APPENDIX F

BWA WTP Existing Condition Evaluation

December 2013

CDM Smith

Technical Memorandum No. 1

BWA WTP Existing Condition Evaluation

1.1 Introduction

The Brazosport Water Authority (BWA) treats and delivers water to the Cities of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek and Richwood, as well as two Texas Department of Criminal Justice prisons and the Dow Chemical Company. The existing BWA Water Treatment Plant (WTP) is located in Lake Jackson (as shown in **Figure 1-1** on the following page). The BWA water supply is provided by a 45,000 ac-ft/yr run-of-the-river rights from the Brazos River. This permit has a priority date of 1964. BWA's water supply is tied to Dow's water supply by virtue of the diversions from the Brazos River into the Harris or Brazoria Reservoir and releases from these reservoirs to the Dow fresh water canal. Water is diverted to the Brazoria Reservoir, located at river mile 24 when fresh water is available at this location. During periods of low flow, the salt water wedge from the Gulf of Mexico moves up the Brazos River and fresh water diversions are moved to the Harris Reservoir located at river mile 44. Water from the Harris Reservoir is released into Oyster Creek and then diverted to the fresh water canal. Water from the Brazoria Reservoir is released into Buffalo Camp Bayou and diverted to the fresh water canal. The water treatment plant diverts water from the fresh water canal. This Plant was constructed in 1987 to serve Brazosport Water Authority customers.

As part of the Brazoria County Water Master Plan, CDM Smith completed an evaluation of the current Plant systems in order to provide recommendations to BWA that would improve their existing WTP and transmission system, as well as increase the capacity of the Plant and transmission system to meet projected water demands of their existing participating customers and potential customers in Brazoria County. As part of this evaluation, CDM Smith completed the following:

- Review of water quality regulations as they relate to the Plant;
- Review of the current water quality and potential impacts on the Plant;
- Assessment of the existing water treatment plant;
- Identification and evaluation of near-term upgrade and expansion alternatives; and,
- Identification and evaluation of long-term upgrade and expansion alternatives.

1.2 Water Quality Regulations

Water quality standards are established to ensure that safe and aesthetically acceptable drinking water is supplied to the public. Drinking water standards are established by the Texas Commission on Environmental Quality (TCEQ) to assure the safety of public water supplies. These standards, presented in Chapter 290, Subchapter F of the Texas Administrative Code, comply with the Federal "Safe Drinking Water Act" and the "Primary Drinking Water Regulations", promulgated by the Environmental Protection Agency (EPA). The complete National Primary Drinking Water Regulations and a list of contaminants and their maximum contaminant levels may be accessed on the U.S. Environmental Protection Agency Web site (www.epa.gov/safewater/contaminants/index.html).

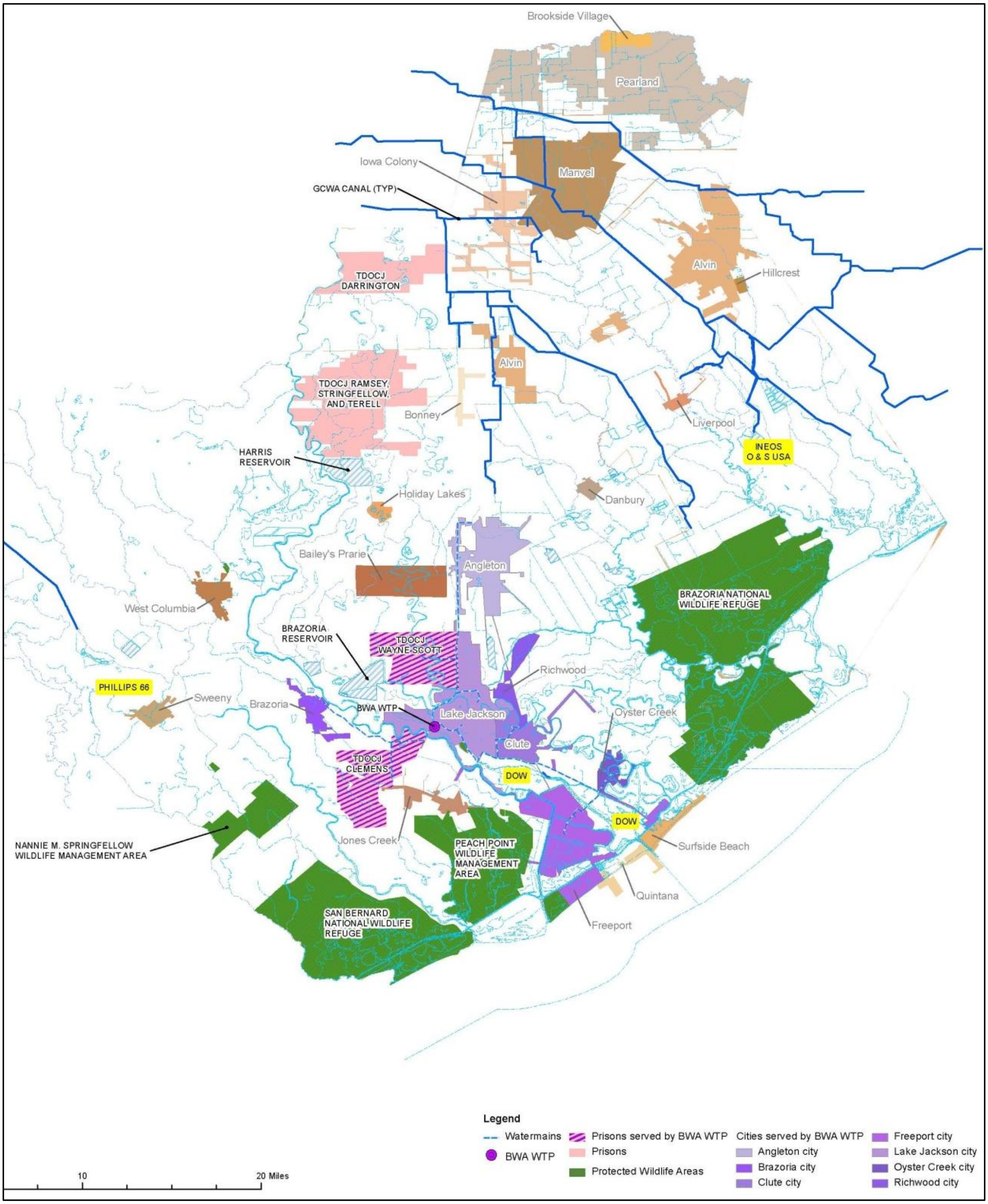


Figure 1-1 Map of Brazoria County

The National Secondary Drinking Water Regulations are recommended standards developed by the EPA to address constituents that may impact the aesthetic quality of drinking water.

These standards are typically included to improve consumer satisfaction. These parameters include inorganic and physical characteristics:

- Inorganic characteristics include such parameters as total dissolved solids (TDS), hardness, iron, and manganese.
- Physical characteristics include such parameters as taste and odor, color and corrosiveness.

Based on review of available data, BWA is currently in compliance with the EPA and TCEQ regulation requirements for surface water treatment plants. **Table A-1** in **Appendix A** summarizes the primary drinking water regulations and presents the current compliance status for the BWA WTP.

1.3 Water Quality

The source water for the Brazosport Water Authority (BWA) Water Treatment Plant (WTP) is the Brazos River via the Harris and Brazoria Reservoir and the fresh water canal system. This section reviews the raw, finished, and distribution system water quality.

1.3.1 Brazoria Reservoir Raw Water Quality

The source water for the BWA WTP is the Brazos River via the Harris and Brazoria Reservoir and the fresh water canal system, which was constructed in 1954. The Brazoria reservoir has a capacity of 21,000 acre-feet and a surface area of 1,865 acres at a crest elevation of approximately 31 feet above mean sea level. Approximately 8,000 acre-feet are usable. The Harris Reservoir has a capacity of 7,000 acre-feet and a surface area of 1,663 acres at a normal maximum surface elevation of approximately 43 feet above mean sea level. Approximately 5,200 acre-feet are usable.

The most recent water quality data are shown in the following **Table 1-1**.

Table 1-1 Raw Water Characteristics

Year or Range		Characteristic	Unit	Average Level	Maximum Level	Minimum Level
2008	2010	Turbidity	NTU	49	113	24
2008	2010	Alkalinity	mg/L	142	313	12
2008	2010	TOC	mg/L	4.56	13.80	1.80
2008	2010	pH	NU	7.85	8.17	7.05
2008	2010	Hardness	mg/L	179	224	126
2008	2010	TDS	mg/L	319	476	4.16
2008	2010	Arsenic	mg/L	0	0.002	<0.005
2008	2010	Barium	mg/L	0.16	0.34	0.10
2008	2010	Copper	mg/L	0.01	0.03	0.006
2008	2010	Nickel	mg/L	0	0.004	<0.005
2008	2010	Lead	mg/L	0	<0.005	<0.001
2008	2010	Sulfate	mg/L	48	78	33
2008	2010	Chloride	mg/L	103	166	40
2008	2010	Nitrate	mg/L	0.72	0.98	<0.50
2008	2010	Fluoride	mg/L	0.53	0.84	0.30
2008	2010	TTHM	ug/L	UD	UD	UD
2008	2010	HAA5	ug/L	<1.0	<1.0	<1.0
2008	2010	E. coli	(CFU/100 mL)	115	548	2

1.3.2 Finished Water Quality

The Plant finished water consistently meets all regulatory requirements, and filtered water turbidities are good. BWA is also currently meeting the compliance schedule required by the Long Term 2 Enhanced Surface Water Treatment Rule. The most recent data are shown in the following **Tables 1-2 through 1-8**.

Table 1-2 Average Residual Chlorine in Distribution System

Year or Range		Disinfectant	Average Level	Minimum Level	Maximum Level	Source of Chemical
2008	2012	Chloramine (total chlorine)	2.03	1.0	5.0	Disinfectant used to control microbes.

Table 1-3 Disinfection Byproducts

Year or Range		Contaminant	Average Level	Minimum Level	Maximum Level	MCL	Unit of Measure	Source of Contaminant
2008	2011	Total Haloacetic Acids	9.63	<1.0	11.90	60	ug/L	Byproduct of drinking water disinfection.
2008	2011	Total Trihalomethanes	11.98	UD	13.60	80	ug/L	Byproduct of drinking water disinfection

Table 1-4 Unregulated Contaminants

Year or Range		Contaminant	Average Level	Minimum Level	Maximum Level	Unit of Measure	Source of Contaminant
2008	2011	Chloroform	4.4	UD	8.6	ppb	Byproduct of drinking water disinfection.
2008	2011	Bromoform	1.7	UD	2.1	ppb	Byproduct of drinking water disinfection.
2008	2011	Bromodichloromethane	3.0	UD	3.5	ppb	Byproduct of drinking water disinfection.
2008	2011	Dibromochloromethane	3.9	UD	4.6	ppb	Byproduct of drinking water disinfection.

Table 1-5 Regulated Contaminants

Year or Range		Contaminant	Average Level	Minimum Level	Maximum Level	MCL	MCLG	Unit of Measure	Source of Contaminant
				Inorganic Contaminants					
2008	2011	Arsenic	-	<0.001	<0.005	10	0	ppm	Erosion of natural deposits; runoff from orchards; runoff from glass and electronics production wastes.
2008	2011	Barium	0.11	0.08	0.13	2	2	ppm	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits.
2008	2011	Fluoride	0.59	0.22	1.18	4	4	ppm	Erosion of natural deposits; water additive which promotes strong teeth; discharge from fertilizer and aluminum factories.
2008	2011	Nitrate	1.15	<0.50	1.98	10	10	ppm	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits.
				Organic Contaminants					
2008	2011	Atrazine	0.78	0.29	1.90	3	3	ppb	Runoff from herbicide used on row crops.

