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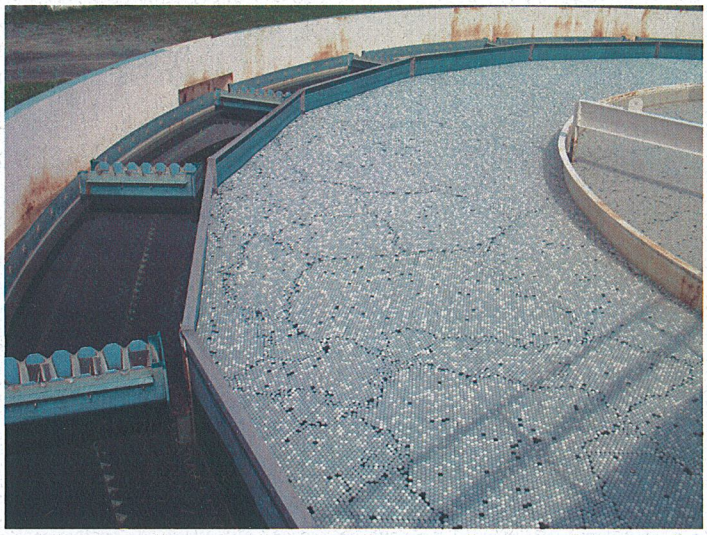
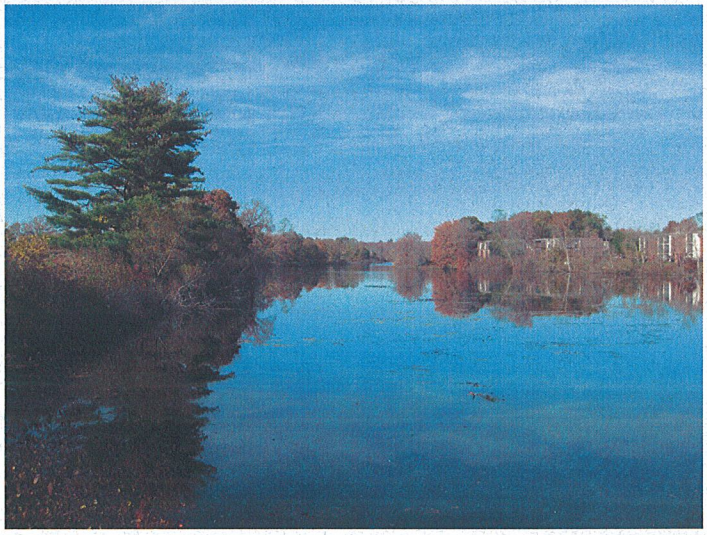
Rhode Island
WATER RESOURCES BOARD

BCW

Evaluation of the Bristol County Water Authority Sources, Interconnections and Treatment Plant

Revised May 2010





Final Report

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May 25, 2010

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Warren, Rhode Island 02885

Subject: Bristol County Water Authority
Evaluation of Sources, Interconnections and Child Street Treatment Plant
Final Engineering Evaluation Report

Dear Mr. Mendes and Mr. DeLise:

In accordance with our agreement dated July 1, 2009, CDM has completed an engineering evaluation report to evaluate the existing Bristol County Water Authority (BCWA) sources, interconnections, and Child Street water treatment plant (WTP). We evaluated the WTP for its ability to provide adequate treatment capacity while meeting all regulatory compliance requirements. Our report summarizes our analysis and evaluation and presents recommended improvements so that the BCWA can continue to provide safe and aesthetically pleasing water to its customers.

Following completion of our draft report in December, both the Rhode Island Water Resources Board (RIWRB) and BCWA provided input and review comments. Our final report incorporates these suggested revisions. CDM has also revised the final report to incorporate additional RIWRB review comments from April 2010. We wish to acknowledge and thank both the RIWRB and the BCWA for your assistance and cooperation throughout the course of this study.

This evaluation and report was prepared by CDM personnel under my direct supervision. Megan Moody, P.E. served as the Project Manager and Matthew Gallant was the primary Project Engineer. Walter Pitts, P.E. served as the Senior Technical Advisor and Reviewer. Jack Keaney, P.E., Carol Rego, P.E., Katherine Mello, P.E., and Jeffrey Diercks, P.E. also provided senior technical input during the course of the study.

