ZONE 3 OF THE FLOOD CONTROL AND WATER CONSERVATION DISTRICT OF SAN LUIS OBISPO COUNTY

LOPEZ WATER TREATMENT PLANT AUDIT

FINAL REPORT

B&V Project 97260.400
B&V File A
June 2002

QA/QC by JAH, May 2002

TABLE OF CONTENTS

CHAPTER 4. WTP ASSESSMENT AND AUDIT....................................4-1

CHAPTER 5. POTENTIAL IMPROVEMENTS....................................5-1

APPENDICES

TABLES

FIGURES

Acknowledgment

The following individuals have contributed to this document and their contribution is gratefully acknowledged:

Christine Ferrara	San Luis Obispo County
Carmen Fojo	San Luis Obispo County
Percy Garcia	San Luis Obispo County (Retired)
Craig Kesler	San Luis Obispo County
Ron Coleman	San Luis Obispo County
Faith Zenker	San Luis Obispo County
Nola Snowbarger	San Luis Obispo County
John Beaton	San Luis Obispo County
Shane Taylor	Arroyo Grande
Don Spagnolo	Arroyo Grande
Rocky Rogers	Pismo Beach
Dennis Delzeit	Pismo Beach
Ron Henderson	Black & Veatch
Bruce Corwin	Black & Veatch
Dennis Allen	Black & Veatch
Gary Logsdon	Black & Veatch
Perri Standish-Lee	Black & Veatch
Bob Hulsey	Black & Veatch
George Budd	Black & Veatch
Jay Hesby	Black & Veatch
Jeff Lodge	Black & Veatch
Jennifer McNutt	Black & Veatch
Alex Herrera	Black & Veatch
Ty Tadano	Black & Veatch
Jim Garing	Consultant

Chapter 1. Introduction

This report presents the Lopez Water Treatment Plant Audit (Audit). In this section of the report, background information on the project is provided, project methodology is described, and abbreviations and acronyms are listed.

1.1 Background Information

Zone 3 of the County of San Luis Obispo's Flood Control and Water Conservation District (District) is responsible for operation and regulatory compliance of the Lopez Water Treatment Plant (WTP). The District's major goals are to meet contractual water allocations and to ensure the safety of the public by meeting current and impending regulations established by the California Department of Health Services (DHS).

Source water for the WTP originates from various creeks that flow to Lopez Lake (Lake). The lake is a full body contact recreational water body, which has camping, boating, fishing, and water sports within its watershed. Lake water is conveyed through a 20-inch diameter raw water pipeline approximately 17,000 feet in length. Water discharges from the lake to the Terminal Reservoir for a minimum detention time of 30 days prior to entry to the WTP.

The WTP, originally constructed in 1970, provides conventional treatment and has operated without upgrade or expansion at an average capacity of 6 million gallons per day (mgd). Existing facilities continue to provide water to South County consumers located in the Cities of Arroyo Grande, Pismo Beach, Grover Beach, Oceano, and Avila Beach. Approximately 45,000 residents rely on this treated water as either their primary or supplemental source of supply.

The WTP is now more than 30 years dd, and much of the equipment is nearing the end of its useful life. Although the actual capacity is adequate, additional redundancy is needed. Key water quality concerns are consistently meeting the turbidity goal of the California *Cryptosporidium* Action Plan (CAP) and state and federal requirements for total organic carbon (TOC) reduction goals and future requirements for disinfection by-products (DBPs), specifically total trihalomethanes (TTHMs).

1.2 Project Method

The goals of the Audit were to:

- Evaluate water quality regulations and implement modifications to achieve regulatory compliance with current and foreseeable future regulations.

- Assure compliance with DHS requirements, including requirements for State Revolving Fund (SRF) funding.
- Optimize treatment processes to meet existing and future regulations.
- Identify general WTP improvements, including structural, electrical, and fire suppression integrity; features needed to provide redundancy; and optimization of the instrumentation and control system.
- Review worker safety and WTP staffing requirements.
- Prepare a prioritized plan for facility improvements.

Major project tasks are presented in Table 1.1. This table also identifies report section(s) where the findings and results of these tasks are described. One of the most important parts of the project approach was continuing interaction with the District and Zone 3through a series of four workshops. The workshops enabled continuing involvement of District staff as project objectives were sharpened and refined. At one of the workshops, best available treatment strategies were reviewed and screened. Representatives from DHS participated in this workshop, and this timely input from regulatory agency staff also helped to refine the project focus as well as the final recommendations.

Table 1.1: Summary of Project Tasks

Task	Description	Report Section(s)
Data Collection and Review	Review records.	Appendix E, Data Inventory
Regulatory Compliance Evaluation	Review applicable regulations for raw and finished water; identify treatment limits of most relevance to District.	Chapter 2, Regulatory Issues Chapter 3, Water Quality Evaluation Appendix A, Regulatory Discussion Appendix C, Pre-treatment Assessment Appendix D, Algal Control
Facilities Assessment	Conduct field investigations, interviews with WTP staff, and other activities required to assess: • Lopez Lake Intake Tower; Raw Water Pipeline; Terminal Reservoir Intake Facility • Code Compliance (Structural, Electrical, Fire Alarm-Suppression System) • System Redundancy • Safety • Staffing • Instrumentation and Controls Conduct bench-scale testing of coagulants.	Chapter 4, WTP Assessment and Audit Appendix B, Bench Scale Testing Memorandum Appendix F, WTP Photographs Appendix G, Pipeline Inspection Report Appendix H, Staff/ Operator Interviews

Task	Description	Report Section(s)
Process Evaluation/ Optimization Studies	Evaluate coagulation, flocculation, sedimentation, filtration, and disinfection.	Chapter 5, Potential Improvements Appendix I, Water Softening Calculations Appendix J, Chemical Pretreatment Appendix K, General Process Selection Criteria Appendix L, Clear Water Reservoir CT Calculation Memorandum
Pilot Testing	Perform pilot testing of DAF.	Chapter 6, Pilot Study Appendix M, Pilot Testing Protocol Appendix N, Leopold Final Report on Pilot Testing Appendix O, Leopold Chronology Logbook Data Appendix P, Pilot Plant Water Quality Testing Data
Improvements Development	Develop process and facilities improvements.	Chapter 7, Final Recommendations
Implementation Plan Development	Develop prioritized plan for improvements.	Chapter 4, WTP Assessment and Audit

1.3 Abbreviations and Acronyms

The following abbreviations and acronyms are used in this report:

AA	atomic adsorption method
ADA	Americans with Disabilities Act
ATS	automatic transfer switch
Audit	Lopez Water Treatment Plant Audit
AWWA	American Water Works Association
BAT	Best Available Technology
Cal-OSHA	California Occupational Safety and Health Administration
$CaOH_2$	lime
CAP	*Cryptosporidium* Action Plan
CFE	combined filter effluent
CIP	clean-in-place
CT	contact time
DAF	dissolved air flotation
D/DBPR	Disinfectants/Disinfection ByProducts Rule
DBPs	disinfection byproducts
DHS	California Department of Health Services

District	Flood Control and Water Conservation District
DOC	dissolved organic carbon
DT	detention time
EPA	United States Environmental Protection Agency
ESWTR	Enhanced Surface Water Treatment Rule
FACA	Federal Advisory Committee
ft.	feet
GAC	granular activated carbon
GFCI	ground fault circuit interrupter
gpd	gallons per day
gpm	gallons per minute
gpm/sf	gallons per minute per square foot
HAAs	haloacetic acids
HPC	heterotrophic plate count
HVAC	heating, ventilation, and air conditioning
IDSE	Initial Distribution System Evaluation
IESWTR	Interim Enhanced Surface Water Treatment Rule
$KMnO_4$	potassium permanganate
kW	kilowatt
Lake	Lake Lopez
LF	linear foot
LRAA	locational running annual average
LT1ESWTR	Long-Term 1 ESWTR
LT2ESWTR	Long-Term 2 ESWTR
MCC	Motor Control Center
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDB	main distribution board
M/DBPR	Microbial Disinfection ByProducts Rule
MF	microfiltration
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
ml	milliliter
MPN	most probable number
MRDLs	Maximum Residual Disinfectant Levels
MSS	membrane system supplier
Na_2CO_3	lime with soda ash
NaOH	caustic
NDMA	N-Nitrosodimethylamine
NF	nanofiltration
ng/L	nanograms per liter
NOM	natural organic matter
NTU	nephelometric turbidity unit
O&M	operations and maintenance

pCi/L	pico curies per liter
PLC	programmable logic controller
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
QA/QC	quality assurance/quality control
RAA	running annual average
RFP	request for proposal
RO	reverse osmosis
rpm	revolutions per minute
SCA	Short Circuit Ampere
SCADA	system control and data acquisition
SDS	simulated distributed system
SDWA	Safe Drinking Water Act
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
SMCI	secondary maximum contaminant level
SRF	State Revolving Fund
SUVA	specific UV absorbance
SWTR	Surface Water Treatment Rule
T&O	taste and odor
TAC	technical advisory committee
TDS	total dissolved solids
THMs	trihalomethanes
TOC	total organic carbon
TON	threshold odor number
THAAs	total haloacetic acids
TTHMs	total trihalomethanes
TR	Terminal Reservoir
UBC	Uniform Building Code
UF	ultrafiltration
UFRV	unit filter run volume
µg/L	micrograms per liter
UPS	uninterruptible power supply
UV	ultra-violet light
WTP	water treatment plant

Chapter 2. Regulatory Issues

2.1 Introduction

This chapter summarizes the findings of the Regulatory Compliance aspects of the WTP Audit. The Black & Veatch team reviewed pertinent regulations and their impact on the existing WTP prior to upgrades. This was used to establish treatment goals for the WTP. An outline of applicable regulations for raw and finished water is summarized in a matrix (Table 2.3) that presents regulations and their treatment limits for each of the water quality parameters that are vital to the continued delivery of a safe and reliable drinking water. A more detailed review of regulatory issues is provided in Appendix A.

2.2 Regulations to Impact San Luis Obispo County

Implementation of the 1996 Safe Drinking Water Act (SDWA) led to many new regulations. Some have been issued in final form while others are under continued development. Table 2.1 presents a summary of 14 regulations having a potential impact on the District.

The key rules that will have an impact on the District are discussed below and summarized in Table 2.3.

2.2.1. Stage 1 Disinfectants and Disinfection Byproducts Rule

Historical data demonstrates that the WTP frequently exceeds the Interim Enhanced Surface Water Treatment Rule's (IESWTR) Maximum Contaminant Level (MCL) for total trihalomethanes (TTHMs) of 80 micrograms per liter (µg/L). In addition, the rule requires increased total organic carbon (TOC) removal; testing has shown that enhanced coagulation is difficult for the WTP given the characteristics of the District's raw water.

The District will have difficulty meeting the requirements of this rule. To meet the TTHM MCL, the District has several options including: optimization of TOC removal, use of chlorine dioxide as a primary pre-oxidant and installation of an organics removal process such as granular activated carbon (GAC) or membranes to remove TTHM precursors prior to disinfection with chlorine.

2.2.2. Interim Enhanced Surface Water Treatment Rule

The District is not currently able to meet the requirements of the D/DBPR. In addition, Black & Veatch has recommended that the District use an alternative disinfectant. For these reasons, Black & Veatch recommends the District develop a disinfection profile and calculate a disinfection benchmark.

Table 2.1 : Summary of Regulations Having Potential Impact on the District

Rule	Key Dates	Key Provisions	Impacts to District
Interim Enhanced Surface Water Treatment Rule	November 1998 (Finalized) January 2002 (Compliance Date)	MCLG of zero for *Cryptosporidium*, *Cryptosporidium* removal requirements, turbidity monitoring provisions, requirements for covers on new finished water reservoirs	Should consider developing a disinfection profile. High turbidity levels in treated water may make compliance difficult. More monitoring required. Filtered water turbidities are not always in compliance with Interim Rule and California operation requirements (see Chapter 3).
Stage 1-Disinfectants and Disinfection Byproducts Rule	November 1998 (Finalized) January 2002 (Compliance Date)	Lowers MCLs for total trihalomethanes (80 µg/L), total haloacetic acids (60 µg/L), bromate (10 µg/L), and chlorite (1 mg/L).	Based on review of raw water quality, the WTP would be required to achieve 15% to 30% removal of TOC through enhanced coagulation (the District plans to meet this requirement through pretreatment upgrades). Need to reduce THM levels to meet RAA.
Arsenic Rule	January 2001 (Finalized) January 2006 (Compliance Date)	Establishes a MCL of 10 ppb for arsenic	None Expected
Sulfate	August 2001 (Decision to regulate)	MCL of 500 mg/L for sulfate.	None Expected
Radon Rule	May 2002 (expected)	Will establish final MCLG and MCL in addition to an AMCL for Radon	None Expected
Filter Backwash Rule	June 2001 (Published)	Requirements for recycle streams and self assessment	Compliance required

Rule	Key Dates	Key Provisions	Impacts to District
Microbial/Disinfection Byproducts Stage 2 M-DMP Agreement in Principle	Expected for proposal in 2002	Stage 1 MCLs for TTHM (80 µg/L) and HAA (60 µg/L). Stage 2 levels proposed at 80/60 LRAA, 10 µg/L for bromate (bromate MCL to be reviewed in 6 years).	Need to reduce THM levels from current levels to consistently meet LRAA in distribution system. Removal of organic precursors will be required if chlorine is used as a primary disinfectant. Need to conduct disinfection profile and calculate a disinfection benchmark before any modifications to the treatment process. Long-term Rule initially will require additional monitoring to determine "bin" classification and associated requirements. Additional log removal/inactivation of Cryptosporidium may be required. Compliance can be based on combination of tools from "Toolbox."
MTBE	Effective May 2000	California SMCL- 5ppb, MCL- 13ppb.	Continue monitoring.
Lead and Copper Rule revisions	January 2000 (Finalized) January 2001 (Compliance Date)	A treatment technique requirement for optimal corrosion control treatment based on Action Levels (ALs) for lead (15 µg/L) and copper (1,300 µg/L) at consumers' taps.	Lake Lopez water is not corrosive.
Radionuclides (except Radon)	December 2000 (Finalized) December 2003 (Compliance Date)	MCLG of zero for all radionuclides, establishes new MCLs for Gross Alpha, and Uranium	More monitoring requirements.
Perchlorate	January 2002 (action level established)	Action level for perchlorate established at 4 ppb.	None Expected.
NDMA		Action level 0.00001 ppb.	None Expected.
Unregulated Contaminant Monitoring Rule	September 1999 (Finalized) Implementation in stages	Establishes three lists of chemical contaminants requiring monitoring	Additional Monitoring.

This rule also reduced the allowable finished water turbidity from the present 0.5 nephelometric turbidity unit (NTU) allowed under the Surface Water Treatment Rule (SWTR) to 0.3 NTU. With its current treatment train, the District will have difficulty meeting this turbidity requirement.

2.2.3. California Interim Enhanced Surface Water Treatment Rule

DHS developed the California IESWTR to provide changes to the federal that would increase the level of protection from exposure to pathogens, especially *Cryptosporidium*. The main impact to the District would be increased monitoring of filter effluent; combined filter effluent turbidity continuous monitoring increases from every 4 hours to every 15 minutes.

2.2.4. Arsenic Rule

It is anticipated that the change in the arsenic MCL will not impact the District. Average concentration of arsenic from the WTP is 3.7 µg/L, whereas the recently updated MCL is 10 µg/L.

2.2.5. Sulfate

The sulfate MCL will not have an impact on the District. The average sulfate concentration at the WTP is 98 mg/L, significantly below the proposed MCL of 500 mg/L.

2.2.6. Radon Rule

It is not anticipated that the District will be impacted by the proposed MCL of 300 pico curies per liter (pCi/L).

2.2.7. Filter Backwash Rule

This rule applies to all systems that use surface water, or groundwater under the direct influence of surface water, which filter and recycle. The WTP will be required to provide detailed recycle information to the State and will be required to perform a one-month recycle self-assessment. Aside from documentation requirements, the impact of the rule will be minimal.

2.2.8. Microbial/Disinfection By-Products Stage 2 M-DBP Agreement in Principle

The District will have significant difficulty meeting the requirements of both parts of this law. For the Stage 2 D/DBP Rule, the District has the same options as those discussed as part of the Stage 1 Rule. To meet the *Cryptosporidium* inactivation requirements, the District may need to consider:

- Addition credit for optimized turbidity removal
- UV
- Membranes
- Source control
- Chlorine dioxide

2.2.9. MTBE

The District is not anticipated to have difficulty meeting the current California-adopted MCL of 13 ppb; the District should continue to monitor MTBE concentrations.

2.2.10. Lead and Copper Rule

Historical treated water suggests that the District will not have difficulty meeting the 15 µg/L and 130 µg/L MCLs for lead and copper, respectively. Therefore, the Lead and Copper Rule should not impact WTP operations.

2.2.11. Radionuclides

The radionuclides rule establishes the following

Table 2.2 - MCLs and MCLGs for Regulated Radionuclides

Regulated Radionuclide	MCL	MCLG
Beta/photon emitters	4 mrem/yr	Zero
Gross alpha particle	15 pCi/L	Zero
Combined radium-226/228	5 pCi/L	Zero
Uranium	30 µg/L	Zero

The District is required to complete monitoring under this rule by December 31, 2007; except for monitoring requirements, the rule will not impact the District.

2.2.12. Perchlorate

DHS revised the action limit downward to 4 µg/L; the District is required to continue monitoring for perchlorate as an unregulated contaminant.

2.2.13. NDMA (N-nitrosodimethylamine)

Currently, there are no monitoring requirements for NDMA; therefore there are no impacts to the District. .

2.2.14. Unregulated Contaminant Monitoring Rule

The effect of this rule on the District is one of monitoring, testing, and reporting data to EPA. This is a one-time monitoring effort, and the Rule does not set maximum contaminant levels for any contaminants. Large systems will need to conduct monitoring for the 12 chemical contaminants identified in List 1. Monitoring for contaminants on List 2 will be for a selected group of water systems only. Monitoring is not currently scheduled for contaminants identified in List 3.

2.2.15. *Cryptosporidium* Action Plan

This California state rule provides for increased turbidity goals, increased alarm and public notification requirements, and more frequent sanitary survey updates.

2.2.16. Summary

As shown in Table 2.1 and discussed above, six of the 14 regulations evaluated as part of the Audit require no mitigating action on the part of the District. These are the Arsenic Rule, Sulfate Rule, Radon Rule, MTBE, Lead and Copper Rule, and NDMA requirements. Three more will have minimal impacts, requiring collection of sample data or additional monitoring. These are Radionuclides, Perchlorate, and the Unregulated Contaminant Monitoring Rule.

The five remaining regulations will require mitigating actions by the District in order for the Lopez WTP to achieve regulatory compliance. These regulations and potential mitigating actions are summarized in Table 2.3. Treatment strategies have been specifically selected to address compliance issues discussed herein and are further developed in Chapter 5.

Table 2.3: Potential Mitigating Actions Matrix

Regulation	Potential Mitigating Actions
Interim Enhanced Surface Water Treatment Rule	WTP upgrades will be required to meet treated water turbidity requirements. Complete required monitoring. Will most likely be required to develop a profile of microbial inactivation levels.
Stage 2- Disinfectants and Disinfection Byproducts Rule	Lake Lopez water treated at Lopez WTP will require treatment modifications to meet Stage 2 DBP Rule. (*Current THM levels exceed the Stage 1 MCLs periodically. Precursor removal will be required long-term if chlorine is used as the primary disinfectant).*
Filter Backwash Rule	The District will provide detailed recycle treatment information to the state. Will also be required to perform a one-month, one-time recycle self-assessment.
Microbial/Disinfection Byproducts Stage 2 M-DMP Agreement in Principle	See comments on Stage 1 Disinfectants and Disinfection Byproducts Rule. In addition, the District should evaluate treatment optimization as well as alternative disinfectants, ClO_2, ozone, and UV to achieve protozoan level inactivation/removal. Other tools can include watershed controls, optimized pre-treatment. Membrane treatment for filtration

Chapter 3. Water Quality Evaluation

3.1 Introduction

Assessment of raw water quality and identification of associated treatment requirements is a key element in the process of upgrading the Lopez WTP to meet existing and future regulations. This chapter summarizes the results of a preliminary water quality evaluation and some initial jar testing of water drawn from the Terminal Reservoir. This chapter also includes recommendations for additional monitoring to assess the impact of new regulations on needed WTP upgrades. Water quality at different intakes from the lake and the Terminal Reservoir were reviewed for treatability, compliance with existing and future regulations, and to help with process selection and resource operation. The discussion below addresses raw water quality, and treated water quality requirements. Any recommended improvements must consider these requirements.

3.2 Raw Water Quality

3.2.1. General Physical /Mineral Constituents

Raw water for the WTP is delivered from Lake Lopez via the Terminal Reservoir. Selected water quality criteria for raw water delivered from Lake Lopez as measured at the entrance to the WTP are summarized in Table 3.1.

Table 3.1: Raw Water Quality

Criteria	Range	Median
Turbidity, NTU	0.3 – 5	1.25
Temperature, °C	11 – 25	
pH	6.92 – 8.8	8.0
Alkalinity (mg/L)	220 –320	268
Hardness (mg/L)	303 – 420	345
TDS (mg/L)	386 – 614	480
Color	5 – 14	
Odor (TON)	1 –30	4.4

The source water is generally of very low turbidity and moderately high dissolved mineral content.

3.2.2. Microbiological Contaminants

Coliform are indicator organisms generally used to measure the effectiveness of water disinfection or to provide indication of the relative quality of a raw water supply. Coliform are typically present in water contaminated with human and/or animal feces. *E.Coli* is a normal inhabitant of the digestive tract. Presence of E.Coli in water samples has been used as evidence of fecal contamination by other pathogenic microorganisms.

Results of coliform monitoring in water entering the Terminal Reservoir and raw water entering the WTP indicate water quality from a microbial perspective provides signs of summer contamination. Total coliform concentrations in the Terminal Reservoir and Lake Lopez are presented in Figure 3.1. Total coliform concentrations range from 4 to 9,000 most probable number (MPN)/100ml in raw water entering the WTP and from 11 to 5,000 MPN/100ml in Lake Lopez water (except for one episode on August 21, 2000 when a 16,000 MPN/100ml was recorded). E.Coli in Lake Lopez water have been at 2 or <2 MPN/100 ml, E.Coli in the Terminal Reservoir however range from <2 to 800 MPN/100ml. E. Coli data in the Terminal Reservoir are presented in Figure 3.2.

No data is available for *Giardia* and/or *Cryptosporidium* in the raw water. The District will need to collect monthly samples for *Cryptosporidium* analysis for 24 months using Method 1622/23 to determine bin classification for compliance with Long Term Stage 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).

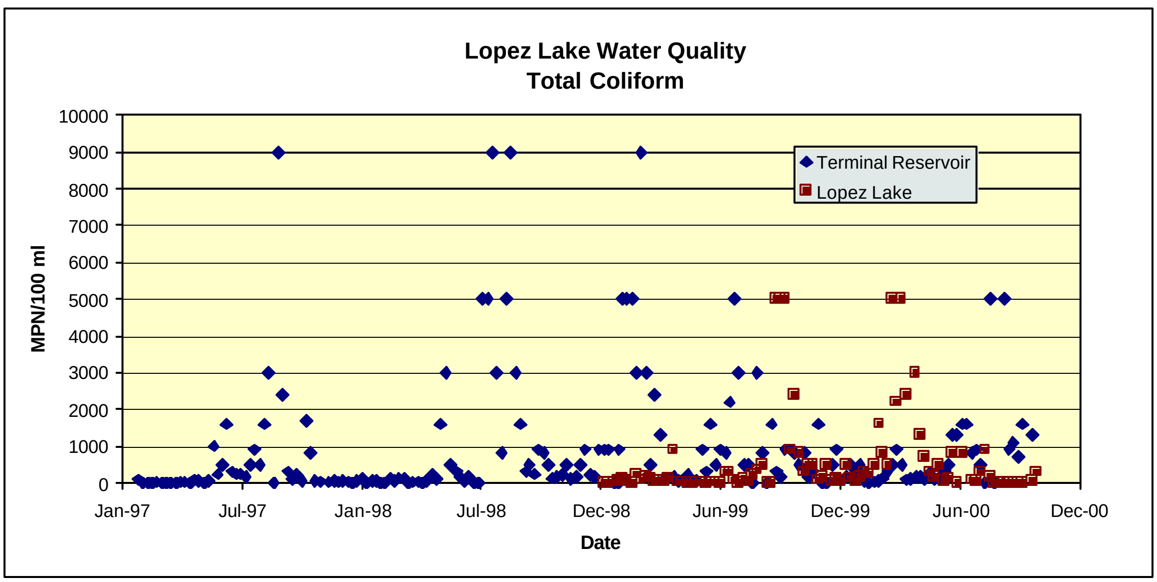


Figure 3.1: Total Coliform Concentrations in the Terminal Reservoir and Lake Lopez

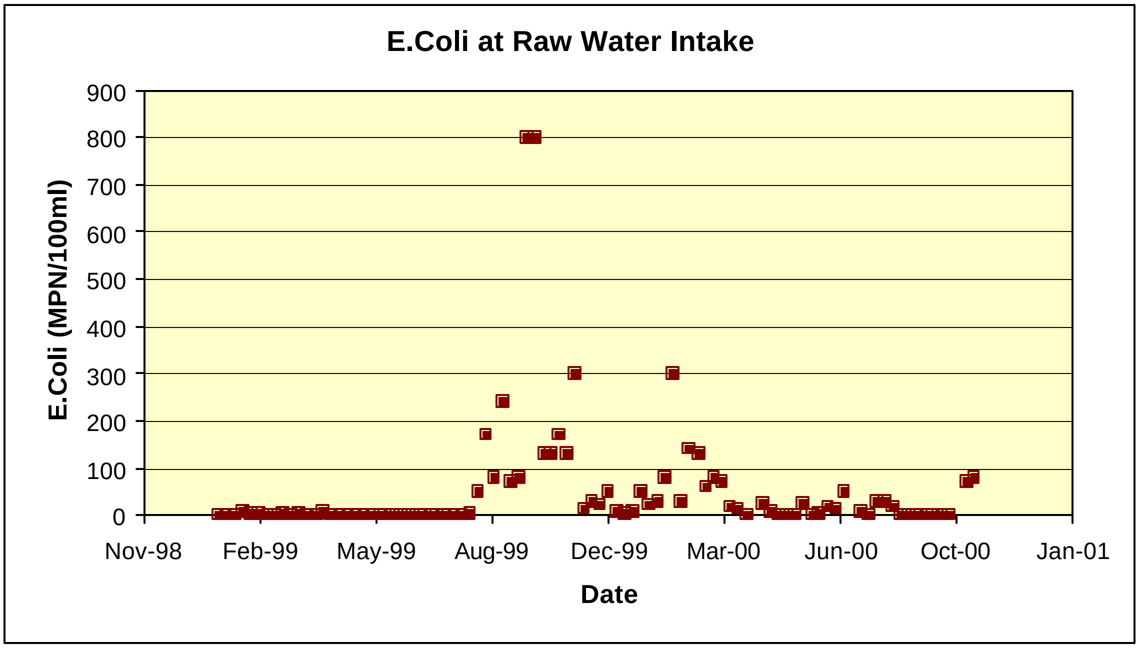


Figure 3.2: E. Coli in Raw Water Entering the WTP

3.2.3. Total Organic Carbon

TOC data in the raw water range between 4 and 5 milligrams per liter (mg/L) with a maximum level of 8 mg/L recorded in February 1999.

The Stage 1 D/DBP Rule requires surface water systems to implement a treatment technique to reduce DBP precursors. Reduction of DBP precursors will eventually minimize the formation of unknown DBPs. This treatment technique is known as enhanced coagulation. Enhanced coagulation is the process of obtaining additional TOC removal by adding increased doses of coagulant. Surface water systems using conventional filtration treatment must operate in the enhanced coagulation mode.

In order to comply with treatment technique requirements, a two-step approach was developed:

- Step 1 involves determination of a TOC removal requirement, whereby the treatment plant must achieve a required percent reduction of TOC between the raw water source and the Combined Filter Effluent (CFE). The required percent TOC reduction is dependent on the raw water TOC and alkalinity.