Table 1-6 Secondary and Other Constituents Not Regulated

Year or Range		Constituent	Average Level	Minimum Level	Maximum Level	Secondary Limit	Unit of Measure	Source of Constituent
2011	2011	Aluminum	0.021	-	-	.05	ppm	Abundant naturally occurring element.
2008	2011	Bicarbonate	153	137	178	NA	ppm	Corrosion of carbonate rocks such as limestone.
2011	2011	Calcium	43.2	-	-	NA	ppm	Abundant naturally occurring element.
2008	2012	Chloride	111	57	160	300	ppm	Abundant naturally occurring element; used in water purification; byproduct of oil field activity.
2008	2011	Copper	0.033	0.001	0.049	1	ppm	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives.
2008	2011	Hardness as Ca/Mg	170	123	215	NA	ppm	Naturally occurring calcium and magnesium.
2011	2011	Magnesium	11.9	-	-	NA	ppm	Abundant naturally occurring element.
2008	2011	Nickel	-	<0.001	0.002	NA	ppm	Erosion of natural deposits.
2008	2012	pH	7.63	7.20	8.20	7	units	Measure of corrosivity of water.
2009	2011	Sodium	78	66	94	NA	ppm	Erosion of natural deposits; byproduct of oil field activity.
2008	2012	Sulfate	58	27	85	300	ppm	Naturally occurring; common industrial byproduct; byproduct of oil field activity.
2008	2012	Total Alkalinity as CaCO3	125	112	146	NA	ppm	Naturally occurring soluble mineral salts.
2008	2012	Total Dissolved Solids	393	260	496	1000	ppm	Total dissolved mineral constituents in water.

Table 1-7 Total Organic Carbon

Year or Range		Contaminant	Average Level	Minimum Level	Maximum Level	Unit of Measure	Source of Contaminant
2008	2011	Source Water	4.56	1.80	13.80	ppm	Naturally present in the environment.
2008	2011	Drinking Water	3.31	1.40	11.40	ppm	Naturally present in the environment.
2008	2011	TOC Removal	24.6	-	-	% removed	NA

Table 1-8 Turbidity

Year or Range		Contaminant	Highest Single Measurement	Lowest Monthly % of Samples Meeting Limits	Turbidity Limits	Unit of Measure	Source of Contaminant
2008	2011	Turbidity	0.47	98.9	0.3	NTU	Soil runoff.

1.4 Existing Facility Conditions and Expansion Considerations

The BWA WTP was constructed in 1987 in Lake Jackson to serve to the Cities of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek and Richwood, as well as two Texas Department of Criminal Justice prisons and the Dow Chemical Company. Since then, several major facility improvements have been constructed to meet the increasing water demands brought about by development in Brazoria County.

BWA currently holds contracts to provide water to these customers, which are presented (with their current contract amounts), in **Table 1-9**.

Table 1-9 BWA WTP Customers and Contract Amounts

Customer	Water Contract Amount (mgd)
Angleton	1.80
Brazoria	0.30
Clute[1]	1.00
Freeport	2.00
Lake Jackson	2.00
Oyster Creek	0.095
Richwood	0.235
Dow	1.00
TDCJ	0.75

[1] Contract amount could increase by 1.0 mgd as recently requested by the City.

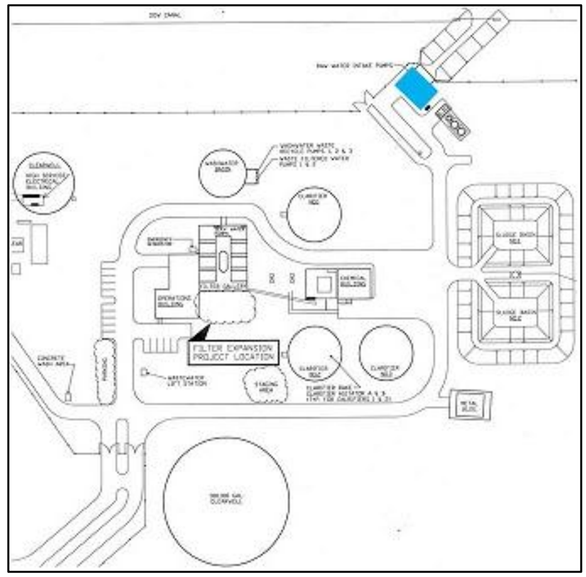
The BWA WTP has a capacity of 17.8 million gallons per day (mgd). The future demands in 2025 and 2040 are 26 mgd and 32 mgd, respectively. Based on the future projected demands, future Plant capacity will need to be increased.

CDM Smith visited the Plant on May 24, 2012, to assess the current condition of the Plant processes and assets. In addition, an electrical and instrumentation and control site visit was conducted November 20, 2012, to review the state of the electrical and SCADA systems currently installed at the Plant. This section provides an overview of the capacity and condition of these existing equipment and facilities. Additionally, recommendations for improvements at the Plant and the probable costs for these improvements are provided.

1.4.1 Treatment Process Overview

Treatment is achieved using solids contact clarification and filtration. Water is pumped into the Plant from the Raw Water Intake by six raw water pumps. Following treatment, finished water is stored in one of two clearwells onsite and then transferred to the transmission system by four high service pumps. Waste solids throughout the process are sent to the site's two sludge basins. These processes, along with raw water pumping and conveyance and chemical injection, are discussed individually in the following subsections.

1.4.2 Raw Water Intake, Pumping and Conveyance Facilities



The Raw Water Intake and Pump Station (highlighted in blue in the figure to the right) are located east of the BWA WTP site and uptake water from the fresh water canal using a vertical concrete intake structure. The intake and pump station consist of two trash screens, four fine bar screens, and six raw water pumps and appurtenances. The intake structure is 31-feet wide and approximately nine-feet deep at the entrance. The raw water flows through the trash and fine screens, and into the 17.5-foot intake, where the water elevation is approximately 7.1 feet above the finished floor.

The Raw Water Pump Station consists of six vertical turbine pumps, which have a combined capacity of 27.6 mgd. Three pumps are part of the original construction, while the other three pumps were installed by Plant personnel at a later date. Five of the six pumps are equipped with variable frequency drives. The raw water pump parameters are presented in **Table 1-10**. The raw water pumps draw water out of the canal and convey it to the WTP through a dedicated 36-inch ductile iron pipeline into the splitter box at the beginning of the process train. The flow to the Plant is controlled by a flow control valve.

Table 1-10 Raw Water Intake Pump Parameters

Parameter	Value
Number of Pumps	6
Pump Capacity	2,200 gpm (1) 3,400 gpm (5)
Total Capacity	27.6 mgd
Firm Capacity	22.8 mgd

At the pump station, BWA has the ability to add alum or polyaluminum chloride (PAC) as a coagulant aid, copper sulfate for algae control, and cationic polymer. Granular activated carbon can be added for taste and odor control but is not used often at the Raw Water Pump Station due to limited detention time.

The raw water pumps are in good working condition; however, based on population projections (which will be presented in the Facility Master Plan), additional pumps may be needed in order to meet the 2040 max day demands.

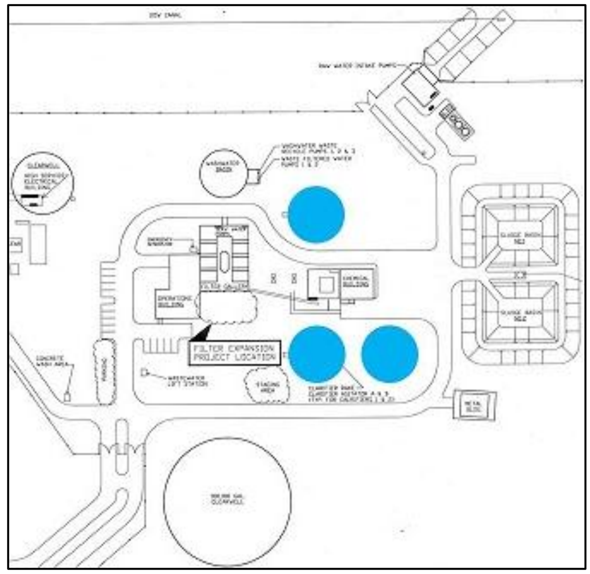
For the 36-inch conveyance piping, with a water demand of 26 mgd, the velocity in the piping will be at just above five feet per second (fps), which is acceptable, and could reach as high as high as 7.0 fps with a water demand of 32 mgd. As the plant reaches these demands, additional pipeline will need to be constructed.

The capacity of the intake and pump station controls the capacity of the entire Plant. Future Plant expansions will increase the velocity in the intake and through the raw water pipeline. CDM Smith recommends a physical hydraulic modeling study be conducted to determine the intake and pump station capacity more precisely.

1.4.3 Water Treatment Plant

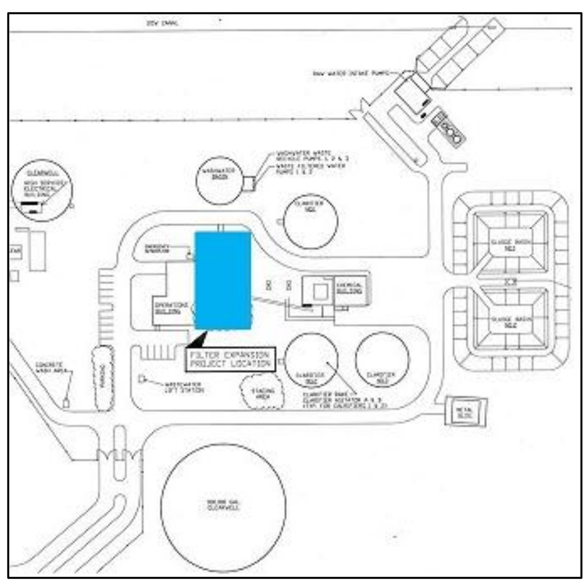
The treatment process consists of solids contact clarification and filtration. These processes are discussed individually in the following subsections.

1.4.3.1 Clarification



The Plant has three clarification trains (highlighted in blue in the figure to the right) – two constructed in 1987 and one in 1994. The original two clarifiers have an 82-foot diameter and a wall height of 22 feet (not including conical bottom). The third one is 100-foot in diameter and has a wall height of 22 feet, 2 inches (not including conical bottom). The original two clarifiers have a volume of 7.6 million gallons (MG) each, while the third clarifier has a volume of 11.3 MG; the total volume is 26.5 MG. Prior to the clarifiers, there is a splitter box that receives flow from the Raw Water Pump Station and sends it to the three clarifiers through a 24-inch pipeline. The splitter box is experiencing a siphoning effect that causes hydraulic surging. This in turn causes an offensive chemical gas smell. CDM Smith recommends venting the splitter box to allow for air to continuously escape.

Chlorine dioxide is injected prior to clarification and monitored in each of the clarifiers. Polymer and coagulant are also injected. The decant water from the sludge basins and the washwater waste from the filters are sent back to the splitter box prior to the clarifiers by a three-inch PVC line and a six-inch ductile iron line, respectively. It is recommended that each of these lines have flowmeters added.



The clarifiers are in need of painting but are in fair working condition, and they have enough capacity with all three online to meet the 2025 demands. However, the current clarification capacity will not meet the 2040 demands – an additional 100-foot diameter clarifier will be needed.

1.4.3.2 Filtration

The existing filtration system at the BWA WTP includes eight granular media filters (highlighted in blue in the figure to the right). Six of these filters were constructed and placed into operation in 1987, with two additional filters added in 2004. Although the filters were installed in separate projects, the design for each project was essentially the same. The existing filters with one filter out of

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service have a total combined surface area of 2,496 square feet (sf) (356.5 sf/filter). The filters have a combined firm rated capacity of 18 mgd based on a filtration rate of 5.0 gpm/sf.