CDM has appreciated the opportunity to conduct this study, and trust that you will contact us if we can be of further assistance.

Should you have any questions, please feel free to contact me at (401) 457-0308.

Very truly yours,

Robert M. Otoski, P.E., BCEE
Associate
Camp Dresser & McKee Inc.

cc: Kenneth Burke, Chief of Staff & General Manager (RIWRB)
Domenic Soignoli, Robert Keith (BCWA)
Walter Pitts, P.E., Megan Moody, P.E. and Matthew Gallant (CDM)

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Section 1
Introduction

1.1 Background

The Bristol County Water Authority (BCWA) strives to provide a continuous, reliable and redundant supply of high quality drinking water for all of its customers in Barrington, Bristol and Warren, Rhode Island. The BCWA serves over 50,000 people in these three communities and has always sought to provide these customers with safe and aesthetically pleasing water. The primary sources of drinking water supply for the BCWA are the Providence Water Supply Board (PWSB) and the BCWA's Child Street Water Treatment Plant (WTP) located at 472 Child Street in Warren, Rhode Island. However, the Child Street WTP, owned and operated by the BCWA, operates below its design capacity. The BCWA could therefore be vulnerable to water shortages should their connection with the PWSB become temporarily inoperable or unavailable in an emergency. In cooperation with the Rhode Island Water Resources Board (RIWRB), several studies and plans have been completed to help protect, enhance and improve the existing water system. However, one cohesive document has not been developed for future planning and implementation. This report evaluates the source water, interconnections, and water quality at the Child Street WTP.

The Child Street WTP was originally constructed in 1908 with a reliable design capacity of 4 million gallons per day (mgd) and a maximum capacity of 5 mgd. Even with recent upgrades, the WTP has only been able to operate at a capacity between 1- and 2 mgd. Given the age of the facility and the enactment of more stringent drinking water regulations in recent years, balancing all the regulatory requirements has been extremely challenging for the BCWA and has limited the maximum amount of water produced by the Child Street WTP.

The BCWA currently uses chlorine dioxide both as an oxidant for manganese removal and as a primary disinfectant to meet "CT" disinfection regulatory requirements. The WTP needs to achieve simultaneous compliance between two of the United States Environmental Protection Agency's (USEPA) Safe Drinking Water Act (SDWA) rules – the Surface Water Treatment Rule (SWTR), which dictates disinfection "CT" requirements, and the Stage 2 Disinfection/Disinfection Byproduct (D/DBP) rule, which dictates organics removal and places limits on byproduct formation. A regulated byproduct of chlorine dioxide is chlorite, which is limited to a maximum concentration of 1.0 mg/L.

Given the issues balancing and meeting these two regulatory requirements, the RIWRB sought a consulting engineer to evaluate and recommend improvements to the existing Child Street WTP. Specifically, the RIWRB requested that solutions be identified and investigated to improve the reliable treatment capacity at the Child Street WTP in order for the BCWA to maintain a reliable and redundant supply of potable water.

1.2 Purpose

The purpose of this evaluation is to evaluate the water quality and treatment process at the BCWA Child Street WTP in order to develop treatment alternatives to increase the reliable treatment capacity of the WTP while meeting all regulatory requirements. Specifically, CDM evaluated historical water quality, the existing treatment process and then developed and evaluated alternative treatment options to try to increase capacity and decrease the resulting chlorite formation per the D/DBP rule, while maintaining the required "CT" disinfection requirements per the SWTR. In addition, an evaluation of the reservoirs, wells, well sites and emergency interconnections was completed.

1.3 Project Approach & Objectives

To increase the reliable treatment capacity at the Child Street WTP, CDM's approach was to evaluate the performance of the WTP in two specific areas and then use the results of this analysis to develop and evaluate treatment alternatives that find the right balance between all drinking water regulatory requirements. The two major areas of investigation were the water quality/treatment process and the hydraulic capacity of the WTP. Water quality considerations included raw water quality, existing finished water quality, and regulatory requirements (present, proposed changes and consumer expectations). Physical hydraulic capacity considerations include existing capacity of the major processes, potential available capacity as well as limitations of the WTP.

