Sewerage and Water Board of New Orleans

Carrollton Water Treatment Plant

Water Quality Master Plan

Final

July 2015

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Abbreviations

AL	action level
CCT	corrosion control treatment
CF	cubic feet
CFE	combined filter effluent
CIP	capital investment program
CPE	comprehensive performance evaluation
D/DBPR	Disinfectant/Disinfection By Products Rule
DBP	disinfection byproduct
ENO	Entergy New Orleans
EPA	Environmental Protection Agency
ESWP	Electrical Safe Work Practices
FRP	fiberglass reinforced plastic

GPD	gallon per day
GPM	gallon per minute
HAA5	sum of five haloacetic acid species
HP	horsepower
HZ	Hertz
IESWTR	Interim Enhanced Surface Water Treatment Rule
IFE	individual filter effluent
LCR	Lead and Copper Rule
LRAA	locational running annual average
LSI	Langlier Saturation Index
LT2ESWTR	Long-Term Enhanced Surface Water Treatment Rule
MCL	maximum contaminant level
MGD	million gallons per day
MRDL	maximum residual disinfectant level
NOM	natural organic matter
NRS	Industrial Avenue River Station
ORS	Oak St. River Station
PAC	powder activated carbon
PLC	programmable logic controllers
POE	point-of-entry
PPE	personal protective equipment
PSI	pounds per square inch
RAA	running annual average
RPM	revolutions per minute
SF	square feet
SMCL	secondary maximum contaminant level
SOR	surface overflow rate
SWBNO	Sewerage and Water Board of New Orleans
SWBPP	Sewerage and Water Board of New Orleans Power Plant
SWTR	Surface Water Treatment Rule
TCR	Total Coliform Rule
TOC	total organic carbon

TTHM	total trihalomethanes
VFD	variable frequency drive
WQP	water quality parameter
WTP	water treatment plant

1. Introduction

The Sewerage and Water Board of New Orleans (SWBNO) owns and operates a potable water treatment and distribution system to provide the residential, commercial and fire protection needs of the City of New Orleans (City). Water is supplied to meet system demands by two water treatment plants (WTPs) - the Carrollton and the Algiers WTPs. The Carrollton WTP provides an average flow of 144 million gallons per day (MGD) to the East Bank customers; while the Algiers WTP provides an average 10.4 MGD to the West Bank customers. Both facilities use the Mississippi River as their source of supply.

Both facilities have been providing safe and reliable drinking water to customers throughout the City. The treatment plants and distribution system have evolved over the years to meet the increasing needs of the area while maintaining the necessary high quality standards for drinking water. Current and upcoming regulations are continuing to impact treatment and operations. In addition, much of the equipment at both plants is original and has reached the end of its useful service life. In light of these considerations, the SWBNO has elected to complete a comprehensive condition and treatment process assessment of both WTPs. The condition and treatment process assessments are not only central to meeting regulatory requirements, but also essential to identifying the SWBNO's short and long-term capital planning and revenue needs. The comprehensive needs assessment will be used to develop a 20-year capital improvements plan (CIP) program that provides a roadmap for delivering safe and reliable drinking water to all of the SWBNO's customers.

1.1. Project Scope

The SWBNO has retained the ARCADIS/Trigon/Manchac team to complete a comprehensive Water Treatment Plant Master Plan and 20-year capital improvements program for the Carrollton and Algiers WTPs. The main objective of this Water Treatment Plant Water Master Plan is to provide the SWBNO with a comprehensive planning document that describes the features of each system, evaluates treatment performance with respect to water quality goals and regulatory requirements, and reviews the infrastructure necessary to support the current and future needs of the SWBNO. The Water Master Plan identifies and analyzes the SWBNO's major water treatment plant infrastructure needs and provides a list of projects and actions that address these needs in the form of a Capital Improvements Program (CIP) that optimizes the use of the SWBNO's resources and ensures financial feasibility. This Water Master Plan will serve as a guidance document for water improvements over the next twenty years.

The evaluation completed as part of this project was focused on operations, including the water quality of individual unit processes, reliability and redundancy, and production capacity. The operations assessment was limited to the Carrollton and Algiers treatment processes. Raw water supply, distribution infrastructure, and power systems were not reviewed as part of this project.

Key objectives of this Master Plan include:

- Providing the SWBNO with a planning document that can serve as a detailed roadmap for implementation of short, medium and long-term improvements for the SWBNO's treatment systems at their WTPs.
- Providing the SWBNO with a true "living" document that can be updated as conditions change.
- Providing a framework to prioritize improvements that will continue to provide the highest quality of water to the SWBNO's residents in a cost effective manner, while meeting the needs for future growth and maintaining system reliability.
- Providing one comprehensive source of reference for SWBNO current infrastructure and regulatory compliance needs.
- Reducing problems encountered during system modification due to lack of accurate records.

The results of the inspections and assessments for the Carrollton WTP are presented in this report, along with discussions of rehabilitation and replacement alternatives, opinions of probable costs, and recommended improvements. In consultation with SWBNO staff, the ARCADIS team has developed a staged program of recommended CIP projects, which addresses the 20-year planning needs at the Carrollton WTP. The assessment and recommended CIP projects for the Algiers WTP are presented in a separate report.

1.2. Background

The treatment system at the Carrollton WTP was constructed and modified in several phases. The current system includes four flocculation and sedimentation basins, three contact basins, 36 dual media filters, ten ground-level storage tanks, and three on-site pump stations. The four flocculation and sedimentation basins function as two separate treatment pairs of a single system. These are designated as the G and L Basins. Settled water from the G and L Basins are combined following sedimentation. Chlorine and ammonia are added to form chloramines for primary disinfection. Water then flows into the three contact basins (C Basins). The chloraminated water flow is then split between the Sycamore and Claiborne filtration facilities. The current design capacity of the Carrollton WTP is 240 MGD. A schematic of the existing Carrollton WTP process is presented in Figure 1-1.

The Carrollton WTP is supplied raw water from two intake structures on the East bank of the Mississippi River. Raw water is distributed to the WTP from the Oak St. River Station (ORS) or Old Pumphouse and the Industrial Avenue River Station (NRS), respectively. Currently, the G Basins are fed primarily from the ORS and by additional raw water supplied from the NRS. The L Basins are primarily fed by the NRS, but can be served by the ORS. A 54- inch and a 48-inch diameter line exit the ORS. The 54-inch diameter line feeds raw water to the south side of the G Basins. The 48-inch diameter line also feeds the G Basins, entering from the east. The 54-inch diameter line from the ORS is interconnected to two parallel 48-inch diameter lines feeding raw water from the NRS to the L Basins.

Chemicals can be applied to the raw water prior to the WTP. In the past, potassium permanganate was added at the intake pump stations for taste and odor control. This system is currently abandoned and powdered activated carbon (PAC) is now used for taste and odor control. PAC is added at the WTP after the static mixers in the G and L basins. Ferric sulfate is used as a coagulant and added in conjunction with a polymer at the inlet of the G and L Basins. The polymer serves as a coagulant aid to enhance floc formation and improve the sedimentation process.

The G-Basins are two identical treatment trains that include rapid mixing, flocculation, and sedimentation. Rapid mixing is accomplished by four static mixers, while flocculation is accomplished with horizontal paddle mixers. The sedimentation area includes an overflow weir and a sloped floor with four draw off points and monorake system for residuals removal. The two L Basins are smaller than the G Basins and each include a single static mixer for rapid mixing, perpendicular flocculators and five draw off points, and a monorake system for residuals removal.

Following flocculation and sedimentation, the settled water from the G and L Basins is combined and routed through distribution channels to three contact basins (C Basins). Chlorine and ammonia are added to the water in the distribution channels. The C Basins provide extended chloramine contact time for disinfection prior to filtration. Lime and polyphosphate are also added upstream of the C Basins for pH adjustment for corrosion control treatment. Fluoride is also added to the process water prior to filtration in the C Basin effluent channel for dental health reasons.

The existing filtration system is composed of two separate filtration facilities, the Sycamore and Claiborne Facilities. The Sycamore Facility includes 28 dual-media filters that consist of Filter Nos. 1-10, installed in 1906; and Filter Nos. 11-28 installed in 1932. The Sycamore filters are operated at loading rates of up to about 2.2 gpm/sf. The Claiborne Filter Facility is composed of eight dual-media filters installed in 1950, which are also operated at loading rates up to about 2.2 gpm/sf. Both filtration facilities have filters of a dual cell design. This design includes two separate filter cells separated by a center gullet.

Filtered water from the Sycamore and Claiborne Filters is either pumped directly to the distribution system or to ten ground storage tanks located near the Claiborne Facility which provide a total of approximately 36 million gallons of storage. These storage tanks provide backwash water for the filters as well as provide feed water for the distribution system. Three distribution pump stations are located on-site. These include the Claiborne High Lift Pump Station, the Panola Street Station, and the High Lift Building (Spruce Street). Interconnections between the filter galleries provide filtered water to the three pump stations.

Backwash water from the Sycamore and Claiborne Filters is drained to an on-site backwash equalization basin. Suspended matter is allowed to settle from the backwash water. The settled water is then recycled from the equalization basin back to the G or L Basins for treatment.

FIGURE 1-1

CARROLLTON WTP TREATMENT PROCESS SCHEMATIC

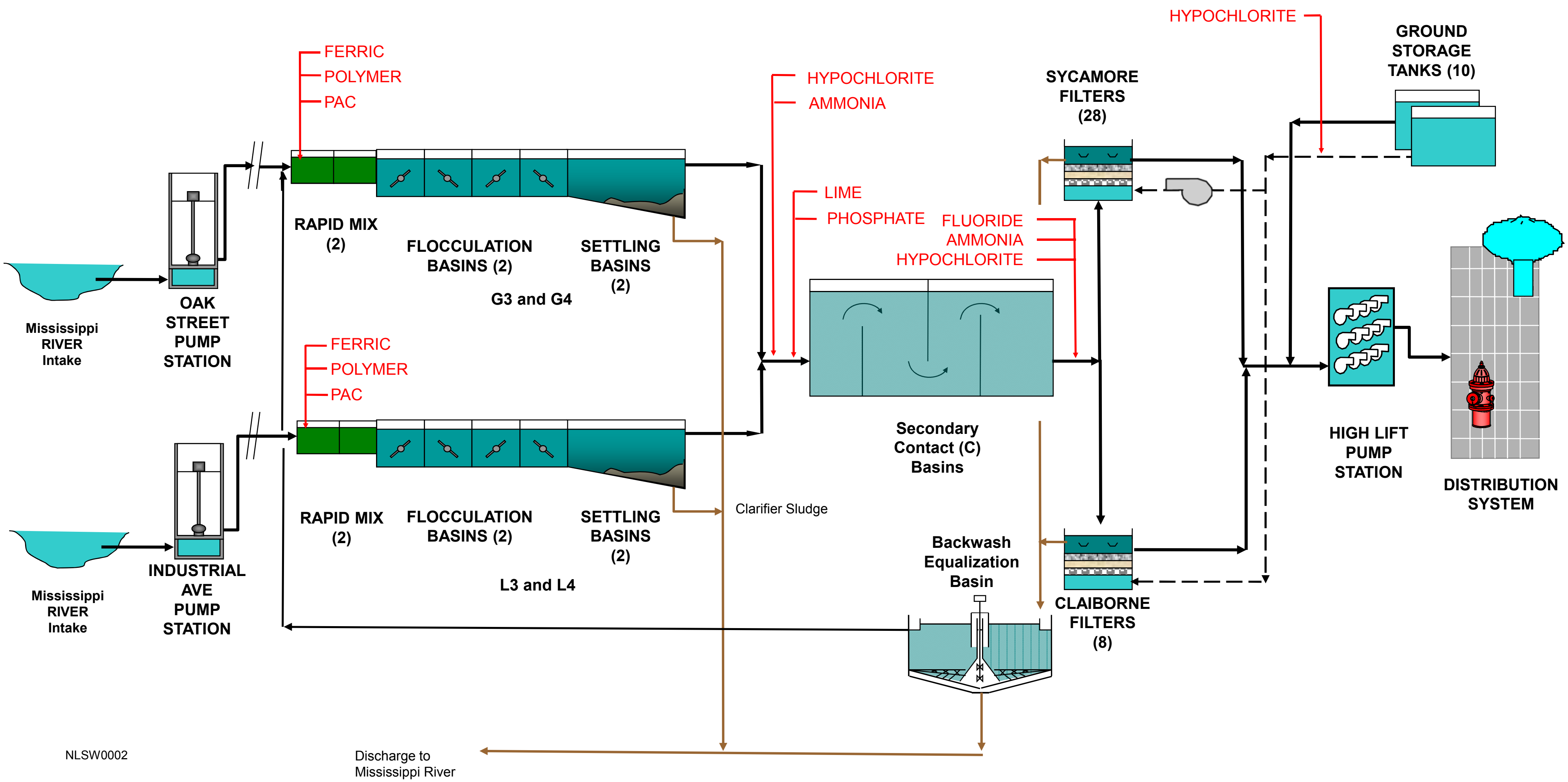

FIGURE 1-1

1.3. Report Organization

The Water Master Plan report for the Carrollton WTP is organized as follows:

- *Section 2 Water Quality and Treatment Performance* – This section evaluates current treatment performance at the Carrollton WTP with respect to meeting key regulatory requirements and the SWBNO's water quality goals.

- *Section 3 Treatment Process Assessment* – This section identifies needs with respect to Process Mechanical, Chemical Storage and Feed, and Residuals Handling Systems at the SWBNO's Carrollton WTP and presents alternatives and recommendations to address improvements required at the plants to meet regulatory/water quality, capacity, equipment condition, maintenance and operational needs. An assessment of the SWBNO's supply and distribution systems, including high service pumping was not included as part of this evaluation.

- *Section 4 Electrical Assessment* - This section identifies needs with respect to the Electrical Assessment of the various treatment process areas at the SWBNO's Carrollton WTP. It should be noted that an assessment of the facility's power supply, generation and distribution systems was not included as part of this evaluation.

- *Section 5 Structural Assessment* - This section identifies needs with respect to the Structural Assessment of the various treatment process structures at the SWBNO's Carrollton WTP and elevated ground storage tanks. It should be noted that administrative buildings and other structures not part of the treatment process were not included as part of this assessment.

- *Section 6 Prioritization of Improvements/Recommended 20-year CIP Implementation* - This section discusses the approach used to group and prioritize projects and develop the 20-year CIP for the Carrollton WTP, and presents the recommended list of prioritized projects and CIP implementation schedule.

2. Water Quality Performance

2.1. Introduction

This section discusses existing conditions and evaluates current system performance at the Carrollton WTP with respect to meeting regulatory requirements and water quality goals. An evaluation was completed to identify water quality constraints, treatment performance issues or regulatory compliance concerns. The evaluation consisted of:

- Examining the Sewerage and Water Board of New Orleans' (SWBNO's) existing regulatory requirements and associated water quality goals.
- Assessing historical water quality and operational data with respect to meeting regulatory requirements and water quality goals.
- Reviewing treatment process performance and identifying capital and operational improvements to meet regulatory, water quality and treatment objectives.

Section 2.2 summarizes the plant's water quality goals and performance, Section 2.3 discusses residuals handling requirements, while Section 2.4 summarizes historical chemical usage requirements used in assessing capacity and rehabilitation requirements of the chemical systems in Section 3.

2.2. Water Quality Goals and Performance

The Carrollton WTP has successfully provided clean, reliable and safe water to its customers since it has been in operation. The facility produces high quality water that meets Federal Drinking Water Standards. The plant's current water quality goals as well as a review of key operational data in relation to these goals are discussed in the following sections.

2.2.1. Water Quality Goals

Table 2-1 summarizes the key water quality goals for the Carrollton WTP. Most have been adopted from federal and state regulations.

Table 2-1: Carrollton WTP Water Quality Goals

Parameter	Water Quality Goals
CORROSION CONTROL	
pH	9.0
90^{th} percentile distribution system copper	<1.3 mg/L (Lead and Copper Rule - LCR)
90^{th} percentile distribution system lead	<15 µg/L (LCR)
PRIMARY DISINFECTION	
Giardia removal/inactivation	3.0-log (Surface Water Treatment Rule -SWTR, Interim Enhanced Surface Water Treatment Rule - IESWTR)
Virus removal/inactivation	4.0-log (SWTR, IESWTR)
Cryptosporidium removal/inactivation	3.0 log (Long-Term 2 Enhanced Surface Water Treatment Rule - LT2ESWTR, Bin 1)
SECONDARY DISINFECTION	
Chlorine residual	Residual detectable in greater than 95% of monthly samples (SWTR)
Point of entry Cl_2	▪ Min. 0.2 and <4.0 mg/L (IESWTR)
PARTICULATES	
Combined filter effluent samples	<0.3 NTU in 95% of monthly samples collected at 4-hr intervals (IESWTR)
Individual filter effluent samples	<0.5 NTU after 4-hr of continuous operation , based on 2 consecutive samples taken 15 min apart (IESWTR)
Maximum combined filtered effluent	<1.0 NTU (IESWTR)
Maximum individual filtered effluent	< 0.5 NTU at any time, based on 2 consecutive samples taken 15 min. apart (IESWTR)
MICROBIAL PROTECTION	
Coliforms	< 5% monthly samples coliform positive (Total Coliform Rule - TCR) No E.coli positive samples
Giardia, viruses and *Cryptosporidium*	Zero in raw water (SWTR, IESWTR, LT2ESWTR)
DISINFECTION BYPRODUCTS	

TOC removal	▪ If alkalinity > 120 mg/L as CaCO3,
	  ▪ If TOC < 4.0 mg/L, 15% removal required
	  ▪ If TOC 4-8 mg/L, 25% removal required
	▪ If alkalinity 60-120 mg/L as CaCO3,
	  ▪ If TOC < 4.0 mg/L, 25% removal required
	  ▪ If TOC 4-8 mg/L, 35% removal required

Parameter	Water Quality Goals
Distribution system TTHM (LRAA)	<80 μg/L (Stage 2 Disinfectant/Disinfection By Products Rule - Stage 2 D/DBPR) with goal of < 40 μg/L
Distribution system HAA5 (LRAA)	<60 μg/L (Stage 2 D/DBPR) with goal of < 30 μg/L
INORGANIC/ORGANIC CHEMICALS	
Arsenic	<10 μg/L (Arsenic rule)
Fluoride	<4 mg/L (Fluoride rule)
Nitrate	<10 mg/L (Phase II SOC/IOC Rule)

2.2.2. Water Quality Performance

2.2.2.1. Particulates Removal

The source water for the Carrollton WTP is the Mississippi River, which is susceptible to seasonal events and climatic variation. Considering the large source watershed and various discharges which feed the Mississippi River, significant variation in raw water turbidity is typical for the WTP.

Turbidity is a measure of the cloudiness of water and is used to indicate water quality (e.g., whether disease-causing organisms are present) and filtration effectiveness. Higher turbidity levels are typically associated with higher levels of disease-causing microorganisms, such as viruses, parasites, and some bacteria. The Interim Enhanced Surface Water Treatment Rule (IESWTR) establishes stringent filtered water requirements with respect to turbidity, which include:

- Combined filter effluent (CFE) turbidity must not exceed 1.0 NTU at any given time.
- CFE turbidity must be less than 0.3 NTU in at least 95% of measurements taken each month.
- Systems are required to continuously monitor (every 15 minutes) turbidities for individual filters.
- If turbidity meters fail, systems must take grab samples and measure turbidities for each individual filter every four hours.

Conventional surface water treatment plants meeting the more stringent CFE turbidity requirements are granted 2.5 log *Giardia*, 2-log virus and 2-log *Cryptosporidium* removal credits. Facilities are required to meet the remaining disinfection requirements by chemical inactivation (i.e. chloramines for the Carrollton WTP). Public water systems are required to file an “exceptions report” if at any time the individual filter effluent (IFE) turbidity exceeds 1 NTU in two consecutive readings or if the IFE exceeds 0.5 NTU in two consecutive readings after four hours of filter operation. If no reason for the exceedance can be identified, a filter profile must be performed. If the IFE exceeds 1 NTU in two consecutive measurements in three consecutive months, the facility must perform a self-assessment of the filter. If the IFE exceeds 2 NTU in two consecutive measurements in two consecutive months, the facility must perform a comprehensive performance evaluation (CPE) to attempt to identify the factors limiting filter performance.

The Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) increases the minimum *Cryptosporidium* removal requirement from 2-log to 3-log; however, a 3-log removal credit is granted if facilities continue to meet the CFE turbidity standards from the IESWTR. The LT2ESWTR may also require additional *Cryptosporidium* removal/inactivation based on source water monitoring. Under the LT2ESWTR, facilities were classified into various categories (or bins) based on results of source water *Cryptosporidium* monitoring. A facility's bin classification establishes what, if any, additional (beyond 3-log) additional (beyond 3-log) *Cryptosporidium* removal/inactivation is required. The Carrollton WTP was classified as a Bin 1 facility based on source water monitoring, and as such does not require additional treatment beyond meeting current filtration and disinfection requirements.

Figures 2-1, 2-2, 2-3 and 2-4 show the raw, settled, filtered and finished water turbidities at the Carrollton WTP for 2013. The 95th percentile finished water turbidity at the Carrollton WTP for 2013 was about 0.12 NTU. Based on the data and discussions with plant staff, the Carrollton WTP has successfully complied with all CFE requirements (i.e., must not exceed 1 NTU at any given time and must be less than 0.3 NTU in at least 95% of measurements taken each month) despite significant increases in raw water turbidity levels. In addition, the Carrollton WTP has complied with the IFE monitoring requirements based on review of operating data.

As seen in Figure 2-2, spikes in turbidity are routinely observed from the combined sedimentation basins. Increases in settled turbidities are generally observed during the cold water periods, with turbidity spikes as high as 4.3 NTU observed. Settled water turbidity spikes do not always correspond with spikes in raw water turbidity. Spikes are somewhat above what is recommended for the sedimentation basin performance (less than 2 NTU) and may be caused by temperatures and reduced flocculation performance. High settled water turbidities contribute to added solid loading to the filters.

It should be noted that despite routine high settled water turbidities (greater than 2 NTU), filter performance is excellent with consistently low filtered water turbidities that meet CFE and IFE requirements (Figure 2-3) and long filter run times. This is likely because filters are typically run at a low loading rate. The filter performance is similar between the Sycamore and Claiborne filters. The Claiborne filters typically have a slightly higher turbidity, however the 95th percentile for both filters are nearly the identical at 0.15 NTU for Sycamore and 0.16 NTU for Claiborne respectively.

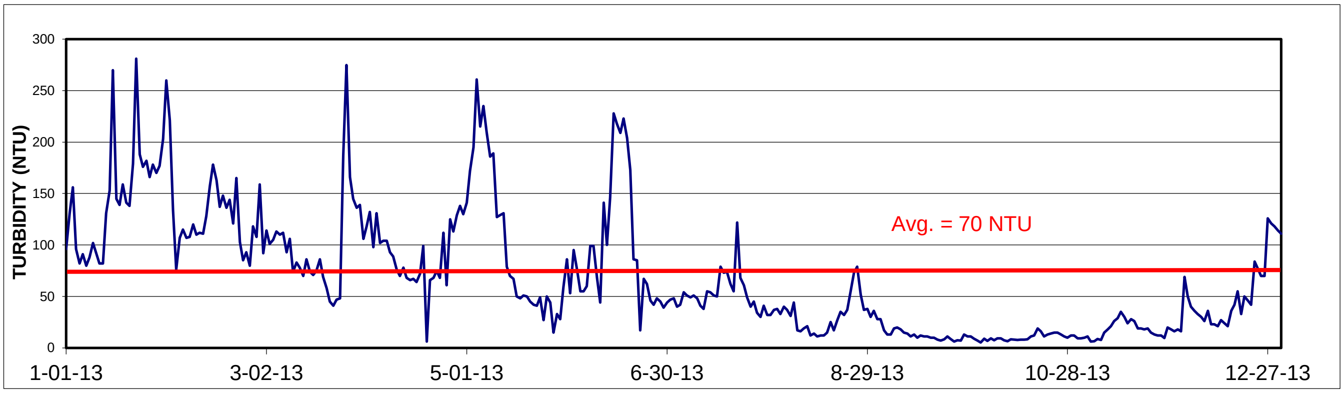

Figure 2-1: Raw Water Turbidity

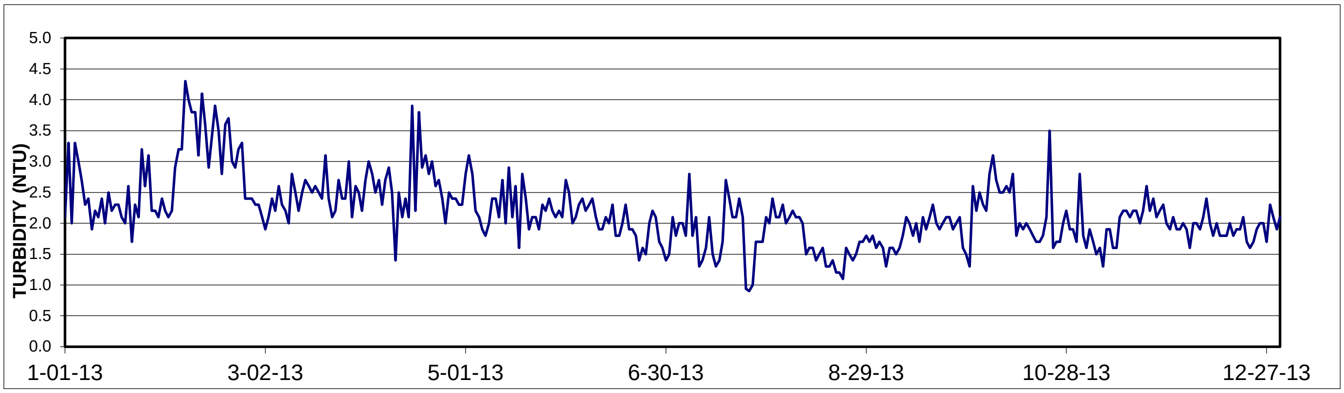

Figure 2-2: Settled Water Turbidity

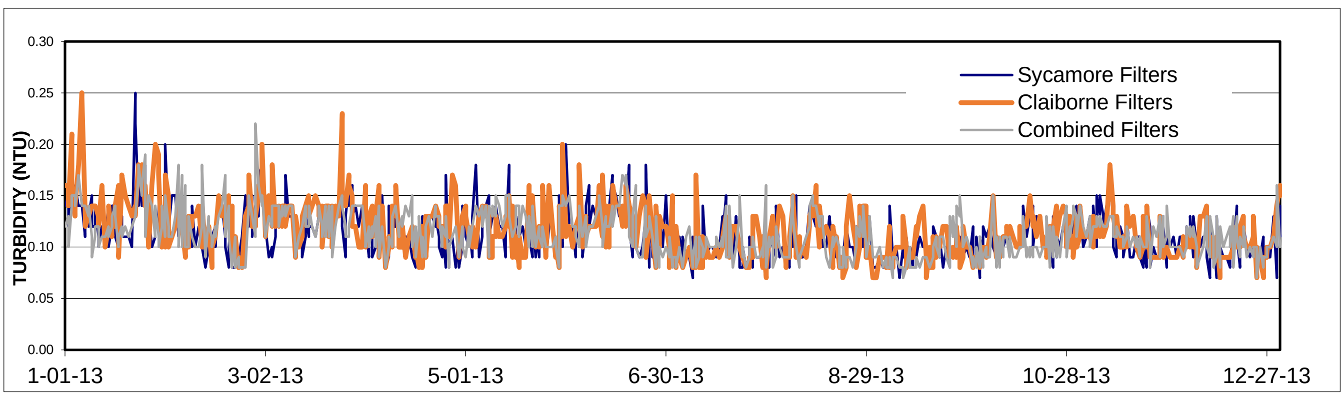

Figure 2-3: Filtered Water Turbidity

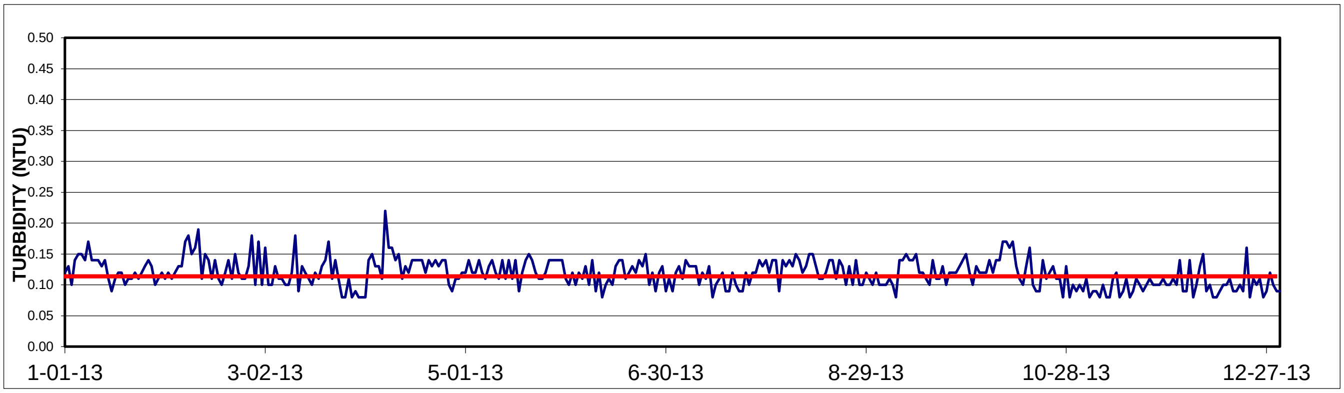

Figure 2-4: Finished Water Turbidity

2.2.2.2. Alkalinity/Hardness

The alkalinity of water is its capacity to neutralize acid. Moderate concentrations of alkalinity balance the corrosive effects of acidity in water supplies, however too much alkalinity can cause problems. Alkaline water has a taste of "soda" and can cause excessive drying of the skin due to the water removing normal skin oils. Hardness in water is mainly caused by the ions of calcium and magnesium. Although hard water has no health effects, using hard water would increase the amount of soap needed and would produce scale on bath fixtures and cooking utensils. Hard water can result in scaling and other impacts to water system infrastructure. Scaling can increase maintenance requirements in WTPs and distribution systems, reduce hydraulic capacity of pipelines, increase pumping requirements due to lost hydraulic capacity, and cause failure of valves and other appurtenances. Figures 2-5 and 2-6 show raw and finished water alkalinities and hardness levels, respectively, at the Carrollton WTP for 2013.

