a downstream valve that will be normally open to allow stormwater to drain to the catchment basin. When off-loading chemicals, the valve will be closed. In the event of a spill, material will be capture in the containment vault where it can be pumped out for disposal or reuse.

6.5.1.4 Sanitary System

The sanitary system at the C/C WTP will be comprised of an on-site septic system. The septic system design will comply with all NMAC Title 20 Chapter 7 Part 3 Liquid Waste Disposal and Treatment requirements. The system will be designed to accommodate liquid waste from the following C/CWTP sources:

- Restroom fixtures and showers
- Breakroom kitchen sink and dishwasher
- Uniform washing machine
- Drinking fountain drains
- Non-hazardous laboratory sample sinks

The C/CWTP will be operated by a maximum of 15 employees with a flow size unit of 35 gallons per day per employee. Flow from occasional visitors is conservatively estimated to be 32 gallons per day. The total anticipated flow from the facility is 552 gallons per day. The septic tank capacity will be approximately 1,500 gallons to accommodate 1.5 times the design flow.

Based on boring test holes conducted at the site, the soil is Type IV sandy clay (AR = 5 sf per gallon per day). For this type of soil the system will require secondary treatment with a low pressure dosing disposal system. Standard requirement for secondary treatment are as follows:

- BOD_5 - < 60 milligrams per liter, < 30 milligrams per liter 6-sample rolling average
- TSS - < 60 milligrams per liter, < 30 milligrams per liter 6-sample rolling average

Based on the design flow, the leachfield absorption area is 3,310 sf, however the required area is reduced to 1,932 sf since secondary treatment is required. The leachfield will consist of a low pressure distribution box, a single pump, and 3 pipe and gravel trenches. The trench dimensions will be 3-ft wide by 100-ft long. The trench depth will consist of 3-ft of gravel below the pipe to incorporated side wall credits. The leachfield will provide a total absorption area of 2,100 sf. Two leachfields will be used at the plant: one for the Operations Building and a smaller system for the Maintenance Building.

6.5.2 Landscaping/Revegetation

6.5.2.1 Landscape design

Plant materials selected for the landscaping at the C/CWTP are indigenous to the Santa Fe pinon-juniper zone. These plants will blend in well with the existing vegetation and are more easily established in the area. The goal of the landscape design is to soften the edges of the structures by providing some camouflaging by strategically locating trees and shrubs. An irrigation system will be designed and installed to keep the area immediately surrounding the Operation Building thriving. In addition, a temporary irrigation system will be designed and installed for the purpose of establishing the reclamation seeding. Every effort will be made to harvest the storm runoff from the structures and direct it to groups of plantings to supplement the irrigation. Swales may be used to capture and direct rainwater to the plants. Trees and shrubs will also provide shade, cooling the facility in the summer as well as serve as windbreaks. Excavated boulders will be included in the landscaping to blend with the surrounding environment.

6.5.2.2 Revegetation

The majority of the land at the C/CWTP will receive reclamation seeding with a specially selected seed mix from the BLM. Seeding will take place on all disturbed areas that are not to be paved. A recommended seed mixture is included as Table 3.2-4 in Section 3.

6.5.3 Geotechnical

Alluvium and various members of the Santa Fe Group underlie the majority of the Project facilities. The Santa Fe Group is a series of unconsolidated Quaternary age sedimentary units. The lithology and cementation of the units composing the Santa Fe Group range widely, from claystone and siltstone to sandstones and gravel/conglomerates. Most of the visible units within the Project area and records of previous nearby investigations indicate that the bedrock units within the area are generally weakly-cemented, and generally pose little difficulty to excavate using conventional drilling and earthwork equipment. Occasional cobbles and boulders will probably be encountered. The complete description of the site is provided in Appendix A – Geotechnical Investigations Report.

6.5.3.1 Geotechnical Recommendations

For the C/C WTP buildings, structures may be supported on conventional spread and strip footings bearing on a minimum of 5-ft to 6-ft of structural fill. The structural fill should extend a minimum of 3-ft laterally beyond the edge of all footings. The foundations may be designed to allow a bearing pressure of 1,500 to 2,000 psf, depending on the area.

The base of exterior footings should be embedded a minimum of 24-inches below the lowest adjacent grade. The base of the footings should be embedded a minimum of 12-inches below the

finished pad grade. The spread and strip footings should be a minimum of 24 and 18-inches wide, respectively.

Lateral foundation loads will be resisted by a combination of passive soil pressure against the sides of the footings and friction along the base. A passive soil resistance of 300 pcf may be utilized.

Prior to fill placement and following footing excavation, the natural soils should be scarified to a depth of 8-inches and moistened to a near optimum moisture content (±3 percent). The exposed soils should then be compacted to a minimum of 95 percent of maximum density. Prior to pouring concrete, footing excavations should be cleaned of any slough, loose soil, or debris. However, it is important to note that backfill compaction adjacent to walls should be performed using relatively light, hand-operated equipment to prevent overstressing the wall and excessive lateral deflections.

Foundations designed and constructed by the DB Contractor are not anticipated to settle more than one-inch. The DB Contractor's design and construction must allow for minor settle of foundations. Vibratory equipment, including pumps, will require mounting on isolated equipment pads to minimize settling.

For building floor slabs, a concrete slab-on-grade may be used. The slabs should be isolated from all foundations, stem walls, wet walls, vibratory equipment and utility lines. Frequent joints should be scored or cut in slabs to control the location of cracks. The slab should bear on a minimum of 5-ft of structural fill. Prior to placing the slab or structural fill, the natural soils should be stripped of vegetation, scarified to a depth of 8-inches, and moistened to a near optimum moisture content (±3 percent). The exposed soils should then be compacted to a minimum of 95 percent of maximum density.

Thickened slabs may be utilized to support interior partitions. The thickened slabs should be a minimum of 12-inches in width and should be designed by the DB Contractor to exert a maximum earth pressure of 500 psf.

If a moisture-sensitive floor covering is utilized, the slab should be underlain by a moisture barrier to prevent "damp slab" conditions. The moisture barrier may consist of a 6-mil polyethylene film or equivalent. The barrier may be overlain with one or two-inches of clean sand to provide a working surface and reduce shrinkage cracking.

The above items are general recommendations. It is the DB Contractor's geotechnical engineer's responsibility to develop recommendations and criteria for the design and construction of the facilities and structures.

6.5.3.2 Presedimentation Basins

The Presedimentation Basin embankment walls will be less than 10-ft above the exterior existing grade of the embankement. The basins will be lined with steel reinforced gunite. The bottom of the basins will be constructed of reinforced concrete. The DB Contractor will need to install the ponds with side slopes no steeper than 1.5:1 (horizontal:vertical).

The natural soils in this area are composed of sandy clay. These soils will expand and contract upon an increase or decrease, respectively, in moisture content. If reinforced gunite is used, some distress to the lining due to expansion and contractor of the underlying soils will occur. To reduce moisture content fluctuations of the underlying soils, an impermeable liner and subdrain should be installed below the gunite and concrete bottom.

6.5.3.3 Subdrain Systems

To prevent the build up of hydrostatic pressures, a subdrain system should be installed below any wet wells or below grade facilities. At the bottom of the overexcavation, the ground surface should be sloped to drain out from below the structure to a minimum grade of 2 percent. A 6-inch thick layer of clean sand should be placed over the bottom of the excavation. The clean sand should be covered with a non-woven filter fabric.

A subdrain pipe should be installed by the DB Contractor around the perimeter of the structure. The subdrain should be 4-inch diameter perforated PVC pipe. The perforated pipe should be wrapped in a non-woven filter fabric. The perforated pipe should be embedded in a minimum of one cubic foot of pea gravel per linear foot. The subdrain should discharge to a positive gravity outfall or to a watertight sump with a float-activated pump. The discharge line should be solid pipe.

6.5.3.4 Retaining Walls – Incidental or Architectural

Incidental or architectural retaining walls constructed in conjunction with this Project are not to exceed 5-ft in height. If higher walls or unusual loading conditions, such as sloping backfill, slopes below retaining wall footings, or surcharges, are anticipated, additional geotechnical investigations will be required by the DB Contractor.

Foundations for small retaining walls may be designed by the DB Contractor for an allowable bearing pressure of 1,500 psf. Retaining wall footings should be a minimum of 18-inches wide and should be embedded a minimum of 24-inches below grade. Retaining wall footings at the C/CWTP site should bear on a minimum of 3-ft of structural fill. Additional details, including loading values, can be found in the attached report.

Compaction information can also be found in the attached report. However, it is important to note that backfill compaction adjacent to walls should be performed using relatively light, hand-operated equipment to prevent overstressing the wall and excessive lateral deflections.

To prevent staining of concrete, the back of retaining walls should be waterproofed prior to backfilling. Weep holes should be constructed near the base of the exterior walls and/or performated drain piping used on the backside of the walls.

6.5.3.5 Leach Fields

The soil types in the C/CWTP area include sandy clays. Therefore, an application rate of 5 sf per gallon per day should be used by the DB Contractor for design and installation of the leach field. This may require non-conventional systems to be installed.

The DB Contractor should review the geotechnical report and the current NMEIB regulations thoroughly when designing the on-site liquid waste disposal systems for this Project. However, in general, the leach field will be located down slope from and a minimum of 15-ft from the structures. This recommendation is intended to reduce the potential from moisture from the leach fields infiltrating into the soils below the structures. Refer to Section 6.5.1.4 for preliminary design criteria for the sanitary system.

6.5.3.6 Asphaltic Concrete Pavement

The criteria for pavement design is shown in Table 6.5-1.

Table 6.5-1 Pavement Design

Location	Asphaltic Concrete Thickness (inch)	Aggregate Base Course Thickness (inch)
Automobile Parking	3	4
Automobile Driveways	3	4
Areas Subjected to Semi-Trucks	5	10

Due to the clay and silty sand soils at the C/CWTP site, a minimum of 12-inches of granular subgrade soils should be placed below the base course. Granular subgrade and compaction requirements should meet the criteria as detailed in the attached report.

The aggregate base course should consist of Class I or Class II material as specified in Section 304 of the *New Mexico Department of Transportation (NMDOT) Standard Specifications for Highway and Bridge Construction*. Base course will require compaction to a minimum of 95 percent maximum density.

The asphaltic concrete should be Class B as described in Section 401 of the *NMDOT Standard Specifications for Highway and Bridge Construction*. The asphaltic concrete should exhibit a minimum Marshall stability of 1,800 pounds and should be compacted to a minimum of 96 percent of maximum Marshall density.

If a gravel-surfaced roadway is used at the C/CWTP for lightly traveled areas, a minimum of 6-inches of aggregate base course should be used. The minimum thickness of the base course should be increased to 8-inches for gravel roads supporting heavy truck traffic. The Owners will be required to periodically blade the roads and/or apply additional base course. However, if the subgrade soils become saturated, the gravel roads may not support heavy trucks.

Prior to placing the base course or concrete, a soil sterilant should be applied. Application will follow the manufacturer's instructions.

The site will be graded to prevent saturation of pavement subgrade soils. If the soils supporting the pavement increase in moisture content the ability to support the pavement is significantly reduced.

Semi-truck parking areas, loading docks, and areas around refuse dumpsters will be paved with Portland Cement Concrete (refer to Section6.5.3.7 – Portland Cement Concrete).

Periodic pavement maintenance, consisting of crack cleaning and sealing, should be performed by the Owners to extend the pavement life. Seal coating(s) may also be used by the Owners after the pavement has been in service for several years to improve appearances and increase pavement life.

6.5.3.7 Portland Cement Concrete

The semi-truck parking areas, loading docks, and areas around the refuse dumpsters will be paved with Portland Cement Concrete. A minimum pavement thickness of 7-inches will be used for either un-reinforced or reinforced concrete pavements. A minimum of 6-inches of aggregate base course should be placed below the pavement.

The aggregate base course should consist of Class I or Class II material as specified by Section 304 of the *NMDOT Standard Specifications for Highway and Bridge Construction*. The base course should

be compacted to a minimum of 95 percent of the maximum density. To minimize settlement and maintenance of the pavement, all fill over utility lines should be placed and compacted.

If truck loading docks will be sunken below the surrounding grade, positive drainage to storm sewers or sump pumps should be utilized to promptly drain the loading docks. "French drains" should not be utilized by the DB Contractor.

6.5.4 Structural Recommendations

These structural requirements provide minimum design criteria and will be used as a guide in the design and construction of all facilities.

The general types of construction will be as follows:

- Cast-in-place concrete or prestressed concrete for liquid containing basins or reservoirs.
- Masonry walls with steel roof for buildings.
- Steel or FRP tanks for chemical tanks.

Foundations of structures will be designed in accordance with the data presented in the project geotechnical report and as recommended by the DB Contractor's geotechnical engineer. In general, the type of foundation for structures will be as follows:

- Mat foundations or continuous spread footings along the walls with slab-on-grade at the center portions for the liquid containing basins or reservoirs
- Continuous spread footings along the walls for masonry buildings
- Ring wall footings or mat foundations for steel tanks
- Concrete pads for chemical storage tanks

Complete structural design requirements are included in the Technical Requirements.

6.5.5 Architectural Design for Water Treatment Facilities

6.5.5.1 Design Standards

All buildings for the BDD Project will be designed to meet the 2004 New Mexico General Construction Building Codes (Title 14 NMAC – Chapters 5 and 7). The buildings must also comply with the requirements of the BLM. In addition, the Operations and Maintenance Buildings are to be designed to achieve a LEED Certification based on the requirements of the U.S. Green Building Council LEED Rating System.

6.5.5.2 Space Planning

The space planning for Operations and Maintenance Buildings was achieved through several iterations of an architectural programming document that included tabulation of spaces to be included along with individual area requirements for each space on the list. Each iteration of the programming document was reviewed with the Owners' staff in a series of workshops, and workshop comments were then incorporated into the next iteration. The programming document was subsequently developed into a building layout plan to establish space relationships and a building footprint. The resulting layout plans have been reviewed by the Owners' representatives and are included in the Technical Requirements and the Preliminary Design Drawings.

The space planning for other buildings at the C/CWTP was based on the needs and functions of the process and equipment.

6.5.5.3 Architectural Style

In the process of designing the buildings for the BDD Project and establishing the Technical Requirements, the project architect prepared sample elevations of indigenous "Contemporary Pueblo Style" and "New Mexico Territorial Style" for the Owners' review and selection. Based on the Owners' preferences, a Territorial style will be used for all of the buildings at the C/CWTP site.

The general characteristics of Territorial Style include:

- Low-slope (two percent) roof with surrounding wall parapets with double row (soldier and rowlock) grade SW clay brick parapet caps in traditional reddish-brown natural clay color
- Exterior wall finish of actual or simulated sand-finish stucco in a light tan color
- Wood trim around windows with a pediment head detail painted white
- Wood post-and-beam supports painted white for covered porches and recessed entries

The colors designated above are traditional Territorial Style colors and must be submitted to the BLM for approval since the C/CWTP is located on that agency's property. The elements cited above for Territorial Style are easily applicable to all of the buildings at the C/CWTP site. This style will also suit the architectural style requirements of the BLM. Application of Territorial Style is illustrated in the Preliminary Design Drawings and Figure 6.5-1.

Figure 6.5-1 Example of Territorial Style Operations Building at the C/CWTP

6.5.5.3 Architectural Construction Requirements

In the process of designing the buildings for the Buckman project and establishing the Technical Requirements, the project architect in collaboration with the process design engineers proposed general requirements for the enclosing shell and the interior finishes and furnishings for the buildings in the project. The buildings are to be constructed of reinforced concrete, precast concrete panels or CMU masonry block. A textured colored stucco finish is to be applied to all buildings. The roofing system will be comprised of a gravel-surfaced 20-year bondable built-up membrane system.

6.5.6 Electrical

6.5.6.1 Electrical Design Approach Overview

Design and construction of the C/CWTP will be required to provide an electrical system which is the heavy-duty, industrial type incorporating quality, reliability, redundancy, energy efficiency, maintainability, safety, and Owners' requests. Design and construction for this facility will be similar to requirements and methods normally applied to municipal water and wastewater treatment plants.

6.5.6.2 Redundancy and Versatility Criteria

The electrical system will be designed for redundancy, reliability and versatility. The following guidelines will be used:

- Dual incoming PNM 12.47kv services each with its own primary metering and secondary selective distribution circuit arrangement
- Dual bussed high voltage (12.47kv) main switchgear with two main and a tie circuit breaker
- Dual 12.47kv distribution feeders to a full capacity 12.47kv-480/277v double-ended substation for each or group of process areas
- Dual bussed low voltage (480-volt) switchgears with two main and a tie circuit breaker and feeder breakers to large VFDs and MCCs
- Dual MCCs, one powering or controlling duty equipment and one for the equivalent standby equipment, one set of process trains on one MCC, the other set on second MCC

With this arrangement, if any one piece of the equipment or one set of the cables fails or is de-energized for maintenance, it will not shut down the entire C/CWTP.

6.5.6.3 Service

The electrical services for the C/CWTP will be a dual 12.47kv 3-phase primary from separate PNM underground feeders for redundancy and reliability. One service will be connected to one of the new feeders from the new Caja del Rio Substation which will be located near the C/CWTP. The second feeder will be connected to another new feeder from the same substation. Each will be separately metered at 12.47kv. If one PNM feeder fails, the entire facility will have the capability to be served by the other.

The PNM switchgears and meter cabinets will be located within an outdoor wall-barriered area for protection from vandalism.

6.5.6.4 Plant Loads

The loads at this C/CWTP will be rated either at 480, 208, or 120 volts. Since the motors are rated at 300 hp or less, a 480 volts, 3-phase system was selected for the utilization voltage. Table 6.5-2 is an electrical load list for the various processes and facilities at the C/CWTP. The electrical loads for the finished water facilities are listed in Section 7.

Table 6.5-2 Estimated Electric Loads for the C/CWTP

Facility/Process	Estimated Connected HP or KW
Raw Water Equalization/Pre-Sedimentation Basins	7 hp + 1 KW
Raw Water Metering	2 hp + 1 KW
Flocculation and Sedimentation Basins	598 hp + 42 KW
Membrane Filtration System (assumes pressure system)	111 hp + 78 KW
Ozone Facilities	40 hp + 212 KW
GAC Contactors	86 hp + 34 KW
Solids Thickening and Dewatering Facilities	596 hp + 36 KW
Chemical Storage and Feed Building	38 hp + 20 KW
Operations Building	20 hp + 64 KW
Maintenance Building	11 hp + 63 KW
Main Electrical Building	3 hp + 5 KW
General Site/Yard	2 hp + 15 KW
Total	1,515 hp + 572 KW

6.5.6.5 Power Distribution

Electrical power will be distributed from the 12.47kv main switchgear in the Electrical Building to four 12.47kv-480/277v double-ended substations located at different process areas due to the large loads at different areas of the C/CWTP. Dual 12.47kv feeders from the main switchgear bus A and bus B will be routed within the C/CWTP via underground duct bank and handhole system. Feeder cables from the switchgear bus A will be separated from the bus B feeders for reliability and redundancy. Two sets of handholes, A and B, will be provided to isolate the A and B feeder cables.

6.5.6.6 Standby Power

Standby power for only the fire pumps and the Administration and Operations Building will be provided. Whenever the normal 480-volt power supply to BS4A and BS5A where the fire pumps are located is lost, the standby diesel engine-generator set (E-G) will be started to provide backup power to the two fire pump controller panels which are provided with their own automatic transfer switches. For further discussions on the fire pump E-G, see Section 7.

Whenever the normal 480-volt power supply to the Administration and Operations Building is lost, the E-G will be started to provide backup power via the automatic transfer switch to the building MCC. The E-G rated for at least 150 KW will power the building electrical loads during power outages. With standby power, critical systems such as the plant SCADA, communication, security, etc., will continue to operate and personnel in the building will be able to continue occupying and carrying on with their duties.

Both E-Gs will be of the diesel engine standby rated type and will be de-rated for the higher altitude of the plant. The generators will be oversized to accommodate pump motor starting and/or harmonic producing loads. The diesel tank for the 150 KW E-G will be the double-wall base-mounted type with a 200-gallon capacity.

A New Mexico Air Quality Notice of Intent Permit has been obtained for the E-G. For compliance with this permit under 20.2.72.202B NMAC, the E-G will be operated only during the unavoidable loss of PNM power and during periodic testing. The E-G will be allowed to operate less than 500 hours per year and must be accompanied by sufficient record keeping by the Owners to verify that the generator is operated less than 500 hours per year.

6.5.6.7 Major Electrical Equipment Criteria

Major pieces of electrical equipment for the C/CWTP will be sized for power handling capacity to accommodate initial and known future loads plus a minimum reserve capacity of 25 percent. Transformers will have an additional 12 percent capacity when they are operated at 65 degree C rise, instead of at 55 degrees. By adding fans to the transformers, they can provide about an additional 13 percent capacity for a total of 25 percent. Pieces of equipment will be required to be de-rated for the plant elevation of 6,500-ft amsl so that they will be over-sized to provide the required capacity and/or rating.

The electrical system design will incorporate the use of copper conductors, busses, terminals, windings and splices. The use of aluminum conductors, lugs, etc., will not be permitted since they will reduce reliability and increase maintenance requirements.

Pieces of equipment will be designed, built and tested to applicable NEMA, ANSI/IEEE and UL standards.

12.47kv Main Switchgear

Each PNM service will feed an indoor 12.47kv main switchgear with cables in conduits. The switchgear will be furnished with two main circuit breakers, a tie circuit breaker and feeder circuit breakers for the double-ended substations with 12.47kv-480/277v transformers located at different parts of the C/CWTP.

The high voltage switchgear main, tie and feeder circuit breakers will be the draw-out, electrically operated vacuum type. The main and tie circuit breakers will be controlled by an automatic transfer system to provide automatic switch over of power in case there is a power failure on the upstream side of one of the switchgear main circuit breakers.

Double-ended Substation

Two feeders from the main switchgear will supply each side of a double-ended substation with fully rated 12.47kv-480/277v pad-mounted oil-filled or indoor transformers protected by vacuum circuit breakers located in an adjacent weatherproof housing. The transformer secondary at 480/277 volts will feed each side or bus of the low voltage switchgear or the low voltage MCCs located in the major electrical load areas of the C/CWTP.

Low Voltage Switchgears

Each transformer secondary of the double-ended substation will supply power to one side of the low voltage switchgear which will be furnished with two main circuit breakers, a tie circuit breaker and feeder circuit breakers for the MCCs. The switchgear main, tie and feeder circuit breakers will be the draw-out, electrically operated power air type.

Automatic Transfer Switches

Each ATS will provide 480-volt power from either MCC A or MCC B to the dry-type transformer. The normal source will be designated as the power from MCC A and the standby source as from MCC B. If the power from MCC A fails, the ATS will automatically switch to the MCC B power, if available, after a time delay.

Panelboards

Because of the ATSs, the 208/120-volt, 3-phase, 4-wire panelboard for miscellaneous loads, lights, and receptacles and the 240/120-volt, single phase, 4-wire panelboard for instrument loads will be fed from either the A or B source for reliability. The dry-type transformer for the instrument panelboard will be the noise isolation type to provide clean power to the instruments.

6.5.6.8 Variable Frequency Drives

VFDs for the pumps and other process pieces of the equipment with motors 50 hp and above will be the 480-volt, 18-pulse clean power type in packaged free-standing NEMA 1 enclosures each with an incoming circuit breaker. The 18-pulse VFDs will be used to mitigate their harmonics generation and allow compliance more easily with PNM and IEEE 519 Standards requirements. Reduction of harmonics will minimize harmful effects on the plant distribution system such as overheating of equipment and introducing interference to sensitive electronic equipment. VFDs will be furnished with an output filtering system to minimize the damaging effects on the cables and motor insulation due to over-voltage and dv/dt conditions.

VFDs for the smaller motors will be the 6-pulse type. They will be furnished with incoming inductors to lessen the harmonics.

6.5.6.9 Motor Control Centers

MCCs will house main circuit breaker, combination breaker-motor starters, and feeder circuit breakers for the VFDs, package process equipment and 480-208/120 and 480-240/120 volt dry-type transformers for panelboards. Breakers and starters for the multiple process equipment and pumps of each type will be located in different MCCs so that the failure of one MCC will not shut down the portion of the C/CWTP.

6.5.6.10 Underground Conduit System

Underground conduit systems will be a minimum 2-inch diameter, Schedule 40 PVC conduits encased in concrete. All ductbanks, except those for area lighting, will have steel reinforcement. Concrete handholes will be provided as necessary for ductbank entry into buildings and structures and for change of direction.

All conduits originating from buildings and structures and terminating in handholes will be sealed with conduit sealing bushings to prevent moisture transmission, rodents and snakes entering into enclosures, panels, buildings and structures.

6.5.6.11 Exposed Conduit Systems

Exposed conduits inside and outside will be the hot-dipped GRSC type. Conduits located over water and in contact with the soil will be the PVC bonded GRSC type.

6.5.6.12 Wires and Cables

Low Voltage (600-Volt) Wires and Cables

600-volt cables for control and power, No. 8 AWG and smaller, will have Type XHHW insulation. Power cables No. 6 AWG and larger will have Type RHW-USE insulation. Conductors will be the stranded copper type.

Minimum size conductor for 120 volt or greater power circuits will be No. 12 AWG. Minimum size 120 volt or greater conductors within control panels and switchboards will be No. 14 AWG.

Terminations for power wires and cables will be made with color-coded wrought copper compression type connectors with lug hole(s) using the tool and die as recommended by the connector manufacturer.

Stranded control conductors will be lugged at terminations except where terminations are made on devices available only with box terminals. Lugs will be the locking spade type. Terminal blocks will be the strap-screw type.

High Voltage (15kv) Cables

15kv cables will be the annealed tinned copper, Class B concentric lay, 133 percent shielded, MV-105 type, insulated with a thermosetting EPR compound over an extruded, non-conducting high dielectric stress control layer, with a semi-conducting shield applied directly over the primary insulation.

All material used in terminating and splicing high voltage cables will be as recommended by the cable manufacturer. Cables will be terminated and spliced in accordance with the kit supplier's drawings.

Rodent-Resistant Cable Coating

In handholes and exposed locations, rodent and fire-resistant coating will be applied to the entire exposed cable and wire surfaces. Cable coating will be required to have been tested successfully for rodent resistance. The specified manufacturer Hy-Tech has a product in which multiple lab studies conducted at New Mexico Tech have verified that the rodents always avoided the treated cable insulation. See additional information in Section 3.

6.5.6.13 Lighting

Light fixtures within buildings and structures will be the fluorescent type with energy-efficient F32T8 tubes and electronic ballasts. LED type exit fixtures with batteries will be provided over doors leading to the outside. Also, emergency lighting fixtures with batteries will be provided for egress during power outages.

Light fixtures located outside will have bullet-proof shields and will be the cut-off type for compliance with the New Mexico Night Sky Protection Act. Light fixtures for illuminating water surfaces within open structures will be the watertight stainless steel fluorescent type controlled by locally mounted switches.

All fixtures will be suitable for 120 vac power, except for the road and parking lot light fixtures which will be at 480 vac.

All lamps will be the green end cap type which has low mercury content for qualifying as non-hazardous by the NMED Hazardous Waste Bureau. The NMED has adopted the Federal Universal Waste Rule and allows lamps to be disposed as normal standard solid waste if the mercury content of each lamp is below the TCLP limit of 0.2 mg/L. Each lamp will be required to have a certification showing it has passed successfully the third party test for TCLP limit for Mercury in accordance with EPA Method 1311 of Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846.

6.5.6.14 Receptacles

Convenience (115 volt) receptacles will be spaced at least every 30-ft in all enclosed process areas and at least every 40-ft in open structure areas with mechanical pieces of equipment.

All convenience receptacles located outdoors, in enclosed process areas, in restrooms, and near kitchen and laboratory sinks will be the GFCI type. Receptacles will have the weatherproof covers outdoors and in areas subject to hose-downs.

In laboratories and kitchens where pieces of equipment and appliances with high wattage ratings may be located, each receptacle will have its own dedicated circuit to prevent nuisance tripping of panelboard circuit breakers.

All convenience receptacles will be identified with labels indicating the originating panelboard and circuit designations.

6.5.6.15 Lightning Protection System

Buildings, superstructures, etc., will be protected by lightning protection systems which will be bonded together and to the plant grounding system.

6.5.6.16 Discussions with Electrical Utility

Discussions, correspondences and meetings have been held with PNM regarding the upcoming project and the required electrical services for the C/CWTP. PNM has developed a preliminary single line diagram, site location, and electrical load data for this plant and is in the process of developing an agreement with the Owners.

In addition, PNM will be building a new 115kv-12.47kv substation, designated as Caja del Rio, near the C/CWTP to meet the electrical demand of the plant.

6.5.7 Instrumentation and Control

6.5.7.1 Performance and Design Criteria

System architecture and improvements must provide some basic functional capabilities required from any selected instrumentation and control (I&C) system approach. The features and capabilities are divided into numerous categories: data highway; system architecture; process controller units; operator workstations; data acquisition and management. The performance and design criteria for each of these elements are outlined in the following paragraphs.

Data Highway

The plant-wide computer system must provide secure operation and limit the effects of subsystem or component failure to an economically justifiable small area of the C/CWTP or processes. The most critical component is the data highway communications system that connects the entire plant processes. Therefore, the system must be provided with redundant communication paths, as a minimum to achieve secure service.

System Architecture

One factor frequently overlooked when considering control system implementation, particularly computer-based equipment, is that the primary intent is to assist the operator. Too often, plant operations are changed to fit the capabilities of the system to such an extent that the whole interaction becomes inefficient. In the treatment plant, operators consider the whole plant as a series of distinct, yet interdependent, sets of processes. Each operator is only responsible for processes that are assigned to them, but they need to understand how their process relates to the others. Therefore, to conform to the proposed plant operating philosophy, the new plant-wide computer system must utilize distributed process controllers, comprising of the following system components:

Process Controller Units at all major process areas

Field-mounted, environmentally hardened or commercially available, desktop operator workstations at key operating locations

An Operations Center where the operators are normally based

These system components will be interconnected to form an integrated plant-wide monitoring, control and data management system.

In addition, the plant-wide computer system should also include data management to provide long-term plant performance data, assist with plant operation optimization, and generate management reports. The system must also provide equipment performance information such as equipment run times, operating/out-of-service status, and provide maintenance scheduling and status information to plant staff throughout the facilities.

The time required for the system to respond to operator action alarm conditions will not exceed two seconds. The plant-wide system will be designed to accommodate future changes and updates in software and hardware.

The Plant-wide system will also have several levels of security to limit control and configuration changes to the assigned people. The Plant-wide system will be designed to maximize staff utilization, and training will be provided in configuring, operating and maintaining the system. Diagnostic software will be provided to aid in troubleshooting hardware and resolving failures.

Process Controller Units

At the low end of the plant-wide system are the field instruments, final control elements, and local control devices. The plant-wide system will interface with the field devices through local process controllers, such as PLCs or DCUs using fieldbus or direct-wired connections.

Each process controller must be able to handle a specific area of the plant alone, without requiring availability or operation of any other plant-wide computer system-based units. The process controllers should be able to operate completely alone and perform all signal conversions and calculations required, and logic and control functions, and transmit/receive information from other units over the high-speed data highway. The process controllers should be intelligent microprocessor-based devices.

In the event that any portion of the plant-wide system fails, a manual backup capability comprised of conventional manual loaders and indicators for analog signals, and switches and lights for discrete signals will be available at the local control panels (LCPs) for the operator to control the process. However, in the backup mode, centralized (from area control room) control will only be available for a few critical processes and equipment because new backup panels will be provided only for critical processes.

The main data highway resident process controllers should be provided in a redundant (fault-tolerant) configuration. The processors must have some level of internal self-test diagnostic programs to enable automatic failover to the backup processor in case of primary processor malfunction. In addition, each processing unit must be capable of interfacing with conventional signals, as well as fieldbus resident devices. To support the operational requirements of the DCUs/PLCs, each unit should contain software to perform numerous functions detailed in the Technical Requirements.