The major goals and objectives of this evaluation were to:

- Collect and review all pertinent data on water quality, WTP performance, process requirements, as well as sources and interconnections;
- Perform an evaluation of the BCWA's sources and interconnections that evaluates general conditions, water quality, regulations, potential sources (i.e., well sites, interstate connections, etc.) and present recommendations;
- Review current and proposed drinking water regulatory requirements and evaluate the WTP's ability to comply with all SDWA requirements, especially during extreme fluctuations in raw water quality;
- Review the existing treatment process design, operational strategy and performance to gain a better understanding of the performance characteristics of the Child Street WTP;
- Assess the current conditions and specific reasons why the WTP cannot be run at the intended reliable design capacity;

- Evaluate existing disinfection practices at the Child Street WTP, including alternate disinfectants, and address regulatory requirements for any recommended changes to the disinfection scheme;
- Conduct bench scale testing to evaluate the effects that chlorine dioxide has on the clarification process in terms of organics removal;
- Develop potential treatment alternatives based on historical data, regulations, process evaluation, bench scale testing and disinfection evaluation;
- Evaluate technical feasibility, performance, ease of implementation, advantages, disadvantages and cost effectiveness for each potential treatment alternative; and
- Prepare a report documenting the findings of the evaluation.

1.4 Report Organization

This evaluation report is divided into six basic sections, as follows:

- **Section 1** provides background information and a project description, as well as the purpose, approach and objectives of the evaluation.
- **Section 2** presents an evaluation of existing supply sources, interconnections, general water quality conditions, pertinent source water regulatory information, potential water sources and outlines recommendations for BCWA's sources and interconnections.
- **Section 3** discusses regulatory requirements and establishes water quality objectives and design criteria pertaining to the Child Street WTP and reviews historical raw and finished water quality at the Child Street WTP.
- **Section 4** describes the existing treatment process employed at the Child Street WTP, including detailed descriptions of each treatment process, and summarizes treatment plant limitations.
- **Section 5** presents an alternatives evaluation for various treatment options, including a disinfection analysis and evaluation of alternate disinfectants, discusses bench and full scale testing results, provides a summary matrix of feasible treatment alternatives complete with advantages and disadvantages, and provides conceptual engineering sketches of the various alternatives.
- **Section 6** presents CDM's conclusions and recommendations for the preferred alternative and approach; presents estimated planning level probable costs associated with engineering and construction for facility upgrades, rehabilitation and/or replacement; and presents a present worth analysis of all the potential improvement options for comparative purposes.

Section 2
Evaluation of Sources & Interconnections

The subject of the quantity and quality of the source water in Bristol County, Rhode Island has been a past topic of much concern and study. Although the primary focus of this report is the evaluation of the BCWA Child Street WTP, CDM has presented a review of the BCWA's water sources, including reservoirs, wells, well sites and interconnections. Adequate sources of water are vital for the BCWA to continue to provide safe, reliable and aesthetically pleasing potable water to its customers, either through its own treatment means or through interconnections.