As shown in Figures 2-6 the raw and finished water hardness follow the same pattern over the course of the year, where finished water hardness is consistently higher than the raw water (about 12% higher). A similar trend is observed for raw and finished water alkalinities. Finished water hardness and alkalinity levels are higher than the raw water concentrations because lime is added for pH adjustment. The average raw water alkalinity for Carrollton is 101 mg/L with a range of 72 mg/L to 139 mg/L as $CaCO_3$, while the average finished water alkalinity is 114 mg/L with a range of 78 mg/L to 160 mg/L as $CaCO_3$. The average raw water hardness is 141 mg/L with a range of 101 mg/L to 188 mg/L as $CaCO_3$ and the average finished water hardness is 163 mg/L with a range of 122 mg/L to 203 mg/L as $CaCO_3$. Raw water hardness and alkalinity levels generally tend to increase during the summer and fall months. Finished water hardness levels are generally in the range considered to be moderately hard to hard.

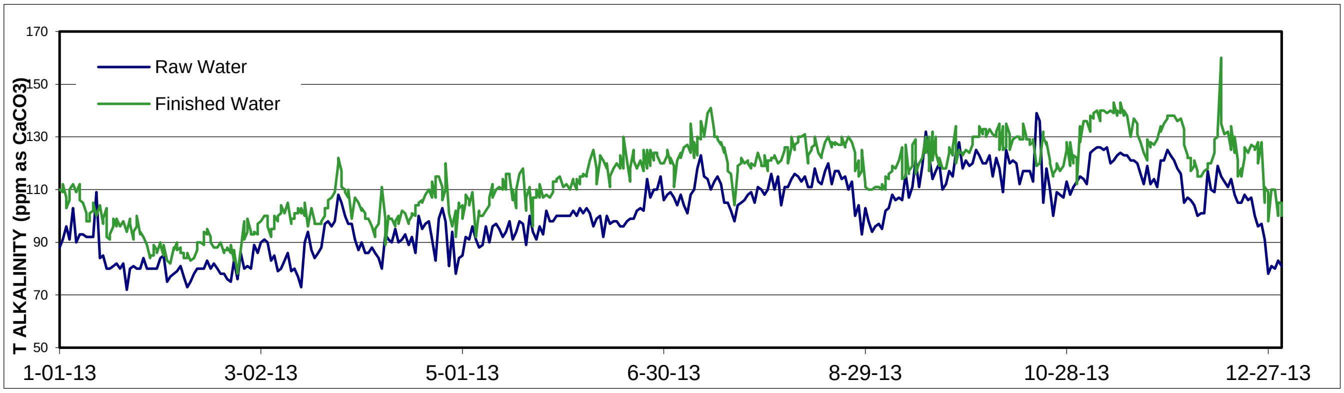

Figure 2-5: Raw and Finished Water Alkalinity

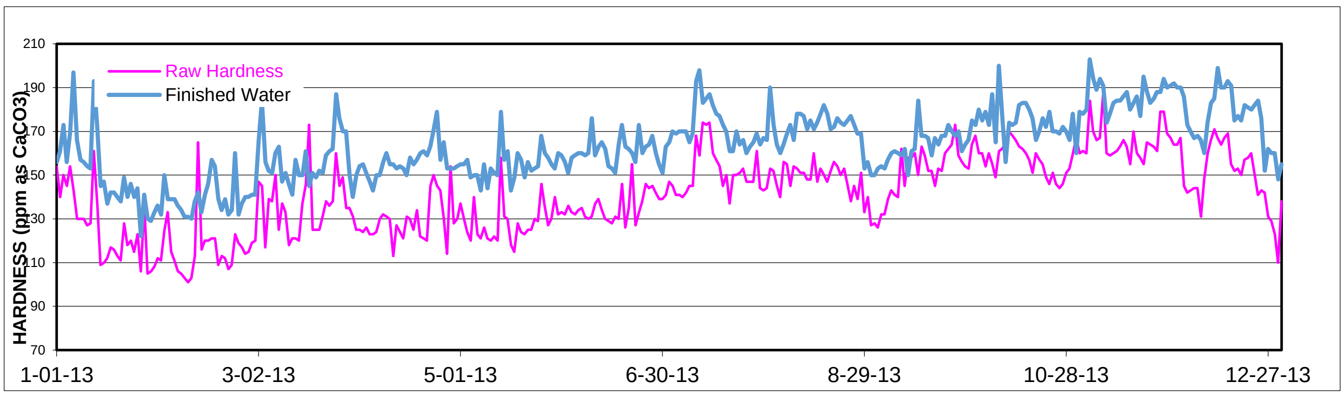

Figure 2-6: Raw and Finished Water Hardness

2.2.2.3. Coliforms

Coliform bacteria is naturally present in the environment, however fecal coliforms and *E. coli* only come from human and animal fecal waste. Coliform is not a health threat in itself, but it is used to indicate whether other potentially harmful bacteria may be present. The Total Coliform Rule requires that less than 5% of monthly samples collected in the distribution system be coliform positive. Table 2-2 summarizes the Total Coliform results for 2013.

As seen in Figure 2-7, despite significant fecal coliform concentrations in the raw water, only two samples had a coliform positive result (the amounts detected represent between 0-0.5% positive samples tested monthly) in 2013. As seen in Table 2-2, only two samples tested positive for Total Coliforms out of 2,346 samples (0.09%). Neither of the 2 Total Coliform positive samples was *E. coli* positive and the MCL during this evaluated period was not exceeded.

Table 2-2: Total Coliform Analysis Results for the Carrollton WTP (2013)

2013	River	Plant Tap	Distribution System
Maximum (Colonies / 100 ml)	3,700	5	4
Minimum (Colonies / 100 ml)	86	0	0
Average (colonies / 100 ml)	610	0	0
Number of Samples	365	365	2,346
Number of Samples Negative	0	364	2,344
Number of Samples Positive	365	1	2*

* Neither of these 2 total coliform positive samples was *E. coli* positive, and neither resulted in a violation of the Total Coliform Rule.

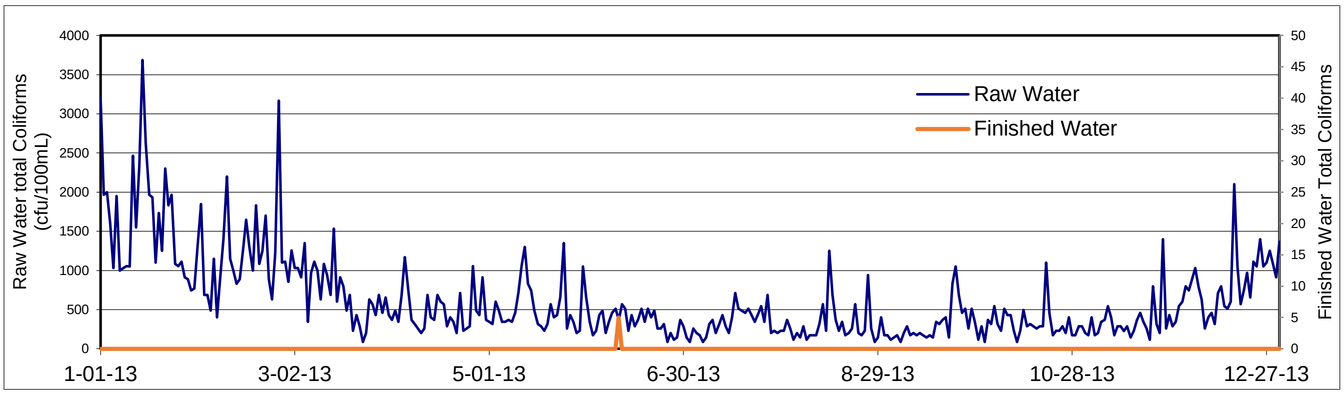

Figure 2-7: Raw and Finished Water Coliforms

2.2.2.4. Corrosion Control Treatment

The Lead and Copper Rule (LCR) requires utilities to perform routine at-the-tap monitoring of lead and copper at cold water taps in homes/buildings that are at high risk for lead/copper contamination. The rule requires large systems to conduct water quality parameter (WQP) monitoring in addition to tap samples for lead and copper every six months unless the system qualifies for reduced monitoring. The action level (AL) is exceeded when the 90th percentile value of all samples in a given LCR monitoring period exceeds 0.015 mg/L for lead or 1.3 mg/L for copper. An AL exceedance triggers other requirements such as corrosion control treatment (CCT), public education, and lead service line replacement.

The current CCT strategy at the Carrollton WTP is pH adjustment to a target pH of 9.0 to form a passivating film in the distribution piping that decreases soluble lead and copper concentrations. pH is adjusted by adding lime at an average dosage of 20-25 mg/L. The Carrollton WTP has had no issue in complying with the LCR and has consistently maintained both lead and copper levels well below the action levels. The plant has qualified for reduced monitoring, and now monitors lead and copper levels at the tap only once every three years at a reduced number of sites.

Plant staff has noted calcium precipitation in the C-Basins and filters when trying to meet the target pH of 9.0 for corrosion control in the summer. During these periods, the plant limits the pH to about 8.7 to reduce the amount of precipitation that occurs. The plant also adds polyphosphate to help reduce precipitation on the filters. Figure 2-8 shows that the plant routinely operates at a pH below 9.0 to minimize precipitation issues. As seen in Figure 2-9, a noticeable increase in the Langlier Saturation Index (LSI) is observed in the summer months of the last four years, confirming that calcium carbonate precipitation is likely occurring as noted by plant staff.

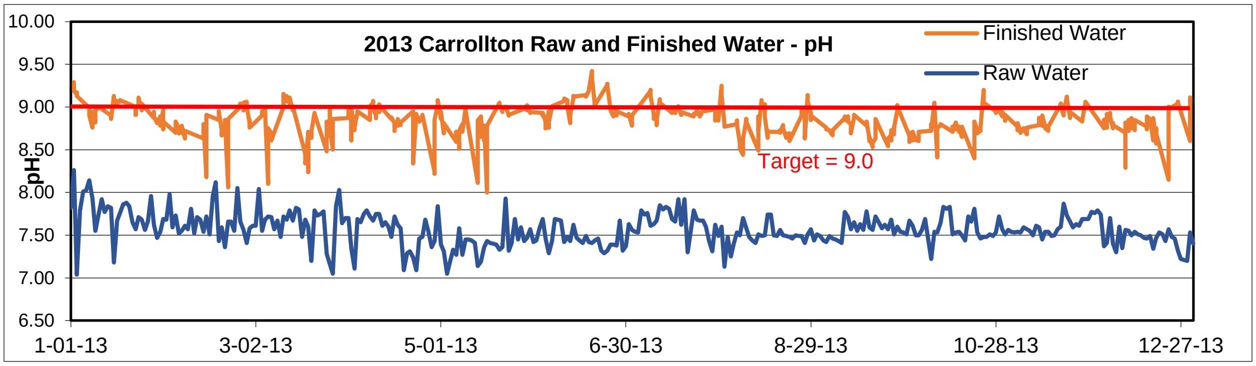

Figure 2-8: Raw and Finished Water pH

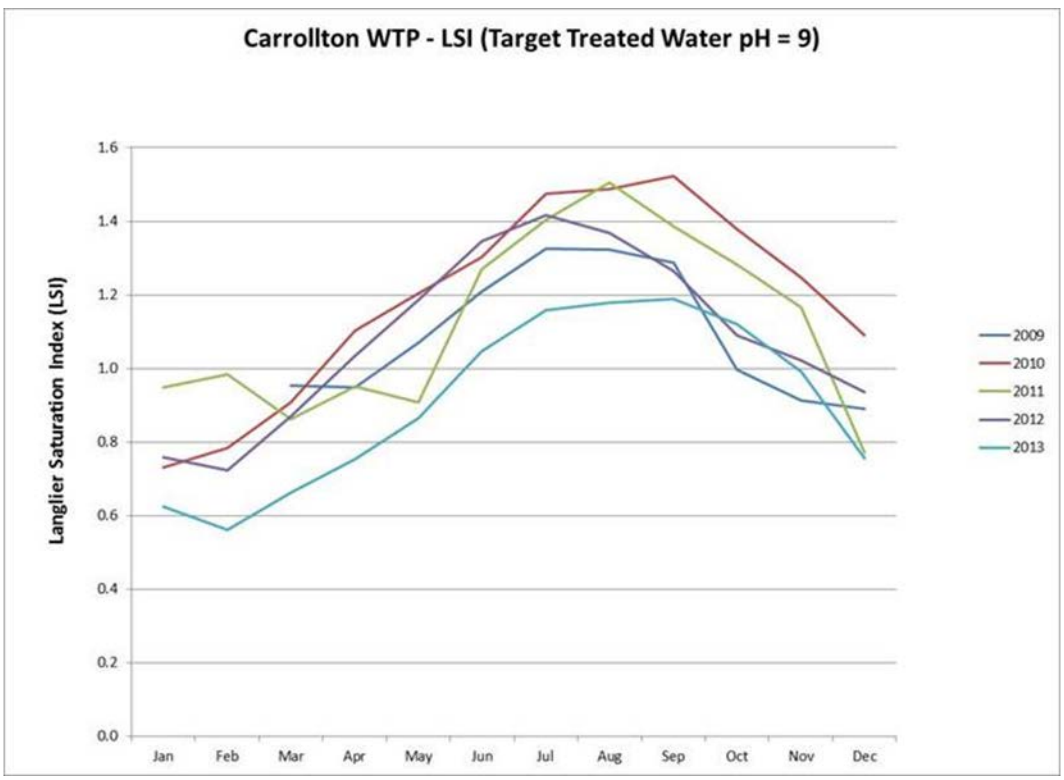

Figure 2-9: Langlier Saturation Index

Figure 2-8 shows that the plant cannot consistently meet the target pH of 9.0 primarily due to concerns associated with precipitation in the C Basins and filters. The target pH of 9.0 was established several years ago as the water quality goal needed for effective CCT. Although the plant is not meeting the target pH goal, the plant has consistently maintained lead and copper levels well below the action level, indicating that the current operating pH (about 8.7) is effective from a corrosion control treatment standpoint. It is recommended that the plant target a lower pH of about 8.7 throughout the year to minimize the precipitation that occurs in the C basins and filers. It is anticipated this target pH will be adequate to maintain continued compliance with the LCR. In addition, operation at the lower target pH will reduce the amount of lime addition required.

Alternatively, the SWBNO can consider eliminating pH adjustment through lime addition and convert to a phosphate-based corrosion inhibitor as a CCT strategy. This would allow for operation at a lower target pH approximately 7.3-7.8), further reducing the potential for precipitation. It should be noted that a change to a phosphate-based corrosion inhibitor would change the water chemistry in the distribution system and potentially result in potential unintended consequences (such as biological regrowth in the distribution system, increased phosphorus loadings to the wastewater treatment plant system, and increased disinfection byproduct (DBP) formation).

Given that the current strategy of adjusting pH has been very effective at meeting the LCR, it is recommended that the plant continue to use pH adjustment for CCT.

2.2.3. Disinfection and DBPs

Disinfection. The Carrollton WTP is required to provide 3-log removal for *Giardia*, 4-log removal for viruses and 3-log removal of *Cryptosporidium*. As discussed in Section 2.2.3, the Carrollton WTP meets the CFE requirements of the IESWTR, granting it 2.5-log *Giardia*, 3-log *Cryptosporidium*, and 2-log virus removal credits. The remaining disinfection requirements are made up by inactivation with free chlorine and chloramines.

Disinfection is achieved with the use of free chlorine and chloramines for primary disinfection. The required CT (residual concentration×effective contact time) is achieved with the contact time beginning in the C Basin influent passage and continuing through to the distribution system point of entry (POE). . The distribution system point-of-entry (POE) disinfectant residual typically ranges between 3.0 - 3.5 mg/L as total chlorine.

Figures 2-10 and 2-11 show the CT for viruses and *Giardia* from 2010-2013 at the Carrollton WTP. As seen, the Carrollton WTP has consistently maintained a CT that exceeds the required log inactivation for both viruses and Giardia, meeting regulatory requirements.

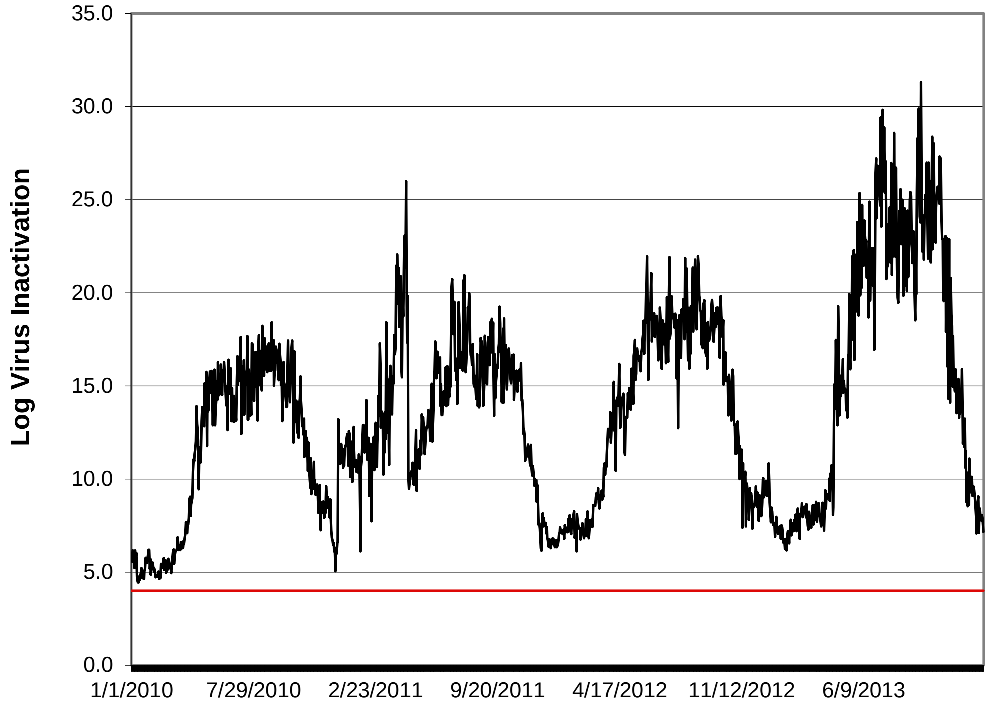

Figure 2-10: 2010-2013 CT Virus Removal

2010 – 2013 CT - Giardia

Figure 2-11: 2010-2013 CT Giardia Removal

Figure 2-12 shows the finished water total, free chlorine, and ammonia concentrations for 2013. As seen, the plant has consistently maintained a point of entry to the distribution system chlorine residual ranging from 0.4 mg/L and 4.0 mg/L, which is above the minimum requirement of 0.2 mg/L in 95% of monthly samples and below the maximum of 4.0 mg/L. The average ammonia residual is 0.15 mg/L with a minimum of 0.01 and maximum of 0.38 mg/L.

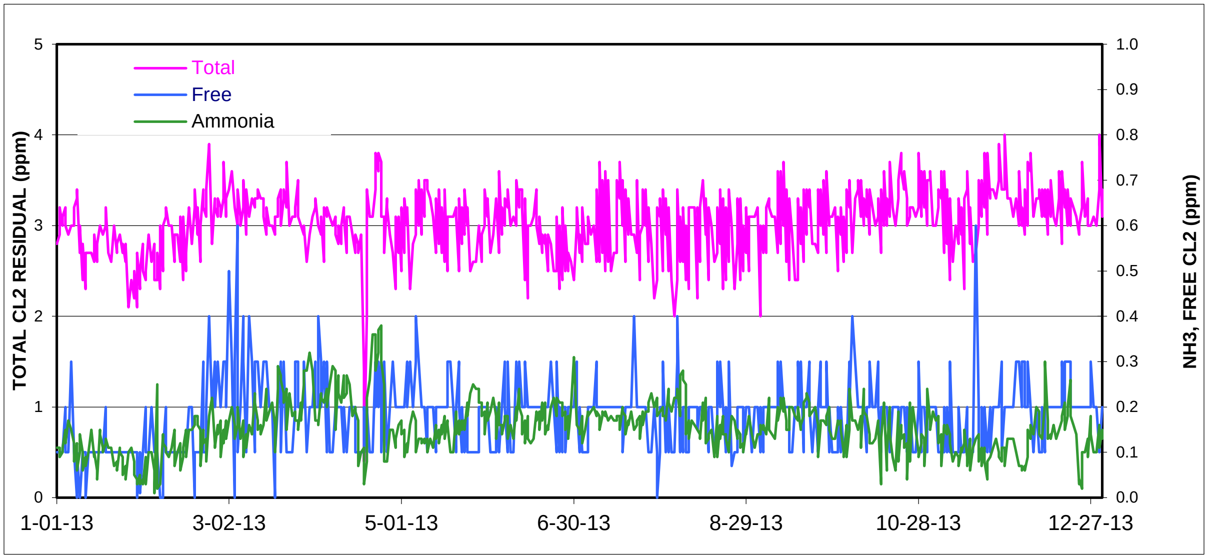

Figure 2-12: 2013 Finished Water Residuals

Disinfection Byproducts. The Stage 1 Disinfectants/Disinfection Byproducts Rule (Stage 1 D/DBPR) established MCLs, maximum contaminant level goals (MCLGs), and maximum residual disinfectant levels (MRDLs). The MRDLs for disinfectants and MCLs for DBPs regulated as part of the Stage 1 D/DBPR are shown in Table 2-3.

Although the Stage 1 D/DBPR includes an MCL for bromate, this contaminant is only a concern for systems that utilize ozone in any part of their treatment. Similarly, since chlorine dioxide is not used, the levels established for chlorine dioxide and chlorite do not apply for the Carrollton WTP. The Carrollton WTP must comply with the chloramine MRDL and requirements for total trihalomethanes (TTHMs) and the sum of five haloacetic acid species (HAA5). Compliance with the TTHM and HAA5 MCL was based on the running annual average (RAA) of quarterly averages of all samples taken in the distribution system.

Table 2-3 Stage 1 DBPR Summary

Parameter	MRDL	MRDLG	MCL	MCLG
DISINFECTANTS				
Chlorine (mg/L as Cl_2)	4.0	4.0		
Chloramines (mg/L as Cl_2)	4.0	4.0		
Chlorine Dioxide	0.8	0.8		
DISINFECTION BYPRODUCTS				
TTHM[1] (µg/L)			80	
HAA5[2] (µg/L)			60	
Bromate (µg/L)			10	0
Chlorite (µg/L)			1.0	0.8

[1] Total trihalomethanes is the sum of the concentrations of chloroform, bromodichloromethane, dibromochloromethane, and bromoform.
[2] Haloacetic acids (five) is the sum of the concentrations of mono-, di-, and trichloroacetic acids and mono- and dibromoacetic acids.

The Stage 2 D/DBPR increased the compliance challenge facing most drinking water utilities. Although the Stage 2 D/DBPR does not change any of the previous MCLs, it did require utilities to identify locations representative of high TTHM and HAA5 concentrations through an Initial Distribution System Evaluation (IDSE) and changed the manner in which compliance with the TTHM and HAA5 standards is determined. Compliance is now based on locational running annual averages (LRAA) in which the average concentration at each compliance monitoring location must be less than the MCL. This approach is intended to provide more equitable water quality relative to DBPs to a utility's customers regardless of where they live in the distribution system.

DBPs are not an issue at the Carrollton WTP. The plant has consistently maintained TTHM and HAA5 concentrations well below the MCLs of 80 µg/L and 60 µg/L, respectively. As such, the plant is currently on reduced monitoring. The highest experienced LRAA TTHM concentration for 2013 was 26 µg/L while the highest LRAA for HAA5 (2013) was 19 µg/L.