- Step 2 involves an alternative TOC removal requirement. If a treatment plant cannot meet the percent reduction outlined under Step 1, then the system must perform jar tests to determine the maximum TOC removal achievable for that particular water. The system must then seek DHS approval for the alternative minimum percent TOC removal.

A system may be exempt from enhanced coagulation if it meets at least one of six alternative compliance criteria (see Appendix A).

Based on a review of Lopez Lake raw water quality, the WTP would be required to achieve 15% to 30% removal of TOC through enhanced coagulation if conventional filtration is used. However, the WTP's current TOC removal ranges from 9 to 35% with an average rate of removal of 16%.

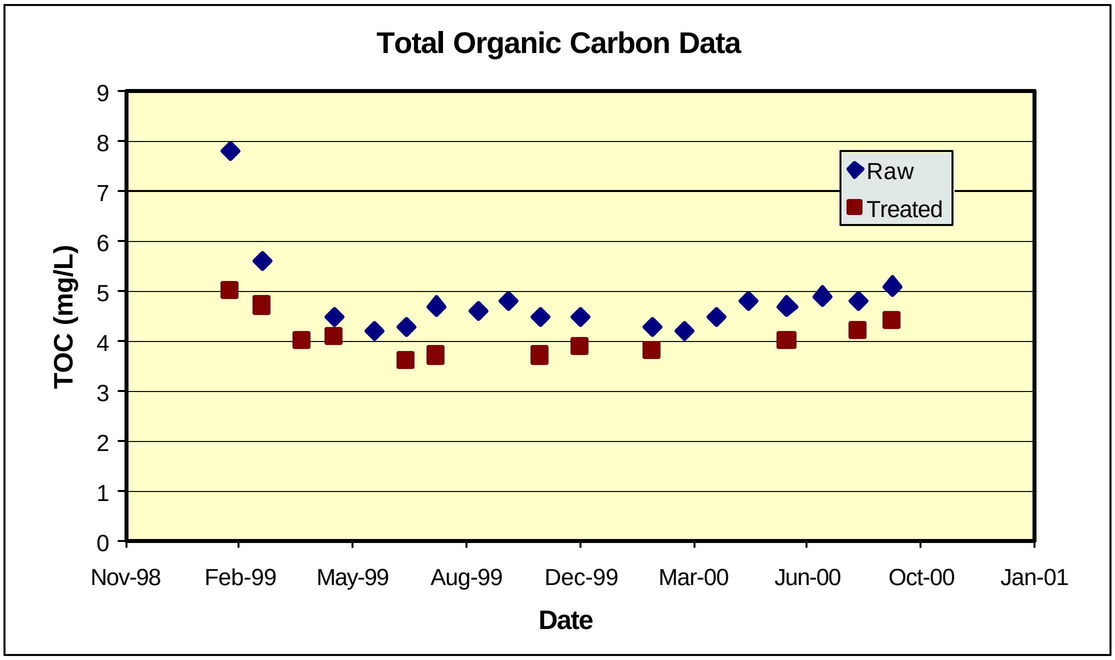


Figure 3.3: TOC concentrations in raw and filtered water

3.2.4. Iron and Manganese

Anaerobic conditions at the lower levels of Lake Lopez and the Terminal Reservoir leads to release of dissolved minerals such as iron and manganese. Manganese levels in the raw water range from about 10 to 1200 ppb. At the Terminal Reservoir, levels reach a maximum of 200 ppb and a median of about 35 ppb. Levels are higher at the end of summer and fall when the Lake turns over. Table 3.2 summarizes iron and manganese levels at the Lake intakes and Terminal Reservoir.

Manganese can go through sequential reducing and oxidizing cycles in sedimentation basins and other locations within the WTP that can lead to the formation of a small, colloidal precipitate carried onto the filters. Even when this manganese is present at low levels, the resulting precipitate can penetrate filters and add to the turbidity. While this may not be an issue for the WTP, a complete understanding of the manganese profile within the WTP is critical to either eliminate this from consideration or for developing a solution to limit the influence of manganese on filtered water turbidity. The use of chlorine dioxide has helped other plants handle manganese problems.

Table 3.2: Iron and Manganese Levels

Description	Iron (ppb)			Manganese (ppb)		
	Range			Range		
	Min.	Max.	Median	Min.	Max.	Median
Lopez Lake						
Intake 1	16	750	71.2	5	42	12.3
Intake 2	12	640	57.7	5	96	20.1
Intake 3	17	330	55.0	5	100	23.0
Intake 4	13	240	52.7	5	340	44.3
Intake 5	11	180	59.3	5	650	126.0
Intake 6	17	2500	82.8	9	1200	254.1
Terminal Reservoir						
Intake 06'	1	190	24.7	10	200	34.1
Intake 12'	6	180	25.1	9	200	34.6
Intake 18'	7	740	30.8	11	200	35.9

3.2.5. Trace Organics

The sanitary survey and water quality data reported no positive trace organics.

3.2.6. Algae Species

Algae episodes occur annually at both Lopez Lake and the Terminal Reservoir. Algae counts peak from the end of the summer through the fall season, during the months of August, September, October, and November. During these months, the count of blue-greens and diatoms go up. The raw water odor exceeds the Secondary Maximum Contaminant Level (SMCL) of 3 threshold odor numbers (TONs). Odor numbers peak to 15 TONs in the raw water. Color ranges from 5 to 16 color units in the raw water. The SMCL for color is 15 units.

The Terminal Reservoir site promotes algae growth, and algae counts at the Terminal Reservoir are higher than counts at the Lake Lopez intakes. Table 3.3 includes the range and median at the Lopez intake and the Terminal Reservoir. Blue-green algae counts are highest at Lopez Lake intakes 1 and 2 and Terminal Reservoir levels 06' and 12'.

Table 3.3: Algae Counts at the Lopez Lake Intakes and the Terminal Reservoir

Description	Calculated Total Algae			Blue-Green Algae		
	Range		Median	Range		Median
	Min.	Max.		Min.	Max.	
Lopez Lake						
Intake 1	0	24,000	1,403	0	24,000	1,012
Intake 2	0	14,000	868	0	14,000	534
Intake 3	0	6,000	354	0	5,100	1,592
Intake 4	0	1,700	93	0	450	12
Intake 5	0	1,200	50	0	79	3
Intake 6	0	1,100	36	0	96	4
Terminal Reservoir						
Intake 06'	0	69,000	2,039	0	9,100	69
Intake 12'	0	71,000	2,056	0	7,100	59
Intake 18'	0	73,000	2,079	0	3,200	38

Algae exude organic substances (exocellular polymers) in their life processes and they lyse to release dissolved organic matter when they die naturally or when oxidized. Control of algae and prevention of algal blooms would help improve the source water quality. Algae control will help treatability by coagulation and filtration and will reduce Natural Organic Matter (NOM), precursors of DBPs, as both the organics given off by living algae and algal decomposition products can react with chlorine to form trihalomethanes. Removal of algae prior to oxidation will improve treatability.

Efforts have been made to control algae in the Terminal Reservoir with copper sulfate. However, copper is toxic and also kills non-target organisms such as zooplankton and fish fry. The following are other potential disadvantages of its use:

- Possible blooms of copper-resistant algal species following treatment
- Possible oxygen depletion caused by decay of significant amounts of bloom material
- Excessive copper accumulation in WTP sludge may reduce ultimate disposal options

In order to develop a method of algae control to eliminate or reduce the severity of taste and odor events, more information is needed to determine the causes of the algal blooms. Black & Veatch recommends a two-phased approach: (1) implementation of a data collection program, to define the source(s) of the algal blooms, and (2) an evaluation of management strategies most appropriate for the District.

Data Collection

A monitoring program including the collection of biological, physical, and chemical data from both the Terminal Reservoir and Lake Lopez should be developed.

Management

There are several different strategies for dealing with algal blooms. These strategies would be dependent upon the source(s) of the blooms and can be categorized into the following:

- Chemical precipitation and inactivation
- Physical Methods
- Biological Methods

Algal control is discussed in more detail in Appendix D.

3.2.7. Source Water Comparison

Table 3.4 highlights the advantages and disadvantages of use of Lopez Lake source water versus the Terminal Reservoir. Based on our analysis of source water quality, Black & Veatch recommends continued use of the Terminal Reservoir as the best near-term solution.

Table 3.4: Water Quality Comparison for Source Water

Lopez Lake	
Advantages	*Disadvantages*
Could eliminate two sources	Direct use not permitted by DHS
Water quality comparable to Terminal Reservoir	Direct use would require a waiver from DHS
Pilot study shows treatment system same as TR	More chance of contamination due to body contact
Deeper Lake and larger with more volume	Stratification[1]
Terminal Reservoir (TR)	
Advantages	*Disadvantages*
Continued existing operation with no problems	Upcoming regulations may regulate algae toxins. Continued use of copper sulfate may provide concerns with meeting these regulations.
Water quality comparable to Lopez Lake	Removal of aquatic weeds
Pilot study shows treatment system same as Lake	
Protects the public water supply better than lake	

[1]This occurs in summer with algae at the surface and iron and manganese from bottom sediments impacting water quality in lower part of reservoir. The only way to fix the problem is with aeration or recirculation. This will be the only way you could eliminate iron and manganese issue

3.3 Treated Water Quality

3.3.1. Turbidity

Combined filter effluent turbidity at the WTP exceeded the *Cryptosporidium* Action Plan (CAP) goal of 0.1 nephelometric turbidity unit (NTU) 21% of the time during 2000.

Seasonally variable performance of the coagulation process is evident in data that clearly demonstrates deterioration in filter performance as water temperature increases. One factor that has been discussed in previous reports is the occurrence of algae under warm water conditions and the adverse influence on floc integrity. While this is inevitably an important factor that can lead to deterioration of filter performance, experience at other water treatment facilities indicates that other factors can also be significant. These include variation in the optimum pH of coagulation with temperature and the effect of manganese cycles within the WTP. Both of these factors also have the potential for exerting adverse influence during warm water conditions.

Coagulation performance at the Lopez WTP is strongly influenced by a high alkalinity condition that requires a degree of pH adjustment to achieve the lower pH conditions that are often more favorable for alum and some other coagulants during the summer period. Both alternative coagulants and alternative coagulation conditions will need to be further assessed to determine the best fit for this WTP to meet both cold and warm water coagulation conditions.

3.3.2. Distribution System Coliform / Heterotrophic Plate Counts

Treated water bacteriological quality is good. Heterotrophic Plate Counts (HPCs) are occasionally high in some parts of the distribution system when temperatures are warmer.

3.3.3. Disinfection By-Products

WTP effluent THMs range from 60 to 120 ppb and frequently exceed 80 ppb (as shown in Figure 3.4).

The Stage 1 TTHM and HAA5 MCLs are listed in Table 3.5. For TTHMs and HAA5, a system is in compliance with these MCLs when the running annual average (RAA) of quarterly averages of all samples taken in the distribution system, computed quarterly, is less than or equal to the MCL. If the RAA computed for any quarter exceeds the MCL, the system is out of compliance. EPA believes that, by meeting MCLs for TTHMs and HAA5, water suppliers will also control the formation of other DBPs not currently regulated that may also adversely affect human health.

Table 3.5: MCLs for Trihalomethanes, Haloacetic Acids, and Bromate

Constituent	MCL	Compliance Basis
TTHM	80 µg/L	Running Annual Average (RAA) of quarterly samples in distribution system; four samples per plant per quarter
HAA5	60 µg/L	

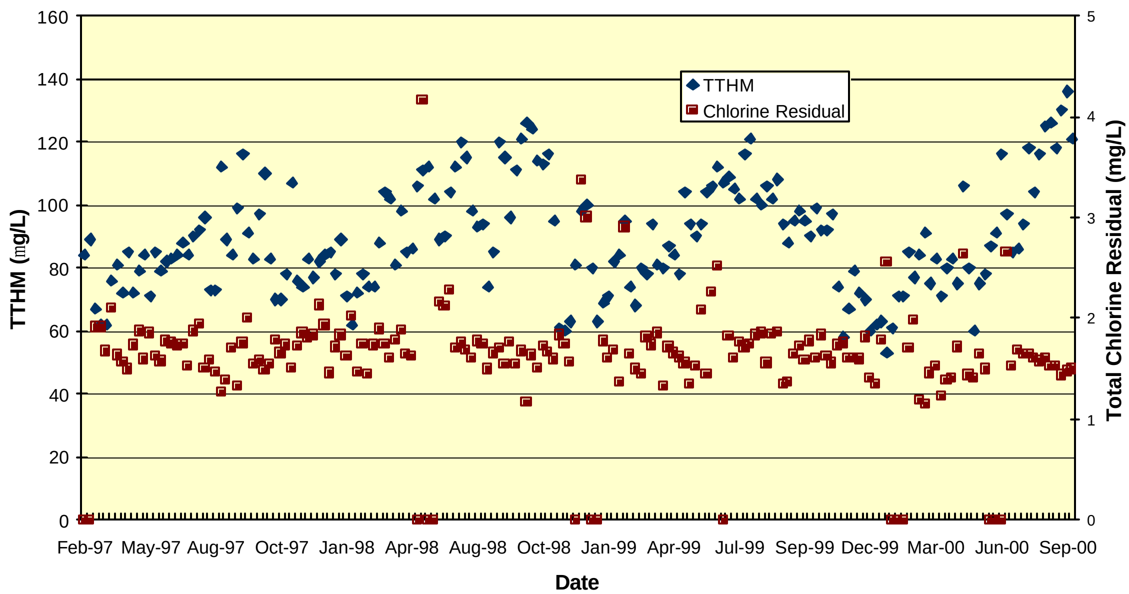


Figure 3.4: TTHM and Chlorine Residual in WTP Effluent

Review of TTHM data shows that TTHM in the distribution system will exceed the RAA MCL of 80 micrograms per liter (µg/L). Although extensive HAA5 data was not available for review, available data indicates that the District will not have a problem complying with the 60µg/L HAA_5 MCL.

An initial review of the existing sampling point for locational running annual average (LRAA) indicates that some points in the distribution system will not be able to consistently meet the 80 µg/L MCL (for discussion of Phase 2 of the Stage 2 –D/DBP Rule, refer to Appendix A).

3.4 Jar Test Results

The District currently exceeds the Stage 1 D/DBPR MCL for TTHMs. The best available technology (BAT) for meeting this is enhanced coagulation. In addition, the IESWTR requires TOC reduction; TOC removal can be achieved through addition of coagulants, addition of filter / coagulant aids, or through pH adjustment. Bench scale testing was conducted on raw water for several coagulants to determine optimum coagulant and dosing conditions. The following summarizes the results of bench scale jar testing; please refer to Appendix B for further information.

Initial jar test results indicate that, at the pH encountered at the WTP, only 9% to 13% TOC reduction can be expected through enhanced coagulation. Table 3.6 presents the jar test results.

Table 3.6: Summary of Jar Test Results

	40 mg/L Ferric	50 mg/L Ferric	40 mg/L Alum + 3 mg/L CatFloc	50 mg/L Alum + 3 mg/L CatFloc	10 mg/L JC 1679 + 10 mg/L Alum	20 mg/L JC 1679 + 10 mg/L Alum
Final pH	7.6	7.5	7.76	7.81	8.04	8.08
Filtered Turbidity	-	0.218	0.347	0.33	0.208	-
Adjusted pH	8.01	7.98	7.8	8.15	8.11	8.2
Cl_2 Residual	1.43	1.25	1.07	1.17	1	1.2
Raw Water TOC	4.6	4.6	4.6	4.6	4.6	4.6
Filtered TOC	4.2	5	4.9	4	4.8	4.2
Total THM	10.53	9.96	13.31	11.13	22.1	12.73

Appendix C provides a discussion of characteristics under which optimal coagulation is to be expected for the Lopez WTP. This discussion indicates that optimal coagulation may occur at conditions of lower pH.

Due to the high alkalinity of the source water, pH adjustment due to the addition of coagulant is more difficult. Additional studies are recommended to attempt adjustments in pH, which may achieve better results. The pH can be lowered by adding an acid or by adding carbon dioxide. Since the alkalinity of the water is high, pH adjustment will be easier to achieve using an acid; acidified coagulants are also available and should be considered.

3.5 Potential Regulatory Compliance Strategies

This chapter has identified potential regulatory challenges in the following areas:

- Stage 1 D/DBP Rule (Near Term)
  - 80 µg/L Distribution System RAA MCL for TTHM
  - Treatment Technique for TOC Removal (Enhanced Coagulation)

- Stage 2 D/DBP Rule (Long Term – Effective 2002 +/-)
  - Phase 1: 120 μg/L LRAA for TTHM (possible concern)
  - Phase 2: 80 μg/L LRAA for TTHM (certain problem)
- Long-Term 2 Enhanced Surface Water Treatment Rule (Long Term – Effective 2002 +/-)
  - Potential issue with *Cryptosporidium* inactivation, uncertain at this time
- *Cryptosporidium* Action Plan
  - Violation of 0.1 NTU filter effluent

With the exception of the potential issue with *Cryptosporidium* inactivation, which is uncertain at this time due to lack of data, all of the future regulatory challenges involve DBPs. Some potential options for dealing with the regulatory challenges are as follows:

- *Stage* 1 D/DBP Rule TTHM MCL of 80 μg/L RAA
  - Optimize TOC removal through use of coagulants and improved treatment process.
  - Use chlorine dioxide as primary pre-oxidant.
  - Install organics removal processes such as GAC or membranes to remove TTHM precursors prior to disinfection with chlorine
- Stage 2 D/DBP Rule TTHM MCLs, Phase 1 and Phase 2
  - Same options as Stage 1 TTHM MCL
- Long-Term 2 Enhanced Surface Water Treatment Rule *Cryptosporidium* Inactivation
  - Additional credit for optimized turbidity removal
  - Ozone
  - UV
  - Membranes
  - Source Control
- *Cryptosporidium* Action Plan
  - Pretreatment optimization
  - Reservoir aeration and restoration to reduce algae and manganese.
  - DAF to remove algae before oxidation
  - Chlorine dioxide as pre-oxidant
  - Filter operation improvements
  - Membranes

3.6 Summary

Treatment strategies assessed in Chapter 5 will need to address the above water quality concerns and the final solution will need to provide assurances that the selected alternative can treat the difficult source water and provide quality treated water to the District's customers.

Chapter 4. WTP Assessment and Audit

4.1 Introduction and Background

This chapter summarizes the findings of the WTP Audit performed by Black & Veatch. The purpose of the WTP audit and assessment was to assess the functionality and physical condition of existing facilities and identify potential improvements necessary to bring them into full compliance with regulations, improve water quality, and protect worker safety.

The Black & Veatch team reviewed the existing WTP data and drawings listed in Appendix E. A plan of action was then developed for the fieldwork portion of the work. A hydraulic profile of the existing WTP was reproduced to show the existing flow of WTP water and to assist in evaluating options for modifications to the existing process (See Figure 4.1). This profile provides a basis for understanding the components and their location in the treatment process. Major components included in the audit were:

- Lopez Lake Intake Tower
- Lopez Lake Outlet Works
- Raw Water Pipeline
- Terminal Reservoir
- Hydroelectric Facility
- Clearwater Reservoir (2,100,000 gallons)
- Domestic Water Tank (50,000 gallons)
- Wash Water Tank (300,000 gallons)
- Administration Building
- Chemical Building
- Filter Building
- Ammonia Building
- Treatment Units
  - Flocculation/Sedimentation Basins, Rapid / Flash Mixer, Filter Units
- Raw Water Influent Vault

A detailed investigation of the WTP was conducted between March 12, 2001 and March 16, 2001. The remainder of this chapter discusses the findings of the WTP audit and assessment. Suggestions for possible update, repair, or replacement are included in Chapter 7. WTP photographs and a separate pipeline assessment report are included in Appendices G and H, respectively.

The various improvements discussed in this chapter may or may not be required in conjunction with the final selected upgrade alternative, however some remedial actions contained herein will be required regardless of the treatment alternative selected. In other words, the recommended remedial actions may be included within a treatment upgrade alternative rather than need to be completed

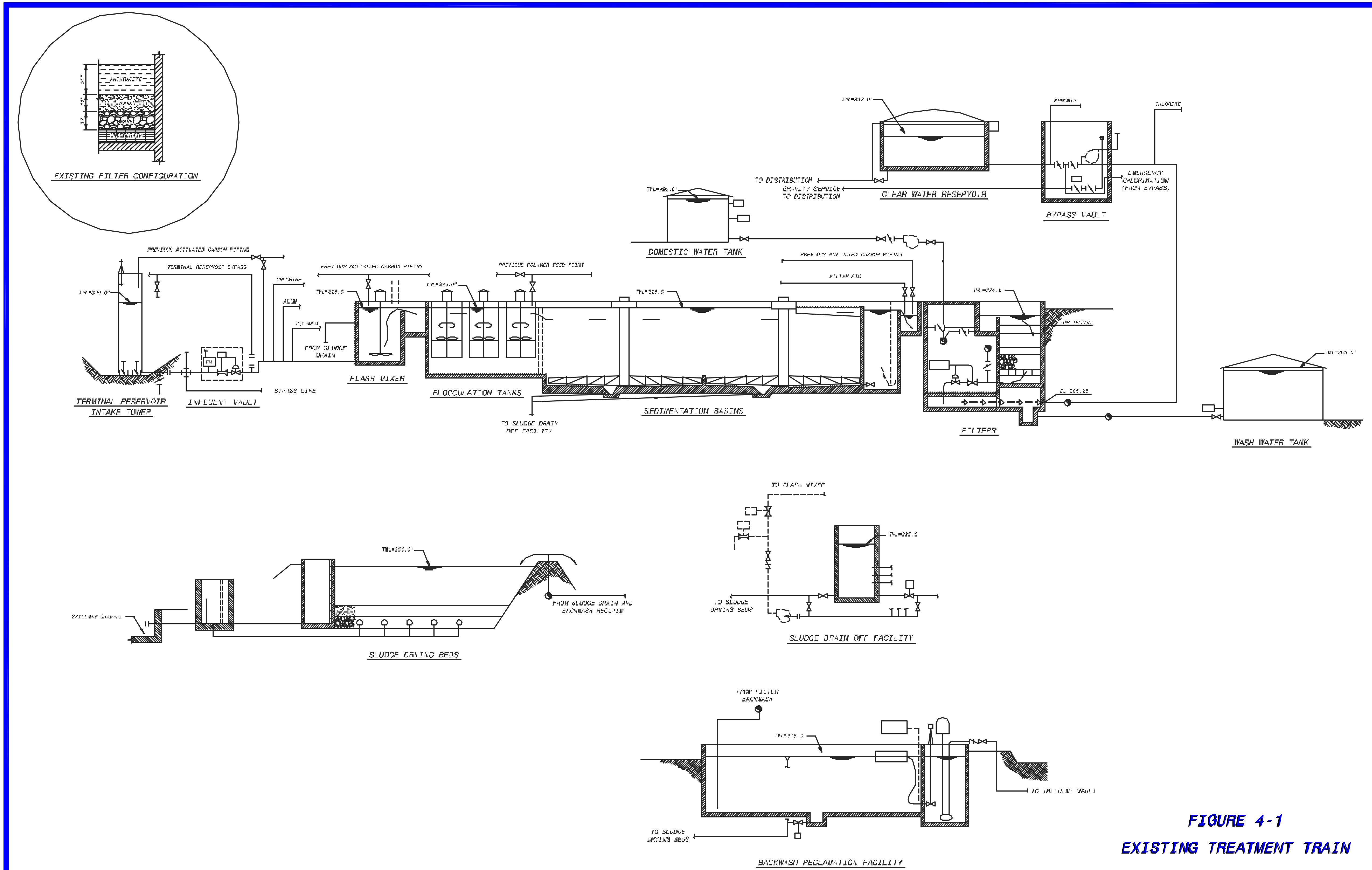


FIGURE 4-1

EXISTING TREATMENT TRAIN

independently.

4.2 Lopez Lake Intake Tower

A functional review of the Lopez Lake Intake Tower consisted of inspection of the existing components integral to the intake tower. The gates and valving that comprise the raw water release from the lake are in good condition, but have no redundancy. Interviews with operations personnel were conducted concerning the existing intake and its expected reliability during the life of the reservoir. There seems to be limited concern that the intake tower would not continue to function in its current condition for the long-term. Other observations included:

- At the time of the audit, the log boom was constructed out of telephone poles strung together and a large tree trunk had passed over the log boom and was sitting next to the outlet gates.
- Access to the gates involves walking down a very steep concrete stairway; at the time of the audit, there were no handrails on either side. The concrete stairs continue to the water surface where there are measurement rods that enable water level readings.
- There are multiple gates and gate selection is dependent on water quality. The physical operation of the gates is done manually at the facility.

From interviews with WTP personnel, there is no reason to believe that the Intake Tower will not be able to meet the WTP's future needs. A modification to the log boom has been made since the audit such that it can be adjusted according to water level. The stairway leading to the gates has been provided with handrails since the audit. Upgrades to gate operation should be made such that gates may be operated remotely.

4.3 Lopez Lake Outlet Works

The Outlet Works is connected to the Intake Tower via pipeline from the tower. Observations of the outlet works were as follows:

- As part of the seismic retrofit of the Lopez Lake Dam, this entire facility will be relocated.
- The existing facility was designed to enable addition of gaseous chlorine; apparently the new facility will not have this capability.
- This facility has a bypass to provide a minimum stream flow of 4 mgd. Adjustment of this flow is done manually.

Because the Outlet Works is being reconstructed under separate contract with the District, no additional work will be required as part of any upgrade or retrofit to the Lopez WTP.

Raw Water Pipeline

An evaluation of the 20-inch raw water pipeline between the intake tower at Lopez Lake and the Terminal Reservoir included:

- Reviewing O&M Manuals.
- Potholing at strategic points selected by WTP personnel. (The District supplied the excavation equipment to effect this inspection.)
- Performing several tests to determine pipeline condition and the condition of the surrounding soil.
- Inspecting existing air-vacuum relief valve stations.
- Reviewing existing geotechnical reports.
- Reviewing existing plans to establish flexibility of pipe at encased crossings to handle seismic movement.

Based on review of the elements listed above, along with discussion with staff related to known condition of the raw water pipeline, the need for TV inspection of the pipeline was not deemed necessary and the condition of the pipeline was found to be good. However, due to the age of the air-vacuum relief valves, it is recommended that they be replaced.

Further discussion of the pipeline condition and inspection is contained in Appendix G.

Sections of the raw water pipeline from Lopez Lake may cross Arroyo Grande Creek aboveground. These sections would be at risk of contamination and/or pipeline failure and should either be replaced or upgraded to ensure no possibility of intrusion or loss of flow to the Terminal Reservoir. Flexible connections would be included as part of the upgrades.

4.4 Terminal Reservoir

Evaluation of the Terminal Reservoir included assessment of the current procedure of impounding raw water at the Terminal Reservoir and analysis of options available for control of water quality at the reservoir, including:

- Algal bloom control
- TOC removal
- pH adjustment
- Prechlorination

A water quality analysis was completed along with a review of the continued use of the Terminal Reservoir and the option for bypassing the reservoir. This data is covered separately in Chapter 3. Other observations included:

<u>Terminal Reservoir Flow Control Valve</u>

- The Cla-Valve can only be operated manually at the vault. Remote control capability, perhaps through SCADA based on reservoir level, needs to be incorporated.

<u>Terminal Reservoir Outlet Tower</u>

- A total of 5 gates are available. They are manually operated with floor stand hand wheel actuators.
- The facility appears in good shape structurally. There were no reports of operation or maintenance issues related to the outlet.

The pilot study (discussed in Chapter 6) has shown that upgrades to the WTP will provide enhancements to the system such that existing water quality from the Terminal Reservoir may be treated to a level that will meet regulatory requirements. As such, the only difference between use of Lake water versus use of Terminal Reservoir water is that the WTP would require a waiver from the DHS in order to use Lake water. **Therefore, Black & Veatch recommends continued use of the Terminal Reservoir.** Treatment processes and costs will be similar regardless of source water. The Terminal Reservoir was not drained during the WTP audit; therefore assessment of its longevity is based on feedback from operations personnel. Based on this feedback, we do not foresee any major problems with continued use of the Terminal Reservoir and believe it should be able to last for the life of the expanded WTP, 20 years.