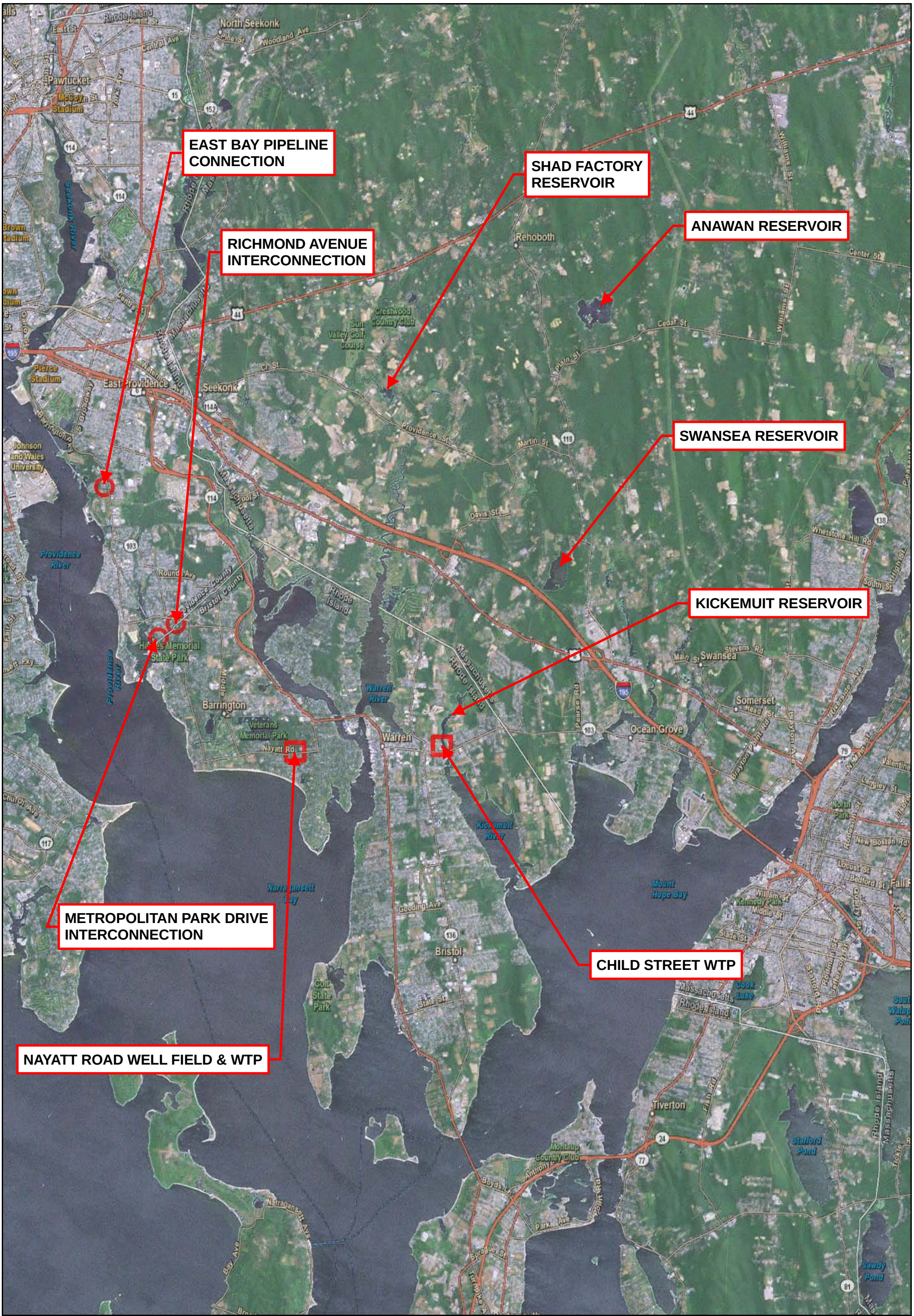
This section presents an evaluation of existing supply sources, interconnections, general conditions, pertinent regulations, and potential water sources. Much of the information presented in this section was gathered by CDM through research of available records and conversations with BCWA officials and staff. Since the primary focus of this report is the evaluation of the Child Street WTP, special attention is given in this section to the supply sources for the WTP. The performance of the Child Street WTP and its ability to supply adequate capacity is contingent upon an adequate amount of available raw water from the BCWA surface water reservoir sources.