Filters No. 1 through 6 were originally designed with clay tile underdrains that have since been retrofitted with air scour systems. The newer filters, Filters No. 7 and 8, were designed with stainless steel tepee underdrains and air scour. All filters include a dual media filtration bed consisting of 18-inches of anthracite coal and 12-inches of sand supported atop 12-inches of gravel.

Although the existing filters were constructed in two phases, all eight filters operate in parallel. The clarified water from each of the three clarifiers flows into the filter influent channel. This water is evenly distributed among the on-line filters. In addition to the commonality of the filter influent channel, the filtered water pipe header, filter waste backwash water pipe, backwash supply piping, and air scour piping are shared.

During normal filter operation, clarified water enters a filter gullet from the filter inlet channel via an 18-inch inlet butterfly valve. The gullet wall and the washwater troughs are submerged during normal operation with the operating water surface elevation maintained at 23.7 to 27.7 feet. Settled water flows directly from the gullet to the filter bed and then down through the media. The filtered water collects in the underdrain system, flows from the end of each underdrain lateral, passes through a 12-inch outlet pipe, and into the filtered water header. The filtered water is then conveyed through a common filtered water header pipeline to one of two clearwells.

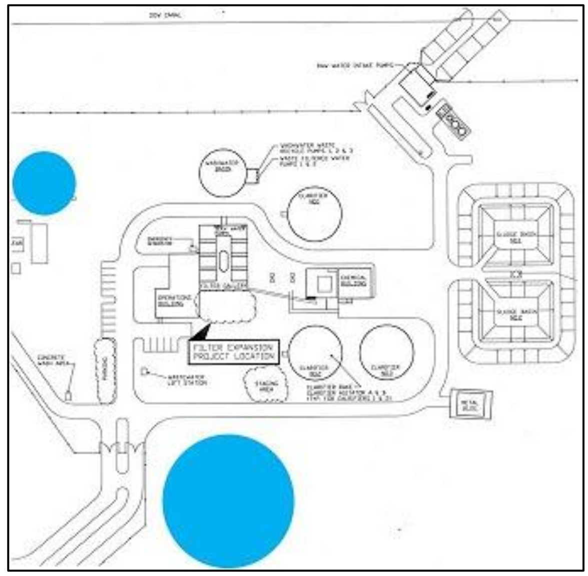
The filters are in good working condition; however, they will need more capacity to meet future demands. In order to meet the 2025 demands, four additional filters will need to be constructed. Another two will need to be built to meet the 2040 demands.

1.4.3.3 Filtered Water Conveyance

At the BWA WTP, filtered water is conveyed through the effluent junction box to the clearwells for obtaining disinfection CT credit and storage. The filters have an underdrain that collects water after it passes through the filter media. Water flowing through these underdrains is metered using a venturi meter located in the filter pipe gallery. The Plant is also equipped with turbidity meters to monitor individual filter turbidity performance to comply with regulatory requirements.

Using the current 36-inch piping for the effluent junction box, with a water demand of 24 mgd in 2025, the velocity in the piping will increase to just above five feet per second, which is acceptable, and reach as high as 6.6 fps in 2040 with a water demand of 36.6 mgd. With the addition of new filters, upgrades to the effluent junction box and effluent piping are recommended.

1.4.3.4 Finished Water Storage



The BWA WTP stores finished water in two onsite clearwells (highlighted in blue on the figure to the right), with a combined storage volume of 1.3 MG. The original clearwell has an 88-foot diameter and a wall height of 10 feet, 5 inches, with a capacity of 0.4 MG. The second clearwell has a 137-foot diameter and a wall height of 10 feet, 5 inches, with a capacity of 0.9 MG. Filtered water flows to the large baffled clearwell and then to the high service pump station wet well. The small clearwell floats off the wet well.

The storage volume available in the clearwells provides contact time and therefore plays a significant role in the Plants' disinfection capability. Clearwells should be operated in compliance with approved CT study to assure proper disinfection.

TCEQ requires a minimum finished water storage capacity to equal or exceed five percent of the rated plant flow. At 17.8 mgd 0.89 MG of clearwell capacity is required. The TCEQ minimum does not take into account the treatment process used at the BWA Plant. The solids contact clarifiers used do not work well with significant changes in flow. With a small clearwell, the flows to the clarifiers are constantly changing in response to rapid changes in clearwell levels which makes operations difficult. It has been CDM Smith's experience that with solids contact clarifiers, that a minimum clearwell volume of 30 percent of plant capacity should be provided. For the 17.8 mgd plant, that results in a clearwell capacity of 5.3 MG. In addition to efficient operation of the plant processes, the BWA WTP serves areas that are prone to hurricanes. As a health and safety measure for the BWA customers, they should consider providing clearwell capacity equal to the average day demand which is currently 10 mgd.

1.4.3.5 High Service Pumps

Finished water stored in the BWA WTP clearwells is supplied to the distribution system by four, 6,000-gpm VFD-controlled, high service pumps. They pump to the Brazoria Ground Storage Tank (GST) and 14 GSTs in Clute, Richwood, Oyster Creek, Freeport (two tanks), Lake Jackson (two tanks), Angleton (two tanks), TDCJ(two tanks), and Dow (two tanks). Pump parameters are presented in **Table 1-11**.

Table 1-11 High Service Pump Parameters

Parameter	Value
Number of Pumps	4
Pump Capacity	6,000 gpm
Total Capacity	34.6 mgd
Firm Capacity	25.9 mgd

Note: The fourth pump is being installed by BWA.

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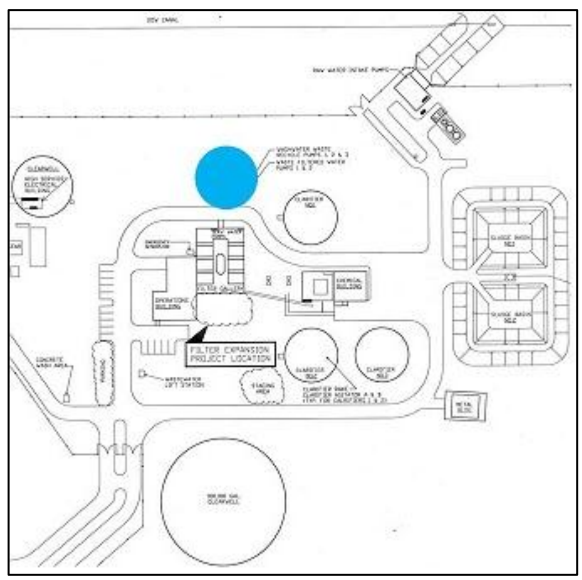
These pumps are in good operational condition. Based on water demand projections, no additional pumps will be needed to meet the 2025 demands, with an additional pumping capacity of at least 3,500-gpm needed for the 2040 demands.

The high service pump station also houses two 8,000-gpm backwash pumps with VFDs and two 700-gpm plant water pumps with VFDs.

1.4.3.6 Filter Backwash and Recycle System

The Plant employs dual-media gravity filters consisting of anthracite and sand, on top of support gravel. Filters are monitored for turbidity, headloss, and run time to determine when backwashing is required. Filters are normally backwashed based on time as opposed to turbidity or headloss. Backwashing directs flow upwards through the filter to wash out floc that has collected on the media and requires a significant amount of flow. The water to be used for backwashing is taken from the clearwell and pumped directly to the filters. One 8,000-gpm vertical turbine backwash pump conveys needed backwash water through a venturi flow meter on the backwash water pipeline that feeds into the basin to control which filter will be backwashed. A backwash rate of up to 22 gpm/sf is available from one of the two pumps (one duty, one standby), more than sufficient for efficient backwashing.



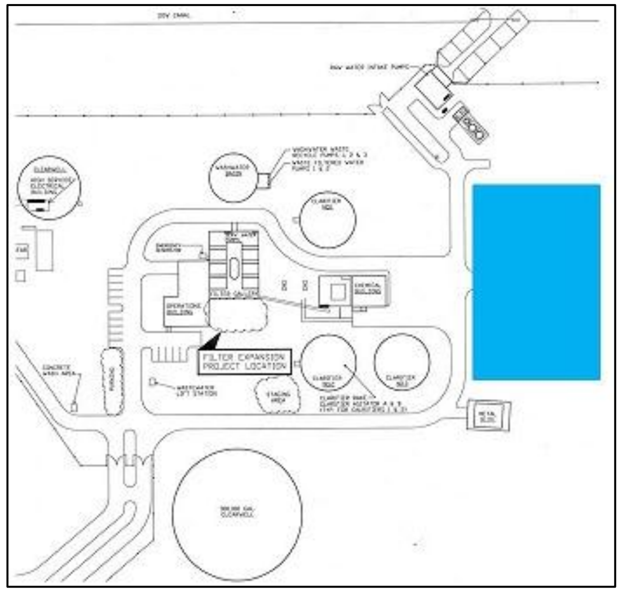
The waste filter backwash water is collected and piped to the washwater water recovery basin highlighted in blue to the right. Recycle pumps pump the waste backwash water to the raw water pump discharge header.

CDM Smith estimated the backwash water requirements for each filter. Assuming a conservative backwash rate of 20 gpm/ft^2 for 20 minutes, approximately 142,000 gallons are used for each backwash. The washwater recovery basin has a volume of approximately 300,000 gallons or approximately the volume of two backwashes. The Plant has three operational recycle pumps. It is critical that the backwash recycle pumps be of sufficient capacity to recycle the backwash water with a one to two hour period to allow for each filter to be backwashed consecutively without exceeding basin capacity.

TCEQ regulates recycled flows streams at water treatment plants. The flow may be returned to the process at any point upstream of coagulant addition, which BWA WTP does.

1.4.3.7 Plant Residuals and Handling

The sludge generated during clarification is sent to two sludge basins onsite (highlighted in blue on the figure below). Sludge from each clarifier is collected in a hopper and conveyed to one of these basins. The decant water from these two basins can be sent back to the raw water pump header using two dedicated pumps.



The Plant has three sludge waste Gravity flow valves and one standby pump. Currently, the sludge pumps located by the clarifiers have been disabled so sludge flows by gravity from the clarifiers to the sludge basins.

The sludge basins and pumps are in fair condition. Pump capacities are unknown so further investigations will need to be completed to determine if additional equipment will be required to meet future demands.

1.4.4 Chemical Feed Systems

As discussed above, BWA WTP adds several chemicals to the water in order to meet their treatment objectives. Chlorine, ammonia, and chlorine dioxide are used for disinfection purposes. Alum or polyaluminum chloride is used as the primary coagulant for treatment purposes. Cationic polymer is used as a coagulant and filter aid. Anionic polymer is available for use as a coagulant aid. Other chemicals, including powdered activated carbon, copper sulfate, fluosilicic acid and caustic, can be added for aesthetic or health reasons. This section summarizes the configuration of these chemical feed systems and outlines recommended improvements.

1.4.4.1 Chlorine

The BWA WTP uses chlorine for two purposes: to produce chlorine dioxide for disinfection and to form chloramines for additional disinfection and distribution system residual. Chloramines are formed by adding chlorine, in solution form, and ammonia to the water.

Chlorine is delivered by truck in one-ton cylinders that are stored in the area located in the chemical building between the primary clarifiers. A monorail system is used to move cylinders inside the building and for placement on scales adjacent to a manifold, through which chlorine gas is fed to chlorinator units. The feed system is a vacuum feed system. **Figure 1-2** is a photograph that shows the chlorine cylinders. Three chlorinator units meter and control the amount of chlorine gas.