2.2.4. Total Organic Carbon Removal

The Stage 1 D/DBPR also requires surface water systems using conventional treatment to implement a treatment technique to remove total organic carbon (TOC), a surrogate measure of DBP precursors such as natural organic matter (NOM). Table 2-4 summarizes the TOC removal requirements. Compliance with the TOC removal requirements is based on an RAA of quarterly values. The TOC removal requirements vary based on the alkalinity and TOC of incoming raw water. The TOC removal required at the Carrollton WTP varies on a seasonal basis. Data from 2011-2013 was analyzed for TOC removal. As seen in Figure Nos. 2-13, 2-14 and 2-15, the plant does not achieve the TOC removal requirement about 25% of the time. There generally are higher concentrations of TOC entering the plant during the months of May through September, during which times the removal requirements increase due to increases in source water TOC and decreases in source water alkalinity.

Table 2-4: Required Removal of TOC by Enhanced Coagulation For Plants Using Conventional Treatment

SOURCE WATER TOC (mg/L)	SOURCE WATER ALKALINITY (mg/L as $CaCO_3$)		
	0 to 60	**>60 to 120**	**>120[c]**
>2.0 - 4.0	35.0%	25.0%	15.0%
>4.0 - 8.0	45.0%	35.0%	25.0%
>8.0	50.0%	40.0%	30.0%

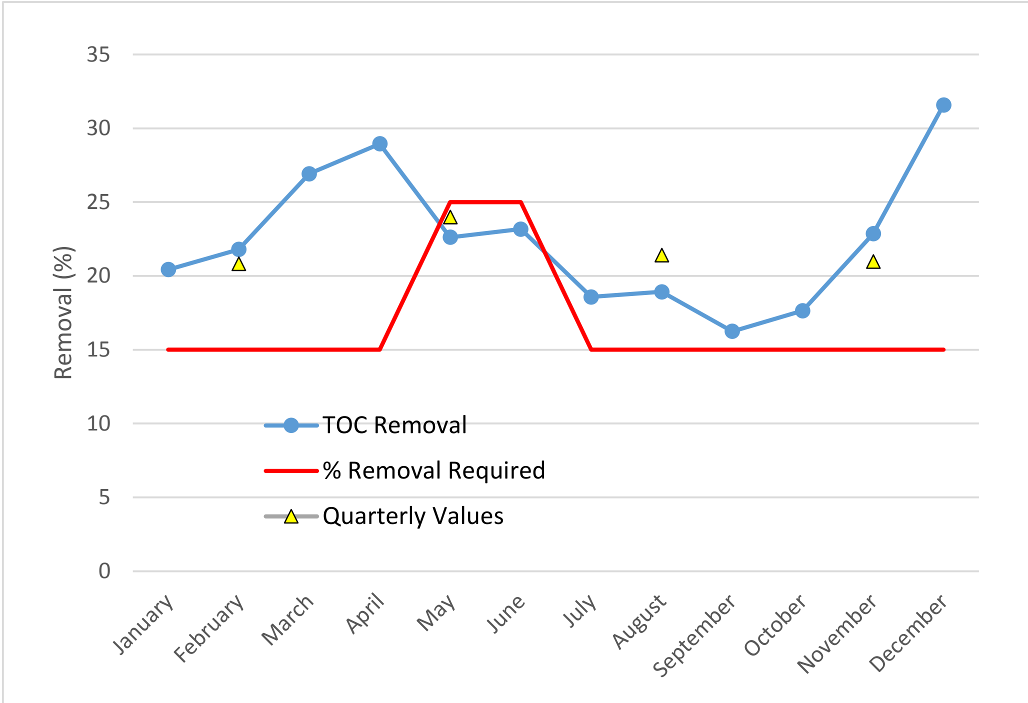

Figure 2-13: 2011 TOC Removal

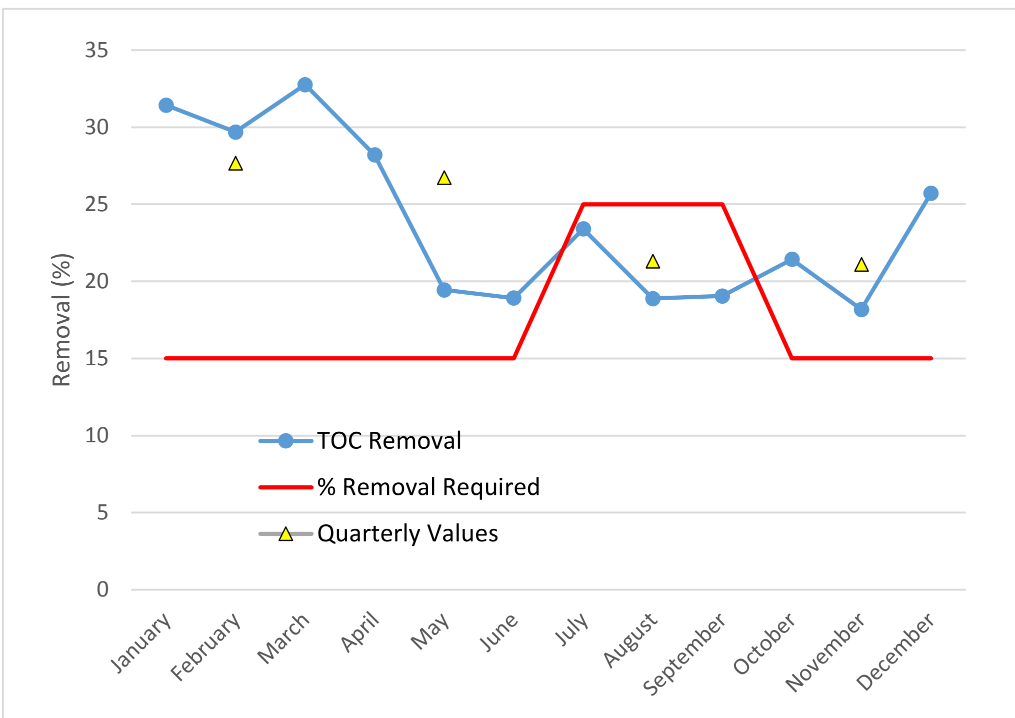

Figure 2-14: 2012 TOC Removal

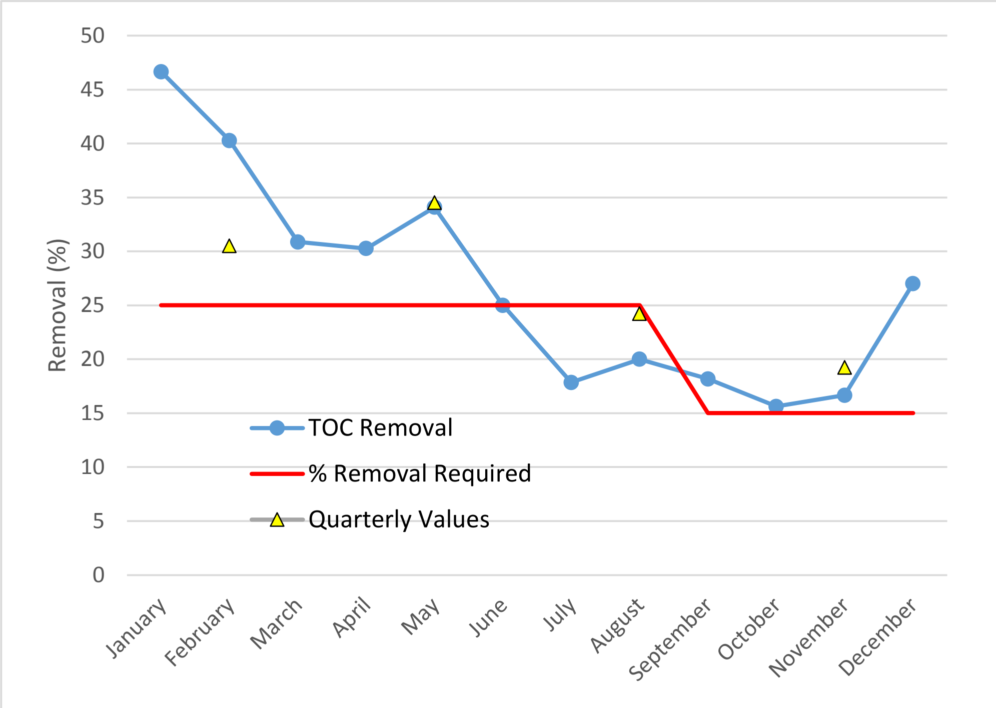

Figure 2-15: 2013 TOC Removal

The "TOC Reduction Assistance Program" completed by Alan Plummer Associates, Inc. in 2012 evaluated historical water quality data and current coagulation practices, and conducted jar tests to identify recommendations to improve TOC removal performance at both facilities. Jar tests looked at alternative coagulants, pH, mixing intensity, order of chemical addition, PAC addition, and lime addition to identify impacts on TOC removal performance. The jar testing found that ferric sulfate (which is currently used at both plants) is more effective than Ferrion, ferric chloride, and alum at TOC reduction. Testing also found that coagulating at a lower pH would improve TOC reduction. Testing showed that the rapid mixing and flocculation mixing intensities at both facilities can be optimized to improve TOC removal (in addition to improving turbidity removal and reduced chemical usage). Separating the coagulant and polymer application points did not impact TOC removal performance. This is expected since cationic polymer (which is currently used at both facilities) performs better if it is added alongside the coagulant. This is because cationic polymer is meant to aid the coagulant in achieving charge neutralization. Nonionic and anionic polymers tend to operate better if they are added after a floc has already formed since they are meant to aid in floc formation.

Based on results from the 2012 study, review of recent operating data, conversations with plant staff and experience with other facilities, the following improvements and modifications are recommended to improve TOC removal performance at the Carrollton WTP (refer to Section 3 for additional details):

- Continue use of ferric sulfate and polymer for enhanced coagulation. Current ferric sulfate and polymer dosages should be sufficient to meet TOC removal requirements; however, the current chemical application method is not optimum for effective chemical dispersion. It is recommended that the chemical feed be modified to maximize mixing, provide even distribution and optimize coagulation performance. Alternate chemical coagulants were not found to improve TOC removal performance in the 2012 study.

- Reconfigure the rapid mix in the G-Basins to increase mixing intensity, this would include installing vertical mixers in place of the current static mixers, the addition of vertical mixers would decrease the chemical consumption of the plant and increase the G values in the mixers into the recommended range for a more effective coagulation.
- Modify flocculator rpm in both G and L Basins, this would include installing variable frequency drives (VFDs) on the flocculators to bring the basins within the recommended G values.
- Adding a perforated baffle wall between the flocculation and sedimentation areas in the G basin to better distribute flow through the basin and a perforated baffle wall at the outlet side to decrease the weir overflow rate
- Add PAC at the raw water intake if it is discovered that the coagulation/flocculation improvements above are insufficient to meet TOC removal requirements. PAC will adsorb NOM and help remove TOC. It should be noted that routine PAC addition will increase solids loadings to the G and L Basins; however, this is a readily settleable solid that should not negatively impact clarification performance. The added solids load, however, will likely require more frequent cleaning of the basins.
- Operate three basins at a time instead of two to decrease loading per basin and increase TOC removal. Recommended rehabilitations to the basins will reduce maintenance requirements and allow operation of three basins at a time.
- If needed, evaluate the efficacy of chlorine dioxide addition on TOC removal in the sedimentation basins. Chlorine dioxide has been shown to oxidize organic matter resulting in “smaller” (from a molecular weight perspective) TOC molecules which are better removed by coagulation and improving TOC removal as a result.

Other advanced treatment options such as ozonation and biofiltration are available to enhance TOC removal performance. However, implementation of these advanced treatment processes is not considered necessary at this time. The improvements above are expected, based on the limited data available, to be sufficient to provide the required TOC removal. Should additional improvements be required, more advanced treatment alternatives, such as ozone or granular activated carbon can be considered.

2.2.5. Secondary Drinking Water Standards

The U.S. Environmental Protection Agency (EPA) has established National Secondary Drinking Water Regulations that set non-mandatory water quality standards for 15 contaminants. EPA does not enforce these “secondary maximum contaminant levels” or “SMCLs.” They are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. These contaminants are not considered to present a risk to human health at the SMCL.

Table 2-5 shows the requirements from EPA and the current level of the Carrollton WTP from 2013.

Table 2-5: Secondary Drinking Water Standards

Parameter	SMCLs	Carrollton WTP 2013
Aluminum, mg/L	0.05-0.2	0.02
Chloride, mg/L	250	35
Copper, mg/L	1.0	0.00
Fluoride, mg/L	2.0	0.79
Iron, mg/L	0.3	0.02
Manganese, mg/L	0.05	0.00
pH	6.5-8.5	9.0
Silver, mg/L	0.1	0.00
Sulfate, mg/L as SO_4	250	44
TDS, mg/L	500	268
Zinc, mg/L	5.0	0.00

As seen, the Carrollton WTP levels are all below the secondary drinking water standards with exception of pH, which is higher to meet corrosion control treatment requirements.

2.2.6. Taste and Odors

Taste and odor of the Carrollton WTP drinking water is an important customer service and satisfaction issue. Though the presence of taste and odor compounds does not necessarily pose a health risk, it can contribute to diminished customer confidence in the water supply system. Objectionable tastes and odors are frequently due to a combination of water quality characteristics. Although some inorganic contaminants such as metals can impart taste to water, the main sources of odor-bearing substances are organic materials. They can cause persistent problems at part per billion levels. The sources of these compounds are diverse and can be manmade or biological in origin.

The biological compounds are the most common sources of odors in water and have been a seasonal problem for users of the lower Mississippi River. The “natural” compounds are usually the result of algal blooms and other biological activity in reservoirs and slow moving rivers. Blue green algae and actinomycetes regularly produce geosmin and 2,4-methylisoborneol (MIB), which are known to impart earthy-musty smells to water. Such conditions exist periodically in the River in summer when there is a lack of rain in the watershed areas causing slower velocities. This low flow combined with the summer heat, plus a clarity in the river due to particulate settling not normally possible at higher velocities, contributes to ideal conditions for taste and odor conditions to occur. The Carrollton WTP’s current practice of adding PAC at the G and L Basin inlets to remove odor-causing compounds from the water is only marginally effective.

Plant staff has noted that existing system has insufficient capacity and the application point does not provide adequate adsorption time to effectively address all taste and odor events. A new PAC system with sufficient feed capacity is recommended with feed points at raw water intakes to improve taste and odor removal performance (refer to Section 3 for additional details).

2.3. Residuals Handling

Residuals streams generated at the Carrollton WTP are comprised of turbidity and chemical sludge from the coagulation and pH adjustment processes. Residual streams are currently discharged to the River through a permitted National Pollutant Discharge Elimination System discharge. The requirements of the permit include monitoring and reporting for pH and flow, and coagulant usage. No anticipated regulations are expected to prevent the current practice of discharging residual streams to the Mississippi River. As such, the need to alter the current sludge handling practice is not necessary at this time.

2.4. Chemical Usage

The chemicals used at the Carrollton WTP include: polymer and ferric sulfate injected at the head of the G and L Basins, sodium hypochlorite, sodium hexametaphosphate, ammonia and lime injected into the effluent channel after the G and L basins, and fluoride injected in the effluent channel after the C Basins.

Table 2-6 presents the chemical usage information of the Carrollton WTP from 2013.

Table 2-6: Chemical Usage at Carrollton WTP for 2013

Chemical	Average	Range
Powdered Activated Carbon, mg/L	<8.0	-
Ferric Sulfate, mg/L (as Fe^{3+})	6.08	3.80-6.85
Lime, mg/L	21.75	12.39-28.11
Polymer, mg/L	4.53	3.39-6.04
Sodium Hypochlorite, mg/L (as available Cl_2)	5.57	4.1-7.33
Ammonia, mg/L	1.06	0.80-1.21
Sodium Hexametaphosphate, mg/L	0.65	0.48-0.90
Fluoride, mg/L	0.28	0-0.63

Note: Data from 2013 Operational Details Report

3. Treatment Process Assessment

3.1 Introduction

The evaluation completed as part of this project included identifying critical operational assets that could potentially affect water quality and plant production capacity, and that are critical to the reliability of operations at the Carrollton WTP. The team assessed the suitability and condition of the various plant treatment processes to identify system deficiencies, mechanical or structural deterioration, operational constraints, and/or reliability concerns related to treatment performance and compliance with long-term water quality objectives and regulatory requirements. These assessments were based on:

- Review of available data, plans, records and reports;
- Site visits and inspections of readily-accessible facilities; and
- Discussions with SWBNO engineering, operations, and maintenance personnel.

In general, treatment systems at the Carrollton WTP are functioning well and continue to produce potable water for the East bank that meets all existing drinking water standards. Although the plant has consistently maintained excellent treatment performance, much of the equipment has reached the end of its useful service life and requires rehabilitation or replacement.

The results of the assessments are presented in this section, along with discussions of rehabilitation and replacement alternatives, implementation considerations, and recommended improvements over the 20-year master planning period.

3.2 G Basins

Raw water enters the G Basins (G3 and G4) from a common raw water influent channel. This channel is supplied with water from three connections. These connections include two 48-inch diameter pipelines and an 84-inch diameter connection served by a 54-inch diameter pipeline. Raw water enters a G Basin through a set of three (4 ft by 4 ft) sluice gates. The water then flows through four static mixers (Figure 3-1). Currently, mechanical mixing equipment is not installed in any of the rapid mix basins. There are four mixing basins per treatment train for the G Basins for a total of 8 rapid mix basins. The dimensions of these rapid mix basins are 20’ W x 120’ L x 18’ D with a total volume of 1,510 cubic feet (cf) and a hydraulic residence time of about 49 seconds per basin (based on a combined maximum hydraulic flow rate of 160 MGD for both basins). The calculated G value for the static mixers falls short of the recommended range. The recommended range is 600-1000 s^{-1}, currently with 4 mixers the G value is 120 s^{-1} Optimization of the rapid mix for G Basins would require the installation of a new, low headloss mixing system. Ferric sulfate and polymer are added concurrently at the inlet of each static mixer.

Figure 3-1: G Basin Static Mixers

Following ferric and polymer addition, water enters the flocculation area (Figure 3-2). Each flocculation basin is a single train with two rows of flocculators positioned in parallel to the water flow. Both rows are paddle-type flocculators mounted on horizontal drive shafts. The motors are constant speed and connected to the flocculator shafts by a drive chain. The flocculation area for both G-Basins have dimensions of 32' W x 480' L x 17'-6" D, providing a total volume of 268,800 cf and a hydraulic residence time of about 36 minutes per basin (based on a combined maximum hydraulic flow rate of 160 MGD. Each basin has adequate detention time for effective flocculation at average flow conditions. Mixing energies in the flocculators could be adjusted to promote better floc formation. This could result in improved turbidity reduction in the basins. The rotational speeds of the flocculators could be adjusted so that the G values in each stage fall within recommended ranges.

Figure 3-2: G Basin Flocculation Basin

Flocculated water flows from the flocculation basins, around a sharp cornered turning area, through directional butterfly gates (which are currently inoperable), and into the G3 and G4 sedimentation basins (Figure 3-3). The G3 basin has a sedimentation volume of 938,875 cf. At a flow of 80 MGD, the surface overflow rate (SOR) is about 1,490 gallons per day per square foot (gpd/sf), and the detention time of 126 minutes, with a rise rate of 1.03 gallon per minute per square foot (gpm/sf). At a flow of 80 MGD, the G4 basin with a volume of 970,200 cf, operates at a SOR of 1,440 gpd/sf and theoretical detention time of 130 minutes, with a rise rate of 1.0 gpm/sf. The recommended SOR range for a conventional settling basin is between 700 to 1,000 gpd/sf with a typical value of approximately 850 gpd/sf. As seen, the SOR of the G Basins is approximately one and a half times higher than the maximum recommended SOR for effective clarification. Based on achieving a SOR of 1,000 gpd/sf, the maximum combined treatment capacity of G3 and G4 Basis is approximately 110 MGD.

The horizontal velocity through the basins is about 4.0 feet per minute (ft/min) and the weir loading rate is about 172,000 gpd/ft based on a combined maximum flow rate of 160 MGD. The recommended weir loading rate typically ranges between 17,300 – 26,000 gpd/ft. The weir loading rate for the G Basins is currently approximately ten times higher than recommended rates for sedimentation basins. The current sedimentation process in the G basins is limited due to the existing design configuration that leads to a SOR that is well above design standards.

Figure 3-3: G Basin Sedimentation Basin

The inlet butterfly gates of the G Basins are largely inoperable due to calcification and corrosion from past softening operations. The gates are positioned at various angles as seen in Figure 3-4, with some completely open and others completely closed. As a result, influent flow is likely preferentially channeled through the open gates resulting in an uneven flow distribution into the basins and reduce the effective settling area of the basins by the formation of dead spots.

Figure 3-4: G Sedimentation Basin Inlet Butterfly Gates

The flocculator drives for the G3 and G4 basins were replaced between 2005 and 2006. Each basin has eight drive units consisting of a 7.5 horsepower (hp) electric motor driving a right-angle speed reducer followed by a chain drive which powers eight (8) sets of horizontal paddles. The paddles consist of fiberglass "U" sections supported on a carbon steel frame. The paddle wheels are supported by, fluted rubber pillow block bearings lubricated with potable water. The paddle wheel shafts are carbon steel with stainless steel sleeves at each bearing location.

Motors on all of the drivers were rebuilt in 2008. Disconnects and "RUN/STOP" controls are housed in stainless steel cabinets and are in good condition. Some paddle frames have considerable corrosion. Flocculator and frame mounting fasteners appear in good condition. There is some corrosion between dissimilar metals on the steel paddle shafts. The water-lubricated pillow blocks show some signs of corrosion. There are no belt guards on the rake drivers. The drive machines are in good condition, but do not have speed control.

The following deficiencies, operational needs and major capital improvement requirements were identified for the G-Basins:

- Two raw water lines to the G basins are out of service due to flowmeter issues, leaving only one line available to feed the G Basins. Any issues with this line will effectively take out both G-Basins from operation, significantly impacting production capacity at the plant.
- The static mixers provide inadequate mixing during low flows and also generate excessive headloss during high flow conditions, limiting the hydraulic throughput of the G Basins. The calculated G value for the static mixers falls short of the recommended range.
- The existing constant speed motors for the flocculation equipment do not allow for speed variation, which may inhibit optimization of the flocculation process.

- Plant staff has noted that the flocculators work well; however, they are maintenance intensive and require long basin down-times to complete maintenance activities.
- The sedimentation area inlet butterfly gates are inoperable and likely causing uneven flow distribution through the sedimentation area.
- Coagulant and coagulant aid distribution to the four static mixers per basin is uneven, unreliable and requires regular operator attention
- Monorake and sludge system operation is inefficient. The current sludge removal system requires frequent operator intervention to maintain consistent operation
- The settled water effluent channel isolation gates are leaking significantly and in very poor condition.
- The SOR and weir loading rates are well above recommended loading standards for effective sedimentation. Based on meeting a recommended SOR of 1,000 gpd/sf, the capacity of each G basin is limited to about 55 MGD. High settled water turbidities observed for the G Basins are likely due in part to operating the basins well above the recommended loading rate. It should be noted, that despite elevated settled water turbidities, filtered water turbidities have consistently met target levels (see Section 2).

G Basin performance can be improved by implementing design modifications that allow for operation at the higher loading rates while still achieving effective sedimentation. Modification options considered for the G Basins include (1) adding perforated baffle walls, and (2) installing tube settlers. The addition of a perforated baffle wall between the flocculation and sedimentation areas would improve basin hydraulics and enhance performance by providing better flow distribution. Additionally, a perforated baffle wall at the outlet of the sedimentation basin would increase the overflow area reducing the weir overflow rate. The outlet baffle wall would need to be located above the sludge blanket levels and configured not to interfere with the monorake sludge removal system. Installation of tube settlers on a portion of the sedimentation basin would significantly increase the capacity of the basins by increasing the effective settling area of the sedimentation basins (design SORs for tube settlers can range between 2,800 gpd/sf to 4,300 gpd/sf.). Implementation of tube settlers would require replacing the existing monorake and sludge withdrawal system with a different system since the monorakes would interfere with the tube settlers. A chain and flight sludge collection system could be used in conjunction with the tube settlers. This type of sludge withdrawal system would require leveling the basin floor and reconfiguring the basin and sludge piping. Given the length of the basin, separate collectors would need to be provided to cover the entire basin. Rehabilitation of the G Basins to include a ported baffle wall and tube settlers (along with replacement of the monorake system with a chain and flight system) is estimated to cost $20,350,000.

Another option considered to address the high SORs and weir loading rates is retrofitting a new ACTIFLO high rate clarifier(s) to replace the G Basins. The ACTIFLO system is a high rate compact clarification system that uses microsand and polymer to enhance floc formation and serve as a ballast, significantly increasing the settling velocity. This ballasted settling allows for short detention times and high SORs, significantly reducing the footprint requirements compared to a conventional sedimentation basin. In addition, the ACTIFLO typically achieves better treatment performance with respect to turbidity, TOC, algae, particle counts, Cryptosporidium, iron, manganese, arsenic and NOM removal than conventional sedimentation basins. An

ACTIFLO clarification system could be installed within the existing G basins to increase sedimentation basins to a combined capacity to 140 mgd. The current practice is to utilize one G and one L basin, so the L-Basins would still be utilized if this were to occur. However ACTIFLO is a different system than conventional coagulation so there would be two operational procedures for the similar plant processes, which is something the SWBNO would have to consider.

The total estimated cost to install one 70 mgd ACTIFLO high rate clarification system within one of the G-Basins is approximately $23,000,000. Replacing both G-Basins with the ACTIFLO system would cost approximately $46,000,000. The installation could be done one basin at a time, by installing two 35 mgd ACTIFLO treatment trains in parallel per G-Basin. The treatment trains of the ACTIFLO system are each 78’3” long, 32’0” wide with a height of 24’6”. The flocculation basins would contain two treatment trains to reach the capacity required per basin. The flow from the ACTIFLO system would be directed into the current effluent channel, which is the same as the current configuration.

Recommended G-Basin Improvements

As previously indicated, at design conditions the G Basins are currently overloaded with respect to typical design criteria for SOR and weir loading rates. This has resulted in occasional settled water turbidities that are higher than what is generally desired for the sedimentation process. However, the existing basin configuration generally provides good settling performance and does not currently appear to negatively impact filter performance, in part due to the further settling of solids that occurs in the C Basins prior to the filters, (i.e., filters consistently meet the CFE and IFE requirements and achieve long run times). It is recommended that the existing basins be rehabilitated as discussed in the bullets below.

A more comprehensive reconfiguration of the basins (e.g., installing tube settlers or replacing the basins with ACTIFLO high rate clarification units) should be further evaluated and implemented if treatment rates increase and/or settled water turbidities and filtered water performance decreases to a point where compliance may be impacted.