2.1 Summary of Sources & Interconnections

Historically, the BCWA has treated two sources of its own water and has utilized potable water purchased through various interconnections to supply its customers in the towns of Barrington, Bristol and Warren, Rhode Island. These sources and interconnections, shown on **Figure 2-1** and **Figure 2-2**, are:

- Kickemuit Reservoir System and the Child Street WTP
- Nayatt Road Well Field and Treatment Facility
- East Bay Pipeline connection from the Providence Water Supply Board (PWSB)
- Two 8-inch emergency interconnections with the City of East Providence, Rhode Island

Through 1998, the BCWA provided customers in the Warren and Bristol areas of its system with treated surface water from the Kickemuit Reservoir and the Child Street WTP. Customers in Barrington were supplied with treated groundwater through the Nayatt Road Well Field and Treatment Facility. During periods of extreme demand or droughts, the BCWA supplemented these two sources with water from its interconnections with the adjacent City of East Providence, Rhode Island, whose water system is supplied solely by a connection with the PWSB water system (Budlong Road connection). Presently, the BCWA supplies its customers with water from the East Bay Pipeline connection and with its own treated surface water from the Kickemuit Reservoir system and the Child Street WTP. The BCWA's most recent system-wide average day demand (ADD) and maximum day demand (MDD)



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BRISTOL COUNTY WATER AUTHORITY
CHILD STREET WTP WATER QUALITY EVALUATION

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Feet

FIGURE 2-1
SOURCES AND INTERCONNNECTIONS

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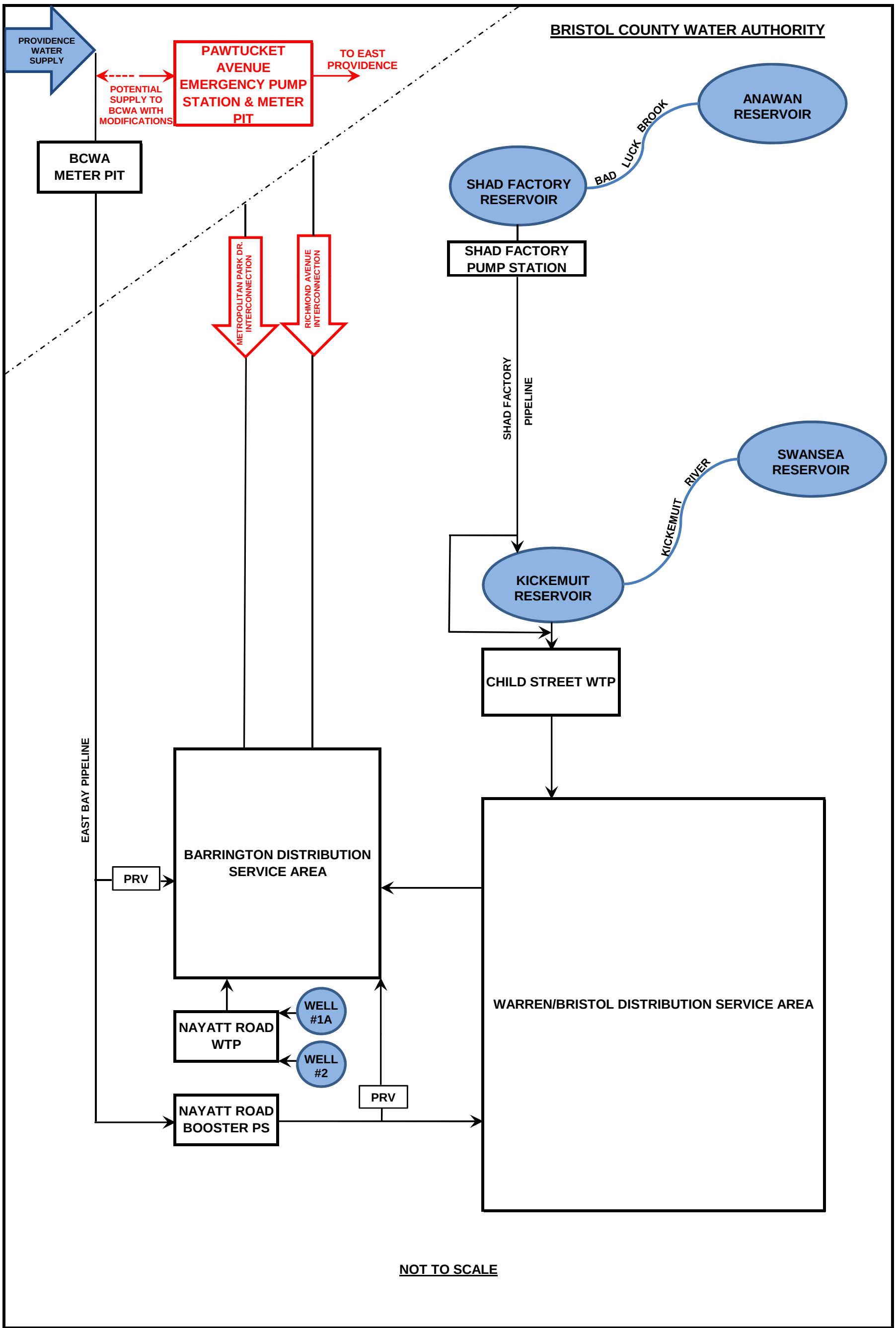