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Figure 1-2 Chlorine Cylinders at BWA WTP

The Plant is configured with the capability to apply chlorine solution at the splitter box, prefiltration, and at the effluent junction box. The chlorine is equipped with a total of three vacuum chlorinator units. The amount that can be withdrawn from any individual cylinder is limited by the vacuum requirements of the chlorinators and the ambient temperature surrounding the chlorine cylinders.

The chlorinator room is equipped with a chlorine gas leak detector. TCEQ requires these detectors to be installed in both the chlorinator room and chlorine storage room of these facilities to notify the operators in the event of a leak. Additionally, TCEQ requires that either a full-face, self-contained breathing apparatus (SCBA) or a supplied air respirator that meets Occupational Safety and Health Administration (OSHA) standards and a small fresh bottle of fresh ammonia solution for testing be readily accessible to each chlorinator room. SCBA are current located within the Control Room, adjacent the Chlorine Storage area, and outside door of Chlorinator room. A one-ton repair kit is also on-site at BWA.

Equipment capacities are unknown at this time so further investigations will need to be completed to determine if additional equipment will be required to meet future demands.

1.4.4.2 Ammonia

The BWA WTP utilizes liquid ammonium sulfate (LAS) to react with the chlorine solution added to the water to form chloramines. Although chloramines are less reactive than free chlorine for disinfection purposes, chloramines produce lower levels of regulated disinfection by-products and a more stable longer-lasting residual in the distribution system than free chlorine.

Under normal operating conditions, operations personnel feed the chlorine and ammonia at a ratio of approximately 4:1. This may result in overfeeding ammonia at times if the chorine demand in the raw water is high or if chlorine is consumed in the treatment process units.

Tanker trucks deliver LAS to the chemical fill station at the chemical building. All bulk storage tanks are located within concrete spill containment areas large enough to contain at least the volume of the storage tank. The Plant has two ammonia feed pumps that have the capability to apply ammonia at the splitter box and/or the effluent junction box. All equipment is in fair condition. Metering pump and other equipment capacities are unknown at this time so further investigations will need to be completed to determine if additional equipment will be required to meet future demands.

1.4.4.3 Chlorine Dioxide

BWA WTP has two on-site chlorine dioxide generating units, which combines sodium chlorite and chlorine gas to create chlorine dioxide. The chlorine dioxide can be injected at the raw water intake or into the splitter box prior to clarification. The chemical building houses one 6,400-gallon sodium chlorite storage tank. Chlorine dioxide can be injected at the raw water line before the splitter box and/or the raw water line at the intake. All equipment is in fair condition. Metering pump and other equipment capacities are unknown at this time so further investigations will need to be completed to determine if additional equipment will be required to meet future demands.

1.4.4.4 Polymer

BWA WTP has the option to add cationic polymer as a coagulant aid into the raw water pump header at the raw water pump station. In addition, anionic polymer can be injected as a coagulant aid at the splitter box. There is one 6,400-gallon low molecular weight (LMW) polymer storage tank holding cationic polymer, which is in the chemical storage bay located by raw water pump station, and one 250-gallon high molecular weight (HMW) bin holding anionic polymer located inside main chemical building. Two LMW polymer blending units convey the polymer through PVC pipe to be injected at the raw water line before the splitter box and/or the raw water line at the intake. One HMW polymer blending unit conveys the polymer through PVC pipe to be injected at the clarifier mixing chamber and/or the filter influent pipe. All polymer equipment is in good condition. Metering pump and other equipment capacities are unknown at this time so further investigations will need to be completed to determine if additional equipment will be required to meet future demands.

1.4.4.5 Coagulant

The Plant has the option to add alum or polyaluminum chloride for coagulation. Both are injected in the pump header at the Raw Water Pump Station. Coagulant is delivered to the Plant by trucks and stored in two 10,000-gallon bulk storage tanks. Metering pumps are used for pumping the coagulant to the application point.

1.4.4.6 Fluoride

BWA WTP has the capability to add fluoride to reduce tooth decay in the form of fluosilicic acid, also called hydrofluosilicic acid. The dose must be carefully controlled to achieve an optimum finished water level of approximately 0.8 mg/L. Higher levels can cause mottled teeth and low doses provide no benefit. Fluoridation is not required by TCEQ.

Typically, fluoride is injected after filtration; however, it can also be injected into the raw water at the head of the Plant. Although the recommended fluoride target residual (in the distribution system) is approximately 0.8 mg/L, normally there is a small background concentration of fluoride in the raw water, so the applied dose required to meet a residual of 0.8 mg/L typically ranges from 0.6 mg/L to 0.7 mg/L.

1.4.4.7 Additional Chemicals

In addition to the above mention chemicals, BWA WTP also injects corrosion inhibitor at the effluent junction box to help protect the distribution system piping. All corrosion inhibit piping is PVC, and the chemical Bay houses one 6,400-gallon tank and one 55-gallon day tank of corrosion inhibitor and two metering pumps. All equipment is in fair condition. Granular activated carbon can be injected at the head of the Plant to help with color, taste and odor issues. However, it is not used very often and has limited detention time available for effectiveness.

1.4.5 Disinfection

BWA WTP currently uses chlorine dioxide and chloramines as the disinfectants. These systems were discussed previously. This section outlines the current TCEQ approved CT study.

TCEQ has currently approved the CT study for the Plant, which dictates how much disinfection credit the Plant can receive for a given set of water quality characteristics and disinfectant dose. Below provides a brief discussion of the approved CT study and highlights any significant bottlenecks or opportunities for improved disinfection performance.

The existing TCEQ approved CT study divides the Plant into four disinfection zones, D1 through D4, with zone D2 having three subsections. The first zone consists of the raw water piping. The clarifiers, clarifier piping and clarifier effluent boxes constitute the second zone; the filters, the third zone, and the clearwell, clearwell piping and high service sump pump, the fourth zone. The majority of the effective contact time (T10) at this Plant is contained in the second zone, D2. **Table 1-12** details each disinfection zone.

Table 1-12 Summary of Disinfection Zones

Disinfection Zone	Treatment Unit	Volume (gallons)	Flow Rate (mgd)	Baffling Factor	T10 (min)	
					Unit	Zone
D1	Raw water piping	16,394	17.967	1	1.314	1.31
D2A	Clarifier #1 (1)	841,562	5.085	0.3	71.501	72.38
	Clarifier effluent drop box (1)	2,693	5.085	0.1	0.076	
	Clarifier piping	2,844	5.085	1	0.805	
D2B	Clarifier #2 (1)	841,562	5.085	0.3	71.501	72.62
	Clarifier effluent drop box (1)	2,693	5.085	0.1	0.076	
	Clarifier piping	3,672	5.085	1	1.040	
D2C	Clarifier #3 (1)	1,341,873	7.798	0.3	74.342	75.08
	Clarifier effluent drop box (1)	3,367	7.798	0.1	0.062	
	Clarifier piping	3,672	7.798	1	0.678	
D3	Dual media filter #1 (1)	18,537	2.566	0.7	7.282	50.97
	Dual media filter #2 (1)	18,537	2.566	0.7	7.282	
	Dual media filter #3 (1)	18,537	2.566	0.7	7.282	
	Dual media filter #4 (1)	18,537	2.566	0.7	7.282	
	Dual media filter #5 (1)	18,537	2.566	0.7	7.282	
	Dual media filter #6 (1)	18,537	2.566	0.7	7.282	
	Dual media filter #7 (1)	18,537	2.566	0.7	7.282	
	Dual media filter #8 (1)	18,537	2.566	0.7	7.282	
D4	Clearwell influent piping (1)	22,740	17.967	1	1.823	25.49
	Clearwell (new) (1)	532,187	17.967	0.5	21.327	
	Clearwell effluent piping (1)	25,697	17.967	1	2.060	
	High service pump sump (1)	34,542	17.967	0.1	0.277	

Table 1-13 summarizes the disinfection performance under cold-water conditions. The inactivation ratio measures how much CT credit is achieved by the treatment process relative to how much is required by TCEQ. Total values less than 1.00 indicate that the treatment process is not able to meet regulatory requirements. TCEQ limits the allowable chlorine and chloramine residual to 4.0 mg/L.

Table 1-13 Disinfection Performance at 17.97 mgd and 5° C

Zone	Disinfectant	Chlorine Residual (mg/L)	Inactivation Ratio	
			Giardia	Viruses
D1	Chlorine Dioxide	0.1	0.01	0.05
D2A	Chlorine Dioxide	0.1	0.81	2.53
D2B	Chlorine Dioxide	0.1	0.82	2.54
D2C	Chlorine Dioxide	0.1	0.84	2.63
D3	Chlorine Dioxide	0.1	0.08	0.25
D4	Chloramines	3.0	0.11	0.18
Plant Total			1.02	3.01

As can be seen from the summary table above, the Plant will narrowly meet the disinfection CT requirements for *Giardia* inactivation at rated Plant capacity and low temperature. This also assumes that at chlorine dioxide residual can be maintained through the filters. Provisions for additional downstream detention time for chloramine disinfection, such as an additional clearwell volume, would provide a safety factor for meeting disinfection requirements.

1.4.6 Treatment Capacity Summary

CDM Smith evaluated the capacity of each treatment process for the Plant to determine the Plant capacity. **Figure 1-3** summarizes the capacity of each treatment process. As shown in the figure, the current Plant capacity is 17.97 mgd. Based on firm capacity, the limiting process is the clearwells, followed by filtration and disinfection. (Disinfection is determined by CT study.) The clarification process has the greatest amount of excess firm capacity, followed closely by the high service pumping.

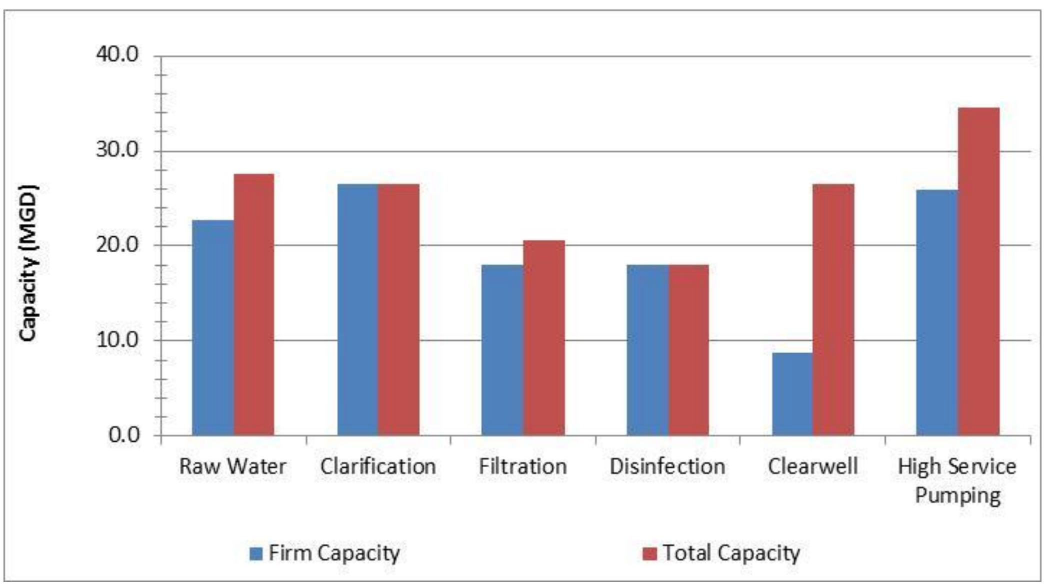


Figure 1-3 Treatment Capacity Per Process

CDM Smith
Document Code

1.4.7 Plant Electrical System

This section summarizes the electrical evaluation of the existing electrical system at the BWA Water Treatment Plant and proposes recommended improvements to correct any noted deficiencies and to improve the electrical system reliability and Plant personnel safety.