4.5 Evaluation of Hydroelectric Facility

Black & Veatch examined the existing hydroelectric facility at the Terminal Reservoir. This evaluation determined that it is not economically feasible to operate the hydroelectric facility. Issues that would require resolution prior to the hydroelectric facility being upgraded and used include:

- Is the permit to operate current or is there a need for a new permit? Will repairing the facility result in permit issues?
- Is it best to have the operation privatized or operate in another manner?
- When in use, only a maximum of 4 mgd can enter the Terminal Reservoir. This does not allow for maximum WTP flow of 6 mgd.

District staff requested that a technical evaluation of the hydroelectric facility be completed to address the condition of the hydroelectric facility, its potential to operate, its effects on water quality, and the economic advisability of upgrading the facility to allow 6 mgd to flow through the generator unit.

Condition of the Hydroelectric Facility

Based on visual inspection and records reviewed, it is our technical opinion that the hydroelectric facility is structurally sound and that its equipment could be brought back to operating order with general maintenance. The piping and valving appear in fairly good condition, but the valves will have to be exercised to confirm adequate operation.

Potential to Operate

Based on past operational records, it is our opinion that this facility can operate to a limit of ± 4 mgd passing through the generator. Anything greater will not allow for proper operation. Since the Lopez WTP is a 6 mgd plant, the hydroelectric facility would not allow for full WTP operation to 6 mgd. The current WTP cannot operate with the hydroelectric facility online given that limitation.

Effects on Water Quality

Based on previous data illustrating that there were adverse water quality effects from hydroelectric facility operation, we believe that the causes of such effects are directly related to the way the hydroelectric facility is designed to discharge. In order to ensure there would be little or no impact from the hydroelectric facility, we would recommend that the facility only be operated if upgraded and the discharge rehabilitated to prevent such problems.

Economic Advisability of Operation

Based on its water quality and capacity limitations, it is not advisable to operate the hydroelectric facility in its current condition. Since the existing and proposed upgrade to the WTP allows for a maximum capacity expansion to 12 mgd, the most advisable upgrade of the hydroelectric facility would be to 12 mgd. The cost to upgrade the facility to 12 mgd and to permit such a facility would be an insurmountable task for the District. Therefore, it is not economically feasible to upgrade and operate the hydroelectric facility.

4.6 Administration Building

The existing laboratory is inadequate for in-house water quality testing. WTP staff presently perform regular water quality analyses for alkalinity, pH, hardness, turbidity, color, chlorine residual(s), particle counts, color, conductivity, and temperature. The District currently sends water samples to a contract laboratory for analysis of microbial contaminants including coliforms and heterotrophic bacteria, disinfection by-products, synthetic organic compounds, volatile organic compounds, inorganic compounds, as well as radionuclides. Therefore, the laboratory should be expanded to provide for onsite testing. In addition to a new laboratory, the administration building should be expanded to provide adequate operator office space and a meeting room; the electrical and instrumentation systems should be upgraded to include modern equipment. Structural needs will be discussed separately below.

4.7 Structural Inspection

This section presents the results of a visual inspection and review of all available record drawings for the County of San Luis Obispo's Lopez WTP facilities evaluated under the Lopez Water Treatment Plant Audit. The overall objective for this portion of the study effort was to conduct preliminary structural evaluations in order to identify necessary upgrades required to bring these facilities up to current seismic design standards.

Condition of existing structures was visually inspected and assessed with respect to the original record drawings as follows:

- Evaluate the general structural condition of the facilities (hammer blow tests of concrete walls and slab – hammer blow test consists of hammering surface with a conventional hammer).
- Identify any apparent or visible structural deficiencies.
- Verify that the structure was constructed in accordance with available record documents.
- Note any alterations or deviations from the record drawings.
- Identify potential structure behavior without actual detailed engineering analysis.

Current versions of the following technical standards were used as benchmarks for preparation of the seismic evaluations that are included in this report:

- For steel tanks: AWWA D100 and D-110
- For concrete reservoirs: ACI 350R (draft)
- For buildings: 1997 Uniform Building Code (UBC)
- Design methodology similar to the one contained in FEMA Technical Assistance Manual 310

Field Investigation

A meeting with the WTP's O&M staff was conducted to briefly discuss the work to be covered during the audit. In addition, coordination of site access and security issues before commencing the field inspections were discussed.

Earthquake Performance

Most of western California is within Seismic Zone 4. All new construction and major reconstruction of existing facilities must now be designed to meet the provisions of the Uniform Building Code (UBC) for Seismic Zone 4. The latest issue of the UBC for Seismic Zone 4 produces much higher seismic loading and stricter detailing requirements than previous editions of the UBC.

For a Zone 4 seismic event, ground motion can cause some structural and nonstructural damage and the intended functional use of a structure may be interrupted. The performance goals for buildings in this zone, post earthquake, are classified into three levels: Suitable for Immediate Occupancy (I.O.), Life Safety (L.S.), and Collapse Prevention (C.P.). The usual code design requirements are based on the L.S. level. The I.O. level goal is for a structure to remain functional after an earthquake with a magnitude of I.O. level or smaller. Obviously, in order for the facility to remain in service after a major level of earthquake ground motion, piping and equipment must also remain functional as well as the structure. B&V believes I.O. is the best goal for the Lopez WTP.

Site-Specific Observations and Retrofit Recommendations

Because the facility was constructed in 1970, it was designed for lower seismic loading than loads required by the latest UBC. In addition, the structures may not meet the stricter detailing requirements and therefore would not be able to resist higher seismic loading. Therefore, it is recommended, as a minimum, that all structures designed prior to 1997 be evaluated in depth for necessity of seismic upgrade. It should be noted that the visual inspection performed for this evaluation does not confirm that all information and details shown on the available record drawings were incorporated. For example, with the information provided on the drawings, we may be able to evaluate the reinforcement call outs, however we cannot verify that the material was included as part of the final product unless further tests are done such as taking core samples or x-rays.

Depending on whether further design is required, and upon the District's approval, it is recommended that these older facilities be further evaluated as part of design. Evaluation shall include, but not be limited to the following:

- Penetration tests of concrete and masonry including ultrasonic thickness measurements of metal elements.

The following facilities were included in the structural audit:

Reservoirs:
Clearwater Reservoir
Domestic Water Tank
Wash Water Tank

Buildings:
Administration Building
Chemical Building
Filter Building

Ammonia Building

Treatment Units:
Rapid Flash Mixer
Flocculation Basins
Sedimentation Basins
Filter Units

Other Facilities:
Hydroelectric Facility
Raw Water Influent Vault

4.7.1. Reservoirs

Clearwater Reservoir (2,100,000 gallons)

This reservoir is a partially-buried, circular, reinforced concrete structure designed in 1968 by Koebig & Koebig, Inc. and built in 1969. Only one foot of the structure protrudes above grade. The tank has an inside diameter of 150 feet and is 19 feet tall. The roof is a dome inflatable cover installed with the original WTP. There were no specifications or details available for review on the inflatable roof. A roof system, such as the one on the Clearwater Reservoir, has an expected lifetime of 10 to 15 years. Record drawings do show anchorage details between the roof and the walls; however, these connections should be checked to verify conformance with the latest UBC. The year of design and construction lead to the assumption that these connections may not be adequate since the connections may have been designed for lower seismic loading than loads required by the latest UBC.

Freeboard is not indicated on the plans. This may indicate a likely upward pressure on the roof during a design seismic event that may tear the roof fabric from the anchors. It appears that the walls are designed without lateral support at the top. The hammer blow test of walls was acceptable. Outer surfaces of the perimeter walls, those portions above grade, were checked for deterioration. The walls above grade had minor shrinkage cracks and honeycombs that appear to be part of normal construction finish. Based on drawing review, the wall-to-foundation interface appears to have adequate detailing for anchorage. The latest draft of the ACI 350R standard does not permit construction of unanchored, unconfined water tanks in Seismic Zones 2B or higher. Some form of anchorage is provided between the wall-foundation interface, but the reservoir wall and roof interface should be verified.

Reservoir piping was not visible during the site visit. As-built drawings indicate that there is one 36-inch common inlet/outlet pipe, one 18-inch overflow pipe, and one 8-inch drainpipe. Drawings indicate a flexible expansion joint for the drainpipe. However, no expansion joints are indicated for the inlet/outlet and overflow piping.

Concerns:

Based on the inspection outlined above, we have concerns with the anchorage of the roof to the walls, the cover or roof system itself, the long-term ability of walls to withstand forces, flexibility of inlet and outlet pipes in case of movement, and potential contamination issues.

Domestic Water Tank (50,000 gallons)

This reservoir is an unanchored steel tank with an inside diameter of 24 feet and a height of 16 feet. The tank was fabricated and erected as part of the Lopez Water Supply Project. Drawings provided by the County of San Luis Obispo do not include tank or roof details. The tank foundation is a concrete ring that is partially buried. Minor shrinkage cracks were evident on the foundation, which appears to be in adequate condition. It is possible that the tank is vulnerable to buckling and lateral movement off its foundation during an earthquake. Internal sloshing of stored water during an earthquake may cause damage to the roof. The freeboard level should be verified to establish if sloshing would cause such damage.

As-built drawings indicate that there is one 8-inch common inlet/outlet pipe, one 6-inch overflow pipe, and one 6-inch drainpipe. Drawings do not indicate flexible expansion joints for the piping.

No assessment of tank corrosion was made during the inspection, however the roof's coating system is peeling.

Concerns:

Based on our inspection, we are concerned with the ability of the footing/tank connection to resist lateral forces as well as uplift and believe that it requires anchorage. We also believe that further analysis needs to be performed to ensure that tank bottom, wall, and roof thicknesses are adequate. We are concerned with flexibility of inlet and outlet pipes in case of movement and potential contamination issues.

Wash Water Tank (300,000 gallons)

This reservoir is an unanchored steel tank with an inside diameter of 48 feet and a height of 24 feet. As with the Domestic Water Tank, this tank was fabricated and erected as part of the Lopez Water Supply Project. Drawings provided by the County of San Luis Obispo do not include tank or roof details. The tank foundation is a concrete ring that is partially buried. Minor shrinkage cracks were evident on the foundation, which appears to be in adequate condition. It is possible that the tank is vulnerable to buckling and lateral movement off its foundation during an earthquake. Internal sloshing of stored water during an earthquake that may cause damage of the roof should be verified with the provided freeboard.

As-built drawings indicate that there is one 18-inch common inlet/outlet pipe, one 6-inch overflow pipe, and one 6-inch drainpipe. Drawings do not indicate flexible expansion joints for the piping.

No assessment of tank corrosion was made during the inspection, however the roof's coating system is peeling.

Concerns:
Based on our inspection, we are concerned with the ability of the footing/tank connection to resist lateral forces as well as uplift and believe that it requires anchorage. We also believe that further analysis needs to be performed to ensure that tank bottom, wall, and roof thicknesses are adequate. We are concerned with flexibility of inlet and outlet pipes in case of movement and potential contamination issues.

If membrane filtration is selected as the recommended upgrade, it is possible that this tank may no longer be required. In this case, the District may consider abandoning it in place or dismantling it and obtaining whatever salvage value available.

4.7.2. Buildings

Administration Building

Koebig & Koebig, Inc originally designed the Administration Building in 1968. The facility is constructed of 8-inch reinforced concrete block bearing walls, which support a flexible diaphragm roof consisting of timber beams and rafters and plywood sheathing. The shear walls resist lateral forces. The facility's foundation is composed of 4-inch thick reinforced concrete slab and perimeter strip footings.

The pitched roof diaphragm, roof ridge beam, and ledgers show signs of deterioration. The wood shows splitting and decay both on the interior and exterior surfaces. Interfaces between the roof and walls showed minor separation. The adequacy of the roof diaphragm needs to be verified, including actual nailing pattern since nailing requirements on the record drawings were not verified.

The masonry shear walls supporting the roof diaphragm have cracks, which are less than 1/16-inch wide; therefore there are limited concerns. (FEMA says 1/8–inch cracks are of concern.) Available record drawings show reinforcement details; however, since this facility was initially constructed in the 1960's, it is assumed that the facility does not meet the requirements of reinforcement spacing and anchorage as defined in Section 2106 of the 1997 UBC.

The expected level of performance of this facility through a seismic event should be considered Life Safety, since ground motion associated with a zone 4 seismic event may cause structural and nonstructural damage. After review of existing information and the field inspection, it appears that the structure may not be suitable for immediate occupancy after a zone 4 design-basis seismic event.

During our inspection, various nonstructural elements could not be evaluated because they were not visible to view. The following are items that may require additional attention:

- Water heater and boiler room piping lateral restraints.
- Heating, Ventilation, and Air Conditioning (HVAC) ducts restrained per SMACNA.
- Ceiling tiles not laterally braced.
- Electrical and control equipment lateral bracing.
- Shelves and file cabinets anchoring.

Concerns:

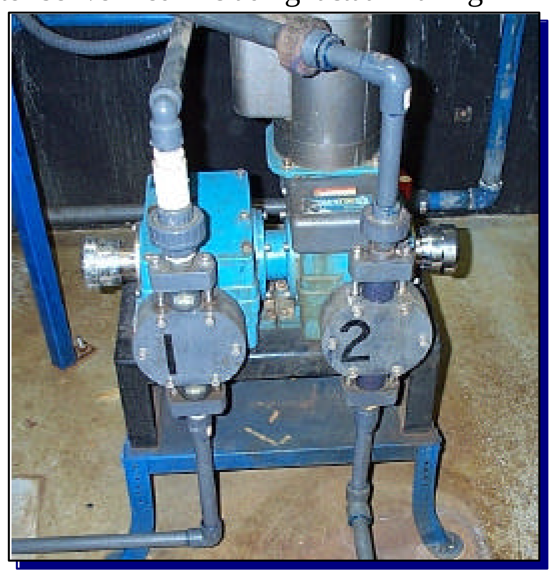
Based on our inspection, we are concerned with deterioration and the ability of the facility to resist lateral forces as well as uplift and believe that it requires anchorage. We also believe that further analysis is needed to ensure that the roof is adequate.

Chemical Building

Originally designed in 1968 by Koebig & Koebig, Inc., the Chemical Building is a reinforced masonry bearing wall building with flexible wood diaphragm superstructure that sits on a reinforced concrete box substructure. Existing record drawings lack details for reinforcement. The 8-inch perimeter shear walls resist lateral forces. Based on the year of construction, the building may not meet the requirements of Section 2106 of the 1997 UBC pertaining to adequate reinforcement or anchorage.

The flexible roof diaphragm consists of timber beams and rafters and plywood sheathing. The connection system used to connect the walls and floor may not be adequate. The operation floor, where the chemical storage and electrical room area is located, has a 6-inch reinforced concrete suspended slab. The substructure consists of 12-inch thick reinforced concrete walls and a 6-inch thick slab foundation. The foundation slab shows signs of deterioration. Although the hammer blow test on the slab was acceptable, the slab showed cracks and exposure of aggregate. Aggregate exposure is due to past practices that led to chemical spillage on the foundation slab. The basement slab was observed to have 1/8 to 1/4-inch cracks that do not pose a problem. The cracks appear to have been injected with epoxy grout and do not appear to be growing in separation.

The pitched roof diaphragm roof ridge beam and ledgers show signs of deterioration. The wood shows splitting and decay both in the interior and exterior surfaces. Interfaces between the roof and walls showed minor separation. The adequacy of the roof diaphragm needs to be verified including actual nailing pattern since nailing requirements on the record drawings were not verified.



The Chemical Building piping infrastructure consists of small diameter piping. The piping is equipped with adequate vertical support but lacks any lateral restraint. Also, it appears that there are no flexible expansion connections. The facility does not provide any means of containment or separation of chemicals. The chemical storage tanks, although small in size, do not contain any lateral restraint system. Small metering pumps also lack anchorage. The electrical gear appears to lack lateral restraint and the record drawings do not include anchorage details to verify. Lateral restraint needs to be provided.

The outside concrete reinforced loading dock showed visible cracks greater than 1/16-inch wide. These cracks do not appear to be part of normal construction finish such as shrinkage, but appear to be due to the loading capacity of the dock being exceeded.

The staircase leading into the chemical injection area may not meet the requirements of OSHA and the UBC. The staircase width between the handrails does not meet the minimum width requirement of 36 inches.

Concerns:

Based on our inspection, we are concerned with deterioration and the ability of the building to resist lateral forces. The building and piping systems require anchorage. We are concerned with flexibility of pipes in case of movement and potential contamination issues. We are concerned that chemical containment does not separate bases from acids.

Filter Building

This facility is a concrete shear wall building with a stiff roof diaphragm. The building sits above the filter gallery (the filter gallery is discussed later). The superstructure is composed of 8-inch reinforced concrete shear walls, which resist lateral forces. The rigid diaphragm roof consists of a 6-inch thick reinforced concrete suspended slab.

The visual inspection and hammer blow test verified that the building appears to be constructed in accordance with the documents and with no major structural deficiencies or concerns that would immediately affect its use. Should membrane filtration be selected, this building will either need to be retrofitted or demolished.

Ammonia Building

This light steel frame structure, originally designed by the County of San Luis Obispo Engineering Department in 1990, sits on a reinforced concrete slab-on-grade. Record drawings for the metal building itself were not available for review, thus the shear walls, which resist lateral forces, could not be reviewed to confirm that properly detailed anchorage connections to the foundation were included. The visual inspection appears to show that the building was constructed in accordance with the documents, and therefore, there appears to be no other major structural deficiencies or concerns that would immediately affect the use of the building.

4.7.3. Treatment Units

Flocculation/Sedimentation Basins, Rapid Flash Mixer

These facilities are buried, reinforced concrete basins, with the exception of the rapid flash mixer, which is a reinforced concrete box. The basin walls are buried underground, which prohibited visual inspection of the exterior of the structure. The County of San Luis Obispo did shut down one of the treatment trains for interior inspection. The drawings show details for anchorage between the foundation and the basin walls and between the walls and the roof slab. Those portions of the walls exposed to view inside the basin showed honeycombs that appear to be the result of normal construction finish and not due to age. The wall surface below the operation surface water level appears to be slightly etched;

above the water line the wall appears solid and smooth. The small aboveground portions of the basin showed minor shrinkage cracks that are considered to be part of the normal construction finish. Hammer blow tests of exposed areas were acceptable.

The sludge collection mechanism in the sedimentation basin appears normal, and no physical sagging or tilting was noticed. Steel tension rods support the collection arms from the center column. The coating on the rods and the turnbuckles is failing. The turnbuckles have corroded threads. It appears that due to corroded threads on the turnbuckles, the turnbuckles were replaced; however these new turnbuckles should be maintained so that they do not have to be replaced.

The baffles in the flocculation basin are timber members, anchored with bolts and square washer plates that are exhibiting initial to moderate stages of corrosion. Some of the baffles displayed signs of wood splitting and deterioration. The coating on the baffles is also failing.

The perimeter guardrail is a two-rail system. As defined in Section 509 of the 1997 UBC, the open space between the intermediate rail of guardrails in areas of commercial and industrial-type occupancies that are not accessible to the public shall be such that a sphere 12 inches in diameter cannot pass through. In order to meet current code requirements, a new guardrail should be installed.

Inside the sludge room, there were missing grating panels which is a potential fall hazard, and the lights lacked lateral restraint.

Concerns:

Based on our inspection, we are concerned with the ability of the basins to accept long-term fluid loading. Guardrail should be updated to meet current code. The baffles should be replaced. We are concerned with lighting restraint for earthquake forces. Missing grating panels in the sludge room should be replaced.

Filter Units

Constructed as part of the Lopez Water Supply Project, these facilities are buried, reinforced concrete boxes. The filters and filter gallery walls are buried underground, which prohibits visual inspection of the exterior of the structure. The filters were in service at the time of inspection. The drawings show details for

anchorage between the foundation and the filter walls and between the walls and the roof slab. Those portions of the walls exposed to view inside the filter gallery showed honeycombs and calcium buildup at the cold joints; these appear to be the result of normal construction finish and not due to age. Aboveground portions of the filters showed minor shrinkage cracks considered to be part of the normal construction finish. Hammer blow tests of exposed areas were acceptable.

Inside the filter gallery, pipes supported off the reinforced concrete beam and lights supported off the roof slab did not have a lateral restraint system.

<u>Concerns:</u>

Based on our inspection, we are concerned with lateral forces and recommend anchorage of piping and lighting in the filter gallery. Should membrane filtration be selected, this facility will need to be totally revised for such use.

4.7.4. Other Facilities

<u>Hydroelectric Facility</u>

This reinforced masonry bearing wall building with flexible roof diaphragm was originally designed by ER&A (Energy Research & Applications, Inc.) in 1983 and was constructed in 1984. This facility sits on a reinforced concrete box foundation. This partial underground drywell consists of 8-inch walls. The drywell sits on an 8-inch slab with spread footings foundation. It appears that the drywell was constructed in accordance with the documents with no major structural deficiencies or concerns that would immediately affect the use of the facility.

The superstructure, or powerhouse, consists of reinforced masonry blocks, which resist lateral forces and support a diaphragm roof consisting of truss framing twin rib aluminum sheathing. The connection details shown on the record drawings appear to be adequate for the transfer of loads to the shear walls. Reinforcement provided in the 8-inch shear walls (#5 @ 48 inches o/c. vertically) nominally meets the reinforcement spacing requirements outlined in Section 2106 of the 1997 UBC. The powerhouse's reinforced concrete floor showed exposed aggregate evident of past operational practices.

Powerhouse piping is adequately restrained vertically but requires lateral restraint. From the plans, it appears that there are no flexible expansion connections on the discharge headers or suction. Site evaluation of other nonstructural components revealed the following deficiencies:

- Anchorage of electrical gear not visible; anchorage appears to be inadequate.
- Roof shingles coming off.

Note that this facility has not been in operation for a period of years due to mechanical problems, as indicated by the District.

Concerns:

Based on our inspection, we are concerned with the ability of the piping to resist lateral forces and believe that it requires anchorage. We are concerned with flexibility of inlet and outlet pipes in case of movement and potential contamination issues. Since the recommendation is to not use this facility, no upgrades should be made to this facility unless or until the decision to upgrade and use is made.

Raw Water Influent Vault

The raw water influent vault is a reinforced concrete box and did not show structural deficiencies. The vault does have small honeycombs and cracks; however, these are assumed to be part of the normal construction finish and are not of concern.

It also appears that during a seismic event the underground substructure would move with the ground motion and not experience structural deficiencies. Signs of corrosion were evident on the vault hatch covers and mechanical coupling.

Note that record drawings were not available for this structure. Thus, dimensions, reinforcement, and connection details could not be evaluated.

Concerns:

Based on our inspection, we are concerned with the coating system on the hatch cover and mechanical coupling condition.

4.8 Electrical, Fire Alarm - Suppression System, Instrumentation & Controls

These notes present the results of a visual inspection and review of all available record drawings for the County of San Luis Obispo's Lopez WTP facilities evaluated under the Lopez WTP Audit. The overall objective for this portion of the study effort was to conduct preliminary electrical, fire alarm, and instrumentation and control evaluations and identify the necessary upgrades required to bring these facilities up to current design standards.

The scope included visual inspection and drawing review for the existing facilities as follows:

- Evaluate the general condition of the facilities.
- Identify any apparent or visible deficiencies.
- Verify that the facilities were constructed in accordance with available record documents.
- Note any alterations or deviations.

4.8.1. Field Investigation

A short meeting with the WTP's O&M staff was conducted to briefly discuss the work to be covered during the audit. In addition, coordination of site access and security issues before commencing the field inspections were discussed.

4.8.2. Influent Vault

The influent vault contains a sump pump, sample pump (115V, 1 phase, manufactured by CAL pumps), and a Venturi flowmeter with Honeywell transmitter. Some electrical wires are routed exposed (without conduits) inside the vault.

4.8.3. Administration Building

The following features were observed:

1. Administration building's main panelboard is Panel "LA," manufactured by ITE Imperial Corporation, 120/208V, 3 phase, 225 amps, 4 wire, and 42-circuit panel. The panel is dated back to the 1970's and the breakers are old and most likely irreplaceable.
2. The short circuit ampere rating (SCA) of breakers was not readable, but breaker ratings are probably rated at 10,000 amperes and they may be rated as low as 7,500 amperes. The upstream 112.5KVA transformer feeding this panel (along with panels "LC," "LF," "LR," and "LS") did not have an impedance value on the nameplate. The transformer impedance determines the amount of short circuit current that the transformer will allow

to pass through and consequently determines the short circuit rating of breakers downstream of the transformer. Since this value is unknown, we will use a common and conservative value of 2.7%, which calculates to about 12,000 amperes of fault current. This value clearly exceeds the short circuit rating of some of the older breakers. This low short circuit rating of the breakers is not safe during fault conditions. This issue or concern is true for all panels that are fed from this transformer.

3. Lighting fixtures are fluorescent type, T12, 40-watt lamps. These are also present in all buildings/areas in the WTP.
4. Main control console dates back to the 1970s. Wiring inside control console is extremely messy, unorganized, and unidentified. The maintenance crew is having a very difficult time tracing and troubleshooting the wires inside the control console. There are eight newer recorders (about 5 to 6 years old) mounted on the console. The latest control drawings and prints of control console are not accurate and are useless for troubleshooting.

4.8.4. Sludge Pump Room

The following observations were made:

1. There are two wall-mounted terminal cabinets without front covers. Wires are messy, unidentified, and bundled up in cabinets. Some wires have been spliced with tape and wing nuts, which is not safe.
2. Distribution panel "LS" enclosure has rusted through and is in very bad shape. The panel is an ITE Imperial Corporation panel with old style breakers.
3. Lighting fixtures are enclosed type and seem to be newer, however, supports were improperly installed (the fixture supports are not straight) and seem to be rusted through.

4.8.5. Flocculator Area

The following observations were made:

1. Flash mixer is a Westinghouse, 460/230V, 3 phase, 10 horsepower motor that seems to be in average running condition. The control station is old and rusty.
2. The 3 horsepower mixers are U.S. electric, 460V, 3 phase, 1800 RPM motors that seem to be in average-to-poor running condition. The control stations and their conduits are old and rusty.
3. The 1 horsepower mixers are Leeson, TEFC type, 460V, 3 phase motors that seem to be in average-to-poor running condition. The control stations and their conduits are old and rusty.

4.8.6. Sedimentation Basin Area

The following observations were made:

1. Sludge collector motors, control stations, overload and alarm switches, and exposed conduits are old and rusty. Could not verify if the overload torque switches are functional.

4.8.7. Control/Filter Buildings 1 and 2

The following observations were made:

1. Panel "LF" in filter building #1 is an ITE Imperial Corporation panel, 120/208V, 3 phase, 100A with 30 circuits.
2. The control consoles in both buildings are similar in condition to the main control console in administration building. Wires inside control consoles are unidentified and tangled together.

4.8.8. Pipe Gallery

The following observations were made:

1. Two wash water pumps are made by U.S. Electric. They are 15 horsepower, 208-230/460V, 3 phase motors that seem to be in fair condition. Control stations and conduits stubbing out of floor are rusty.
2. Motor operated valves (MOV) seem to be in fair condition but may need replacement in near future. Some MOV's are missing electrical terminal board covers.
3. HACH, model 1720C turbidimeters seem to be fairly new and can be reused with an upgraded PLC control system.
4. Several conduit runs have more than the total of 360 degrees (allowed by code) of bending radius between pull points.

4.8.9. Hydroelectric Facility

The following observations were made:

1. According to WTP staff, the hydroelectric facility has not operated for several years due to mechanical difficulties. The electrical control panel has been neglected and is full of spider webs. The generator and other equipment look old and are in poor shape.
2. Single three-phase transformer bank, rated 112.5 KVA was found on a power pole.
3. Three single-phase transformer banks, each rated at 10KVA were found on another power pole.