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FIGURE 2-2
BRISTOL COUNTY WATER AUTHORITY
CHILD STREET WTP WATER QUALITY EVALUATION
WATER SYSTEM SCHEMATIC

were 3.9 mgd and 5.6 mgd, respectively, according to their fiscal year 2008 annual report. The following paragraphs further discuss each of the BCWA supply sources and interconnections.

2.1.1 Kickemuit Reservoir Surface Water Supply System

The BCWA maintains a surface water supply that consists of four separate reservoirs – the Kickemuit Reservoir, the Shad Factory Reservoir, the Anawan Reservoir and the Swansea Reservoir. All of these surface water bodies combine and collect at the primary source water reservoir, the Kickemuit Reservoir in Warren, Rhode Island, directly adjacent to the Child Street WTP. The Kickemuit Reservoir is the original source of supply. The total usable volume from these four reservoirs is about 356 million gallons (MG). According to the BCWA's most recent *Clean Water Infrastructure Plan* submitted to the Rhode Island Department of Health (HEALTH) in October 2007, an analysis conducted in 1998 determined that the safe yield of the BCWA's surface water supplies was 3.40 mgd. Pertinent information for these reservoirs is presented in **Table 2-1**.

	Kickemuit Reservoir	Shad Factory Reservoir	Anawan Reservoir	Swansea Reservoir
Location	Warren, RI	Rehoboth, MA	Rehoboth, MA	Swansea, MA
Status	Active	Active	Active	Active
Surface Area (acres)	50	50	126	77
Watershed Size (square miles)	4.4	26.8	2.6	1.0
Total Storage Capacity (MG)	41	39	226	154
Usable Storage Capacity (MG)	35	39	128	154

Table 2-1
Summary of Source Water Reservoirs

These four reservoirs are part of two watersheds. The Palmer River watershed consists of the Anawan and the Shad Factory Reservoirs. The Kickemuit River watershed consists of the Kickemuit and Swansea Reservoirs. As previously noted, all of the sources combined at the Kickemuit Reservoir, the terminal surface supply for the Child Street WTP.

The BCWA updated their safe yield analysis of their reservoir system in 1998. The safe yield analysis was updated to conform to the preferred method of safe yield analysis as required by the Rhode Island Department of Environmental Management (RIDEM) Division of Water Supply Management. As defined by RIDEM regulations, safe yield is the maximum dependable withdrawal which can be made continuously

from a surface water supply source without causing unacceptable effects during a critical dry period with a one percent chance of occurrence or one which is equivalent to the drought of record, whichever is worse. This *Revised Final Report: Safe Yield Analysis* prepared for the BCWA in November 1998 by another consulting engineer concluded that the safe yield of the Anawan/Shad Factory Reservoir (Palmer River watershed) was 2.1 mgd and the safe yield of the Swansea/Kickemuit Reservoir (Kickemuit River watershed) was 1.3 mgd. Therefore, the total safe yield of the BCWA surface water reservoir system was determined to be 3.4 mgd.

This safe yield report also makes note of two golf courses that withdraw water from the Palmer River prior to the Shad Factory Reservoir and several local farms that also withdraw water from the Shad Factory Reservoir. The amount of water withdrawn by these users at the time this safe yield report was written was unknown, and therefore the actual safe yield may have been somewhat less than the original estimate. Since these users are in Massachusetts, they are subject to the Massachusetts Water Management Act (WMA), which enforces unmetered users to install meters. CDM inquired about the usage from these users, but the BCWA did not have estimates of this usage to provide CDM during preparation of this report. The BCWA should obtain metered estimates of water withdrawals from these users, if it has not done so already, to adjust their safe yield as required.