1.4.7.1 Existing Condition

1.4.7.1.1 Overall Plant Electrical Distribution

The existing electrical power distribution system is a single bus radial system. The electric utility serving this Plant is CenterPoint Energy. A single utility-owned overhead service comes to the Plant on the north side of the property. The utility-owned pole mounted transformer steps-down the primary voltage to the Plant distribution voltage of 4160V, 3-Phase. Backup power is provided from a 1500KVA, 4160V, 3-phase standby diesel engine driven generator located on the north side of the property. Normal utility power terminates at a 4160V switchgear enclosure located near the electrical building and generator. The generator power feed terminates at the second 4160V switchgear located near the generator. Both feeders from the 4160V switchgear secondaries, then connect to a single bus at the 4160V motor control center (MCC) located in the Electrical Building. The Generator Control Panel monitors normal power and controls opening and closing of the 4160V switchgear breakers. The switchgear breaker for the normal power is normally closed (NC), and the switchgear breaker for the generator feed is normally open (NO). When normal power is lost, the generator control panel opens the normal power switchgear breaker and closes the generator switchgear breaker. A descriptive one-line diagram of the existing Plant's electrical distribution is shown in **Figure 1-4**.

The Plant also has a 225A, 120/208V, 3-phase propane engine generator as a backup to serve some critical loads at the Operation Building.

The Plant's power system experiences intermittent voltage sags and surges or complete loss of power. It appears that these events occur more often during lightning and thunderstorm events.

There is no up-to-date formal arc flash analysis performed for the electrical equipment. None of the electrical equipment is labeled with the arc flash categories.

Other than the personal protection equipment (PPE) at the electrical building, there is no formal implementation for the PPE requirements as defined by the Occupational Health and Safety Administration (OSHA).

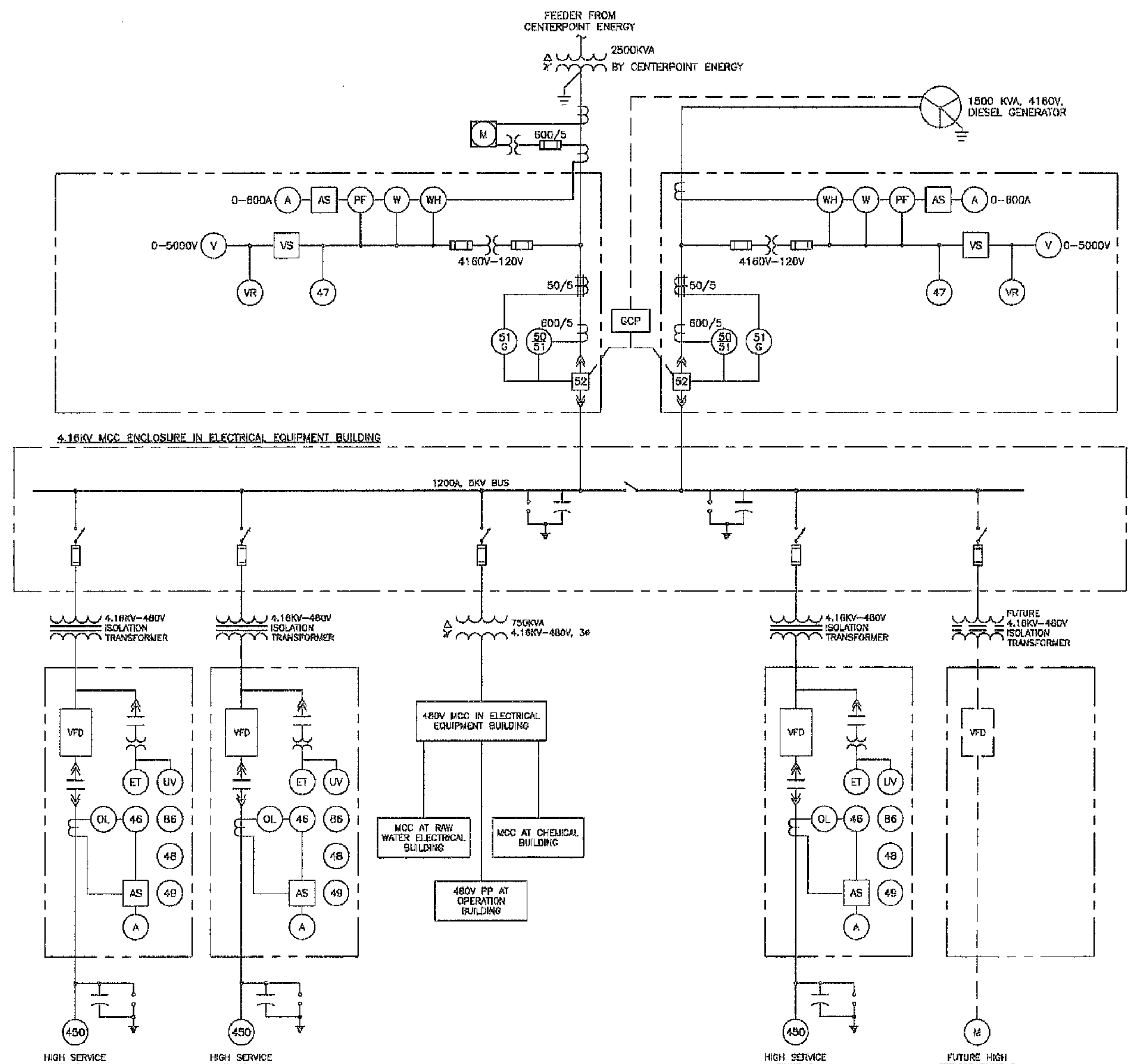
1.4.7.1.2 4160V Switchgear

The 4160V main and generator switchgear consist of a vacuum breaker assembly. The main breaker has a remote breaker open/close operator panel to minimize the exposure to arc flash energy.

Both switchgears are over 20 years old and are in fair condition. However, the electromechanical protective relays are obsolete and parts are not readily available.

1.4.7.1.3 4160V Motor Control Center

The 4160V MCC was installed in 1988. The branch protective devices are fusible load interrupter switches. The fused interrupter switches serve 4160V-480V, 3-phase transformers for the VFDs that



ABBREVIATIONS:

GCP – GENERATOR CONTROL PANEL
A – AMMETER
AS – AMMETER SWITCH
VFD – VARIABLE FREQUENCY DRIVE
OL – OVERLOAD
ET – ELAPSED TIME METER
UV – UNDERVOLTAGE
V – VOLTMETER
VR – VOLTAGE REGULATOR
VS – VOLTMETER SWITCH
W – WATTMETER
WH – WATT/HR METER
46 – PHASE BALANCE CURENT RELAY
47 – PHASE SEQUENCE VOLTAGE RELAY
48 – INCOMPLETE SEQUENCE RELAY
49 – THERMAL RELAY
50 – INSTANTANEOUS OVERCURRENT RELAY
51 – AC INVERSE TIME OVERCURRENT RELAY
51G – TIME OVERCURRENT GROUND RELAY
52 – AC CIRCUIT BREAKER
86 – LOCKOUT RELAY
MCC – MOTOR CONTROL CENTER
PP – POWER PANEL

EXISTING PLANT ELECTRICAL ONE LINE

DIAGRAM 1
–

CDM Smith

Figure 1-4 Existing One-Line Diagram

drive the High Service Pumps. The MCC also feeds the 750 KVA, 4160V-480V, 3-phase transformer, which is the source of all the Plant's 480V MCCs.

The 4160V MCC is in fair condition; however, replacement parts are often hard to obtain or no longer stocked.

1.4.7.1.4 4160V Standby Generator

The Plant's standby power source is a 4160 Volt diesel engine driven generator. The generator is rated for 1500 KVA and has sufficient capacity to serve the Plant's loads. There are two, 3,000-gallon diesel storage tanks, which have enough capacity to run the Plant's loads for two to three days.

The generator was installed around 1993 and is in good condition. It is located indoors on a raised platform. The generator previously had vibration issues, but they have been corrected. The motorized louver for the air intake does not open fast enough, resulting in a generator shutdown. The Plant has provided a temporary solution leaving the roll-up door partially open with a bug screen blocking the dust, bugs, and debris from entering the generator building.

1.4.7.1.5 480V Motor Control Centers

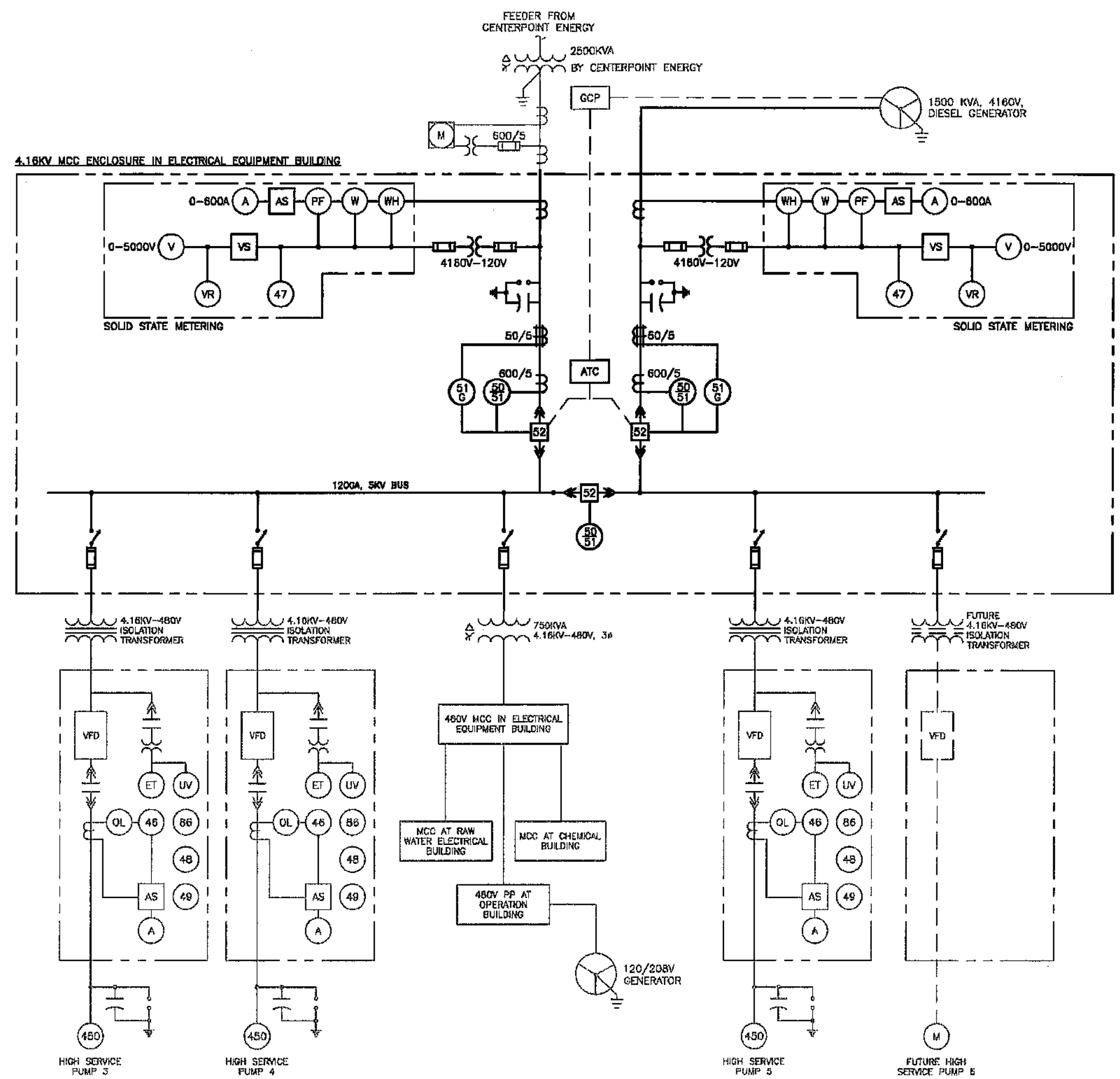
The 480V MCCs at the High Service Pumps Electrical Building, the Raw Water Pump Electrical Building, and the Chemical Building are in good condition. They are installed in climate-controlled buildings.