Operator Workstations

These devices are currently envisioned to be commercially available, desk-top type personal computer based workstations. A number of suppliers also offer portable, wireless communications operators workstations. This technology would offset the need for field located workstations and could provide operator access to the system from anywhere at the plant.

The operator workstations or control stations will serve as universal interfaces for plant personnel. All workstations should be capable of providing a full function interface to serve the needs of process operators, process engineers, maintenance personnel, and plant management. A multilevel

password system or access card could provide access control of workstation functions. The system should also have the ability to allow a read-only function on a display. Workstation functions are detailed in the Technical Requirements but include process observation, alarm acknowledgement, control action, data review, and report generation.

Data Acquisition and Management

Decisions based upon inaccurate data are ineffective at best. Therefore, the accuracy of the collected data within a plant-wide system determines the effectiveness of the decision-making process. In addition, the operator must have some indication of that accuracy to assure the validity of the decision. The latter is achieved by the use of quality tags.

Different colored letters or "tags" alongside any displayed parameter would indicate its quality. As a minimum, this should include "tags" for the following conditions: the data is not current; the value has been manually entered and is not being scanned and that the field device is broken and the value shown in the last good value. Color tagging is requested also to indicate status relative to advisory or emergency limits.

The process controller to which the point is connected performs data acquisition. The data are then available for use by other nodes on the data highway. Data scanning requirements differ depending upon the type of data being monitored (e.g., analog or discrete). Detailed requirements for analog data, discrete data, data transfer, alarms and events processing, management of historical data, calculated points processing, reporting, database development and communications and data hardware are outlined in the Technical Requirements.

6.5.7.2 Initial Screening of Alternatives

An initial screening of instrumentation and control alternatives was evaluated for the C/CWTP including a review of current technology and future development.

Overview of Current Technology

It has been over thirty years since the first digital computer based control system was used to replace the analog and pneumatic systems for water treatment process control. At first digital minicomputers were used to provide data acquisition, logging, reporting and some process controls. A few far-sighted municipalities even used digital minicomputers to provide direct digital control (DDC) of their plant processes.

The use of digital computer control initially met limited success partly on account of the then prevalent computer technology for process control and partly on account of limited support provided by the municipalities. The digital control systems of the 1970s were driven by the computer technology of the 70s. The control systems were monolithic and centralized. The I/O wiring was expensive to install. The digital minicomputers used required extensive programming and application software had to be developed for each project. The costs were high. There was no standardization and the high level of specialized support required to operate and maintain these systems disillusioned the users. The vendors suffered on account of extensive cost overruns in application software integration.

The advent of the microprocessor improved the situation somewhat. The microprocessors permitted remote multiplexing of input and output signals to be executed at the "site" thereby reducing wiring costs - wiring did not have to be run all the way back to the computer room. Digital communication became the backbone of signal transfers.

Remote multiplexing also permitted some degree of signal conditioning and signal preprocessing at the multiplexer, thereby reducing computer central processor load and improved system throughput. Some remote multiplexers were also pre-programmed to hold the last output until such time as an operator could intervene and take charge of process control. Systems that included remote multiplexers were the systems of choice in the late 70s and early 80s.

The early 80s saw the introduction of the digitally based Distributed Control Systems (DCSs) into the water marketplace. Traditional instrumentation and control system manufacturers introduced systems that were integrated from a hardware, software and communication standpoint. Commonality of components, on-board diagnostics and true geographic distribution of monitoring and control significantly improved control system reliability. The modular nature of the DCS will provide enhanced system expandability. It was now possible to buy "small" and make the system "grow" as the requirements changed. Preprogrammed control algorithms and display screens reduced the level of effort required to assemble, configure and commission the system. The systems began to gain acceptance by operators who now felt they had a tool that they could use.

A typical mid to large-scale water treatment plant that was built around the early 80s uses a DCS. Treatment plants that have upgraded their control systems have also selected the DCS technology for process control.

During this period there was also significant development in industrial, automotive manufacturing control systems. Such control systems required frequent execution of sequential tasks that were changed periodically as new production work was initiated. These tasks were being performed by hard-wired relay logic that was very expensive and time consuming to modify. A better and less expensive strategy was needed; one that did not require wholesale wiring changes.

This need facilitated the development of industrial, software based process controllers that were performing the sequential tasks previously performed by hard-wired relay logic. These devices were designed to be located on the plant floor; thus they were of robust construction. The devices substituted software ladder logic in place of relay logic and became known as Programmable Logic Controllers (PLCs).

The original applications for PLCs were as simple “black boxes” buried away in back of control panels, performing specific, infrequently changed tasks, with very limited operator interface or reporting capabilities. These devices were simple, robust, reliable, low cost, and could be handled easily by plant electricians who were used to working with relay ladder logic.

During the past twenty years, PLCs have acquired a wide range of applications, have become more sophisticated, developed networking capabilities, and have sprouted a large number of third party software firms that provide data acquisition, reporting, and operator interface packages. The PLC manufacturers in general have stayed out of the system implementation arena and allowed system integrators to provide those functions.

Today, the trend is to provide products that can perform any user application needs. Therefore, the DCS suppliers are providing direct interfaces to a number of PLCs, and in general try to offer equipment that cost and perform similarly to PLCs. The PLC manufacturers on the other hand, are offering products with much more capabilities that are more like the DCS type systems, units with programming capabilities in several different modes such as Ablock functions≅ in addition to the traditional ladder logic.

Therefore, the two technologies are converging and in the near future both types of products will offer similar capabilities. The only differences that will likely remain are in the way systems are implemented and maintained. The DCS suppliers will continue to provide systems (both turnkey and user applied), while PLC manufacturers will continue to sell products and allow third party system integrators to provide applied systems to the end user.

Overview of Today's Control System

A typical architecture of today's WTP control system consists of the following elements:

Process Controller

This is a microprocessor based front-end processor that interfaces directly with the field devices and is physically located in a plant area whose process variables are connected to the unit. The controllers perform signal pre-processing, execute process control in accordance with pre-programmed strategies and can operate as stand-alone devices that provide continuous process control. The controllers can also serve as devices that store trends and limited historical information related to a few process variables. Typically, several controllers are used to distribute control to the individual process areas.

A high-speed proprietary network connects distributed process controllers to permit process data interchange between controllers for supervisory control purposes. A limited function operator interface can be connected to the controller to enable the operator to initiate control commands and make set point changes at the controller, if conditions so warrant.

Operator Interface

This device serves as the primary window into the process. This device can range from a cost-effective personal computer based system to a more powerful workstation with the ability to display, archive, log, trend and modify process control algorithms. The functional requirements of the operator interface typically determine the size and sophistication of the device.

The operator interface is generally located in a control room that serves as the control center for a plant process area. The operator interface is connected to the distributed controller by a high-speed communication network. The communication protocol permits the operator interface to interrogate any distributed controller, acquire data from the controller and to transmit to the controller desired set point changes to execute process control.

The operator interface can also view the current control strategies, modify the control strategies and download these strategies into the controller. The operator interface device's main function is to provide the operator with the tools required for the operator to exercise process control.

Data Highway

The data highway is a high-speed communications network that interconnects the distributed controllers and the operator interfaces. The data highway provides the path for process data to be shared between the distributed controllers and the operator interfaces. Process variable data, set points, alarm limit violations, equipment status and operator initiated equipment ON/OFF commands are transmitted to/from the operator interface. Peer-to-peer communication between distributed controllers facilitates supervisory process control where a process variable in one process area can be transmitted to control the process in another area.

The data highway is implemented by either twisted pair wires, coaxial cable, or by fiber-optic cable and transmitter/receivers. The network is wired either in a loop (ring), in a star, or in a bus arrangement, depending upon the control system vendor's implementation of the communication

network. The data throughput rates usually vary from 1 MBPS to 100 MBPS. Redundant data highways are used to provide uninterrupted process monitoring and control.

The data highway is generally proprietary in nature, i.e. each vendor adapts a standard communication protocol to his system to enable a quick data exchange between processors and process variable displays on the operator interface display terminals. IEEE 802.3 and 802.4 standards are typically used in today's control systems. Gateways, or communication protocol translators, are used to permit non-vendor devices to interface with the vendor's data highway. The gateways are customized for a particular application, although interfaces to support standard data interchanges are available in some systems.

Hardware

The tremendous increase in inexpensive and cost-effective computational power and memory devices that has occurred in the past 15 years will accelerate at an even faster pace in the next 10 years. Computational power will continue to expand rapidly from the present state of the art. By using portable tablet-style devices and wireless links, independence of fixed stations can be created. There is a potential for future control systems to gather more data about more functions in greater detail and then fine-tune them to take advantage of that information. The key to the successful integration of these developments again is in software - not hardware. Computational power will not be the limit to achieve the change in the strategy for exploiting new control, sensor, and measurement technology.

Signal Transmission

The emerging Foundation Fieldbus standard specifies a standard, digital field bus for field instrumentation. However, it is not likely that all smart instruments will be able to utilize this bus. Some manufacturers will maintain proprietary aspects of existing instruments. There will be more standardization, but some proprietary aspects will remain. However, all new field signal installations will push towards digital busses versus the current 4-20 mA de facto standard.

Vendors will have to maintain I/O cards for traditional analog signals (4-20 mA,), but cost of interfacing will eventually discourage their use on new installations. For the near future, we will probably see instruments that can communicate both digitally and in an analog fashion (field selectable). There is too large an existing installed base of analog devices to be totally abandoned by the owners and manufactures.

Data Transmission

Data transmission has become more standardized, with fiber optic cabling becoming the norm, with speeds increasing. Networks have become more standard. New installations feature the use of a broadband backbone formed from a fiber optic cable with multiple channels for use by a variety of plant functions, such as process control, maintenance, engineering (design/as-builts), security, training, laboratory information, management information, fire protection, and the like.

Systems Architecture

Decisions on system configuration need not be hardware-driven. Use of name brand personal computer and workstations as operator interface devices are the norm.

Operations

Operator interface devices will be readily available to operators as they walk through the plant. Today, rugged flat-screen technology is available in relatively high-resolution color displays. Protection of the keyboard from dust, dirt, and moisture in an industrial environment has long been an issue, but now has been addressed with touch-screen technology.

Alternatives for Evaluation

The two major approaches for a PCCS of the magnitude required for the BDD facilities would be the DCS, single supplier approach or the "open" approach utilizing PLCs and an integrator. A third approach is touched on, the Fieldbus option, which is included to provide an example of developing technology that in all likelihood is what the future holds for PCCSs. In summary, the alternatives which will be evaluated for the C/CWTP controls system are as follows:

Alternative 1 - Implement Distributed Control System
Alternative 2 - Implement PLC-Based Distributed Control System
Alternative 3 - Implement Foundation Fieldbus-Based Controls

These alternatives are evaluated in the next subsection.

6.5.7.3 Evaluation of Alternatives

Alternative 1 - Implement Distributed Control System

This alternative provides new hardware and software, and expands the control capability to all process areas using a distributed control system with networked, highway resident distributed control units (DCUs), and proprietary, highly-bundled software products.

Distributed controls and processing have been developed by instrumentation and control system manufacturers to address the need for distributed, continuous process operation and improved operating security.

These systems offer robust construction, local and remote process I/O capabilities, completely stand-alone operation if required, and high-speed data highway communication link with other DCUs and data processing computers. In addition, current technology offers data highway resident operator workstations, thus operator stations may be connected anywhere on the network rather than directly to a DCU, and failure of any DCU will not also remove an operator station from operation.

The manufacturers of DCSs normally furnish a fully applied, turnkey system representing a single source of responsibility. They could also provide implementation and start-up support to plant staff if the staff performs those functions.

The disadvantage of using a particular manufacturer's DCS is that, in the past (and to an extent even today), most manufacturers produced proprietary systems which could not be easily interfaced with other manufacturer's systems. Thus, the user became very closely associated with and dependent on the manufacturer. This may not be a critical issue if the plant staff intends to standardize on a particular manufacturer's products to reduce inventory of spares, assure continuous availability for products, and accessibility to technical personnel when needed.

However, today most users want the ability to purchase and interface equipment from various sources, and to obtain a system that enables them to keep up with technology as time progresses without having to replace the entire system.

Most DCS manufacturers are currently offering "open-architecture" type systems that allow the user to replace operator's workstations, peripheral devices, and certain DCU modules with "third-party," off-the-shelf equipment. However, it is difficult to interface different manufacturers' DCS products. Nevertheless, these manufacturers are planning on conforming to some standard communications protocols, thus making it possible in the future to interconnect different manufacturer's systems.

Implementation of a DCS system is a reasonable approach for developing the PCCS in terms of long range cost effectiveness if internal plant support capabilities are not developed. These systems provide a highly integrated suite of software modules that have been used and debugged on previous projects of the supplier. Thus, it will require less effort to implement, debug, and start-up by the supplier's trained technical staff.

On the other hand, these systems are designed to be used on a variety of process applications, tend to be very sophisticated and complex, and generally require a higher level of technical approach than similar PLC-based systems using off-the-shelf software. This option results in a system approach that requires continued manufacturer/system supplier support for hardware and software maintenance.

The cost for both hardware and application software is increased, but system integration, checkout, and start-up costs are decreased.

Alternative 2 - Implement PLC-Based Distributed Control System

PLCs are available from a large number of suppliers and offer a wide range of capabilities from simple relay logic to fully automatic control systems. Today's PLCs can offer large memory capacity, PID control functions similar to analog controllers, and both local and remote I/O capabilities, while retaining their traditionally rugged construction. Most PLC manufacturers also offer a data highway communication link to interconnect PLCs (from the same manufacturer) into a distributed network. In addition, PLC manufacturers are committed to some form of uniform communications protocol, such as Ethernet TCP/IP, which eventually will allow different manufacturer's PLCs to communicate with each other over a common communication link.

A PLC-based distributed control system might be advantageous for use with a phased implementation schedule. Later phases of the project would conceivably implement different models of the manufacturer, or even products of a different manufacturer, as long as the open architecture type communication protocol is available. It is also a generally accepted premise that PLCs will cost less than similar control systems using distributed control units (DCUs).

Historically, the basic disadvantage of using PLCs has been that the units themselves are designed for sequential tasks or batch type of control applications involving very minimal operator interaction, and not very well suited for continuous controls that require frequent operator adjustments, such as those encountered in water treatment processes. The units are best suited as dedicated controllers for automatic equipment operation with start-up/shut-down sequencing, not requiring frequent operator intervention, or as sub-controllers to a higher-level data acquisition and control system.

Currently, most PLCs still require a "relay ladder logic" type programming that is a functional equivalent of electrical control wiring diagrams. However, most of the major PLC and DCS manufacturers have committed to developing software that will comply with the IEC-1131 standard that allows system programming in standardized structured text, and functional block diagrams in addition to ladder logic.

Furthermore, even though fairly sophisticated operator station type of programs are available for data acquisition, display generation, reporting, and historical trending, the operator interface programs are generally from a third party software house, such as " Intellution's iFIX," and "Rockwell's RSView." Their application would provide a totally independent, open configuration, but it will require plant staff involvement in its maintenance and its future improvements. This may not pose a major problem if the Owners are committed to maintaining a technical staff that will become thoroughly familiar and proficient with the systems use and maintenance.

The PLC manufacturer would not be the system supplier. These manufacturers traditionally have sold equipment (standard hardware and software) to system integrators who provided the application software and furnished a turnkey type system. Thus, warranty problems could involve a "third" party.

In addition, using a phased implementation schedule, each phase represents a relatively small control system contract thus making it attractive for small systems houses to bid on the project. Under the current procurement policies, it is also likely that a different systems integrator would furnish each new phase with its own unique software package. Therefore, even though the units likely can communicate with each other, each unit may require different programming.

A cost effective implementation approach using PLCs could be achieved if the Owners makes a commitment to establish full internal support for hardware and software maintenance for the systems. A project implementation team could be formed that would include the Owners' technical support staff, the DB Contractor, and technical support staff from the manufacturers of the hardware and off-the-shelf software.

Standard off-the-shelf hardware and software products could be procured, and the project team could provide the integration and implementation services that have traditionally been provided by third party system integrators. During the implementation process, the Owners' technical support staff would become thoroughly familiar with the system and its long-term support requirements.

Alternative 3 - Implement Foundation Fieldbus Based Controls

Fieldbus technology is an all-digital, serial, two-way communication system that interconnects field equipment such as sensors, controllers, and final control devices. Fieldbus is a Local Area Network (LAN) for instruments used in both process control and manufacturing automation with built-in capability to distribute the control application across the network.

The fieldbus is designed to retain the desirable features of the 4-20 mA analog systems such as standardized physical interface to the wire, bus powered devices on a single wire pair and intrinsic safety.

In addition, the fieldbus offers the following functional capabilities:

- Increased capabilities due to full digital communications.
- Reduced wiring and wire terminations due to multiple devices on one wire pair.
- Increased availability of competitive products due to interoperability requirements.
- Reduced loading on control room located equipment due to possible distribution of some control and input/output functions to field devices. Flow transmitters or valve actuators could perform the PID control algorithms.

Foundation Fieldbus is an industry standardized version of several different fieldbus approaches that has been in the making for over eleven years. It is a product of long-term negotiations between the leading instrumentation and control system suppliers, and it offers seamless integration of different manufacturers products over a single network cable with uniform hardware connection and application software implementation features.

The Foundation Fieldbus uses standard function blocks to implement control strategies. The consistent, standard function blocks allow distribution of functions in field devices from different manufacturers in an integrated seamless manner.

The use of a single cable or wire pair for interconnection and integration of multiple field devices using digital serial communications, reduces the requirements for Acontroller≅ (PC, PLC, or DCU) input/output hardware.

More manufacturers offer fieldbus based instruments or devices with standard Foundation Fieldbus interfaces. We recommend that fieldbus be designed for networking of field located instrumentation and final control devices, but retain a PLC or DCU as the controller for each local fieldbus network.

This approach is identical to the PLCs-based alternative. However, the additional expected costs associated with the smart field devices will be offset by the cost savings achieved through reduced wiring and elimination of input/output modules, while retaining for the time being the data acquisition and control logic in the controller.

6.5.7.4 Recommended Approach

The following recommendations should be implemented to support the planned processes and best position the Owners' for the implementation of the ultimate PCCS.

Provide unit process control for all the processes. The unit process control should be PLC-based using an off the shelf, client-server HMI software. This approach will result in "Islands of Control" that will be configured to provide highly efficient monitoring and control of the upgraded or new processes. In addition, if the proper guidelines are followed in the implementation of these upgrades, these "Islands" could be easily integrated into the PCCS.

Provide the Communications Backbone consisting of the pathways (conduit) and media (fiber optic cables) that will provide a network to interconnect all the processes and data handling areas of the PCCS. Configuration should be in a ring style allowing for two pathways to any network switch.

To assure a uniform approach, the OC recommends the process control systems be developed under instrumentation system supplier under the DB Contractor. The scope of work would include the task of coordinating the development of the process databases, graphics, and control strategies with the process designs. This will help to assure continuity between the different process control areas and between the facilities.

The plant control system should be equipped with wireless networking capabilities to allow management, operations, and maintenance staff convenient access to the system data. This link will be an 802.11g compatible system and will provide logical connection between a roaming PC tablet platform operating Windows XP and the terminal server located in the central control room. This approach will allow minimal re-configuration effort in the event of replacement of a damaged

tablet. Adequate security measures shall be activated to ensure that no un-authorized use is allowed.

6.5.8 SCADA and Telemetry

Refer to Section 8 for SCADA and telemetry at the C/C WTP.

6.5.9 Communications

6.5.9.1 Telephone

The telephone communications system will match and be compatible with existing systems presently in use at other Owners' facilities. All the necessary arrangements will be made with Qwest to provide dial tone service to the telephone backboard within the new facilities. Interview the C/CWTP operators will be interviewed to determine preferences before programming the operation of the telephone system including voice mail.

KSU telephone platform will have a maximum configuration of 12 lines X 32 stations. The system will expand in 3 lines X 8 stations increments. The system for the C/CWTP will be configured a 6 lines X 16 stations. The system will provide for CTI (Computer Based Telephony) applications. The system shall be capable of on-site programming via handset or Windows based software. The telephone system will have day and night modes of operation and will have standard 110VAC, 60 Hz power requirements.

The voicemail system will be self contained digital voice processing system that will manage and distribute calls via automated attendant. It will have the following features:

- menu routing
- smart transfers and dial by name
- unlimited number of mailboxes
- minimum 70 hours of voice storage
- on-site or remote administration via handset or Windows-based software.

The phones that will be provided will have the following standards features: speed dial and last number called, hard keys (hold, transfer, conference, flash, mute, forward); programmable buttons for specialized features; time and date, as well as, call information on phones with displays. The C/CWTP will be equipped with nine 8-button enhanced speaker phones and four 30 button executive display speaker phone.

The telephone system will meet the following UPS requirements:

- 120VAC in/120VAC out
- 20 minute run time for connected telephony equipment
- auto self test
- auto voltage regulation
- network grade line conditioning with surge protection and filtering
- sine-wave output

- status indicator LED's, as well as, overload and replace battery indicators
- intelligent battery management system
- maintenance-free sealed leak proof lead acid batteries.

The system will be installed in accordance with applicable codes and the manufacturer's instructions. The system supplier will provide on-site supervision of the installation, as well as, start-up and training. All system wiring will be run in conduit and termination of telephone cables will be performed by the system supplier. The installation will include punch down blocks, CAT 3 telephone jacks; CAT 5 data jacks. The entire system will be tested per the manufacturer's recommendations to demonstrate proper system operation.

6.5.9.2 Fiber Optics

Fiber optic receivers and transmitters will be furnished and installed as required to support communications with remote sites. Card cage(s) with power supplies to mount the fiber optic components will be provided.

6.5.9.3 In-Plant Communications

The system for amplification of wireless communications in the C/CWTP will match and be compatible with existing CSI – Cellular Specialties Inc. systems presently in use at Owners' other facilities. The services of the supplier of the amplifier system will be employed to design, prepare detailed installation drawings and material specifications, install and test.

A technician from the system supplier will perform a pre-installation site survey to evaluate the system requirements. The system supplier will utilize the facility's floor plans and data gathered from the pre-installation site survey to create a detailed model that predicts RF propagation within the facility. The system supplier will provide a depiction of power levels throughout the system, identify cable routes and equipment locations.

After the system has been installed, the system supplier will take field measurements to ensure the system meets FCC regulations, wireless service provider standards, and customer performance criteria. At a minimum, RSSI, BER and Tx power measurements shall be made to verify coverage, as well as serving site ID in donor cell implementation. Upon completion of the installation of the system, the system supplier will provide as-built documentation.

6.5.9.4 Wireless Plant Control Communications

In response to an expressed desire to have full flexibility and maneuverability in the operation of the facility, the plant control system shall be equipped with wireless networking capabilities to allow management, operations, and maintenance staff convenient access to the system data. With such a system it will be feasible to roam the plant property with a wireless portable PC and still be able to view information about and initiate control of the plant processes. This capability can be as wide ranging as to include the entire plant view, or may be configured to selected areas or system functions, depending on the Owners' comfort with the feature. The hardware selection for such a roaming workstation platform would be a PC tablet form factor and would require no special software installation on the tablet PC to perform this function.

The wireless link will be an industry standard 802.11g compatible system and will provide logical connection between a roaming PC tablet platform operating Windows XP and the terminal server located in the central control room. This approach will allow minimal re-configuration effort in the event of replacement of a damaged tablet.

Adequate security measures shall be activated to ensure that no un-authorized use is allowed and shall make maximum use of the IEEE 802.11i security standards to achieve the required protections.

6.5.10 HVAC, Plumbing and Fire Protection

6.5.10.1 HVAC

The C/CWTP consists of the following buildings: Operations Building, Maintenance Building, Clarification Facilities, Membrane Building, Ozone Building, GAC Contactors, Centrifuge Building, Finished Water Pump Station, and Chemical Building.

The HVAC system in the C/CWTP will consist of systems necessary to meet the numerous functions. Systems will provide comfortable conditions in buildings and areas intended for human occupancy.

- In wet areas or areas with potential for condensation, maintain a low relative humidity (RH) to minimize or eliminate condensation and corrosion. Where outside air is required for ventilation, the outdoor air will be treated by heating and filtering as required.
- Electrical rooms will be provided with mechanical cooling for heat removal and reduction in potential corrosion in the electrical room.
- Telecommunication rooms will be provided with mechanical cooling for heat removal and reduction in potential corrosion in the room.
- Operation spaces will be provided with ventilation where they will be occupied spaces. In addition spaces that may be entered by plant personnel will be ventilated in accordance with applicable codes and good engineering practices
- Ventilation will use multiple supply fans in each space with relief dampers. Supply fans will have both outdoor and return dampers to provide a minimum supply temperature during cold weather.
- Mechanical Room ventilation will use multiple supply fans in each space with relief dampers. Supply fans will have both outdoor and return dampers to provide a minimum supply temperature during cold weather.
- Break Rooms will be provided with mechanical cooling for heat removal
- Rest Rooms, Janitors Rooms, Laundry and Lockers will be provided with continuous ventilation with exhaust air from adjacent spaces
- Conference and Training Rooms will be provided with mechanical cooling for heat removal
- File/Copy/ Supply Room will have intermittent ventilation
- Offices, Reception and Library will be provided with mechanical cooling for heat removal
- Laboratories will be provided with mechanical cooling for heat removal, exhaust hoods, and 100% exhaust
- Control Rooms will be provided with mechanical cooling for heat removal
- Crew Rooms will be provided with mechanical cooling for heat removal
- Instrument and Electrical Shop will be provided with mechanical cooling for heat removal

- Welding Shop, Equipment Maintenance Shop, Maintenance Parts Warehouse, Vehicle Maintenance Shop, will have intermittent ventilation
- Roll-off Container Room will have continuous heated ventilation
- Centrifuge Room will have continuous heated ventilation
- Polymer Room will be provided with mechanical cooling for heat removal
- Chemical storage areas will have continuous heated ventilation

Due to the toxic nature of ozone and specific code requirements regarding ozone generation, ozone area must be well ventilated. Ventilation will include continuous heated ventilation, and emergency ventilation. Location of exhaust and makeup air shall be positioned to evenly sweep air across the room and prevent accumulation of gas at any one point. The HVAC system will be manually reset to normal mode after a level 0, 1, or 2 condition.

An Emergency Ventilation ON and Ventilation OFF switch shall be located outside the ozone room to manually energize or de-energize the ventilation systems. The switch shall be break glass type and shall be labeled "VENTILATION SYSTEM EMERGENCY SWITCH". A RUN/OFF indicator light shall be provided at the switch to indicate fan operation status.

HVAC Codes and Standards

Design of C/CWTP HVAC facilities shall comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Commercial Building Code
- 2003 New Mexico Mechanical Code
- 2003 New Mexico Energy Conservation Code
- New Mexico Boiler Code
- ASHRAE
- NFPA standards
- SMACNA standards
- AMCA
- AABC
- NEBB

Design Criteria

The design will be based on outdoor design conditions of 10 degrees F DB during the winter and 96 degrees F DB, with a 60 degrees F MWB during the summer. Air density will be based on an elevation of 6500-ft amsl.

Selection of condensers for air-conditioning units will be based on 106 degrees.

Indoor Design Conditions

The design of cooling and heating systems for specific spaces will be based on the indoor conditions shown in Tables 6.5-3 through 6.5-10.

Table 6.5-3 Operations Building Indoor Design Temperatures and Ventilation Rates

Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Electrical room	85/55	0.25 cfm/sf	▪ Provide mechanical cooling with separate unit. ▪ Provide continuous ventilation
Telecom Room	85/55	0.25 cfmsf	▪ Provide mechanical cooling with separate unit ▪ Provide continuous ventilation
Mechanical Room	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Lunch Room/Kitchen	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Vestibule	78/70		▪ Provide heating
Storage	78/70		▪ Provide mechanical cooling
Unisex Restroom	78/70	▪ 6 ACH ▪ 2.0 cfm/sf ▪ 75.0 cfm/fixture	▪ Provide continuous mechanical ventilation with air from adjacent spaces
Conference and Training Room	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Men's Restroom and Locker Room	78/70	▪ 6 ACH ▪ 2.0 cfm/sf ▪ 75.0 cfm/fixture	▪ Provide continuous mechanical ventilation with air from adjacent spaces
Janitor/Laundry	78/70	▪ 6 ACH ▪ 2.0 cfm/ sf ▪ 75.0 cfm/fixture	▪ Provide continuous mechanical ventilation with air from adjacent spaces
Women's Restroom and Locker Room	78/70	▪ 6 ACH ▪ 2.0 cfm/ sf ▪ 75.0 cfm/fixture	▪ Provide continuous mechanical ventilation with air from adjacent spaces
File/Copy/ Supply Room			▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Secretary	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Reception Lobby/Waiting	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Control Room	78/70	20.0 cfm/person	▪ Provide mechanical cooling with a separate unit ▪ Provide continuous ventilation
Superintendent Office	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Library	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Plant Manager Office	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Maintenance Manager Office	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Future Office	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Future Office (2)	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Lab. Supervisor Office	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
General Laboratory	78/70	20.0 cfm/person	▪ Provide mechanical cooling ▪ 100% Exhaust ▪ Exhaust hoods
Lab Storage & Gas Rm.	78/70		▪ Provide mechanical cooling
Microbiology Lab	78/70	20.0 cfm/person	▪ Provide mechanical cooling ▪ 100% Exhaust ▪ Exhaust hoods

Table 6.5-4 Maintenance Building Indoor Design Temperatures and Ventilation Rates

Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Mechanical	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation. ▪ Unit heater
Electrical	85/55	0.25 cfm/sf	▪ Provide mechanical cooling with separate unit. ▪ Provide continuous ventilation
Men's Toilet	78/70	▪ 6 ACH ▪ 2.0 cfm/sf ▪ 75.0 cfm/fixture	▪ Provide continuous mechanical ventilation with air from adjacent spaces
Janitor	78/70	▪ 6 ACH ▪ 2.0 cfm/sf ▪ 75.0 cfm/fixture	▪ Provide continuous mechanical ventilation with air from adjacent spaces
Women's Toilet	78/70	▪ 6 ACH ▪ 2.0 cfm/sf ▪ 75.0 cfm/fixture	▪ Provide continuous mechanical ventilation with air from adjacent spaces
Crew Room	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Instrument Electrical Shop	85/55	0.25 cfm/sf	▪ Provide mechanical cooling with separate unit ▪ Provide continuous ventilation
Welding Shop	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Equipment Maintenance Shop	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Maintenance Parts Warehouse	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Vehicle Maintenance Shop	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater ▪ Multiple exhaust connections for engine servicing

Table 6.5-5 Sedimentation/Flocculation Building Indoor Design Temperatures and Ventilation Rates

Type of Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Clarifier Area	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater

Table 6.5-6 Membrane Building Indoor Design Temperatures and Ventilation Rates

Type of Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Membrane Room	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Blower Room	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Pressure Membrane Room	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Pump Room	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater

Table 6.5-7 Ozone Building Indoor Design Temperatures and Ventilation Rates

Type of Area	TEMP (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Mechanical/ Boiler room	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Storage			▪ Unit heater
Ozone Generator Room	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal ▪ emergency 12 ACH	▪ Provide continuous heated ventilation ▪ Activate by O3 sensor or switch ▪ Maintain negative pressure ▪ Shutdown switches at all doors ▪ Unit heaters
Electrical Room	85/55	0.25 cfm/sf	▪ Provide mechanical cooling with separate unit. ▪ Provide continuous ventilation

Table 6.5-8 GAC Contactors Indoor Design Temperatures and Ventilation Rates

Type of Area	TEMP (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
GAC Contactors	Ambient + 10/55		• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation ▪ Unit heater

Table 6.5-9 Centrifuge Building Indoor Design Temperatures and Ventilation Rates

Type of Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Centrifuge Room	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal	▪ Provide continuous heated ventilation when operating centrifuges ▪ Unit heaters
Electrical Room	85/55	0.25 cfm/sf	▪ Provide mechanical cooling with separate unit ▪ Provide continuous ventilation
Office	78/70	35.0 cfm/person	▪ Provide mechanical cooling ▪ Provide continuous ventilation
Stair	10/55		▪ Unit heaters
Roll-off Container Room	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal	▪ Provide continuous heated ventilation when operating centrifuges ▪ Unit heaters
Polymer Room	85/55	0.25 cfm/sf	▪ Provide mechanical cooling ▪ Provide continuous ventilation

Table 6.5-10 Chemical Building Indoor Design Temperatures and Ventilation Rates

Type of Area	Temp (°F) Summer / Winter	Outdoor Air Ventilation Minimum Criteria	Design Features
Reserved Area	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal	▪ Provide continuous heated ventilation ▪ Unit heaters
Calcium Thiosulfate	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal	▪ Provide continuous heated ventilation ▪ Unit heaters
Electrical Room	85/55	0.25 cfm/sf	▪ Provide mechanical cooling with separate unit ▪ Provide continuous ventilation
Corridor	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Chemical Room	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal	▪ Provide continuous heated ventilation ▪ Unit heaters
Spare Chemical System	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal	▪ Provide continuous heated ventilation ▪ Unit heaters
Fluoride Room	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal	▪ Provide continuous heated ventilation ▪ Unit heaters
HVAC Boiler Plumbing	Ambient + 10/55		▪ Intermittent heat removal ventilation using multiple units ▪ Provide continuous mechanical ventilation ▪ Unit heater
Chemical Room	Ambient + 10/55	▪ 6 ACH ▪ 1 cfm/sf ▪ Or as required for heat removal	▪ Provide continuous heated ventilation ▪ Unit heaters

LEGEND
N/A = Not Applicable
AC = A complete change of air for the specific volume
ACH = Air Changes per Hour

For additional information on systems and zoning of units and number of units required, refer to system diagrams.