The following rehabilitations and improvements are recommended for the G-Basins:

- Replace the venturi meter instrumentation and valves on the back-up 48-inch raw water line to place this line back in service and ensure a redundant feed line is available for the G-Basins.
- Replace the static mixers with new vertical mixers within the rapid mix basins to enhance mixing performance and eliminate poor mixing and hydraulic constraints associated with the current static mixers. New vertical mixers can be retrofitted into the existing rapid mix basin openings.
- As the existing drives fail and require maintenance, replace all drives and motors for the flocculators. This includes adding variable speed drives. Mixing energies in the flocculators could be adjusted to promote better floc formation, resulting in improved turbidity reduction in the basins. The ability to manipulate the mixer speed will allow the operator to increase mixing efficiency and enhance the flocculation process.

- Continue to refurbish the G-Basin flocculators as part of the plant's scheduled routine preventative maintenance of the basins as they are taken offline. It is recommended that flocculator refurbishment be completed at least once every 5-years to ensure reliable operation.
- Replace the sedimentation area inlet butterfly gates with a perforated baffle wall to ensure a more even distribution can be maintained into the sedimentation basins.
- Replace the settled water effluent channel isolation gates with new gates.
- Operate three of the four basins at all times as a strategy to lower the loading rate into each sedimentation basin. This should help improve sedimentation basin performance and lower the solids loading to the filters. It should be noted that overloading of the basins may still occur during high demand periods even with three basins in service.
- Separate the coagulant and coagulant aid application points from each other. Four separate coagulant feed points will be maintained for each G-Basin with each feed point including an electrically actuated valve and flowmeter to provide more even chemical feed distribution and improve coagulant monitoring and control. These chemical feed improvements along with replacement of the static mixers with vertical mixers, and replacement of the chemical feed system to provide flow paced dosage, will improve coagulant performance and likely reduce chemical usage.

3.3 L Basins

A single 48-inch diameter pipeline supplies raw water to each of the two L Basins (L3 and L4). The influent passage into each basin is an eight-foot wide channel. Downstream of the influent channel, the raw water flows over an inlet weir and splits between either of two flocculation basins. A single static mixer in each L Basin provides the required hydraulic mixing of the coagulant and polymer. The G value for the static mixer (Figure 3-5) operates within the recommended range of 600-1000 s^{-1}, currently the L Basin has a G value of 728 s^{-1}, as evidenced by significant turbulence observed within the rapid mix channel.

Figure 3-5: L Basin Static Mixers

Following ferric sulfate and polymer addition, water enters the flocculation basins (Figure 3-6). Each flocculation basin is divided into two parallel trains with ten rows of flocculators positioned perpendicular to the water flow. The individual rows include three, paddle-type flocculators mounted on a horizontal drive shaft. A single motor located between the two parallel basins operates two adjacent drive shafts (Figure 3-7 and 3-8). There are four flocculation basins with dimensions of 32' W x 150' L x 17'-6" D, with a volume of 84,000 cf and hydraulic residence time of 45 minutes (at a combined flow rate of 80 MGD). The flocculators are paddle-type (4 paddles per mixer), there are 10 rows with 3 mixers per row. The L-Basin flocculators have constant speed motors, which limits the manipulation of the flocculation process. This may inhibit optimization of the flocculation and coagulation process.

Figure 3-6: L Basin Flocculation Basin

Figure 3-7: L Basin Paddle Driver at Deck Level

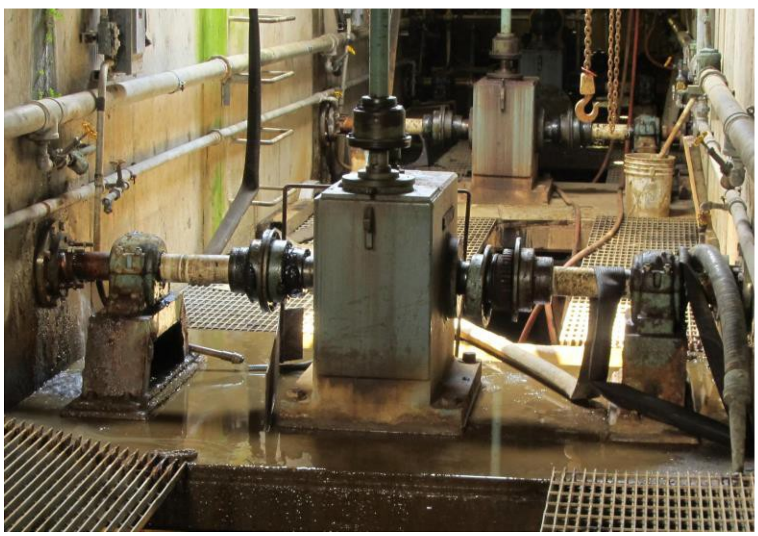

Figure 3-8: Paddle Driver at Gallery Level

Flocculated water enters each sedimentation basin (Figure 3-9) through a fiberglass, ported baffle wall. There are two sedimentation basins (L3 and L4) with a volume of 402,000 cf and average depth of 14 ft. At a flow of 40 MGD through each L basin, the SOR is about 1,390 gpd/sf, and the detention time is about 108 minutes, this is less than the 240 minutes (4 hours) detention time that Ten States Standard recommends. The recommended SOR of a conventional settling basin is 700 to 1000 gpd/sf with a typical value of approximately 850 gpd/sf. As seen, the SOR of the L basins is approximately 1.4 times higher than the maximum recommended SOR for effective clarification. Based on achieving a SOR of 1,000 gpd/sf, the maximum combined treatment capacity of the L3 and L4 Basins of approximately 58 MGD.

The horizontal velocity through the basins is about 3.8 feet/minute and the weir loading rate is about 62,000 gpd/feet based on a combined maximum flow rate of 80 MGD. The recommended weir loading rate typically ranges between 17,300 – 26,000 gpd/sf, as such, the weir loading rate for the L Basins is approximately three times higher than the recommended rates for sedimentation basins.

Figure 3-9: L Basin Sedimentation Basin

The following deficiencies, operational needs and major capital improvement requirements were identified for the L Basins:

- The flocculator drives are from the late-1970s and beyond their expected useful service life. The horizontal gearboxes were refurbished on each basin during the last flocculator rebuild. Both L basins were in operation at the time of the inspection, so the paddles could not be inspected. The drive units operate well with the exception of the drive motors. Plant staff noted that there are problems with water entering the motors due to the fabricated rain hoods. Some motors were observed to have a rattling sound, indicating either bearing failure or loose rain hoods. Several of the motors had damaged bearings.
- Below deck, some of the coupling between the gear box and paddle shaft were disconnected and undergoing repairs.
- Considerable leakage at most of the stuffing boxes contributed to a wet environment. These conditions are not conducive to machinery maintenance and equipment longevity.
- Removed or missing grating in the machinery gallery are safety concerns as well as the lack of shaft guards and a combination of water and oil on the floor throughout the galleries.
- The SOR and weir loading rates are well above recommended loading standards for effective sedimentation. Based on meeting a recommended SOR of 1,000 gpd/sf, the capacity of each L basins is limited to about 57.4 MGD. High settled water turbidities observed for the L Basins are likely due in part to operating the basins well above the recommended loading rate. It should be noted, that despite elevated settled water

turbidities, filtered water turbidities have been consistently met target levels (see Section 2).

As with the G Basins, L Basin performance can be improved by implementing design modifications that allow for operation at the higher loading rates while still achieving effective sedimentation. The same modification options discussed for the G Basins would apply for the L Basins (see discussion on Section 3.2).

Recommended L-Basin Improvements

Similar to the G Basins, the L Basins are currently overloaded with respect to typical design criteria for SOR and weir loading rates. This has resulted in occasional settled water turbidities that are higher than what is generally desired for the sedimentation process. However, the existing basin configuration generally provides good settling performance and does not currently appear to negatively impact filter performance, in part due to the further settling of solids that occurs in the C Basins prior to the filters, (i.e., filters consistently meet the CFE and IFE requirements and achieve long run times). It is recommended that the existing basins be rehabilitated as discussed in the bullets below.

A more comprehensive reconfiguration of the basins (i.e. installing tube settlers or replacing the basins with ACTIFLO high rate clarification units, as previously discussed) should be further evaluated and implemented if influent flow rates increase and/or settled water turbidities and filtered water performance decreases to a point where compliance may be impacted. The cost for both L-Basins to be replaced with a 70 mgd ACTIFLO system would be approximately $23,000,000, see G-Basin discussion for configuration).

The following rehabilitations and improvements are recommended for the L-Basins:

- Replace all drives and motors for the flocculators. This includes adding variable speed drives. Mixing energies in the flocculators could be adjusted to promote better floc formation, resulting in improved turbidity reduction in the basins. The ability to manipulate the mixer speed will allow the operator to increase mixing efficiency and enhance the flocculation process.
- Continue to refurbish the L-Basin as part of the plant's scheduled routine preventative maintenance of the basins as they are taken offline. It is recommended that flocculator refurbishment be completed at least once every 5-years to ensure reliable operation.
- Replace the stuffing boxes with a packless, watertight sealing system for the flocculators' shaft penetrations into the machinery gallery.
- Operate three of the four basins at all times as a strategy to lower the loading rate into each sedimentation basin. This should help improve sedimentation basin performance and lower the solids loading to the filters. Lower hydraulic loading rates will reduce the mixing energy within the static mixer; however, high mixing energies are still expected at the reduced loading rate if three of four basins are operated. It should be noted that overloading of the basins may still occur during high demand periods even with three basins in service.

3.4 C Basins

Settled water from the G and L Basins is combined and routed to the C Basins (Figure 3-10), which provide additional clarification and primary disinfection contact time. Chlorine and ammonia are added at the inlet to the C Basins to form chloramines for primary disinfection. Lime and polyphosphate are also added at the inlet of the C Basins to adjust pH for corrosion control. There are three C basins (C1/2, C3/4 and C5/6). C1-C4 provide a combined surface area and average depth of 346,000 sq. ft and 12.7 ft, respectively; while Basins C5/6 provide a combined surface area and average depth of 262,000 sq. ft and 13.2 ft, respectively. The active C-Basins have a total volume of about 59 million gallons. At a design flow of 160 MGD, this volume provides about a 9 hour contact time.

Figure 3-10: C Basins

The C basins have two 50 hp flash mixers (Figure 3-11) used for mixing the sodium hypochlorite solution prior to entering the C basins. The flash mixers were added shortly after 2000 and are in good condition. It was noted that one of the mixers had excessive flexing of the base support. To address this issue, the base has been redesigned and replaced with a longer base on the adjacent mixer. A longer base was onsite at the time of the inspection to replace the base on the remaining mixer.

Figure 3-11: Flash Mixers (with redesigned base-back mixer)

The following deficiencies, operational needs and major capital improvement requirements were identified for the C-Basins:

- There is significant leakage in the channel from the G and L basins to the C basins. Likewise, significant leakage within the C-Basins does not allow draining of the basins for cleaning or maintenance activities.
- Solids carryover from the G and L basins requires periodic removal of accumulated solids within the C-Basins. The plant has procured a small dredger to periodically remove accumulated solids from the C-Basins while still in service. The dredger has been effective at removing solids from the C basins; however, this operation is cumbersome and labor intensive and does not provide a complete long-term solution. A large crane is required to place the dredger into the C-Basins and dredged out solids are currently discharged to the adjacent sedimentation basins.
- Several birds were observed on the water surface of the uncovered C-Basins, potentially leading to contamination of the clarified and disinfected water prior to filtration. Plant staff noted that there has only been one instance when a fecal positive sample was recorded downstream of the C Basins.

Recommended C-Basin Improvements

The recommended improvements for the C-Basins are summarized as follows:

- Assess and implement identified structural repairs to address current leakage within the C-Basins. This assessment should also evaluate leakage observed in the G and L-Basins and in the channel between the L and C-Basins.
- Implement improvements to facilitate removal of residuals using the existing dredger from the C-Basins. These improvements should include provisions to facilitate placing the dredger in the C-Basins. This can be accomplished by installing a permanent or removable access ramp. A new dedicated booster pump station and sludge line that ties

into the existing permitted sludge disposal line for the G and L-Basins should be provided for disposal of the dredged out solids from the C-Basins.

3.5 Filtration and Backwash Systems

Filtration at the Carrollton WTP is split between two filter facilities; the Sycamore and the Claiborne Filters. The Sycamore filters consist of 28 filters total, 10 of which were installed in 1906 (Filter Nos. 1 - 10) and the remaining 18 installed in 1932. The Sycamore filters each have a surface area of 1,432 sf. The Claiborne complex consists of 8 filters installed in 1950. Each Claiborne filter has a surface area of 5,240 sf. The filters at both complexes consist of two cells each, divided by a center gullet.

3.5.1 Sycamore Filters

The Sycamore filters are operated at a rate of about 2.2 gpm/sf. Due to hydraulic restrictions, Filter Nos. 1 - 10 are operated at a lower rate and all filters currently use the original manual filter controls. Several of these filters are currently not operational. Hydraulically actuated valves control the loading rate. All filter operations are performed manually from local control consoles and normal filter production is 2-3 MGD per filter. The dual media sits above a concrete bottom with perforated copper piping or Leopold clay blocks used for the underdrain system. Original drawings show the filters were designed with 36-inches of sand, with later modifications adding 10 inches of anthracite.

Both filter systems for the Carrollton plant use the ground storage tanks (GST) for backwash water. The level in the filter backwash equalization basin is measured before and after a backwash to determine wash water consumption. To aid in disinfection, sodium hypochlorite is added to the backwash water prior to washing the Sycamore filters.

Operator scheduling sets the backwash schedule at seven days for the filters at Sycamore. Filter backwashes are performed for approximately ten to twenty minutes at a rate of 16,000-20,000 gpm (11.2-14.0 gpm/sf). Based on visual observation of filter backwash during the inspection, it appears this rate is adequate to fluidize the bed to achieve effective cleaning of the media. The Sycamore complex has a single backwash pump that is operated in hand during each backwash. These filters have no filter-to-waste capability.

Figure 3-12: Deteriorated Condition of Raw Water Piping Filter Nos. 1-10 at Sycamore

Figure 3-13: Example of Debris in Filter

3.5.1.1 Filter Backwash and Booster Pumps

The Sycamore filters have a single backwash pump, which is estimated to be 70 to 80 years old. The backwash pump (Figure 3-14 and 3-15) is a vertical, direct-drive mix flow pump. The pump discharge is 36 inches in diameter. The drive is an electric motor rated for 200 hp at 450 revolutions per minute (rpm). The motor was converted from 25 hertz (Hz) to 60 Hz in 1983. There is no record of a comprehensive rebuild during the life of the pump, which is a long time for a pump to be in continuous service without a rebuild. The pump operated at the time of the inspection and ran smoothly. There was a considerable amount of water leaking through the stuffing box even when the pump was not running. The packing gland is located below the water level of the filter beds. The water from the leaking stuffing box drains to the sump pumps in the filter gallery. The plant operator stated that the machine shop has to regularly repack the shaft gland. Plant personnel indicated that there is a problem with the shaft or bearings requiring the constant repacking of the shaft gland.

Figure 3-14: Existing Backwash Pump

Figure 3-15: Backwash Pump

There are two booster pumps (Figure 3-16). Many of the valves in the Sycamore Filter Gallery are hydraulically operated. The booster pumps are used to boost water pressure to a level needed to operate the hydraulically-operated valves. One booster pump is an in-line pump with a water line from the water distribution system and boosts the water pressure from approximately 60 to 65 pounds per square inch (psi). The second pump draws water from the clearwell at the filter complex and pumps it into the water line serving the hydraulic system. The second pump is designed to provide operating pressure for the hydraulic system in the event of loss of pressure from the water distribution system, but it can also be used to boost water pressure by supplying additional water to the line operating the hydraulic system.

Figure 3-16: Booster Pump

3.5.1.1.1 Compressed Air System

The compressed air system at the Sycamore Facility consists of an Ingersoll Rand compressor (Figure 3-17) rated at 446 standard cubic feet per minute of air at 125 psi and an air receiver (Figure 3-18) with an estimated volume of 1,200 cf. Maximum compressor operating pressure is set between 85 to 90 psi. The air compressor was installed in 2004. The air tank is believed to date back to the earliest filters constructed around 1906. The compressor was operating at the time of the inspection and is in good condition. The air system has a cross connection to the 25-cycle power generator building air system for auxiliary compressed air. The compressor is also used as an auxiliary unit for the compressed air system at the power generation plant.

The air receiver dates back to 1906. There are no records of any inspections since the air receiver was installed more than 100 years ago. Substantial corrosion is visible on the outside of the receiver and the inspection cover has heavily corroded bolts. The condition of the interior of the receiver is unknown. Also, there is a substantial amount of flaking paint on the exterior, which, considering the age of the receiver, is probably lead paint. The air receiver would likely not pass the Gas Association Pamphlet C-6-1968 and 1962 inspection required by OSHA.

The compressed air system is connected to the old air dryer system, which is not functional per plant staff. The connection from the new compressor to the old air dryer system is not properly valved causing the compressor to continuously cycle. It is recommended that a new air dryer system be provided and piping and valving modifications be made to improve air quality, operation and reduce compressor cycling.

The compressed air tank was installed as part of the original building in 1906. The tank currently does not hold pressure due to leaks and is not currently used to maintain pressure for the compressed air system. Given the age and condition of the tank, and the fact that the Sycamore Filter Complex will be replaced with a new filtration complex (see recommendations below), no improvements to the compressed air tank are recommended.

Figure 3-17: Air Compressor

Figure 3-18: Air Receiver

3.5.1.2 Sump Pumps

There are two types of sump pumps (Figure 3-19) in the basement of the Sycamore Filter Gallery. The older section of the filter gallery has a submersible pump and a line shaft pump driven by a motor located at the plant operator level of the building. The newest section of the filter gallery has the original line shaft centrifugal pumps with the motor at deck level and the pump located at the bottom of the basement. The motors on the line shaft pumps were rewound in 2011, converting the motor from 25 Hz to 60 Hz. Piping upstream from the pump is heavily corroded as is nearly all of the piping below the plant operator floor level.

Figure 3-19: Sump Pump

The following deficiencies, operational needs, and major capital improvement requirements were identified for the Sycamore Filters:

- Currently only 19 of the 28 filters are operational due to various equipment issues significantly limiting the maximum day production from this facility. Structural issues are found throughout the filter complex. 8 of 19 rate of flow controllers are not operational.
- All filter gallery piping is severely corroded and many sections, including the raw water feed piping, have exceeded expected useful life, see Figure 3-12.
- Valves and actuators are in poor condition with many not operational.
- Hydraulic actuators and all instrumentation controls are in poor condition.
- The lower filter gallery stays extremely wet from leaking filter walls, piping, and valving creating an environment which compounds deterioration of all equipment and increases maintenance work load.
- Media loss has led to a decreased level of anthracite. As little as 2 inches of anthracite is measureable in some filters.
- Debris and mudballs present in filters will lead to diminished run times and filter effluent quality, see Figure 3-13.
- Uneven filter cleaning is noticeable during backwash. Staff have noticed increasing backwash issues that can be attributed to deterioration of the underdrain system.
- Sycamore filters have a single backwash pump. The pump is in poor condition and has significant leaks. All associated piping and valving are also in poor condition and leak.
- No air scour system is in place for these filters. An air scour system will improve filter cleaning during a backwash.
- The current air supply system is not adequately dried. Wet air adds to corrosion and instrument deterioration.
- The compressed air tank is in poor condition and cannot maintain system pressure.
- There is only one backwash pump for the entire Sycamore Filter Complex. Failure of this pump would shut down the entire filter complex and significantly limit the treatment

capacity of the plant. The pump is over 70 years old, has never been rehabilitated, is in poor condition and is well past its useful service life.

- The body of the backwash pump shows considerable corrosion and there is a considerable amount of leakage through the stuffing box of the pump.
- The in-line booster pump only boosts the pressure for the hydraulic system by 5 psi despite having a pump rating of 125 psi. The reason for such a low boost in pressure is because of the numerous leaks in the lines and hydraulic cylinders. Plant staff noted that the 5 psi boost is just enough to get some of the hydraulic valves to operate.

Recommended Sycamore Filters, Filter Backwash and Booster Pump Improvements

The dual media filters and associated piping, valves and appurtenances at Sycamore have exceeded their useful service life and require significant rehabilitation and replacement for long-term operation. The severe corrosion and deterioration of most all equipment, piping, valving, and structures found at the Sycamore filter complex places the Carrolton WTP in a position of imminent filter system failure. Losing use of the Sycamore filter complex due to a failure of any one piece of equipment will make it difficult for the WTP to ensure required finished water production rates can be met. Given the age and poor condition of the Sycamore Filter complex, a comprehensive rehabilitation of this facility is not recommended since rehabilitation would be complex in particular within the filter piping galleries. Also, the resulting configuration of the filters after rehabilitation, would not be ideal for long term operation and maintenance activities. As such, it is recommended that the entire filter complex be replaced.

Though a more thorough evaluation of filtration alternatives is needed (i.e., rapid sand filtration versus membrane filtration), a membrane filtration facility is assumed for the purposes of discussion. The SWBNO is ultimately very familiar with conventional media filtration facilities and their operation. However, a membrane filtration facility may provide some benefits. Just as a new media filtration facility would, a new membrane facility will ensure a long term solution for providing high quality filtered water to meet the production needs required now and in the future. However, the construction of a new membrane filtration complex can likely be staged more easily, allowing portions of treatment capacity to be brought on-line incrementally while the older filters are phased out of service. A membrane filtration facility is also likely to have a smaller footprint than conventional filters, which may also provide some benefit on a site with limited availability. Construction of a new facility also minimizes the work needed immediately at the existing filters.

A low-pressure microfiltration or ultrafiltration type membrane system is recommended. This type of system can be designed to allow for the installation of a skid configuration. The skid configuration will allow the WTP to install a set number of skids to meet required production rates with room to expand as funding becomes available or demand increases.

Since the new membrane filtration complex could take several years to design and construct, it is recommended that minimal capital investment be completed in the Sycamore filter complex in the short-term to keep sufficient production capacity at the plant while the new filtration facility is constructed. It is recommended that any short-term rehabilitation be focused on Filter Nos.

11-28 only while the older Filter Nos. 1-10 should be abandoned. The investments made in filters 11-28 will ensure adequate filtration capacity and water quality performance while a new filter complex can be constructed.

The recommended critical short-term improvements for the Sycamore Filter complex that should be implemented to provide enough production capacity while the new filtration facility is constructed, are summarized as follows:

- Abandon Filter Nos. 1-10.
- Replace the backwash pump and provide a redundant backwash pump for improved reliability. The backwash pump is a critical piece of equipment that is needed to maintain production capacity at the plant.
- Optimize the filter backwash process, including use of a low and high wash rate.
- Replace all valves for Filter Nos. 11-28.
- Replace the dryer for the air system and replace all corroded air piping. Although in poor condition, no improvements are recommended for the existing compressed air tank since the Sycamore Filter complex will be replaced with a new facility.
- Replace the filter media and clean the underdrains for Filter Nos. 11-28

3.5.2 Claiborne Filters

The Claiborne filters are operated at a rate of about 2.2 gpm/sf, they are also controlled by the wet-well level and fluctuate throughout a normal operational day. Typical operation is 5 MGD through each filter cell and as much as 10 MGD per cell is possible. Claiborne filters have a perforated concrete underdrain system. The current sand and anthracite media has been in place for more than 15 years.

Filter run times for Claiborne backwash cycles are based on head-loss through the filters and typically run 130 to 150 hours between backwashes. Backwash controls are limited and no air scour is available. Approximate wash water required per filter is 600,000 gallons as determined by the Claiborne filter gallery backwash flow totalizer. Plant staff noted that the filter backwash rate is adequate to fluidize the bed to achieve effective cleaning of the media. The filter backwash recycle system has a limited flow capacity and requires the backwashes of each to be scheduled.

The following deficiencies, operational needs and major capital improvement requirements were identified for the Claiborne Filters:

- No air scour system is in place for these filters. An air scour system will improve filter cleaning during a backwash.
- Filter monitoring and control for the Claiborne facility is done locally for each individual filter using the original filter controls. There is no central filter monitoring and control system.
- The installation of a hypochlorite storage and feed system to chlorinate the backwash stream will prevent excessive biological growth on the filter media leading to longer possible filter run times and faster backwash cycles. Backwash water from GSTs likely has a low chlorine residual, which can lead to biological growth.

- The last media replacement was 15+ years ago. The media in all eight filters needs to be replaced.
- Hydraulic cylinders, valves, and actuators require maintenance and in some places, replacement. Some valves are submerged and inaccessible with no way to determine condition.
- Current air system serving the Claiborne filters is not operational. Air is supplied from Sycamore filter complex. This feed system does not supply dry air further adding to corrosion and instrument issues.
- There is limited pumping capacity of the filter backwash recycle system, which limits and constrains the time when filter backwashes can occur.

Recommended Claiborne Filters, Filter Backwash and Booster Pump Improvements

The recommended improvements for the Claiborne Filters are summarized as follows:

- Replace the compressed air and dryer system at the Claiborne filter complex.
- Implement an annual filter media replacement and underdrain cleaning and inspection program for the Claiborne filter complex. It is recommended that at least one filter should be inspected and media replaced every year until all eight filters have been replaced.
- Add an air scour system to improve filter backwash performance of the Claiborne filters.
- Replace all valves, actuators, and cylinders to prevent excessive maintenance requirements and ensure full functionality.
- Assess and implement GST mixing improvements and increase tank turnover to maintain disinfectant residual levels on the backwash and minimize the potential for biological growth on the filter media. If needed, provide a new hypochlorite storage and feed system near the GSTs to boost disinfectant levels in the backwash stream.
- Long term: Replace the Claiborne Filter complex by expanding the capacity of the new filtration facility constructed to replace the Sycamore filter complex (See Sycamore Filter recommendations).

3.5.2.1 Storage Tank Pumps

There are two pumps (Figure 3-20) for pumping from the filters to the storage tanks. The pumps are driven by 350 hp motors. The pumps are located in a building housing pumps for the distribution system and controls for the Claiborne Filters. Both pumps are 48-inch mixed-flow pumps. The total dynamic head (TDH) for the pumps is estimated at 40 feet since the storage tanks tops out at 30 feet. Both pumps have 25 Hz motors. The newer pump has four speeds, from 265 rpm to 350 rpm. The older pump has 16 speeds. Both pumps are in good condition. The plant should continue to maintain these pumps in accordance with the manufacturer's recommended schedule.

Figure 3-20: Storage Tank Pumps

3.5.3 Backwash Waste Equalization Basin

There are four backwash water recycle pumps (Figure 3-21). The pumps are designed to transfer water from the Backwash Waste Equalization Basin to the G and L Basins for recycling of spent backwash water to the head of the plant. Two of the pumps are 75 hp units and two are 150 hp units. Presently, one of each of the 75 hp and 150 hp pumps is operating; the others have been removed. There is a spare mount for a fifth pump. Overall, the recycle pump facility is in poor condition with only two of the four pumps operable. The remaining pumps are operational but their life expectancy is limited.
There is an ongoing contract to remove the two remaining pumps and replace them with new pumps.