4.8.10. Chemical Building

Electrical room

The following observations were made:

1. Main distribution/service switchboard's service busbars are exposed and uninsulated and not do not have barrier to the bottom half (distribution part) of the switchgear. This is not safe and is in violation of National Electrical Code (NEC) requirements.
2. The main motor control center (MCC) is made by ITE, 600 ampere, 3 phase, 3-wire panel, dated 2/20/1970. MCC is fed from the main distribution board (MDB) with three #750Kcmil tap conductors. The size and insulation type of tap wires was not shown on the wires. Breakers are old style breakers which may be very difficult, if not impossible, to replace.
3. Panelboard "LC" is 120/208V, 100A, 3 phase, 4 wire, 30 circuit panel made by ITE. Panelboard has old style breakers.
4. Old ONAN transfer switch with the older, smaller generator is not used anymore and should be removed.
5. 112.5 KVA transformer does not have an impedance value on its nameplate. This value is required in order to determine the available SCA through the transformer.
6. New ATS is ONAN, 225 amperes, 277/480V, 3 phase. The ATS does not appear to be grounded.
7. #3/O cables are used between load side of 400-ampere breaker in MDB and line side of 200-ampere wall mounted breaker feeding the ATS. #3/0 cables are rated for 200 amperes and cannot be wired to a 400-ampere breaker.
8. Distribution panel "DP" is an ITE, 400-ampere, 120/208, 3 phase, 4-wire panel, dated back to 1970. Breakers are old style breakers which may be very difficult, if not impossible, to replace.
9. Small MCC panel is 120/208V, 600 ampere, 3 phase, 4 wire, dated 2/23/1970. The MCC main bus is tapped off distribution panel "DP." The size and insulation type of tap wires was not shown on the wires. Breakers are old style breakers which may be very difficult, if not impossible, to replace.

Shop, Polyelectrolyte Room, Activated Carbon Room, & Chlorine Cylinder Room

The following observations were made:

1. The shop and polyelectrolyte and chlorine cylinder pumps do not have significant electrical equipment other than lighting, receptacles, and a wall fan for the shop.
2. Polyelectrolyte and Chlorine Cylinder rooms do not have significant electrical equipment.

3. The Activated Carbon room has a mixer and a dust collector. This equipment seems very old, in fair-to-poor condition, and the nameplates were not readable.

Basement

The following observations were made:

1. Caustic Soda and Alum pumps have been removed. However, the control stations for these pumps have been abandoned in place on the east wall. The abandoned switches do not have covers, and exposed wires are hanging from the switches. It is not known if any of these wires are hot.
2. The wireways installed on the basement ceiling are missing covers. There are bare, hot, exposed wires hanging from these wireways. The wires inside the wireways are not tagged or identified.
3. Several fire alarms, pull stations, and indicators have been wired in the basement. Apparently, the intent was to meet Fire Marshal's requirements. Wiring between these devices are exposed and stapled to the wall.
4. The domestic water pumps are made by U.S. Motors, 3500 RPM, 460V. Pump number 2 (M-19) seems to be newer. Pump number 1 (M-18) seems very old and worn out. Conduits stubbing up to motors and control stations are rusted through and in poor condition.
5. Disconnect switch for rotodip motor on north wall seems old and in poor condition. A receptacle has been installed on the top of the disconnect switch.

4.8.11. Outside Equipment

The following observations were made:

1. The portable Onan generator seems newer and in good condition. It is a 75KW (93.8KVA) unit that is connected to a 480V, 3 phase, 200-ampere receptacle, located outside on the north wall of the chemical building. WTP staff indicated that the generator has come online successfully and with no problems several times during electrical outages.
2. Two blowers at the clear water reservoir are newer and seem to be in good condition.
3. The old small generator located outside, at the northeast corner of the chemical building is not used and should be removed.

Based upon assessment of the existing system, it is proposed that the entire electrical and control system be upgraded and replaced.

4.9 General Water Treatment Plant Observations

On-Site Fire Systems

- There are limited fire systems on-site and all buildings are in need of adequate systems. This includes both local and remote notification for facilities.

Influent Vault

- Since the vault is located in the parking lot, parking near the vault should be limited.
- The vault requires confined space entry. Confined space equipment needs to be kept on site and the staff should be familiar with the requirements.

Rapid Mix

- Chemical is dripped into basin at the water surface. This practice should be eliminated and the upgrade should include proper injection and mixing equipment.
- Rotation and configuration of the existing mixer forces the flow to the "B" train of the WTP.
- The mixer should be upgraded and/or replaced.

Flocculation

- Baffle walls do not extend to bottom. A serpentine arrangement would assist with better mixing.
- Existing flocculators are constant speed and should be replaced with new flocculators during the WTP upgrade, which are designed with proper "g" factor.

Sedimentation

- Inadequate sludge collection system

Filters

The following inappropriate features were noted:

- Boiling observed during backwash sequencing.
- Uneven surface wash energy noted.
- Mounding of media.
- No automation of backwash sequence.
- Backwash duration based on visual inspection, no standardized method.
- Backwash troughs have holes from corrosion.
- Surface wash equipment does not rotate horizontally, offset on shaft.
- Washwater and domestic water are pumped from filtered water piping. This impacts the pressure that the surface wash is capable of depending on various water demands at the WTP.

All of the above indicate a need to replace the filter system during the WTP upgrade.

Filter Gallery

- Valves and actuators show signs of age and wear. These need to be replaced.
- Pipe insert through base slab near washwater pumps presents a tripping hazard. This should be repaired to eliminate the hazard.
- Vent has chemical piping routed through ductwork. This should be repaired and the piping rerouted.

Ammonia Building

- Chemicals stored on base slab without containment. Containment is required.
- Ammonia pumped via one pump without backup. Redundancy should be provided.
- Ammonia is flow paced; the accuracy of the flow needs to be confirmed. New controls should be provided.

By-Pass Vault

- Better mixing of ammonia is required in pipe; perhaps a static mixer could be installed prior to sample line.
- Leak proof access hatches that are either lighter or have hydraulic lift should be installed.
- The vault requires confined space entry. Confined space equipment needs to be kept on site and the staff should be familiar with the requirements.

Clear Water Reservoir

- The hypalon cover appears to have some small pinholes and areas that experience localized stress. It should be replaced.

Finished Water Meter Vault

- This vault is located in the Lopez Drive roadway. Access through a second manhole from inside property fencing should be provided.
- The meter is not very accurate and should be replaced.

Chemical Building

- Provide appropriate ventilation.
- Provide appropriate alarms and strobes.
- Provide appropriate secondary containment for all tanks.
- Provide appropriate separate pumps with backup for all chemical pumps.
- Provide appropriate wiring placed within conduit.
- Replace potable water pumps.
- Remove chemicals that are old and no longer used.
- Replace roof such that it is compatible with chemical storage.
- Provide ADA compliance for new WTP upgrade.

Administration Building

- ADA compliance will be required for new WTP upgrade.

Ammonia Building

- ADA compliance will be required for new WTP upgrade.

Filter Building

- ADA compliance will be required for new WTP upgrade.

4.10 System Redundancy

The Lopez WTP infrastructure and system components were inspected to establish options available to create a more dependable and maintainable WTP. It is not feasible to provide complete redundancy for the entire WTP, e.g. major process units. Instead, it is proposed that maintenance-intensive items such as pumps, be provided with a standby unit to provide redundancy.

4.11 Safety

Existing WTP facilities were reviewed from an overall cursory review to assess worker safety and basic OSHA compliance. A thorough OSHA compliance review was not completed as a part of this work and should one be required, it should be performed separately. Existing operational procedures were reviewed as they relate to chemical handling, containment, confined space, RMP's, emergency response planning, and evacuation procedures. Recommendations presented for suggested changes to previously established procedures along with new standards for future compliance are included under discussions for each of the various locations. **This report only identifies unsafe conditions observed during our site surveys. A safety audit was NOT conducted. The District should conduct a safety audit separately to identify all unsafe conditions and CalOSHA compliance deficiencies.**

4.12 Staffing

Black & Veatch completed a review of District staffing at the WTP, laboratory, and at all District facilities that support the operation of the Lopez WTP. This is discussed further in Chapter 7.

4.13 Improvement Prioritization

A workshop was held on April 6, 2001 to review preliminary audit findings and discuss proposed suggestions for improvements. This workshop also served to prioritize improvements in order of importance to implement. District staff developed the following prioritization of improvements:

1. Public Health (non-negotiable)
   - Regulatory Compliance
   - Code Compliance
   - Redundancy
2. Worker Safety (non-negotiable)
3. Reliability
4. Water Quality Improvements (water quality above regulatory requirements)
5. Optimization of Operation

The following table places the discussed improvements in these categories.

	RANKING	(1)	(2)	(3)	(4)	(5)	
Facility	Description	Public Health	Worker Safety	Reliability	Higher Wtr Quality	Opt. of Operation	Comments
Facility-Wide	Ensure all structures are ADA compliant		x				
	Reroute piping from clearwater reservoir to transmission main					x	
	Coat or seal all structures to be reused						
	Provide a full set of safety gear and equipment						
	Fire alarm system	x					
	Test the septic tank and leach field						
Lopez Lake Intake Tower	No handrails on stairs		x				
	Gate operation					x	
Lopez Lake Outlet Works	Relocation for seismic retrofit			x			This facility is to be relocated as part of a separate project.
	Manual flow control					x	
Raw Water Pipeline	Replace air and vacuum relief valves	x					
	Repair / replace aboveground sections	x					
	Provide flexibility for seismic events	x					
Terminal Reservoir	Remote control for Cla-Valve					x	
	Aquatic Weed Removal					x	
	Hydroelectric Plant					x	
	Operation privatized?					x	
	Allowable flow not maximized			x			
Clearwater Reservoir	Replace cover			x			
	Extend wall foundation & install a restraining ring beam			x			
	Carbon fiber sheet wrapping on exterior sidewall			x			
	Flexible expansion connec-tion to inlet/outlet pipes	x					
	Seismic actuated valves in an accessible valve vault			x			
	Grating at pipe entrance inside tank				x		
Domestic Water Tank	Recoat exterior			x			
	Extension of ring footing			x			
	Anchorage	x					
	Soil anchor installations			x			
	Thickening of bottom shell by additional plates			x			
	Stiffeners for the roof using steel members			x			
	Reduce storage capacity of tank to minimize weight			x			
	Flexible expansion connection to inlet/outlet pipes	x					
	Seismic actuated valves in an accessible valve vault			x			
Wash Water Tank	Extension of ring footing			x			
	Anchorage	x					
	Soil anchor installations			x			
	Thickening of bottom shell by additional plates			x			
	Stiffeners for the roof using steel members			x			
	Reduce storage capacity of tank to minimize weight			x			
	Flexible expansion connec-tion to inlet/outlet pipes	x					
	Seismic actuated valves in an accessible valve vault			x			
Administration Building	Water heater & boiler room piping lateral restraints	x					
	HVAC ducts restrained per SMACNA		x				
	Bracing of ceiling tiles		x				
	Electrical & control equipment lateral bracing		x				
	Shelves & file cabinets anchoring		x				
	Replace deteriorated wood members	x					
	Restraint straps for water heater & boiler room piping		x				
	Inject epoxy grout into surfaces with cracks			x			
	Replace panel with newer panel			x			
	Replace fluorescent lighting fixtures with energy efficient					x	
	Replace roof	x					
	Replace and properly install lighting fixtures					x	
Chemical Building	Widen staircase		x				
	Upgrade ventilation, alarms, strobes		x				
	Provide redundant chemical pumps			x			
	Replace potable water pump			x			
	Remove old chemicals	x					
	Remove corrosion and apply Sika Top Seal 107			x			
	Apply epoxy grout & polymer modified mortar			x			
	Lateral restraints for piping tanks, and electrical gear		x				
	Flexible expansion joints					x	
	Replace deteriorated wood members	x					
	Provide anchors for metering pumps		x				
	Provide containment for various chemicals	x					
Ammonia Building	Shear walls may need anchorage to foundation		x				
	Provide secondary containment			x			
	Provide redundant pump			x			
	Provide new flow controls			x			
Flocculation / Sedimentation Basins, Rapid Flash Mixer	Coating system for sludge collection mechanism			x			
	Replace guardrail		x				
	Replace deteriorated baffles and new coating system			x			
	Replace grating panels		x				
	Provide lateral restraints for lighting		x				
Filter Units	Provide lateral restraints for lighting		x				
Hydroelectric Plant	Possible anchorage of electrical gear		x				
	Lateral restraints for piping		x				
	Flexible expansion connections to the piping			x			
	Sandblast floor slab and apply Sika TopSeal 107			x			
Raw Water Influent Vault	Apply new coating system to vault hatch covers			x			
	Replace piping mechanical coupling			x			
	Raceway system for electrical wiring		x				
	Receptacles moved to top of vault					x	
	Replace wires and cables			x			
	Receptacles replaced with GFI		x				
	Limit parking near vault					x	
Bypass Vault	Install static mixer	x					
	Replace hatches		x				
Finished Water Meter Vault	Intsall new manhole			x			
	Replace flow meter			x			
Sludge Pump Room	Replace panelboard "LS" and lighting fixture supports			x			
	Provide covers for open terminal cabinets		x				
	Tag wires and group to facilitate trouble-shooting					x	
	Splice/connect wires per electrical codes		x				
Flocculator Area	Replace control stations and their conduits			x			
Sedimentation Basin Area	Replace exposed conduit system w/ control stations, alarm, and torque switches		x				
Control/Filter buildings 1&2	Replace panel with newer panel			x			
	Replace panelboard "LS" and lighting fixtures			x			
	Replace control consoles w/ PLC based controls & communication			x			
Pipe gallery	Replace rusted conduits & control stations					x	
	Pull/junction boxes in conduit runs w/ >360 deg bending radius					x	
	Mount MOV terminal board section covers					x	
Hydroelectric Plant	Study to determine feasibility of plant use			x			
Chemical Bldg-Electrical rm.	Update of electrical distribution system			x			
	Replace #3/O cables btween 400 ampere main breaker & 200 ampere wall mounted breaker feeding the ATS			x			
	Replace tap conductors			x			
	Replace panel with newer panel			x			
	Replace lighting fixtures			x		x	
Chemical Bldg- Shop, Polyelectrolyte Rm,	Upgrade lighting fixtures to T8, 32 watt lamps w/ electronic ballasts			x			
Activated Carbon Rm, Chlorine Cylinder Rm	New mixer & dust collector in Activated Carbon room		x				
Chemical Bldg- Basement	Covers on open/abandoned control switches		x				
	Tag & cover spare/unused wires		x				
	Protect wires for fire alarm system and put in raceways		x				
	Replace roof	x					
	Replace conduit stub-ups & control stations for wp			x			
	Replace disconnect switch for rotodip motor			x			

Chapter 5. Potential Improvements

5.1 Introduction and Background

The review of the water quality data and the need to comply with regulations both present and future presented in Chapter 2 and 3 leads to the conclusion that the pretreatment and filtration portions of the existing WTP need to be updated, repaired, and/or replaced. This chapter develops alternatives to address the need for adequate coagulation, proper flocculation, quality sedimentation, updated filtration, and valid disinfection. Nine treatment process approaches are developed and evaluated against economic and non-economic criteria. Also described are the results of two screening workshops with District staff, technical advisors, and DHS representatives. A preferred treatment strategy is then recommended.

More detailed information is provided in Appendices I, J, and K.

5.2 General WTP Design Criteria

This project focused on WTP upgrades to enable the Lopez WTP to continue to provide a 6 mgd capacity. The Lopez WTP is currently designed for the following parameters:

Capacity (mgd)	6.0
Hydraulic (mgd)	6.8
Nominal Detention Time (DT) (Minutes)	
Flash Mixer	0.5
Flocculation	32.0
Sedimentation	165.0
Sedimentation	
Overflow Rate (gpd/ft2)	938
Nominal Weir Loading (gpm/lf)	5.45
Clearwell (MG)	0.16
Clear Water Res. (MG)	2.1
Filters (Dual Media)	
Nominal Filter Rate (gpm/ft^2)	2.95
Backwash Rise Rate (in./min)	32
Surface Wash Rate (gpm/ft^2)	0.75

5.3 Water Quality

As described in detail in Chapter 3, raw water for the Lopez WTP is very difficult to treat and requires careful evaluation for final process recommendation.

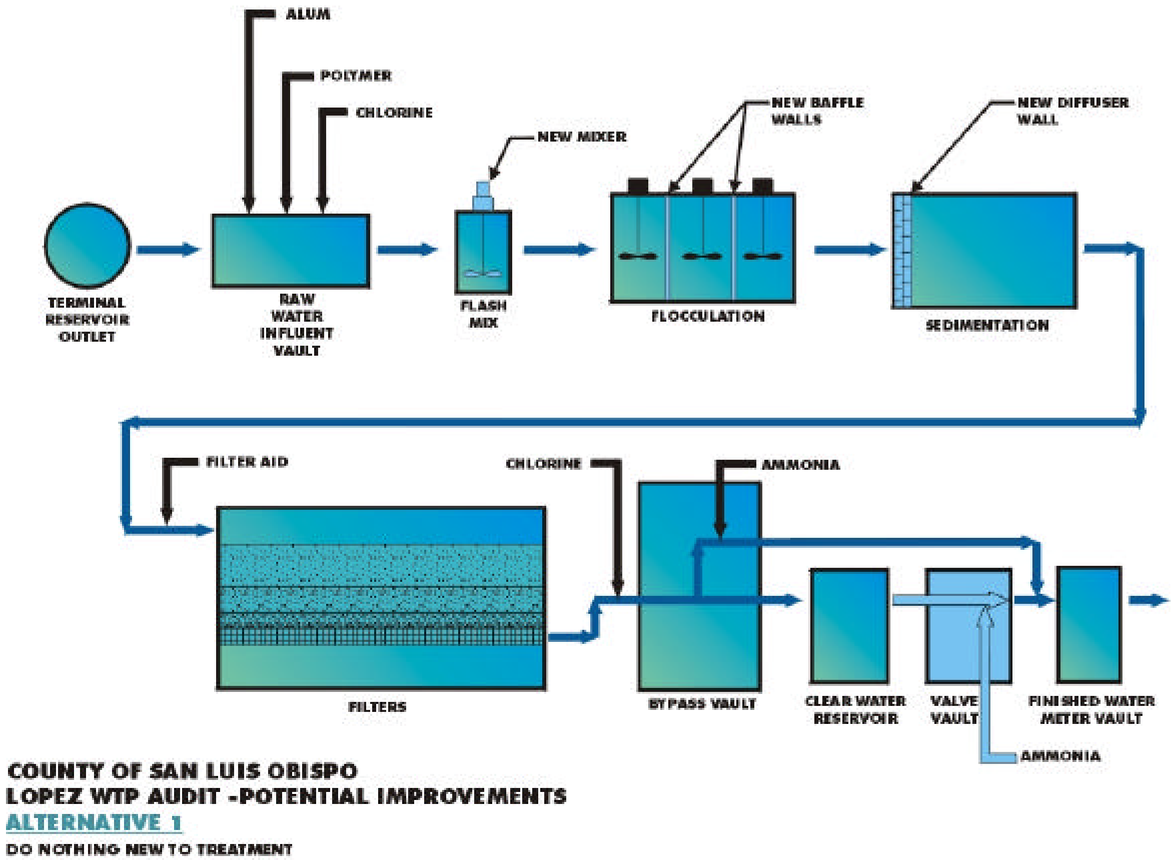
5.4 Potential Improvements

Black & Veatch initially looked at seven alternative strategies for improvement to the WTP:

1. Enhance Existing Pre-Treatment
2. Upgrade Existing Pre-Treatment and Conventional Filters
3. Upgrade Existing Pre-Treatment and New Membrane Filters
4. Upgrade with New Ballasted Flocculation/Sedimentation Pretreatment and Conventional Filters
5. Upgrade with New Ballasted Flocculation/Sedimentation Pretreatment and Membrane Filters
6. Upgrade with New Pre-Treatment, DAF, and Conventional Filters
7. Upgrade with New Pre-Treatment, DAF, and Membrane Filters

Each is discussed below.

5.4.1. Implement Current Plan – Enhance Existing Pre-Treatment



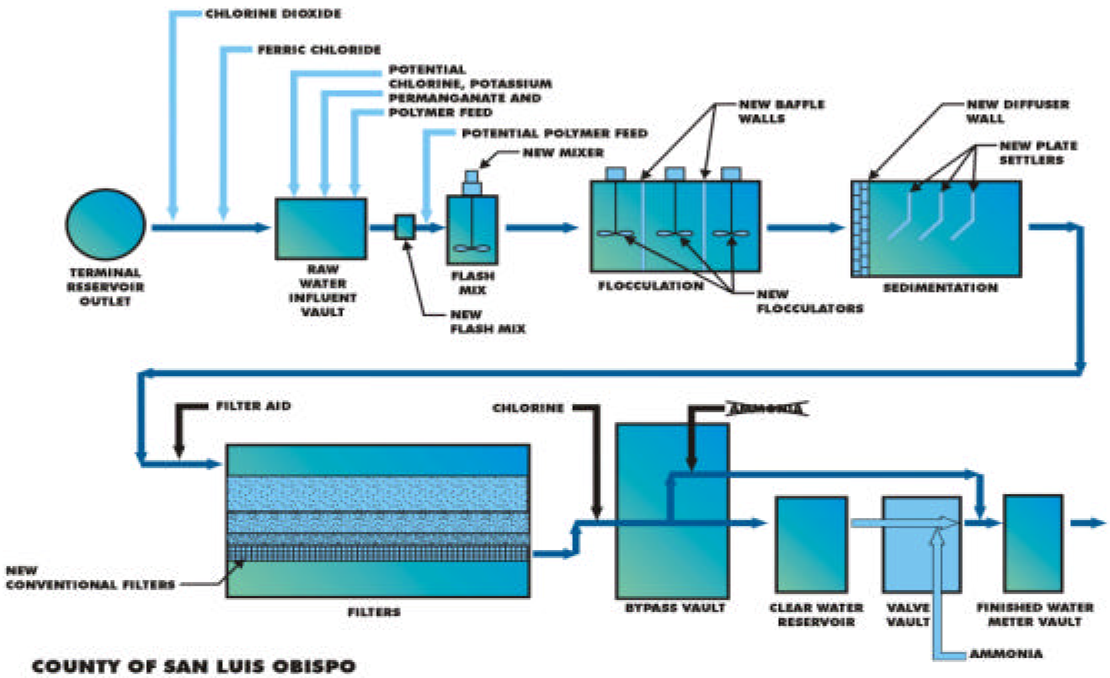
The following changes to the existing facilities would be made under this alternative:

- The flash mix would be upgraded as previously designed by others.
- New rapid mix equipment already purchased would be installed.
- Improvements would be made to the flocculation baffle walls and sedimentation diffuser wall.
- Improvements would be made to the method of feeding chemicals.

Filter improvements would not be provided, but would be required to meet CAP requirements.

This alternative should be viewed as the base alternative, and is not recommended by Black & Veatch, as it will not effectively solve compliance problems in the long term.

5.4.2. Upgrade Existing Pretreatment and Conventional Filters



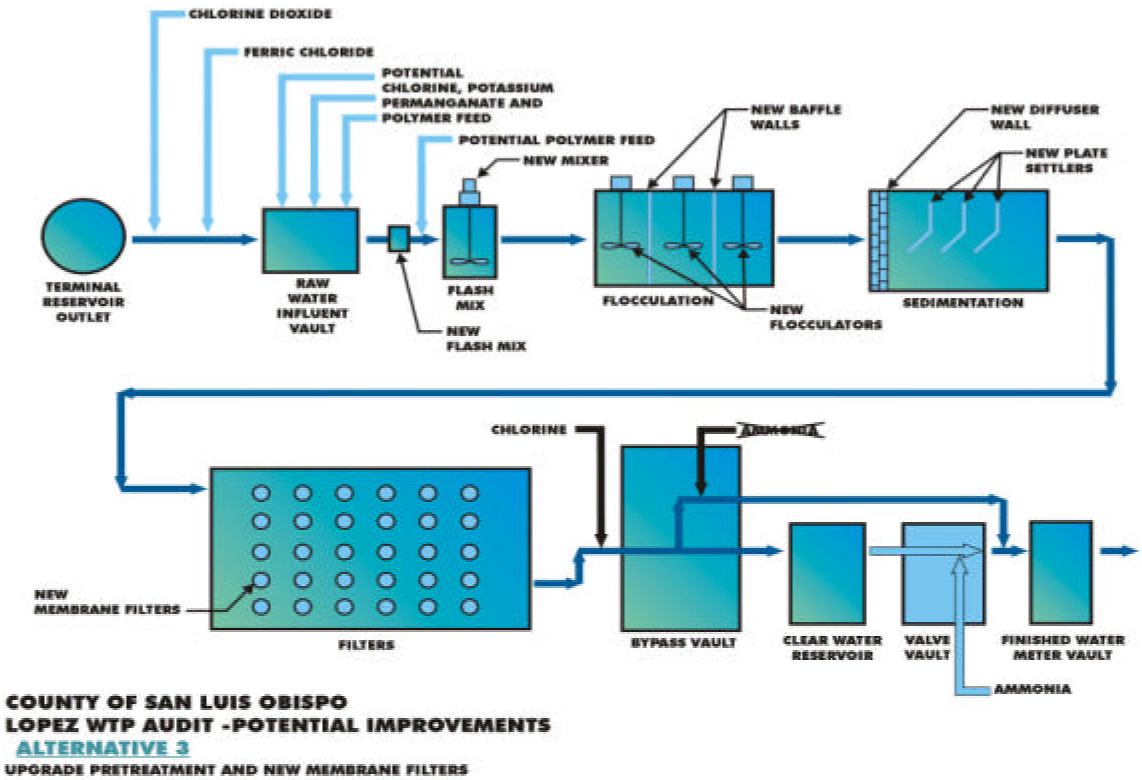
COUNTY OF SAN LUIS OBISPO
LOPEZ WTP AUDIT -POTENTIAL IMPROVEMENTS
ALTERNATIVE 2
UPGRADE PRETREATMENT AND CONVENTIONAL FILTERS

The following changes to existing facilities would be made under this alternative:

- A new chlorine dioxide supply ahead of the influent meter would be added.
- Options for feeding polymer, potassium permanganate, and chlorine ahead of a new flash mix system would be provided.
- A new flash mix system would be added.
- An option to feed polymer ahead of second stage rapid mix would be provided.
- A new flocculation system in the existing flocculation basins would be added.
- A retrofitted sedimentation system using plate settlers along with new sludge rakes would be added.
- The underdrains and the media in the existing filters would be upgraded using conventional dual media technology.
- Other improvements would be required to structures, electrical systems, etc., as discussed in Chapter 4.

This alternative would not achieve the turbidity goal of the CAP. Therefore, a variance from the CAP would be required, making this alternative ineligible for the SRF.