6.5.10.2 Plumbing Systems

The plumbing at the C/CWTP will consist of systems necessary to meet the numerous functions.

- Drain systems with vents where required for sanitary, process rain water, equipment and HVAC condensation drain systems.
- Special waste systems for laboratories, chemical rooms will be included.
- Sump pumps and discharge piping systems.
- Water systems including hot and cold potable water, utility water (non-potable) for process use, and tepid emergency water system for emergency safety showers/eye wash units and sample water systems
- Additional plumbing systems will include natural gas system, compressed air system, and vacuum system for laboratories and special gas systems for laboratories.

Plumbing Codes and Standards

Design of plumbing systems at the C/CWTP shall comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Plumbing Code
- 2003 IFGC
- ASPE design guides
- ANSI Z358.1: Emergency Eyewash and Shower Equipment, 1998
- AWWA
- NMED Title 20 Chapter 7 Part 3: Liquid Waste Disposal and Treatment Requirements

Description of Recommended Systems

Each water system will have its own backflow prevention device to eliminate cross-contamination of the plant's potable water system. All backflow devices shall be protected against freezing and to facilitate maintenance.

The potable water system will include cold water for drinking water fountains, lavatories, water closets, urinals, janitor's mop sink, and exterior hose bibs and hot water for lavatories, janitor's mop sink.

The sanitary system will include restroom fixtures, floor drains and Drinking fountain drains.

The Process Drain system will be independent of the sanitary sewer and will include floor drains in process areas and Trench drain in Ozone Building.

Rainwater Leaders will be based on a Rainfall rate of 2.0 inches per hour (0.021 gpm per square foot) for a 100-year storm. This is the 1 hour rainfall rate per 1997 UPC.

Plumbing Fixtures

Water closets, urinal and lavatories will be provided with infrared sensing devices (no manual faucets or levers). Fixtures will comply with the American Disabilities Act (ADA). All hose bibs will be provided with individual vacuum breakers. Emergency Safety showers and eye washes will be provided with an alarm light and horn for local alarming.

6.5.10.3 Fire Protection

Fire protection systems are not anticipated for the following buildings: Sedimentation/Flocculation Building, Membrane Building, GAC Contactor Building and other smaller buildings.

Fire protection systems are anticipated for the following buildings: Operations Building, Maintenance Building, Ozone Building, Centrifuge Building and Chemical Building. The fire protection systems will include wet, dry and pre-action sprinkler systems based on the requirements of the space. The DB Contractor is responsible for agency approval and design of the fire protection systems based on its design of the facilities.

Fire Protection Codes and Standards

Design of fire protection systems at the C/CWTP shall comply with the applicable portions of the following codes and latest standards:

- 2003 International Fire Code (IFC)
- National Fire Protection Association (NFPA) standards
- Factory Mutual (FM)

Design Criteria

Isolate the fire system from the plant's potable water system via a double-check type backflow preventer.

An NFPA rated backup fire pumping system will draw from the Finished Water Reservoirs and the BS5A pipeline to provide fire suppression water when the C/CWTP is out-of-service. The fire pumps will be connected to a dedicated NFPA compliant emergency generator as well as the primary PNM plant service with an automatic transfer switch.

One potable water main shall be brought into the building and split into the required water systems. Sprinkler heads will be the fully recessed type with white cover plates in finished areas with acoustical tile or gypsum board ceiling; the upright type will be used in areas without finished ceiling tiles. Chemical area sprinklers shall be wax-coated type.

Fire department Siamese type connections are to be provided in the DB Contactor's design, as required by NFPA, to be located within 50-ft of approved fire lane. A yard hydrant system will be provided around and within the C/C WTP site. This system will pull water from the BS5A pump station and pipeline.

6.5.11 Security Systems

Security and personnel protection measures to protect the Project facilities during construction, start-up, and initial operation will be provided. During construction, temporary security measures will be provided as necessary to protect the facilities, equipment, and personnel.

6.5.11.1 Security Objectives

Security and personnel protection systems must be included for each facility to reduce risk to the integrity of these facilities and to protect the public water supply. The following security and personnel protection issues, at a minimum, will be addressed:

- Threats to the source water and water treatment facilities
- Threats to the pump stations
- Threats to the distribution systems/booster stations
- Threats to the SCADA/telemetry system
- Fire detection and notification
- Communications

Threats may be in the form of one or more of the following: vandalism, criminal acts, sabotage/terrorism, or deliberate/malevolent acts by employees (either present or former).

The designed and installed security system will be compatible with the City of Santa Fe's existing security system at Canyon Road WTP and will be expandable to Owners' other water facilities.

6.5.11.2 Recommended Security Systems

The design will incorporate the following to protect the C/CWTP:

- 8-ft high perimeter colored vinyl coated chain-link fencing with concertina wire around the C/CWTP facility with warning signage for deterrence and protection
- A decorative wall with access gate (card access) will be used at entrance in lieu of chain link fence
- Perimeter buried cable intrusion detection alarm system along entire length of perimeter fencing will be provided. This perimeter protection system will be integrated into the CCTV system and provide control to camera presets and recording functions.
- Shackled-protected locks to prevent breach with a bolt cutter or firearm
- Bullet-proof rated restricted access signage, including signage restricting access to the control room to authorized personnel only
- Bullet-proof rated restricted vehicle access signage
- Video surveillance via CCTV cameras (triggered by motion sensors) will be provided. Cameras and lenses will be installed in bullet-resistant metal enclosures. Cameras will be pole-mounted and provide redundant coverage of the entire perimeter of the site, as well as, of each building entrance. This will be the head-end of the CCTV system and will include: pole mounted cameras, lenses, infrared illuminators and bullet resistant enclosures; main digital video recorder and accessories; power supplies; fiber optic interface components; mounting hardware and enclosures.
- CCTV cameras (triggered by motion sensors) will be provided at the entrance to the plant, chemical building east side exterior and west side exterior, ozone generator room and solids handling centrifuge building interior
- Card access/security system will be provided. This will be the head-end of the system and will be complete with main central processing unit; multiplexer(s); alarm panel(s); card reader, electric strikes, request to exit devices, magnetic door alarm contacts and motion sensors at or in the immediate vicinity of each entrance door; glass break sensors in the immediate vicinity of all windows; magnetic window alarm contacts; alarm arming and disarming keypad(s); power supplies; fiber optic interface components. Card access reader (with bullet-resistant covers) for the entry gates will be provided.
- Fire alarm system will be incorporated into the design of facilities
- A KSU telephone system comprised of 'converged' technology which combines traditional digital telephony and VoIP will be provided. Display/speaker phones will be provided. The KSU will be interconnected with the incoming telephone service from Qwest.
- A system for amplification of wireless communications
- Adequate lighting, equipped with bullet-resistant bulb shields, to increase visibility of suspicious activity. Lighting will be motion sensor controlled with manual switch override

All access hatches and doors will be secured with locks. Critical components, including pumps, motors, motor control centers, and SCADA components will be secured within enclosures and hidden from view where feasible. Piping and appurtenances will be installed below ground or within secured structures where feasible. Locking mechanisms will be provided for critical valves and gate operators where applicable.

The design will pay special attention to the chemical storage and feed system areas. Visibility, spill detection/control, containment, and access restrictions will be a priority of the design when providing physical security measures. Employee-activated and duress switches will be required in these areas for notification of emergency situations.

6.5.11.3 Control System Security Requirements

The Owners will rely on the various automated systems (SCADA, telemetry, HMI, etc.) for the operation and control of the Project facilities. Similar to the concepts mentioned in the preceding section, the management and operational security practices of the Control Systems are crucial.

To mitigate risk, several basic security practices will be incorporated in the design for the Control Systems, including the following:

- The equipment will be housed in an appropriate (i.e., wet versus dry environment) lockable cabinet
- PLCs and computer workstations will all be equipped with backup uninterruptible power supplies
- Firewall equipment will be provided to prevent outside hacking into the control system
- Anti-virus software will be installed and updated routinely when updates are available from the software manufacturer
- An off-site backup storage system will be provided for the servers and workstations
- All default passwords will be reset
- Prior to access, individual log-on credentials will be required
- Log-on will be configured to match the responsibility level of the operator/Owners' staff. A minimum of three levels of security will be provided (i.e., general/operator, senior operator, system administrator).
- Log files associated with the user's log-on credentials will be required
- Requirements for appropriate password strength will be provided (i.e., more "complex" passwords for those with higher access privileges, such as an administrator)
- Immediate removal of access privileges upon voluntary, and especially involuntary, termination will be required
- An "inactivity timeout" log-out will be provided to protect the Control System if no one is present in the control room or if the operator has stepped away
- A password to make software programming changes will be required
- Programmed set-point ranges to reject potentially harmful out-of-range adjustments (especially for chemical dosages) will be required

6.5.12 Corrosion Analysis

6.5.12.1 Tanks

Corrosion measures for above ground tanks should adhere to the appropriate NACE standards, including:

- NACE RP-0169-2002 – Standard Recommended Practice: Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
- NACE Standard RP-0388-2001 Cathodic Protection of Internal Submerged Surfaces of Steel Water Tanks.
- NACE Standard RP-0193-2001 External Cathodic Protection of On-Grade Steel Tank Bottoms.

Furthermore, the tank internal cathodic protection system should not be activated until the internal coating warranty has expired. Additionally, a separate external cathodic protection system is required for the external metallic surfaces of the tank that interface with sand or soil with or without a ring-wall installed. The external system requires that anodes are installed directly under the tank.

6.5.12.2 Pipelines

A corrosion analysis was completed for the water treatment plant piping area. The report documenting the methodology, results and recommendations are included in Appendix B. These paragraphs summarize the recommendations for the water treatment plant.

The soils along the water treatment indicate relatively low consequence and risk of corrosion, based on the laboratory analysis of the collected soil samples. The recommendations are based upon a 100-yr service life, vary with the pipe material and are presented by material.

Corrosion Requirements for DIP

If the DB Contractor selects DIP for any water treatment plant pipelines the corrosion protection measures shall consist of polyethylene encasement.

Corrosion Requirements for CCP

If the DB Contractor selects CCP for any portion of the water treatment plant pipelines, the corrosion protection measures shall consist of electrical continuity bonding (isolated from foreign structures using dielectric isolation fittings) with test stations and have cathodic protection in accordance with NACE RP-0169-2002 criteria.

Corrosion Requirements for HDPE or PVC Pipe

Plastic pipe is typically not susceptible to corrosion. However, the pipeline supplier must demonstrate the pipe material meets the 100-yr service life requirements if the DB Contractor selects the use of plastic pipe for any portions of the water treatment plant pipelines.

Corrosion Requirements for Steel Pipe

If the DB Contractor selects Steel Piping for any portion of the water treatment plant pipelines, the corrosion protection measures shall consist of electrical continuity bonding (isolated from foreign and above ground structures using dielectric isolation fittings), test stations, a dielectric coating, and cathodic protection in accordance with NACE RP-0169-2002 criteria.

7.1 Finished Water Demands and Criteria

7.1.1 City and County Demands

Finished water from the C/CWTP will be distributed to both the City and County customers through two finished water booster stations (BS4A and BS5A). Demands for the City and County were determined from two sources. City demands were based upon the water distribution model recently revised by Boyle Engineering. The County demands were based upon data provided by the County for all proposed interconnections or existing meters. The model already included County demands for the existing meter locations off of Richards Avenue and Cerrillos Road. The demands and fire flows were updated at the meters to reflect the revised data provided by the County. Table 7.1-1 presents the County consumer and fire flow demands by location for 2020. A similar table was not prepared by location for City as this data was already loaded into the model for each planning scenario completed by Boyle Engineering. Although the fire flows are included in the model, it is assumed fire flows are provided from storage and not from BS5A. Not providing fire flows in the County distribution system though BS5A eliminates the need for fire pump with standby power for BS5A. The Owners agreed to this pipeline sizing approach.

Table 7.1-1 County Demands and Fire Flow by Interconnection Location

Interconnection Location	2020 Peak Flow	Fire Flow
West Sector - Sunflower Drive (near Las Campanas)	0.27-mgd	1,000 gpm
CR-62/South Meadows Road	0.15-mgd	3,500 gpm
Airport Development District (Caja/NM-599)	0.49-mgd	4,000 gpm
SW Sector (1-25 and NM-599)	0.61-mgd	4,000 gpm
South Sector (Cerrillos Road Meter)	0.67-mgd	4,000 gpm
SE Sector (Richards Avenue Meter)	0.85-mgd	3,500 gpm

7.1.2 Modeling of WTP Facilities

The OC utilized the City's H2OMAP WATER distribution model that was recently revised by Boyle Engineering to complete steady-state modeling for the finished water facilities. Various revisions were made to the model to reflect current or proposed conditions after the BDD facilities are constructed. The following bullets summarize the changes made to the model:

- This model was converted from version 3.5 to the most recent version of H2OMAP 6.0
- The 2015 model scenario was used for the analysis. The 2020 model scenario is based upon an addition of pipeline grids to reflect needed future infrastructure but the sizes, layout and details of this infrastructure were only preliminary estimates (per the Boyle Report). Use of the 2015 model reflects the actual infrastructure built as part of the BDD Project and does not assume the undefined infrastructure is built.

- The County demands and fire flows were added or revised based upon the data in Table 7.1-1.
- Pipelines constructed since 2003 were added to the model based upon GIS water system mapping provided by the City. These pipelines included 12- and 10-inch lines along South Meadows and Rufina; extension of the 12-inch line on Agua Fria; additional 8-inch lines connecting the 12-inch lines between Agua Fria and Rufina; and 12- and 10-inch pipelines between Cerrillos Road and Richards Avenue.
- Revision of details for the BDD facilities: finished water storage at WTP changed from 20-MG to 7.5-MG, refinement of pipeline sizes and refinement of pump curves for BS4A and BS5A.
- Connected new BDD pipelines to existing pipelines in the following locations: BS4A Pipeline connected to the 18-inch inlet to the BS3 surge tank; NM-599 Pipeline connected to the 14-inch pipeline at Airport Road and the 16-inch County pipeline at I-25; and South Meadows Road pipeline connected to the 12-inch line at Agua Fria.

The objectives of the steady-state hydraulic model were as follows:

1. Pump water to the SW Sector Tank from BS5A to supply the County system and adequately maintain the water level in this tank
2. Select the pipe sizes and pumps necessary to meet the supply demands for the area

7.1.3 Recommendations

The preliminary design recommendations for the finished water pipelines and the two finished water booster stations, based upon the modeling, are summarized below:

- A 30-inch pipeline is recommended for the BS4A Potable Water Pipeline to convey 8.9-mgd flow now and up to 15-mgd flow in the future
- A 24-inch pipeline is recommended for the Caja del Rio Potable Water Pipeline and the South Meadows Road Potable Water Pipeline
- A 16-inch pipeline is recommended for the NM-599 Potable Water Pipeline
- Upgrades within the existing City distribution system between the South Meadows connection point and the SW Sector Tank are recommended to fix the predicted bottlenecks in providing flow to this area
- Additional storage may be needed for fire flow requirements. Modeling will be ongoing during preliminary design to determine the storage requirements and the ability of the proposed La Tierra Tank to meet this requirement at the proposed or an alternative location

The location of the finished water pipelines are shown on Figure 1.1-1 in Section 1.

7.2 Finished Water Pipelines

The finished water pipelines of this project have been separated into four pipeline segments generally named for the roadway the pipeline follows as it traverses toward its destination.

7.2.1 Pipe Alignments

7.2.1.1 Pipe Route and Cover

The finished water pipelines will be constructed within roadways or the roadway ROW in all cases. The BS4A Potable Water Pipeline begins at the C/CWTP and ends at existing BS3 being installed primarily within the Las Campanas Drive ROW. The Caja Del Rio Potable Water Pipeline begins at the C/CWTP and ends at NM-599. This pipeline will be within the western road ROW. The South Meadows Road Potable Water Line begins at a tee provided in the Caja Del Rio Potable Water Pipeline at the intersection with NM-599. This pipeline traverses northerly within the frontage road ROW for NM-599 and turns south at South Meadows Road where it connects to a soon to be built 24-inch pipeline north of the Santa Fe River. The soon to be built pipeline will be suspended from a proposed bridge crossing the Santa Fe River south of the interconnection location. This pipeline will extend to the termination point at the intersection of Agua Fria and South Meadows Road as shown on the Preliminary Design Drawings. The inclusion of the pipeline across the river in the bridge project occurred too late to remove this portion of the pipeline from the Preliminary Design Drawings and thus a portion of the alignment on those Drawings is outdated. Construction of the bridge and pipeline will be completed late 2007 or early 2008. The NM-599 Potable Water Pipeline begins as a continuation of the Caja Del Rio pipeline at a 90-degree bend at the intersection of Caja del Rio Drive and NM-599. This pipeline continues along the NM-599 western road ROW to Interstate 25 where it will be bored under I-25 and connected to an existing 16-inch County pipeline.

The depth of cover over finished water pipelines will be a minimum of 4-ft except at arroyos which will be 6-ft or greater. Pipeline trench details are included in the Preliminary Design Drawings.

7.2.1.2 Air Release Valves and Other Appurtenances

Control valves are to be designed by the DB Contractor in consultation with the Owners' and the OC. Air/Vacuum relief valves will be installed on the pipeline at locations determined through surge modeling. Recommendations from surge modeling conducted during preliminary design are presented in Appendix E and summarized in Section 7.2.5. The DB Contractor will be responsible for final surge mitigation device recommendations based upon final pipeline material selection. Stub outs and pipeline interconnections are designated on the Preliminary Design Drawings and in the Technical Requirements.

7.2.1.3 Impacted Utilities

Numerous utilities will be encountered during the construction of the finished water pipelines. Many of the utilities are noted on the Preliminary Design Drawings but not all are warranted accurate or shown. At minimum, the DB Contractor will encounter buried fiber optic, buried single- and three-phase electric, sanitary sewer, treated effluent, water, and gas and overhead telephone and electric. The DB Contractor will be required to work with local utilities and utility locators prior to excavation to protect the existing utilities. A PNM inspector must be present for construction of all gas pipeline crossings.

7.2.2 Pipe Sizes, Materials and Lengths

The BS4A Potable Water Pipeline is a 30-inch diameter pipeline approximately 4.3 miles in length. The Caja Del Rio Potable Water Pipeline is 24-inch diameter, approximately 4 miles long. The NM-599 Potable Water Pipeline is a 16-inch diameter pipeline approximately 4.75 miles in length. The

South Meadows Road Potable Water Line is approximately 1.2 miles in length and is 24-inches in diameter.

Materials for the potable water pipelines may be DIP, CCP or SCLC. Selected pipe materials will be adequate for the maximum operating pressures (with all duty and standby pumps in operation) at BS4A and BS5A plus the surge pressure designated under the appropriate pipe material ASTM or AWWA standard. As an option, the DB Contractor should consider pipeline materials with lower pressure ratings for construction of distant reaches of the NM-599 Potable Water Pipeline. Pipeline diameters were selected to optimize the pipeline capacity, electric costs due to friction losses and velocity requirements.

Various pipe materials were evaluated for use in the BDD Project. Pipe materials were evaluated for their ease of construction, cost, reliability, availability at design diameter and operating pressures and compatability with site soils.

SCLC, DIP and CCP pipe have also been selected as acceptable materials for the finished water pipelines because of their long record of success in this application. Local and nation-wide pipeline contractors have extensive experience with these materials, and no special equipment is required for their installation. Pipelines made of these materials are available across the southwest in many sizes and with many lining and coating materials, making their repair with an identical product a routine matter. These materials are available at the design pressure ratings and diameters. Corrosion control measures will be necessary for non-plastic pipelines used for the BDD Project as discussed elsewhere in this PDR and the Technical Requirements.

7.2.3 Geotechnical

A draft geotechnical report including field data dated March 10, 2006 for the entire BDD Project has been prepared and can be found in Appendix A. The geotechnical report indicates that much of the native material will be suitable for inclusion in the installation of the various pipelines being constructed for this project. However, it will be the DB Contractor's responsibility to identify useable material to meet their final pipeline design.

7.2.3.1 Pipeline Bedding and Backfill

Bedding and Backfill for Concrete Cylinder Pipe

Bedding for CCP will be a Controlled Low Strength Material (CLSM) composed of water, Portland cement, native trench material and fly ash. CLSM will exhibit an ultimate compressive strength of between 150 and 200 psi. Slump during placement will be approximately 10-inches. [Note: the use of CLSM for backfilling in the pipe zone is still under study.]

The bedding material will be placed to the following dimensions:

Below the pipe: 4-inches
Atop the pipe: 12-inches
Each side of the pipe to the undisturbed sides of the trench

Backfill for CCP will be native trench material placed above the CLSM for the entire width of the trench, compacted to 85 percent maximum density in off-road undeveloped areas, 90 percent beneath dirt roadways and 95 percent adjacent to or beneath paved roads.

Bedding and Backfill for Ductile Iron Pipe and Steel Cement Mortar Lined and Coated Pipe

Bedding material for DIP and SCLC will be sand, gravel or crushed stone to a depth of 1/8 of the pipe diameter or 4-inches minimum.

Backfill will be native trench material free of rock larger than 3-inches in any direction 12-inches from the pipe, free of any rock larger than 12-inches in any direction and free of frozen or organic material. Compaction will be 85 percent in off road, undeveloped areas, 90 percent beneath dirt roadways and 95 percent adjacent to or beneath paved roads.

7.2.4 Corrosion Analysis

A corrosion and stray current analysis was completed for the finished water pipeline alignments. The report documenting the methodology, results and recommendations are included in Appendix B. These paragraphs summarize the recommendations for the four finished water pipelines.

Soil samples were not collected along the finished water pipeline alignments because of access limitations. Field resisitivity was measured for the all alignments and that data forms the basis of the recommendations. The recommendations are based upon a 100-yr service life, vary with the pipe material and are presented by material.

7.2.4.1 Corrosion Requirements for DIP

If the DB Contractor selects DIP for any or all of the NM-599 or the South Meadows Road Potable Water Pipelines, the corrosion protection measures shall consist of polyethylene encasement. If the DB Contractor selects DIP for any or all of the BS4A or Caja del Rio Potable Water Pipelines, no supplemental corrosion protection is required and the DB Contractor shall install standard manufacturer pipe only.

7.2.4.2 Corrosion Requirements for CCP

If the DB Contractor selects CCP for any portion of the finished water pipelines, the corrosion protection measures shall consist of electrical continuity bonding (isolated from foreign structures using dielectric isolation fittings) with test stations and have cathodic protection in accordance with NACE RP-0169-2002 criteria.

7.2.4.3 Corrosion Requirements for Steel Pipe

If the DB Contractor selects Steel Piping for any portion of the finished water pipelines, the corrosion protection measures shall consist of electrical continuity bonding (isolated from foreign and above ground structures using dielectric isolation fittings), test stations, a dielectric coating, and cathodic protection in accordance with NACE RP-0169-2002 criteria.

7.2.5 Surge Protection

A surge analysis was completed for the finished water pipelines. The surge analysis was completed using H2OSurge software, developed by the University of Kentucky in conjunction with MWHSoft. The finished water conveyance system surge analysis is documented in Appendix E.

For the finished water system, the worst-case scenario was judged to be power failure, when the system is operating at its peak design flow. A pump station power failure with pump stations

operating at their planned peak design flow of 15-mgd for BS4A and 10-mgd for BS5A was evaluated. Information on maximum pressure rise or drop through the system following failure of the pumps was then compiled. Based on the model results, the OC developed recommended mitigation measures for the finished water system.

Worst-case pressure transients result when a power failure occurs with the system operating at its peak design flow. With no mitigation, pressure drops throughout the pipeline, with most of the pipeline reaching full vacuum conditions. Hydropneumatic surge tanks are required at both finished water booster stations to protect the system from downsurge. Hydropneumatic surge tanks should be sized for each facility as follows:

- BS4A: 500-gallon surge tank, 40 percent air/60 percent water ratio (steady-state operating pressure of 65 psi, at 6,500-ft amsl elevation)
- BS5A: 1,000-gallon surge tank, 40 percent air/60 percent water ratio (steady-state operating pressure of 175 psi, at 6,500-ft amsl elevation)

Vacuum relief valves should be provided at several locations along the pipeline, at local high spots, or other locations determined through modeling. For valves at locations where significant quantities of air may be drawn into the pipeline, valves should be equipped with a slow closing feature to avoid rapid expulsion of air from the system, which could cause a secondary high-pressure transient upon closure of the air valve. Options include APCO S-1500C, Vento-Mat RBX series, or combination valves with surge check feature. Valves at other locations can be standard combination valves. Recommended vacuum relief valve locations and sizes are under review and revision and will be finalized in Table 7.2-1 for the final PDR. Refer to the pipeline plan and profile drawings in the Finished Water Pipelines drawing set for station locations.

Table 7.2-1 Preliminary Locations and Sizes of Vacuum Relief Valves[1]

Location	Size	Notes
BS4A Potable Water Pipeline		
Station 184+00	See Note	Combination: Large Orifice 4-inch, Small Orifice 0.2-inch
Station 188+20	See Note	Combination: Large Orifice 4-inch, Small Orifice 0.2-inch
Station 206+90	See Note	Combination: Large Orifice 4-inch, Small Orifice 0.2-inch
Caja del Rio Potable Water Pipeline		
Station 13+00	TBD	
Station 55+00	TBD	

[1]Stationing based on Preliminary Design Drawings
TBD – to be determined by Board's Engineer

Note that additional modeling is underway to determine if finished water pipeline segments can be eliminated or reduced while still distributing 10-mgd from BS5A. The surge recommendations will be revised based upon final pipeline alignments.

The DB Contractor will be responsible for completing its' own surge protection system analysis during final design based upon final proposed pipeline alignments and pumping equipment.

7.2.6 Scour Studies

A scour study was performed to estimate scour depth at locations where the finished water pipelines crosses arroyos and rivers. The scour study is included as Appendix C. This section summarizes the results and recommendations from the scour study.

Topographical cross sections were collected for one wide and one deep arroyo and the Santa Fe River and the depth of scour was estimated using various computational methodologies. The minimum scour depth was determined to be essentially zero feet in "typical" arroyos. The scour depth for Arroyo Chamisos was estimated at nearly 7-ft. The scour depth for the Santa Fe River was estimated to be nearly 23-ft. For protection of the pipe in the typical arroyos, the normal pipeline cover under roadways (4-ft) was increased by a 50 percent safety margin to 6-ft cover. Most arroyo crossings along the finished water pipeline alignment will be similar to the "typical" crossing. The crossings at the Arroyo Chamisos and the Santa Fe River will be based upon a cover depth equal to the scour depth (7- or 23-ft) plus a 2-ft safety margin.

Arroyo crossing details, other than cover depth, are not discussed in the scour study report. However, the Preliminary Design Drawings include typical arroyo crossing and specific arroyo crossing details. In general, the pipeline cover depth is 6-ft (or greater and discussed above) and a 12-inch thick concrete cutoff wall will be constructed downstream of the arroyo crossing. Five crossings (Arroyo Calabasas, Arroyo de Los Frijoles, Santa Fe River, Arroyo de Los Chamisos and Arroyo Hondo) will also require concrete encasement of the pipeline.

7.2.7 Archaeological Sites

The finished water pipelines will traverse through two identified archaeological sites. Table 7.2-2 identifies the significant archaeological sites along the finished water pipeline LA Number. These sites will be fenced and monitored during initial ground disturbing activities.

Table 7.2-2 Significant Archaeological Sites along the Finished Water Pipelines

LA	Pipeline Station Location	Adverse Affect	Preconstruction Treatment	Construction Treatment
137075	123+00 to 125+00 Caja del Rio Pipeline	Effects avoided by constructing in disturbed areas	None	Fence and monitor
138574	120+00 to 121+00 BS4A Pipeline	Effects avoided by constructing in disturbed areas	None	Monitor

7.2.7.1 Construction Oversight and Monitoring

Compliance with Section 106 of NHPA (16 U.S.C. § 470) is required for the Project. The OC has received SHPO concurrence that Project effects have been mitigated for the known sites. The OC will provide a qualified archaeologist to monitor initial ground disturbing activities throughout the project. Employees and sub-contractors of the DB Contractor will be trained on archaeology site avoidance procedures, the need to identify potential cultural resources, and the procedures to follow if resources are observed during construction. If any unidentified cultural resources are encountered during construction, construction activities in the vicinity of the discovery will cease and the archaeologist and Owners will be immediately notified.

7.2.7.2 Inadvertent Damage to Cultural or Natural Resources

If natural or cultural resources are inadvertently damaged, the immediate area will be secured to prevent further impacts. The DB Contractor will notify the OC environmental coordinator as quickly as is reasonable. The OC will develop a plan to mitigate the inadvertent damage in consultation with the appropriate agencies.

7.2.8 Right-of-Ways

The finished water pipelines will be installed within permanent ROWs dedicated for the installation of water pipelines. In addition, temporary construction easements (temporary use areas) have also been established as working areas and to store material and supplies as well as construction equipment. All work must be done within the environmental survey limits identified on the Preliminary Design Drawings. Numerous agencies (BLM, the New Mexico Stand Land Office and NMDOT) will issue ROWs for the permanent areas and the temporary use areas as outlined in the permitting discussion in Section 10.6. The OC prepared legal descriptions for the ROWs identified in the Preliminary Design Drawings. The DB Contractor will have to revise the legal descriptions if there are any revisions to either the permanent ROW or the temporary use areas.

7.2.9 Revegetation

A clear demarcation of the limit of disturbance will be established at the commencement of construction. Disturbance due to construction of the pipeline shall be as minimal as possible. As far as possible, the alignment for the pipeline will be located in a manner to minimize the number of trees and other established landscaping that will require removal. Trees that have been identified as transplantable will be removed and trees to remain on site will be protected. Any trees removed must be marked prior to clearing, surveyed for birds nests, and chipped. A limited amount of the cleared material can be used as slash piles off-site. All topsoil will be removed and stockpiled nearby to be reused in reclamation.

Reclamation of the Finished Water Pipelines will include reclamation seeding with a specially selected seed mix for Pinon-Juniper Areas from the BLM and NMDOT in the disturbed areas. The stockpiled topsoil will be replaced over the pipeline in the seeding operations.