Figure 3-21: Recycle Pumps

3.5.4 Finished Water Storage

3.5.4.1 Ground Storage Tanks

Finished water storage consists of four 4 million gallon pre-stressed concrete GSTs and six 3.3 million gallon steel GSTs. The tanks hold a combined 35.8 million gallons. The tanks are operated in parallel and the piping to the tanks is configured in such a way that filtered water first goes to a clearwell which serves as a wet well for two low-lift pumps that are used to fill the tanks. The clearwell also serves the Claiborne pump station. The "off-line" storage (i.e., finished water does not need to flow through the tanks to go to distribution) can be used to feed the distribution system or provide filter backwash supply to both the Claiborne and Sycamore Filters.

The two most important factors in maintaining water quality in storage tanks are volume turnover and mixing efficacy. The American Water Works Association (AWWA) recommends the complete volume of a storage tank be turned over every 3-5 days (reference) which is equivalent to 20 to 33 percent volume turnover per day. The Carrollton GSTs are approximately 30 feet tall.

The SWBNO provided GST level data for a two week period in November (Figure 3-22). Based on the data provided, the tanks do have regular daily fill and draw patterns. The most significant observation regarding the tank level data is the amount of turnover. There is approximately 5 feet of draw down in the tank on a daily basis – or roughly 15 percent of the tank volume (5 feet divided by 30 feet total depth). More turnover would help to better maintain water quality within the tanks. Regarding the fill and draw cycles, for the period evaluated, the tank is filled over a roughly 12-hour period and drains over a 12-hour period. Generally speaking, this is a nearly ideal situation as it maximizes mixing during both the fill and draw cycles. However, further evaluation is needed to assess mixing parameters such as inlet velocity to determine the effectiveness of the mixing.

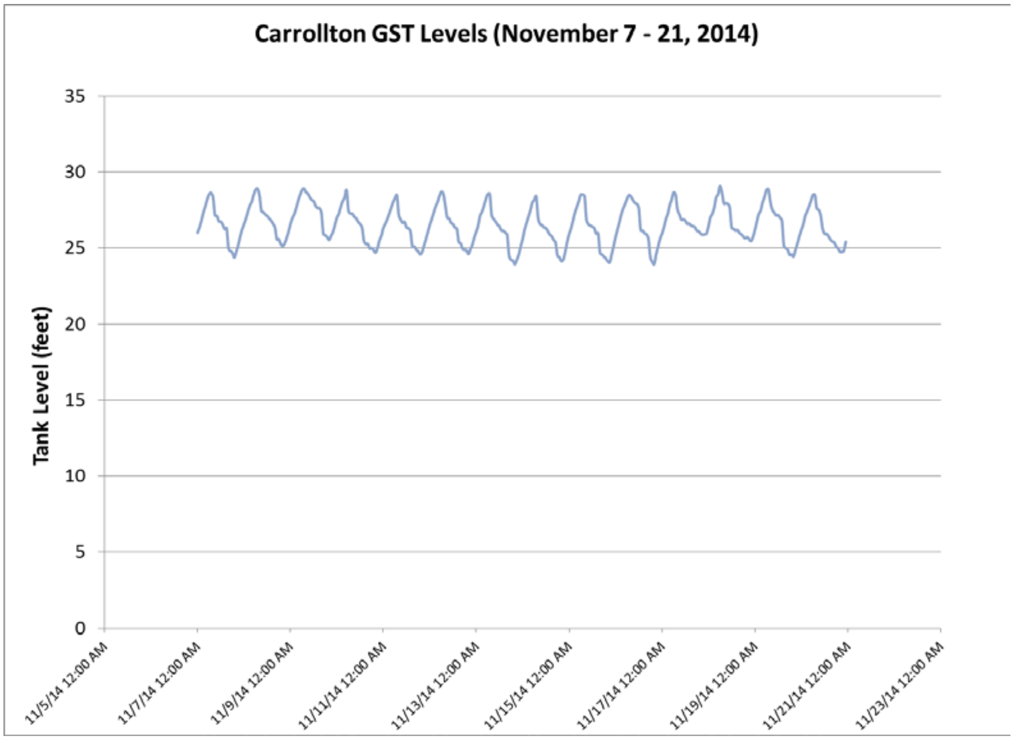

Figure 3-22: Carrollton Steel GST Levels (November 7-21, 2014)

Temperature probes were installed in one of the Carrollton steel GSTs for a period of approximately ten days in November 2014. Figure 3-23 shows the results of the temperature monitoring, as well as the tank level and ambient temperature during the monitoring period.

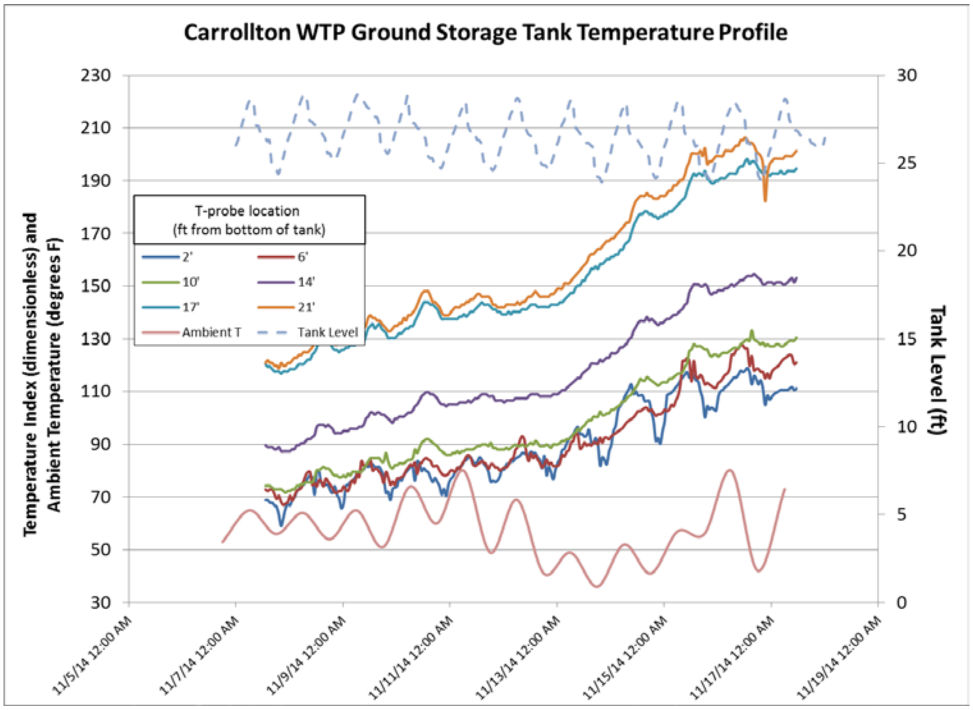

Figure 3-23: Carrollton GST Temperature Profile (November 15 – 19, 2014)*

*Due to calibration errors the tank water temperatures are reported as a dimensionless "temperature index". The temperature index was calculated by subtracting 95 from the reported temperature. The index is not intended to reflect the actual tank water temperature and the data reported are useful only for the purposes of observing trends at each depth within the tank. A more thorough evaluation is recommended to better characterize tank mixing.

Note in Figure 3-23 that there were calibration errors in the temperature probes at the start of the monitoring period. Tank water temperatures were adjusted to create a "temperature index" by subtracting 95 from the reported temperature; however, the index should not be construed as the actual temperature in the tank, and the data are useful only for the purposes of comparing trends at the various levels within the tank. Further, while the relative trends at each depth within the tank are considered in this discussion, the temperature index itself also has some issues. For example, it is not possible that temperatures increased by more than 60 degrees within the tank over the monitoring period. The index was created solely for the purpose of displaying the data and to show the actual ambient temperature on the same axis without losing too much resolution.

A few general trends can be observed in the data presented in Figure 3-24. First, the temperatures at all levels in the tank rise during the day when the tank is draining and fall at night during the fill cycle. This follows trends in ambient temperature and is expected, particularly in steel tanks, as the ambient temperature has more influence on the tank water temperature.

Also of note in the data are the temperature indices of the bottom three probes in the tank (Figure 3-24). The temperature index for each of these three probes started at approximately the same value. During the drain cycle/over the course of a day, the temperature index of these three probes begins to diverge indicating thermal stratification. However, the temperature indices of these three probes converge during the fill cycle, indicating that at least the bottom third of this tank is mixing (at least in the vicinity of the temperature probes which were installed in the general vicinity of the inlet pipe). Unfortunately, due to the quality of the data no further conclusions can be drawn regarding the mixing efficacy of the tank.

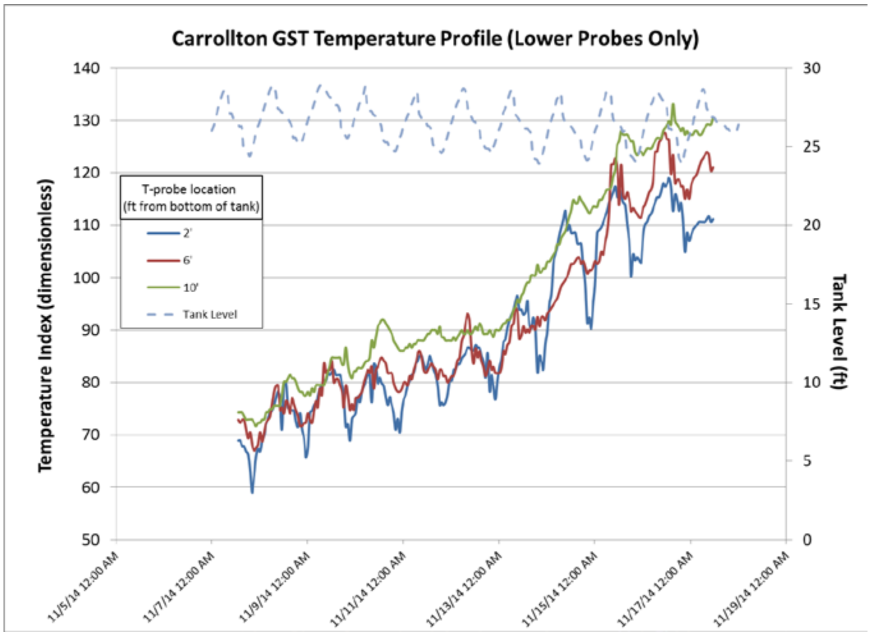

Figure 3-24: Carrollton GST Temperature Profile Lower Probes Only (November 15 – 19, 2014)*

*Due to calibration errors the tank water temperatures are reported as a dimensionless "temperature index". The temperature index was calculated by subtracting 95 from the reported temperature. The index is not intended to reflect the actual tank water temperature and the data reported are useful only for the purposes of observing trends at each depth within the tank. A more thorough evaluation is recommended to better characterize tank mixing.

Due to the relatively low volume turnover in the Carrollton GSTs, stratification is expected and water quality degradation is anticipated to be occurring in the upper levels of the tank. While the lower third of the steel tanks appears to be mixed at least in the vicinity of the temperature probes, no conclusions can be drawn regarding the outer perimeter and upper levels of the tank. Though no data are currently available for the concrete tanks, due to the relatively low turnover and their larger diameter, stratification is also likely in those tanks.

More detailed evaluation is recommended to confirm the mixing characteristics of both the concrete and steel tanks. The following actions are recommended:

1. Coordinate tank fill and draw cycles between Operations and Pumping & Power to attempt to drain at least 20 percent and ideally up to 33 percent of the tank volume daily.
2. Conduct a study to more thoroughly evaluate tank mixing efficacy and turnover, including computational fluid dynamic modeling of the tank during fill and draw cycles

to determine the optimum operation and inlet/outlet configuration to improve mixing and minimize water quality degradation.
3. Consider properly designed and sized mechanical mixing if insufficient turnover and mixing are not possible with passive mixing improvements, such as changes in tank operation and inlet/outlet modifications.
4. Evaluate the impact of improved mixing on backwash water supply and the need to boost chlorine residual in the backwash water.

3.6 Chemical Storage and Feed Systems

3.6.1 General Considerations

The chemicals used for water treatment at the Carrollton WTP are summarized in Table 3-1

Table 3-1 Chemicals Utilized at Carrollton WTP

Chemical	Use
Chlorine	Disinfectant (with ammonia to form chloramines)
Lime	Corrosion control
Ferric Sulfate	Coagulation
Ammonia	Disinfectant (with chlorine to form chloramines)
Fluoride	Dental Hygiene
Powdered Activated Carbon (PAC)	Taste & Odor
Polyphosphate	Prevent scaling of filter media/Corrosion control
Cationic Polymer	Coagulation Aid

With the exception of the chlorine system, the majority of the chemical storage and feed systems at the Carrollton WTP are older systems that have reached the end of their useful service lives.

Planning for replacement of the Carrollton Plant WTP chemical storage and feed systems, except for the chlorine system, should begin as soon as possible. Part of that planning must include verification that the replacement system meets the current State requirements for chemical storage (quantity, safety, and control requirements) and feed capability (feed rate capacity and redundancy requirements).

Many of the chemical storage systems at the Carrollton WTP are not located in containment areas, a standard practice at most water treatment facilities, nor are feed pumps generally located within curbed areas to contain leaks or spills. Access to all chemical systems is not restricted to "authorized personnel only." As new facilities are designed, controlling access to chemical storage and feed areas should be a design consideration. Wash down stations not only aid plant personnel in maintaining the cleanliness of equipment and systems, but such stations can be key components in controlling leaks or spills. Every chemical storage and feed system must be equipped with such stations.

The injection points for all systems must be examined, and in most cases improved. For many chemicals, the injection points are open pipe discharges with inadequate mixing. One case of this is the polymer and coagulant injection point. In this instance the two chemicals (ferric sulfate and polymer) are combined and fed into static mixers which do not provide the mixing energy necessary for effective coagulation. In some instances, this can result in excessive chemical usage as more chemical is required to achieve adequate dispersal.

Adjustment of chemical dosage at the Carrollton WTP is typically a manual process and not flow paced. As each system is upgraded, instrumentation that not only introduces automatic dosage control, but also provides system status instrumentation monitoring capability to a plant-wide central monitoring station should be included.

The ferric sulfate, polyelectrolyte, and polyphosphate storage tanks are not equipped with level monitoring systems. There is no central data monitoring station where such information is available to plant operators.

Generally, the age and condition of the chemical systems at the Carrollton WTP, except for the sodium hypochlorite storage and feed system, present a potential safety hazard to plant personnel entering those respective areas. In some areas, such as the Chemical Building, the safety hazards are created by a combination of facility problems, spilled chemicals, and unprotected rotating/operating equipment. Specific system safety weaknesses will be noted in the following sub-sections on the individual chemical systems. Employing a chemically resistant coating on chemical containment areas should be a universally followed practice at the Carrollton Plant.

3.6.2 Sodium Hypochlorite System

The sodium hypochlorite storage and feed system at the Carrollton WTP is the newest system at the plant, having been placed in operation within the past two years. This is a liquid system providing the chlorine as sodium hypochlorite. Sodium hypochlorite (NaOCl) is stored in fiberglass reinforced plastic (FRP) storage tanks, located in a covered containment area (see Figures 3-25 and 3-26). A corrosion resistant coating covers the containment area. While the storage area has a personnel wash down station (Figure 3-25), the area does not have a dedicated potable water supplied wash down station. To wash down the area, plant personnel must utilize hose laid across the decking from the G-Basin area, creating a tripping hazard.

. There are 8 bulk storage tanks that each hold 15,000 gallons, for a total storage capacity of 120,000 gallons. Approximately 6,000 gallons of hypochlorite are used on a daily basis. The plant currently only uses one side of storage tanks (60,000 gallons of storage) to reduce the amount of chemical stored to minimize the degradation of the hypochlorite. The current sodium hypochlorite dosage is 5.6 mg/L which results in a usage of about 6,700 gallons per day assuming a flow of 144 mgd. The storage currently utilized provides about 10 days of storage at this feed rate and flow.

Figure 3-25: NaOCl Storage Area Personnel Washdown Area

Figure 3-26: NaOCl Storage Area

NaOCl is delivered to the plant in trucks and unloaded at an access point outside the containment area towards the southwest corner of the plant site. Figure 3-27 shows a delivery truck unloading NaOCl. Figure 3-28 shows the piping used in the delivery of NaOCl.

Figure 3-27: NaOCl Unloading

Figure 3-28: NaOCl Unloading Piping

Adjacent to the storage containment area is a single-story feed pump building (Figure 3-27). Inside the building, the sodium hypochlorite pumps (Figures 3-29 and 3-30) are located in a containment area to handle any spilled chemicals. A corrosion-resistant coating covers the floor of this containment area. The raised, reinforced concrete pump bases are not coated with a corrosion resistant coating. There are five 1.5 hp Seepex feed pumps. The pumps appear in good condition and plant staff noted that the pumps work well. All hypochlorite is currently added before the C Basins.

Figure 3-29: NaOCl Feed Pumps

Figure 3-30: NaOCl Feed Pumps

The following deficiencies, operational needs and major capital improvement requirements were identified for the sodium hypochlorite storage and feed system:

- There is no permanent potable water line to supply a wash down station for NaOCl system.
- The system does not comply with the safety and warning signage.

Recommended Improvements to the Sodium Hypochlorite System

It is recommended that a permanent potable water line be provided at the sodium hypochlorite storage area to supply wash down water for the hypochlorite system. In addition, it is recommended that proper labeling be provided to comply with safety and warning signage. Both of these items can be implemented in-house as part of the plant's maintenance program.

Long-term replacement of the hypochlorite metering pumps, piping and appurtenances will likely be required within the 20-year planning period as these systems are typically expected to last 10-15 years.

3.6.3 Lime System

The Carrollton WTP lime storage and feed system is a challenge with respect to maintenance and safety. Overall, the lime handling, storage, slaking, and feed components have exceeded their useful service life. The system is old and requires labor intensive measures to keep operational. The system is in need of replacement to ensure continued reliable and safe operation. Prior to replacing the existing lime system, the use of lime and alternatives to a "slaked lime" should be examined and evaluated, including the elimination of lime altogether and changing the corrosion control strategy for the Carrollton WTP.

Figure 3-31: Lime Rail Car and Tug

Figure 3-32: Lime Rail Car and Tug

A yellow "tug" is used to move the lime hopper car from the railroad drop-off point, down a residential street into the Carrollton WTP and to the unloading area next to the Chemical Building (see Figures 3-31 and 3-32). After unloading the lime, plant personnel must return the empty hopper cars to the railroad "drop-off" point for pick up by the railroad. The street along which the hopper rail car must be moved is of typical residential street width with rails installed down the center. To ensure adequate safety clearances plant personnel must contact residents along the street to advise them of the operation and to request they move any cars parked along the street. Unmoved cars can delay this operation for hours. Rail car operations are now accomplished by plant operations personnel as an additional duty. Thus, when a rail car is moved, other plant duties are postponed.

Lime drops from the bottom of the rail hopper car into a pit outside the Chemical Building, where it is moved by a conveyor into a hopper within the building, see Figures 3-33 and 3-34. At an average lime dosage of 22 mg/L and average flow rate of 144 mgd, approximately 10 tons per day of lime are used. Each of the eight bulk storage tanks provides about 100 tons of storage, resulting in a total storage time of about 80 days. The average feed rate for lime is 26,400 lb/d. Each of the three lime slakers has a capacity of 4,000 lb/hr which provides a total slaking capacity of 288,000 lb/d. Each of the five lime feed pumps has a capacity of 100 gpm which provides adequate capacity to meet required feed rates.

Figure 3-33: Lime Unloading Conveyor Receiving Lime from Rail Car – Ground Floor

Figure 3-34: Chemical Building Attic Showing Horizontal Lime Conveyors

A vertical conveyor system (Figure 3-35) is used to transport lime from the rail cars to overhead storage bins. From the overhead storage, the lime is fed to one of two operable slakers on the second floor of the Chemical Building. The slakers process the raw lime to a liquid form for pumping by the lime pumps located on the bottom floor. There are eight screw conveyors, each operated by a 5 hp motor through a worm gear reduction. Only one screw conveyor was operating at the time of the inspection. The conveyor operated as intended with no reported problems. The backup to this system is truck delivery of lime. The delivery trucks are equipped with a pneumatic system which delivers the lime directly to the overhead storage bins.

Figure 3-35: Lime Screw Conveyor

The lime slakers (Figure 3-36 and 3-37) have exceeded their expected useful service lives. Plant operators reported that the slakers require extensive, almost continual maintenance. Personnel often use salvage parts from an inoperable unit to repair other units.

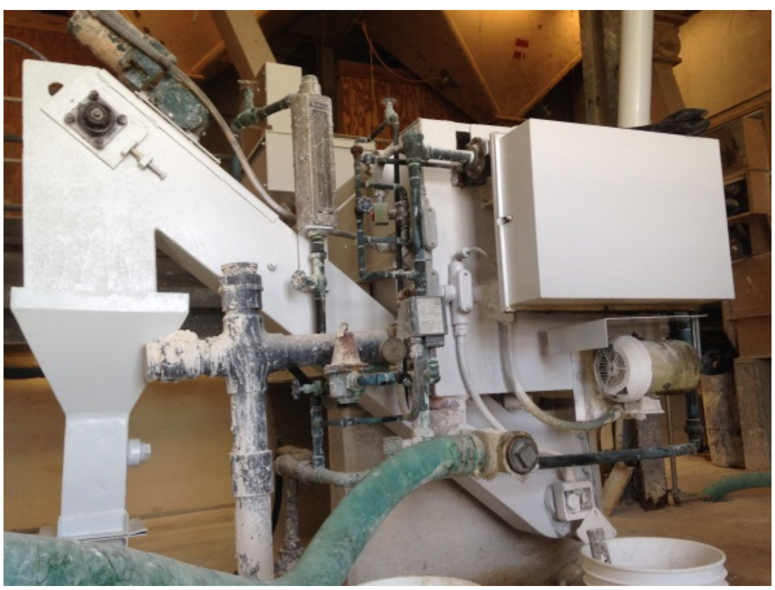

Figure 3-36: Lime Slaker

Figure 3-37: Lime Slaker Area

There are three lime slakers (Figure 3-38) manufactured by Wallace & Tiernan. Two of the slakers are operable while the third is used for spare parts. The slakers are over 20 years old and should be replaced with newer more efficient models currently available. Each slaker has a maximum capacity of 4,000 pounds per hour (lbs/hr), with one slaker typically used at a time. Current lime use is approximately 28,000 pounds per day (lbs/day).

Figure 3-38: Lime Slaker

There are five lime pumps (Figure 3-39, 3-40 and 3-41) used to feed lime upstream of the C-Basins. The pumps are direct-drive and powered by a 5 hp motor operating at 1,750 rpm. The pumps are manufactured by Durco and are Model MK3 STD. Only one pump is typically needed to meet feed requirements. Because of the nature of pumping lime solution, the pumps require frequent disassembling for cleaning and clearing of blockages. When a pump is removed from service for maintenance, another is placed in service to maintain continuity of operation.

The lime pumps are connected to suction and discharge manifolds by rubber hoses. This permits changing quickly from pump to pump. Upon disconnecting a pump from service, the lime solution discharges from the hoses requiring a wash down of the area. Since there are no retaining walls to contain the liquid lime in the hoses, the entire pump area requires hosing after each pump change.

Figure 3-39: Lime Feed Pump Area

Figure 3-40: Lime Feed Pumps

Figure 3-41: Lime Pumps

The following deficiencies, operational needs and major capital improvement requirements were identified for the Lime storage and feed system:

- Lime deliveries are difficult and disruptive process to plant personnel and nearby residents. Moving large, dry powder “hopper” type rail car cars on residential streets is a significant inconvenience to nearby residents, but also a safety concern for both plant employees and nearby residents. Operating the rail car mover and all the steps necessary to move a rail car along a residential street requires a significant manpower demand.
- The lime storage, conveyance, slaking and feed equipment is well past its useful service life and in generally very poor condition, and should be replaced. There is significant lime dust contamination throughout the facility.
- The existing slakers are obsolete, inefficient and spare parts are no longer available for this model.
- The lime feed pumps are routinely out of service and require frequent maintenance.

Recommended Lime System Improvements

Given the poor condition and difficulties associated with the existing lime system, it is recommended that the entire system be replaced with a new system. It is recommended that the plant conduct a study to assess the need for continued lime addition and evaluate available lime or alternate chemical options most suitable for pH adjustment at the Carrolton WTP. The study should assess water quality impacts; implementation, operational, and maintenance requirements; advantages and disadvantages; and costs associated with various lime systems (i.e. quick lime, liquid lime, or hydrated lime) and alternate chemicals to meet treatment requirements for corrosion control.

A complete replacement of the existing lime system should be implemented based on recommendations of the study.

3.6.4 Ferric Sulfate System

Ferric sulfate is added at the static mixers for the G and L basins as a coagulant. It is classified as a Class 8 Corrosive Dangerous Good and Corrosive (C) Hazardous Substance. With a pH of <1 and specific gravity of approximately 1.6, ferric sulfate can be stored in fiberglass, stainless steel or plastic containers.

Ferric sulfate is delivered to the Carrollton WTP in trucks and stored in two 8,000 gallon fiberglass reinforced plastic (FRP) storage tanks, Figure 3-42. Each tank is located in a separate uncoated, reinforced, concrete containment area. A pipe wall penetration in the common wall between the two tanks interconnects the tanks. Each tank is equipped with a galvanized steel ladder providing access to the tank top. Safety handrails are installed on the top of these tanks. Tank level measurement is a visual system, as the liquid level in the tank can be seen through the opaque tank wall.

Figure 3-42: Ferric Sulfate Storage

The two bulk storage tanks provide insufficient volume to meet typical system demands. Based on the average flow of 144 MGD and average dosage of 6.1 mg/L as Fe^{3+}, the tanks provide approximately 2 days of storage, which is far less than the 30 days of storage recommended under Ten States Standards. The current plant flow is under 120 MGD, which results in approximately 3-5 days of ferric storage. The number of deliveries required to support the dosage of this chemical is considered excessive. A major risk of such frequent deliveries is that any delivery disruption can jeopardize the ability of the plant to continue to adequately treat the incoming raw water.

The storage tanks are marked with appropriate CAS and hazard signage. However, the associated piping is not identified or equipped with flow arrows.

There are four Seepex ferric sulfate feed pumps (Figure 3-43) which are housed inside a building located in a containment area adjacent to the ferric sulfate storage area. All of the feed pumps are installed on an uncoated reinforced concrete pump base. The pump building does not have a containment system around the pumps. Chemical feed pump areas should be located in a curbed spill and/or leak containment area and a chemically resistant coating be applied to the area. The current feed pumps are adequately sized to meet current dosage requirements.

As with other chemical systems at the Carrollton Plant, there is no wash down station inside the pump building. Thus any chemical spillage cannot be washed away.

Figure 3-43: Ferric Sulfate Feed Pumps

The following deficiencies, operational needs and major capital improvement requirements were identified for the ferric sulfate storage and feed system:

- There is insufficient bulk storage capacity, requiring chemical deliveries multiple times per month. Under average dosage/flow conditions, the tanks provide approximately 2 days of storage, which is well below the recommended 30-day bulk storage capacity.
- The existing bulk storage tanks are generally in poor condition and will require replacement within the master planning period.
- The chemical feed pumps and associated piping and appurtenances operate well but are nearing the end of their useful service lives and should be replaced within the master planning period.
- No flow pacing or automatic adjustment of ferric sulfate feed is provided for the system, which likely results in chemical overfeeding.
- The area around the pumps shows evidence of multiple spills. The raised concrete pump foundation is discolored, however, it appears to be sound.
- The metering pump building has rotting exterior panels, unfinished interior walls, and is in overall poor condition.