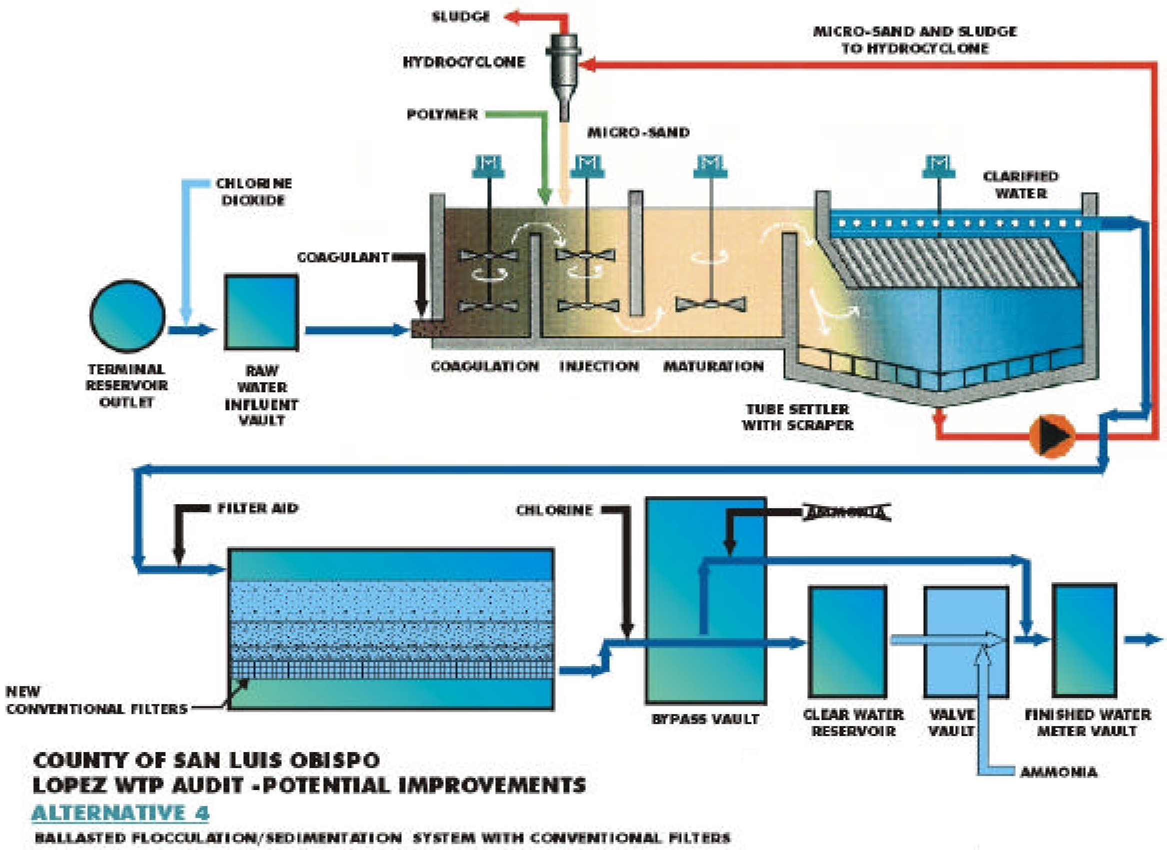
5.4.3. Upgrade Existing Pretreatment and New Membrane Filters



The following changes to the existing facilities would be made under this alternative:

- A new chlorine dioxide supply would be added ahead of the influent meter.
- Options for feeding polymer, potassium permanganate, and chlorine ahead of a new flash mix system would be provided.
- A new flash mix system would be added.
- An option to feed polymer ahead of second stage rapid mix would be provided.
- A new flocculation system in the existing flocculation basins would be installed.
- The sedimentation system would be retrofitted using plate settlers along with new sludge rakes.
- New membrane filters would be added.
- Other improvements would be required to structures, electrical systems, etc., as discussed in Chapter 4.

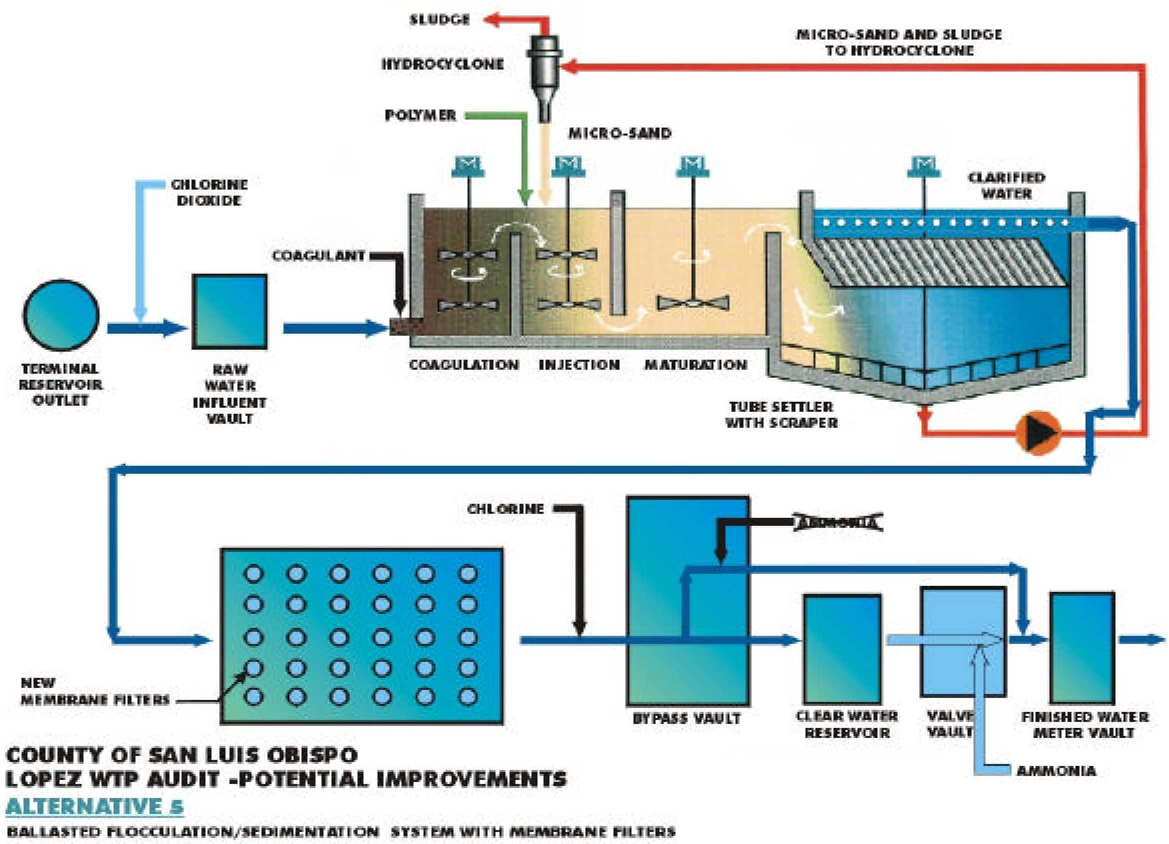
5.4.4. Upgrade with New Ballasted Flocculation/Sedimentation Pretreatment and Conventional Filters



Under this alternative, a Ballasted Flocculation/Sedimentation system for pretreatment would be installed with new conventional filters. This is basically an all-new WTP with improvements to support facilities as discussed in Chapter 4.

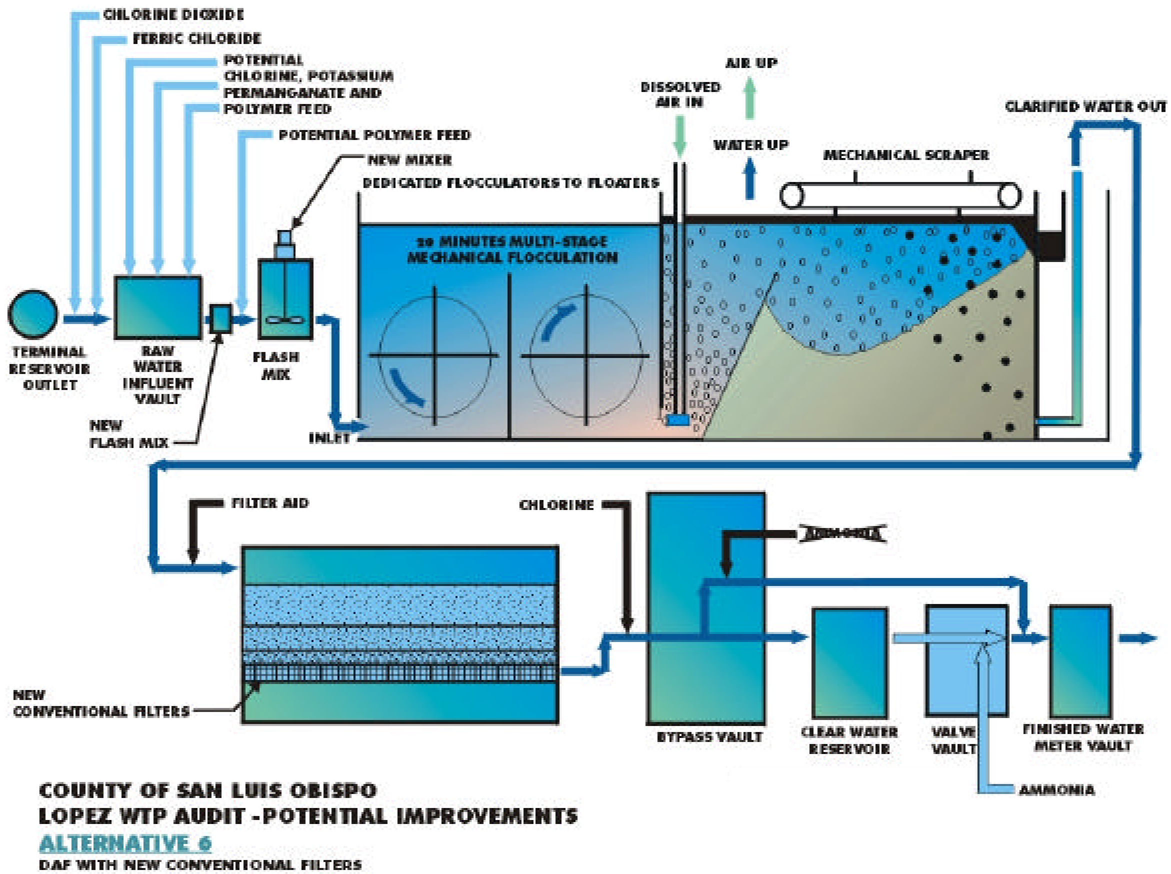
This alternative would not achieve the turbidity goal of the CAP. Therefore, a variance from the CAP would be required, making this alternative ineligible for the SRF.

5.4.5. Upgrade with New Ballasted Flocculation/Sedimentation Pretreatment and Membrane Filters



Under this alternative, a Ballasted Flocculation/Sedimentation system would be used for pretreatment with membrane filters. This is basically an all-new WTP with improvements to support facilities as discussed in Chapter 4.

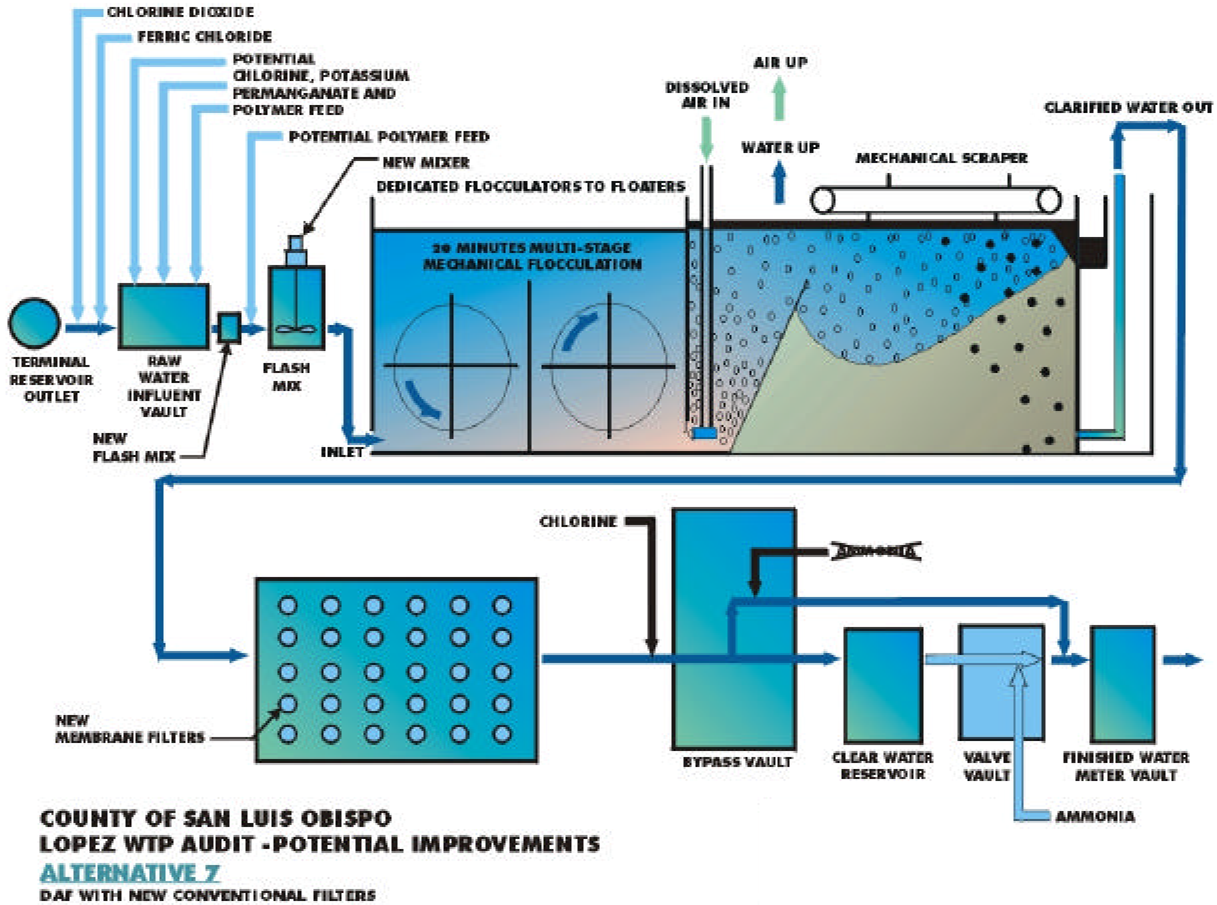
5.4.6. Upgrade with New Pretreatment, DAF, and Conventional Filters



Under this alternative, the previously discussed Alternative 2 would be used with modifications in the flocculation system and then would use a DAF system (flotation/sedimentation). Other improvements are required to structures, electrical systems, etc. as discussed in Chapter 4.

This alternative would not achieve the turbidity goal of the CAP. Therefore, a variance from the CAP would be required, making this alternative ineligible for the SRF.

5.4.7. Upgrade with New Pretreatment, DAF and Membrane Filters



This alternative is ultimately the final recommendation for the WTP upgrade. Under this alternative, the previously discussed Alternative 2 would be used with DAF clarification system (flotation/sedimentation) as under Alternative 6, but membrane filters would be used rather than conventional filters. Other improvements are required to structures, electrical systems, etc. as discussed in Chapter 4.

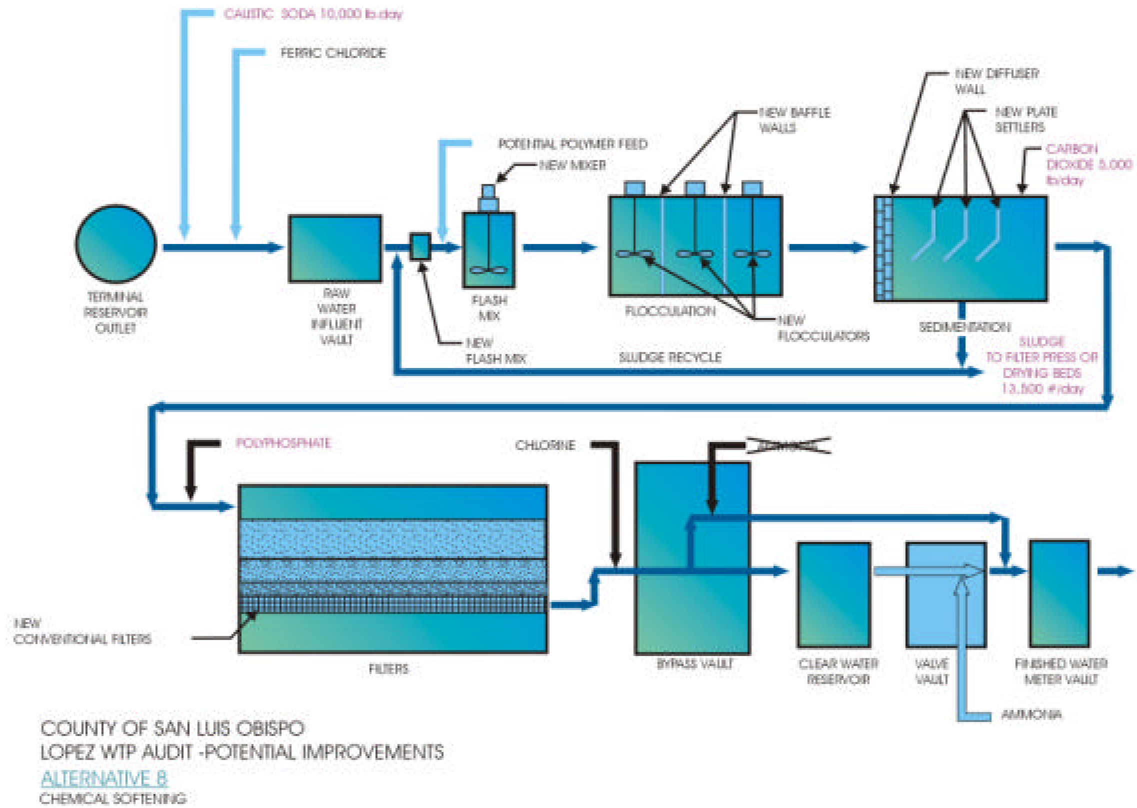
Pilot testing of the DAF (discussed in Chapter 6) demonstrated that small particle breakthrough would occur with the use of conventional filters. It was determined that these particles did not fall within the *Cryptosporidium* size range and the District could have applied for a variance from the CAP. However, DHS representatives informed the District and Black & Veatch that due to the requirement of a variance, the WTP upgrades would not be eligible for SRF unless membrane filtration or water softening was included. For this reason, water softening alternatives were then developed.

5.5 Water Softening Alternatives

After discussion with the District, Black & Veatch developed two softening alternatives. These alternatives were developed to address District staff comments that most complaints from water customers are for problems caused by water hardness and to accommodate the District's desire to be eligible for the SRF funding. Raw water from Lopez Lake is very hard, with an average total hardness of 350 mg/L as $CaCO_3$. Water softening can be used to reduce hardness, while simultaneously treating the water to meet drinking water regulations. The rationale for the water softening alternatives is presented in detail in Appendix I. The two preferred water softening alternatives are:

8. Upgrade Using a Chemical Softening Process and Conventional Filters
9. Upgrade with Partial Softening with Nanofiltration and Conventional Filters

5.5.1. Upgrade using a Chemical Softening Process and Conventional Filters

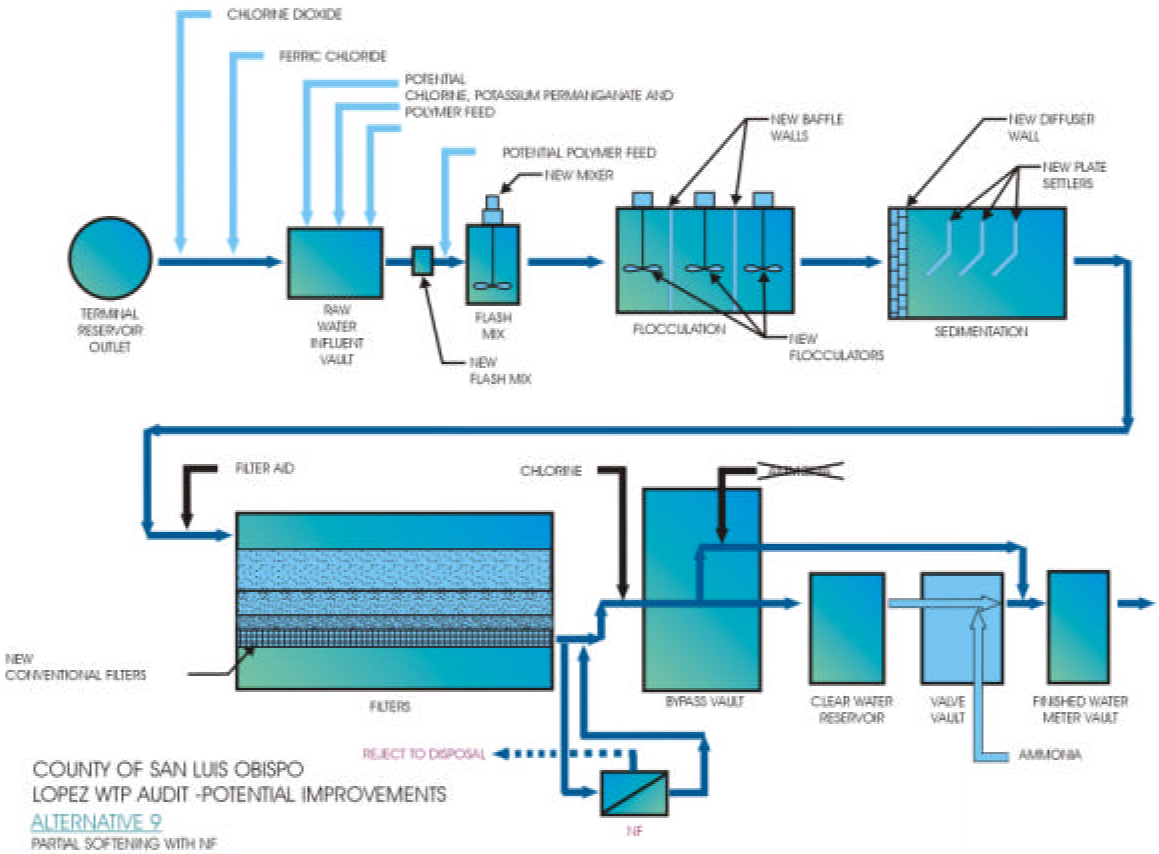


The following changes would be made under this alternative:

- A new caustic supply would be added ahead of the influent meter.
- A caustic storage and feed system would be added.
- A new flash mix system would be added.
- A new flocculation system would be installed in the existing flocculation basins.
- The sedimentation system would be retrofitted with plate settlers and new sludge rakes.
- A liquid carbon dioxide storage, feed, and diffusing system would be installed.
- The underdrains and media in the existing filters would be upgraded using conventional dual media technology.
- Two sludge recirculation or disposal pumps would be added.
- A filter press sludge dewatering system would be installed.

Other improvements are required to structures, electrical systems, etc. as discussed in Chapter 4.

5.5.2. Partial Softening with Nanofiltration and Conventional Filters



The following changes would be made under this alternative:

- A new chlorine dioxide supply would be added ahead of the influent meter.
- Options for feeding polymer, potassium permanganate, and chlorine would be provided ahead of a new flash mix system.
- A new flash mix system would be installed.
- An option to feed polymer would be provided ahead of a second stage rapid mix.
- A new flocculation system would be installed within the existing flocculation basins.
- A retrofitted sedimentation system would be added using plate settlers along with new sludge rakes.
- The underdrains and media in the existing filters would be upgraded using conventional dual media technology.
- A new NF system would be installed.

Other improvements are required to structures, electrical systems, etc. as discussed in Chapter 4.

5.6 Flash Mix Upgrade Alternatives (Coagulation)

Rapid mixing needs to be very fast and thorough when inorganic coagulants are added to water, as the rate of chemical reaction is very swift. Treatment problems can result from inadequate mixing or from discharge of coagulated water from more than one point in a single mixing chamber.

Flash mixing options include in-line static mixers, pump injection (diffusion) mixers, and batch-mix reactors with vertical mixers. Static mixers require available energy from the incoming water line. Therefore, they are not favored in the incoming gravity line. The District has experience with vertical mixers that, if properly designed, would be preferred. Water-champs are in-line mixers that have been effective in retrofit applications.

Black & Veatch recommends that the District install the upgraded system recently purchased plus a new system. (Full system redundancy would not be provided.) Regardless of the method used, there should be no short-circuiting.

5.6.1. Coagulation

Due to the high alkalinity of the source water, pH adjustment to optimize coagulation will be difficult. Historical WTP data demonstrates that coagulant addition has resulted in a pH reduction. However, because of the high alkalinity of the raw water the reduction is not large enough to drop to levels optimal for alum and other aluminum-based coagulants. Historical data appears to confirm this with reduced finished water turbidities in conjunction with lower pH (Appendix C).

The WTP may opt to use acid addition to lower the pH to one more optimal for alum-based coagulants. Alternatively, an acidified alum-based coagulant or a ferric-based coagulant may be used. Since ferric coagulants tend to have a high pH optimum in high alkalinity water, better coagulation may be realized. Polymers are not recommended for use as coagulant aids in conjunction with downstream membrane treatment.

C-Factor Reduction

Reduction of C-factor in distribution piping is known to occur under some conditions when aluminum-based coagulants are used for treatment. This phenomenon is a result of changes in solubility as pH is modified in the presence of a soluble aluminum residual. Solubility for aluminum in water tends to be lowest in a pH range of 6 to 7. When an aluminum-based coagulant is applied at a pH outside this range, there is potential for passing excess aluminum residual into the system. A subsequent change in pH in the system can change the solubility for this residual and result in a post precipitation condition that leads to the accumulation of a chemical slime on pipe walls, with an associated reduction in C-factor.

This is a concern due to the high alkalinity of the raw water and the difficulty that this condition creates insofar as adjusting to a coagulation pH in the region of minimum aluminum solubility. Therefore, conditions that lead to the passage of excess aluminum residuals are present unless extreme measures are taken to adjust the pH in coagulation and filtration processes. A second condition that is typically required for post precipitation is a subsequent reduction in pH in the distribution system that would reduce the solubility of any aluminum that is present. This is less likely to occur in the District's system as compared with other systems due to buffering that is the result of an extremely high alkalinity. However, buffering intensity for a given level of alkalinity varies depending on pH range and tends to be minimal at a pH of 8.5. As this is in the general region of the distribution pH, it cannot be assumed that a degree of pH change is not possible even with the high alkalinity levels that are present in this case. Therefore, some potential for post precipitation may still exist for aluminum-based coagulants.

Less information is available on the effect of iron-based coagulants on post precipitation. The ferric oxidation state of iron that is normally used for coagulation has a much broader range of precipitation than aluminum and may be less susceptible to the solubilization/precipitation cycles that create the conditions for post precipitation with aluminum.

Based on these considerations, there are two key factors for minimizing the effect of post precipitation:

1. Perform coagulation under pH and dose conditions that minimize aluminum residuals to the extent possible. Effort should be made to keep aluminum residuals under 0.2 mg/L as this is the Secondary Maximum Contaminant Limit. Reduction in aluminum residuals also lowers potential health risks.
2. Minimize subsequent pH reductions in the distribution system that will alter the solubility of aluminum.

In cases where post precipitation has led to C-factor reductions, several corrective measures have been applied to restore pipeline capacity. Pipeline cleaning with "pigs" or other methods is a common approach. Also, application of a slightly higher pH in finished water has been successfully applied as a method for dissolving the accumulated precipitate within piping

(Kriewall et. al., Public Works, December 1996). This approach may, however, be less desirable due to the possibility for sudden increase in aluminum levels in the distribution system if the dissolution process is rapid.

5.7 Pretreatment Upgrade Alternatives

Optimization of both existing flocculation and sedimentation basins will be required for the WTP.

5.7.1. Pre-Oxidation

Pre-oxidation is carried out for a variety of purposes including control of tastes and odors, algae control within the WTP, oxidation of iron and manganese, and disinfection. For some source waters, use of pre-oxidation can substantially improve coagulation and filtration performance.

Chlorine dioxide is an oxidant that must be produced on-site. If produced so no free chlorine is present in the oxidant solution, chlorinated disinfection by-products are not formed in drinking water. This oxidant is effective for control of tastes and odors, color, and oxidation of iron and manganese; and control of algae in water treatment plant basins. It is also a strong disinfectant.

The pilot study (discussed in Chapter 6) confirmed that pre-oxidation with chlorine dioxide resulted in reduced TTHM and THAA production when compared to preoxidation with chlorine.

5.7.2. Flocculation Basins

The formation of gentle eddy currents or mild turbulence in water brings about the particle-particle collisions needed to form flocs. Currents or turbulence can be induced in the water by mechanical stirring, by bubbling air into a basin, or by creating multiple changes in flow direction in a long channel (hydraulic flocculation).

Greatest optimization of the treatment process will be achieved at the flocculation basins. However, the summer to winter variations of water quality require installation of mechanical flocculation equipment. Large vertical flocculators with variable speed drives permit flocculation tapering and, with seasonal variations, can turn at higher revolutions to create better floc. This will be especially true in DAF technology. These vertical flocculators are recommended for the Lopez WTP. Slowing down the flocculators and/or increasing coagulant dosages can form a larger settleable floc.