7.3 Finished Water Booster Stations 4A and 5A

7.3.1 Performance and Design Criteria

The Finished Water Pump Station facility is comprised of BS4A and BS5A, the GAC backwash supply pump, chemical injection booster pumps, and all control systems, appurtenances, and surge equipment necessary for the operation of the pumping facilities. In addition, fire protection system water supply and plant utility and potable water are provided from this facility. The finished water flow meters are adjacent to the pump station.

The pipeline for BS4A shall be 30-inch diameter to existing BS3. The pipeline for BS5A shall be 24-inch diameter to the terminus of the Caja del Rio road segment. A complete discussion of the finished water pipelines is in Section 7.2. The GAC backwash water pipeline shall be 16-inch diameter to the GAC contactors.

BS4A and BS5A will be enclosed in a pump station near the finished water storage tanks. Each pump station will consist of four pumps configured to run in parallel, utilizing three duty pumps and one standby pump. The pumps selected for use in BS4A and BS5A are canned vertical turbine pumps that will pump out of a distribution manifold served by the finished water storage tanks. In addition, BS4A will have space for two future pumps, complete with concrete pump and motor mounts, installed supply pipeline and pump cans, electrical supply, and controls connections. Pump motors will be operated using VFDs to maximize pumping rate flexibility, particularly during low demand periods.

On the suction side of each pump a manually operated isolation (gate) valve will be installed. The following appurtenances will be required on the discharge of each pump: combination air and vacuum release valve, check valve, motor operated control valve, and a manually operated isolation valve.

Control valves for each pump will be operated automatically by the C/CWTP control system. Additionally, a local control panel with percentage open display shall be installed at each control valve or at the motor control panel for each pump.

Plant potable and utility water will also be obtained from the finished water pump station. Plant potable and utility water will be taken directly from the BS5A finished water pipeline before leaving the pump station and prior to additional chemical injection. In the event that the finished water booster pumps are not operating and utility or potable water is required, gravity flow from the BS5A pipeline will provide finished water to the treatment plant.

A surge system will be required for both finished water pipelines. A preliminary surge analysis was performed and is presented in Appendix E. At the finished water pump station facility, BS4A will require a 500 gallon surge tank and BS5A will require a 1,000 gallon surge tank. A dedicated air compressor will be required for the surge tanks. Each surge tank shall be an ASME rated pressure vessel for the appropriate operating conditions.

The C/CWTP fire protection system will be provided out of the finished water booster station. Requirements for this facility are discussed in greater detail in section 7.4.9. The fixtures located at the finished water pump station include two booster pumps and a pipeline for sprinkler systems, a pipeline for fire hydrants, fire protection system control center, and a standby engine generator for the booster pumps. Fire protection water supply is provided from the BS5A pipeline.

Backwash pumps will also be installed in the finished water pump station. One canned vertical turbine pump will be installed. Preliminary design requirements for the backwash pumps are a minimum flow of 6,750 gpm at a TDH of 60 feet.

Additional chemical addition at the finished water pump station will include sodium hypochlorite for disinfection, sodium hydroxide for pH adjustment, and zinc orthophosphate for corrosion prevention. Sodium hypochlorite and hydrofluorosilic acid is injected into the contacted water prior to the finished water storage tanks for disinfection and prophylaxis. A chlorine residual monitor will measure the residual chlorine present in the water from the finished water storage tanks. Additional sodium hypochlorite will be added to provide an adequate chlorine residual in the distribution system.

Chemical injection into the finished water pipelines will be achieved using low flow- high head booster pumps to inject a sidestream of contacted water from the distribution manifold into each finished water pipeline. The sidestream for chemical injection will enter the finished water pipelines after plant potable/utility and fire protection water is taken from BS5A to prevent high chemical concentration water from entering the potable water system at the C/CWTP. Chemicals will be metered into the suction side of the chemical feed booster pumps. Chemical metering controls are discussed in Section 6.4.9.

A bridge crane shall be installed for removal and installation of pumps and other large fixtures at the finished water booster station. Each pump shall be installed with isolation valves to facilitate removal of a pump from service.

The inside of the finished water pump station will be provided with HVAC to cool the facility, as the motors and VFDs generate heat during operation.

Two ultrasonic flow meters will be required for the finished water transmission pipelines. Each meter shall be a wetted-type ultrasonic flow meter with a maximum error of 0.5 percent of flow (99.5 percent accuracy) under both maximum and minimum demand conditions.

Minimum service life for fixtures is 25 years in the finished water pump station. This includes major mechanical equipment with a value greater than $10,000.

Design Criteria for the Finished Water Booster Station are shown in Table 7.3-1:

Table 7.3-1 Finished Water Booster Station Performance and Design Criteria

Design Parameter	Value
Booster Station 4A	
Number of Pumps	Four (three duty, one standby)
Maximum Pump Capacity, each	2,100 gpm
Total Capacity, Maximum	8.9-mgd
Minimum Pump Capacity	1,050 gpm (1.5-mgd)
TDH	150-ft
Spare Pump Positions	Two
Ultimate Capacity	15-mgd
Booster Station 5A	
Number of Pumps	Three (two duty, one standby)
Maximum Pump Capacity, each	2,310 gpm
Total Capacity, Maximum	10-mgd
Minimum Pump Capacity	1,150 gpm
TDH	400-ft
Spare Pump Positions	None
GAC Contactor Backwash Pumps*	
Number of Pumps	One
Maximum Pump Capacity	6,750 gpm
Minimum Pump Capacity	3,400 gpm
TDH	60-ft
Fire Pumps**	
Number of Pumps	Two (1 duty, 1 standby)
Maximum Pump Capacity	1,500 gpm
Minimum Pump Capacity	1,250 gpm
Operating Pressure	70 psi

*also discussed in section 6.3.4 - GAC Contactors
** fire protection system design to be confirmedby the DB Contractor and in compliance with IFC

7.3.2 Initial Screening of Alternatives

Alternative screening for the raw water booster stations is discussed in Section 5.2 *Booster Stations 1A and 2A*. The results of the raw water booster station analysis apply to the major pumping equipment at the finished water booster stations.

7.3.3 Alternatives for Evaluation

Refer to Section 5.2 for an evaluation of booster pump alternatives.

For the GAC backwash pump, a gravity-fed backwash system was initially considered to minimize operation costs. This system would either convey water from the finished water storage tanks or the BS5A finished water pipeline to the GAC contactors for backwash cycles. Conveying water from the finished water storage tanks was eliminated because inadequate head was available for this option. Conveying water from the BS5A finished water pipeline was eliminated because

pipeline analysis indicated that ambient or negative pressure conditions could develop in the pipeline under some circumstances. Because neither option seemed feasible, the use of a pumped backwash system was included in the preliminary design. The OC will consider either gravity supply alternatives if the DB Contractor can demonstrate a feasible design.

7.3.4 Evaluation and Cost Analysis

See Section 5.2 for the evaluation of booster pump alternatives.

7.3.5 Recommended Facilities

The recommended facility arrangement for BS4A and BS5A is vertical turbine pumps manifolded to the outlet of the finished water storage tanks.

BS4A will serve the City of Santa Fe water demands from the C/CWTP of up to 15-mgd treated water will be conveyed to the suction side of existing BS3 and subsequently be conveyed to the City's 10-MG storage tank. BS4A will initially have a pumping capacity of 8.9-mgd with room for two additional future pumps to increase the capacity to 15-mgd. Four pumps are recommended: three duty and one standby. Each of the three duty pumps are designed to deliver 2,100 gpm and produce 150 feet of head.

BS5A will serve the City and County of Santa Fe Water demands from the C/CWTP of up to 10-mgd. Treated water will be delivered for City demands by connecting directly into the existing distribution network at the western extents. Treated water will be conveyed to the County by service to an existing reservoir or through metered interconnections. BS5A is required to deliver a total of 10-mgd. Three pumps are recommended: two duty and one standby. Each of the three duty pumps are designed to deliver 3,500 gpm and produce 400 feet of head.

7.3.5.1 Description of Facilities

Booster Station 4A

Vertical turbine pumps will be used for BS4A. Pump motors will be controlled by VFDs and provide a maximum turndown of 50 percent per pump to ensure operational flexibility. VFD Controls will be in the pump station facility and be connected to the C/CWTP control infrastructure. Local operation will be possible.

On the outlet of each pump, an air release valve, check valve, butterfly control valve, and isolation valve will be installed. The air release valve is used to prevent surge and to minimize air in the finished water pipeline. The check valve is used to prevent backflow from the finished water pipeline into the wet well. The check valve selected will prevent backflow and "slamming" in the event that flow suddenly stops, as in a power outage. The control valve will serve several purposes: during pump startup it will remain closed until pumps are producing adequate head to minimize backflow and surge and during operation the control valve will modulate flow from each pump to further control net pumping rate, the manually operated isolation valve will allow for the pump and butterfly control valve to be taken out of service for maintenance and inspection. Additional control valves at the flow meter will not be required.

Flow to BS3 will be metered at the C/CWTP in the finished water pipeline. The flow meter will be installed after exiting the finished water pump station and prior to leaving the C/CWTP site. During preliminary design, ultrasonic flow meters were assumed based upon lower cost, less maintenance, and no pipeline disturbance during service.

Booster Station 5A

Vertical turbine pumps will be used for BS5A. Pump motors will be controlled by VFDs and provide a maximum turndown of 50 percent per pump to ensure operational flexibility. VFD Controls will be in the pump station facility and be connected to the C/CWTP control infrastructure. Local operation will be possible.

On the outlet of each pump, an air release valve, check valve, butterfly control valve, and isolation valve will be installed. The air release valve is used to prevent surge and to minimize air in the finished water pipeline. The check valve is used to prevent backflow from the finished water pipeline into the wet well. The check valve selected will prevent backflow and "slamming" in the event that flow suddenly stops, as in a power outage. The control valve will serve several purposes: during pump startup it will remain closed until pumps are producing adequate head to minimize backflow and surge and during operation the control valve will modulate flow from each pump to further control net pumping rate, the manually operated isolation valve will allow for the pump and butterfly control valve to be taken out of service for maintenance and inspection. Additional control valves at the flow meter will not be required.

Flow to the City and County connections will be metered at the C/CWTP in the finished water pipeline. Other meters may be required at connections in the distribution system. The flow meter will be installed after exiting the finished water pump station and prior to leaving the C/CWTP site. During preliminary design, ultrasonic flow meters were assumed based upon lower cost, less maintenance, and no pipeline disturbance during service.

7.3.5.2 Operation of Facilities

The booster pump stations will be fully automatic and designed to operate unmanned. BS4A will receive a level signal from the tank level at the 10 MG tank. As the level in the 10 MG tank lowers, it will send a signal to start a pump in BS4A. The pump will start up in a preprogrammed operating mode and adjust pumping speed to keep the 10 MG tank level at a predetermined level in cooperation with the pumps at BS3 and BS4. If the water level in the tank continues to drop after a set time interval, a second pump will start and the two operating pumps will operate to maintain a fixed water level in the tank. If the water level in the tank continues to drop after a set time interval, a third pump will start and the three operating pumps will operate to maintain a fixed water level in the tank. As the level in the tank rises above a fixed level the same procedure will be used to turn pumps off.

BS5A will receive a level signal the SW Sector Tank. As the level in the SW Sector Tank lowers, it will send a signal to start a pump in BS5A. The pump will start up in a preprogrammed operating mode and adjust pumping speed to keep the SW Sector Tank at a predetermined level. If the water level in the SW Sector Tank continues to drop after a set time interval, a second pump will start and the two operating pumps will operate to maintain a fixed water level in the SW Sector Tank. If the water level in the SW Sector Tank continues to drop after a set time interval, a third pump will start and the three operating pumps will operate to maintain a fixed water level in the SW Sector Tank. As the level in the SW Sector Tank rises above a fixed level the same procedure will be used to turn pumps off. Additional means for controlling the operation of BS5A are still under consideration.

7.3.5.3 Maintenance of Facilities

See Section 5.2.5.4 for maintenance of booster station pumps.

7.3.5.4 Control Description

See Section 5.2.5.3 for Automatic Start-up and Shutdown sequence of booster station pumps.

7.4 Recommended Booster Stations 4A and 5A and Finished Water Pipelines General Requirements

7.4.1 Civil Site Work

All pipelines will be constructed within easements or ROWs obtained for various agencies. All work must be done within the environmental survey limits identified in the Preliminary Design Drawings. All sites shall be returned to their original contours with all fences, culverts, and other structures returned to their original condition. The civil site work for BS4A and BS5A is discussed as part of the C/CWTP discussion in Section 6.

7.4.2 Landscaping/Revegetation

Reclamation of the Booster Station Facilities is included in the revegetation and landscaping work described for the C/CWTP in Section 6.

Disturbance due to construction of the pipeline shall be as minimal as possible and in all cases must be within the environmental survey limits and the temporary use areas permitted by the agencies. Reclamation of the Finished Water Pipelines will include reclamation seeding of any disturbed area with a specially selected seed mix for Pinon-Juniper Areas approved by the owning agency (BLM, NMDOT, Santa Fe County Public Works or the State of New Mexico Land Office). The stockpiled topsoil will be replaced over the pipeline prior to the seeding operations. A possible seed mixture was shown in Table 3.2-4 (Section 3).

7.4.3 Geotechnical

Alluvium and various members of the Santa Fe Group underlie the majority of the Project facilities. The Santa Fe Group is a series of unconsolidated Quaternary age sedimentary units. The lithology and cementation of the units composing the Santa Fe Group range widely, from claystone and siltstone to sandstones and gravel/conglomerates. Most of the visible units within the Project area and records of previous nearby investigations indicate that the bedrock units within the area are generally weakly-cemented, and generally pose little difficulty to excavate using conventional drilling and earthwork equipment. Occasional cobbles and boulders will probably be encountered. The complete description of the site is provided in Appendix A – Geotechnical Investigations Report.

For the BS4A and BS5A facilities, the structures may be supported on conventional spread and strip footings bearing on a minimum of five feet of structural fill. The structural fill should extend a minimum of three feet laterally beyond the edge of all footings. The foundations may be designed to allow a bearing pressure of 1,500 psf.

The base of the exterior footings should be embedded a minimum of 24-inches below the lowest adjacent grade. The base of the footings should be embedded a minimum of 12-inches below the finished pad grade. The spread and strip footings should be a minimum of 24- and 18-inches wide, respectively.

Lateral foundation loads will be resisted by a combination of passive soil pressure against the sides of the footings and friction along the base. A passive soil resistance of 300 pcf should be utilized for the DB Contractor's design.

Prior to fill placement and following footing excavation, the natural soils should be scarified to a depth of 8 inches and moistened to a near optimum moisture content (±3 percent). The exposed soils should then be compacted to a minimum of 95 percent of maximum density. Prior to pouring concrete, footing excavations should be cleaned of any slough, loose soil, or debris. Additional compaction information can be found in the attached report. However, it is important to note that backfill compaction adjacent to walls should be performed using relatively light, hand-operated equipment to prevent overstressing the wall and excessive lateral deflections.

Foundations designed and constructed by the DB Contractor are not anticipated to settle more than one inch. Therefore, the DB Contractor will be required to design and construct the foundations to tolerate this settlement level. Vibratory equipment, including the pumps, will require mounting on isolated equipment pads to minimize settling.

For the control facilities, a concrete slab-on-grade may be used. The slab(s) should be isolated from all foundations, stem walls, wet walls, vibratory equipment and utility lines. Frequent joints should be scored or cut in slabs to control the location of cracks. The slab should bear on a minimum of 5-ft of structural fill. Prior to placing the slab or structural fill, the natural soils should be stripped of vegetation, scarified to a depth of 8-inches, and moistened to a near optimum moisture content (±3 percent). The exposed soils should then be compacted to a minimum of 95 percent of maximum density.

Thickened slabs may be utilized to support interior partitions. The thickened slabs should be a minimum of 12-inches in width and should be designed by the DB Contractor to exert a maximum earth pressure of 500 psf.

If a moisture-sensitive floor covering is utilized, the slab should be underlain by a moisture barrier to prevent "damp slab" conditions. The moisture barrier may consist of a 6-mil polyethylene film or equivalent. The barrier may be overlain with one or two inches of clean sand to provide a working surface and reduce shrinkage cracking.

The DB Contractor's geotechnical engineer is responsible for developing structural recommendations for these and all other BDD facilities.

7.4.4 Structural

The structural requirements provide minimum design criteria and will be used as a guide in the design and construction of BS4A/BS5A building.

The general types of construction will be cast-in-place concrete or prestressed concrete for liquid containing basins or reservoirs and masonry walls with steel roof for buildings.

Foundations of structures will be designed in accordance with the data presented in the project geotechnical report (Appendix A) and the recommendations of the DB Contractor's geotechnical engineer. In general, the type of foundation for the BS4A/BS5A will be mat foundations or continuous spread footings along the walls with slab-on-grade at the center portions for the liquid containing basins or reservoirs and continuous spread footings along the walls for masonry buildings.

The final structural requirements are to be developed by the DB Contractor's geotechnical engineer.

7.4.5 Architectural Design

7.4.5.1 Design Standards

All buildings for the Buckman project will be designed to meet the 2004 New Mexico General Construction Building Codes (Title 14 NMAC – Chapters 5 and 7). The building for BS4A and BS5A must also comply with the requirements of the BLM.

7.4.5.2 Space Planning

The space planning for this facility was done by the process engineers and did not involve the project architect. The building size, shape and vertical height are determined by the raw water booster pump equipment to be housed.

7.4.5.3 Architectural Style

The architectural style requirements specified in Section 6 apply to BS4A and BS5A.

7.4.5.4 Architectural Construction Requirements

The architectural construction requirements specified in Section 6 apply to BS4A and BS5A.

7.4.6 Electrical

7.4.6.1 Facility Loads

An electric load list for the BS4A/BS5A facility at the C/CWTP is shown in Table 7.4-1. The electrical loads for BS1A were included in Section 4 with the SRF. Since the largest motor is rated at 450 hp, a 480-volt, 3-phase system was selected for the main utilization voltage.

Table 7.4-1 Electric Load List for BS4A/BS5A

Item	Estimated Connected HP or KW	Comments
Finished Water Sample Pump No. 1	0.75	
Finished Water Sample Pump No. 2	0.75	
Reservoir Inlet Valve No. 1	0.5	
Reservoir Inlet Valve No. 2	0.5	
Reservoir Outlet Valve No. 1	0.5	
Reservoir Outlet Valve No. 2	0.5	
Pump 1 (BS4A)	125	VFD
Pump 2 (BS4A)	125	VFD
Pump 3 (BS4A)	125	VFD
Pump 4 (BS4A)	125	VFD (Standby Unit)
Pump 5 (BS5A)	450	VFD
Pump 6 (BS5A)	450	VFD
Pump 7 (BS5A)	450	VFD (Standby Unit)
Discharge Control Valve No. 1 (Pump 1)	0.5	
Discharge Control Valve No. 2 (Pump 2)	0.5	
Discharge Control Valve No. 3 (Pump 3)	0.5	
Discharge Control Valve No. 4 (Pump 4)	0.5	
Discharge Control Valve No. 5 (Pump 5)	0.5	
Discharge Control Valve No. 6 (Pump 6)	0.5	

Table 7.4-1 Electric Load List for BS4A/BS5A

Item	Estimated Connected HP or KW	Comments
Discharge Control Valve No. 7 (Pump 7)	0.5	
Discharge Control Valve No. 8 (Pump 8)	0.5	
Discharge Control Valve No. 1 (Pump 1)	0.5	
Fire Pump	100	
Finished Water Meter No. 1 (BS4A)	*0.2 KW*	
Finished Water Meter No. 1 (BS5A)	*0.2 KW*	
HVAC Allowance	*5 KW*	
Lights	*2 KW*	
Miscellaneous Other Loads	*1 KW*	
Total	*1,958 hp + 8 KW*	

7.4.6.2 Power Distribution

BS4A and BS5A will obtain power from the C/CWTP main switchgear since the stations are located within the plant. Two 12.47kv feeders protected by vacuum circuit breakers off of bus A and bus B will supply each side of an outdoor double-ended substation with fully rated 1,000 KVA, 12.47kv-480/277v pad-mounted oil-filled transformers. Each transformer will be protected by a 15kv-rated vacuum circuit breaker located in an adjacent weatherproof housing. The transformer secondary at 480/277 volts will feed each side or bus of the low voltage Switchgear 7A-7B.

Switchgear 7A-7B will be furnished with two main circuit breakers, a tie circuit breaker and feeder circuit breakers for MCC 7A, MCC 7B, and the two fire pumps. The switchgear main, tie and feeder circuit breakers will be the draw-out, electrically operated power type. The main and tie circuit breakers will be controlled by an automatic transfer system to provide automatic switchover of power in case there is a power failure on the upstream side of one of the switchgear main circuit breakers.

MCC 7A and MCC 7B will each house combination breaker-motor starters for small motor loads, feeder circuit breakers for the booster pump VFDs, and feeder breakers for package process equipment and 480-208/120 and 480-240/120 volt dry-type transformers for panelboards LP-7 and LP-7I for instruments, respectively.

7.4.6.3 Standby Power

The fire pump controller panel will have the capability of being fed from both the switchgear and the 300 KW standby E-G via the integral automatic transfer switch. The controller panel automatic transfer switches will be able to start the E-G whenever its normal power fails to be able to run the fire pump with back-up power and supply water for fire protection for the plant. The E-G will be provided with an integral base-mounted diesel fuel tank with a 300-gallon capacity and will be installed in a building.

A New Mexico Air Quality Notice of Intent Permit has been obtained for the E-G. For compliance with this permit under 20.2.72.202B NMAC, the E-G will be operated only during the unavoidable loss of commercial utility power and during periodic testing. The E-G will be allowed to operate less than 500 hours per year and must be accompanied by sufficient record keeping by the Owners to verify that the E-G is operated less than 500 hours per year.

7.4.6.4 Variable Frequency Drives

VFDs for the BS4A and BS5A pumps will be the 480-volt, the clean power type in packaged free-standing NEMA 1 enclosures each with an incoming circuit breaker and other features as described in Section 6.

7.4.7 Instrumentation and Control

Instrumentation and control was discussed in Section 6.4.18.

7.4.8 SCADA and Telemetry

The Process LAN from the C/CWTP shall be extended to BS4A and BS5A via fiber optic cable. Process control for the booster stations shall consist of PLCs on the process LAN communicating with the SCADA Master at the C/CWTP and other PLCs on the process LAN.

7.4.9 HVAC, Plumbing and Fire Protection

7.4.9.1 Heating, Ventilation and Air Conditioning

The HVAC system in BS4A and BS5A will consist of systems necessary to meet the numerous functions.

In wet areas or areas with potential for condensation, maintain a low relative humidity (RH) to minimize or eliminate condensation and corrosion. Where outside air is required for ventilation, the outdoor air will be treated by heating and filtering as required.

Operation spaces will be provided with ventilation where they will be occupied spaces. In addition spaces that may be entered by plant personnel will be ventilated in accordance with applicable codes and good engineering practices

Ventilation will use multiple supply fans in each space with relief dampers. Supply fans will have both outdoor and return dampers to provide a minimum supply temperature during cold weather.

HVAC Codes and Standards

Design of the HVAC systems for BS4A and BS5A shall comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Commercial Building Code
- 2003 New Mexico Mechanical Code
- 2003 New Mexico Energy Conservation Code
- New Mexico Boiler Code
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- National Fire Protection Association (NFPA) standards
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA) standards
- Air Moving and Conditioning Association (AMCA)
- Associated Air Balance Council (AABC)
- National Environmental Balancing Bureau (NEBB)

Design Criteria

The design will be based on outdoor design conditions of 10 degrees F DB during the winter and 96 degrees F DB, with a 60 degrees F MWB during the summer. Air density will be based on an elevation of 6,500-ft amsl.

Selection of condensers for air-conditioning units will be based on 106 degrees F deg.

Indoor Design Conditions

The design of cooling and heating systems for specific spaces will be based on the indoor conditions shown in Table 7.4-2.

Table 7.4-2 BS4A and BS5A Indoor Design Temperatures and Ventilation Rates

Area	Temp (°F) Summer / Winter	Design Features
Pump Room	Ambient + 10/55	• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation • Unit heater
Lower Pump Room	Ambient + 10/55	• Intermittent heat removal ventilation using multiple units • Provide continuous mechanical ventilation • Unit heater

Refer to system diagrams for additional information on systems and zoning of units and number of units required.

7.4.9.2 Plumbing Systems

The plumbing in BS4A and BS5A will consist of systems necessary to meet the numerous functions of finished work at the C/CWTP, including:

- Drain systems with vents where required for sanitary, process rain water, and equipment.
- Sump pumps and discharge piping systems.
- Water systems including hot and cold potable water, utility water (non-potable) for process use.

Plumbing Codes and Standards

Design of Finished Water Transmission Booster Pump Stations BS4A and BS5A shall comply with the applicable portions of the following codes and latest standards:

- 2003 New Mexico Plumbing Code
- 2003 International Fuel Gas Code (IFGC)
- American Society of Plumbing Engineers (ASPE) design guides
- ANSI Z358.1: Emergency Eyewash and Shower Equipment, 1998
- AWWA
- NMED Title 20 Chapter 7 Part 3: Liquid Waste Disposal and Treatment Requirements

Description of Recommended Systems

Each water system shall have its own backflow prevention device to eliminate cross-contamination of the plant's potable water system. All backflow devices shall be protected against freezing and to facilitate maintenance.

The potable water system will include cold water for drinking water fountains, janitor's mop sink, and exterior hose bibs and hot water for janitor's mop sink.

The sanitary system will include floor drains and drinking fountain drains.

The process drain system will be independent of the sanitary sewer and will include floor drains in process areas.

Rainwater leaders will be based on a rainfall rate of 2.0 inches per hour (0.021 gpm per square foot) for a 100-year storm. This is the 1 hour rainfall rate per 1997 UPC.

Plumbing Fixtures

All hose bibs will be provided with individual vacuum breakers.

7.4.9.3 Fire Protection

Fire protection systems are not required for this building.

7.4.10 Security

Security and personnel protection measures to protect these facilities during construction, start-up, and initial operation will be provided. During construction, temporary security measures will be provided as necessary to protect the facilities, equipment, and personnel.

7.4.10.1 Security Objectives

In order to reduce risk to the integrity of the facilities and to protect the public water supply, included herein are requirements for the design and construction of security and personnel protection systems for the Project facilities. These requirements emphasize the facility design considerations, not the management and operations of the facilities.

For these facilities, as well as the overall project, security and personnel protection will be a major priority for the OC and the DB Contractor. Through the course of the design, the following security and personnel protection issues, at a minimum, will be addressed:

- Threats to the source water and water treatment facilities
- Threats to the pump stations
- Threats to the distribution systems/booster stations
- Threats to the SCADA/telemetry system
- Fire detection and notification
- Communications

Threats may be in the form of one or more of the following: vandalism, criminal acts, sabotage/terrorism, or deliberate/malevolent acts by employees (either present or former).

7.4.10.2 Recommended Security Systems

The following sections outline the physical security and personnel protection requirements for the BS4A, BS5A and the Finished Water Pipelines. Because water systems cannot be made immune to all possible threats, the design of the facilities will address issues of critical asset redundancy, monitoring, response, and recovery to minimize risk.

Booster Stations 4A and 5A

Because these booster stations are on the same site as the C/CWTP and enclosed by the same perimeter fence, the design to protection the water supply and BS4A and BS5A will follow the criteria established for the C/CWTP.

Finished Water Pipeline and Appurtenances

The design will incorporate the following provisions to protect the Finished Water Pipeline and appurtenances:

- The area of aboveground exposure for the pipelines and appurtenances will be reduced
- Back-flow prevention devices
- Bolts/hardware that require a special wrench (where generally available screw-drivers and wrenches would not work) to unlock access hatches and valve vaults
- Pad-locked protective cages over aboveground appurtenances, such as backflow preventors, to restrict access. These cages shall be constructed ½-inch, #13 gage diamond pattern flat rolled expanded steel with all welded construction. The cages shall be of Type 304 stainless steel or protective coated carbon steel with a 2-mil minimum thickness polyester powder coating.
- Locking covers

This section describes the existing City of Santa Fe water Supervisory Control and Data Acquisition (SCADA) system and outlines the changes to the system that are recommended as part of the BDD Project. This section includes information about the master station computer hardware, software and networking equipment, remote terminal units located at the City and County's various remote sites, the radio telemetry that connects the master station computers to the remote sites, and the communications equipment that connects the SCADA network between various facilities.

8.1 Performance and Design Criteria

8.1.1 Definitions

The following definitions have been provided to clarify certain terminology as it applies to this Project.

- **Integration:** The implementation of the functional specification prepared by the Owner's Consultant to create a complete and working system. The Owner's Consultant specifies system performance requirements and provides guidance regarding selection of equipment, material, and software while the Integrator selects the specific equipment to be used on the Project and creates the actual, working system based on these criteria.
- **Integrator:** An organization specializing in the integration of SCADA systems. The Integrator usually purchases all of the major SCADA system components, including master station equipment (computer, monitors, printers, network equipment, etc.), programmable logic controllers, remote terminal units, software, etc. Typically, the Integrator will also fabricate the Remote Terminal Units (RTUs) if they are not "off-the-shelf" components and will perform all software configurations and application specific programming to provide a complete and functional system per the specified performance requirements. Finally, the Integrator will usually be responsible for all system testing, preparation and submission of detailed submittals including O&M manuals, and training of the client. Usually, the Integrator will install the master station equipment. The Integrator may also install the RTUs, antennas, and associated components or provide this equipment for installation by the Installation Contractor. The Integrator will be part of the DB Contractor's team.
- **Installation Contractor:** An organization specializing in the installation of the field components associated with a SCADA system, that is, instruments, raceway systems (conduit, wire, boxes, etc.), incidental electrical work (lighting, receptacles, etc.), grounding system, antenna masts/towers, and, in most cases, the Integrator-furnished antennas (and associated components) and RTUs. The Installation Contractor will typically purchase the equipment that it will install, with the exception of the RTUs and antennas (and associated components), which are furnished by the Integrator.

- **Factory Acceptance Test:** Tests performed in the Integrator's facility prior to shipment of equipment to the field to substantiate that the system performs in accordance with the Specifications.
- **Site Acceptance Testing:** A series of tests performed in the field before the system is turned over to the Owners to substantiate that the system performs in accordance with the Specifications.
- **Availability Test:** A test to determine the availability of the system over a period of time after it is substantially complete. Availability is the ratio of uptime to uptime plus downtime.
- **Remote Terminal Unit (RTU):** A fabricated assembly consisting of many components, including a programmable logic controller (PLC), radios, modems, routers, power supplies, etc., mounted to a subpanel inside of an enclosure.
- **Front End Processor (FEP):** A PLC, connected to the SCADA master station computers, which is responsible for polling the RTUs, making control decisions, and transmitting control commands to the RTUs.
- **Master Station:** In a SCADA system, the computer or computers on which the SCADA software maintains a real-time database of the field conditions associated with each device connected to each RTU.

8.1.2 Qualifications

The Integrator, as defined above, will be part of the Project's DB Contractor's team. The Integrator will be a part of the DB Contractor's team when the team is selected by the Owners. The Integrator must meet certain qualifications that will be spelled out in the Technical Requirements.

Typically, required qualifications include licensing, bonding capacity, insurance, compliance with labor and other applicable laws, financial solvency, etc. In addition, the Integrator is required to show that they have the resources available to perform the Project. This includes having a record of successful completion of similar projects and having the resources on staff to perform the major elements of the project. Minimum qualifications may also be established for key members of the Integrator's team, including the experience of the Project Manager, Systems Engineer, Software Engineer, and Field Installation Supervisor. Finally, the Integrator, as an organization, must have completed a specified number of similar projects.

8.1.3 Existing System Description

8.1.3.1 General

The City of Santa Fe operates a SCADA system to control and collect data from the City's water wells, reservoirs, tanks, and booster stations. The system was designed by Timberline Engineering of Albuquerque, New Mexico beginning in February 1997. Design was complete in April of 1998, and the contract for construction was awarded to General Electric Team Controls (later re-named GE Automation Services) in June 1998. Construction of the system began in June 1998 and was complete in January 2000. The system has been in operation for nearly six years, and the City is satisfied with its performance.