1.4.7.2 Proposed Improvements

1.4.7.2.1 Overall Plant's Electrical Distribution

The existing 4160V MCC is proposed to be replaced with a split-bus system consisting of a Main-Tie-Main (MTM) 4160V MCC. This means that the MCC has two main and tie breakers. During normal operation the tie breaker would be closed and only the normal main breaker or the emergency main breaker would be closed, but never both. Mechanical and electronic interlocks would be installed to prevent the two main breakers to be in the closed position. If one side of the MCC is out of service, the main breaker for that side would be open, and the tie breaker would be closed allowing the entire bus to be serviced from one side only. The MTM configuration can also implement automatic transfer controls (ATC) for the stand-by generator feed, eliminating the need for the upstream switchgears. The MTM would have to be service entrance rated. A descriptive one-line diagram of the proposed Plant's electrical distribution is shown in **Figure 1-5** on the following page. The existing electrical equipment building would most likely have to be extended or a new building would have to be installed to house the new 4160V MCC.

The proposed modification described above is considered the least expensive option compared to other improvement types, such as dual utility feeds MTM system. The dual utility feeds MTM system will improve the system reliability compared to the proposed system, but would require obtaining the second utility feed from CenterPoint Energy. The feasibility of bringing the second utility service to the plant would have to be investigated. Preferably the second utility service would be physically separated from the main service, and would come from a different substation. BWA would have to cover the entire cost for bringing the second utility service, if available. Since the plant has a back-up generator, this step may not be necessary.



ABBREVIATIONS:

GCP – GENERATOR CONTROL PANEL
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AS – AMMETER SWITCH
VFD – VARIABLE FREQUENCY DRIVE
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UV – UNDERVOLTAGE
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51G – TIME OVERCURRENT GROUND RELAY
52 – AC CIRCUIT BREAKER
86 – LOCKOUT RELAY
MCC – MOTOR CONTROL CENTER
PP – POWER PANEL

PROPOSED PLANT ELECTRICAL ONE LINE DIAGRAM 1

CDM Smith

Figure 1-5 Proposed One-Line Diagram

It is recommended that the utility be contacted to investigate if the power quality issues at the Plant are caused by external sources. Immediate improvements include installing surge protective devices for power distribution equipment and UPS systems for the control power.

The National Electrical Code (NEC) requires that all electrical equipment be marked with a label to warn qualified personnel of potential electric arc flash hazards. The warning labels are required to state arc flash boundary, the incident arc energy, the safe working distance and the category of PPE. Therefore, an arc flash analysis is recommended to determine the potential exposure to the arc hazards in the electrical distribution system at the Plant.

1.4.7.2.2 4160V Switchgears

Because the existing switchgears are at the end of their useful life and replacement parts are hard to find, it is recommended that both switchgears be replaced with new switchgears. It is recommended that the new switchgears be equipped with vacuum breakers and solid-state relays with maintenance setting. This improvement would increase the reliability of the electrical system and reduce the arc flash category rating. However, if the 4160V MCC is replaced as recommended in Section 1.4.7.2.1 these switchgears are not required any longer.

1.4.7.2.3 4160V Motor Control Center

It is recommended that the 4160V MCC be replaced with a MTM type switchgear equipped with solid state protective relays and vacuum breakers for both the incoming and the branch circuits. As indicated in Section 1.4.7.2.1, the MTM configuration of this MCC would improve the system reliability and serviceability.

1.4.7.2.4 4160V Standby Generator

The generator is in good condition and does not have to be replaced in the near future. It should continue to be routinely serviced and maintained. The motorized intake louver is recommended to be replaced to allow ample air entering the building and avoid nuisance generator shutdown.

1.4.7.2.5 480V Motor Control Centers

No improvement is required for the 480 Volt MCCs.

1.4.8 Instrumentation and Control

CDM Smith visited the Plant to walk the site and review the state of the electrical and SCADA systems currently installed at the plant. A conference call was also held with John Gross of Gross Solutions, the Authority's system integrator. The follow sections describe the current state of the SCADA system and make recommendations for the future of the system.

1.4.8.1 Existing Conditions

The current SCADA system is an OPTO-22 system that was installed over the course of several years. The system consists of 14 remote sites that communicate back over a cellular telemetry system to the main system at the Plant. There are four remote terminal units (RTU) within the Plant that control systems inside the Plant. The remote sites were installed during the period from 1998 to approximately 2000. The RTUs in the Plant were installed approximately six to seven years ago.

The existing OPTO-22 system uses the LC4 series of RTUs. The RTUs all seem to be in good condition and the control panels that they are mounted in are all in climate controlled areas. The panels have been kept neat and clean and this have attributed to the RTUs long life. The general condition of the control wiring appears to be good and everything is well labeled.

The SCADA operator interface terminals are running OptoDisplay Runtime Version R4.1a with a build date of January 20, 2005. The operating system is Windows XP Professional version 5.1.2600. The Dell machine that is running the software is an Optiplex 360 that, according to Dell, shipped on August 20, 2009. The warranty on the machine expired on August 21, 2012.

The existing cellular telemetry system that connects the Plant to the remote water delivery sites uses Dataremote CDS-9060 cellular modems. The Authority has service with Verizon. The modems use the CDMA network and communicate data from the remotes sites back to the Plant using a serial protocol. The system works well and the service has been reliable.

The system is being maintained by the system integrator, John Gross. Mr. Gross has clearly done an outstanding job of maintaining the system as well as maintaining the system documentation. The operations and maintenance staff have a great deal of confidence in Mr. Gross and his capabilities.

1.4.8.2 Proposed Improvements

The SCADA system in its current state is fully functional and in good condition. The components, however, are all obsolete and finding replacement parts will be a challenge going forward. It is recommended that the system be updated to newer, more easily available equipment to ensure parts availability.

According to the Opto-22 Web site, the components used in the existing system have reached the end of life and quantities are limited to stock on hand. It is recommended that the existing processors be replaced with newer processors that are more readily available. If desired, other manufacturers of PLC equipment could be evaluated to make the best selection. However, based on the Authority's history with the Opto-22 equipment and the service provided on that equipment by Mr. Gross, the best option at the point seems to be updating to the newest Opto-22 model.

As a part of the Optp-22 upgrade it would be recommended to update to the latest version of the software, PAC Display. The PAC Display software is compatible with Windows 7 so it would be recommended to upgrade to Windows 7 since Microsoft is ending support of Windows XP on April 8, 2014. The operator terminals are using three year old Dell computers. Typically a computer can be expected to last five to seven years. However, with the software upgrades being recommended it would also be a good idea to upgrade the computers.

The existing cellular telemetry system is based on the Verizon CDMA system. Verizon is currently moving away from the CDMA system and toward the LTE system. It would be recommended to replace the cellular routers at the same time that the RTUs are being upgraded. A multiple band model that would communicate both LTE and CDMA would be recommended to ensure that the system does not become obsolete in the foreseeable future. It would also allow the new RTUs to communicate via Ethernet rather than serial which would speed up data transfer.

1.4.8.3 Conclusion

BWA has operated and maintained their current SCADA system in its current configuration for more than six years. It has been well maintained and reliable. By incorporating these recommendations the system can be updated to provide many more years of reliable service.

1.5 Proposed Improvements and Capital Costs

Based on an evaluation of the existing plant process, mechanical, electrical and instrumentation/SCADA system, a recommended capital facility plan has been developed. The improvements include:

- 10 MG Clearwell
- High Service Pump Station
- Associated Yard Piping, Electrical and Instrumentation Improvements
- Plant Electrical System Upgrade
- System wide SCADA System Improvements

Capital cost information for the recommended improvement are shown in **Table 1-14**. The total capital cost of the recommended improvements is approximately $14 million. A site plan showing the location of the new clearwell and high service pump station is shown in **Figure 1-6**. It is recommended that these improvements be scheduled for construction as soon as possible.

Table 1-14 Proposed Probable Costs

Item	Description	Quantity	Unit	Unit Cost	Total
1.0 Process Mechanical Equipment					
	Clearwell, 10 MG	1	EA	$3,120,000	$3,120,000
	High Service Pump Station	17,500,000	GPD	$0.20	$3,500,000
	30” Yard Piping	1	LS	$366,000	$366,000
	Instrumentation (5%)	1	LS	$156,000	$156,000
	Electrical (20%)	1	LS	$624,000	$624,000
	Ancillary equipment and piping	1	LS	$312,000	$312,000
	Clearwell Foundation	1	LS	$1,000,000	$1,000,000
	Site Preparation	1	LS	$100,000	$100,000
				Subtotal:	***$9,178,000***
2.0 Electrical					
	Demolition of existing 4160V switchgears, 4160V MCC, and appurtenances	1	LS	$20,000	$20,000
	New 4160V MCC	1	LS	$380,000	$380,000
	Cables, conduits, and miscellaneous	1	LS	$110,000	$110,000
	Perform coordination, short circuit, arc flash study, arc flash labels, and training	1	LS	$20,000	$20,000
				Subtotal:	***$530,000***
3.0 Instrumentation and Control					
	Remote Sites	14	EA	$32,100	$450,000
	High Service DCU	1	LS	$40,000	$40,000

Raw Water DCU	1	LS	$40,000	$40,000
Filter DCU	1	LS	$40,000	$40,000
Master DCU	1	LS	$40,000	$40,000
Computers and Software	1	LS	$50,000	$50,000
			Subtotal:	***$660,000***
			Construction Cost Total:	***$10,368,000***
Contingency (20%)	1	LS	$2,074,000	$2,074,000
Professional Services (15%)	1	LS	$1,556,000	$1,556,000
			Total:	**$13,998,000**

APPENDIX A

Primary Drinking Water Regulations and Compliance Status

June 2013

CDM Smith

Table A-1 Primary Drinking Water Regulations and Current Compliance Status for BWA WTP