The effectiveness of the flocculation process is highest when the flocculation basins have been designed to avoid short-circuiting. When short-circuiting occurs in a basin, water flows through in a time that is shorter than the theoretical detention time. Although short-circuiting in flocculation basins cannot be totally eliminated, minimizing this problem is important because attaining a uniform floc retention time yields a more uniform floc size. When floc sizes range from very small to very large, the larger flocs may settle well while the smallest do not and are carried over to the filters. Attaining a fairly uniform floc size can improve sedimentation performance, particularly when plate settlers are employed. Baffles within each existing flocculation basin will allow for optimization of floc size.

The existing flocculation basins would be modified to permit optimizing treatment. These improvements would include new serpentine flow baffle walls and new mixing units. Any improvements made must include more consideration for washdown and maintenance hose bibs, sample pump configuration changes, sludge drain improvements, ventilation of sludge drain vault, and repair of low spots.

5.7.3. Sedimentation Basins.

To reliably increase loading rates within the current basin footprint, we recommend either installing inclined plate settlers in the existing sedimentation basins along with new sludge rakes or using other methods like ballasted flocculation (Actiflo) or the DAF clarification system that uses flotation and sedimentation.

DAF is an especially effective clarification process for removal of particulate matter that has poor settling characteristics. Low turbidity (< 100 and preferably < 30 NTU) waters with high loadings of low-density particles such as algae or flocculated colored organic material are the major DAF applications.

Based on the alternative analysis and the pilot study discussed in Chapter 6, it appears that DAF is the best solution for the Lopez WTP.

5.8 Filtration

The existing filter media and underdrain systems are old and are experiencing operational problems. They are in need of renovation. Several studies have been completed over the last several years that have included upgrading filter media in select filters, investigations using coring, etc. The key element under consideration for this effort is "What solution is best for the long term?" In an attempt to find that solution, alternative methods of filtration could be implemented.

Based on District water quality goals and their goals of capacity and reliability and DHS redundancy requirements for critical processes, membrane filters are being recommended for the Lopez WTP.

5.9 Disinfection

Free chlorine and chlorine dioxide can serve as the primary oxidant and disinfectant at the WTP. However, while chlorine gas is a proven technology with a good track record, safety concerns have resulted in more stringent ordinances for toxic gases and secondary containment requirements. For these reasons, modifications to the existing chlorine system will be required to bring it up to code. These modifications include construction of improvements to the chlorine storage and feed facility to ensure that it is gas-tight. In addition, a scrubber system capable of neutralizing the accidental release of chlorine from a full one-ton container would be required. Alternatively, the District could change its chlorine gas system to a bulk hypochlorite or onsite sodium hypochlorite generation facility.

Black & Veatch is recommending: (1) onsite sodium hypochlorite generation facility, and (2) a pre-oxidant of chlorine dioxide, potential pre-chlorination, final chlorination, and continuing ammonia feed for chloramines. Black & Veatch recommends using a method of chlorine dioxide generation that does not use chlorine gas if pilot testing proves that it is capable of meeting the District's needs.

Additional information on disinfection recommendations is presented in Appendix K.

5.10 Recommended Treatment Process

The recommended treatment process was developed through two screening workshops and was refined to reflect input from District staff, the District's TAC, and representatives from DHS.

Prior to the workshops, Black & Veatch developed preliminary cost estimates for the nine treatment alternatives described in Sections 5.4 and 5.5. These cost estimates are summarized in Table 5.1. Costs range from $103 per acre-foot per year (afy) for Alternative 1 (Base Case) to $283 per afy for Alternatives 8 and 9 (Water Softening Alternatives).

Black & Veatch also compared the nine alternatives with respect to potential log removal credits and regulatory compliance. Results are shown in Table 5.2and Table 5.3, respectively.

At the workshops, the alternatives were evaluated against the cost and water quality considerations mentioned above. Other evaluation criteria were public

Table 5.1: Estimated Costs

	Alternative 1 Do Nothing	Alternative 2 Pretreatment & Conventional Filters	Alternative No. 3 Pretreatment & Membrane Filters	Alternative No. 4 Actiflo with Conventional Filters	Alternative No. 5 Actiflo with Membrane Filters	Alternative No. 6 DAF with Conventional Filters	Alternative No. 7 DAF with Membrane Filters	Alternative No. 8 Softening with Conventional Filters	Alternative No. 9 Partial Softening w/ Nanofiltration	
Construction Costs										Narrative:
Site Work and Yard piping	$ 442,000	$ 442,000	$ 442,000	$ 442,000	$ 442,000	$ 442,000	$ 442,000	$ 442,000	$ 442,000	These costs were developed based on experience with similar plants
Raw Water Pumps/Piping	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No new facilities are needed
Rapid Mix	$ 12,000	$ 12,000	$ 12,000	n/a	n/a	n/a	$ 12,000	$ 12,000	$ 12,000	This cost is for a new rapid mix in line mixer
Flocculation Improvements	$ 27,200	$ 207,200	$ 207,200	n/a	n/a	Incl. W/ Sed.	Incl. W/ Sed.	$ 207,200	$ 207,200	This cost is for new flocculators and drives
Sedimentation	n/a	$ 470,000	$ 470,000	$ 1,113,750	$ 1,113,750	$ 1,072,468	$ 1,072,468	$ 200,000	$ 200,000	This cost is for new plate settlers except DAF is for new system from supplier
Filter Press	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$ 150,000	n/a	For filter press
Filtration	n/a	$ 585,000	$ 3,950,000	$ 585,000	$ 3,950,000	$ 585,000	$ 3,950,000	$ 585,000	$ 9,585,000	Cost is for upgraded filters except for membranes which are estimated separately
Chemical Feed	n/a	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	Just the cost for minor improvements to chemical feed
Caustic Soda	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$ 150,000	$ 150,000	Cost for caustic soda system on softening only
Alum	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No new facilities are needed
Polymer	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No new facilities are needed
Chlorine Dioxide	n/a	n/a	n/a	n/a	n/a	n/a	$ 150,000	n/a	$ 150,000	Needed for DAF and nanofiltration
Carbon Dioxide	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$ 150,000	n/a	Cost for carbon dioxide system on softening only
Chlorine	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	n/a	n/a	n/a	Upgraded chlorine system only
Hypochlorite	n/a	n/a	n/a	n/a	n/a	n/a	$ 150,000	$ 150,000	$ 150,000	Cost for Hypochlorite system
Ammonia	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	
Buildings	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Incl. W/ Sed.	Included in Other	Included in Other	
Clearwater Reservoir	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	Included in Other	
Electrical & Instrumentation	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000	New System based on similar plant estimates
Other Improvements	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	$ 4,000,000	Cost developed considering all audit work completed
Subtotal	$ 5,081,200	$ 6,346,200	$ 9,711,200	$ 6,770,750	$ 10,135,750	$ 6,729,468	$ 10,256,468	$ 6,526,200	$ 15,376,200	
Contingencies	$ 1,270,300	$ 1,519,050	$ 2,427,800	$ 1,692,688	$ 2,533,938	$ 1,682,367	$ 2,564,117	$ 1,631,550	$ 3,844,050	25% of Subtotal
Engr, Admin, and Legal	$ 762,180	$ 911,430	$ 1,456,680	$ 1,015,613	$ 1,520,363	$ 1,009,420	$ 1,538,470	$ 978,930	$ 2,306,430	15% of Subtotal
TOTAL	$ 7,113,680	$ 8,506,680	$ 13,595,680	$ 9,479,050	$ 14,190,050	$ 9,421,255	$ 14,359,055	$ 9,136,680	$ 21,526,680	
O&M Costs										
Labor	$ 282,498	$ 282,498	$ 315,000	$ 282,498	$ 315,000	$ 282,498	$ 315,000	$ 495,000	$ 495,000	Cost for existing plant from County - Added additional staff to other alternatives 1-Membrane 4-Softeni
Addl Process Energy	n/a	n/a	$ 67,988	n/a	$ 67,988	n/a	$ 67,988	n/a	n/a	Cost for energy used by mebrane filter equipment only
Current Process & Building Energy	$ 27,558	$ 27,558	$ 27,558	$ 27,558	$ 27,558	$ 27,558	$ 27,558	$ 27,558	$ 27,558	Same as existing
Chemical Costs	$ 207,914	$ 207,914	$ 207,914	$ 207,914	$ 207,914	$ 207,914	$ 207,914	$ 207,914	$ 207,914	Same as existing
Caustic Soda	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$ 584,500	$ 584,500	Added costs to softening for chemical
Polymer	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	
Chlorine Dioxide	n/a	$ 10,234	$ 10,234	$ 10,234	$ 10,234	$ 10,234	$ 10,234	n/a	n/a	Added costs for DAF only
Carbon Dioxide $60/ton	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$ 182,600	$ 182,600	Added costs to softening for chemical
Chlorine $209/ton	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	
Hypochlorite	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	
Ammonia $400/ton	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	Incl. Above	
Pipeline Maintenance (Pigging)	$ 12,730	$ 12,730	n/a	$ 12,730	n/a	$ 12,730	n/a	n/a	n/a	Pigging costs
Sludge Operations	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$ 246,000	$ 246,000	Added costs to softening for chemical
Misc. Maintenance Materials	$ 1,183	$ 1,183	$ 1,183	$ 1,183	$ 1,183	$ 1,183	$ 1,183	$ 1,183	$ 1,183	All same as existing plant
Equipment (Vehicles)	$ 8,524	$ 8,524	$ 8,524	$ 8,524	$ 8,524	$ 8,524	$ 8,524	$ 8,524	$ 8,524	All same as existing plant
Lab Costs	$ 48,689	$ 48,689	$ 48,689	$ 48,689	$ 48,689	$ 48,689	$ 48,689	$ 48,689	$ 48,689	All same as existing plant
Overhead	$ 101,000	$ 101,000	$ 101,000	$ 101,000	$ 101,000	$ 101,000	$ 101,000	$ 101,000	$ 101,000	All same as existing plant
Contingencies @10%	$ 69,010	$ 70,033	$ 78,809	$ 70,033	$ 78,809	$ 70,033	$ 78,809	$ 190,297	$ 190,297	
TOTAL	$ 690,096	$ 700,330	$ 788,090	$ 700,330	$ 788,090	$ 700,330	$ 788,090	$ 1,902,968	$ 1,902,968	
$/AF/YR	$ 103	$ 104	$ 117	$ 104	$ 117	$ 104	$ 117	$ 283	$ 283	
$/AF/YR (Including 20 yr debt service)	$ 172	$ 186	$ 248	$ 196	$ 254	$ 195	$ 255	$ 371	$ 490	

Table 5.2: Potential Log Removal / Inactivation Credits

Process Alternative	Pathogen	Total Log Removal / Inactivation		
		Free Chlorine	Ozone[1]	UV[1]
Alternative 1. (Minor modifications)	*Cryptosporidium*	2.0		
	Viruses	6.0		
Alternative 2. Upgrade w/ new filters	*Cryptosporidium*	2.0		
	Viruses	6.0		
Alternative 3. Upgrade w/ membrane filtration	*Cryptosporidium*	4.0		
	Viruses	4.5 – 8.0		
Alternative 4. Actiflo & conv. filters	*Cryptosporidium*	2.0		
	Viruses	6.0		
Alternative 5. Actiflo & membrane filtration	*Cryptosporidium*	4.0		
	Viruses	4.5 – 8.0		
Alternative 6. DAF & conv. filters	*Cryptosporidium*	2.0	4.0	4.0
	Viruses	6.0	(8.0 – 10.0)[2]	6.0 – 8.0[3]
Alternative 7. DAF & membrane filters	*Cryptosporidium*	4.0		
	Viruses	4.5 – 8.0		
Alternative 8. Chem. softening & conv. filters	*Cryptosporidium*	2.0		
	Viruses	6.0		
Alternative 9. Nanofiltration & conv. filters	*Cryptosporidium*	2.0		
	Viruses	6.0		

[1]Ozone and UV log removal credit would also be applicable to Alternatives 2 and 4.
[2]Assumes ozone followed by brief chlorine contact period to inactivate microbes that may be present in biological growth sloughed from filters.
[3]Assumes UV followed by brief free chlorine contact period.

Basis for Total Log Inactivation / Removal Credits

Treatment / Disinfectant	Log Removal/Inactivation for Specified Pathogen	
	Cryptosporidium	Viruses
Conv. Sedimentation / Filtration[1]	2.0	2.0
Membranes (UF / MF)	4.0[2]	0.5 – 4.0[3]
Free Chlorine	0	4.0
Ozone	2.0[4]	(2.0 – 4.0)
UV[5]	2.0	0 – 2.0[6]

[1]Includes conventional sedimentation w/plates, Actiflo, and DAF processes. Applicable to current regulations. Under future regulations, removal credits may be increased for well-operated plants.
[2]CA-approved removal credit for *Giardia*; credit for *Cryptosporidium* expected to be similar.
[3]Removal credit dependent on type of membrane used.
[4]From "Stage 2 M-DBP Agreement in Principle" microbial toolbox.
[5]At 40 mJ/cm^2 UV dosage. (UV not currently CA-approved for surface water treatment.)
[6]Inactivation efficiency dependent on type of virus.

Table 5.3: Alternative Compliance Matrix

Alternative	Regulatory Compliance	Guideline Crypto Action Plan	Enhanced County WQ Goals
1	Doubtful		
2	Possibly		
3	X	X	X
4	X	X w/ Exception	
5	X	X	X
6	X	X w/ Exception	
7	X	X	X
8	X		
9	X		

acceptance, reliability, and ease of operation. The criteria were weighted and scores were assigned. The results of the evaluation are shown in **Table 5.4**.

Black & Veatch's initial recommendation was to base the preliminary design on Alternative 6, a process train that included DAF for pretreatment, media filtration, and final disinfection by ultraviolet UV light. As discussed in Chapter 6, the DAF pilot that was run in the fall of 2001 at the Lopez WTP demonstrated that the DAF unit capably removed particles to smaller than *Cryptosporidium* range (less than one micron).

However, as a pretreatment process, DAF was unable to condition the water to prevent filter media breakthrough of very fine particles. (On a single occasion, as described in the pilot study.) This breakthough condition put the WTP above the CAP goal of 0.1 NTU. Discussions with DHS indicated that a variance from the CAP could potentially be obtained, and that UV would be helpful (necessary) to obtain this variance. However, DHS cautioned that failure to meet all provisions of the CAP would disqualify the District from qualifying for the SRF.

In a workshop held with the District's TAC on November 7, 2001, Black & Veatch recommended Alternative 6 and outlined its risks. Alternative 6 is the lower net present worth alternative, even when consideration is given to financial differences for not obtaining the low interest rate SRF loan. At the November workshop, the District also requested evaluation of a previously dismissed alternative, softening, which became Alternative 8.

After completing the evaluation of Alternative 8, Black & Veatch met with the District TAC in at a Workshop on March 19, 2002. At the Workshop, Black & Veatch presented updated costs and comparisons of Alternative 7, Membrane

Table 5.4: Alternative Process Comparison Matrix

	Public Acceptance	Capital Cost	Life Cycle Costs	Reliability	Ease of Operation	Quality	State Revolving Loan Fund	Score	Remarks
Weight	2.0	1.0	1.0	1.5	1.5	1.5	2.0		
Treatment Technology									
Alternative 1 Upgrade flash mix, baffle flocculation, sedimentation diffuser wall.	2	10	10	2	6	2	2	4.10	"Do - nothing" alternative
Alternative 2 Upgrade flash mix, new chlorine dioxide, new ferric chloride, baffle flocculation, sedimentation diffuser wall, new conventional filters.	8	8	8	7	7	7	3	6.62	Sedimentation does not cope well with algae, so quality and reliability are lowered
Alternative 3 Upgrade flash mix, new chlorine dioxide, new ferric chloride, baffle flocculation, sedimentation diffuser wall, new flocculators, new plate settlers, new membrane filters.	6	5	6	8	8	9	8	7.29	Quality is higher because of membrane filters, but life cycle costs are also higher
Alternative 4 New chlorine dioxide, ballasted flocculation/sedimentation, and new conventional filters.	8	7	7	7	6	7	5	6.67	Quality should be as good as that of Alternative 2, but reliability and operation may be difficult because ballasted flocculation can be quite pH-sensitive
Alternative 5 New chlorine dioxide, ballasted flocculation/sedimentation, and new membrane filters.	6	4	4	7	7	9	8	6.71	Quality should be as good as that of Alternative 3, but again pH sensitivity of ballasted flocculation relates to operations and reliability
Alternative 6 New chlorine dioxide, new ferric chloride, dissolved air floatation, and new conventional filters.	8	9	9	8	7	6	3	6.81	DAF is more reliable for algae treatment and gives better quality. Also, easier operations.
Alternative 7 New chlorine dioxide, dissolved air floatation, and new membrane filters.	8	5	6	9	8	9	8	7.81	Quality should be better than that of Alternative 6 due to the use of membranes in conjunction with DAF; reliability should be the same. Will have higher life cycle costs.
Alternative 8 Add chemical softening, upgrade flash mix, new chlorine dioxide, new ferric chloride, baffle flocculation, sedimentation diffuser wall, new conventional filters.	8	4	2	5	3	9	8	6.05	Softening is quite labor intensive and expensive overall. Still has the issue of not coping well with algae, so quality and reliability are lowered
Alternative 9 Upgrade flash mix, new chlorine dioxide, new ferric chloride, baffle flocculation, sedimentation diffuser wall, new conventional filters, add side stream softening using nanofiltration.	8	2	1	5	2	9	8	5.62	Softening is quite labor intensive and expensive overall. Still has the issue of not coping well with algae, so quality and reliability are lowered

Notes:
(1) Life cycle costs taken at 8% over 30 years.
(2) Rating: 10 = best, 0 = worst.

Public Acceptance has to do with providing water quality within budgeted funds so no effect on rates.
Given a weight of 2 because of the significance of providing water quality.
Capital Cost is merely the cost of the facilities.
Given a weight of 1 because it should be considered but should not be a major decision factor.
Life cycle costs are again merely the costs for operation for the life of the facilities over 30 years.
Given a weight of 1 because it should be considered but should not be a major decision factor.
Reliability is the potential for the treatment process to meet regulatory and quality standards consistently.
Given a weight of 1.5 because this factor is more important than costs but less important than public acceptance.
Ease of operation is the ability of the WTP to be operated easily.
Given a weight of 1.5 because this factor is more important than costs but less important than public acceptance.
Quality is the ability of the process to provide quality water under any circumstances.
Given a weight of 1.5 because this factor is more important than costs but less important than public acceptance.
Reliability, ease of operation, and quality were considered equally important.

Filtration and Alternative 8, Chemical Softening. The comparison of the two is shown in Table 5.5.

Table 5.5: Comparison of Alternatives 7 and 8

	Membrane Filtration	Chemical Softening
Staffing	Higher Level of Automation I&C/PCS troubleshooting Capable of Remote Operation	More labor intensive Significant increase in solids and chemical handling Recommend continuous staffing
Regulatory Compliance	Will meet CAP	Should meet CAP
Public Acceptance	No change in TDS	Lower TDS could result in less reliance on water softeners by South County water users.
Pipeline Deposition	Decreased, probably not eliminated	Eliminated
Reliability of Treatment Process	High Highly automated filtration with multiple levels of redundancy	More troublesome to start-up. Highly dependant on chemical feed systems. Potential problems such as filter plugging.
Safety	Improved. Fewer chemicals required than current process	Increased concern. Significant increase in quantity of chemicals handled, including sodium hydroxide (caustic, irritant) and carbon dioxide (inhalation hazard).
Construction/Design Schedule	Procurement/Piloting of pretreatment/membranes will add 3-4 months	Conventional design-bid-construct schedule
Capital Cost	$14,400,000 (based on DAF with pressure membranes rated at 6-mgd firm capacity).	$9,200,000
Annualized Debt Service	$927,000	$ 592,000
O&M Cost/Year	$788,000	$ 1,903,000
Total Cost/Year	$ 1,715,000	$ 2,495,000
Cost/Acre-Ft/Year. Current WTP is $172	$ 255	$ 371

Based on the above comparison, Black & Veatch recommended proceeding with the recommendation of Alternative 7 to the District TAC, due to the lower life-cycle cost. A flow diagram of the potential future treatment train is shown in Figure 5.1.

In addition to the recommended treatment process, there are other water quality improvement alternatives that may be worth considering for the long term including:

- Aeration both in Lake Lopez and the Terminal Reservoir
- Reservoir restoration – Aquatic weed removal / capping bottom sediment

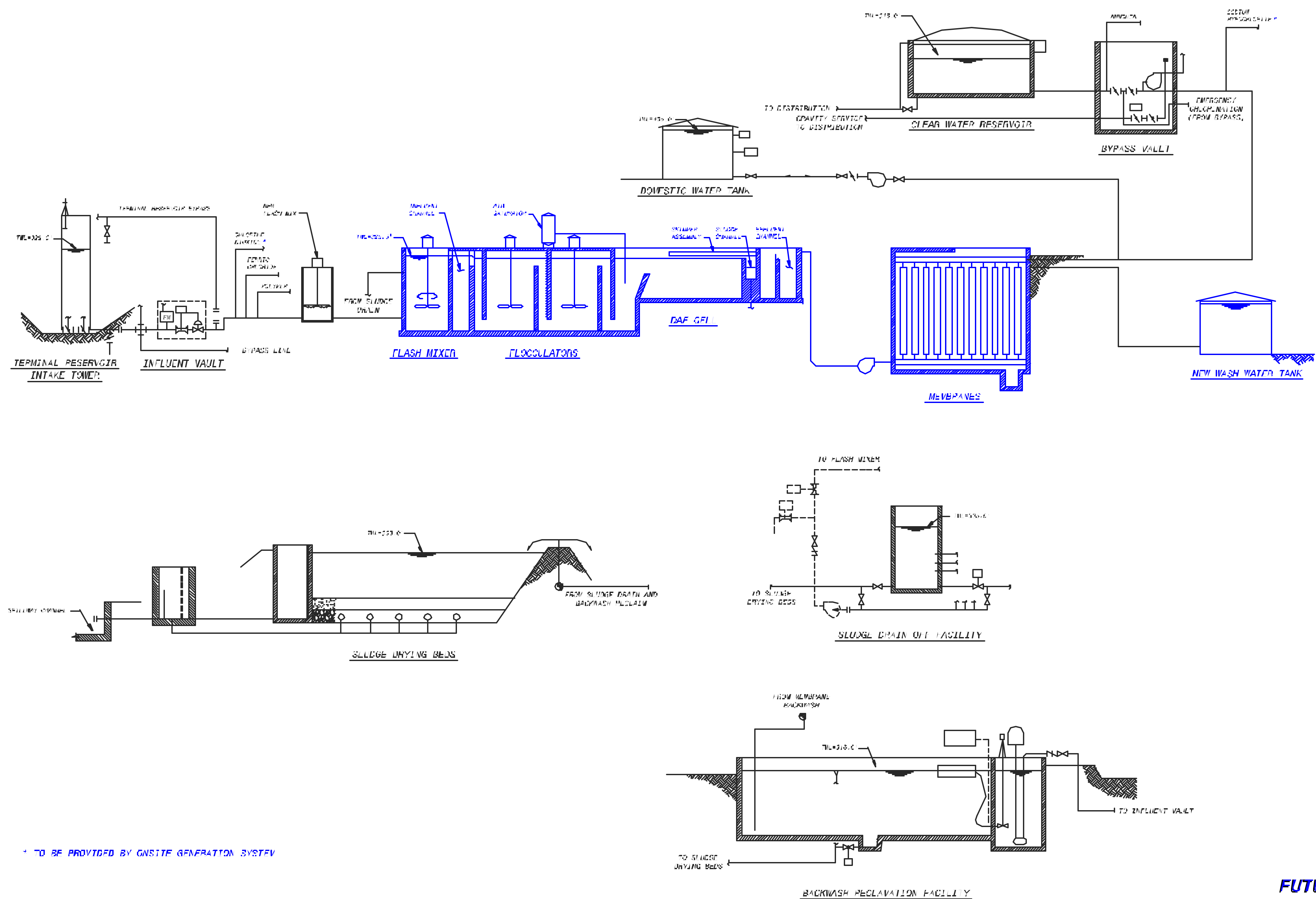


FIGURE 5-1

FUTURE TREATMENT TRAIN

Chapter 6. Pilot Study

6.1 Introduction and Testing Objectives

Black & Veatch conducted a pilot testing program at the Lopez WTP during September and October 2001, using a pilot trailer containing a dissolved air flotation (DAF) system and two dual media filters rented from F.B. Leopold Company, Inc. (Leopold). As a subcontractor to Black & Veatch, Leopold provided a field engineer to operate the pilot plant under the guidance of Black & Veatch. This chapter presents a summary of the pilot testing. The testing protocol with detailed descriptions of major equipment and testing procedures is included as Appendix M. More detailed testing data is contained in Appendices N, O, and P.

DAF was selected for pilot testing at the Lopez WTP because the raw water is known to contain low-density particles such as algae that have poor settling characteristics. DAF is a process in which water is coagulated and flocculated, and then a recycle stream of water containing air bubbles under high pressure is introduced into the flocculated water. As air bubbles are gradually released, they rise to the top of the water and float the floc particles. Solids are skimmed off the water surface in this separation process as float sludge. This prepares the water for effective filtration. A DAF system can be easily installed in the existing sedimentation basins of the Lopez WTP. The floated sludge from a DAF clarifier can have a solids content ranging from 1% to 3% (conventional yields 0.5-1.5% solids), sometimes exceeding 3%, making the sludge easier to manage than that from other clarification processes.

Manganese, TOC, turbidity, and DBPs are parameters of concern at the WTP in addition to algae. The main objectives of the DAF pilot testing were to determine the applicability of DAF as an effective pretreatment to dual media filters in order to address these water quality concerns and to optimize the process criteria and operation conditions for full-scale design and cost analysis. Preoxidants including chlorine dioxide, potassium permanganate, and chlorine were tested during the pilot program to evaluate their effects on DBP formation and manganese removal.

The District's water quality goals are:

Clarified water turbidity	0.5 to 1.0 NTU
Granular media filter effluent turbidity	0.05 NTU
Granular media filter effluent turbidity after backwash and filter restart	<0.15 NTU spike
Manganese in filter effluent	0.01 mg/L
DBPs (TTHMs, THAAs)	0.04 mg/L, 0.02 mg/L

6.2 Pilot Plant Operations

Pilot testing equipment included a mobile DAF pilot plant rented from Leopold and a chlorine dioxide generator rented from CDG Technology Inc. (CDG). The Leopold DAF pilot plant was contained in a trailer, complete with three chemical feeders, two static mixers, a two-stage flocculation unit, a DAF clarifier system, two pilot filters, a sludge holding tank and sludge pump, and on-line monitoring equipment including pH and conductivity meters, temperature gauges, turbidimeters, and particle counters. The CDG chlorine generator used a solid sodium chlorite cartridge to react with chlorine to generate chlorine dioxide. The major pilot equipment systems are described in more detail in Appendix M. Pictures of the pilot plant on location are displayed below.

A schedule of the pilot testing is included in Section 4 of Appendix M. The pilot trailer was delivered to the Lopez WTP site on September 4, 2001. After equipment setup and chemical preparation, chemical coagulation optimization started on September 7 and lasted until September 12. Coagulants tested included JC 1647, PAX, ferric chloride, JC 1679, and alum. JC 1647, JC 1679, and PAX are special blends of polyaluminum chloride with cationic polymer. JC 1647 was found to be the most effective coagulant for DAF operation. Incidentally, JC 1647 was also found to be the most effective coagulant in bench-scale jar tests conducted by District laboratory staff (Appendix B). The project team decided to use JC 1647 as the primary coagulant for the continuous (24-hour, 7-day/week) DAF pilot testing which started on September 13 using raw water from the Terminal Reservoir as feed. The raw water source was switched to Lopez Lake water on September 26, and testing ended on October 3, 2001. A chronology of chemical addition events during the entire pilot testing is presented in Appendix O. The chemicals include coagulants, oxidants, sulfuric acid, and filter aids.