- The feed distribution of the chemical is manually controlled by adjusting valves on the feed header at the G-Basins. This chemical application method is not ideal for optimum coagulation performance.
- The area around the pumps shows evidence of multiple spills. The raised concrete pump foundation pad is discolored, however it appears to be sound. Inside the pump building, chemical spillage has deteriorated the protective paint coating on the polyelectrolyte polymer feed pumps. Since these pump bases are quite stout, the deteriorated paint coating most likely will not shorten the life of the pumps.

This building, while appearing to be soundly constructed, is not finished inside. Thus, the building offers no cold weather protection, although the building does appear to keep rain off the pumps. The pumps are installed on an uncoated reinforced concrete pump base. The pump building does not have a containment system around the pumps.

Ferric Sulfate System Recommendations

The following rehabilitations and improvements are recommended for the ferric sulfate storage and feed system:

- Install two additional 8,000 gallon bulk storage tanks, along with associated piping, appurtenances, and containment for the existing system, in the immediate term to address the current bulk storage capacity deficiency. These additional tanks will provide at least a week's works of ferric sulfate storage in the short term.
- Modify the chemical application points and feed piping and valving for both G-Basins to improve chemical application, mixing and distribution to optimize coagulation performance and minimize chemical usage.
- Replace the entire ferric sulfate storage and feed system in the short-term given that the existing equipment and storage tanks are nearing the end of their useful service lives. The new ferric storage and feed system can be installed in a new chemical storage and feed facility that also houses the polymer and fluoride systems. Alternatively, the new ferric sulfate system can be housed in a separate facility from these other chemical systems. Further evaluation is needed to identify implementation requirements, advantages and disadvantages, and costs of to determine whether these chemical storage and feed systems should be housed in a combined facility or kept separate.

3.6.5 Ammonia System

Ammonia is added in conjunction with chlorine to form chloramines for primary disinfection of the settled water. Chloramines are not as strong a disinfectant as free chlorine, requiring higher dosages and contact times to meet CT requirements. Chloramines, however, reduce the formation of disinfection byproducts (DBPs) and provide a more persistent residual in the distribution system.

The ammonia storage system at the Carrolton WTP consists of one 10,000 gallon fixed steel pressure tank located outside adjacent to the Administration Building. The ammonia feed system (Figures 3-44 thru 3-47) employs the storage tank pressure as the prime driver to move the ammonia gas to the injection points. This is typical of ammonia feed systems. The ammonia feed system consists of two direct feed ammoniators, each with a feed capacity of 3,000 lb/d. The ammoniators each include a pressure reducing valve and flowmeter. Ammonia is currently added downstream of the hypochlorite application points before entering the C-Basins. There is capability to add ammonia downstream of the C-Basins; however, this feed point has not been used. The average ammonia dosage is 1.0 mg/L, with a typical target application ratio of chlorine to ammonia ranging between 3:1 and 5:1. Based on a 1.0 mg/L dosage and average flow of 144 mgd, the existing bulk storage tank provides approximately 25 days of storage capacity. The existing 3,000 lb/d feed units have adequate capacity to meet daily demands and a peak flow of 240 mgd and dosage of 1.0 mg/L.

Pressurized feed piping, while adequately supported, is not anchored to pipe supports completely.

Figure 3-44: Ammonia Storage Tank

Figure 3-45: Ammonia Loading Piping

Figure 3-46: Ammonia Feed Room Piping

Figure 3-47: Direct Feed Ammoniator

The following deficiencies, operational needs and major capital improvement requirements were identified for the ammonia storage and feed system:

- The single ammonia storage tank provides no redundancy and could preclude the addition of ammonia if an issue arises with the tank, interconnecting piping and/or appurtenances.
- The storage tank system is poorly identified and not labeled with appropriate warning of safety signs.
- Tank loading protocol is not posted in the area. Pressurized piping, while adequately supported, is not protected from damage by being struck by vehicles, hand carts, etc. Fill and empty valves (at the loading station), while capped, are not equipped with valve wheel locking devices.
- The ammonia feed building has a portable space heater on the table with the ammonia feed piping. This space heater is currently used to prevent piping from freezing up due to

the evaporative cooling properties of ammonia gas expansion. While the piping appears in generally sound condition, the pressure regulating valves show signs of extended use.

Recommended Ammonia System Improvements

The following rehabilitations and improvements are recommended for the ammonia storage and feed system:

- Provide a redundant ammonia bulk storage tank. If adding a second storage tank will increase the on-site ammonia gas storage quantity beyond what is recommended or required by State regulations, a second, smaller tank can be provided or two smaller tanks could be installed to replace the existing larger tank. As a part of this evaluation, alternative locations on the site for ammonia storage should be evaluated. The current location is adjacent to administrative buildings and could pose a hazard in the event of an ammonia leak.
- Establish with the regulatory agencies if the ammonia bulk storage system needs to be enclosed and provided with an emergency scrubber system.
- Provide third direct feed ammoniator for redundancy
- Continue standard pressure testing of the tank as required by the State. If the tank fails the pressure test, it should be replaced.
- Provide proper labeling and safety warning signage and properly support piping within the feed building.

3.6.6 Fluoride Systems

Fluoride is added to the treated water to prevent dental caries. Fluoride (fluorosilicic acid) is added prior to filtration in the effluent channel of the C-Basins. Fluoride is stored in a single double-walled 10,000 gallon FRP storage tank located near the ammonia storage tank. The tank is labeled by name and has the CAS number and hazards signs placed in clear view. Two metering pumps located inside the combination fluoride-ammonia feed building (Figure 3-48 and 3-49), are fed from the bulk storage tank. Under an average flow of 144 mgd and an average dosage of 0.28 mg/L as Fl^-, the bulk storage tank can provide approximately 30 days of storage. The feed pumps are adequately sized to meet the dosage requirement at the design flow. No flow pacing or automatic adjustment of the fluoride feed system is provided.

The fluoride storage tank is mounted directly on a raised concrete foundation/base. Wire strapping is used to secure the tank in addition to a metal strap and anchor system (Figure 3-50).

Figure 3-48: Fluoride Feed Pumps

Figure 3-49: Fluoride Feed Pumps

Figure 3-50: Fluoride Storage Tank

The following deficiencies, operational needs and major capital improvement requirements were identified for the Fluoride storage and feed system:

- There currently is no fluoride day tank, which has been required by the regulatory agency in the latest sanitary survey. The day tank is required to ensure any accidental overfeed conditions are limited to the volume of the day tank only, limiting the potential for overdosing that could occur.
- The bulk storage tank, feed pumps, piping, valves and appurtenances are in poor condition and should be replaced.
- The feed room lacks a containment area where the fluoride feed system pump and the piping manifold are located. There is also no wash down system (hose bib and hose) installed within the building.
- No flow pacing or automatic adjustment of fluoride feed is provided for the system, which may result in chemical overfeeding.

Recommended Fluoride System Improvements

The following rehabilitations and improvements are recommended for the fluoride storage and feed system:

- Provide a day tank, transfer pump and associated piping and appurtenances to the existing fluoride system in the short term, to meet regulatory agency requirements for a day tank.
- Replace the entire fluoride storage and feed system in the mid-term given that the existing equipment and storage tank are nearing the end of their useful service lives. The new fluoride storage and feed system can be installed in a new chemical storage and feed

facility that also houses the ferric sulfate and polymer systems. Alternatively, the new fluoride system can be housed separate from these other chemical systems. Further evaluation is needed to identify implementation requirements, advantages and disadvantages, and costs of to determine whether these chemical storage and feed systems should be housed in a combined facility or kept separate.

3.6.7 Powdered Activated Carbon System

PAC is added to the raw water for taste and odor control and when chemical or fuel spills occur in the River near the plant intake. Taste and odors are generated on a seasonal basis by algae and other naturally occurring organic compounds. PAC can also adsorb organic compounds from chemical spills to prevent potentially harmful organics from entering the WTP.   PAC is added on an intermittent basis as needed to the raw water prior to entering the G and L Basins.

The PAC storage system is comprised of a 5,000 gallon FRP storage tank (Figure 3-51), recirculation pump (Figure 3-52), and associated piping and appurtenances. Both the FRP storage tank and recirculation pump are located outside the Chemical Building along the southward-facing wall. There are two feed pumps housed within the Chemical Building. Plant staff noted that the feed pump capacity is typically insufficient to reliably feed enough PAC to address taste and odor events (the maximum dosage they can meet is about 1 mg/L). Overall, the storage system is constructed of primarily corrosion resistant materials. Only minimal corrosion was noted during the inspection. The FRP storage tank exterior exhibited some UV degradation and is cracked and leaking.

Figure 3-51: PAC Storage Tank

Figure 3-52: PAC Recirculation Pump

The recirculation pump appears to be in good condition and is reportedly working satisfactorily.

The PAC storage tank is not within a containment area. The PAC feed system is located on the ground level of the Chemical Building along the south wall of the building (Figure 3-53). As with all other chemical systems in the Chemical Building, this system is coated in spilled lime (dust and slaked lime). Since the pumps, motors and piping are coated in lime as well as PAC, a thorough assessment of their physical condition was difficult to complete. Electrical controls and panels are splattered with lime, making the controls difficult to read. A plant operator cannot touch the controls without contacting spilled, dried lime.

The PAC pumps appeared to be operational, however, some general housekeeping is needed in the area. No nearby wash down station was noted to aid in maintaining the area. Typically, the PAC feed dosage control is manual, with no requirement for instrumentation signal on pumping dosage being relayed to a plant central monitoring station.

Figure 3-53: PAC Feed Pumps

The following deficiencies, operational needs and major capital improvement requirements were identified for the PAC storage and feed system:

- The existing PAC system does not provide enough bulk storage and feed capacity to reliably address taste and odor events.
- PAC is currently added within the WTP immediately prior to the G and L Basins, which is not an optimal location for effective PAC adsorption. The feed point should be located as close as possible to the intake, to maximize adsorption contact time and ensure removal of organics prior to entering the sedimentation basins.
- The bulk storage, transfer pumps, feed pumps, piping and appurtenances are generally in poor condition and should be replaced.
- The metering pumps are located within the Chemical Building and are covered in lime.

Recommended PAC System Improvements

It is recommended that the PAC system be replaced with a new storage and feed system located near one of the WTP intakes, similar to the PAC system for the Algiers WTP. An evaluation should be completed to determine the feasibility of using the existing abandoned potassium permanganate facility located near the WTP intake for PAC storage and addition. If unfeasible, a new facility should be constructed near the intake structure to allow PAC addition at this location.

3.6.8 Polyphosphate System

Polyphosphate is added upstream of the C-Basins as a sequestering agent to prevent the precipitation of calcium carbonates and hydroxides from lime addition, reducing the amount of calcification that can occur on the filter media.

Polyphosphate is stored in a 6,000 gallon FRP storage tank (Figures 3-54 and 3-55) located on the south side of the Chemical Building adjacent to the PAC bulk storage tank. This tank is mounted on a raised reinforced concrete base and secured by wire straps equipped with turnbuckles. The feed system consists of two metering PulsaFeeder pumps located inside the Chemical Building. Typical dosages range between 0.5 to 1.5 mg/L. Plant staff noted the existing system can meet typical dosage requirements.

Containment areas with controlled means of drainage are recommended for most liquid storage systems.

A tank loading connection is adjacent to the tank. This connection is housed within a corrosion resistant, raised stainless steel box with a hinged lid. The loading connection is not labeled. In fact, other than the word "polyphosphate" stenciled on the side of the tank, there are no markings, safety signs, etc. in the vicinity of this tank.

This tank's exterior exhibits minor UV degradation. But no evidence of fatal tank damage or impending failure was noted.

Figure 3-54: Polyphosphate Storage Tank

Figure 3-55: Polyphosphate Storage Tank

Located inside the Chemical Building, the polyphosphate feed system, is coated with lime (in addition to its own chemical). This system is constructed of primarily corrosion-resistant materials. However, due to the extensive lime coating the equipment, determining the true condition of the system was difficult. Since lime cannot be practically cleaned from equipment and piping, a complete system replacement (and relocation outside the lime contaminated area that is the interior of the Chemical Building) is recommended.

While little leakage was noted in the system at the time of the inspection, a rag was in use to control polyphosphate leaking from a joint in the system piping/tubing.

Feed pumps (Figure 3-56) in this system are from the Pulsatron series of PulsaFeeder diaphragm pumps. This model of PulsaFeeder pump utilizes 110 voltage through a standard 110 volt convenience outlet and has a capacity of 240 gpd. The pump controls are located on the face of the pump. Both features make replacing these pumps relatively easy since no specialized skills or licenses are usually required.

Figure 3-56: Polyphosphate Feed Pumps

The following deficiencies, operational needs and major capital improvement requirements were identified for the polyphosphate storage and feed system:

- This storage tank is not within a containment area as required by the Louisiana Department of Environmental Quality (LDEQ). The storage tank should be located in a containment area to control and handle any spilled or leaked chemical.
- The chemical feed pumps are operational but nearing the end of their useful service life. The pumps, piping, and appurtenances are located within the Chemical Building and are covered in lime.
- No flow pacing or automatic adjustment of polyphosphate feed is provided for the system, which may result in chemical overfeeding.

Recommended Polyphosphate System Improvements

It is recommended that containment be provided for the bulk storage tank. The chemical feed pumps, piping, valves and appurtenances should also be replaced and located in an area where they cannot be contaminated by lime. Provisions for this feed system should be included in the evaluation of the Chemical Building to be conducted as part of the lime study recommended in Section 3.6.3. The system should include flow pacing and automatic feed adjustment to optimize chemical usage and performance.

3.6.9 Cationic Polymer System

Polymer is added as a coagulant aid to improve floc formation and settling by particle destabilization. Polymer is added concurrently with ferric sulfate at the static mixers of the G and L Basins.

The polymer system consist of two 8,000 gallon FRP storage tanks providing a total storage volume of about 16,000 gallons (Figure 3-57). The feed system consists of four metering pumps (two duty and two standby units). The polymer feed pumps (Figure 3-58) are housed inside a concrete block building adjacent to the polymer storage tanks.

The tanks are bolted to raised foundation reinforced concrete pads. The tank tops are equipped with galvanized steel anchor straps. A single, vertical ladder provides access to an elevated platform spanning the top hatches of each tank. The loading stations for each tank are stainless steel top hinged boxes, which inside contain a quick-disconnect hose coupling. Chemical is delivered to the plant via commercial tank truck, which provides its own pressure differential to unload the polymer. The tank is filled from the top. A wire mesh guard is installed over the drain valve in each tank. Those drain valves are Schedule 80 PVC with a capped quick connect hose fitting installed.

Based on an average flow of 144 MGD and average dosage of 4.5 mg/L, the bulk storage tanks provide approximately 3 days of storage, which is well below the 30 days of storage recommended by Ten States Standards. The four existing pumps have a capacity of 10 gallons per hour (gph) each and meet dosage requirements under average operating conditions.

Figure 3-57: Polymer Storage Tanks

Figure 3-58: Polymer Feed Pumps

The following deficiencies, operational needs and major capital improvement requirements were identified for the polymer storage and feed system:

- The storage tanks are not located within a containment area to protect against leaks or spills and there is no anchor wiring attached to existing straps to secure the tanks.
- The tanks, pumps, piping, valves and appurtenances operate well but have reached the end of their useful service lives.
- Polymer is currently added at the static mixer of the G-Basins through the same pipe as the ferric sulfate. The feed rate and distribution of the chemical is manually controlled by adjusting valves on the feed header at the G-Basins. This chemical application method is not ideal for optimum coagulation performance.
- No flow pacing or automatic adjustment of polymer feed is provided for the system, which likely results in chemical overfeeding.

Recommended Polymer System Improvements

It is recommended that the entire polymer storage and feed system be replaced in the mid-term given that the existing equipment and storage tank are nearing the end of their useful service lives. The new polymer storage and feed system can be installed in a new chemical storage and feed facility that also houses the ferric sulfate and fluoride systems. Alternatively, the new polymer system can be housed separate from these other chemical systems. Further evaluation is needed to identify implementation requirements, advantages and disadvantages, and costs of to determine whether these chemical storage and feed systems should be housed in a combined facility or kept separate.

3.7 Residuals Handling System

Residual streams generated at the Carrolton WTP include clarifier sludge generated from turbidity removal and chemical addition for coagulation, and pH adjustment; and filter backwash wastewater.

3.7.1 G3 and G4 Basins

The existing sludge collection equipment in each G Basin is a monorake type system. The monorakes move along a rail system scraping sludge to collection sumps at multiple locations within the sedimentation basin. There are three sludge collection sumps that remove sludge from the basins to the G Basin Sludge pump station, where solids are pumped through a single 20" sludge line for discharge to the Mississippi River. Plant staff noted that the three withdrawal points are insufficient and not adequately spaced to effectively remove sludge from the basins. Staff has modified an existing 8" grit removal pipe at the end of the sedimentation basin to serve as a fourth sludge withdrawal point. This modification has only been marginally effective because the line is undersized and not at the optimum location.

The rake mechanisms do not contact the bottom of the basins and therefore a layer of sludge remains in the basins. This sludge must be periodically removed from the flocculation and sedimentation areas. This is a very labor intensive operation that can take about 3-4 months to complete, and is required before any maintenance activities can be completed on the flocculation basin equipment or monorake skirt.

The rake drivers (Figure 3-59) are wire rope and drum machines which transport a truss-mounted rake along the rectangular sedimentation basins. There is one machine and rake for each basin. The rake drivers were manufactured by Dorr-Oliver EIMCO and are powered by a 1.5 hp electric motor. The machines are vintage 1950s. The rakes have a forward and aft blade which switches over upon reversal of travel.

The rake drivers are in good condition and are regularly repaired on site when needed. The machine shop has the capability of manufacturing any required part. Safety concerns exist from the lack of belt guards and lack of guards over the exposed wire rope within the handrails.

Figure 3-59: Rake Driver

There are three horizontal, centrifugal mud pumps for the G basins (Figure 3-60). The pumps are directly driven by 50 hp motors operating at 710 rpm. The pumps were installed in the 1940s. Repairs are carried out as needed on the pumps by the machine shop. At the time of the inspection, all three (3) pumps were operable. The pumps cannot be operated in conjunction with the newer C basins pumps because the C basin pumps, when operating, produce a higher head condition which cannot be overcome by the either the G or L basins mud pumps.

With the exception of leaking stuffing boxes, the pumps were observed to be in good condition. Plant staff indicated that one pump is normally operated at a time, but it is possible to operate multiple pumps. The piping arrangement and sizes allow for this. The three pumps provide a high degree of redundancy.

Figure 3-60: G-Basin Mud Pumps

3.7.2 L3 and L4 Basins

Similar to the G3 and G4 basins, the existing sludge collection equipment in each L-Basin is a mono-rake type system. The mono-rakes move along a rail system scraping sludge to collection sumps in the sedimentation basin. There are five sludge collection sumps that remove sludge from the basins to the L Basin mud pumps, which pump sludge through the same single 20" sludge line used for the G-Basin solids for discharge to the River. Plant staff noted that the five withdrawal points are sufficient and effective at removing sludge from the basins.

Each of the L basins has two mud pumps (Figure 3-61). The pumps are vertical, direct drive centrifugal pumps. The motor for the pump is located on the deck level of the basins and a shaft extends to the machinery galley floor level where the pumps are located. The motors are 60 hp operating at 1175 rpm. The pumps were installed in the 1970s. At the time of the inspection, the pumps were not in operation, but it was reported that they are operable and in good condition. It is noted that the pumps cannot not be operated in conjunction with the newer C basins pumps because the C basin pumps, when operating, produce a higher head condition which cannot be overcome by the L basins pumps. As a result, the L basin pumps have, on several occasions, flooded the machinery galleries in the L basins.

Figure 3-61: L-Basin Mud Pumps

3.7.3 C Basin Mud Pumps

There are two wash down pumps for the G, L, and C basins (Figure 3-62). The sludge pumps are driven by 300 hp at 895 rpm electric motors and are direct- drive units. Neither pump was operated at the time. The motors for the pumps were located in an enclosed building and appeared to be in good condition. The plant operator stated that both pumps were operational and there have not been any problems with their operation, except as noted previously when operating with the L and G basins pumps.

Figure 3-62 C Basin Mud Pump

The following deficiencies, operational needs and major capital improvement requirements were identified for the Residual Handling System:

- The three sludge withdrawal points for the G basins are insufficient and not adequately spaced to effectively remove sludge from the basins. Staff has modified an existing 8" grit removal pipe at the end of the sedimentation basin to serve as a fourth sludge withdrawal point. This modification has only been marginally effective because the line is undersized and not at the optimum location.
- There are no guards over the exposed drive belts and wire rope on walkways.
- There is no local torque indication on the drives.
- The monorakes are maintenance intensive, there are overtorque issues from bent tracks and the monorake routinely stops near the basin end due to heavy solids buildup.
- There is a common 20" sludge withdraw line that constrains operations for the G/L basins sludge pumping, basin drainage and backwash operations.
- Basin cleaning is labor intensive and can take up to 4 months per basin.
- Surface corrosion on piping and valves is evident. Additionally everything is used aged and is no longer in its useful service life. Operational constraints and cavitation due to low suction head are noted.
- Current residuals removal from the C-Basins using the dredger is a labor intensive and difficult process. In addition, dredged solids are currently discharged to adjacent sedimentation basins.

Recommended Residuals Handling System Improvements

The following rehabilitations and improvements are recommended for the Residuals Handling system at the Carrolton WTP:

- Install a new 30” sludge line to provide redundancy and eliminate operational constraints associated with the current single 20” sludge line.
- Replace or rehabilitate the monorake system, including tracks and controls for the G and L basins.
- Replace the G Basin sludge pumps, piping, valves and appurtenances.
- Modify the sludge withdrawal configuration in the G Basins to provide four sludge withdrawal sumps adequately spaced and sized for optimum sludge removal.
- Install belt guards on the rake drivers for the G and L Basins.
- Provide electrical lockouts to prevent operating the G or L Basin sludge pumps at the same time as the C Basin pumps until the 30” line is commissioned and the discharges can be separated.
- Provide instrumentation for remote monitoring of monorake, sludge pump, and sludge valve operation.
- Provide torque indication on monorake drives (local and remote).
- Implement improvements to facilitate dredging of solids from the C-Basins and incorporate a new pump station and sludge line that ties into the existing permitted sludge disposal line for the G and L-Basins (refer to Section 3.4 for additional details).

4.0 Electrical

4.1 Background

The original Carrollton WTP was constructed at the present location in the early 1900s. The electrical power for the original Carrollton plant was generated at the SWBNO Power Plant (SWBPP) located on the southwest side of the WTP, see Figure 4-1.

Today, the Carrollton plant receives power from underground feeders from the SWBPP and an electrical service from Entergy New Orleans (ENO) Power Company. The power from the SWBPP feeders is 25 cycle power. The power from the ENO service is 60 cycle power. Today, almost all of the electrical motors run on 60 cycle power. Some of the High Service Pumps in the WTP are still 25 cycle.

The Pumping and Power Division of SWB operates, maintains and manages the previously described power system at this plant. This report will focus only on the treatment process equipment operated, maintained and managed by the Water Treatment Division of SWBNO.

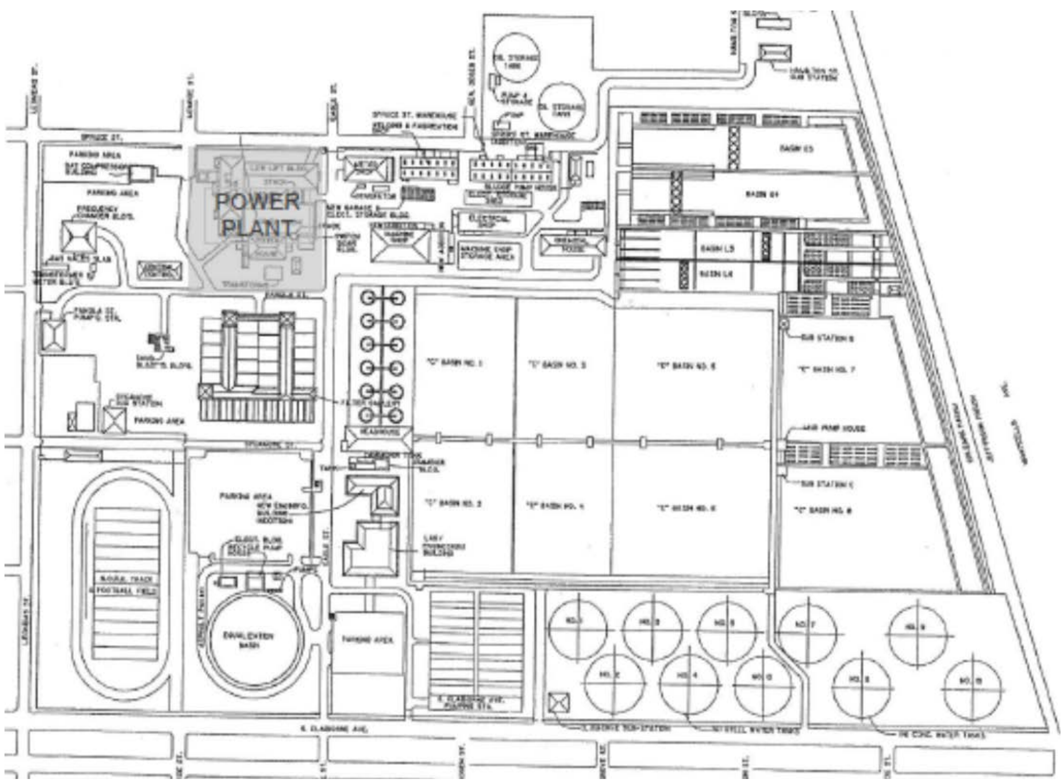

Figure 4-1: Carrollton WTP Site Plan

4.2 G and L Basins - Control Panel Upgrades

There are two “G” basins and two “L” basins at this WTP. Each of the four basins is a long rectangular concrete basin with travelling bridge sludge collector mechanism. The sludge collector mechanisms are the Dorr Oliver/Eimco Monorake system. This system uses a steel cable to move the travelling bridge back and forth down the length the basin. The travelling bridge is above the water line and the sludge scraper is below the water line and the travelling bridge. A control panel controls the movements of the system and senses the end of travel at each basin end, occurrence of any excess cable tension on the steel cable mechanism, etc.

The control panels currently have the following needs for repair and upgrade:

- Control panels have reached the end of their service life.
- Switches and Lights on the front door of control panels are in poor condition and need replacement.
- Control panels are hardwired “relay type control panels” using control relays and timing relays for control components. This type of control panel implements only one control/protection strategy and is difficult to adjust or modify to implement new control/protection strategies.

Recommended G and L Basin Control Panel Upgrades

It is recommended that the control panels be replaced in both of the G and L basins, utilizing programmable logic controllers (PLCs) for ease in making control and protection strategy changes. PLC’s will allow for local, flexible control of monorake and sludge valve operations, as well as provide a means for remote monitoring of basin sludge component operation. Providing LED indicating lights on the front door will allow for long lamp service life.