Requirements	Compliance Status
Filter Backwash Recycling Rule (FBRR)	
▪ Recycled flows (spent filter backwash, thickener supernatant and liquids from dewatering processes) must be sent through all conventional or direct filtration processes, or to an alternate state-approved location.	▪ Within compliance based on provided data.
Lead and Copper Rule (LCR)	
▪ AL of 0.015 mg/L for lead and 1.3 mg/L for copper; AL based on the 90th percentile of all tap water samples. ▪ Exceeding an AL is not a violation, but can result in additional treatment and monitoring requirements. ▪ Monitoring required at cold water taps in homes and buildings every six months, with the number of sampling locations dictated by the population served.	▪ Within compliance based on provided data. ▪ Max copper level from 2008-2011 is 0.49 mg/L, with an average of 0.033 mg/L. ▪ Lead levels from 2008-2011 are less than 0.005 mg/L.
Stage 2 Disinfection Byproducts Rule (Stage 2 DBPR)	
▪ Bromate MCL - 0.010 mg/L; TTHM MCL - 0.080 mg/L; HAA5 MCL – 0.060 mg/L ▪ Four distribution sampling points for each water treatment plant - one site with representative average DBP levels from the Stage 1 DBPR monitoring sites, one with high HAA5 levels, two with high TTHM levels. ▪ Basis for determining compliance is LRAA of quarterly samples (i.e., the TTHM and HAA5 standards must be met at each sampling location). ▪ One set of quarterly samples taken during the peak historical month for DBP levels. ▪ Distribution system sampling points will be determined through an IDSE consisting of one year of monitoring, about every 60 days, at eight sampling sites for each water treatment plant (in addition to the Stage 1 DBPR compliance monitoring sites). ▪ Systems with data sets available that meet EPA guidelines, or with sufficiently low DBPs (TTHM and HAA5 concentrations less than 0.040 mg/L and 0.030 mg/L, respectively) in all samples taken in the last two years, are exempt from IDSE monitoring. IDSE monitoring deadlines vary by system size according to **Table A-2**. ▪ Must meet new averaging requirements by the deadline shown in Table A-2. States may allow water systems requiring capital improvements an additional two years to comply.	▪ Within compliance based on provided data. ▪ TTHM and HAA5 within limits at a max of 0.012 mg/L and 0.014 mg/L, respectively (Bromate data unavailable). ▪ Sampling and monitoring within regulations. ▪ Exempt from IDSE monitoring based on TTHM and HAA5 data provided.
Total Coliform Rule (TCR)	

▪ MCLG of zero for total coliforms, including fecal coliforms, Escherichia coli (E. coli).
▪ MCL for total coliforms based on the presence or absence of coliforms, as follows:
  ▪ Systems that collect at least 40 samples each month violate MCL if more than 5.0% of monthly samples are total-coliform-positive.; Systems that collect less than 40 samples each month violate MCL if two or more of the monthly samples are total-coliform-positive.
  ▪ Systems violate the MCL if any repeat sample is fecal-coliform or E. coli positive.
  ▪ Systems violate the MCL if any repeat sample is total-coliform-positive following a fecal-coliform- or E. coli-positive routine sample.
▪ Monthly monitoring within distribution system, with routine sampling depending on population served and water source. Repeat sampling is required for all routine samples that are total-coliform-positive. MCL bases compliance on monthly sampling results.
	▪ Within compliance based on provided data.

Table A-1 Primary Drinking Water Regulations and Current Compliance Status for BWA WTP

Requirements	Compliance Status
Surface Water Treatment Rule (SWTR)	

▪ MCLG of zero for Giardia lamblia, viruses and Legionella.
▪ Personnel meet state-established qualifications to operate all water systems.
▪ Water systems reliably achieve the following:
  ▪ At least 99.9% (3-log) removal and/or inactivation of Giardia lamblia between point where surface water runoff does not recontaminate raw water and point downstream before/at first customer
  ▪ At least 99.99%(4-log) removal and/or inactivation of viruses between point where surface water runoff does not recontaminate raw water and point downstream before/at first customer.
▪ Conventional water treatment systems meet the following turbidity requirements:
  ▪ Combined filtered water turbidity must be less than/equal to 0.5 NTU in at least 95% of monthly samples.
  ▪ Combined filtered water turbidity must never exceed 5 NTU [TCEQ: 5.0 NTU].
▪ Conventional water treatment systems complied with the combined filtered water turbidity requirements based on sampling performed at least once every four hours.
▪ Filtered water turbidity standards in Interim Enhanced Surface Water Treatment Rule (IESWTR) have since replaced the SWTR's filtered water turbidity requirements.
▪ Disinfection treatment process achieves at least 3-log removal and/or inactivation of Giardia lamblia and at least 4-log removal and/or inactivation of viruses; system complies if it achieves a CT (disinfection residual x effective contact time) value greater than the SWTR's required CT value (CTreq).
▪ Disinfectant residual concentration at the entrance to the distribution system cannot be less than 0.2 mg/L [TCEQ: 0.2 mg/L free chlorine or 0.5 mg/L chloramine] for more than 4 hours. Compliance based on continuous monitoring of disinfectant residual.
▪ Disinfectant residual concentration in the distribution system cannot be undetectable [TCEQ: less than 0.2 mg/L free chlorine or 0.5 mg/L chloramine] in more than 5.0 percent of the samples each month, for any two consecutive months. Compliance based on samples taken at same locations, times as bacteriological samples collected under TCR.
▪ Must achieve at least 0.5-log inactivation of Giardia cysts and 2-log inactivation of viruses by disinfection.
	▪ Within compliance based on provided data.
	▪ See IESWTR for compliance with turbidity standards.
	▪ Achieves at least 0.5-log inactivation of Giardia cycsts and 2-log inactivation of viruses based on 2011 CT study.

Interim Enhanced Surface Water Treatment Rule (IESWTR)	

▪ MCLG of zero *for Cryptosporidium*, set at the genus level (i.e., *Cryptosporidium*) rather than the species level (i.e., C. Parvum).
▪ Filtration water systems remove at least 99% (2-log) of *Cryptosporidium* between point where surface water runoff does not recontaminate raw water and point downstream before/at first customer.
▪ Conventional treatment or direct filtration water systems meet the following turbidity requirements:
  ▪ Combined filtered water turbidity must be less than/equal to 0.3 NTU in at least 95% of monthly samples.
  ▪ Combined filtered water turbidity must never exceed 1 NTU [TCEQ: 1.0 NTU].
▪ Systems comply with combined filtered water turbidity requirements based on four-hour sampling intervals.
	▪ Within compliance based on provided data.
	▪ Annual avg TTHM/HAA5 below requiements so disinfection profile not required.
	▪ Meets all turbidity standards.
	▪ All filtered water turbidity requirements met so filter profile not required.
	▪ Disinfection profile not required because all 2011-2012 TTHM and HAA5 concentrations below limits.

Table A-1 Primary Drinking Water Regulations and Current Compliance Status for BWA WTP

Requirements	Compliance Status
▪ Conventional treatment or direct filtration water systems provide continuous turbidity monitoring of each individual filter and report the following events to the state monthly: ▪ Any individual filter with filtered water turbidity greater than 1.0 NTU in two consecutive measurements taken 15 minutes apart. ▪ Any individual filter with filtered water turbidity greater than 0.5 NTU at the end of the first four hours of filter operation, based on two consecutive measurements taken 15 minutes apart. ▪ If system cannot identify obvious reason for abnormal filter performance, must provide TCEQ with filter profile within seven days. ▪ If individual filter exceeds 1.0 NTU filtered water turbidity, based on two consecutive measurements taken 15 minutes apart at any time in each of three consecutive months, system must report the exception to TCEQ and assess filter. If individual filter turbidity exceeds 2.0 NTU [TCEQ: any combination of filters exceeding 2.0 NTU], based on two consecutive measurements taken 15 minutes apart at any time in each of two consecutive months, system must report the exception and arrange for TCEQ or a third, TCEQ-approved, party to perform a comprehensive performance evaluation. ▪ Prepare "disinfection profile" if system's annual average TTHM concentration is 0.064 mg/L or more, or annual average HAA5 concentration is 0.048 mg/L or more, based on samples taken in distribution system over one year. ▪ The system's disinfection profile is based on daily monitoring conducted over a one- to three-year period; must include historical inactivations of Giardia lamblia, and, for systems using chloramines or ozone, viruses. ▪ Systems must measure daily disinfectant residual, disinfectant contact time, water temperature and pH (where necessary). ▪ Systems required to prepare disinfection profile must consult with the state before making one or more of the following changes to their individual disinfection strategies: ▪ Moving disinfectant application point (other than routine seasonal changes already approved by state); ▪ Changing the type of disinfectant; ▪ Changing the disinfection process; and ▪ Making any other state-required change. ▪ System must conduct sanitary surveys no less frequently than every three years for community systems, and no less frequently than every five years for non-community systems. ▪ Unfiltered systems control *Cryptosporidium* as part of the watershed protection program. ▪ Water systems cover all facilities holding finished water for which construction began after February 16, 1999. [TCEQ: All facilities holding finished water must be covered.]	

Table A-1 Primary Drinking Water Regulations and Current Compliance Status for BWA WTP

Requirements	Compliance Status
Long-Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)	
▪ Applies only to surface water or groundwater public water systems under the direct influence of surface water and serving fewer than 10,000 persons.	▪ Does not apply to BWA
Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)	
▪ Provide additional removal and/or inactivation of *Cryptosporidium* for source waters with more than 0.075 oocysts per liter, as **Table A-4** shows. ▪ Cover uncovered finished water reservoirs or treat the reservoir discharge to the distribution system to achieve at least 4-log virus inactivation, unless approved otherwise by the state. [TCEQ: All facilities holding finished water must be covered.] ▪ Source water *Cryptosporidium* level (bin classification) for each water treatment plant will be the maximum running annual arithmetic average for 24 months of monitoring, using EPA Method 1622/23 (total oocyst count, uncorrected for recovery). Systems may collect at least 48 samples and use average of all samples. Systems that have equivalent historical data or achieve at least 2.5-log removal/inactivation of *Cryptosporidium*, in addition to conventional treatment, will be exempt from further monitoring. See Table A-4 for additional removal and/or inactivation of Cryptosporidium. ▪ If required, systems will achieve additional removal and/or inactivation of *Cryptosporidium* using methods contained in a "microbial toolbox." **Table A-3** shows the components of the toolbox that the negotiating committee developed. ▪ Affected water systems will have three years following the initial bin classification to meet treatment requirements associated with the bin. States may give water systems requiring capital improvements another two years to comply. A second round of *Cryptosporidium* monitoring will be required six years after the initial bin classifications are established. **Table A-5** summarizes the compliance deadlines for this rule.	▪ Within compliance based on provided data. ▪ All facilities holding finished water are covered. ▪ Monitoring protocols are as required.
Stage 1 Disinfection Byproducts Rule (Stage 1 DBPR)	
▪ Chlorine MRDLGs and MRDLs - 4.0 mg/L and 4.0 mg/L, respectively ▪ Chloramine (as Total Cl2) MRDLG and MRDL - 4.0 mg/L and 4.0 mg/L, respectively ▪ Chlorine dioxide (as ClO2) MRDLG and - 0.8 mg/L and 0.8 mg/L, respectively ▪ Chlorine/chloramines monitoring – same locations, time in distribution system as total coliforms ▪ Chlorine/chloramines compliance – running annual arithmetic average, computed quarterly, of monthly averages of all samples. ▪ Chlorine dioxide monitoring – one sample/day/plant at entrance to distribution system; If daily sample exceeds MRDL, additional samples are required in distribution system on following day. ▪ Chlorine dioxide compliance – consecutive daily samples. ▪ Rule allows for short-term increases of chlorine and chloramines if needed to protect public health or to control specific microbiological problems. ▪ TTHM MCL – 0.080 mg/L: Chloroform MCLG – 0 mg/L; Bromodichloromethane MCLG – 0 mg/L; Bromoform MCLG – 0 mg/L; Dibromochloromethane MCLG – 0.06 mg/L	▪ System within compliance based on provided data. (Bromate and Chlorite data unavailable). ▪ Monitoring protocols are as required.