As described in Appendix M (Section 5), critical parameters such as pH, turbidity, particle count, temperature, and flow rate were continuously monitored with on-line instrumentation. The Leopold field engineer analyzed samples for iron, manganese, aluminum, and color with a spectrophotometer. District laboratory staff occasionally collected samples for metal analysis with the atomic absorption method (AA), and for other analyses such as alkalinity, algae count, total organic carbon (TOC) and UV_{254} absorption, color, odor, chlorine dioxide, chlorite, chlorate, simulated distribution system (SDS) THMs, and HAAs.

6.3 Pilot Testing Results and Discussions

Detailed testing results and analytical data are presented in Appendix N (Leopold Final Report) and Appendix P (District's Analytical Results). The results are summarized and discussed below.

6.3.1. Turbidity and Particle Count

Turbidity of raw water, DAF effluent, and filtered water was continuously monitored on-line at the pilot plant. Turbidity data for raw water and DAF effluent is presented in Figures 1, 13, and 14 of Appendix N. The turbidity of raw water from the Terminal Reservoir ranged from 1.4 to 2.6 NTU and that from Lake Lopez ranged from 0.35 to 1.7 NTU during the testing period. Upon stabilization, the DAF system performed very well at a surface loading rate of 4 gpm/ft^2 with 35 mg/L of JC 1647 for turbidity reduction. DAF effluent turbidity was less than 0.5 NTU most of the time and was as low as 0.3 NTU. Low DAF effluent turbidities were found especially when raw water directly from Lake Lopez was treated, except near the end of testing when pre-oxidation was discontinued and coagulant dosage was reduced. DAF performance easily met the goal of clarified water turbidity of 0.5-1.0 NTU. Surface loading rate testing indicated that the DAF unit could be operated at a rate of up to 8 gpm/ft^2 without causing any significant performance deterioration.

Head loss versus effluent turbidity, for both pilot filters over the entire testing period, are shown in Figures 31 and 32 in Appendix N. During the first week of

continuous testing, the pilot filter effluent turbidity ranged from 0.2 to 0.3 NTU. At the same time, the WTP was experiencing high filter effluent turbidity. Apparently, there was an algae bloom in the Terminal Reservoir during this period, and the District treated the reservoir with copper sulfate and acid. After the first week, the pilot filter effluent turbidity began to decrease, but it was still higher than 0.1 NTU until September 24 when the raw water turbidity decreased to less than 1.5 NTU. Filter effluent turbidity decreased to below 0.1 NTU on September 25 and decreased to approximately 0.05 NTU after the raw water source was switched to Lake Lopez. However, as Lake Lopez raw water turbidity increased, filter effluent turbidity also increased to approximately 0.1 NTU. Overall, pilot testing did not meet the District turbidity goal of 0.05 NTU in the filter effluent. However, it did meet the combined filter turbidity standard of 0.3 NTU (95th percentile) required by DHS as amended by the IESWTR.

Attempts to improve the filter performance in turbidity reduction including lowering filter loading rate (3 gpm/ft^2 versus 4 gpm/ft^2), pH adjustment (acid feed), coagulant aid, and filter aid feed were not effective in significantly improving filter effluent turbidity reduction. District laboratory staff conducted a bench-scale test by filtering a pilot filter effluent sample through a 0.45-micron filter. The turbidity decreased from 0.25 NTU to 0.08 NTU, indicating that there were fine particles (both larger and smaller than 0.45 micron in size) in the filter effluent.

The particle count data provided a different perspective on filter performance. The average raw water particle count (2-20 micron) was approximately 10,000/mL. The average DAF effluent particle count was approximately 800/mL and was as low as 100/mL with 1.5 mg/L of chlorine dioxide as pre-oxidant. This represents 92 to 99% particle removal. The filter effluent particle count averaged 50/mL and was as low as 10-12/mL with 1.5 mg/L of chlorine dioxide feed as pre-oxidant. The pilot filter performance in particles >2 micron was excellent. The log removal (DAF with filter) for total particles >2 micron was above 2.8 during the 'best' period and averaged 2.2-2.3 during the 'worst' period. This easily met the 2-log *Cryptosporidium* removal requirements of the IESWTR. Runs of the pilot filters were at least 48 hours in length at a surface loading rate of 4 gpm/ft^2. This is equivalent to a unit filter run volume (UFRV) of larger than 11,200 gal/ft^2-run, which is excellent and indicates that DAF is a good pretreatment alternative.

The discrepancy between the turbidity and particle count results is anomalous. Usually with particle counts less than 100/mL, the turbidity would be below 0.1 NTU. This discrepancy indicates that there are colloidal particles in the filter effluent that are smaller than 2 microns in size. These colloidal particles are very difficult to flocculate and are small enough to penetrate the filters. Based on present knowledge, these particles are not protozoans such as *Cryptosporidium* (2-5 micron) and *Giardia lamblia* (5-15 micron). Previous studies by the District's consultant (John Carollo Engineers, 1996) indicated that there were silica-based submicron particles (diatoms, micas, kaolinite, illite, etc.) in the raw water that were very difficult to coagulate due to their high intensity negative surface charge and morphologic structure. Removal of these submicron particles may require membrane processes such as microfiltration (MF) or ultrafiltration (UF), which can remove particles 0.1 micron or smaller.

Raw and filtered samples from the pilot plant were sent to Leopold's Research and Development Laboratory for microscopic examination. Leopold reported that some diatoms, including Fragilaria and circular unicellular algae were present in the filtered water sample. It is suspected that the particles that passed through the filters may be a combination of diatoms and colloidal silica, but without the protozoans. Communications with DHS (Kurt Souza and Rick Sakaji) indicated that, if it were demonstrated that the particles were not of the *Cryptosporidium* size range, the CAP guidelines (specifically the 0.1 NTU filter effluent turbidity) might not apply. In that case the turbidity standard to be complied with would be 0.3 NTU as required by IESWTR, as long as other requirements such as CT are met.

6.3.2. Iron and Manganese

Iron and manganese concentrations were monitored frequently during the pilot testing. Iron concentrations in raw and filtered water were very low during the entire testing period, a good deal below the SMCL of 0.3 mg/L. Raw water manganese concentrations ranged from 0.028 to 0.06 mg/L. Figure 16 of Appendix N shows raw water and DAF manganese concentrations. With few exceptions, the DAF removed manganese to below 0.03 mg/L when an oxidant was used. Filter effluent manganese concentrations are shown in Figure 34 of Appendix N. Filter effluent manganese concentrations were generally below 0.02 mg/L, but higher than the goal of 0.01 mg/L. As mentioned earlier, the Leopold field engineer conducted manganese analyses with a spectrophotometer. District laboratory staff also analyzed manganese with AA. Manganese concentrations obtained by the District are presented in Table 5-1. With one exception, all filter effluent manganese concentrations were at or below the District goal of 0.01 mg/L. It is interesting to note that the exception occurred when potassium permanganate ($KMnO_4$) was used as the pre-oxidant. It is believed that the analyses by AA should be more accurate than the analyses by the spectrophotometer. Therefore, it is assumed that the goal of 0.01 mg/L was met.

Table 6.1: Manganese Concentrations by Atomic Absorption (mg/L)

Date	Source*	Raw	DAF Effluent	Filter Effluent	Oxidant	Dosage (mg/L)
06-Sep	T.R.	0.03			None	
10-Sep	T.R.	0.047	0.013		None	
12-Sep	T.R.	0.034		0.01	ClO_2	0.5
14-Sep	T.R.	0.029		0.008	ClO_2	0.5
18-Sep	T.R.	0.023		<0.005	ClO_2	1.5
20-Sep	T.R.	0.02		<0.005	ClO_2	1.5
24-Sep	T.R.			0.021	$KMnO_4$	0.5
25-Sep	T.R.			<0.005	Cl_2	3.2
27-Sep	Lake			<0.005	Cl_2	3.2
28-Sep	Lake			<0.005	ClO_2	1.5
01-Oct	Lake			<0.005	ClO_2	1.25
02-Oct	Lake			<0.005	Cl_2 (Filter)	2
03-Oct	Lake			<0.005	Cl_2	2

* T.R. = Terminal Reservoir

6.3.3. Disinfection By-Products

The purpose of the preoxidant testing was to evaluate the effects of the preoxidants on DBP formation in a worst-case scenario when post chlorination (not chloramination) was used. Detailed analytical results of the SDS DBPs are included in Appendix P. Table 5-2 shows a summary of the 48-hour SDS DBPs (TTHMs and THAAs). As expected, the data indicates that using preoxidants other than chlorine (or no preoxidant) reduced the formation of TTHMs and THAAs. At higher chlorine dioxide dosages, DBP reduction was higher. However, it is interesting that $KMnO_4$ had a much greater percentage reduction in DBPs than chlorine dioxide. This is contrary to the experience of Black & Veatch in other projects. Unfortunately, there is only one data point to support this phenomenon. In general, DBP concentrations were much lower in treated water from Lopez Lake than from the Terminal Reservoir.

Table 6.2: 48-hour SDS DBP Analysis Results

Pre-oxidant	Dosage (ppm)	TTHM (ppb)	THAA (ppb)	Source
ClO_2	0.5	122.6	48.9	T.R.
ClO_2	1.5	81.7	53.5	T.R.
ClO_2	0	108.8	49.1	T.R.
$KMnO_4$	0.5	55.4	28.4	T.R.

Pre-oxidant	Dosage (ppm)	TTHM (ppb)	THAA (ppb)	Source
Cl_2	3.2	141.6	73	T.R.
ClO_2	1.5	40.3	28.8	Lake
ClO_2	1.25	37.3	34.4	Lake
ClO_2	1.25	39.3	50.8	Lake
Cl_2	2	73	58.3	Lake
Cl_2 (Pre-filter)	2	78	43.7	Lake

* T.R. = Terminal Reservoir

The DPB goals could easily be met by using a pre-oxidant such as chlorine dioxide or $KMnO_4$ to oxidize manganese and enhance coagulation, and use post-chloramination for CT and residual requirements. Chlorine dioxide appears to be effective in manganese oxidation and in enhancing particle removal efficiencies in the DAF and pilot filters. One major concern with chlorine dioxide is the residual chlorite concentration, which has an MCL of 1.0 mg/L. The District's analytical results (Appendix P) indicate that chlorite concentrations exceeded 1.0 mg/L when the chlorine dioxide dosage was 1.5 mg/L. It was also possible that the pilot chlorine dioxide feed rate was inaccurate as the total chlorite and chlorate levels exceeded the chlorine dioxide dosage of 1.5 mg/L during lake water testing. Nevertheless, it would be prudent to limit the chlorine dosage to 1.0 mg/L. However, if a higher chlorine dioxide dosage is required, a ferrous salt can be incorporated in the coagulation process. Ferrous salts can reduce chlorite to chloride, which has no known deleterious effects.

6.3.4. Algae and TOC

Algae removal is one of the main advantages of DAF as a water pretreatment process. During the pilot testing period, an algae bloom occurred. As shown in Table 5-3, DAF had over 96% algae removal when the algae counts were relatively high. When the raw water source was switched to Lopez Lake water, the algae count in the raw water decreased dramatically. The removal percentage dropped off, but the DAF effluent algae count was quite low. The pilot testing data demonstrated that DAF was effective in algae removal.

Table 6.3: DAF Algae Removal Data (Total Counts, Org/mm^2)

Raw	DAF Effluent	% Removal	Source
3,500	93	97.3	T.R.
2,000	0	100	T.R.
4,000	110	97.3	T.R.
3,200	110	96.6	T.R.

Raw	DAF Effluent	% Removal	Source
2,100	25	98.8	T.R.
4,500	97	97.8	T.R.
3,900	86	97.8	T.R.
140	58	58.6	Lake
330	29	91.2	Lake

* T.R. = Terminal Reservoir

Raw water TOC concentration ranged from 5.3 mg/L to 6.3 mg/L as presented in Table 5-4. TOC removal by DAF or filter ranged from 11 to 24%, with an average of 16.8%. This is lower than the 25% removal required by enhanced coagulation for Lake Lopez (source water with TOC of 4.0-8.0 mg/L and alkalinity >120 mg/L). Bench-scale tests conducted previously indicated that TOC removal by enhanced coagulation was difficult. The District may want to choose the alternative compliance criteria of using an alternative preoxidant and post-chloramination to limit TTHM and HAA5 to <0.04 mg/L and 0.030 mg/L, respectively.

Table 6.4: Pilot Testing TOC Data (mg/L)

Source	Raw Water	DAF or Filter Effluent.	% Removal
T.R.	6.3	5.4	14.3
T.R.	5.4	4.1	24
T.R.	5.4	4.6	14.8
T.R.	5.3	4.7	11
T.R.	5.5	4.4	20
T.R.	5.6	4.5	19.6
T.R.	5.5	4.6	16.4
Lake	5.4	4.8	11.1
Lake	5.7	4.6	19.3
Lake	5.6	4.6	17.9
Lake	5.9	4.8	18.6
Lake	5.5	4.7	14.5
Average	**5.6**	**4.7**	**16.8**

* T.R. = Terminal Reservoir

6.3.5. Color and Aluminum

Color removal by DAF was quite effective. Figures 17 and 18 in Appendix P show the apparent and true color levels in raw water and DAF effluent, respectively. Raw water apparent color ranged from 16 to 52 color units. The DAF effluent apparent color averaged approximately 10 color units. The true color in DAF effluent averaged approximately 6 color units, which is well below the limit of 15 color units.

The aluminum residual in filter effluent was relatively high (see Appendix P). When raw water from the Terminal Reservoir was treated, the aluminum residual was well below the general treatment goal of 0.2 mg/L. However, when Lake Lopez water was treated, the 0.2 mg/L goal was exceeded twice. This was probably due to the higher pH of the Lake Lopez water. The raw water pH of the Terminal Reservoir averaged approximately 8.25 while that of Lake Lopez averaged approximately 8.4. Aluminum (from polyaluminum chloride) is more soluble at a higher pH.

6.3.6. Float Sludge

During pilot testing, DAF float sludge samples were sent to the Leopold laboratory for analysis of total solids. The average solids concentration was 2.35%, which is higher than that for other sedimentation processes. The higher solids content may translate to easier management and faster dewatering.

6.4 Conclusions and Recommendations

The pilot testing at the Lopez WTP demonstrated that DAF is an effective pretreatment process for particle and algae removal. However, because of the presence of submicron particles, which were very difficult to coagulate, filter performance did not meet the District's turbidity goal of 0.05 NTU in the filter effluent (during the upset event in September), but could meet the DHS requirement of 0.3 NTU. The log removal of particles >2 micron by DAF/filtration was considerably higher than the *Cryptosporidium* log removal of 2.0 in filter systems required by IESWTR, and thus an exception to the *Cryptosporidium* Action Plan could be granted if the District chooses to meet DHS requirements with minimum capital expenditure. However, if the District's water quality goals are to be met, a more expensive membrane process such as MF or UF could be implemented with appropriate pretreatment. An economic analysis of the various treatment alternatives was presented in Chapter 5.

Pre-oxidation by chlorine dioxide was found to be effective in manganese oxidation and in enhancing particle removal by DAF and filters. It is recommended that a full-scale chlorine dioxide test be conducted to determine its effectiveness in reducing DBPs (with post-chloramination) and in enhancing particle removal. However, the dosage should be kept to a maximum of 1.0 mg/L to avoid high chlorite residual in the treated water from Lopez WTP. If a higher chlorine dioxide dosage were required, the use of ferrous sulfate as a supplemental coagulant would be necessary to convert residual chlorite to chloride.

Chapter 7. Final Recommendations

This chapter provides a summary of recommendations for each portion of the WTP investigated as part of Black & Veatch's audit. Investigation into the needs of the WTP is discussed in detail in Chapter 4. These improvements should be implemented based on the priority listing contained at the end of the chapter.

The following general improvements are recommended:

- Reroute the existing piping configuration from the clear water reservoir to the transmission pipeline.
- Provide all structures that are to be reused a complete protective coating or sealer that will provide extended life to the concrete. (This was completed in spring 2002.)
- At a minimum, evaluate all structures designed prior to 1997 for necessity of seismic upgrade.
- Ensure all structures are ADA compliant.
- Upgrade or replace the entire electrical and instrumentation system including SCADA.
- Provide an adequate fire alarm system including both local and remote notifications in all buildings.
- Provide maintenance-intensive items, such as pumps, with a standby unit to provide redundancy.
- Provide the WTP with a full set of safety gear and equipment including confined space entry equipment, gear, and measuring devices.
- Test the septic tank and leach field for percolation time and efficiency. Pump the septic tank during this process.

Recommendations regarding specific areas of the WTP are summarized below.

7.1 Lopez Lake

The Intake Tower should be able to meet the WTP's future needs. However, the following recommendations were made:

- The log boom should be modified such that it can be adjusted according to water level.
- Handrails should be provided on the stairway leading to the gates.
- Gate operation should be upgraded so that it can be accomplished remotely.

The Outlet Works is being reconstructed under separate contract with the District. Therefore, additional improvements as part of any upgrade or retrofit to the Lopez WTP are not needed.

7.2 Raw Water Pipeline

It is recommended that the air-vacuum relief valves be replaced due to their age. Those sections of the raw water pipeline from Lopez Lake that may cross Arroyo Grande Creek aboveground would need to be repaired or replaced to ensure no possibility of intrusion or loss of flow to the Terminal Reservoir. Flexible connections should be included as part of the upgrades. As an alternative, pipeline rehabilitation with a continuous liner may be considered.

7.3 Terminal Reservoir

Based on feedback from operations personnel, we do not foresee any major problems with the continued use of the Terminal Reservoir and believe it should be able to last for the life of the expanded WTP (20 years).

Based on review of data from the pilot study, it is anticipated that the WTP, as improved with the recommendations herein, will be able to meet regulatory treatment standards for treated water using either water directly from Lopez Lake or the Terminal Reservoir. However, the WTP would require a waiver from the DHS to use Lake Lopez water. **Therefore, Black & Veatch recommends continued use of the Terminal Reservoir.**

The following are recommended for the Terminal Reservoir:

- Upgrade the flow control valve to provide remote control capability.
- Remove aquatic weeds in the Terminal Reservoir.
- If the District were to require water quality improvements to the Terminal Reservoir in the future, Black & Veatch recommends consideration of capping of bottom sediments or aeration.

7.4 Hydroelectric Facility

After review of the condition of the hydroelectric facility and its potential effects on water quality, Black & Veatch believes that, while operation is viable, the upgrades necessary are cost-prohibitive and the facility should not be used in the future. Based on this, several recommendations made during the audit for repair have not been expanded upon herein.

7.5 Raw Water Influent Vault

For security reasons, parking near the vault should be limited. In addition, entry into the vault falls within confined space entry regulations. Confined space equipment should be kept on site, and personnel should be trained and familiar with the requirements.

Structural Recommendations:

- Clean and apply new coating system to vault hatch covers.
- Replace piping mechanical coupling.

Electrical Recommendations:

- Provide a raceway system (conduits, condulets, LB's, junction boxes, etc.) for electrical wiring inside the vault.
- Move receptacles to the top of the vault to prevent possible flood damage. For personnel and maintenance safety issues, receptacles should be replaced with GFCI (Ground Fault Circuit Interrupter) type receptacles.
- Replace wires and cables.

7.6 Pretreatment

Under the recommendation accepted by the District (Alternative 7 from Chapter 5), each of these treatment processes will be upgraded or replaced.

Rapid Mix

Black & Veatch recommends placing the new mixer that the District has purchased in the existing rapid mix chamber. In addition, the District should place an additional mixer within the recommended pretreatment upgrade, for a total of two mixers. This should provide adequate mixing and redundancy.

Flocculation / Sedimentation

Membrane filtration by itself or even with coagulant feed ahead of the membranes, typically is not very effective in removing organics and certain inorganic contaminants. The purpose of pretreatment for membranes is different than that for conventional treatment, because pretreatment is not necessary to meet the turbidity goal of < 0.1 NTU. Membrane filtration will be able to achieve this without the need for pretreatment.

Black & Veatch recommends pretreatment upstream of membrane filtration in order to improve removal of dissolved contaminants, such as color, dissolved organic carbon (DOC) and DBP precursors. Onsite pilot work and bench scale testing indicate that pretreatment will be necessary for proper conditioning of the raw water prior to introduction to the membranes. Failure to remove organics would most probably result in an inability to meet the Stage 1 DBP-Rule and would require the membranes to operate at a very low flux rate or require chemical cleaning more frequently than every 21 days.

Black & Veatch believes that DAF is the best available technology (BAT) for pretreatment of this water. Therefore the costs presented for pretreatment of the recommended process is for DAF. The DAF upgrade will include new flocculators and a new process to replace sedimentation. The entire DAF process will fit within one of the existing sedimentation basins. Figure 7.1 illustrates the potential DAF configuration. The configuration assumes that two 3-mgd DAF units (for a total capacity of 6 mgd) will fit within one of the existing basins.

Pretreatment should be confirmed during design. In whatever pretreatment process is selected, Black & Veatch recommends that the pretreatment process be piloted with the selected membrane process during the process procurement step, as discussed in the following subsection on membrane filtration.

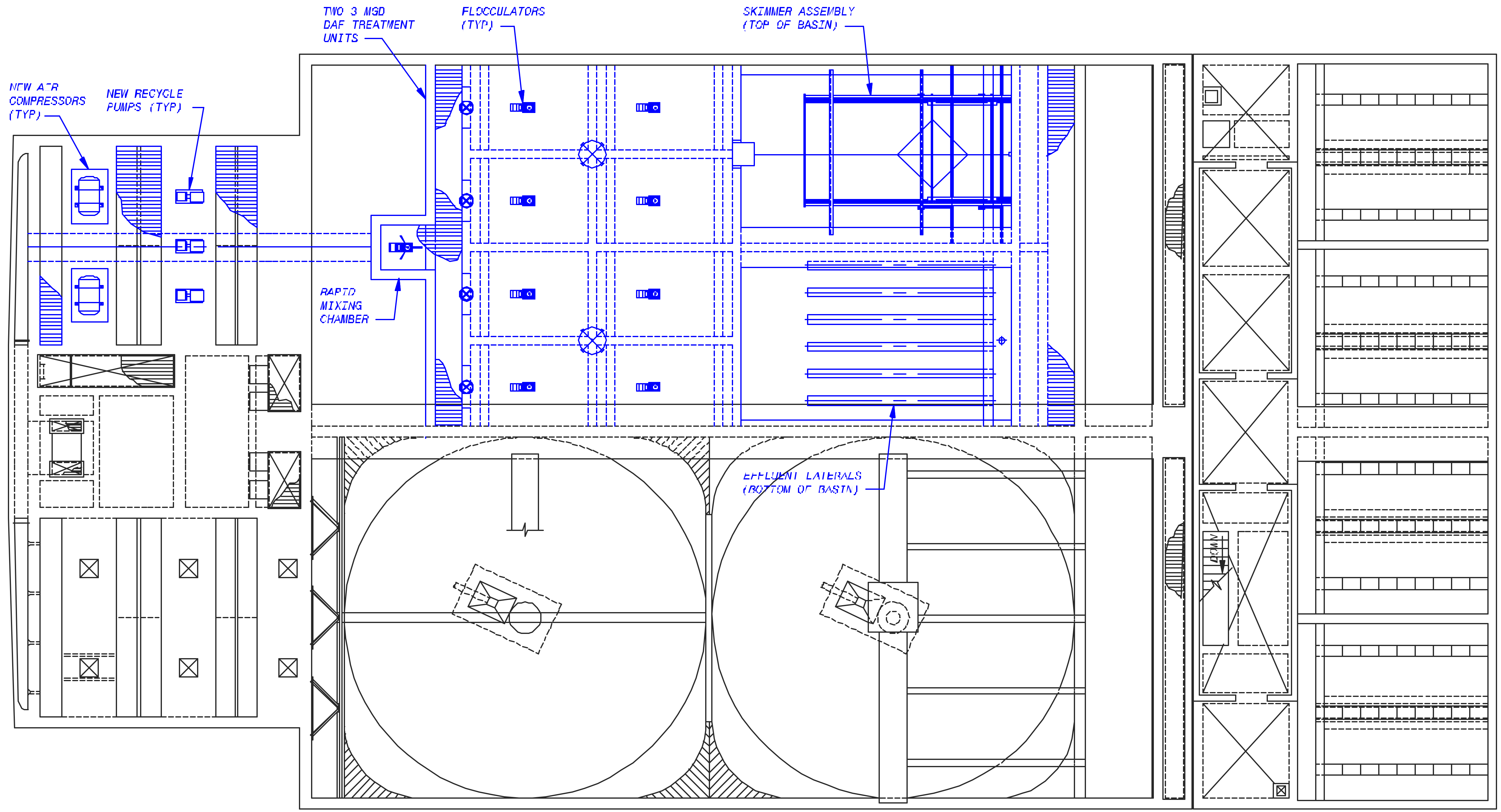


FIGURE 7-1

FUTURE TREATMENT LAYOUT

7.7 Filtration

Under the accepted recommendation, the existing filter units will be replaced with membrane units. The membranes will be placed either in or on top of the existing filter basin; therefore, structural and electrical recommendations for the buildings will be included in the WTP upgrade.

The difficulty for the designer in preparing plans and specifications for membrane filtration is the reality that currently seven vendors that have received DHS certification to provide potable water membrane filtration equipment in California. See Figure 7.2.

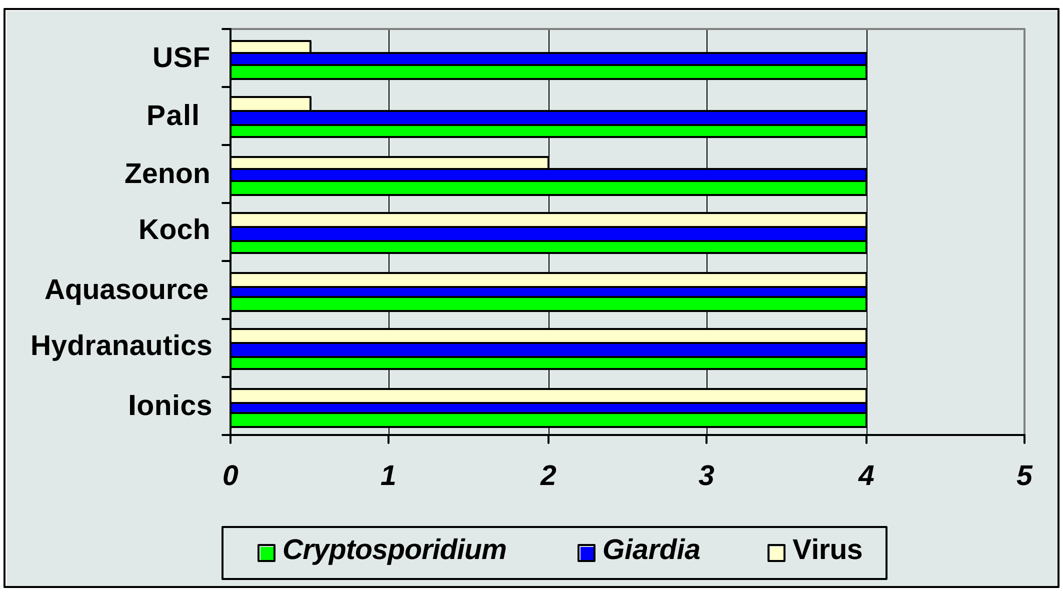


Figure 7.2: DHS Removal Credits for Membrane Vendors

The seven vendors have different system approaches to providing membrane system design but these approaches have similarities. Five of the vendors, Aquasource, Hydronautics, Ionics, Koch, and Pall, use pressure driven systems, as shown in Figure 7.3.