Figure 4-2: L3 Basin Control Panel

4.3 G and L Basins – Replace Deteriorated Power and Control Wiring

The G and L Basins power and control wiring has begun aging. As such, it can be considered either at or near the end of its service life. The G basin flocculation drive wiring was replaced with 60 Hz conversion. In the last 10-15 years, the G and L basin sludge sump limit switches were replaced with timers with commensurate wiring. The existing PLCs installed on G3 and G4 have not functioned well and are currently not perceived to be beneficial by plant staff. The PLCs were designed as an after-thought and have not been integrated well. Figure 4.3 below shows wiring that needs to be replaced. Replacing the wiring as a preemptive measure will provide the benefit of avoiding unscheduled down time on one or more of the basins.

The G and L Basins power and control wiring currently has the following needs for repair and upgrade:

- Survey all wiring on the four basins to obtain a condition assessment in order to establish the extent of wiring deterioration.
- Include Megger testing (insulation testing) in the survey to determine wiring insulation viability.
- Include condition assessment of conduit and junction boxes.

Recommended G and L Basin Deteriorated Power and Control Wiring

It is recommended that the wiring identified as “needing replacement” be replaced. If a majority of the wire is in this condition, replace all of the wiring on the four basins. Replace exposed conduits and junction boxes that need replacement and replace missing junction box covers.

Figure 4-3: Junction Box with Deteriorated Wiring and Missing Cover

4.4 Chemical Building – Replace Electrical System

Some of the Chemical Building electrical equipment has been in place for multiple decades. However, some of the 60 Hz wiring is fairly new, including the hypochlorite feed system and lime equipment. The ferric and polymer feeds are approximately 10-15 years old. Feed wiring for the other systems is original and considered to be either at or near the end of its service life. Figures 4-4 to 4-6 below show the condition of this equipment. Replacing this equipment, including conduit and wiring, as a preemptive measure, will provide the benefit of avoiding unscheduled process down time.

The Chemical Building electrical equipment currently has the following needs for repair and upgrade:

- Rusted and deteriorated panelboard. Wireway with missing end plate. Conduits improperly installed. Telephone wire should be installed in conduit. This is typical for much of the electrical equipment in building.

Figure 4-4: Deteriorated Electrical Equipment

- Panelboard enclosure. Interior has been removed from the panelboard and the enclosure is now used as a junction box (unintended purpose). The unit is now rusted and deteriorated. This is typical for much of the electrical equipment in building.

Figure 4-5: Deteriorated Junction Box

- Rusted and deteriorated Lime Pump combination motor starters.

Figure 4-6: Deteriorated Motor Starters

Recommended Chemical Building Electrical System Improvements

It is recommended that the electrical system inside the chemical building in its entirety including all conduit and wire be replaced.

4.5 General Recommendation

It is recommended that the following be included with all renovation projects that are done at the Carrollton WTP:

- Assess all power cables from the process area being renovated back to the plant power entry point. This assessment would include megger type cable testing or high-potential cable testing to measure the integrity and viability of the insulation of each cable.
- Include cable replacement in the renovation project for any cables that require replacement. This needs to be done because each cable has a finite life and failure of a major electrical feeder can cause the outage of an entire treatment area with the end result being plant shutdown until power is restored.
- Assess all circuit breakers and fused switches from the process area being renovated back to the plant power entry point by performing testing on them.
- Include circuit breaker and fused switch replacement in the renovation project for any units that require replacement.
- Assess all transformers from the process area being renovated back to the plant power entry point by performing testing on them. Include transformer replacement in the renovation project for any units that require replacement.

4.6 Arc Flash Labelling of Electrical Equipment

OSHA (General Duty Clause and 29 CFR 1910) and the National Electrical Code (NFPA 70, Sec. 110.16) require an employer to protect both in-house and contracted workers from electric shock and arc flash. OSHA recommends and consults national consensus standard NFPA 70E, *Standard for Electrical Safety in the Workplace*, for compliance in this regard. Among NFPA 70E requirements, the equipment owner is required to field-label electrical equipment with a label containing the available incident energy or required level of personal protective equipment (PPE) [NFPA 70E-2012, Sec. 130.5(C)].

It is recommended that the following done as part of regular maintenance at Carrollton WTP:

- Establish an Electrical Safe Work Practices (ESWP) policy per NFPA 70E.
- Audit ESWP every 3 years per NFPA 70E.
- Perform an Arc Flash Hazard Analysis and label each piece of electrical equipment. Labels inform electrical workers of PPE class required to work on electrical equipment that is energized. Audit Arc Flash analysis every 5 years per NFPA 70E.
- Provide adequate supplies of PPE and insulated tools.
- Train and periodically retrain workers.
- Perform maintenance on electrical equipment to maintain arc current magnitudes and arc durations at the levels used in the Arc Flash Hazard Analysis calculations.

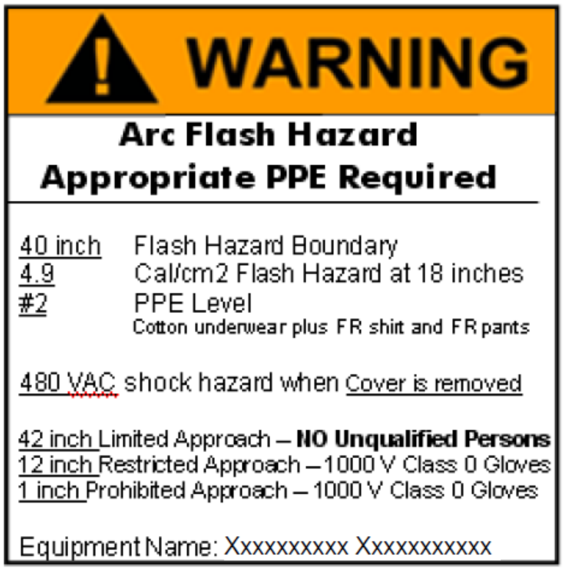

Figure 4-7: Equipment Arc Flash Label

5. Structural Assessment

The purpose of the structural assessment was to inspect the integrity and quality of the water treatment components at the Carrollton WTP.

The structural assessment of the Carrollton WTP consisted of visual inspections of the structures. Except for the dewatered G4 Basins, all structures were online and observations were possible only above the water line. There were no structural tests made for the inspection, and no thickness measurements were taken for the steel members.

5.1 G-Basins

The slabs and walls for the G3 and G4 basins are constructed with reinforced concrete, and supported on a foundation of timber piles. Combined dimensions of these two structures are 550 feet to 632 feet in length and 280 feet in width. The structures are approximately 18 feet from top of slab to top of walls. Timber piles are spaced generally on an 8 foot by 8.5 foot grid. The flocculation and sedimentation basins are constructed integral with each other, with G3 and G4 being integral. Flocculation basins have flocculators supported on concrete pedestals (Figure 5-1).

Figure 5-1: Dewatered G3 Basin with Flocculators

Original plans for G3 and G4 date back to the early 1900s. There were major modifications to the structures in 1953. In this modification, walls and pedestals were added, a new reinforced slab concrete was constructed over the existing slab, sumps were added, 0.75 inch diameter “T” anchors were installed in the timber piles, and 103 relief check valves with under-slab gravel drains installed. It should be noted that the “T” bars were driven just eight inches into the piles.

The withdrawal force for the bars driven only eight inches in to the timber piles would amount to only a small anchorage force to counteract uplift pressures; the real defense for uplift are the relief valves. Concrete for this structure was found to be in fair condition during the site inspection.

The inspection of the basins revealed the following issues: rust and corrosion on exposed steel weir plates, cracks in the floor slabs, weeds growing in cracks in the slab of G4, exposed cable drives and motors (which could be a safety hazard), minor cracks in walkways, and rust on the steel machinery supports, handrails, manhole covers, and sluice gates. None of these issues are considered detrimental to the structural integrity of the basins.

An issue reported by plant operators is the amount of water that flows into the structures from groundwater when the basins are dewatered (Figure 5-2). Water flowing upward from the relief valves into the basins during dewatering relieves upward pressure on the slabs and is necessary to reduce uplift pressures.

It is recommended that piezometers be installed around the G Basins to monitor groundwater levels during dewatering operations. The piezometers will tell the plant staff when the best time is to schedule tank dewatering and will also help determine if dewatering wells are needed during the maintenance activities.

Figure 5-2: Dewatered Sedimentation Basin with Ground Water Infiltration

5.2 L-Basins

The slabs and walls for the L3 and L4 flocculation and sedimentation basins are reinforced concrete and supported on a foundation of timber piles. Combined dimensions of these two structures are 640 feet in length by 294 feet wide. The structures are approximately 16 feet from top of slab to top of walls. Timber piles are spaced generally on a 6.5 foot by 7.0 foot grid. Basins L3 (Figure 5-3) and L4 are a continuous concrete structure. This structure was in operation at the time and only the portions of the structure above the water level could be observed.

Original plans for L3 and L4 date back to the decade of 1910, with major modifications incorporated in 1981. In this modification to the structures, walls and pedestals were added, a new reinforced slab concrete was constructed over the existing slab, sumps were added, and 1-inch diameter "T" anchors were installed in the timber piles. It should be noted that the "T" bars were driven 22 inches into the piles. The withdrawal force for the bars driven 22 inches in the timber piles should each provide about 4,000 pounds of anchorage force to counteract uplift pressures.

The inspection revealed the following issues: the soil-supported slab at the western end of the basins is experiencing settlement, walkways had some minor cracks, and rust on the steel machinery supports, handrails, manhole covers, and sluice gates. None of these issues affect the structural integrity of the structure.

The recommendations are to install a piezometer to monitor groundwater elevations during dewatering, sand blast and paint exposed steel and provide cover protection over exposed cable drives.

Figure 5-3: L3 Basin

5.3 C Basins

The C Basins (Figure 5-4) were online during the site visit, so only the components above the water line were inspected. The concrete observed above the water level was in good condition. The walls for these basins are pile-founded, inverted “T” walls. Slabs are 6-inch thick reinforced concrete, soil-founded and reinforced with wire mesh. Dimensions for the basins are 500 feet in width, 706 feet in length and 14 feet in height.

Plant operators noted that when these basins are dewatered, a lot of water seeps into the basins. It was described that in one instance, a dewatered basin slab had lifted a few inches. Since the slabs are soil-founded, uplift pressures caused by the groundwater levels, would overcome the weight of the 6-inch concrete slab, resulting in either the slabs lifting or water pressures being relieved through cracks in the slab. The plant currently does not dewater the basins due to the significant leakage and the potential for uplift of the basin slab. As such, the plant currently uses a dredge to periodically remove solids accumulated in the basins.

The maintenance area between basins L4 and C5 is currently always flooded. This area should be dry, but according to plant staff, this area became flooded after C Basin improvements were completed in the 1990’s.

One solution for fixing the uplift problem for these slabs is to anchor them down by the installation of micro piles. This fix would also require the placement of a new slab overlay. This modification would be at a significant cost.

The recommendation is to install piezometers to monitor groundwater elevations during any dewatering or partial dewatering of these basins. It is recommended that a study be conducted to assess mitigation strategies of current infiltration and leaks from the G, L and C basins. This study should also evaluate current flooding between basins L4 and C5.

Figure 5-4: C Basins at Carrollton WTP

5.4 Chemical Building

There were no structural issues revealed in the inspection of the Chemical Building (Figure 5-5).

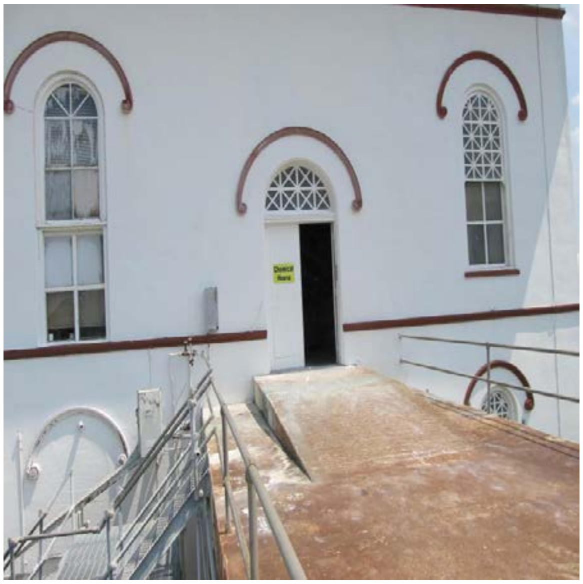

Figure 5-5: Chemical Building at Carrollton WTP

5.5 Sodium Hypochlorite Facility

This is a new, pre-engineered steel frame building with open sides (Figure 5-6). Essentially, it provides cover for the hypochlorite tanks. There were no structural issues with this building with the exception of 3-inch diameter plastic pipe lines that run vertically to the top of the tanks with an unsupported length of approximately 12 feet; this could pose a problem in hurricane wind velocities.

It is recommended that lateral supports be provided at the vertical mid-span of the pipe.

Figure 5-6: Sodium Hypochlorite Facility at Carrollton WTP

5.6 Sycamore Filter Gallery

The Sycamore Filter Gallery is the oldest filter facility in the Carrollton WTP. Concrete walls and walkways for the filters, which are outside of the building, appear to be in good structural condition (Figure 5-7).

During the inspection of the Sycamore Filter Gallery, flaking paint and rust were observed in the building. Because of the age of the structure, it is likely that the paint contains lead which will require special procedures in removal and disposal. The corrosion extends to the roof trusses, steel beams and steel columns. The first floor slab, which is supported by steel beams, had several cracks, but these should not affect the structural integrity of the slab. Beams supporting the concrete floor, pipe straps and hangers, and steel columns in the pipe gallery had significant rust and corrosion. The thickness of any steel member should be measured before adding any temporary loads to ensure sufficient strength. Piping in the gallery is severely corroded with several areas where pipe thickness is likely less than the minimum recommended for continued safe use of this piping.

The piping in the gallery needs to be replaced. Removing and replacing piping in the pipe gallery will likely require the removal of the building superstructure and the concrete floor slab. This will necessitate, as a minimum, a partial shutdown of the filter facility (i.e., one wing at a time). Considering that the total capacity of the Sycamore Filter Gallery cannot be taken out of service, along with the extreme costs of these repairs, it is likely more cost-effective to construct a new filter facility. A detailed discussion of other needs and recommendations associated with the Sycamore filter complex is presented in Section 3.

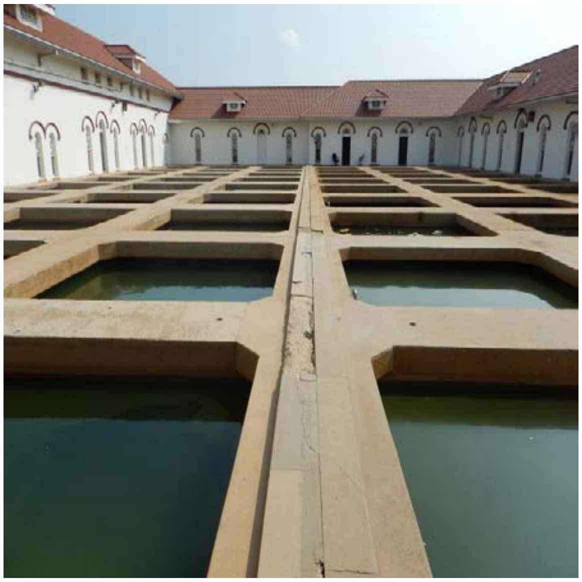

Figure 5-7: Sycamore Filter Gallery at the Carrollton WTP

5.7 Claiborne Filter Gallery

The Claiborne Filter Gallery was constructed circa 1960. It was in operation at the time of the inspection and appeared to be performing well (Figure 5-8). Concrete for the filter structures and the building's steel rigid frame and walls were in good structural condition.

The following issues were observed during the inspection: rust and corrosion on the exterior equipment under the steel hatch (a minor maintenance problem). The south exterior wall of the filter structure had water leaking at some of the vertical construction joints (Figure 5-9).

Figure 5-8: Claiborne Filter Gallery at the Carrollton WTP

Figure 5-9: Water leak from a vertical construction joint at the Claiborne Filter Gallery

5.8 Backwash Waste Holding Tank

The backwash waste holding tank (Figure 5-10) is a concrete in-ground tank that is 220 feet in diameter with the top of slab at elevation 12.1 feet, and the top of wall at elevation 30.1 feet (the elevations are referenced to Board Datum). It is pile-supported on concrete piles which are anchored into the 12-inch slab. This tank was not dewatered at the time of the inspection, so only the concrete above the water line was inspected. Concrete above the water line, in the circular walls, looked very good.

Figure 5-10: Backwash Waste Holding Tank at the Carrollton WTP

5.9 Ground Storage Tanks

The ten ground storage tanks (Figure 5-13) near South Claiborne Avenue were inspected. Since the tanks were in service, only a visual inspection was performed on the tank exteriors. There are six steel tanks and four concrete tanks. Both steel and concrete tanks appeared from the outside to be in good condition. The paint system on the steel tanks was good; for aesthetic reasons, the concrete tanks need to be painted.

The steel GSTs were inspected in 2004 and found to have several deficiencies. During the inspection it was noted that the caulking and backing rod between the roof beams and the roof were coming apart, and in some cases missing (Figure 5-11). There was also corrosion reported where the beams are anchored into the wall (Figure 5-12). Since the interior of the tanks was not inspected recently, it is assumed that their condition further deteriorated. It is recommended that an inspection be conducted of each steel GST to evaluate the extent of the corrosion and determine the repairs necessary. Identified improvements should be implemented in the short term.

Figure 5-11: Caulking and Backing Rod in GSTs

Figure 5-12: Corrosion of GST Roof Beams

Figure 5-13: Ground Water Storage Tanks at the Carrollton WTP

5.10 Elevated Storage Tank

The New Orleans East Elevated Storage Tank is over 125 feet high, with a diameter of 105 feet and a capacity of 2 million gallons, see Figure 5-14. A 2009 inspection revealed that the storage tank had numerous corrosion holes both in the roof and sides, see Figure 5-15. The roof was open, the previous inspection stated that a roof hatch was missing, the interior stiffener plates were badly corroded.

The tank is in poor condition and several improvements would need to be implemented to rehabilitate the tank and place it back in service. The tank has been offline since 2009 and plant staff has noted that the tank will not be needed to meet system demands or provide distribution system storage. As such, it is recommended that the tank not be placed back in service. Given the tank's poor condition, it is recommended that the tank be demolished and the area cleared.

Figure 5-14: Elevated Storage Tank

Figure 5-15: 2009 Inspection Photos of Elevated Storage Tank

It was noted that the manned buildings within the Carrollton WTP are not equipped with stormproofing provisions (such as storm shutters) to protect employees from strong storms and hurricanes. Although stormproofing measures are considered outside the scope of this water quality master plan report (and not included in the CIP), it is recommended that the SWBNO consider and evaluate implementing stormproofing provisions at all manned buildings within the Carrollton WTP.

6. Capital Improvement Plan

6.1. Introduction

The Carrollton WTP requires capital improvements to provide for rehabilitation or replacement of equipment that has or will exceed its useful service life, to address water quality issues, redundancy needs, and increasingly stringent regulatory requirements.

In this Section, recommended improvements identified in Sections 2, 3, 4, and 5 were reviewed and grouped with other related improvements to form several capital improvement projects. This Section discusses the approach used to group and prioritize projects and to develop the 20-Year CIP for the planning period from 2015 through 2035. A recommended list of prioritized projects and a CIP implementation schedule are also presented.

6.2. CIP Prioritization

6.2.1. Prioritization Approach

In this Section, various improvements were reviewed to determine their relative importance and priority. Each item was assigned a priority score varying from 1 to 5, based on relative importance and priority. The priority scores represent timeframes for implementation of improvements and studies based on the following specific drivers:

- Ability to meet current and future average and peak capacity requirements.
- Ability to meet current and future regulatory requirements.
- Physical and performance conditions.
- Equipment age.
- Reliability and frequency of operation and maintenance (O&M) issues.
- Consequence of equipment failure on plant system operation.

Each priority corresponded to a recommend range of implementation years over the 20-year planning period as shown in Table 6-1. For example, items assigned a priority score of 1 are in need of immediate attention and should be addressed in years 0 to 2 of the 20-year CIP. Identified improvements were grouped based on location, equipment type, and priority to form several capital projects. Projects were arranged in order of importance based on the priorities assigned to each item, as well as staff preferences. Project durations were estimated based on project experience for similar projects and include all phases from planning and design through construction. Projects were then used to create a 20-year CIP implementation schedule, with costs distributed based on the estimated project durations.

Table 6-1: Recommended CIP Implementation Years by Priority

Priority Score	Priority	CIP Implementation Years
1	Immediate	Yrs 0 - 2
2	High	Yrs 2 - 5
3	Medium	Yrs 6 - 10
4	Low	Yrs 11 - 15
5	Lowest	Yrs 16 - 20

When distributing costs over the duration of the project, it is sometimes unrealistic to expect that an equal expenditure of funds will occur in each year. Instead, many projects typically experience a bell-curve distribution where there is a "ramp-up" period at the beginning followed by increased expenditures in the middle of the project, and a decrease in expenditures as the project comes to a close. The following assumptions were used in developing the annual expenditures for projects in the CIP:

- Planning and design phases together were assumed to account for 15 percent of the total investment cost of the project. This initial expenditure includes all fees paid to consultants for study and design tasks.
- The length of the planning and design phases was set according to the durations of the project. The cost for these initial phases was distributed evenly across their duration.
- The remaining funds (85 percent) were assumed to be spent during the bid, construction, and start-up phases of the project. The allocation of funds was distributed according to a bell-curve.
- The overall distribution of funds depended on the length of the project.

Table 6-1 shows the estimated percent of project funds spent each year of the project, with the shaded cells representing expenditures during the planning and design phases and unshaded cells showing expenditures during the construction phase. For example, in a 6 year project, 15 percent of the costs are spent on planning and design evenly during the first two years, and the remaining 85 percent is distributed in a bell-curve in the final four years.

Table 6-2: 20-Year CIP Cost Distribution

Project Duration (Years)	Percent of Costs Expended in Year					
	1	2	3	4	5	6
1	100	–	–	–	–	–
2	15	85	–	–	–	–
3	15	50	35	–	–	–
4	7	8	50	35	–	–
5	7	8	25	45	15	–
6	7	8	15	40	20	10

1. Shaded cells indicate planning and design phase expenditures.

6.2.2. Cost Estimates

Opinions of probable construction costs were developed for the treatment system capital projects. Estimated costs were also developed for the recommended studies and reports. Capital project costs include equipment, labor, materials, installation, and incidentals.

The compiled capital project costs are consistent with an Association for the Advancement of Cost Engineering (ACEE) Class 4 estimate, where the project definition is between 1% and 15% and engineering design is 1% to 5% complete. The typical purpose of this level of estimate is for conceptual studies or feasibility evaluations. These estimates are primarily stochastic in nature (i.e., they are based on inferred or statistical relationships between similar projects and/or equipment quotes with additional factors applied). Class 4 estimates are generally prepared based on limited information and thus they have a wide accuracy range, typically -15 to +30%. These estimates can successfully be used by owners for budget estimating purposes. Costs are presented in Table 6-3, and items are presented in 2015 dollars. Due to the preliminary nature of the projects at this time, the costs presented include the following provisions:

- Installation Factor – Estimated at 25 percent of the equipment cost.
- Design/Construction Contingencies – Estimated at 40 percent of the subtotal capital cost.
- Contractor's Overhead and Profit and Mobilization, Bonds, Insurance – Estimated at 20 percent of the subtotal construction cost.
- Engineering, Administration and Legal Costs – Estimated at 20 percent of the subtotal construction cost.

6.2.3. Recommended Studies

To provide additional information necessary for shaping future decisions with respect to regulatory requirements and future treatment/infrastructure/equipment projects, the following studies and reports are recommended over the course of the planning period:

1. **Lime System Evaluation at the Carrollton WTPs –** Study to assess lime feed system alternatives and recommended improvements at the Carrollton and Algiers WTPs;

2. **Sycamore Filter Replacement –** Study to assess alternatives for a new Filter Complex to replace the Sycamore Filters and preliminary design.

3. **Sludge Removal Improvements to G Basin –** Study to assess the improvements to the C Basins to minimize leaks into the basin to aid sludge removal issues.

4. **Assess leakage in G, L, and C Basins –** Study assessment and report, with drawings review and inspection of tanks.

5. **Assess Ground Storage Tank Mixing –** Study to evaluate mixing and turnover in the ground storage tanks, identify and implement physical and operational improvements to enhance mixing and turnover and improve water quality

6. **SCADA System Installation**–Study to assess the benefits of installing a SCADA system to monitor plant operations.

7. **Steel GST Inspection – Inspection to evaluate the condition of the interior of the steel GSTs.**

6.2.4. Prioritization Results

Table 6-3 presents a summary of the studies and future improvements discussed and recommended with respect to the Carrollton WTP's treatment system infrastructure. The table also includes prioritization scores and planning-level costs. ARCADIS grouped recommended improvements into projects for inclusion into the SWBNO's CIP for the 20-year master planning period.

Costs for the Carrollton WTP were developed for 35 identified studies and capital improvements, which together total approximately $287.5M (in 2015 dollars). The individual improvements were grouped into a total of 7 studies/reports and 28 capital improvement projects based on location, and priority. The highest priority projects recommended for immediate implementation include: Studies (1-6), (1) Routine Refurbishment of G and L Basins Flocculators, (2) Air System Improvements at Sycamore and Claiborne Filters, (3) Backwash Supply Pump Improvements at Sycamore Filters, (4) Filter Media Replacement and Related Filter Rehabilitations at Claiborne Filter Complex, (5) Short-term Chemical Feed System Improvements, (6) Replace all valves and actuators for Sycamore Filters 11-28, (7) High priority improvements to the G-Basins, (8) Filter Media replacement at Sycamore filter complex, (9) Addition of Redundant Sludge Line, (10) Air Scour addition at Claiborne Filter Complex. Table 6-3 provides a summary of the recommended project groupings and prioritization.

It should be noted that 41% of the costs for the CIP for the Carrollton WTP start in years 2-5 (Group 2 – High ranked). There are only 11 projects (31% of total projects) in this category, however they are a significant portion of the Project Cost. The first (Group 1 – Highest ranked) accounts for 49% of the No. of projects, but only 11% of the total Project Costs because there are Studies included in this Group and there are several less expensive, but higher-priority, projects.