8.1.3.2 System Architecture

The SCADA System Architecture, described below, is depicted in Figure 8.1-1, Existing SCADA System Block Diagram.

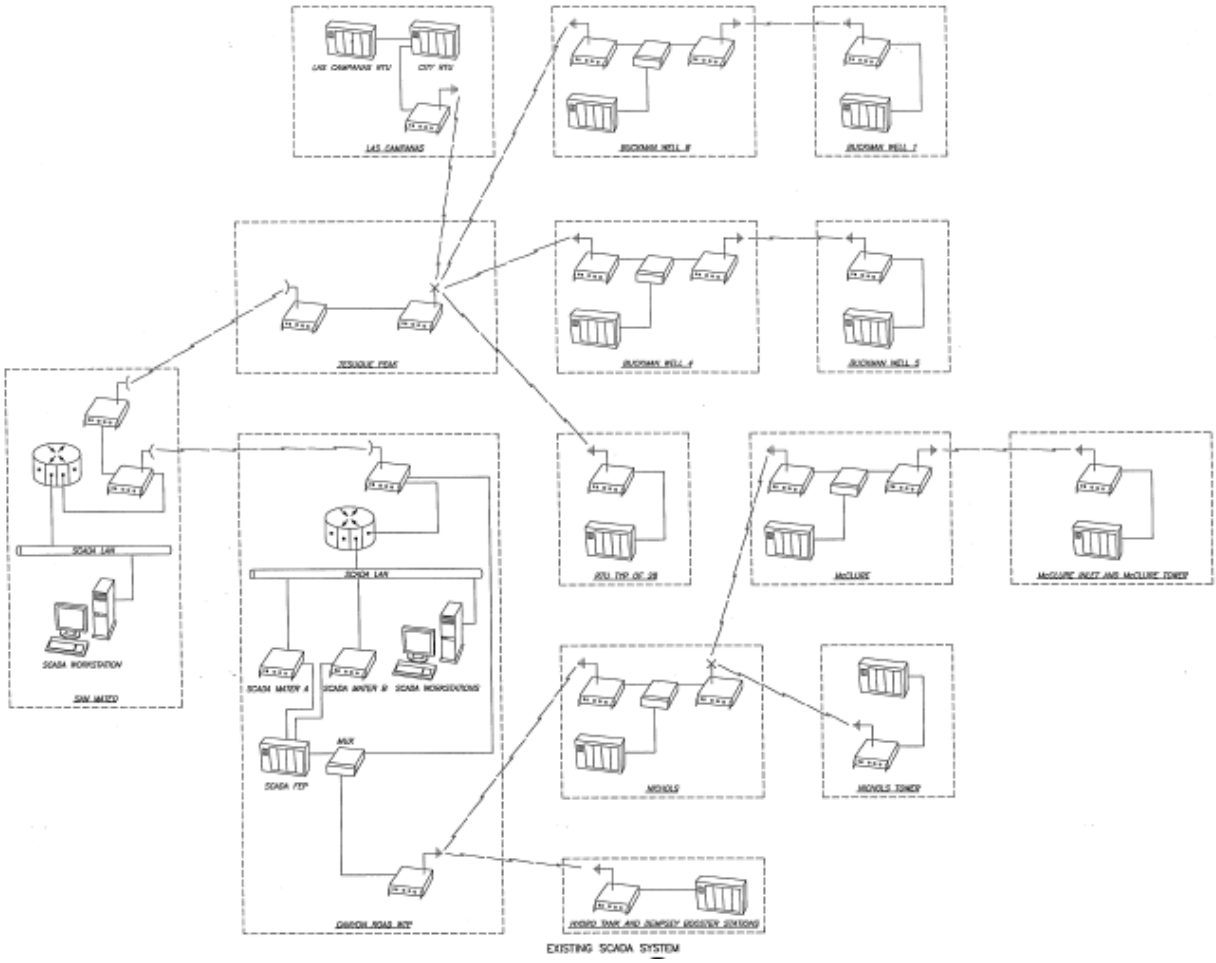


Figure 8.1-1 Existing SCADA System Block Diagram

Source: Timberline Engineering Inc.

8.1.3.3 Process Control

The SCADA system uses a control architecture in which control decisions are made in Programmable Logic Controller (PLC) based RTUs located at each of the remote facilities. These control decisions are based on comparing field data with control setpoints. When a process variable exceeds a control setpoint, an RTU will initiate a control command. For example, if a tank level drops below a setpoint in a booster pump station RTU, the RTU will control the booster pump to start.

Field data that is compared to setpoints can be obtained locally by the RTU if the process variable is local to the site, or it can be collected from a different RTU and relayed to the first RTU via radio. The radio system is a Multiple Address System (MAS), which links a dual-redundant PLC-based Front End Processor (FEP) at the Canyon Road Water Treatment Plant (Canyon Road WTP) to all the RTUs through a master radio on Tesuque Peak. The FEP polls each of the RTUs for data and passes the necessary data from one RTU to another so that control decisions can be made in the PLC. Communications between the MAS master radio and the FEP use a microwave radio system operating at 928 and 952 MHz. Because there is no line of sight between the Canyon Road WTP

and Tesuque Peak, the system uses a microwave repeater at the Administrative Offices on San Mateo Rd (San Mateo Office).

Several RTUs do not have adequate line of sight to Tesuque Peak to communicate with the MAS master radio, so the system also employs end-link repeater radios operating in the 900 MHz spread spectrum band to complete the communications to the more remote RTUs. Specifically, Buckman Well 8 serves as a repeater for Buckman Well 1, and Buckman Well 4 serves as a repeater for Buckman Well 5. In addition, a spread spectrum radio at the Canyon Road WTP links the FEP with Nichols Reservoir, which has a spread spectrum radio to connect it to the tower at Nichols Reservoir and to McClure Reservoir. McClure Reservoir, in turn, has a spread spectrum radio to connect it to the McClure Inlet and the McClure Tower. The spread spectrum radio at the Canyon Road WTP also links the FEP with Dempsey Booster and Hydro Tank.

8.1.3.4 User Interface

The SCADA system has a dual-redundant master station computer and a set of operator workstations. Data from the FEP is communicated to the master station computer, which maintains a real-time database for display and a historical database for report and trend generation. Real-time conditions are displayed on the SCADA workstations so that operators can assess the condition of the system and make man-in-the-loop control decisions. Operators can change operational setpoints for field equipment and can command field equipment to change state (start, stop, open, close) through the operator workstations. Those commands are sent to the FEP which passes them on to the appropriate RTUs.

The master station local area network (LAN) is extended to the San Mateo Office through the same 960 MHz microwave radio link that connects the FEP to the MAS master radio. An operator workstation is available at the Administrative offices for access to SCADA information.

8.1.3.5 Input/Output

The Input/Output (I/O) in the existing SCADA system is contained in the SCADA real-time database and in the FEP. Documentation of those points is up to date and available from the City when needed by the Integrator. The system currently has approximately 2800 points including real I/O and pseudo-points in the SCADA master station software.

8.1.3.6 Remote Access and Network Security

The existing SCADA system was designed to allow access to data on the master station computer through other computers on the SCADA Local Area Network (LAN) with appropriate username and password combinations. The system was not designed to connect to other networks nor was it designed to connect to the Internet. As a result the SCADA system security is limited to username and password combinations managed by the SCADA software. Software update control methods are discussed in Section 8.1.4.7.

8.1.4 Replacement System Description

8.1.4.1 General

Modifications to the SCADA system are required to support the C/CWTP. The existing SCADA master station computers will be replaced, but the existing RTUs will not be modified. This design decision is based on the following facts:

- The SCADA system is currently in excess of five years old. The current schedule calls for this project to be complete prior to 2010, at which time the SCADA system will be 10 years old. After 10 years, computer hardware and networking equipment are due for replacement.
- As a result of this project, most of the personnel responsible for the SCADA system will be located at the C/CWTP rather than at the existing Canyon Road WTP. Therefore, it makes sense to relocate the SCADA master station equipment to the new WTP.
- The SCADA RTUs, unlike computer equipment, are composed of industrial components with a much longer life span. At this time, there is no reason to undertake replacement of the RTUs.

While the computer hardware will be replaced, the SCADA software will not. The City has a significant amount of experience with the SCADA software, Citect, and has kept that software up to date and working well. Because SCADA software has to be configured based on the equipment connected to it and the controls and displays needed from it, replacing the software would require a significant integration effort that would increase project cost and risk and not provide significant benefit.

In addition, the City uses Operator-10 (Op-10) software from AllMax Software for report generation and maintenance management. Like Citect, the City has a significant investment in experience with Op-10 and is satisfied with the software. Therefore, Op-10 will be used in on the Project as the maintenance management software and the SCADA report generator.

8.1.4.2 System Architecture

The conceptual design of the new SCADA system is outlined below and shown in Figure 8.1-2, Replacement SCADA System Block Diagram.

8.1.4.3 Process Control

Process control for the existing water production and distribution facilities is performed in the PLC at the Canyon Road WTP. The existing process control algorithms will remain unchanged in the new system.

The Nichols, McClure, Dempsey Booster, and Hydro Tank remotes are currently communicating with the FEP at the Canyon Road WTP via unlicensed 900 MHz radio, and the Canyon Road WTP process control PLCs communicate with it via wire. The code for polling and controlling these RTUs and PLCs will continue to reside in the Canyon Road WTP FEP. A new PLC will be installed at the C/CWTP to act as an FEP, polling the existing remote sites via MAS radio and implementing the control algorithms.

Moving the polling and control responsibilities from the Canyon Road WTP to a new FEP at the C/CWTP will require the Integrator to reproduce the functionality of the existing FEP in the new FEP. To reduce project cost and risk, the new FEP will be a Modicon Quantum PLC so that the existing code can be installed in the new FEP without compatibility issues.

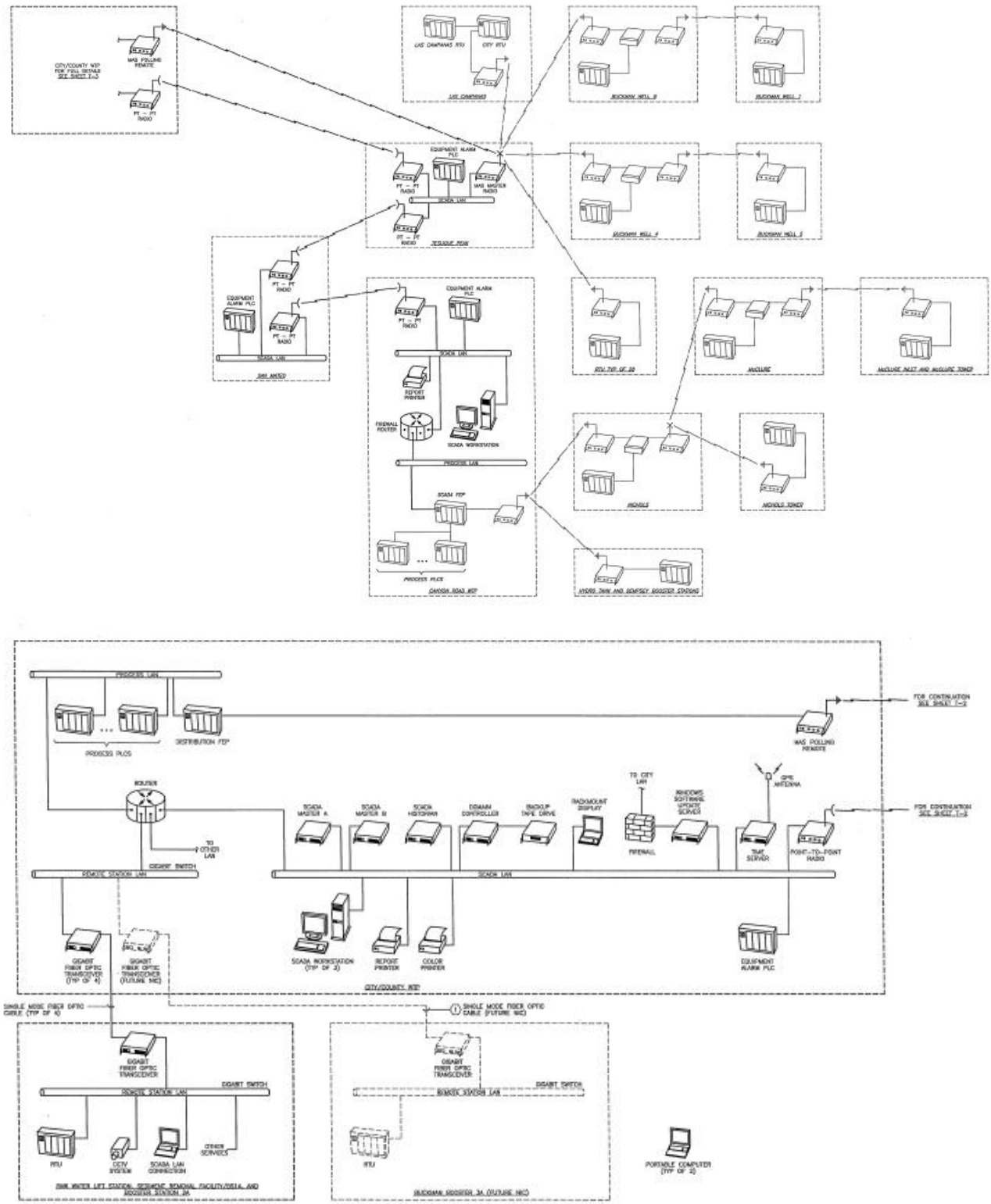


Figure 8.1-2 Replacement SCADA System Block Diagram

Source: Timberline Engineering Inc.

For the purposes of cutover, the existing PLC program in the Canyon Road WTP FEP will be modified with a piece of ladder logic to be able to turn off or on the polling and control algorithms. Then during cutover, the Canyon Road WTP PLC could be switched to poll only the Canyon Road WTP, Nichols, McClure, Dempsey Booster, and Hydro Tank PLCs. If cutover needs to be halted

for any reason, the Canyon Road WTP FEP could be switched back to polling all remotes. When cutover is complete, the excess code in the Canyon Road WTP FEP should be removed.

Process control for the C/CWTP will reside in PLCs on a network at the C/CWTP and be integrated into the Citect SCADA software. Because the PLCs are local to the plant, the SCADA master station computers will poll the plant process PLCs directly; the FEP will not be involved.

Process control for the RWLS, SRF/BS1A, BS2A, and the future BS3A: The process LAN will be extended via fiber to each of the new facilities, and PLCs in those facilities will be connected to the LAN. Those PLCs will then be able to communicate with each other in a peer-to-peer fashion and with the SCADA master computer to acquire the data necessary to make control decisions.

8.1.4.4 User Interface

The existing system uses Citect software as the user interface. The City has significant investment in Citect, and has dictated that the new SCADA system be an extension of the existing Citect software. Custom screens have been built to show the status of each of the existing remote sites providing the site's data and controls. New screens will be developed for each of the new facilities constructed under this project.

The Integrator will be required to segment the existing SCADA system into two Citect "projects" to simplify maintenance and reduce project risk. One project will contain standard symbols and other standards to be used on both the existing and new SCADA screens, and the second project will contain the screens for the existing system based on the standards. Once that effort is complete, the Integrator can create the screens for the new facilities as a new project drawing on the standards. Using this approach, the new facilities can be tested and started up without affecting the performance or reliability of the existing facilities.

As part of segmenting the existing system into two projects, the Integrator will be tasked with reviewing the system configuration in a value engineering assessment with Citect applications staff to insure conformity and compatibility with Citect products as they are currently applied in the system, and incorporate recommendations for system improvements. While it is not obvious that such improvements are necessary, it would be prudent to have an expert opinion on the subject while work is being performed.

8.1.4.5 I/O

The Integrator will require I/O lists for the existing and new systems. The point count for the existing and new systems will have to be calculated, and the Citect license may need to be upgraded to accommodate the higher point count. The existing system has a Citect license for 5000 points, of which 2800 points are used. The next increment in license size is "unlimited."

The existing points will be re-distributed between the Canyon Road WTP FEP and the new FEP. New I/O points at the facilities other than the C/CWTP will be integrated into the new FEP.

8.1.4.6 Networking

The C/CWTP will include several PLCs controlling various aspects of the process. These PLCs will be connected on an Ethernet LAN, called the "process LAN," which will be connected to the SCADA LAN through a router. The router will be programmed to allow the SCADA host computers to interrogate the process PLCs, but not to allow other SCADA LAN communications to pass to the process LAN. This approach requires a minimum of integration effort and provides the process LAN good protection from traffic congestion caused by the SCADA LAN.

8.1.4.7 Remote Access and Network Security

Current networking technology can allow interconnection of the SCADA system with the Owner's other computer networks and with the Internet. Some owners find that such interconnectivity provides benefit to the enterprise; however, it also introduces risks.

Interconnecting the SCADA system to any network provides a path for computer viruses and hackers to disrupt the control system and possibly allow malicious outsiders to take control of pumps and valves in the water utility. While the risk of malicious outsiders controlling facilities is very low, there is a very real risk of viruses or other attacks resulting in the system failing to collect data, display data, and allow users to manually change setpoints and control facilities. Consequently, significant cost and effort must be expended to ensure the system is as secure as it can be before it is interconnected with other networks.

The greatest advantage of network access to SCADA is to allow a mobile workforce to access SCADA data, and possibly SCADA control screens from their homes, offices, remote facilities, and any other location with Internet access. This allows a utility without a round-the-clock operations staff to respond to SCADA alarms in a timely manner. In the case of the City and County of Santa Fe, the Owners plan to maintain a 24/7 workforce at the C/CWTP trained to respond to alarms from the SCADA system. Therefore, in discussions with the City, the City indicated that they would see little advantage to this sort of interconnection.

The other primary advantage of interconnectivity is the ability to link SCADA data with engineering, planning, and other enterprise data across the organization. Based on discussions with City employees, however, it appears that there is not a great need for this type of connectivity at this time. Therefore, the Owners have mandated that the SCADA system not be interconnected to the Owners' networks and the internet.

However, much of the software used on computers today is continuously updated by the vendors over the Internet, it is important to have a mechanism whereby the software on the SCADA network can be updated as necessary to correct critical flaws discovered after the software is released. The recommended method for resolving this dilemma is to install a computer which connects to the Internet through a firewall on one interface and to the SCADA LAN through the second interface. The computer can then act as a Windows Software Update Server (WSUS), which connects to Microsoft's Windows Update website, downloads updates, and propagates those updates to computers on the SCADA LAN. Using a WSUS, the system administrator has control over when the WSUS connects to the Internet, what updates are downloaded, and when and if the updates are propagated to the other computers on the network. This solution will give the Owners the ability to keep their software up to date without the security issues of direct Internet access.

In addition to software updates, most computers synchronize their internal clocks to a time server on the Internet. Because the Internet will not be available to computers on the SCADA network, an internal time server will be required. The time server will be a dedicated machine with a global positioning system (GPS) satellite antenna to receive time signals from the GPS network.

8.1.5 Communication to Existing and New Sites

The existing SCADA system communicates between the master station computers and the RTUs using the following three communications methods:

- FEP to the master radio on Tesuque Peak through a 960 MHz point-to-point radio link with a repeater at the San Mateo Office.
- Master radio to remote radios via licensed MAS radio (with two unlicensed 900 MHz MAS end-link repeaters).
- FEP to Nichols, McClure, Dempsey Booster, and Hydro Tank remotes via unlicensed 900 MHz MAS radio.

In addition, the SCADA system uses the 960 MHz point-to-point link to connect the SCADA master computers at the Canyon Road WTP to a SCADA workstation at the San Mateo Office.

In the new SCADA system, the FEP at the Canyon Road WTP will continue to communicate with the PLCs at the Canyon Road WTP via copper cable and with the RTUs at Nichols, McClure, Dempsey Booster, and Hydro Tank via unlicensed MAS radio. The other existing RTUs will communicate with a new FEP at the C/CWTP through an MAS master at Tesuque Peak. The SCADA master computer will poll both FEPs to get all the data for existing facilities in the system.

The MAS master radio on Tesuque Peak is an older generation of analog MDS equipment for which replacement parts are getting scarce. To provide a modern, digital platform and an upgrade path for the eventual replacement of the remote radios, the master station radio will be replaced with a current MDS 9790 offering, which is backward compatible with the existing remote radios. Figure 8.1-3 shows Tesuque Peak from Buckman Well 11.

Figure 8.1-3 View of Tesuque Peak from Buckman Well 11

8.1.6 Point-to-Point Communications

Existing point-to-point communications consist of a 960 MHz licensed system between the Canyon Road WTP and Tesuque Peak through a repeater at the San Mateo Office. The radios were manufactured by Microwave Data Systems (MDS) and provide the following bandwidth:

- 256 kbps channel between the SCADA network at the Canyon Road WTP and a SCADA workstation at the San Mateo Office.
- Two 9,600-bps channels to connect the redundant FEPs to the MAS radio on Tesuque Peak.
- Two 1,200-bps channels to connect the diagnostics on the radios and multiplexers to the diagnostic computer at the Canyon Road WTP.

The 960 MHz radio is no longer manufactured by MDS and at some point will need to be replaced with newer technology. For this project, the 960 MHz radios will be replaced with unlicensed 5 GHz Ethernet radios such as the MDS FIVE Series. The MDS FIVE Series-100 provides Ethernet interface operating at 100 Mbps full duplex. These radios make it a simple matter to connect

network switches at the C/CWTP, Canyon Road WTP, and the San Mateo Office, thereby extending the SCADA LAN to all three facilities.

Unlike the Canyon Road WTP, the new C/CWTP has line of sight to Tesuque Peak. The most effective way for the FEP at the C/CWTP to communicate with the MAS master radio on Tesuque Peak is through a "polling remote" radio. In a polling remote system, the FEP will communicate with a radio at the C/CWTP that will transmit polling messages to the master radio on Tesuque Peak. The master radio will be configured as a repeater, receiving the polling commands from the FEP and retransmitting them to the remotes. The remote radios will respond to the master radio which will retransmit the messages to the polling remote. Using this method, no point-to-point communication to the master radio on Tesuque peak is necessary, and the number of pieces of equipment that must work for polling to occur is greatly reduced.

In addition to replacing radio equipment, antennas and waveguide, this solution will require upgrading the wood pole that supports the antennas at the San Mateo Office to a steel monopole to meet the twist and sway requirements of a higher frequency system. The new system will also require an additional radio and antenna at Tesuque Peak to communicate with the new C/CWTP. While antenna space on the towers at Tesuque Peak is very limited, it is expected that there will be room for one additional radio of this type. However, this will need to be verified during design.

The site of the C/CWTP has line of sight to Tesuque Peak from ground level. Because the exact type and size of man-made obstructions between the tower location and Tesuque Peak are not known at this time, a 40-foot tower is the minimum recommended for a major site like the C/CWTP. Figure 8.1-4 shows a 40-foot monopole used for communication between Buckman Well 11 and Tesuque Peak. In addition to communications with the MAS master radio on Tesuque Peak, the C/CWTP will need to communicate with the San Mateo Office and the Canyon Road WTP.

Figure 8.1-4 Example of Monopole for Communications

If direct communications between the C/CWTP and those facilities was possible, repeating off Tesuque Peak would not be necessary. Unfortunately, the path between the C/CWTP and the Canyon Road WTP is blocked by the hill near the Canyon Road WTP and is not feasible. Therefore, the San Mateo Office repeater is required to connect the Canyon Road WTP with the C/CWTP. Analysis shows that a direct link could be established between the C/CWTP and the San Mateo Office, but it would require a 100-foot tower at the C/CWTP. Because a tower of that size is often found objectionable by nearby residents, Tesuque Peak will be used as a repeater.

8.1.7 Integration

System integration will begin with selection of the Integrator. As stated in the discussion of qualifications, above, the Integrator will be required to meet certain qualifications to ensure they are capable of performing the required tasks. During Integration, there will be a series of review meetings to ensure the Integrator is making progress and is meeting the requirements. At a minimum, preliminary and critical design reviews will be held during which the Integrator will demonstrate their progress on both the hardware and software development efforts.

The design phase of the integration effort will culminate in a Factory Acceptance Test (FAT). The FAT will be held at the Integrator's facility and may be witnessed by the Owner. During the FAT the Integrator will demonstrate that the system performs the required functions. Upon successful completion of the FAT, the Integrator will be allowed to ship the SCADA system to the Owner's facility and begin installation.

The installation phase will include individual site acceptance tests during which the Integrator performs a formal test of the installation of an RTU and its associated instruments, wiring and communications. Individual site acceptance tests will be performed and documented by the Integrator, and these tests may be witnessed by the Owner. Upon completion of installation of the entire system, an overall system Site Acceptance Test (SAT) will be held. The SAT will be witnessed, and successful completion will mark the end of the Integration Phase and start of the Availability Test.

The Availability Test is a three month time during which the system is operated and any system failures that affect critical system functions are documented. At the completion of the Availability Test, the Owners will calculate the ratio of system uptime to the sum of system uptime and system downtime. If that ratio exceeds the specified limit, the system passes the test, and the Warranty Phase begins.

8.1.8 Specific Performance Requirements

Specific performance requirements will be called out in the technical requirements portion of the contract documents. Requirements will be identified for specific aspects of the system as well as overall measures. Two key system-level requirements are system response and system availability.

8.1.9 System Response Requirements

8.1.9.1 General

Because SCADA systems poll their RTUs sequentially over relatively slow communications channels, requirements are needed to ensure latencies in the system do not make the system unresponsive or incapable of stable control. Three aspects of responsiveness are generally specified, the amount of time it takes to activate a command in the field based on an operator's actions, the amount of time required to update all the field data, and the speed at which the SCADA system draws screens.

8.1.9.2 Requirements

The Contractor will be required to baseline the system performance in the following areas, and ensure the replacement system does not degrade system performance below the specified levels. If the existing system performance does not meet these requirements, the Contractor will be required to show that the replacement system performs at least as well as the existing system. Prior to beginning the new work, the Contractor shall test and document the existing system performance to establish the system baseline.

- Activate control output at RTU within 2 seconds of operator's issuance of a command.
- Activate control output at RTU within 2 seconds of automatic control strategy execute command.

- Provide feedback to the operator that a pending control action has been issued, but the change of state has not been reported from the field.
- Update I/O points in realtime database at a maximum interval of 30 seconds exclusive of the time required for writing values to the RTUs.
- Update screen within 2 seconds of moving to a new screen.

8.1.10 System Availability Requirements

System availability requirements are tested during the availability testing phase as detailed above.

8.1.10.1 Definitions

- "Availability" is the ratio of Uptime to the sum of Uptime and Downtime, as defined below.
- "Uptime" is the number of minutes from startup or restart to the issuance of a service call due to loss of critical system functions. Service calls made due to system failover with no loss of critical functions will not impact System Availability.
- "Downtime" is the number of minutes between the issuance of a service call due to loss of critical system functions and the successful restart of the system minus Deadtime.
- "Deadtime" is the number of minutes from the issuance of a service call due to loss of critical system functions to the point at which a service person begins to work on the problem, not to exceed two hours.
- "Loss of critical system functions" is the failure of SCADA equipment resulting in one or more of the following conditions:
- Failure to process and report an alarm condition.
- Failure to log historical data.
- Failure of individual Control Loops.
- Failure of FEP to communicate with, monitor, or control multiple RTUs.

8.1.10.2 Requirements

- Documented Availability: 99.95% minimum. (Approximately one hour of "downtime" in 2200 hours of testing). The 30-day acceptance test availability will be relaxed to 99.8% to allow for response to early "infancy" failures and service response time.
- 3 service calls to correct the same symptom, maximum, during Availability Test.
- 10 service calls, maximum, within the Availability Test period.

8.2 Alternatives Evaluation

8.2.1 Communications to New Water Facilities

8.2.1.1 Overview of Alternatives

At a minimum, communications to the new facilities must allow the SCADA master computers to collect data and make control commands. In addition to the SCADA communications, the Owners have communications needs for the Buckman facilities that require greater bandwidth than an MAS radio system provides. These requirements include video surveillance at the facilities and

telephone extensions from the C/CWTP to the facilities. Two practical possibilities exist to accommodate these communications needs: high-bandwidth radios and fiber optics.

8.2.1.2 Radio Alternative

A radio solution would require radios at each new BDD facility to communicate with the C/CWTP through repeaters at Tesuque Peak. The radio system could be configured with 5 GHz unlicensed radios at each remote facility providing 100 Mbps full duplex Ethernet between the remote sites and Tesuque Peak which would be combined onto a 100 Mbps full duplex connection to the C/CWTP. The radios would also provide two wayside T1 channels for additional services such as telephone. For the purposes of estimating the cost, it was assumed that the 5 GHz radios would be hot-standby terminals to provide sufficient reliability to carry the SCADA data.

The radio solution would require line of sight between the antennas at the remote sites and the antenna on Tesuque Peak. Furthermore, it is recommended that microwave antennas be installed a minimum of 40-feet above ground level to reduce vandalism. Required tower heights are summarized the Table 8.2-1.

Table 8.2-1 Required Antenna Centerlines

Site	5 GHz Tower Height (feet)
RWLS	40
BS1A	40
BS2A	40
BS3A	90
C/CWTP	40

8.2.1.3 Fiber Optics Alternative

The fiber optic solution would involve installing 2-inch PVC conduit along the pipeline right-of-way and pulling in 8-fiber single mode outside plant cable to each of the remote facilities. One cable would be routed from the C/CWTP through BS2A, BS1A and the RWLS. One pair of fibers would be dedicated between the C/CWTP and each facility with three spare pairs. Additional fiber pairs allow flexibility for a second network connection if needed. A second cable would be routed from the C/CWTP to BS3A when BS3A is constructed.

8.2.1.4 Alternative Analysis

The cost of high bandwidth communications was estimated, and the results are shown in Table 8.2-2.

Table 8.2-2 Communications Cost Summary

Option	Engineer's Opinion of Probable Cost
5 GHz Microwave Radio	$431,000
Fiber Optics	$992,000

Radio scores over fiber optics based on lower initial cost, and also because the fiber optic cable is a single point of failure. A trenching accident that severs the fiber optic cable would leave the four facilities without communications until the cable could be repaired.

The fiber optic solution has four advantages over the radio solution. First, fiber optics provides much greater bandwidth than radio. Rather than having the remote sites share a 100 Mbps channel to the C/CWTP, they would each have a pair of fibers that could transmit data at gigabit speeds. This advantage is important when connecting sites that have a need for very high-speed communications such as several simultaneous video feeds.

Second, fiber optics eliminates the need for towers. This can be significant, especially if installation of a 90-foot tower at BS3A and 40-foot towers at the other sites is unacceptable. For many systems, the choice of fiber over radio is directly attributable to the need to eliminate tall towers dotting the landscape.

Third, fiber optics eliminates the need for antennas, which can be attractive targets to vandals. It is fairly common for antennas in remote areas to be used as targets by vandals with firearms. In this system, if an antenna was destroyed by vandals, the video surveillance and any other communications services carried on the radio would be out of service until a tower crew visited the site and replaced the antenna.

Fourth, the fiber optic solution does not require equipment maintenance on Tesuque Peak. The microwave radio solution, by contrast, would require a significant increase in the amount of electronic equipment the Owners would have to maintain on Tesuque Peak. Because the radio facilities on Tesuque Peak are difficult to access, especially in the winter, repairing a failed radio on Tesuque Peak is costly and time consuming compared to replacing a failed fiber optic module at one of the BDD facilities. Therefore, limiting the amount of equipment on Tesuque Peak is seen as an advantage of fiber optics.

8.2.1.5 Recommendation

A major objective for the project is high reliability. Because of the amount of vandalism at the existing Buckman facilities, including evidence of people shooting at water facilities, microwave communications has the potential to be very problematic. The likelihood of a trenching accident along the pipeline right-of-way is considered very low and the likelihood of vandalism to the radio antennas is consider very high. Therefore, despite the higher construction cost, it is expected that avoiding the cost of replacing radio antennas that have been shot or otherwise vandalized will result in a fiber optic solution having lower overall cost to the Owner. Consequently a fiber optic solution was chosen.