Table A-1 Primary Drinking Water Regulations and Current Compliance Status for BWA WTP

Requirements	Compliance Status

▪ HAA5 MCL – 0.060 mg/L: Dichloroacetic acid – 0 mg/L, Trichloroacetic acid – 0.3 mg/L
▪ Bromate – 0 mg/L MCLG, 0.010 mg/L MCL; Chlorite – 0.8 mg/L MCLG, 1.0 mg/L MCL
▪ TTHM/HAA5 monitoring - Four samples/quarter/plant; One sample taken at location representative of maximum residence time in distribution system; three at locations representative of system variability.
▪ TTHM/HAA5 compliance - Running annual arithmetic average, computed quarterly, of quarterly arithmetic averages of all samples.
▪ Bromate monitoring - One sample/month/plant; applicable only for plants using ozone.
▪ Bromate compliance - Running annual arithmetic average of monthly samples, computed quarterly. Chlorite (monthly) monitoring - Three samples/month/plant; applicable only for plants using chlorine dioxide. One sample taken near first customer; one at location representative of average residence time in distribution system; one at location representative of max residence time in distribution system. Samples must be collected on same day.
▪ Chlorite (monthly) compliance - Monthly arithmetic average of samples.
▪ Chlorite (daily) monitoring - One sample/day/plant; applicable only for plants using chlorine dioxide; sample taken at entrance to the distribution system.
▪ Chlorite (daily) compliance - Violation of MCL triggers additional distribution system monitoring.
▪ Treatment or precipitative softening [TCEQ: all systems] remove DBP precursors, and thereby, reduce DBPs by enhanced coagulation or enhanced softening, unless one or more of the following alternative compliance criteria apply:
  ▪ TOC concentration in raw water is less than 2.0 mg/L.
  ▪ TOC concentration in treated water is less than 2.0 mg/L.
  ▪ TOC concentration in raw water is less than 4.0 mg/L; alkalinity in raw water greater than 60 mg/L (as $CaCO_3$); and either TTHM and HAA5 concentrations in distribution system are less than 0.040 mg/L and 0.030 mg/L, respectively, with any disinfectant; or the water system has made a clear and irrevocable financial commitment to technologies that will limit the levels of TTHMs and HAA5 in the distribution system to less than 0.040 mg/L and 0.030 mg/L, respectively. [TCEQ: No provision for clear and irrevocable financial commitment to technologies that will limit levels of TTHMs and HAA5 in the distribution system.]
  ▪ TTHM and HAA5 concentrations in distribution system are less than or equal to 0.040 mg/L and 0.030 mg/L, respectively, with disinfection by chlorine only.
  ▪ SUVA in raw water is less than or equal to 2.0 liters per milligram-meter (L/mg-m).
  ▪ SUVA in treated water is less than or equal to 2.0 L/mg-m, where SUVA is determined in water before the addition of disinfectants or oxidants. (Bench-scale testing is required for plants that add disinfectants or oxidants before the treated water sampling point.)
  ▪ Treated water alkalinity is less than 60 mg/L (as $CaCO_3$) [TCEQ: and the system cannot meet Step 1 TOC removal] for softening systems.
  ▪ Magnesium hardness removal is greater than or equal to 10 mg/L (as $CaCO_3$) [TCEQ: and the system	

Table A-1 Primary Drinking Water Regulations and Current Compliance Status for BWA WTP

Requirements	Compliance Status
cannot meet Step 1 TOC removal] for softening systems. ▪ (Stage 1) DBPR allows states to approve alternative minimum TOC removal (Step 2) requirements for conventional treatment systems that cannot reasonably meet the TOC removal requirements shown in **Table A-6**. The alternative TOC removal (Step 2) requirement, which must be established by bench- or pilot-scale testing, is the level at which additional coagulant reduces: ▪ TOC removal to a rate of 0.3 mg/L per 10 mg/L alum addition or an equivalent addition of iron coagulant (this is termed "point of diminishing returns"); or ▪ pH to the enhanced coagulation Step 2 target pH shown in **Table A-7**. ▪ Systems that use raw water with an alkalinity of less than 60 mg/L (as CaCO3), and for which small amounts of alum or iron coagulant reduce the pH below 5.5 before significant TOC removal occurs, must add the necessary chemicals to maintain the pH between 5.3 and 5.7 until the rate of TOC removal reaches 0.3 mg/L per 10 mg/L alum addition or an equivalent addition of iron coagulant. Stage 1 DBPR also allows states to waive enhanced coagulation requirements for systems that cannot achieve 0.3 mg/L TOC removal per 10 mg/L alum additions at all doses of alum or an equivalent addition of iron coagulant. ▪ Systems comply with the enhanced coagulation and enhanced softening requirements based on the running annual arithmetic average of monthly samples, computed quarterly. ▪ Monitoring includes raw water TOC and alkalinity, and treated water TOC. Water systems must start monitoring 12 months before the compliance deadline to take full advantage of the rule's provisions for alternative minimum Step 2 TOC removal requirements. [TCEQ: Water systems serving at least 10,000 persons must comply with monitoring and reporting requirements beginning January 1, 2001.]	

Note: All compliance status statements are based on the data provided by BWA. Incomplete or inaccurate data provided could affect the compliance status noted.

AL = action level
MCLG = maximum contaminant level goal
MCL = maximum contaminant level
HAA5 = haloacetic acids
LRAA = locational running annual average
IDSE = initial distribution system evaluation
MRDLG = maximum residual disinfectant level goal
NTU = nephelometric turbidity units
TOC = total organic carbon
MRDL = maximum residual disinfectant levels
TTHM = total trihalomethane

Table A-2 Compliance Timeline for Stage 2 DBPR

Public Water Systems	Actions: Submit IDSE monitoring plan, system specific study plan, or 40/30 certification	Complete an initial distribution system evaluation (IDSE)	Submit IDSE Report	Begin subpart V (Stage 2) compliance monitoring
CWSs and NTNCWSs serving at least 100,000	October 1, 2006	September 30, 2008	January 1, 2009	April 1, 2012
CWSs and NTNCWSs serving 50,000 – 99,999	April 1, 2007	March 31, 2009	July 1, 2009	October 1, 2012
CWSs and NTNCWSs serving 10,000 – 49,999	October 1, 2007	September 30, 2009	January 1, 2010	October 1, 2013
CWSs serving fewer than 10,000	April 1, 2008	March 21, 2010	July 1, 2010	October 1, 2013
NTNCWSs serving fewer than 10,000	NA	NA	NA	October 1, 2013

* States may grant up to an additional two years for systems making capital improvements.

Table A-3 Microbial Toolbox for Additional Removal and/or Inactivation of *Cryptosporidium*

Toolbox option	*Cryptosporidium* credits
	Source Toolbox Components
Watershed control program	0.5-log credit. (Section 1.2.5.1)
Alternative source/intake management	No prescribed credit. (Section 1.2.5.2)
	Pre-Filtration Toolbox Components
Presedimentation basin with coagulation	0.5-log credit during any month that presedimentation basins achieve a monthly mean reduction of 0.5-log or greater in turbidity or state-approved performance criteria. Basins must operate continually with coagulant addition and all plant flow must pass through the basins. (Section 1.2.5.3)
Two-stage lime softening	0.5-log credit for two-stage softening where chemical addition and hardness precipitation occur in both stages. All plant flow must pass through both stages. (Section 1.2.5.4)
Bank filtration	0.5-log credit for 25-foot setback; 1.0-log credit for 50-foot setback. Aquifer must contain granular material and in at least 90 percent of the length of a core, grains less than 1.0 mm in diameter constitute 10 percent of the material. Average turbidity must be less than 1 Nephelometric Turbidity Unit (NTU). No presumptive credit for bank filtration that serves as pretreatment when source water monitoring is performed from the well (after bank filtration). (Section 1.2.5.5)
	Treatment Performance Toolbox Components
Combined filter performance	0.5-log credit for CFE turbidity ≤ 0.15 NTU in at least 95 percent of samples each month. (Section 1.2.5.6)
Individual filter performance	0.5-log credit (in addition to the combined filter performance credit) for IFE ≤ 0.15 NTU in 95% of samples each month and no filter > 0.3 NTU in two consecutive measurements. (Section 1.2.5.7)
Demonstration of performance	Credit based on demonstration to the state. (Section 1.2.5.8)
	Additional Filtration Toolbox Components
Bag or cartridge filters (individual filters)	Up to 2.0-log credit based on the removal efficiency demonstrated during challenge testing with a 1.0-log factor of safety. (Section 1.2.5.9)
Bag or cartridge filters (in series)	Up to 2.5-log credit based on the removal efficiency demonstrated during challenge testing with a 0.5-log factor of safety. (Section 1.2.5.9)
Membrane filtration	Log removal credit up to the removal efficiency demonstrated during challenge test if supported by direct integrity testing. (Section 1.2.5.10)
Second stage filtration	0.5-log credit for second separate granular media filtration stage if treatment train includes coagulation prior to first filter. (Section 1.2.5.11)
Slow sand filters	2.5-log credit as a secondary filtration step; 3.0-log credit as a primary filtration process. No prior chlorination for either option. (Section 1.2.5.12)
	Inactivation Toolbox Components
Chlorine dioxide	Log credit based on measured contact time (CT) in relation to CT table. (Section 1.2.5.13)
Ozone	Log credit based on measured CT in relation to CT table. (Section 1.2.5.14)
UV	Log credit based on validated UV dose in relation to UV dose table; reactor validation testing required to establish UV dose and associated operating conditions. (Section 1.2.5.15)

(For additional information see the designated Section from the LT2ESWTR State Implementation Guidance Document – EPA August 2007)

Table A-4 Additional Removal and/or Inactivation of *Cryptosporidium*[a]

Bin Number	Source Water Average *Cryptosporidium* Concentration (oocysts/L) [b]	Additional *Cryptosporidium* Removal and/or Inactivation
1	<0.075	None
2	≤0.075 and <1.0	1 log
3	≥1.0 and <3.0	2 logs [c]
4	≥3.0	2.5 logs [c]

a For conventional treatment plants that fully comply with IESWTR.
b Based on EPA Method 1622/23 and samples no less than 10 liters, uncorrected for recovery.
c Must include at least 1-log inactivation using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters or in-bank filtration.

Table A-5 Compliance Timeline for LT2ESWTR

Systems that serve…	≥ 100,000 people (Schedule 1)[1]	50,000 to 99,999 people (Schedule 2)[1]	10,000 to 49,999 people (Schedule 3)[1]
Submit: Sample Schedule and Sample Location Description	July 1, 2006	January 1, 2007	January 1, 2008
Must begin the first round of source water monitoring by…	October 2006	April 2007	April 2008
Submit Grandfathered Data (if applicable)	December 1, 2006	June 1, 2007	June 1, 2008
Submit Bin Classification (Filtered) or Mean Cryptosporidium Level (Unfiltered)	March 2009	September 2009	September 2010
Comply with additional LT2ESWTR treatment technique requirements[2]	April 1, 2012	October 1, 2012	October 1, 2013
Must being second round of source water monitoring by…	April 2015	October 2015	October 2016

1 Your schedule is defined by the largest system in your combined distribution system.
2 State may allow up to an additional 2 years for capital improvements to comply with the treatment technique.

Table A-6 Step 1 Requirements for Removal of TOC by Enhanced Coagulation or Enhanced Softening [a]

Raw Water TOC (mg/L)	Raw Water Alkalinity (mg/L as CaCO3)		
	0 - 60	> 60 - 120 [TCEQ: ≥ 60 to 120]	> 120[b] [TCEQ: ≥120]
> 2.0 – 4.0 [TCEQ: ≥2.0 - 4.0]	35.0%	25.0%	15.0%
> 4.0 – 8.0 [TCEQ: ≥ 4.0 - 8.0]	45.0%	35.0%	25.0%
> 8.0 [TCEQ: ≥ 8.0]	50.0%	40.0%	30.0%

a Percent removal is between raw water and combined filter effluent.
b Systems practicing softening must meet TOC removal requirements in this column.

Table A-7 Enhanced Coagulation Step 2 Target pH

Raw Water Alkalinity (mg/L as CaCO3)	Target pH
0 – 60	5.5
> 60 – 120	6.3
> 120 – 240	7.0
> 240	7.5

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