Table 6-3
Sewerage and Water Board of New Orleans
Water Quality Master Plan
Summary of Recommended Project Groupings and Prioritization for the Carrollton WTP
FINAL

Item No.	Item	Facility	Type	Description	Priority	Initial CIP Impl. Yrs.	Total Estimated Project Cost (2015$)
Recommended Studies							
Study 1	Lime System Evaluation	Carrollton WTP	Study	Study to assess lime feed system alternatives and recommended improvements	1	0-2	$ 60,000
Study 2	Sycamore Filters Replacement	Carrollton WTP	Study	Study to assess alternatives for a new Filter Complex to replace the Sycamore Filters and preliminary design	1	0-2	$ 250,000
Study 3	Sludge Removal Improvements to C-Basins	Carrollton WTP	Study	Evaluate the improvements of C basins to minimize leaks into the basin to address sludge removal issues	1	0-2	$ 200,000
Study 4	Assess leakage in G, L, and C Basins	Carrollton WTP	Study	Study assessment and report, with drawings review and inspection of tanks	1	0-2	$ 130,000
Study 5	Assess Ground Storage Tank Mixing	Carrollton WTP	Study	Evaluate mixing and turnover in the ground storage tanks, identify and implement physical and operational improvements to enhance mixing and turnover and improve water quality.	1	0-2	$ 100,000
Study 6	SCADA System Installation	Carrollton WTP	Study	Study to assess the improvements of installing a SCADA control system	1	0-2	$ 150,000
Study 7	Steel GST Inspection	Carrollton WTP	Study	Study to inspect the condition fo the steel GSTs including the extent of corrosion	1	0-2	$ 20,000
						Subtotal - Studies	*$ 910,000*
Recommended Capital Improvement Projects							
Project 1 - Routine refurbishment of G and L Basin flocculators							
P-012	Refurbish G and L Basins Flocculators	Carrollton WTP	Renewal/ Replacement	Refurbishment of flocculators for L Basins (Routine maintenance-one basin every 5 years, start with L3 refurbishment)	1	0-2	$ 200,000
						Subtotal - Project 1	*$ 1,000,000*
Project 2 - Air System Improvements at Sycamore and Claiborne filters							
P-005	Air System replacement (Claiborne) and new air dyer and minor piping/valving modifications (Sycamore)	Carrollton WTP	Renewal/ Replacement	Includes complete replacement of the compressed air and dryer system at the Claiborne filter complex, and dryer replacement and minor piping/valving modifications at the Sycamore filter complex to improve system operation	1	0 - 2	$ 140,000
						Subtotal - Project 2	*$ 140,000*
Project 3 - Backwash supply pump improvements at Sycamore filters							
P-004	Replace Existing Backwash Supply Pump and Add Redundant Backwash Pump	Carrollton WTP	Capacity/ Redundancy	Replacement of the backwash pump and associated piping and appurtenances and installing a redundant backwash pump at the Sycamore filters	1	0 - 2	$ 1,160,000
						Subtotal - Project 3	*$ 1,160,000*
Project 4 - Annual Filter Media Replacement and Related Filter Rehabilitations at Claiborne Filter Complex							
P-009	Media replacement and underdrain cleaning and inspection.	Carrollton WTP	Renewal/ Replacement	Includes annual removal and replacement of filter media, cleaning and inspection of 2 filters per year at the Claiborne Filter Complex	1	0-2	$ 3,600,000
						Subtotal - Project 4	*$ 18,000,000*
Project 5 - Short Term Chemical Feed System Improvements							
P-011	Add day tank and transfer pump to Fluoride System	Carrollton WTP	Safety	Includes adding a Day Tank for chemical dosing and transfer and metering pumps with piping connections.	1	0-2	$ 50,000
P-014	Install two additional Ferric Sulfate bulk storage tanks	Carrollton WTP	Capacity/ Redundancy	Includes installing one additional bulk storage tank, containment, piping, valves and appurtenances for ferric sulfate	1	0-2	$ 210,000
Ch-03	Short term - Provide containment for Polymer bulk storage tanks	Carrollton WTP	Safety	Containment for existing system	1	0-2	$ 160,000
P-025	Rapid mix basins chemical feed improvements	Carrollton WTP	Water Quality	Includes separating coagulant and coagulant aid with individual pumps for each basin, adding electrically actuated flow control, and tieing into the plants control system.	1	0-2	$ 30,000
						Subtotal - Project 5	*$ 450,000*
Project 6 - Replace all valves (Sycamore Filters No. 11-28)							
P-010	Valve replacement Sycamore Filters 11-28	Carrollton WTP	Renewal/ Replacement	Includes replacement of all valves for Filter Nos. 11 - 28 at the Sycamore Filter Complex	1	0-2	$ 3,750,000
						Subtotal - Project 6	*$ 3,750,000*
Project 7 - High Priority Improvements to the G-Basins							
P-001	Replace static mixers with vertical mixers for the G-Basins	Carrollton WTP	Water Quality	Replace existing static mixers with vertical mixers, includes the related structural improvements required for the mixers.	1	0 - 2	$ 740,000
P-002	Add Speed Control to G-basin Flocculators	Carrollton WTP	Water Quality	Replace all drives and motors in the G-Basins, includes adding variable speed drives to provide increased flocculation control	1	0 - 2	$ 790,000
S-001	Sump Pump Installation in G3 and G4 Basins	Carrollton WTP	Renewal/ Replacement	Install new sump pumps in G3 and G4 for improved sludge removal	1	0 - 2	$ 140,000
P-018	Install Perforated Baffle Wall and provide access for Bobcat	Carrollton WTP	Water Quality	Install Perforated Baffle walls to G and L Basins and provide access for Bobcat equipment	1	6-10	$ 490,000
						Subtotal - Project 7	*$ 2,160,000*
Project 8 - Filter Media Replacement at Sycamore Filter Complex							
P-023	Media Replacement	Carrollton WTP	Water Quality	Includes annual removal and replacement of filter media in 6 filters per year at the Sycamore Filter Complex	1	0-2	*$ 2,950,000*
						Subtotal - Project 8	*$ 8,850,000*
Project 9 - Addition of Redundant Sludge Line							
M-001	New 30" Redundant Sludge Line	Carrollton WTP	Capacity/ Redundancy	Addition of a second 30" waste line to provide redundancy and allow basin draining and sludge pumping at the same time.	1	0 - 2	$ 7,620,000
						Subtotal - Project 9	*$ 7,620,000*
Project 10 - Air Scour addition at Claiborn filter Complex							
O-002	Air Scour blower addition for Claiborn filter complex	Carrollton WTP	Water Quality	Air scour system for Claiborne Filters	1	0-2	$ 820,000
						Subtotal - Project 10	*$ 820,000*
Project 11 - Structural Modifications/Improvements for Carrollton WTP							
S-006	Install single piezometer for G3 and G4	Carrollton WTP	Other	Piezometer purchase and installation	2	2-5	$ 6,000
S-007	Install single piezometer for L3 and L4	Carrollton WTP	Other	Piezometer purchase and installation	2	2-5	$ 6,000
S-008	Install three piezometers for C-Basins	Carrollton WTP	Other	Piezometer purchase and installation	2	2-5	$ 15,000
						Subtotal - Project 11	*$ 27,000*
Project 12 - Steel GSTs Improvements and Rehabilitation							
O-002	Improvements to the current steel GSTs	Carrollton WTP	Safety	Rehabilitation of the steel GSTs	2	2-5	$ 5,230,000
						Subtotal - Project 12	*$ 5,230,000*
Project 13 - Complete replacement of fluoride storage and feed system							
Ch-01	Fluoride storage and feed system replacement	Carrollton WTP	Renewal/ Replacement	Entire system replacement	2	2-5	$ 190,000
						Subtotal - Project 13	*$ 190,000*
Project 14 - Complete replacement of ferric sulfate storage and feed system							

Table 6-3
Sewerage and Water Board of New Orleans
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Ch-02	Ferric sulfate storage and feed system replacement	Carrollton WTP	Renewal/ Replacement	Entire system replacement	2	2-5	$	930,000
						Subtotal - Project 14	*$*	*930,000*
Project 15 - Flow Instrumentation and valve improvements to 48" RW line								
P-017	Flow instrumentation and valve improvements to existing 48-inch raw water line to G-Basins	Carrollton WTP	Capacity/ Redundancy	Includes installing new Venturi meter to existing RW line, gate valve replacement and line flushing	2	2-5	$	270,000
						Subtotal - Project 15	*$*	*270,000*
Project 16 - GST Mixing Improvements								
M-007	Install mixers on ten GSTs	Carrollton WTP	Water Quality	Mixers installation for GSTs	2	2-5	$	640,000
						Subtotal - Project 16	*$*	*640,000*
Project 17 - Refurbishment and improvements of G and L Basin monorakes								
M-004	Refurbish G-Basins Monorakes	Carrollton WTP	Renewal/ Replacement	Includes rehabbing rake drivers, realign/replace tracks and controls replacement	2	2-5	$	770,000
M-008	Refurbish L-Basins Monorakes	Carrollton WTP	Renewal/ Replacement	Includes rehabbing rake drivers, realign/replace tracks and controls replacement	2	2-5	$	770,000
M-009	Install guards on wire rope and drive belts for the monorakes in the G-Basins	Carrollton WTP	Safety	Install monorakes wire ropes and drive belt guards	2	2-5	$	40,000
M-010	Install guards on wire rope and drive belts for the monorakes in the L-Basins	Carrollton WTP	Safety	Install monorakes wire ropes and drive belt guards	2	2-5	$	40,000
M-014	Replace Stuffing Boxes with Dry Seals	Carrollton WTP	Renewal/ Replacement	Replacement of stuffing boxes with dry seals for the paddle shaft penetrations into the machining gallery in flocculation basins	2	2-5	$	730,000
E-001	Replace Monorake Control Panels at G and L Basins	Carrollton WTP	Renewal/ Replacement	Replacement of control panels at G and L basin monorakes	3	2-5	$	110,000
E-002	Replace Wiring and Junction Boxes at G and L Basins	Carrollton WTP	Renewal/ Replacement	Includes Megger testing of all wiring and replacement of deteriorated wiring, along with JB cover replacement for those missing	3	2-5	$	70,000
						Subtotal - Project 17	*$*	*2,530,000*
Project 18 - Replace PAC system								
Ch-04	Replace PAC system in new facility at raw water intake	Carrollton WTP	Renewal/ Replacement	Includes new PAC bulk storage, feed system, building, and feed point near the raw water intake	2	2-5	$	3,560,000
						Subtotal - Project 18	*$*	*3,560,000*
Project 19 - Replace Lime Storage and feed system with recommended system								
Ch-07	Replace Lime Storage and feed system with recommended system	Carrollton WTP	Renewal/ Replacement	Includes full replacement of system in the lime building	2	2-5	$	5,730,000
						Subtotal - Project 19	*$*	*5,730,000*
Project 20 - C-Basin sludge removal improvements								
P-024	Improvements to the current sludge removal process	Carrollton WTP	Renewal/ Replacement	Add ramp for dredge, a booster pump and tie-in to existing sludge discharge line	2	2-5	$	210,000
						Subtotal - Project 20	*$*	*210,000*
Project 21 - New membrane filtration complex to replace Sycamore filters								
O-004	Construction of a new 120-MGD facility to replace Sycamore complex	Carrollton WTP	Renewal/ Replacement	Sycamore filters replacement	2	2-5	$	98,700,000
						Subtotal - Project 21	*$*	*98,700,000*
Project 22 - New Hypochlorite System for Claiborne Filter Backwash								
O-001	New Hypochlorite Storage and Feed System	Carrollton WTP	Water Quality	Construction of a new hypochlorite storage and feed system for Claiborne complex	3	6-10	$	160,000
						Subtotal - Project 22	*$*	*160,000*
Project 23 - Rehabilitation of Sludge Handling System								
M-005	Replace G-Basin Mud Pumps, Piping and Valves	Carrollton WTP	Renewal/ Replacement	Full replacement of pumps, piping, and valves	3	6-10	$	1,160,000
M-013	Replace L-Basin Mud Pumps, Piping and Valves	Carrollton WTP	Renewal/ Replacement	Full replacement of pumps, piping, and valves	3	6-10	$	1,140,000
P-003	Settled Water Effluent Channel/Flume Gate improvements for G Basins	Carrollton WTP	Renewal/ Replacement	Replace settled water effluent channel isolation gates and related structural improvements	3	6-10	$	1,770,000
						Subtotal - Project 23	*$*	*4,070,000*
Project 24 - SCADA System								
E-005	Install SCADA System	Carrollton WTP	Safety	New SCADA System	4	11-15	$	30,000,000
						Subtotal - Project 24	*$*	*30,000,000*
Project 25 - Additional Ammonia System Improvements								
Ch-06	Redundant ammonia storage tank and ammoniator	Carrollton WTP	Capacity/ Redundancy	Redundant ammonia storage tank with same capacity as tank in place including an additional ammoniator	4	11-15	$	460,000
						Subtotal - Project 25	*$*	*460,000*
Project 26 - Demolish abandoned elevated storage tank								
S-005	Demolish and remove 2 MG water storage tower	Carrollton WTP	Safety	Demolition and removal of 2 MG water tower	4	11-15	$	150,000
						Subtotal - Project 26	*$*	*150,000*
Project 27 - Complete replacement of polymer storage and feed system								
Ch-03a	Polymer storage and feed system replacement	Carrollton WTP	Renewal/ Replacement	Entire system replacement	4	11-15	$	490,000
						Subtotal - Project 27	*$*	*490,000*
Project 28 - Filtration complex expansion to replace Claiborne filters								
O-005	Expand filtration facility to 220 MGD capacity to replace Claiborne filter complex	Carrollton WTP	Renewal/ Replacement	Claiborne filters replacement	5	16-20	$	89,310,000
						Subtotal - Project 28	*$*	*89,310,000*
						Total Costs - Carrollton WTP (2015$)	**$**	**287,517,000**

The total estimated project costs were grouped by improvement discipline and are shown in Figure 6-1. As seen, the largest portion of the costs required is for renewal/replacement improvements. There were 21 improvements categorized in this group, or 36% of the total individual improvements, and the costs made up 80% of the total CIP. The next largest category of improvements was safety-related improvements associated mostly with the installation of a SCADA system, chemical system containment and storage, and water quality improvements to the process components. These improvements only made up 24% of the total number of improvements and 13% of the total CIP costs.

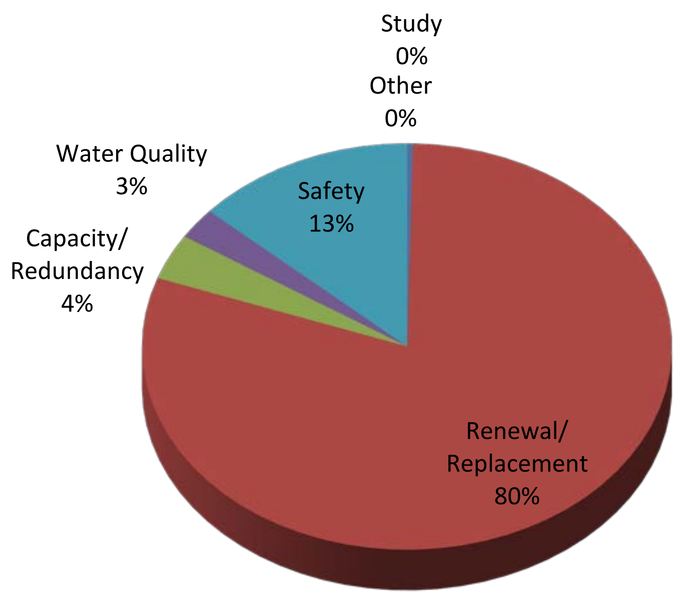

Figure 6-1: Total Costs by Improvement Discipline

The total estimated project costs were also grouped by process area and are shown in Figure 6-2. As seen, the largest portion of the costs required is for Filter improvements. There were only 9 improvements categorized in this group, or 18% of the total individual improvements; however the costs made up 75% of the total CIP. The next largest category of improvements was "Other" improvements associated mostly with installation of a SCADA system for the Carrollton WTP. These improvements only made up 18% of the total number of improvements and 14% of the total CIP costs. This Figure also shows that although the Flocculation/ Sedimentation process area projects were 35% of the total number of projects but only 3% of the total cost. This is due to the high expense it would require for the Sycamore filters, and eventually also the Claiborne filters, to be fully replaced with a new filtration complex compared to the several smaller projects associated with the flocculation/sedimentation systems.

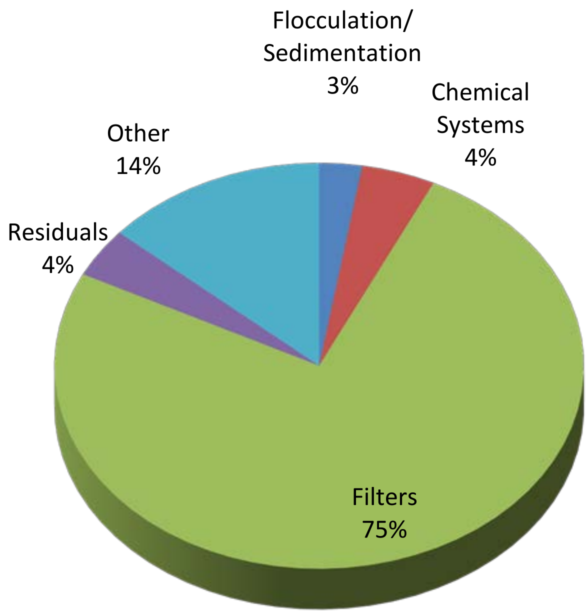

Figure 6-2: Total Costs by Process Area

Table 6-4 summarizes studies/reports and major capital improvement projects by priority. Although seventeen of the "projects" (or 49%) were assigned a priority score of 1 (highest priority), these projects only make up 16% of the total estimated project costs. Eleven projects were assigned a priority score of 2 with the remaining seven projects divided between the lowest three priorities.

Table 6-4: Recommended Projects by Priority

Priority Score	Priority	CIP Implementation Years	No. of Projects	Percent of Projects	Total Costs of Projects	Percent of All Project Costs
1	Immediate	Yrs 0 - 2	17	49%	$44,860,000	16%
2	High	Yrs 2 - 5	11	31%	$118,017,000	41%
3	Medium	Yrs 6 - 10	2	6%	$4,230,000	1%
4	Low	Yrs 11 - 15	4	11%	$31,100,000	11%
5	Lowest	Yrs 16 - 20	1	3%	$89,310,000	31%

6.3. 20-Year CIP Schedule

The 20-year CIP schedule is shown in Table 6-5. The total estimated capital costs over the 20-year planning period are about $275.7M.

Figure 6-3 shows the annual and cumulative capital expenditures over the 20-year planning period from 2015 through 2035. The costs are relatively evenly distributed, with the largest total expenditures planned for fiscal years (FY) 2021/2022 through 2024/2025. In these years, the largest portions of capital expenditures occur for the new membrane filtration complex to replace Sycamore filters, the lime storage and feed system replacement, and the ferric sulfate storage and feed system replacement. It should be noted that the major improvements affecting the shape of the figure below include the replacement of the Sycamore filters between the years of 2019-2024 and the replacement of the Claiborne filters between the years of 2030-2035, the other costs are fairly evenly distributed over the 20-year period.

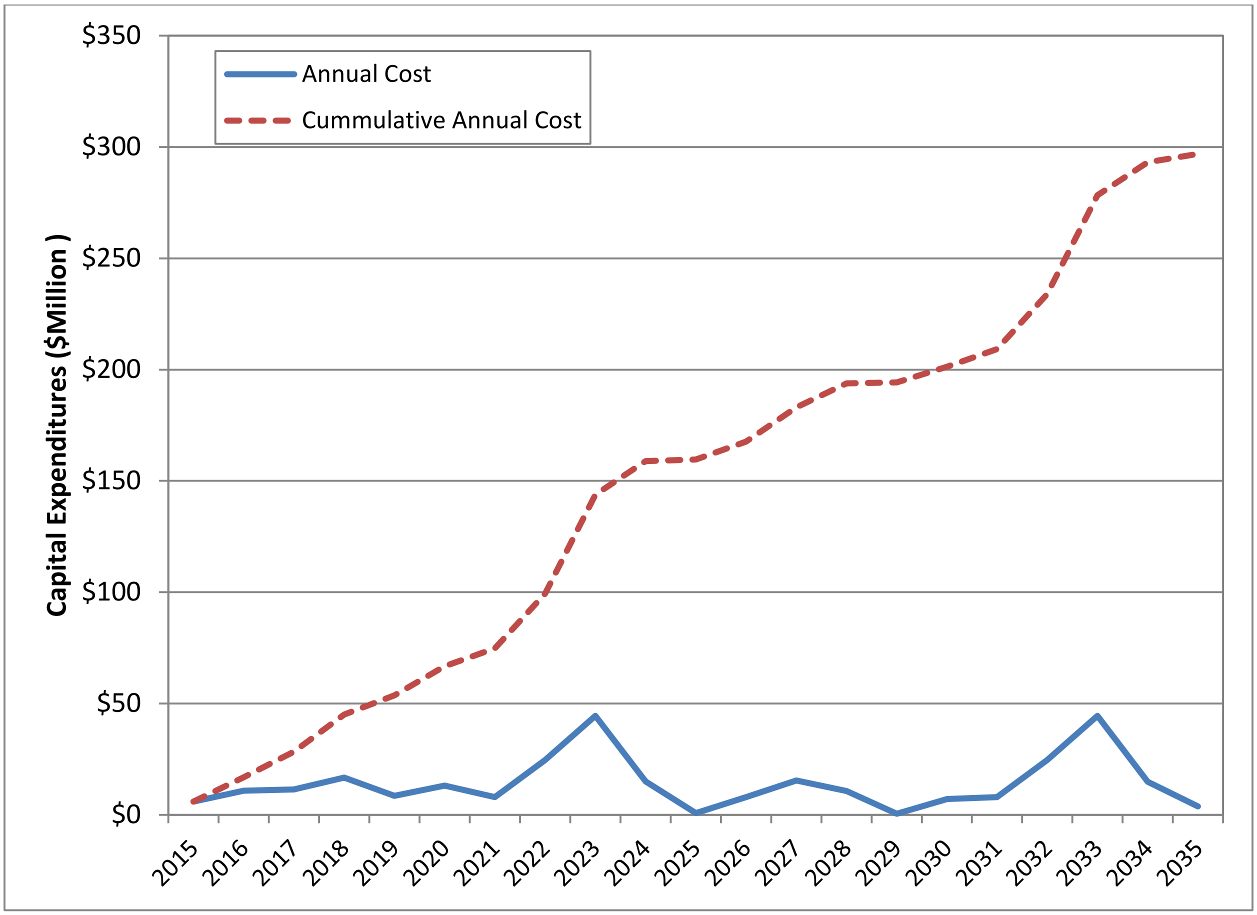

Figure 6-3: Annual and Cumulative CIP Capital Expenditures

CARROLLTON WATER TREATMENT PLANT - WATER QUALITY MASTER PLAN
NEW ORLEANS, LOUISIANA
Table 6-5: 20-Year CIP Implementation Schedule-FINAL

Item	Item Description	Priority	Project Duration (years)	Total Estimated Project Cost (2015 dollars)	Year												
					2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026 - 2030	2031 - 2035
					0	1	2	3	4	5	6	7	8	9	10	11 - 15	16 - 20
Study 1	Lime System Evaluation	1	1	$60,000	$60,000												
Study 2	Sycamore Filters Replacement Study	1	1	$250,000	$250,000												
Study 3	Sludge Removal Improvements to C Basin	1	1	$200,000	$200,000												
Study 4	Assess Leakage in G, L and C Basins	1	1	$130,000	$130,000												
Study 5	Assess Ground Storage Tank Mixing	1	1	$100,000	$100,000												
Study 6	SCADA System Evaluation	1	1	$150,000	$150,000												
Study 7	Steel GST Inspection	1	1	$20,000	$20,000												
1	Routine refurbishment of G and L Basin flocculators	1	1	$1,000,000	$200,000					$200,000					$200,000	$200,000	$200,000
2	Air System Improvements at Sycamore and Claiborne filters	1	1	$140,000	$140,000												
3	Backwash supply pump improvements at Sycamore filters	1	2	$1,160,000	$174,000	$986,000											
4	Annual Filter Media Replacement and Related Filter Rehabilitations at Claiborne	1	1	$18,000,000	$3,600,000	$3,600,000	$3,600,000	$3,600,000									$3,600,000
5	Short Term Chemical Feed System Improvements	1	2	$450,000	$67,500	$382,500											
6	Replace all Valves (Sycamore Filters No. 11-29)	1	3	$3,750,000	$562,500	$1,875,000	$1,312,500										
7	High Priority Improvements to the G-Basins	1	3	$2,160,000	$324,000	$1,080,000	$756,000										
8	Filter Media Replacement Sycamore Filter Complex	1	1	$8,850,000		$2,950,000	$2,950,000	$2,950,000									
9	Addition of Redundant Sludge Line	1	2	$7,620,000			$1,143,000	$6,477,000									
10	Air Scour addition at Claiborne filter complex	1	1	$820,000			$820,000										
11	Structural Modifications/Improvements for Carrollton WTP	2	1	$27,000			$27,000										
12	Steel GST Rehabilitation	2	4	$5,230,000			$366,100	$418,400	$2,615,000	$1,830,500							
13	Complete replacement of fluoride storage and feed system	2	2	$190,000			$28,500	$161,500									
14	Complete replacement of ferric sulfate storage and feed system	2	2	$930,000			$139,500	$790,500									

CARROLLTON WATER TREATMENT PLANT - WATER QUALITY MASTER PLAN
NEW ORLEANS, LOUISIANA
Table 6-5: 20-Year CIP Implementation Schedule-FINAL

Item	Item Description	Priority	Project Duration (years)	Total Estimated Project Cost (2015 dollars)	Year												
					2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026 - 2030	2031 - 2035
					0	1	2	3	4	5	6	7	8	9	10	11 - 15	16 - 20
15	Flow Instrumentation and valve improvements to 48" RW line	2	2	$270,000			$40,500	$229,500									
16	GST Mixing Improvements	2	2	$640,000			$96,000	$544,000									
17	Refurbishment and improvements of G and L Basin monorakes	2	4	$2,530,000			$177,100	$202,400	$1,265,000	$885,500							
18	Replace PAC system	2	3	$3,560,000				$534,000	$1,780,000	$1,246,000							
19	Replace Lime Storage and feed system with recommended system	2	3	$5,730,000				$859,500	$2,865,000	$2,005,500							
20	C-Basin sludge removal improvements	2	5	$210,000					$31,500	$105,000	$73,500						
21	New membrane filtration complex to replace Sycamore filters	2	5	$98,700,000						$6,909,000	$7,896,000	$24,675,000	$44,415,000	$14,805,000			
22	New Hypochlorite System for Claiborne Filter Backwash	3	1	$160,000										$160,000			
23	Rehabilitation of Sludge Handling System Improvements	3	2	$4,070,000											$610,500	$3,459,500	
24	SCADA System	4	3	$30,000,000												$30,000,000	
25	Additional Ammonia System Improvements	4	1	$460,000												$460,000	
26	Demolish abandoned elevated storage tank	4	1	$150,000												$150,000	
27	Complete replacement of polymer storage and feed system	4	2	$490,000												$490,000	
28	Membrane filtration complex expansion to replace Claiborne filters	5	5	$89,310,000												$6,909,000	$91,791,000
			TOTALS	**$287,517,000**	**$5,978,000**	**$10,873,500**	**$11,456,200**	**$16,766,800**	**$8,556,500**	**$13,181,500**	**$7,969,500**	**$24,675,000**	**$44,415,000**	**$14,965,000**	**$810,500**	**$33,659,500**	**$3,800,000**