8.3 Recommended Facilities

The project will include replacement of the existing Citect SCADA system with a new system based on the same software. The new system will have its master computers at the C/CWTP and will communicate with the existing RTUs using the existing MAS radio system. The SCADA LAN at the C/CWTP will be linked to the SCADA LAN at the Canyon Road WTP via new 5 GHz Ethernet radios with repeaters at Tesuque Peak and the San Mateo Office. These radios will replace the existing 960 MHz radios connecting the Canyon Road WTP to the San Mateo Office and Tesuque Peak.

The project will install fiber optics along the pipeline right of way between the C/CWTP and the other new BDD facilities. The fiber will be used to provide video surveillance of the remote BDD facilities, telephone extensions to the facilities, and other services as needed. Communications between the SCADA master computers at the C/CWTP and RTUs at the new facilities will also use the fiber optic system.

In addition, future connection of existing Buckman well field facilities may be made by the City to enhance the control and monitoring of these facilities.

9.1 Background

Access to portions of the BDD Project facilities (i.e., Diversion Structure, RWLS, SRF, BS1A, and BS2A) will be provided via the existing County Road 77 (Buckman Road and Camino La Tierra), which also provides access from NM 599 to the Rio Grande and the City of Santa Fe Buckman Well Field. This approximately 15-mile long road traverses BLM, USFS, State of New Mexico, and privately-owned land. Current traffic uses include ranching, outdoor recreation, and maintenance of the existing water and utility facilities and amount to an average of 19 vehicles per weekday and 99 vehicles per weekend day.

At this time, there are no residential dwelling units requiring access via Buckman Road, although side roads off Buckman Road do access residential dwellings. There are 250 existing lots, patented in the 1960's that could be developed. In addition, there is a 15-lot, 50-acre-minimum lot size subdivision near the north end of Buckman Road. For the BDD Project, roadway upgrades to improve safety include widening horizontal curves, reducing vertical curves, adding gravel base, and building barriers are required for safety.

Pipelines and facilities for the BDD Project from the point of diversion to Camino La Tierra will be located within existing easements adjacent to or on Buckman Road. Therefore, the Buckman Road portion of County Road 77 will require improvements by the DB Contractor. The length of Buckman Road from the end of the paved portion (Camino La Tierra) to the Rio Grande is approximately 11 miles. Figure 9.1-1 shows the current condition of Buckman Road near the RWLS site.

Figure 9.1-1 Current Condition of Buckman Road Near RWLS

The majority of the information available for the existing Buckman Road was compiled by the Tierra-LopezGarcia Group in *"The Buckman Roadway Study for the Buckman Water Diversion Project, Santa Fe, New Mexico,"(Study)* prepared for the Sangre de Cristo Water Division in February 2004. The *Study* includes a comprehensive evaluation of the Buckman Road area, proposed future development, the existing roadway conditions, the need for roadway improvement, a safety and risk analysis, a cost estimate of the road improvement alternatives, and conceptual roadway design drawings (both existing and proposed).

In the *Study,* the existing road was evaluated to determine whether additional pavement is needed or if additional maintenance will be required to accommodate the additional truck traffic proposed to access

the new BDD Project facilities. The *Study* also evaluated the existing drainage/arroyo locations and provided a recommendation for the numerous drainage crossing structures. Construction of the roadway will be subject to construction stipulations is the US Army Corps of Engineers (USACE).

Utilizing the *Study,* as well as recommendations from the USACE's 404 Permit stipulations, further evaluations were performed by the OC to determine the applicability of the *Study's* recommendations for the Buckman Road improvements. Revisions and/or additions to the *Study's* recommendations are included with the OC's Preliminary Design.

For the operation of the BDD facilities, the Owners' staff will make daily visits to observe conditions and perform minor maintenance at the facilities along Buckman Road. In addition, almost daily hauling of solids from the SRF will take place if the sediment can not be returned to the river.

Truck traffic for removal of the sediment from the Near-River Facilities to the existing Caja del Rio Landfill will cause the road traffic to increase dramatically. Therefore, the DB Contractor shall incorporate the trucking operation into the new roadway design. Per the OC's Preliminary Design, approximately 1,000 truck trips per year may be necessary to remove solids from the SRF during high sediment loading of the Rio Grande.

9.2 Design Criteria

The design criteria presented herein assumes a permit is not obtained for returning sediment to the river. In the event a permit is obtained, the roadway design criteria will be less stringent. This alternative design is described in the Technical Requirements and shown on Sheet DA-1 of the Preliminary Design Drawings as the "Deduction Alternate."

9.2.1 Roadway

The existing Buckman Road is an unpaved, Santa Fe County maintained rural road classified as a two-lane, two-way rural road or a "local lane" by the Santa Fe County Code. The existing surface is dirt and the current alignment crosses numerous drainage channels, washes, and/or arroyos. The majority of the existing Buckman Road does not meet the Santa Fe County Code for design surface, width, elevation, alignment, slope, and/or drainage. To meet the Santa Fe County Code requirements, these features will need to be rectified by the DB Contractor, including improvements to the existing horizontal and vertical alignment of Buckman Road, as well as drainage improvements. The vertical alignment of the roadway must be coordinated with the location and depth of existing utilities. Cut will not be allowed over buried utilities unless the DB Contractor obtains approval for and relocates existing utilities at it's own expense.

Table 9.1-1 summarizes the Buckman Road improvements required for the BDD Project.

Table 9.1-1 Buckman Roadway Improvement Criteria

Roadway Criteria	Description
Geotechnical	Required by the DB Contractor
Subgrade/Basecourse	Minimum 6-inch surface thickness of crushed gravel base course
Design Speed	25 mph
Horizontal Alignment	Minimum horizontal curve radius of 280 feet; super elevation rate of 4 percent
Vertical Alignment	Maximum grade of 10 percent; minimum stopping sight distance of 155 feet with "k" values of 12 for crest vertical curves and 26 for sag vertical curves
Width of Travel Way	20 feet (10-foot travel lanes in each direction) centered on the 38-foot right-of-way (ROW)
Clear Zone	From the edge of the traveled way to the ROW line; tree removal to be minimized by DB Contractor
Roadside Slopes	Fore slopes to be 1V:4H or flatter; (1V:2H) where indicated on the plans
Roadside Barriers	Installed at points of unusual risk (as determined by the DB Contractor)

9.2.2 Drainage

Buckman Road crosses the Canada Ancha, a major drainage carrier, as well as over 100 other arroyo crossings and unnamed drainage basins. Improvements by the DB Contractor to the roadway will incorporate drainage structures to convey the runoff in these areas. These improvements will be accomplished by the DB Contractor with concrete dip sections, or other approved methods of conveying stormwater across the road, as shown on the Preliminary Design Drawings. It is important to note that the stationing referred to on the Preliminary Design Drawings is the stationing provided by Tierra-LopezGarcia Group in the *Study*, which is independent of the OC's stationing on the non-Buckman Road Preliminary Design Drawings.

The crossings (a minimum of 29 crossings) will be sized by the DB Contractor to accommodate the 25-year storm flows, with provisions to safely pass the 100-year storm flows.

The DB Contractor shall also utilize adequate stormwater erosion control features including but not limited to drainage swales, check dams, and rip rap. The erosion control features shall be designed according to Santa Fe County standards.

9.3 Design Considerations

The design considerations discussed below assume the permit to discharge sediment back to the Rio Grande is not obtained. In the event that the permit is obtained, the design considerations will be less stringent and per the Technical Requirements and Preliminary Design Drawings for the Deduction Alternate.

9.3.1 Roadway

For the BDD Project, the DB Contractor will bring Buckman Road up to Santa Fe County Code. The DB Contractor's design should optimize excavation and backfill of the roadway to minimize disturbance of the land. Buckman Road will remain open at all times during construction operations. The DB Contractor will provide proper signs and delineation devices to maintain traffic in work areas in accordance with NMDOT Maintenance and Protection of Traffic Procedures. In order to meet County code, Buckman Road must meet the criteria specified in Table 9.1-1, detailed as follows:

- **Geotechnical Investigations:** A geotechnical evaluation of the entire Buckman Road will be performed by the DB Contractor. Additional investigations may be required in the areas between the existing BS1 and Buckman Well 9 access road. Some locations along the roadway may require a modified design due to poor existing soils conditions.

Modifications may include undercutting or "over-excavating" to correct for poor subgrade material strengths, or the inclusion of geotextile fabrics to improve stability and longevity of the road.

- **Subgrade/Base Course:** The DB Contractor will provide a minimum 6-inch surface thickness of crushed gravel base course. The base course used shall conform to the requirements outlined in the NMDOT *Standard Specifications for Road and Bridge Construction*. Subgrade materials (6-inches) shall conform to the NMDOT's *Pavement Design Directive* (IDD-2006-6) which states that subgrade material strengths shall be based on AASHTO T 190, *Resistance R-Value and Expansion Pressure of Compacted Soils*.
- **Design Speed:** As specified by the Santa Fe County Code, the design speed for the improved Buckman Road shall be 25 mph. With this speed, the geometrics shall provide a safe, continuous vehicle operation under general conditions.
- **Horizontal Alignment:** The DB Contractor will make every effort to construct the project within the right-of-way specified and to maintain the natural contours of the existing roadway. For the project design speed of 25 mph; the minimum horizontal curve radius allowed for a gravel road surface is 280-ft as specified by AASHTO. The super elevation rate will be 4 percent based on a gravel surface and the design speed of the improved Buckman Road.
- **Vertical Alignment:** The DB Contractor will make every effort to maintain the natural contours of the existing roadway. Improved Buckman Road maximum grade for the project design speed with rolling terrain will be 10 percent as specified by AASHTO. The minimum stopping sight distance for a 25 mph design speed and two lane road shall be 155-ft with "k" values of 12 for crest vertical curves and 26 for sag vertical curves. Minimum or greater than minimum stopping sign distance will be provided in all cases. The vertical alignment of the roadway shall not interfere or lessen the depth of existing buried utilities unless the DB Contractor relocates those utilities at it's own expense.
- **Width of Travel Way:** As specified by the Santa Fe County Code, the DB Contractor shall construct a roadway centered on the 38-ft ROW to a width of 20-ft feet consisting of two 10-ft travel lanes in each direction for the entire length of the improved Buckman Road. Shoulders will not be constructed and are not included in the width specified.
- **Clear Zone:** The DB Contractor shall provide a clear zone adjacent to the improved Buckman Road as specified by AASHTO. The clear zone recovery area will be from the edge of the traveled way to the ROW line. Narrower clear zone areas can be provided where there are environmental concerns such as maintaining the natural roadside features. More liberal clear zone widths should be provided on the outside of sharp curves and at the end of steep down grades. The DB Contractor will be allowed to trim selected trees with prior approval from the USFS and/or BLM. The DB Contractor shall minimize the number of trees removed.
- **Roadside Slopes:** The DB Contractor will construct fore slopes of the improved Buckman Road to 1V:4H and flatter where possible except as shown on the plans in some areas as 1V:2H. Roadway cut sections should be designed with adequate ditches to accommodate drainage flows along the roadway. The fore slopes shall be deep enough to provide drainage of the roadway base and subbase.
- **Roadside Barrier:** As specified by AASHTO Roadside Design Guide, roadside barriers for the improved Buckman Road shall be installed at points of unusual risk as determined by the DB Contractor. The DB Contractor will obtain approval from the County of Santa Fe for the final design prior to the installation of roadside barriers.

9.3.2 Drainage

Concrete dip sections shall only be used at arroyo crossings where the proposed vertical alignment matches the elevation of the existing vertical alignment. It will be the DB Contractor's responsibility to provide an approved method to convey stormwater under the road at arroyo locations where the proposed vertical alignment is at a greater elevation than the existing vertical alignment. Prior approval for the use of concrete dip sections must be obtained from the County of Santa Fe. All drainage structures and means of stormwater conveyance shall conform to the requirements outlined in the NMDOT *Standard Specifications for Road and Bridge Construction* and any other NMDOT Standard Drainage Details available.

The DB Contractor will be required to perform a detailed analysis of the drainage requirements prior to final design to accommodate all stormwater flows and to verify the need for drainage structures at any and all arroyo crossings located within the project limits. The OC and the County of Santa Fe shall provide approval of the DB Contractor's final design prior to the commencement of construction. The design shall also consider appropriate placement and use of erosion control measures such as drainage swales, check dams and rip rap.

The DB Contractor should be aware that this may not be the extent of the DB Contractor obligations for improving Buckman Road. Although Buckman Road is regulated by Santa Fe County, USFS or BLM may provide additional design criteria for the roadway improvements. Therefore, the DB Contractor shall coordinate any additional stipulations for the improvements prior to the commencement of construction.

9.4 Permitted Alignment and Features

Prior to the commencement of construction of the Buckman Road improvements, the DB Contractor will be required to complete the documentation to obtain the road ROWs from the BLM and the USFS. The responsibility for obtaining the ROWs for the BDD Project pipelines will be with the DB Contractor, although the OC has begun the acquisition process. Separate ROWs are required for the Road and the pipelines and separate ROWs are needed from each permitting entity. To limit the extent of environmental impacts of the Buckman Road improvements, the DB Contractor shall maintain the natural features of the terrain, vegetation, and drainage configuration of the areas. In addition to the design guidance provided herein, the DB Contractor shall adhere to the permitting, easement, and other regulatory stipulations provided in the Environmental and Cultural Resources Plan. All disturbance during construction and the permanent road must be within the environmental survey limits identified on the raw water pipeline Preliminary Design Drawings. Environmental survey work was also completed between Dead Dog Well and existing BS3 (to the eastern extent of federally-managed land). The Buckman Road Improvements in this area must also be within the environmental survey limits that will be provided to the DB Contractor. In general, the environmental survey limits encompassed an area at least 140-ft wide along the road and existing City water pipeline corridor.

10.1 Introduction

This Project Implementation section describes how the BDD Project will be implemented by the DB Contractor, and how the DB Contractor will use the Preliminary Design Drawings and the Technical Requirements. This section also includes an implementation schedule, permitting and easement requirements, staffing recommendations and preliminary construction and O&M cost estimates.

10.2 Use of Preliminary Design in Design Build

The OC's Preliminary Design consists of the Technical Requirements and the Preliminary Design Drawings. Both the Technical Requirements and the Preliminary Design Drawings will be an integral part of the Step 2 RFP documents and ultimately the DB Contract. The requirements set forth by the OC in the Technical Requirements and the Preliminary Design Drawings with regards to the selected unit treatment processes, equipment, construction materials, and other project requirements, are the minimum requirements that the DB Contractor must adhere to. The DB Contractor will be responsible for all aspects of the design, permitting, construction, and performance of the BDD Project facilities.

10.3 Technical Requirements

The Technical Requirements are the minimum technical, design, construction, and performance requirements that the DB Contractor must adhere to. The Technical Requirements, provided as Volume III of the RFP, cover all aspects of the Project facilities, including the following:

- Raw water quality baseline conditions and pilot and bench-scale testing results
- Civil and site requirements, including modifications to Buckman Road
- Operability and maintainability requirements for the Project facilities and equipment, including automation requirements
- Equipment quality requirements
- Degree of equipment and process unit redundancy
- Process and process equipment requirements including: water quality regulations (both existing and foreseeable near-term regulations), process design criteria (such as flow rates for specific unit processes), chemical storage and feed system requirements, residuals/solids handling requirements, blending water quality requirements, and materials requirements
- Structural and architectural requirements, including materials and aesthetics, and minimum space requirements, room features, etc.
- Security systems and features for the C/CWTP and other Project facilities

- HVAC, plumbing, and fire protection requirements and applicable codes
- Electrical and instrumentation/control requirements, including the level of automation of the Project facilities, standby power, UPS, and the necessary instrumentation for water quality control and monitoring
- O&M requirements for a computerized O&M Information System and a Facilities Maintenance Management System
- Telemetry and SCADA requirements for the new facilities, as well as communication requirements with the existing facilities
- Landscaping and revegetation requirements for the pipeline alignments, the near river facilities, and the C/CWTP
- Corrosion control requirement for the pipelines, equipment, and process basins
- Construction and implementation requirements
- Project communication and documentation requirements
- Data on the existing utility locations, agency right-of-way (ROW) stipulations, constraints for pipeline alignments, and other known permitting constraints
- Project environmental requirements and constraints, including natural and cultural resource protection requirements
- Project facilities startup and operation requirements, including specific testing and operational performance standards

The DB Contractor will be required to verify and enhance the Preliminary Design and adhere to the final Technical Requirements in the preparation of its' final design, specifications, and documentation.

10.4 Connection to Existing Facilities and Systems

For all utility interconnections, including water, electrical, and SCADA, required for the Project, the DB Contractor is required to submit an Interconnection Plan to the OC prior to the commencement of connection activities. The DB Contractor's Interconnection Plan(s) must include, at a minimum, the following:

- A layout of all existing lines, all existing utilities, and the proposed connection location
- An inclusive list of all necessary connection materials
- A detailed schedule documenting the proposed connection execution dates and times, including the duration in which service will be temporarily interrupted
- A communications plan, including all written notifications to the appropriate authority(ies) and/or utility(ies)
- A detailed connection/construction procedure, including existing utility protection methods, public safety precautions (including identification signage), and testing methods

Additional details for the specific Interconnection Plan (i.e., the Water Interconnection Plan) are outlined herein, as well as the requirements provided in the Technical Requirements.

10.4.1 Water

10.4.1.1 General Interconnection Requirements

For both permanent and future service water connections, the DB Contractor will be required to adhere to the requirements set forth in the New Mexico *Standard Specifications for Public Works Construction* for all activities located within Santa Fe County. For activities located within the City of Santa Fe, the DB Contractor shall adhere to the requirements set forth in the City of Santa Fe Public Utilities Department, Sangre de Cristo Water Division Construction Specifications.

The DB Contractor will be required to provide repair services in the event that damage of any kind occurs to an existing main, facility, or service connection. As a general rule, the DB Contractor will not be allowed at any time to convey drainage to any arroyo, or other watercourse during the connection activities.

10.4.1.2 DB Contractor Responsibilities

The DB Contractor will be required to provide all necessary pipe, fittings, and appurtenances for either permanent or for provisions for future service connections to the existing lines as shown on the OC's Preliminary Design Drawings.

When connecting the new water main to an existing main, the use of a tapping saddle (wet tap connections) will be required by the DB Contractor. If portions of the existing pipeline require removal, the segment will be disposed of properly, and the use of an inline tee (with valved branch connection and restrained couplings) will be required by the DB Contractor for connecting to the new line.

Installation of a flange insulating kit (FIK) will be required by the DB Contractor to electrically isolate dissimilar pipe material. New and existing ductile iron pipe will be treated as dissimilar pipe materials, as well as new ductile iron pipe and existing cast iron pipe.

All pressure piping will be rated to a minimum of 150 percent maximum operating pressure and will be fully restrained. The DB Contractor will be required to provide a description of the pipe materials, appropriate restraint methods, and testing procedures in the Interconnection Plan.

10.4.1.3 Connection Schedule

As a safety precaution, the DB Contractor will not commence waterline connection activities during the annual peak flow period (May through September). Likewise, to minimize vulnerability of the existing fire suppression water supply, the maximum duration of waterline down-time will not exceed 4 hours during the DB Contractor's connection activities.

The DB Contractor will not commence connection activities when the temperature is at or below 20 degrees F. All connections made during the winter months shall be protected from freezing. Replacement will be required of all frozen facilities and shall be made at the DB Contractor's expense.

All connection activities will be performed between the hours of 10:00 a.m. and 4:00 p.m. on the same day to minimize disruption to the public water supply. No connections will be made after 4:00 p.m. in order to facilitate the appropriate communications with the OC and/or the utility authorities. However, if after-hours work is required to minimize disruption, it will be required of the DB Contractor after approval by related agencies and coordination with the OC . No

connections will be made without prior acceptance from the OC of the DB Contractor's Interconnection Plan.

10.4.1.4 Communications

Prior to any connection activities, the DB Contractor will be required to first provide a written notice to the OC seven days prior to the proposed connection date.

Should the connection activities affect a resident, a commercial or industrial business, the DB Contractor will be required to provide notification in writing seven days in advance of any installation activities to the affected party. The notice will explain the temporary water shut-off procedure, including the anticipated duration. The shut-off period will be no longer than 4 hours. Work may be required by the DB Contractor during the night and/or weekend hours to facilitate the water service connections.

Should the connection activities affect or expose an existing utility, including existing culverts, gas, underground power, telephone or communication cable, water mains, irrigation lines, sewers, poles or overhead power, and all other utilities encountered along the line of work, the DB Contractor will be required to provide notification in writing seven days in advance of any installation activities to the appropriate utility companies. The notification will include all necessary adjustments of the public or private utility fixtures, pipe lines, and other appurtenances within or adjacent to the limits of construction and request that a representative of the utility watch over the construction activities in areas near or adjacent to their respective utilities.

10.4.1.5 Connection Procedure

The DB Contractor will be required to protect, shore, brace, support, and maintain underground pipes, conduits, drains, and other underground utility construction uncovered or otherwise altered by construction activities. The DB Contractor will be required to provide a detailed description of these protection activities in the DB Contractor's Interconnection Plan.

The DB Contractor will verify the depth, location, size, and materials of all existing water lines and all existing utilities. The DB Contractor will maintain in continuous services all existing culverts, gas, underground power, telephone or communication cable, water mains, irrigation lines, sewers, poles or overhead power, and all other utilities encountered along the line of work, unless other arrangements satisfactory to the owners of said utilities have been made. Arrangements of this type will be made in writing and will be included in the Interconnection Plan submitted to the OC.

The DB Contractor may not provide water connections in such a manner that existing utility facilities or appurtenances within the limits of the proposed construction need to be relocated or adjusted. In the event that existing utility facilities or appurtenances require relocation, only the utility owner will perform the work.

The DB Contractor will keep all fire hydrants and water control valves free from obstruction and available for use at all times.

10.4.1.6 Safety Precautions

The DB Contractor will be required to supply all barricades, safety fencing, signage (including the DB Contractor's telephone number at which it may be reached in the event of customer inquiries), etc. required for public safety. The DB Contractor will exercise care while maintaining a safe working environment for the public in the vicinity of the construction activities. In the event that

damage of any kind occurs to an existing main or residential service connection, the DB Contractor will provide repair services.

The DB Contractor will be required to maintain a "Quick Response and Repair Kit" on site at all times for possible emergencies that may arise during the connection activities. For example, each Kit may contain additional piping materials, dewatering equipment, generators, etc.

As a safety precaution, the DB Contractor will also notify the local fire authority in writing a minimum of seven days prior to any connection activities pertaining to fire suppression, prevention, or protection waterlines.

10.4.1.7 Interconnection Plan

Prior to connection activities, the DB Contractor will be required to submit an Interconnection Plan for each of the proposed waterline connections. The Interconnection Plan will include, at a minimum, the following:

- A layout of all existing water lines, all existing utilities, and the proposed waterline connection location.
- An inclusive list of all necessary connection materials, including pipe, valves, and fittings.
- A detailed schedule documenting the proposed connection execution dates and times, including the duration in which water service will be temporarily interrupted.
- A communications plan, including all prior written notifications to the appropriate authorities and/or utilities and contact information of all representative emergency personnel.
- A detailed connection/construction procedure, including existing utility protection methods, public safety precautions (including identification signage), emergency equipment/ materials, and testing, disinfection, and cleaning methods.

The DB Contractor will submit the Interconnection Plan to the OC a minimum of 30 days prior to the commencement of connection activities. The DB Contractor will not be allowed to proceed with the connection activities until the OC has reviewed the Interconnection Plan.

10.4.1.8 Connection Locations

The DB Contractor will be required to make all connections to the existing systems as shown on the OC's Preliminary Design Drawings including, but not limited to, the following connection locations:

Connections into Existing System

- BS3: The DB Contractor will connect the BS4A Finished Water Pipeline to existing BS3 on the pump suction side. The existing pipeline is an 18-inch ductile iron line connecting BS3 with the surge tank.
- Airport Road and NM 599: The DB Contractor will connect the NM 599 Potable Water Pipeline with the existing east-west 14-inch pipeline located at this intersection.
- NM 599 and Interstate 25 (within Santa Fe County limits): The NM 599 Potable Water Pipeline will be connected to an existing 16-inch water pipeline. An existing tee and valve have been provided by the Santa Fe County Water Resources Department (SFCWRD), therefore, the DB Contractor will be required to remove the cap and block and perform the

connection at this location (installation of a PRV is not required by the DB Contractor). Since this line is currently used as a fire suppression line, the DB Contractor must provide a written notice to the SFCWRD seven days prior to connection activities to facilitate coordination with the SFCWRD staff.

- South Meadows Road and Agua Fria Road: The DB Contractor will connect the South Meadows Road Potable Pipeline into the 12-inch pipeline just south of the existing connection between the east-west 8-inch pipeline and the north-south 12-inch pipeline.

Provisions for Future Connections

- Intersection of the C/CWTP access road and Caja del Rio Road: A blind tee in a valve box will be installed and connected to the Las Campanas Potable Water Pipeline near the intersection of the C/CWTP access road with Caja del Rio Road for a future County distribution line to serve residents to the east (the service area would be near Los Suenos Trail, south of West Cloud March).
- Intersection of Caja del Rio Road and Caja del Rio Landfill Access Road: A blind tee in a valve box will be installed and connected to the Caja del Rio Potable Water Pipeline near the intersection of Caja del Rio Road and the landfill access road for a future fire service pipeline.
- Intersection of Caja del Rio Road and access road to Santa Fe Animal Shelter: A fire hydrant will be installed and connected to the Caja del Rio Potable Water Pipeline on the western side of Caja del Rio Road across from the access road to the Santa Fe Animal Shelter.
- Airport Development District: A blind tee in a valve box will be installed and connected to the NM 599 Potable Water Pipeline near the area north of the NM 599 frontage road and to the west of Caja del Rio Road. A backflow prevention station will be installed at the connection.
- NM 599, south of Airport Road: The DB Contractor will install a blind tee in a valve box and connect to the NM 599 Potable Water Pipeline near the sewer interceptor.
- Intersection of Highway 599 and South Meadows Road: The DB Contractor will install a blind tee in a valve box and connect to the South Meadows Potable Water Pipeline along the frontage road north of NM-599.
- Santa Fe County Road 62: Install a blind tee in a valve box connected to the South Meadows Potable Water Pipeline north of the Santa Fe River and South Meadows Road.

10.4.2 Electrical

The DB Contractor will be required to prepare an Interconnection Plan for all connections to the existing electrical systems, as described in the Technical Requirements. Details pertaining to the connections required for Project tie-ins with the existing electrical systems are covered under Electrical Requirements described in Sections 3, 4, 5 and 6 of this Report.

10.4.3 Telemetry and SCADA

The DB Contractor will prepare an Interconnection Plan for all connections to the existing telemetry and SCADA systems, as described in the Technical Requirements. Details pertaining to the connections required for Project tie-ins with the existing telemetry and SCADA systems are covered under Section 8 (SCADA and Telemetry) of this Report.

10.5 Implementation Schedule

An implementation schedule has been prepared based upon the goal of all BDD facilities being tested and operational by Fall 2009. A bar chart schedule is shown in Figure 10.5-1.

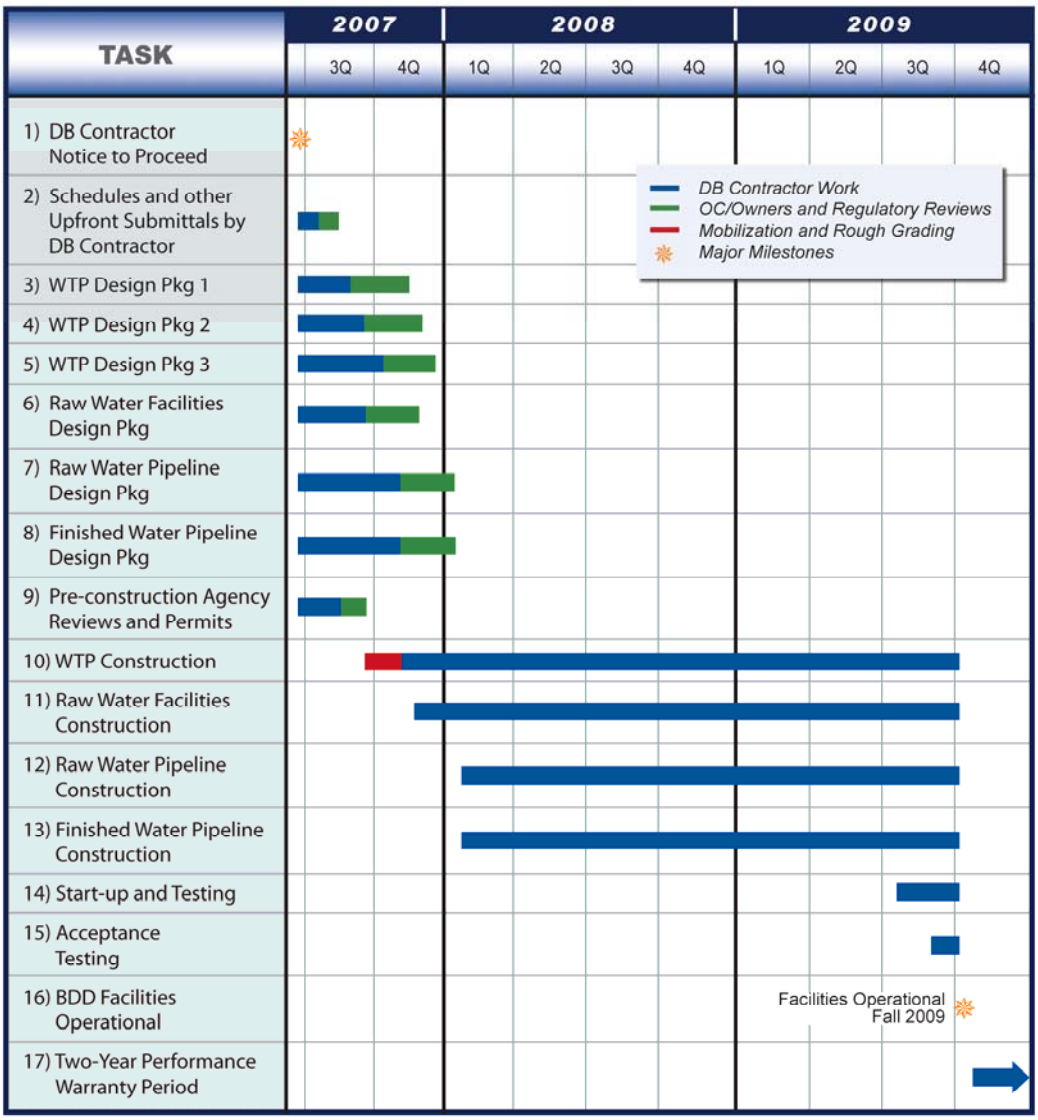


Figure 10.5-1 Implementation Schedule

10.5.1 Contractor Procurement and Contracting

The DB Contractor is being procured through a two step process. Step 1, the RFQ phase was used to short-list potential DB Proposers. Step 2, the RFP phase, requires a technical and business (including lump sum price) proposal. The current schedule for the DB Contractor procurement is summarized in the following bullets:

- The DB Proposers will have the opportunity to review and comment on the draft RFP by September 18, 2006.
- The RFP will be issued to the short-list of DB Proposers by mid-October 2006
- RFPs will be received from the DB Proposers by mid-January 2007

- RFPs will be evaluated and a DB Contractor will be selected in February 2007
- The DB Contract will be signed by April 2007 after negotiations with the selected DB Proposer

This schedule may require changes depending on the timing of the Project's Record of Decision and how the Owners decide to proceed if the ROD is delayed.

10.5.2 DB Contractor Design and Permitting

The schedule has been prepared based on a phased approach to the DB Contractor completing the design, submitting design packages for Owners and OC reviews, submitting design packages for regulatory review, and constructing the various segments of the BDD Project.

There are a number of agencies the BDD Project participants will have to coordinate and interact with to obtain the permits, easements and right-of-ways. Good communication with these agencies throughout the Project is essential.