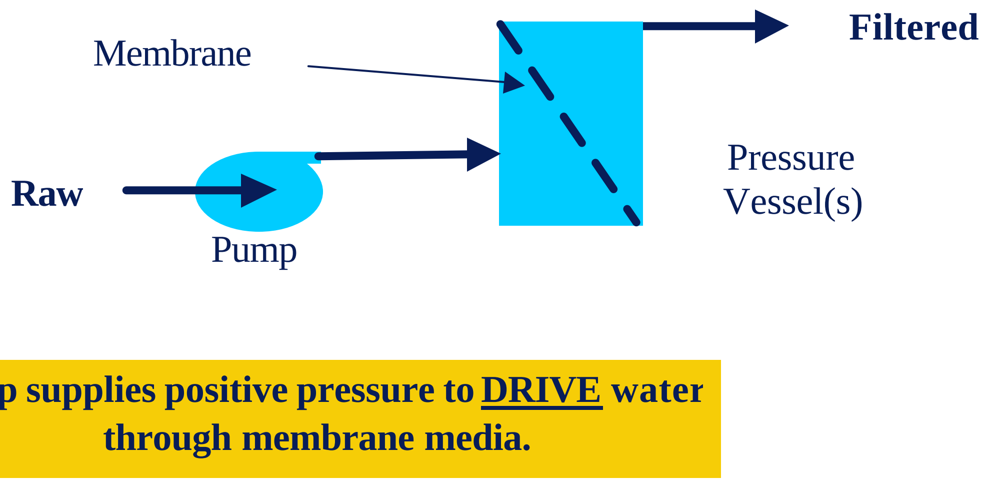


Figure 7.3: Pressure Cartridge Membrane System

One of the membrane vendors, Zenon, uses permeate pumps following the membranes to create a vacuum on the membrane fibers, as shown in Figure 7.4. This type of system is called submerged, or immersed, membrane technology. The seventh vendor, US Filter, has the largest total number of membrane systems in service in California. US Filter now manufactures both pressure cartridge and immersed membrane systems.

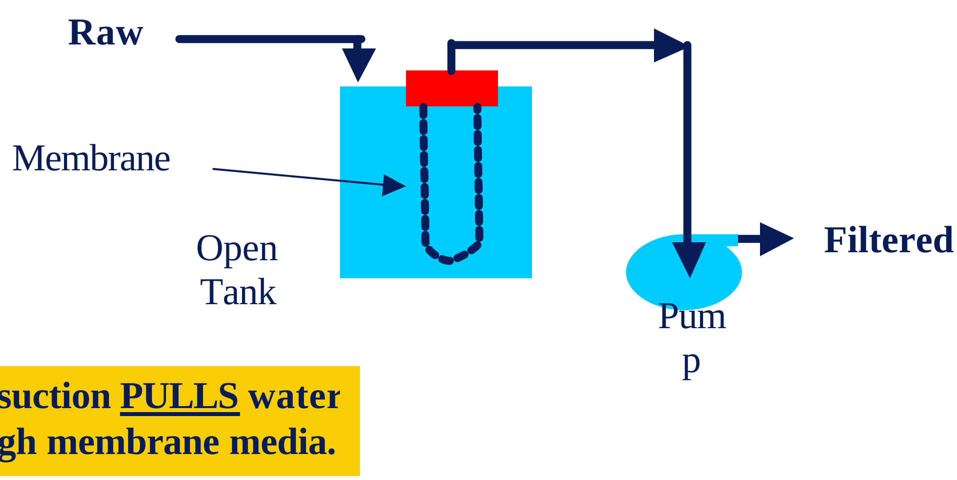


Figure 7.4: Submerged of Immersed Membrane System

7.7.1. Membrane Procurement

Black & Veatch recommends that the District use an evaluated bid process for the selection of the Membrane System Supplier (MSS) for this project. Membrane technology continues to evolve at a dizzying pace. In addition to having DHS certification, it is important to ensure that the membrane system being proposed has operational experience at the time of Bid. Differing requirements for each of the membrane manufacturers' equipment makes it advantageous to select the membrane supplier early in the design process. This will result in the following benefits to the District:

- Provides a more efficient and focused design, as the specific equipment requirements of the system are known.
- Reduces the required coordination effort and minimizes risk for the General Contractor, thereby reducing ***construction*** bid prices.
- Shortens the construction schedule as the MSS can plan for and potentially begin fabrication of the equipment early.
- Reduces the potential for change orders because the design conditions are clearly identified.

7.7.2. Conceptual Alternatives for Lopez WTP

Figure 7.5 and Figure 7.6 present, respectively, a layout for the pressure cartridge membrane system and for the submerged membrane system.

<u>Pressure Cartridge Membrane System.</u> The pressure cartridge system would be accomplished by simply constructing a new, approximately 4,000 square foot building immediately west of the existing treatment train. The building would house the following equipment:

- Membrane filtration skids
- Clean-in-place (CIP) equipment
- Membrane and CIP PLC Control Panels
- Backwash equipment (equalization tank and pumps)
- Compressors for air backwash and valves.

Outside the building, potentially in the effluent end of the existing sedimentation basins would be the:

- Membrane feedwater pumps
- Strainers

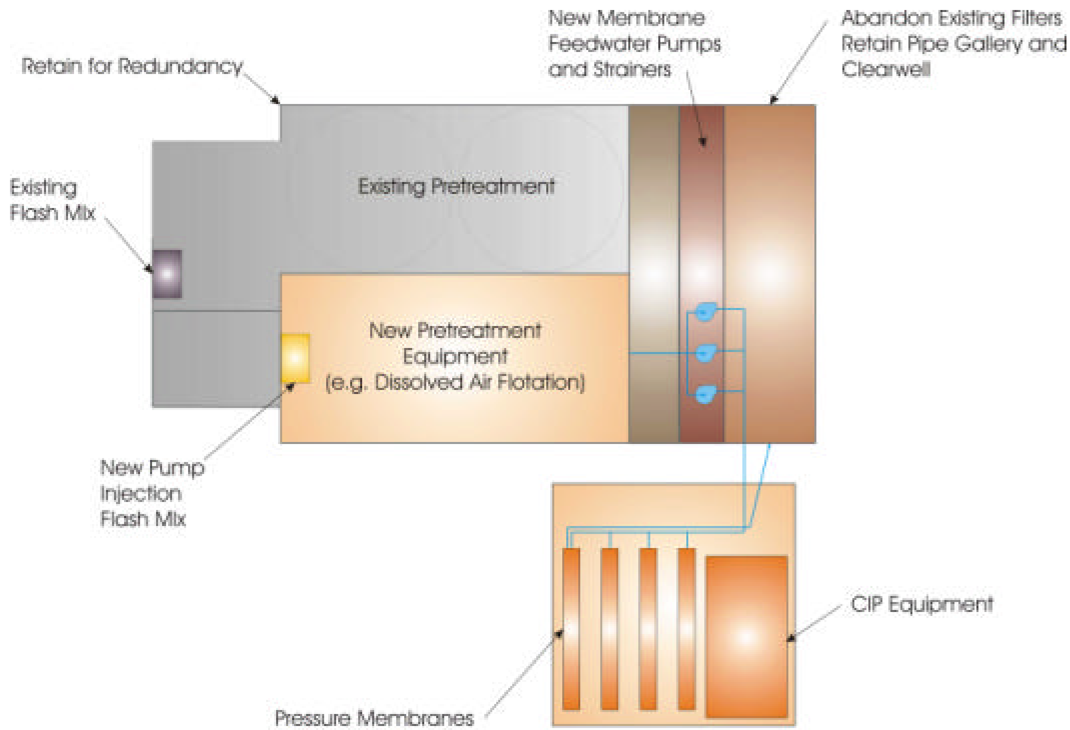


Figure 7.5: Pressure Membrane Alternative

Submerged Membrane System. The submerged membrane system would be constructed in the end of the existing sedimentation basins. With the high rate equipment recommended for pretreatment, the entire basin area would not be needed. Four nominal 2-mgd trains could be constructed, 2 in each sedimentation basin. It would be recommended to put a structure or sunshade over the membrane trains for increased longevity. The existing filter pipe gallery could be used to house the following equipment:

- Horizontal permeate pumps.
- Piping.
- Clean-in-place (CIP) equipment
- Membrane and CIP PLC Control Panels
- Backwash equipment (equalization tank and pumps)
- Blowers for air backwash and valves.

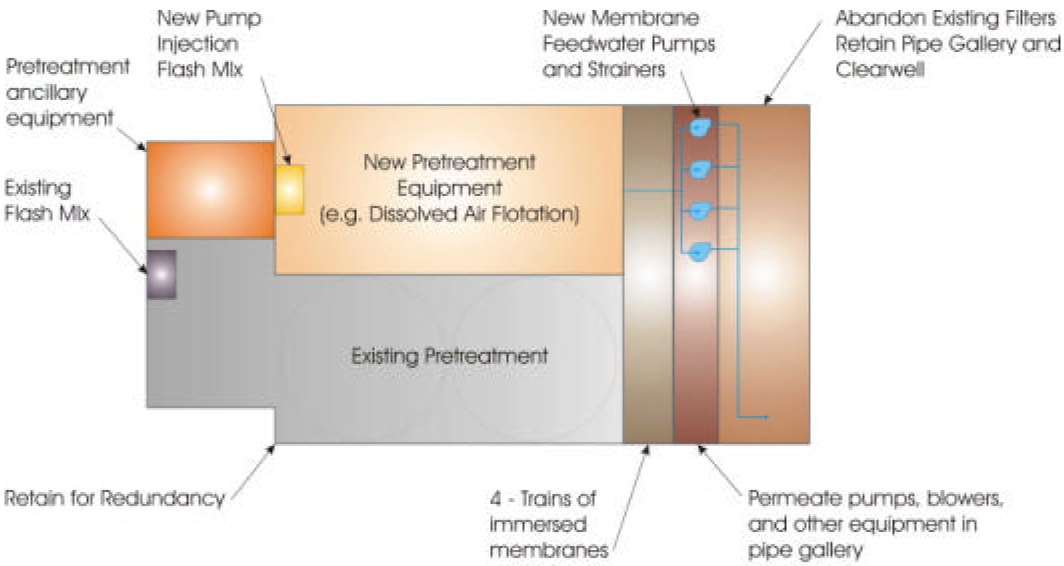


Figure 7.6: Submerged Membrane Alternative

7.8 Disinfection

Black & Veatch recommends a pre-oxidant of chlorine dioxide, potential pre-chlorination, final chlorination, and continuing ammonia feed for chloramines. For chlorination, we are recommending an onsite sodium hypochlorite generation facility. In addition, we recommend providing a stub out during the WTP upgrade for potential future UV disinfection.

7.9 Bypass Vault

Black & Veatch makes the following recommendations:

- Investigate the installation of a mixer prior to the ammonia sample line to provide better mixing.
- Provide ammonia injection prior to the Clearwater Reservoir.
- Install leak proof access hatches that are either lighter or have hydraulic lifts.
- Since the vault requires confined space entry, house confined space equipment on site and train staff of the requirements.

7.10 Clearwater Reservoir (2.1 MG)

Black & Veatch makes the following recommendations:

- Reroute piping from Clearwater Reservoir to transmission main (see Appendix L).

- Once the piping has been re-routed, baffling within the reservoir should be investigated.

Structural Recommendations:

- Replace reservoir roof (cover).
- Check connection of the roof and foundation to the tank perimeter wall. Verify that connection prevents independent movement of the roof during a seismic event.
- Extend the wall foundation around circumference of the reservoir and install a restraining ring beam to prevent excessive lateral movement of the wall.
- Provide carbon fiber sheet wrapping for lower portion of exterior face of reservoir sidewall to provide increased capability for the wall to withstand forces.
- Install flexible expansion connection to common inlet/outlet and overflow pipes to allow for flexibility during a seismic event.
- Provide seismic actuated valves for inlet and outlet piping in an accessible valve vault that would isolate the tank if the pipes became damaged and ensure minimal release of potable water after an earthquake event.
- Provide grating at the pipe entrance inside the tank to minimize spalled concrete from entering the distribution system.

7.11 Ammonia Station

The following are recommended:

- Provide chemical storage with secondary containment
- Provide redundancy for ammonia pumping.
- Provide new flow controls for ammonia.

7.12 Finished Water Meter Vault

Since this vault is located in the Lopez Drive roadway, a second manhole, inside property fencing, should be provided. Additionally, the meter should be replaced with a venturi meter or a buried magnetic flowmeter.

7.13 Domestic Water Tank (50,000 gallons)

The exterior of the domestic water tank should be recoated.

<u>Structural Recommendations</u>:

- Extend the ring footing.
- Install anchorage (tank to foundation) on 18-inch centers to meet anchorage requirements in the Uniform Building Code (UBC). This would address both lateral and vertical displacement during a design seismic event.
- Install flexible expansion connection to common inlet/outlet, drain, and overflow pipes to allow for flexibility during an earthquake event.
- Provide a motion actuated valve in an accessible valve vault to ensure minimal release of domestic water after a seismic event.
- Remove existing roof coating system and recoat.

7.14 Wash Water Tank (300,000 gallons)

Since membrane filtration is being recommended, this tank can either be abandoned or removed and salvaged. The required repairs are not needed unless the District elects to use the tank for some other purpose. If this is opted for, the interior of the wash water tank should be recoated.

<u>Structural Recommendations</u>: (Only if tank is used on site.)

- Extend the ring footing.
- Install anchorage (tank to foundation) on 18-inch centers to meet anchorage requirements in the UBC. This would address both lateral and vertical displacement during a design seismic event.
- Install soil anchors if, during further evaluation, it is determined that the ring foundation cannot take uplift from anchorage.
- Evaluate thickening the bottom shell of the tank by adding additional plates to prevent buckling. This should be verified.
- Evaluate reinforcement of the roof in the form of stiffeners using steel members.
- Install flexible expansion connection to common inlet/outlet, drain, and overflow pipes to allow for flexibility during an earthquake event.
- Provide a seismic actuated valve in an accessible valve vault to ensure minimal release of wash water after an earthquake event.
- Remove existing roof coating system and recoat.

7.15 Sludge Pump Room

Electrical Recommendations:

- Replace panel with newer panel. A new panel will simplify maintenance and breaker replacement.
- Replace the panelboard “LS” and lighting fixture supports.
- Provide covers for the open terminal cabinets in order to prevent the risk of human contact with live wires.
- Identify (tag) and group wires inside the terminal cabinet to facilitate troubleshooting and wire tracing.
- Splice/connect wires in accordance with electrical codes.

7.16 Administration Building

During the WTP audit, Black & Veatch determined that the asbestos roof should be repaired or replaced. Modifications to the existing operations building should include expansion of the operations/plant control area, offices, crew quarters, laboratory, and lockers. Figure 7.7 illustrates the requirements for the future site layout.

In addition, the following structural and electrical recommendations are made:

Structural Recommendations:

- Provide lateral restraint straps for water heater and boiler room piping.
- Provide HVAC ducts with lateral restraints per SMACNA.
- Provide lateral braces for ceiling tiles.
- Anchor and provide latches for shelves and file cabinets.
- Inject epoxy grout into surfaces with cracks.

Electrical Recommendations:

- Replace panel with newer panel. A new panel will simplify maintenance and breaker replacement.
- Replace fluorescent lighting fixtures for all facilities in the WTP with the more energy efficient T8 (32 watt) fluorescent lamps and electronic ballasts.

- Upgrade the controls and wiring for the WTP to a PLC distributed control/SCADA system and remove the old control console.

7.17 Chemical Building

Modifications to the existing chemical building should include a total upgrade to comply with new regulations and best management practices and an expansion to provide for additional chemical storage (Figure 7.7 illustrates the requirements for the future site layout). The following additional general recommendations are made regarding the chemical building:

- Install appropriate ventilation.
- Install appropriate alarms and strobes.
- Provide appropriate secondary containment for all tanks.
- Provide appropriate separate pumps with backup for all chemical pumps.
- Upgrade to appropriate wiring placed within conduit.
- Replace potable water pumps.
- Remove chemicals that are old and no longer used.
- Replace roof to be compatible with chemical storage.

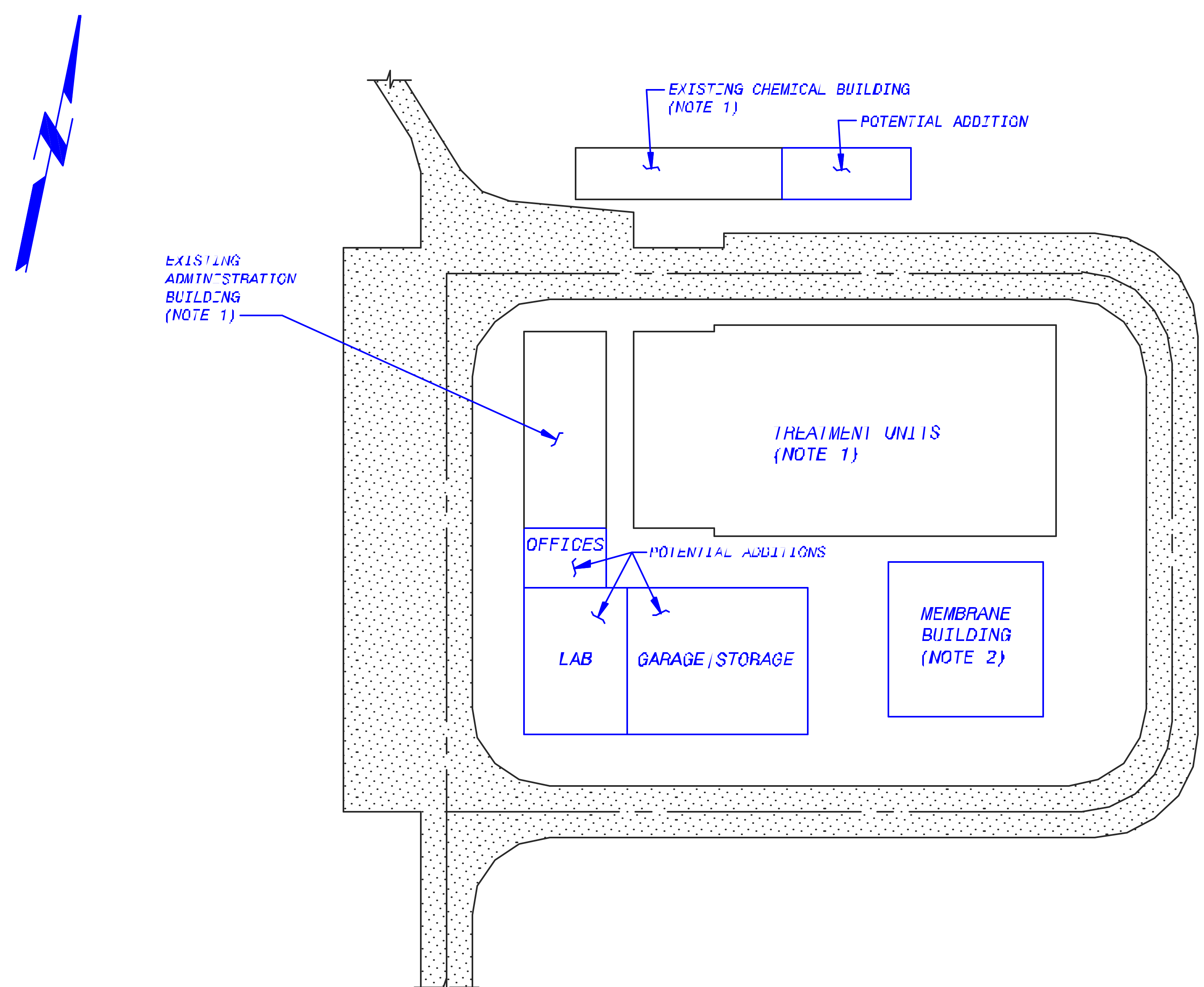
Structural Recommendations:

- Clean exterior surfaces of walls and slab removing corrosion and apply Sika Top Seal 107 as a sealant and preservative.
- Inject epoxy grout into cracks or repair concrete cracks by chipping out damaged areas and then applying a polymer-modified mortar.
- Provide lateral restraints for the piping, tanks, and electrical gear.
- If possible, provide flexible expansion joints on the chemical tanks.
- Provide anchors for metering pumps.
- Provide containment for various chemicals.

Electrical Recommendations:

Electric Room

- Provide complete update of electrical distribution system.



NOTE:

1. ADMINISTRATION BUILDING, CHEMICAL BUILDING AND TREATMENT UNIT UPGRADES WILL BE MADE WITHIN THEIR ORIGINAL FOOTPRINT.

2. REQUIRED FOR PRESSURE MEMBRANE ALTERNATIVE ONLY.

FIGURE 7-7

FUTURE TREATMENT PLANT LAYOUT

- Replace the #3/O cables between 400-ampere main breaker in MDB and 200-ampere wall mounted breaker feeding the automatic transfer switch (ATS).
- Replace tap conductors and modify tapping method used to meet NEC, Article 240-21-b.
- Replace panel with newer panel. A new panel will simplify maintenance and breaker replacement. This applies to all electrical equipment in electrical room.
- Replace lighting fixtures.

Shop, Polyelectrolyte Room, Activated Carbon Room, and Chlorine Cylinder Room

- For improved efficiency, upgrade lighting fixtures in all rooms and basement of chemical building to T8 type, 32-watt lamps with electronic ballasts.

Basement

- Replace covers on open and abandoned control switches on the east side, south wall of basement. Tag and cover all spare/unused wires inside wireways to prevent accidental touch hazard.
- Provide protection of wires for fire alarm system in accordance with NEC.
- Replace the conduit stub-ups and control stations for domestic water pumps. Pump M-18 may need to be replaced in near future.
- Replace the disconnect switch for the rotodip motor.

7.18 Residuals Handling

It is recommended that the existing sludge ponds be cleaned and upgraded to allow for better sludge storage and ultimate disposal.

7.19 Chemical Feed Systems

Existing chemical feed systems will be modified for the WTP upgrade. No new chemicals, except chlorine dioxide and possibly ferric chloride, will be required in the WTP upgrade. The following chemical systems will be retained:

? Alum - Potential coagulant.

? Sodium Hypochlorite in place of chlorine - Primary and residual disinfection.

? Potassium permanganate for taste and odor control as needed.

? Ammonia.

All chemical areas should be provided with applicable code compliance including curbs and holding capacity around each tank, upgrade of each pumping system for redundancy, and all other safety features like eye wash, showers, etc.

7.20 Recommended WTP Staffing

Based on a WTP staff survey, the total number of staff at a 6 mgd capacity WTP was estimated to be one supervisor and between 5 and 10 staff persons including laboratory staff as shown below. The number of operators should be about 2 to 3. The WTP staffing survey data suggest that the current staffing level for the District is appropriate provided the people are dedicated full time to the WTP.

- WTP Supervisor
- Dedicated operators (at least 2-3)
- 24 hour operation
- Dedicated maintenance staff (1-3)
- Dedicated electrical/instrumentation technician (1-2)
- Dedicated laboratory staff (1-2)

DHS has provided information leading Black & Veatch to the conclusion that the upgrades recommended within this Report will not affect the classification ratings of either the WTP or its distribution system. (Based on discussion with DHS, the WTP will remain at a classification of T4 and the distribution system will remain at a classification of D3.) As such, pursuant to Title 22, Division 4, Chapter 13 of the DHS regulations, the chief operator will be required to maintain a minimum Grade IV certification (T4) and the shift operator will be required to maintain a Grade III certification (T3).

The County should be able to comply with the staffing requirements from DHS. Additional training will need to be included with the design and construction of the recommended facilities. The new facilities will include a higher level of process automation, so reliance on programmable logic controllers (PLCs) will require special training in maintenance and troubleshooting.

7.21 Summary

Black & Veatch anticipates that the District will produce a request for proposal (RFP) for consulting services for the design of the upgraded WTP, as described in this chapter. Black & Veatch recommends that the District initiate some improvements while the design process is ongoing.

7.22 Five-Year Capital Improvement Plan

A schedule and approximate cost for a proposed 5-year capital improvement plan (CIP) are provided at the end of this chapter. These encompass the improvements recommended in this Audit Report. Improvements were prioritized based on input gained from workshops conducted with the District.

Five Year Capital Improvement Program and Improvement Prioritization
Lopez Water Treatment Plant

Task Name	*Priority*	*Cost*	
Preliminary Engineering			
Scoping Meeting	1	$ -	
Prepare TDM	1	$ -	
Environmental			
Environmental Studies	1	$ 51,000	
Environmental Determination	1	$ 10,000	
Permit Processing	1	$ 50,000	
Environmental Complete	1	$ 2,000	
Design			
Prepare RFQ	1	$ 7,000	
Send RFQ	1	$ 2,000	
Receive Consultant Qualifications	1	$ 10,000	
Prepare Design RFP	1	$ 6,000	
Final RFP/BOS Letter	1	$ 3,000	
BOS Item/Send RFP	1	$ 2,000	
Consultants prepare proposals	1	$ -	
Preproposal Meeting/Plant Tour	1	$ 2,000	
Review Proposals	1	$ 10,000	
Select Consultant	1	$ 2,000	
Prepare BOS Letter/Contract	1	$ 2,000	
BOS Item	1	$ 2,000	
Design Notice to Proceed			
Consultant prepares 10% Design	1	$ 400,000	
Review Design	1	$ 50,000	
Select Equipment/Pilot proofing	1	$ 50,000	
Consultant prepares 65% Design	1	$ 400,000	
Review Design	1	$ 50,000	
Consultant prepares 90% Design	1	$ 350,000	
Review Design	1	$ 50,000	
Final 100% Design	1	$ 200,000	
R/W & Utilities			
Relocate Utilities	1	$ 100,000	
R/W Certification	1	$ 10,000	
R/W & Utilities Complete	1	$ -	
Construct			
Prepare Bid Package/BOS letter	1	$ 50,000	
BOS Item/send Bid Package	1	$ 50,000	
Bids due	1	$ -	
Contract/BOS Letter	1	$ 10,000	
BOS Item/Contract Award	1	$ 7,000	
Construction			
Notice to Proceed	1	$ -	
Construction Complete	1	$ 8,138,055	*
Environmental Mitigation			
Environmental Mitigation Complete	1	$ -	
Lopez Lake Intake			
Gate Operation	5	$ 10,000	
Raw Water Pipeline			
Replace Air-Vacuum Relief Valves	1	$ 150,000	
Repair/Replace Aboveground Sections	1	$ 500,000	
Provide Flexible Connections	1	$ 50,000	
Terminal Reservoir (TR)			
Remote Control of Flow	5	$ 80,000	
Aquatic Weed Removal	5	$ 150,000	
Raw Water Influent Vault			
Re-Coat Vault Hatch Covers	3	$ 1,000	
Replace Mechanical Coupling	3	$ 50,000	
Electrical Upgrades	vary	$ 10,000	
Install Rapid Mix	1	$ 10,000	
Bypass Vault			
Potentially Install Static Mixer	1	$ 100,000	
Access Hatches	2	$ 75,000	
Clearwater Reservoir			
Replace cover	3	$ 400,000	
Seismic Upgrades	vary	$ 150,000	
Ammonia Building			
ADA Compliance	2	$ 20,000	
Shear Wall Anchorage	2	$ 10,000	
Secondary Containment	3	$ 10,000	
Redundant Pump	3	$ 10,000	
New Flow Controls	3	$ 20,000	
Finished Water Meter Vault			
Install New Manhole	3	$ 40,000	
Replace Flow Meter	3	$ 50,000	
Domestic Water Tank			
Re-Coat Exterior	3	$ 80,000	
Wash Water Tank			
(Abandon in Place)			
Administration Building			
(WTP Electrical and Instrumentation are included with Plant costs above)			
ADA Compliance	2	$ 100,000	
Repair / Replace Roof	1	$ 100,000	
Structural Upgrades & New Expansion	vary	$ 900,000	
Electrical Upgrades for Building	vary	$ 110,000	
Sludge Pump Room			
Electrical Upgrades (included in electrical)	vary	$ -	
Pipe Gallery			
Electrical Upgrades (included in electrical)	vary	$ -	
Chemical Building			
Ventilation, Alarms, Strobes	2	$ 40,000	
Secondary Containment	1	$ 100,000	
Redundant Chemical Pumps	3	$ 100,000	
Replace Potable Water Pump	3	$ 25,000	
Remove Old Chemicals	1	$ 20,000	
Replace Roof	1	$ 100,000	
ADA Compliance	2	$ 100,000	
Structural Upgrades	vary	$ 450,000	
Electrical Upgrades	3	$ 112,000	
Fire Alarm System	1	$ 50,000	
TOTAL CIP COST		***$ 14,359,055***	

* All costs not covered separately above are included in this item