It is anticipated that the DB Contractor will complete design of the Project facilities in stages or packages. Therefore, the design period will overlap with the construction period. The design packages will coincide with the permit applications for NM CID, Santa Fe County Development, the NMED DWB, Santa Fe County Public Works Right of Way for the Caja del Rio Potable Water Pipeline, the NMED Construction Programs Bureau, and various plans and documentation for the BLM and USFS. Permit applications and approvals must be in place prior to work on the applicable portion of the Project. The DB Contractor is responsible for determining the design and permitting schedule necessary to meet the construction schedule outlined in the following section.

10.5.3 DB Contractor Construction

The BDD Project schedule approach utilizes the following construction philosophy:

1. Construction of the C/CWTP, including fabrication and delivery of equipment, will take 25 to 28 months. This portion of the Project has the longest duration of the various subprojects being constructed and is critical to completing the Project within the shortest schedule possible.
2. The Diversion Structure could take at least 8 to 10 months to construct due to the need for a coffer dam and diverting river flow prior to constructing the diversion structure. In addition, there will be a substantial dewatering effort during this construction.
3. The raw water pipeline segment from the diversion to the C/CWTP will take approximately 10 to 12 months based on the use of ductile iron pipe laying at a rate of 200 linear feet per day with substantial surface restoration.
4. Construction of the booster pump stations and the RWLS will take approximately 1 year with the need for fabrication of pumping equipment and electrical gear.
5. The distribution pipelines will take approximately 1 to 2 years to construct, depending on the number of pipe laying crews utilized, based on ductile iron pipeline laying at the rate of 200 linear feet per day with special pipeline segments (jacking and boring) being constructed in a parallel operation.
6. Most major mechanical equipment can be procured in 16 to 20 weeks after approval of submittals. Larger more complex systems, such as membrane and ozone systems, could be

supplied in as much as 6 to 8 months. Site and structure construction can be undertaken prior to and during fabrication of equipment.

7. Major electrical equipment (VFDs, MCCs, PLC systems, etc.) can be fabricated and delivered in 6 to 10 months after approval of submittals.

The construction duration of the C/CWTP has been set at 25 to 28 months with an overall design-build schedule of 30 months based on the anticipated complexity of the facility, separation of facilities, and the materials of construction (i.e., the need for reinforced concrete basins).

The following bullets highlight the completion of the various construction components:

- Substantial completion of the C/CWTP by mid-August, 2009
- Substantial completion of the raw and finished water facilities by September 2009
- Construction and startup complete for all facilities by late October 2009

10.5.4 Performance Testing, Startup and Initial Operation

The DB Contractor will be required to perform various tests prior to Substantial Completion. This Acceptance Testing will be outlined by the DB Contractor in a plan (Acceptance Test Plan) for review by the Owners and the OC . The Technical Requirements include specific Acceptance Testing Standards for each of the facilities and systems of the Project that are to be met by this plan.

The testing, startup and initial operation deadlines are as follows:

- A successful 30-day test conducted according to the Acceptance Test Plan is to be completed during September and October 2009
- All non-performance testing activities (watertightness, functionality, etc) are to be complete prior to the 30-day test
- Training of the Owners' O&M staff is to be completed prior to the 30-day test, but will be an on-going task for the DB Contractor

Substantial completion will be provided based on the work completed and the successful completion of the 30-day test. The DB Contractor Warranties Term, a 2-year period, will then begin. During this period, the facilities will be operated and maintained by the Owners' staff while the DB Contractor provide additional operations management assistance to the Owners. The facilities will need to meet numerous Operating Performance Standards which include the initial Acceptance Testing Standards. These standards are provided in Section 5 of the Technical Requirements.

10.6 Permitting and Easements

The Permits and Easements Plan (Appendix J) presents the scope of permits, easements, and other requirements and commitments for the BDD Project. It includes a summary of each required permit with the anticipated data requirements, expected time frames necessary to complete each item, and the entity responsible for obtaining the permit. Early completion of the time-sensitive items advances the goal of managing the timely completion of the BDD Project.

The BDD Project includes the near river facilities, about 28 miles of raw and treated water pipelines, and the C/CWTP. The project facilities will be located on land managed by the USFS and the BLM, State-owned land, county-owned land, and private property. Permits, easements and other requirements are summarized in Table 10.6-1. Generally the DB Contractor is responsible for obtaining the permits. However, the Board, through the OC, has initiated the permitting process and will have furthered the permitting process prior to the DB Contract date. As indicated in the following sections, such permitting activities by the OC prior to the DB Contract date includes the preparation and submission of permit applications. In these instances, the DB Contractor is listed as the responsible party because the DB Contractor will be responsible for completing the permitting process for any permits, easements or requirements that are not complete before the DB Contract date.

Table 10.6-1 BDD Project Permits and Easements

Responsible Party	Agency	Description	Status
Permits, Right of Way and Requirements from Federal Agencies			
DB Contractor	USACE	US Army Corps of Engineers, Permit for Diversion (Intake) Structure, River, and Arroyo Crossings, *Application, Plan Reviews, and Approval*	Preconstruction Notification completed and submitted to the City on May 19, 2006
DB Contractor	USEPA	US Environmental Protection Agency Notice of Intent and Notice of Termination to Comply with NPDES Permit; US Environmental Protection Agency Storm Water Pollution Prevention Plan; and NMED Certification of NPDES Permit, *Application and Approval*	DB Contractor to initiate
BDD Board	USEPA	US Environmental Protection Agency Sediment Discharge Permit, *Application and Approval*	NPDES permit application received by EPA on April 24, 2006. EPA assigned the application number NM0030848
BDD Board and DB Contractor	US BLM and USFS	Bureau of Land Management and US Forest Service Right-of Way, Temporary Use, and Special Use, *Re-application, Plan Review, and Approval*	Application will be revised
DB Contractor	BLM and USFS	Bureau of Land Management Plan of Development and US Forest Service Operations Report, *Addenda and Revisions*	Draft POD has been prepared
DB Contractor	USFS	US Forest Service Native Plant Revegetation Mitigation Program and Habitat Loss Mitigation, *Plan*	DB Contractor to initiate
DB Contractor	BLM and USFS	Bureau of Land Management US Forest Service Visual Management Objectives, *Plan*	DB Contractor to initiate
DB Contractor	BLM and USFS	Invasive Plant Species Mitigation, *Compliance*	DB Contractor to initiate
DB Contractor	BLM and USFS	Soil Protection Mitigation Techniques, *Plan*	DB Contractor to initiate
DB Contractor	USFWS, NMDGF, and NMSFD	Endangered Species Act and Regulations Concerning Special Status Species and Migratory Birds, *Compliance*	DB Contractor to initiate
Permits, Right of Way and Requirements from State Agencies			
BDD Board	NMDCA	New Mexico Department of Cultural Affairs, National Historic Preservation Act (Section 106) Compliance, *Consultation and Concurrence*	Agency comments on the Draft Archaeological Data Recovery and Mitigation Plan received on June 6, 2006. Data recovery field work expected to start September, 2006.
DB Contractor	NMDOT	NM Department of Transportation Permit to Install Utility Facilities within Public Right of Way, *Application, Plan Review, and Approval*	Right of Way application submitted to City on May 17, 2006
DB Contractor	NMSLO	NM State Land Office Application for Right of Way Easement, *Application, Plan Review, and Approval*	Right of Way application submitted to City May 4, 2006
DB Contractor	NMED AQB	NM Environment Department Air Quality Bureau, *Application and Approval*	Air Quality Notice of Exemption submitted to City on April 6, 2006
DB Contractor	NMED FOD/GWQB	NM Environmental Department Field Operations Division, Liquid Waste Permit and Groundwater Quality Bureau Pollution Prevention Section Notice of Intent Form, *Application, Plan Review, and Approval*	NMED Liquid Waste permit applications for C/CWTP submitted on April 6, 2006 and for BS1A on April 27, 2006

Table 10.6-1 BDD Project Permits and Easements

Responsible Party	Agency	Description	Status
DB Contractor	NMED DWB	NM Environment Department Drinking Water Bureau Approval of Construction or Modification of Existing Public Water Supply System, *Application, Plan Review, and Approval*	DB Contractor to initiate
DB Contractor	NMED CPB	NM Environment Department Construction Programs Bureau, *Plan Review and Approval*	DB Contractor to initiate
DB Contractor	NMFA	New Mexico Finance Authority, *Application for Funding, Plan Review and Approval*	DB Contractor to initiate
DB Contractor	NMED SWQB	NM Environment Department, Surface Water Quality Bureau, permits for NPDES sediment return, NPDES storm water, and USACE dredge and fill, *Certification*	DB Contractor to initiate
DB Contractor	NMCID	NM Construction Industries Division Approval for Construction, *Application, Plan Review, and Approval*	DB Contractor to initiate
Permits, Right of Way and Requirements from Local Agencies			
DB Contractor	Santa Fe County LUD	Santa Fe County Land Use Department, Development Permit Application, *Application, Plan Review, and Approval*	DB Contractor to initiate
DB Contractor	City of Santa Fe	City of Santa Fe Development Permit, *Application and Approval*	DB Contractor to initiate
DB Contractor	Santa Fe County Public Works	Santa Fe County Public Works Department Application For Right of Way, *Application, Plan Review, and Approval*	DB Contractor to initiate
DB Contractor	Santa Fe County	Noise Constraints and Stipulations, *Compliance*	DB Contractor to initiate

10.6.1 Near-River Permitting

The near river facilities are located on USFS land. The permits required for these facilities are:

- USFS, Special Use and Right of Way
- US Army Corps of Engineers, Dredge and Fill (Section 404) permit
- USEPA, National Pollutant Discharge Elimination System (NPDES) for sand return
- USEPA, NPDES permit for stormwater
- NM Department of Cultural Affairs, Archeological clearance
- US Fish and Wildlife Service, Threatened and Endangered Species, migratory birds
- Office of the State Engineer, permit to divert water

USFS, Special Use and Right of Way

The USFS issues Special Use Permits and Temporary Use Authorizations. The USFS Special Use and Temporary Use permit has several components that are referred to in the Permits and Easements Plan (Appendix J) as requirements. Because the BDD Project near-river facilities are within lands managed by the USFS, a Special Use Permit must be obtained prior to conducting any land disturbance activities. Additionally, temporary use authorizations are required for work in areas outside the officially designated ROW. Table 10.6-2 shows the permit applications that will be required for the USFS and BLM. To ensure adequate areas for construction, these permit applications have been started by the OC and will be completed by the DB Contractor.

Table 10.6-2 USFS and BLM Permits

Permitting Agency	Applicant	Permit	Notes
USFS	BDD Board	Near River facilities, ROW and Special Use	A new application will be submitted that will replace the three existing applications. The permit will have a construction phase (permanent areas plus temporary use areas) and an operations phase (permanent areas).
USFS	Santa Fe County	Buckman Road ROW	The use of Buckman Road is historical, but there is no formal ROW for it. The County should submit a new ROW application.
USFS	PNM	Buried cable ROW	PNM has a state-wide permit with the USFS and this would probably fall within that permit. If so, only an amendment to the state-wide permit will be required.
BLM	Santa Fe County	Buckman Road ROW	The use of Buckman Road is historical, but there is no formal ROW for it. The County should submit a new ROW application.
BLM	BDD Board	C/C Water Treatment Plant (WTP) ROW	A new application for the WTP will be submitted that includes the access road and finished water pipelines
BLM	BDD Board	Raw water pipeline ROW	The will be an amended application. The City (on behalf of the BDD Board) will send a letter requesting to amend existing ROW application 103816. Include temporary use areas.
BLM	Las Campanas	Raw water pipeline ROW	Amend the existing application to include just the raw water pipeline between BS2A and BS3A.
BLM	PNM	Electric lines ROW	New application
BLM	PNM	Substation ROW	New application

A requirement of USFS Special Use Permit and Temporary Use Authorizations is a Plan of Development and Operations report (hereinafter referred to as POD). A POD is always required for projects that require an EIS and/or are large in scope. Some of the required information will be mandated through the Record of Decision (ROD) and stipulations to the ROW. A substantial amount of the documentation cannot be completed until final design and will be the responsibility of the DB Contractor through compliance with stipulations of the ROWs. With the exception of temporary use areas and surveying of legal descriptions, the information required for the POD does not require completion until just prior to initiating construction. The temporary use areas and surveying of legal descriptions must be completed prior to issuing the ROW documents as described earlier in this document. The POD will require development of a number of plans as shown on Table 10.6-1 and summarized below:

- **Native Plant Revegetation Mitigation Program and Habitat Loss Mitigation Plan:** Revegetation and restoration of temporary construction areas and disturbed ROW will be required as stipulations of easement agreements with the BLM, USFS, Santa Fe County, SLO and NMDOT.
- **Visual Management Objectives:** protects the quality of the scenic (visual) values of the BLM and USFS lands, design of the facilities must incorporate recommendations from the federal agencies. Building color, architecture, building and roofing materials, building heights, fence coatings and other visible material aspects will be coordinated with the visual management staff for each agency. The DB Contractor is directly responsible for coordinating the selection of these materials, colors, finishes, etc. with the agencies during final design.
- **Invasive Plant Species Mitigation:** The USFS and the BLM have requirements for controlling invasive plant species. The NMDOT also has guidelines for controlling the spread of noxious weeds within their ROW. To comply with these requirements, an Invasive Weeds Management Plan will be developed by the DB Contractor that incorporates the best practices for weed and invasive species control and addresses the control, containment, or eradication of invasive plant species throughout the project.

- **Soil Protection Mitigation Techniques:** Soil loss mitigation covers a wide array of regulations. Although no specific permits or review is required for soil mitigation alone, it is indirectly tied to a number of other permits and plans that will be reviewed for the project. Statements for soil protection stipulations and best management practices can be found in the BLM and USFS ROW and Special Use Permits, USACE CWA Section 404 Permit, and NPDES permit for construction. The DB Contractor will consult with each of the agencies and obtain concurrence to assure compliance with each agency's requirements. The Soil Protection Plan/SWPPP will be developed by the DB Contractor in conjunction with BDD Project design.

All documentation to the agencies for the POD requirement, tracking and submitting the amendments to the POD and stipulated documentation, and continually assess compliance is the responsibility of the OC. The OC will also provide independent monitoring of the DB Contractor and communication with the agencies throughout the course of construction and restoration activities. The DB Contractor will be responsible for ultimately complying with the requirements; the OC has authority to enforce compliance when the DB Contractor is not meeting the stipulations.

US Army Corps of Engineers, Dredge and Fill (Section 404) permit

The US Army Corps of Engineers (USACE) issues dredge and fill permits, in compliance with section 404 of the Clean Water Act. It is anticipated that the BDD Project will require an individual permit, because the combined area of disturbance in waterways will be over a half of an acre, which is the requirement for the national permits issued by the USACE. Areas of waterway disturbance have been surveyed for the "Preconstruction Notification" (permit application) and these include the diversion structure, the coffer dam required while building the diversion structure, areas where pipelines cross arroyos, and areas where Buckman Road requires upgrades in arroyos. The USACE dredge and fill permit will be reviewed and certified by the NMED before it becomes effective. The Preconstruction Notification was submitted to the Owners on May 19, 2006.

USEPA, National Pollutant Discharge Elimination System (NPDES) for sand return

The NPDES Permit from the US EPA would allow sand settled out of the influent water at the BDD Project SRF to be returned to the Rio Grande. The discharge of sand may require a NPDES permit from the US EPA. Discussions about the effluent limits that would be placed in an NPDES permit have been ongoing with the US EPA since 2003 and a permit application has been prepared and was submitted to US EPA at the end of April 2006. The NMED also has the responsibility of certifying the NPDES permit and for conducting an antidegradation review of the discharge. The information required by NMED to conduct the antidegradation review was submitted to NMED at the end of April 2006.

USEPA, NPDES permit for stormwater

A permit for storm water discharges from construction sites is required from US EPA. The USEPA published regulations for construction and construction-related activities, which refer to the actual earth disturbing construction activities and those activities supporting the construction project such as construction materials or equipment storage or maintenance (e.g., fill piles, borrow area, concrete truck washout, fueling). The regulations require measures to control the quality for storm water associated with construction activity, or other industrial storm water directly related to the construction process (e.g., concrete or asphalt batch plants). The USEPA developed "General Permits" to assist in entities compliance with the NPDES regulations without having to prepare an individual permit for each project. For construction activities, this permit is titled *NPDES General*

Permit for Storm Water Discharges from Construction Activities. To apply for coverage under a general permit, the DB Contractor must file a Notice of Intent (NOI) for coverage under the General Permit for Construction Activities with the Region 6 USEPA Office (Dallas, TX) at least 10 days prior to commencement of construction activities. Currently, NMED must certify that the NPDES permit will protect New Mexico water quality standards (See Section 10.6.3). A NOI must be submitted by both the Owner and the DB Contractor.

For construction activities, an *NPDES General Permit for Storm Water Discharges from Construction Activities* must be obtained by the DB Contractor. NMED Surface Water Quality Bureau (NMED SWQB) must certify that the NPDES permit will protect New Mexico water quality standards. Since New Mexico does not issue either NPDES permits under Section 402 or dredge and fill permits under Section 404, New Mexico is authorized to review permits and discharges to ensure the effluent limits will (1) be compatible with appropriate state law; (2) protect water quality standards adopted in accordance with section 303 of the Clean Water Act; and (3) implement an effective water quality plan. The state review, referred to as "certification" can result in the following: (1) approve the discharge without conditions; (2) approve the discharge subject to conditions; (3) deny certification; or (4) waive certification. The OC will complete the NMED SWQB certification requirements for the NPDES permit for sand return and for the dredge and fill (section 404) permit. The DB Contractor must complete the certification review requirements for the NPDES permit for construction activities,

NM Department of Cultural Affairs, Archeological clearance

Archeological clearance is required for compliance with Section 106 of the National Historic Preservation Act. An archaeological survey was conducted during the EIS process to identify archaeological sites within the project footprint. The USFS has consulted with the State Historic Preservation Officer (SHPO) regarding the eligibility of the 15 sites that were identified in the project area. With SHPO concurrence, eight sites were determined to be eligible. Of these 15 sites, three sites need data recovery excavation to complete the SHPO consultation. These three sites plus four additional sites will need to be fenced and monitored prior to construction at or within 100-ft of the site. The OC has received Agency concurrence that Project effects have been mitigated for the known archeological sites. The next step for Section 106 compliance is to develop an Archaeological Data Recovery and Mitigation Plan. This plan has two purposes: 1) to describe the planned data recovery at the three sites identified for data recovery and 2) to articulate the process that will be used to address foreseen and unforeseen future effects to historic properties resulting from construction and operation of the BDD Project. Agency comments were received on June 6, 2006 on the draft Archaeological Data Recovery and Mitigation Plan. A tribal consultation was then initiated on the plan. After tribal concerns are addressed the data recovery field work can begin. Field work is anticipated to begin in September 2006.

US Fish and Wildlife Service, Threatened and Endangered Species, migratory birds

Compliance with the United States Fish and Wildlife Service (USFWS), the New Mexico Department of Game and Fish (NMDGF), and the New Mexico State Forestry Division (NMSFD) requirements for agency coordination and/or consultation for any listed special status species that could be impacted by the BDD Project. In particular, these agencies are concerned about construction activity that could adversely impact or result in the take of special status species listed in Section 3 of the EIS. A formal consultation regarding the impact of the operation of the BDD Project on the Rio Grande Silvery Minnow started in August 2006. It is anticipated the consultation will be completed in the Fall of 2006. The DB Contractor will be responsible for implementing requirements for Special Status Species compliance and participating in continued agency coordination.

Office of the State Engineer, permit to divert water

The Board must obtain approval from the NM Office of the State Engineer (OSE) to divert surface water from the Rio Grande for either San Juan-Chama water rights or native Rio Grande water rights. Additionally, the County must obtain approval from the OSE to change the place, purpose of use and point of diversion of water rights purchased but not originally recognized as a Rio Grande water right in the proposed location.

The City and County jointly submitted an Application for Permit to Divert San Juan-Chama Project Water in the State of New Mexico on September 11, 2003. This application is for the entire 5,605 acre-feet per year of San Juan-Chama water rights shared by the City and County. The application was remanded and the OSE has not acted upon the application.

The City and County attorneys and consultants have been and continue to work with the OSE to further the application and this permit responsibility must remain with the Board. In the event that the surface diversion permit cannot be obtained by the OSE, the Board would not be authorized to divert any waters through the proposed BDD facilities. If the County is unsuccessful in transferring water rights to the diversion location, the maximum allowable diversion will be significantly less than the 1,700 acre-feet per year County water demands outlined in the 40-year water plan.

10.6.2 Permitting and Easements for Pipelines

Permits for right-of-way and easements for pipelines will be acquired from the appropriate entity prior to construction. About 11 miles of raw water pipeline from the river diversion facility to the C/CWTP will be on USFS/BLM managed lands and will require a Right-of-Way (ROW) permit. From the C/CWTP, the treated water pipelines are all within County jurisdiction and require a development permit from the Santa Fe County Land Use Department. Along Caja del Rio Road, about 3.5 miles of treated water pipeline will be in the County road ROW and will require a ROW permit from the Santa Fe County Public Works Department. The treated water pipeline splits along Highway 599 and the northern line goes onto private land. Easements will be negotiated with the private landowners for the pipeline alignment. The treated water pipelines also cross lands owned by the State Land Office and the Department of Transportation.

The permits and easements required for pipelines are:

- USFS Special Use and Temporary Use
- BLM Right of Way
- USEPA NPDES Permit for Storm Water
- Santa Fe County Development Permit
- City of Santa Fe Development Permit
- Santa Fe County Public Works Right of way
- State Land Office Right of Way
- New Mexico Department of Transportation Right of Way
- Easements from Private Landowners

USFS Special Use and Temporary Use

The USFS Special Use and Temporary Use Permit is described in Section 10.6.1

BLM Right of Way

The BLM issues ROWs and Temporary Use Permits for water facilities constructed on BLM-managed lands. Because the BDD Project pipelines cross lands managed by the BLM, a ROW Permit must be obtained prior to conducting any land disturbance activities. For this Project, the permanent ROW along the pipeline corridor will be either 20-ft or 30-ft in width, depending on the location. The temporary ROW along the pipeline corridor is 30-ft or 40-ft in width, depending on the location. However, construction activities require additional land area for work, material stockpiling, equipment storage and other construction needs, which will be determined by the DB Contractor. Some of these temporary use areas are identified on the Preliminary Design Drawings. The DB Contractor will be responsible for updating the legal descriptions for any permanent or temporary ROW that is changed. Table 10.6-3 shows the permit applications that will be required for the USFS and BLM. A Plan of Development and Operations report (POD) is required for the BDD Project. A single POD that meets the requirements of the USFS (Section 10.6.1) and the BLMs will be prepared and submitted for this project.

USEPA NPDES Permit for Storm Water

The USEPA NPDES permit for storm water discharges is described in Section 10.6.1

Santa Fe County Development Permit

The Santa Fe County Land Use Department (LUD) requires a comprehensive plan review before a "Development Permit" is approved and before construction may begin. LUD is responsible for review and approval of construction plans and the issuance of development permits within Santa Fe County. LUD reviews the plans to verify compliance with hydrology, watershed, and terrain management requirements, including soil and slope stability, erosion control, sedimentation, and water runoff to protect water quality and the natural character of the land, within the State of New Mexico. LUD approvals are typically received within 30 days. All proposed facilities, with the exception of one pipeline segment are located within Santa Fe County, outside the City limits. The DB Contractor is required to prepare the submittal package for review by the LUD. A fee is required for the permit application and is based upon the Project valuation. A Fire Impact Fee will be required for the structures. The fees cannot be estimated at this time. Construction must begin with one year of issuance of the development permit and the permit is valid for two years. The DB Contractor will have to request an extension from the County in the event substantial completion is not met prior to expiration of the permit.

City of Santa Fe Development Permit

The City of Santa Fe Planning and Land Use Department approves and oversees construction work within the City Limits. Currently, none of the proposed BDD Facilities are located within the City Limits except for one pipeline segment along NM 599 just east of the airport, in the NMDOT ROW. In the event the City annexes the area where BDD Project facilities are proposed, the work conducted for the Project will be subject to City requirements. The DB Contractor is the responsible party for compliance with the City permitting requirements as necessary.

Santa Fe County Public Works Right of Way

Constructing a pipeline with a ROW for a County Road requires an application and approval from the Santa Fe County Public Works Department. Caja del Rio Road is a County Road and the distribution pipelines planned along Caja del Rio Road will be within the road ROW. The permit application requires general information for the DB Contractor including licensing, insurance and bonding information; a video of the ROW prior to disturbance to establish pre-existing conditions; traffic control plan; dates of construction; and dimensions. The application also requires a $15,000 bond be on file with County Public Works for the duration of the work. The fees associated with

the application are $75.00 per 600-ft of ROW. The work along this ROW, as well as all others, will require revegetation as a stipulation of the ROW.

State Land Office Right of Way

At the intersection of Caja del Rio Road and Highway 599, about 0.75 miles of the treated water pipeline will be on State-owned land and will require a right-of-way permit from the SLO. The applications for right of way require surveyed locations of the pipelines and design drawings of the pipeline installations as well as descriptions of surface restoration, vegetation restoration and erosion control measures. The ROW applications were submitted to the City in May 2006.

New Mexico Department of Transportation Right of Way

The southern line along Highway 599 will be in the NMDOT ROW and that portion of the pipeline will require a ROW permit from the NMDOT. One application for the ROW along NM 599 and final jack/boring locations. If the DB Contractor chooses to install pipelines by J/B at locations other than those permitted, the DB Contractor will be responsible for obtaining an amended ROW permit from the DOT.

Easements from Private Landowners

One portion of the distribution pipeline from the water treatment plant must cross private property within Santa Fe County and the extraterritorial zone of the City. The size of the pipeline, between NM 599 and the Santa Fe River, will be determined during preliminary design. Currently, the proposed pipeline alignment is along an undeveloped and un-maintained dirt road without an engineered or constructed Santa Fe River Crossing. Driving across the river bed is necessary to access this dirt road. Prior to the pipeline installation, a permanent easement and a temporary construction easement must be obtained from the owners. Santa Fe County will obtain easements through the private properties. The OC provided surveyed plats and the locations of the easements to the County in April 2006.

10.6.3 Permits and Easements for the City/County Water Treatment Plant

The C/CWTP will be located on BLM land. The permits required for the C/CWTP include the following:

- BLM, Right of Way
- USEPA, NPDES permit for stormwater
- NMED air quality permit for emergency generators and ozonation system
- NMED liquid waste disposal system permit
- NMED drinking water system approval
- NMED Construction Bureau review and approval and New Mexico Finance Authority
- New Mexico Construction Industries Plan review and approval
- Santa Fe County noise ordinance

BLM Right of Way Permit

The BLM Right of Way permit is described in Section 10.6.2

USEPA NPDES Permit for Storm Water

The USEPA NPDES permit for storm water discharges is described in Section 10.6.1

NMED Air Quality Permit for Emergency Generators and Ozonation System

Two permits must be obtained from the NMED Air Quality Bureau (NMED AQB). There are two air quality permits – one for the standby generators and one for the ozone portion of the C/CWTP. The permit for the standby generators has been prepared and submitted.

NMED Liquid Waste Disposal System Permit

The Field Operations Division (NMED FOD) issues permits for septic systems that are less than 2000 gallons per day. Permits from the NMED FOD are for the septic systems serving the C/CWTP and at BS1A. The permit application for the C/CWTP septic system has been submitted and the BS1A septic system was submitted to the City on April 27, 2006.

NMED Drinking Water System Approval

The NMED DWB requires an *Application for Approval of Construction or Modification of Existing Public Water System*, as mandated by the federal Safe Drinking Water Act and the NM Drinking Water Regulations. For the water treatment plant, each "staged" submittal will build upon the information included in the previous submittal. This stream-lined process will allow for quicker reviews from the DWB, and will allow the DB Contractor to submit for approval at a pace matching their design pace to allow an early construction start. The DB Contractor is responsible for this permit and must be given the flexibility to work with DWB during the design process to further determine the WTP package contents. Furthermore, the OC will have a consultation with the DWB to discuss the preliminary WTP design to obtain pre-approval by the DWB. After this consultation, the DB Contractor will complete the remaining acquisition tasks per the requirements outlined herein. The OC will also be responsible for providing some Owner information for the permit application(s).

NMED Construction Bureau Review and Approval and New Mexico Finance Authority

The submittals to the NMED CPB and the New Mexico Finance Authority (NMFA) are to satisfy requirements for financing of the BDD Project. The mission of the NMED Construction Programs Bureau (CPB) is to make publicly funded loan and grant program funds available to New Mexico local governments; to manage the timely construction and administrative completion of publicly funded water, wastewater, and solid waste projects; and to ensure that projects are environmentally sound, of high quality, and free of waste, fraud, and abuse. The BDD Project will receive funding from the Drinking Water Revolving Loan Fund, which is administered by the New Mexico Finance Authority. In order to receive funding through the CPB, which is distributed on a reimbursement basis, the BDD Project must comply with the requirements in the grant agreement. The OC has completed the submittal requirements for aspects that do not require final design (i.e., to the level of detail described in this PDR). The DB Contractor is responsible for submitting requirements that are based on final design.

New Mexico Construction Industries Plan Review and Approval

The NMCID requires a comprehensive plan review before a "State Building Permit" is approved and before construction may begin. NMCID is responsible for review and approval of construction plans and the issuance of building permits. NMCID reviews plans to verify compliance with electrical, mechanical, and general construction code requirements adopted by the State of New Mexico. NMCID approvals are typically received within 30 days. To facilitate the accelerated timeline of the BDD Project, NMCID will accept the plans from the DB Contractor in staged submittals.

Santa Fe County Noise Ordinance

Santa Fe County's noise ordinance (7.24.1 of Santa Fe County Land Development Code) outlines noise limits for various districts within the County. The BLM Farmington Field Office imposes a noise standard on facilities on BLM managed lands of 48.6 db Leq (defined as the A-weighted noise level averaged over a 24-hour period at a distance of 300-ft from the noise source). This standard is equivalent to noise criteria used by other Federal Agencies such as the USFS. The noise limitations will be outlined as a stipulation in the ROW and Special Use Permit and will impact the selection of equipment and building design by the DB Contractor to ensure that the stipulation noise limitations are met during long term operation of the facilities. The facilities, including the C/CWTP, are surrounded by federal land that provides a buffer for noise.

10.7 Staffing Recommendations

The BDD facilities will significantly expand the duties of the Source of Supply Division of the City's Water Department. The number of employees will increase and the new facilities will present new and highly sophisticated treatment technologies. These new treatment processes, such as ozonation and membrane filtration, will provide the Santa Fe community with a reliable supply of high quality drinking water. The operation of these new facilities will require assembling a staff of well trained, knowledgeable operators and maintenance personnel. Toward that goal, the OC prepared a Staffing Plan (currently in draft form) that includes the following:

- **Staffing Requirements** – A review of the staffing needs for the new BDD facilities
- **Hiring Plan and Schedule** – A schedule for recruiting and hiring plus resources for recruiting
- **Job Descriptions and Wage Recommendations** – Recommendations for modifying job descriptions and wage requirements
- **Training and Transition Plan** – The DB Contractor's training requirements and the OC's Training and Transition Plan

Each of these topics is summarized in the following subsections.

10.7.1 Staffing Needs

The Staffing Requirements section of the OC's plan indicates that a total of 21 full time positions will have to be filled to operate and maintain the new BDD facilities. In addition to the 21 full time positions, the OC recommends that two new positions, custodian and Clerk/Receptionist, be filled to serve both the Canyon Road WTP and the BDD facilities.

The duties of three existing positions (Source of Supply Manager, Equipment Supervisor and the Supply Inventory Supervisor) will be expanded to include the new BDD facilities as well as their current responsibilities. Although the Supply Inventory Supervisor position exists, it is not presently filled.

10.7.2 Hiring Issues

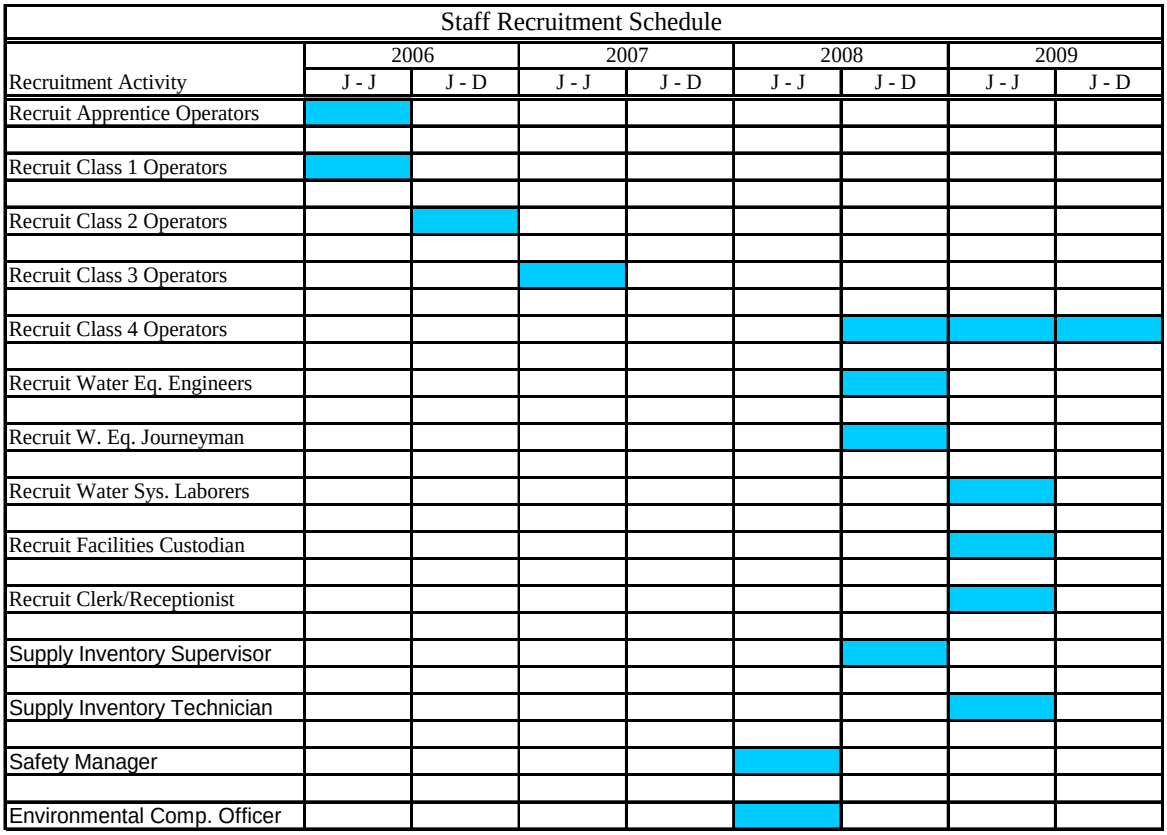
A critical need for the successful operation of the new BDD facilities is recruitment of at least six Class 4 certified operators by that are experienced in the treatment of surface water by 2009. Currently, there are few surface water treatment plants in New Mexico so the availability of operators with surface water treatment experience is limited. The issue is further compounded by the fact that the Canyon Road WTP is likely to see the retirement of at least one Class 4 operator

before the BDD facilities start up in 2009 and possibly the retirement of two more Class 4 operators by 2010. With the likely retirements, the recruitment needs increase to at least seven new Class 4 operators by 2009 and two more in 2010. Table 10.7-1 summarizes the number of Class 4 operators available and the number that will be needed through 2010.

Table 10.7-1 Class 4 Operators: Available/Needed

Year	Have	Required	Need	Comment
2006	6	6	0	Six Class 4 does not include Manager
2007	6	6	0	
2008	5	6	1	One Class 4 retires
2009	5	12	7	Buckman facility starts up – 5 Class 4 needed
2010	3	12	9	Two Class 4 operators retire

The proposed hiring schedule prepared by the OC identifies when the different positions should be filled (see Figure 10.7-1). With respect to the Class 4 operators, it is suggested that Class 1 operators be recruited in 2006 so they can advance to become Class 4 operators by the time the new facilities come on line. Recruiting Apprentice level operators can also be considered for 2006 to meet the Class 4 vacancies that are likely to occur in 2010. The schedule identifies hiring dates for Class 2 and 3 operators in 2007 and 2008, respectively, to meet the Class 4 needs in 2009. How many of each class will have to be recruited during each year to meet the 2009 requirement will depend upon what classification level is hired during each year. In addition to the Class 4 openings that will exist, there will be two Class 3 positions that will have to be filled due to retirements that are expected by 2010.



Note: This is the recommended hiring scenario even though there are other scenarios that could be considered.

Figure 10.7-1 Staff Recruitment Schedule

10.7.3 Wage Considerations

By far, the major staffing issue that must be addressed to successfully operate and maintain the BDD facilities is recruiting and retaining experienced Class 4 certified operators. The supply of Class 4 operators in New Mexico with experience in treating surface water is very limited. At about the same time that the BDD facilities are going to start up, the City of Albuquerque will have just started their new surface WTP and fulfilling their need for operators with surface water treatment experience will increase the demand for experienced Class 4 operators.

A comparison of wage rates offered by seven other utilities that treat surface water for operators at a level equivalent to the City's Water Systems Operator IV (Class 4 certified operator) level indicates that Santa Fe's wage is competitive. The communities used in the comparison by the OC were Dallas and El Paso in Texas, Tempe Arizona, Denver Colorado, Cambridge and Billerica in Massachusetts and Albuquerque New Mexico.

The wage rate ranges established by Santa Fe do not represent a range that a person can progress through in a particular job classification rather, the range represents the minimum and maximum that will be paid within the classification. A person hired in at the bottom of the range for a classification will always be at the bottom for that classification unless the City provides a cost of living adjustment or a new agreement is reached with the union. A person hired into a classification who is not already an employee of the City cannot be hired at a pay rate greater than anyone else in the City in that classification.

As a person advances to higher job classifications, his/her pay rate can be increased and the present policy in the Water Department is that advancement from Water Systems Apprentice to Water Systems Operator I (Class 1 certified operator) or Water Systems Operator I to Water Systems Operator II (Class 2 certified operator) can receive a 10 percent pay raise. Advancing from Water Systems Operator II to Water systems Operator III (Class 3 certified operator) or Water systems Operator III to Water Systems Operator IV can result in a 15 percent pay increase. With this policy, a person hired as a Water Systems Apprentice at the minimum rate of $11.28/hour would be paid a rate of $18.05/hour upon advancing through the levels to become a Water Systems Operator IV; which is at the lower end of the Water Systems Operator IV rate. Even if the person started at the top end of the pay range for a Water systems Apprentice, $16.62/hour, upon advancing through the different levels, his/her rate upon achieving the Water Systems Operator IV level will be $26.60/hour which is $2.06/hour less than the maximum range for a Water Systems Operator IV. What a person who advances through the classification levels will be paid is largely determined by what rate they start at when hired by the City.

With respect to the requirement that no one can be hired into the City at a pay rate higher than anyone else within the City who is at that rate, the result is that most people within a pay classification are grouped about the same pay level. For example, the actual pay range for the Water Systems Operator IV at the Canyon Road WTP is $46,407 to $49,577 which is between $1,691 and $4,861 greater than the $44, 716 that Albuquerque pays their Class 4 certified operators. It is recommended that the operator wages be considered again when the Albuquerque surface WTP starts up to see if they have adjusted their wage rates to attract operators experienced in surface water treatment.

10.7.4 Training and Transition

To prepare and assist newly hired BDD staff, as well as existing O&M staff, to operate and maintain the new BDD facilities, the DB Contractor will be required to provide operations and

maintenance consulting services and training of the Owners' O&M staff prior to Acceptance Testing and during the first two years of operation, the DB Contractor Warranties Term. The DB Contractor's Operations Consultant will be a New Mexico Water Systems Operator Class 4 certified operator.

The DB Contractor's Operations Consultant will provide system operations training that will include both classroom and hands-on training. The systems operations training will build upon the equipment manufacturers' training, which is primarily focused on individual equipment units. The systems operations training that will be provided by the DB Contractor's Plant Manager will integrate process theory, control/instrumentation strategies, process interactions, start-up and shutdown procedures, and process control strategies. The DB Contractor's Operations Consultant will also be responsible for numerous other facility O&M functions:

- Preparation of annual O&M budgets for review and approval by the Owners, tracking and reporting spending, and preparation of spending projections quarterly for each budget category
- Implement a safety training program including periodic training
- Ensure adequate supervision and direction is provided at all times to plant staff and that all work is done under the proper supervision of a Class 4 certified operator
- Develop written standard operating procedures (SOPs)
- Oversee that Owners' personnel correctly execute maintenance tasks necessary to meet warranty requirements including training on the computerized maintenance management system (CMMS) and verification that documentation in the CMMS is adequate.

10.8 Preliminary Opinion of Probable Construction and Project Costs

This section documents the construction and project cost estimate prepared for the draft Preliminary Design Report.

10.8.1 Construction Cost Summary

A construction cost was prepared for all of the BDD facilities based upon the current processes and design criteria documented in this PDR. The detailed construction cost is included in Appendix H.

The total construction cost, escalated to the mid-point of construction (2008 dollars) is $140 million. This total cost include Las Campanas' portion of the shared by (City-County-Las Campanas) as discussed later in this section.

Table 10.8-1 presents a summary of the construction costs for each facility.

Table 10.8-1 Summary of Construction Costs by Facility

Description	Cost
Raw Water Facilities	
Diversion Structure	$ 815,146
RWLS	$2,998,679
SRF	$2,470,003
BS1A	$2,052,539
BS2A	$1,935,530
Pipelines to BS2A	$4,984,549
Pipeline from BS2A to C/CWTP	$4,957,509
Fiber Optic Line	$987,472
Buckman Road Improvements	$2,775,592
Water Treatment Plant Facilities	
Sitework	$1,470,077
Presedimentation Basins	$856,070
Flocculation Basins	$1,943,782
Sedimentation Basins	$2,395,803
Pressure Membrane Building	$6,055,429
Ozone Generation Room	$2,110,675
GAC Contactors	$3,912,059
Finished Water Reservoir (includes BS4A/5A)	$5,326,516
Washwater Equalization Basins	$801,755
Chemical Facilities	$2,350,017
Centrifuge Building	$1,562,114
Thickener Facilities	$3,077,239
Ancillary Facilities	$4,049,300
Electrical & Instrumentation	$5,184,092
Finished Water Facilities	
BS4A Potable Water Pipeline	$1,197,783
Caja del Rio Potable Water Pipeline	$2,731,878
NM 599 Potable Water Pipeline	$3,253,099
South Meadows Potable Water Pipeline	$1,523,815
SUBTOTAL	$75,459,824
Field Office Overhead, 10%	$7,545,982
SUBTOTAL	$83,005,807
Contingency, 14.42%	$11,970,760
Home Office Overhead, 3%	$2,849,297
TOTAL CONSTRUCTION COST	$97,825,864
Margin, 8%	$7,826,069
SUBTOTAL	$105,651,933
Non-OCIP Gen Liability, 0.15%	$158,478
Bond. 2%	$2,116,208
TOTAL CONSTRUCTION COST	$107,926,619
Escalation to Midpoint,12.84%	$13,857,778
NMGRT, 6.31%	7,687,640
TOTAL	$129,472,000

The following data sources and assumptions were used during preparation of the construction cost estimate:

- Preliminary Design Drawings dated June 2, 2006 were used to determined material quantities for each facility
- The following percentages were added to the construction subtotal:
  - 10 percent for field office overhead
  - A 10 percent contingency was added for the raw water pipelines, the finished water pipelines, the membrane facility and the finished water storage reservoirs. A 20 percent contingency was added for the raw water facilities and the other C/CWTP facilities. The weighted contingency added was 14.42 percent. These differing contingencies are reflective of the level of detail on the Preliminary Design Drawings for the facilities.
  - 3 percent for home office overhead
  - 8 percent profit
  - 1 percent for builder's all risk insurance, 2 percent for general liability insurance and 2 percent for bond
- New Mexico Gross Receipts Tax was added to the total construction cost. For the purposes of this estimate, the City of Santa Fe rate of 7.625 percent was used.
- The total construction cost was escalated to the mid-point of construction, July 2008. A 5 percent annual inflation rate was assumed.
- Conversations between the Owners and PNM to determine electric facility payback are ongoing
- Vehicles necessary for facility O&M are not included in the estimate
- Costs for project financing are not included

10.8.2 Raw Water Supply System Costs

The construction costs for the raw water supply system includes the following components: diversion structure, RWLS, SRF, BS1A, BS2A, all raw water pipelines, fiber optic communications cable and upgrades to Buckman Road. The raw water supply system costs presented in Table 10.8-1 include Las Campanas' share. The total marked up construction cost for the raw water supply system is approximately $45.7 million. The pipeline between BS2A and the C/CWTP is for the Owners only and will not be used by Las Campanas. This marked up cost is approximately $8.9 million. The Las Campanas pipeline between BS2A and dead dog well and the Las Campanas components in BS2A total $1.5 million. The remaining raw water system components total $35.4 million. Las Campanas is responsible for their share of the $35.4 million in accordance with the FOPA. Similarly, the County is responsible for their share of the $35.4 million and the $8.9 million in accordance with the FOPA.

10.8.3 Water Treatment Plant Costs

The total escalated cost of the C/CWTP is approximately $74.8 million. Based upon the facility capacity of 15-mgd, the unit cost of the C/CWTP is estimated at nearly $5 per gallon.

10.8.4 Finished Water System Costs

The finished water system consists of BS4A, BS5A and the four segments of finished water pipelines. The total construction cost, escalated to 2008 dollars, is approximately $19.6 million.

10.8.5 Allocation of Construction Costs

The construction costs will be paid by all three project partners based upon agreements under development. Guidance from the City on how these costs will be allocated and assumptions for use in preparation of the allocation calculations are forthcoming.

10.8.6 Project Cost

The estimated project cost includes the estimated construction cost of $129.5 million plus the addition of all other related costs for administration, engineering, permitting, electrical facilities and other items. It is estimated that the BDD Project cost will be approximately $159 million which does not include the project partners' cost of financing. Table 10.8-2 provides a breakdown of the project cost.

Table 10.8-2 Estimated Project Cost

Item	Estimated Amount $Million
Phase A - Conceptual Design of DB Process w/ NMGRT	$1.55
Phase B/C/D/E - Preliminary Design thru Operations	$7.78
Legal/Administration	$1.60
Easement & ROW Acquisition	$0.05
DB Engineering Fee	$8.62
Construction	$129.47
DB Operations Fee	$0.50
PNM Engineering Fee	$0.40
PNM Capital Cost Fee	$3.50
Insurance Broker with Safety Inspector	$0.50
Owner Controlled Wrap-up Insurance (OCIP)	$4.50
Miscellaneous Permitting Costs	$0.10
Miscellaneous Insurance Costs	$0.08
Total	**$158.65**

Note: All costs include the addition of 6.3125% NMGRT except Phase A-D which have 6.75% NMGRT
Note: Costs do not include the cost of financing

The estimated project cost is an estimate due to the uncertainties with some of the related costs, such as:

- Private easement acquisition is underway the there is uncertainty in the estimate cost
- PNM capital costs are estimates at this time
- Alternative energy costs may be included in the future
- The OCIP insurance program is an estimated cost only

In addition, it is recommended that the Owners' provide a reserve for possible change orders that may occur during the project construction such as may occur for unforeseen conditions, additional archaeological/cultural data recovery and other items. Approximately 1 to 3 percent of the construction cost should be held in reserve should the need arise to provide for change orders.

10.9 Preliminary Opinion of Probable Operations and Maintenance Cost

A draft O&M cost estimate was prepared for the Owners' planning needs. This section summarizes the costs and breaks out the cost of operation for the raw water systems, the water treatment plant and the finished water facilities.

10.9.1 O&M Cost Overview and Summary

Preliminary Draft Annual O&M costs were estimated for six categories: personnel, chemicals, materials and supplies, electric use, solids transportation and disposal, replacement items and Buckman Road maintenance. Table 10.9-1 presents a summary of the cost estimate.

The O&M cost, including amortized replacement items such as membranes, results in a total annual cost of approximately $6.77 million dollars in 2006 dollars. This equates to a cost of $2.99 per 1,000 gallons produced. A portion of these O&M costs are attributable to Las Campanas' share for O&M of the raw water facilities as discussed later in this section.

Appendix I includes the detailed spreadsheets for each of the seven cost categories.

Table 10.9-1 Preliminary Draft Annual O&M Cost Summary (2006 Dollars)

Item	Description	Cost/Item	Total Cost
1	Personnel		
	Base Wages	$980,604	
	Overtime	$98,060	
	Benefits	$464,806	$1,543,471
2	Chemicals		
	Ferric Chloride	$263,695	
	Sodium Permanganate	$41,424	
	Sodium Hydroxide	$382,310	
	Muriatic Acid	$1,500	
	Non-ionic Polymer	$79,388	
	Sodium Hypochlorite	$51,013	
	Calcium Thiosulfate	$8,506	
	Liquid Oxygen	$11,123	
	Zinc Orthophosphate	$71,457	
	Fluorosilicic Acid	$3,068	$913,484
3	Materials and Supplies		
	Repair and Maintenance-Water Treatment	$150,000	
	Office Software and Postage	$7,868	
	Operating Supplies	$11,172	
	Communications	$10,000	
	Grounds	$12,500	
	Gasoline/Diesel Fuel	$109,000	
	Uniforms	$12,600	
	Laboratory Fees	$70,000	
	Vehicle Repairs	$46,000	
	Training, Travel & Dues	$10,000	
	Fees	$50,500	
	Contractual Services	$110,700	
	Miscellaneous	$50,000	$650,340
4	Electric Use		
	Raw Water Pumping	$583,051	
	Finished Water Pumping	$66,373	
	Plant & Ancillary Facilities	$240,054	$889,477

Table 10.9-1 Preliminary Draft Annual O&M Cost Summary (2006 Dollars)

Item	Description	Cost/Item	Total Cost
5	Solids Transportation and Disposal		
	SRF Solids Transportation (Included in Items 1 and 3)	$0	
	WTP Raw Water EQ Basin Transportation	$384,740	
	WTP Centrifuge Transportation (Included in Items 1 and 3)	$0	
	Solids Disposal, no tipping fee charged	$0	$384,740
6	Replacement Items		
	Membrane Replacement	$244,379	
	Granular Activated Carbon	$284,093	
	Centrifuge Rehab	$24,635	
	Pump Rehab/Replace	$132,848	$735,955
	Misc. Equipment Repair and Replacement	$50,000	
7	Buckman Road Maintenance		
	County Road Maintenance	TBD	TBD
TOTAL BASE ANNUAL O&M COST		$5,117,468	
	CONTINGENCY, %	15.0%	
SUBTOTAL BASE ANNUAL O&M COST		$5,885,088	
	LEGAL, ADMIN, INSURANCE, %	15.0%	
ESTIMATED TOTAL ANNUAL O&M COST		$6,767,851	
COST PER 1,000 GALLONS		$2.99	

10.9.1.1 General O&M Cost Assumptions

The costs presented in Table 10.9-1 are based upon the following assumptions:

- Raw water diversion and conveyance facilities (i.e., RWLS, BS1A and SRF) operate at 7.8-mgd (annual average flow based upon 8,730 AFY water rights). The pumping of carriage water for sand return to the river was not included
- BS2A and C/CWTP operates at 6.3-mgd
- BS4A operates at 4-mgd (distribution to 10-MG tank) and BS5A operates at 2.2-mgd (distribution to County)
- The cost of maintaining of Buckman Road was not included in this estimate. The County currently maintains this road and will be required to continue to maintain this road under the right-of way agreement with the federal agencies. The amount of maintenance may decrease because of the road improvements however. A line item was added to the summary spreadsheet if the County determines a contribution is needed.
- A 15 percent contingency was added to the annual O&M cost similar to the weighted contingency added to the construction cost estimate
- Fifteen percent was added to the subtotal (including contingency) to account for annual costs of legal, administration and insurance.
- Annual rental fees for the BLM and USFS right of ways is not yet known but is assumed to be included in the legal, administration and insurance cost estimate
- Ongoing financing costs are not included in the estimate

10.9.1.2 Personnel Cost Assumptions

- Costs for personnel wages and benefits were based upon previously presented staffing plan estimates and City benefits data
- The personnel estimate includes a total of 26 employees, of which five employees serve both the C/CWTP and the Canyon Road WTP

- The estimates assume the C/CWTP is manned 24 hours per day with at least two staff on shift

10.9.1.3 Chemical Cost Assumptions

- Chemical doses are based upon projected average doses outlined in the draft PDR as determined from pilot testing or chemical equilibrium modeling
- Chemical estimates assume liquid oxygen used for ozone production; zinc orthophosphate used as a corrosion inhibitor; and sodium hypochlorite delivered instead of on-site generation
- All chemicals will be supplied in liquid form
- Sulfuric acid is not included for enhanced coagulation - a higher average ferric chloride dose (50 mg/L) will be used to depress pH without the addition of acid
- The estimate includes muriatic acid as the preferred membrane clean-in-place chemical. Alternative chemicals are still under consideration.
- Chemical costs were obtained from current Canyon Road WTP contracts or from vendor quotes

10.9.1.4 Materials and Supplies Cost Assumptions

- The material and supplies estimate was generated using the 2006-2007 budget request data for Canyon Road WTP
- Additional security costs were not added as a new charge as the security contract currently in place includes the remote Buckman Well facilities under the existing Canyon Road WTP budget

10.9.1.5 Electric Cost Assumptions

- Electric rates were based on PNM's Rate Schedule 11B which is currently in use for the City of Santa Fe's Water System facilities. The rate of $0.0491/kwhr was used as an average annual unit cost assuming a constant rate of operation over a twelve month period.
- Electric costs do not include a demand charge
- Electric costs include a customer charge for five billings per month (one per meter)
- Pumping costs are calculated using a total dynamic head to determine average flow costs. The Hazen-William formula was used to calculate total dynamic head. The total dynamic head was calculated for each facility using pipeline length and assuming a friction factor of 130, and a total efficiency of 75 percent (product of pump efficiency of 83 percent, motor efficiency of 95 percent and VFD efficiency of 95 percent).
- Electric costs assume the following pipeline diameters: three 20-inch lines between the RWLS and the SRF; 30-inch pipeline between BS1A and the C/CWTP; 30-inch pipeline between BS4A and BS3 and a combination of 24-inch and 16-inch pipelines for BS5A
- Electric costs do not assume operation at off-peak times is maximized for cost savings. Costs will decrease if an off-peak operational strategy is practiced.
- O&M costs for BS4A do not include electric costs for both existing Buckman BS3 and BS4
- For process facilities at SRF and C/CWTP, one process train is assumed to be in operation as the average flow is less than the capacity of one unit in all cases

- GAC backwash is assumed to occur once per week each per the two operational GAC contactors
- The diversion screen cleaning system is assumed to operate a total of 2 hours per day
- One duty chemical feed pump is estimated to be in constant operation for each of seven chemicals used in the treatment process. Three chemicals are used in other processes and not included in this calculation.
- The centrifuge at the C/CWTP operates for 9 hours every two days.
- Conversations between the Owners and PNM to determine electric facility payback are ongoing
- Electric costs for pumping Las Campanas' share of the water at the RWLS, BS1A or BS2A are not included

10.9.1.6 Solids Transportation and Disposal Cost Assumptions

- Solids generation estimates assume an NPDES permit will not be obtained for sand return and instead the sand must be hauled to the Caja del Rio Landfill (or alternative location of similar distance)
- Solids generation at the SRF is based upon a flow of 7.8-mgd at an average TSS concentration of 2,000 mg/L, 25 percent removal of TSS and a solids concentration of 25 percent
- Solids generation in the raw water equalization basins at the C/CWTP assumes an 87 percent removal of solids (from 1,500 mg/L to 200 mg/L TSS) and a solids concentration of 25 percent
- Solids generation from the other processes at the C/CWTP assume a ferric chloride dose of 50 mg/L, with thickening and processing through the centrifuges to generate a 25 percent solids concentration
- Handling and transportation costs for solids from the Raw Water Equalization Basins at the C/CWTP assumes that a contract hauler will provide a front end loader, a 20-cy truck and a driver when each basin is cleaned. The current personnel estimate does not include a dedicated solids handler/driver for this facility. The material will be hauled approximately 4 miles to the Caja del Rio Landfill or to an alternative location at a similar distance, both of which are currently being investigated.
- Two full time employees at the C/CWTP will be dedicated to solids handling from the centrifuge and the SRF such that transportation costs for these solids were not estimated separately. However, vehicle operating costs were included in the materials and supplies estimate.
- Disposal costs (tipping fees at the landfill) were not included in the estimate as Caja del Rio Landfill management staff previously indicated that this fee would be waived. However, new discussions are being held with the Landfill management since there has been talk of a tipping fee of $27/ton. This could add an additional $1.0 to $1.5 million per year to the cost of the BDD facilities. Discussions with the Landfill management are on-going. Alternatively, a beneficial uses are being investigated for the wastes that would not require payment of a disposal fee.

10.9.1.7 Replacement Items Cost Assumptions

- Replacement or major rehabilitation costs were estimated for the following items: membranes, GAC, centrifuges, and high pressure booster pumps
- The replacement or major rehabilitation frequency is estimated to be as follows: membranes - 7 years; GAC - 2 contactors a year - 3 year life on average; raw water pumps - 5 years; finished water pumps - 10 years and centrifuges - 7 years
- Replacement costs were amortized based upon an estimated frequency and discount rate of 5.5 percent
- GAC costs assume new material is being delivered and installed and old material is being removed, transported and disposed by a vendor. On-site GAC regeneration is not recommended and was not considered
- Additional assumptions and information are noted in the detailed spreadsheets included as Appendix I

10.9.2 Raw Water System O&M Costs

10.9.2.1 Summary of Costs

The raw water system components include the diversion, the RWLS, the SRF, BS1A, BS2A, the raw water pipelines and Buckman Road. An individual break out of costs for these facilities is estimated and presented below.

The labor costs are based upon the facility staff (21 employees dedicated full time to the BDD facilities) handling all facilities. At most, the O&M of these facilities will constitute 10 to 15 percent of the personnel time or approximately $230,000 per year. The materials and supplies category includes items that are also common to all facilities. Assuming up to 15 percent is attributable to the raw water facilities, these costs equate to approximately $100,000. Electric use for the raw water facilities is estimated at approximately $580,000 based upon operation of the facilities at their respective annual average rates. This cost can be reduced if an off-peak operational strategy is used. Replacement items for the raw water facilities include pump rehabilitation and replacement at an approximate annual cost of $98,000. There are no chemical costs or solids transportation and disposal costs associated with the raw water facilities. The solids costs are handled in the labor and materials and supplies categories.

The total estimated annual O&M cost for the raw water facilities is approximately $1,010,000. The addition of the contingency (15 percent) and the legal, administration and insurance (15 percent) increases this total to approximately $1.3 million per year.

10.9.2.2 Discussion of Costs

The main O&M cost is the electrical cost to pump the raw water from the river to the C/CWTP - electric comprises 60 percent of the total cost. Electric use varies depending upon the operational methodology. For instance, facilities could be operated mainly at night (off-peak hours) and storage used for supply during peak hours to minimize the electric cost. An initial estimate indicates off-peak operation of the raw water facilities saves approximately $150,000 per year or 15 percent of the annual O&M cost for the raw water facilities.

Several O&M costs will be shared by Las Campanas. Labor and material (gasoline/vehicle) costs for solids handling and disposal from the SRF, pump rehabilitation and replacement, and general

maintenance costs for all raw water facilities with the exception of the pipeline between BS2A and the C/CWTP. Additional electric costs will be realized when Las Campanas is using their share of water - the electric costs in this estimate did not include Las Campanas.

10.9.3 Water Treatment Plant O&M Costs

10.9.3.1 Summary of Costs

The C/CWTP components include all treatment processes, chemical feed processes and all facilities within the confines of the WTP site except for BS4A and BS5A. An individual break out of costs for these facilities is estimated and presented below.

The labor costs are based upon the facility staff (21 employees dedicated full time to the BDD facilities) handling all facilities. These costs comprise all costs not attributable to the raw water or finished water facilities and will constitute 77.5 to 85 percent of the personnel time or approximately $1.2 million per year (based upon 77.5 percent of total). All chemical costs are associated with the C/CWTP and total approximately $900,000 per year. The materials and supplies category includes items that are also common to all facilities. Assuming 77.5 percent is attributable to the C/CWTP, these costs equate to approximately $500,000. Electric use for the C/CWTP is estimated at approximately $240,000 based upon operation of the facilities at their respective annual average rates. This cost can be reduced if an off-peak operational strategy is used. Replacement items for the C/CWTP have an approximate annual cost of $550,000. The solids transportation and disposal costs associated with the C/CWTP are estimated at $385,000.

In total, the annual O&M cost for the C/CWTP facilities is estimated at approximately $3.8 million. The addition of the contingency (15 percent) and the legal, administration and insurance (15 percent) increases this total to approximately $5.0 million per year.

10.9.3.2 Discussion of Costs

Several high or unusual costs were noted during preparation of the O&M estimate. The issues related to the C/CWTP are listed below:

- The chemical cost for ferric chloride has increased substantially in past few years ($0.275/lb now compared to $0.11/lb in 2004) and comprises one third of the total chemical cost. This dramatic increase reinforces the need to design the facilities for the use of a variety of different coagulant chemicals (alum, acidified alum, or ferrous sulfate) and refine operations on a full-scale.
- The higher ferric chloride dose and the recommendation by the University of Washington to blend at a higher pH (7.8) required a high dose of caustic soda. The annual cost for caustic soda is currently estimated at $382,000, which is over 40 percent of the total chemical cost. A significant O&M savings may be realized through the use of hydrated lime in lieu of caustic soda. However, the use of lime has several considerations such as additional capital costs, additional energy costs if fed as slurry, the height of structures and Owners' preference.
- The estimated transportation cost for solids from the Raw Water Equalization Basins are high ($385,000 per year). Hiring staff to transport the material from the Raw Water Equalization Basins and purchase of equipment would not be significantly less expensive than contracting this work because of the infrequent cleaning of these basins.

10.9.4 Finished Water System O&M Costs

10.9.4.1 Summary of Costs

The finished water system components include BS4A, BS5A, and the finished water pipelines. An individual break out of costs for these facilities is estimated and presented below.

The labor costs are based upon the facility staff (21 employees dedicated full time to the BDD facilities) handling all facilities. At most, the O&M of these facilities will constitute 5 to 7.5 percent of the personnel time or approximately $115,000 per year. The materials and supplies category includes items that are also common to all facilities. Assuming up to 7.5 percent is attributable to the finished water facilities, these costs equate to approximately $50,000. Electric use for the finished water facilities is estimated at approximately $67,000 based upon operation of the facilities at their respective annual average rates. This cost can be reduced if an off-peak operational strategy is used. Replacement items for the finished water facilities include pump rehabilitation and replacement at an approximate annual cost of $35,000. There are no chemical costs or solids transportation and disposal costs associated with the finished water facilities. The chemical costs are included with the WTP costs and no solids are associated with these facilities.

The total estimated annual O&M cost for the finished water facilities is approximately $270,000. The addition of the contingency (15 percent) and the legal, administration and insurance (15 percent) increases this total to approximately $360,000 annually.

10.9.4.2 Discussion of Costs

The O&M costs for the finished water systems are fairly distributed through the categories with labor being the most expensive at $115,000. Other main O&M cost is the electrical cost to pump the finished water to distribution. The electric component equate to approximately 25 percent of the total cost. This percentage is lower than the raw water facilities because the pumping head is much less.

10.9.5 Revisions to O&M Costs

These estimated operations and maintenance costs are currently being updated based on City and County comments, discussions with outside agencies and electrical companies and other items. These changes are not reflected in this Report.