As shown by **Figure 2-1**, about 90 percent of the BCWA surface water supply is located in Massachusetts, subjecting the BCWA to the Massachusetts WMA. The Massachusetts Drinking Water Regulations pertaining to the WMA are established by the Massachusetts Department of Environmental Protection (MADEP), and are codified as 310 CMR 36.00. The Massachusetts WMA requires that anyone drawing source waters in Massachusetts have their withdrawals registered or permitted. It also contains requirements for source water protection, water conservation and water use restrictions. Under WMA legislation enacted in Massachusetts in 1985, any water supplier drawing from water sources in Massachusetts in excess of 100,000 gallons per day (gpd) needed to register these withdrawals with the MADEP on or before January 1, 1988. Registered withdrawals are grandfathered withdrawals that existed during the 1981-1985 WMA registration period. After this period, the WMA requires withdrawals to be permitted by MADEP, and these permits periodically evaluated and reapplied for.

The BCWA's October 2007 *Clean Water Infrastructure Plan* indicates the BCWA first registered withdrawals for their surface water supplies in Massachusetts with the MADEP in 1987. The registered volumes include an average withdrawal of 2.7 mgd and a total annual withdrawal of 985.5 million gallons (mg) from the source water reservoirs in Massachusetts. The BCWA has the opportunity to renew these registered volumes every ten years. In 2007, the BCWA renewed this registered withdrawal with MADEP through December 31, 2017. Because the BCWA has never proposed to MADEP to increase their registered withdrawals from the Massachusetts sources, they have never had to permit additional withdrawals. **Appendix A** contains

a copy of the BCWA's WMA Registration with MADEP, which includes conditions, requirements and stipulations that the BCWA must comply with.

According to the RIWRB and RIDEM, the State of Rhode Island does not currently have a formal permitting or registration allocation process for water withdrawals from surface water reservoirs. The authority for such a process rests with the RIWRB, and the State is in the early stages of evaluating what would be required to put an allocation program into place. Currently, new water withdrawals must be applied for with RIDEM for a water quality certification only and existing water withdrawals from drinking water reservoirs rests with each individual water supplier. So, the BCWA is currently the entity responsible for overseeing and managing withdrawals from its Kickemuit Reservoir, in consideration of the safe yield of the reservoir.

Water from the BCWA's largest surface water body, the Anawan Reservoir, flows by gravity through the natural stream channels of the Bad Luck Brook and Palmer River to the Shad Factory Reservoir. From the Shad Factory Reservoir, water is transferred to the Kickemuit Reservoir through about seven miles of 18-inch and 20-inch pipe, known as the Shad Factory Pipeline. Water from the Shad Factory Reservoir can either flow by gravity or be pumped through the Shad Factory Pipeline to the Kickemuit Reservoir. Some water flows by gravity during periods of low demand, but water must be pumped by the Shad Factory Pumping Station during higher demand periods. The Swansea Reservoir flows by gravity through the natural stream beds of the Kickemuit River to the Kickemuit Reservoir.

The Shad Factory Pipeline was originally installed in 1912. It generally follows a north to south route from the Shad Factory Reservoir in Rehoboth, Massachusetts along the Warren/Palmer River to the Kickemuit Reservoir. The pipeline consists of about 33,500 feet of original 18-inch unlined cast-iron pipe and about 2,100 feet of 20-inch welded steel pipe installed in 1946. Due to the age and condition of the pipe, as well as soil conditions, the pipeline is in need of significant repair and upgrading. The pipeline has had numerous leaks and breaks in the past. In fact, given the current frail condition of the pipeline, the Shad Factory Pumping Station could not be operated above a discharge of 40 to 45 pounds per square inch (psi) without increasing the amount of leaks and frequency of breaks along the pipeline. BCWA staff stated that the Shad Factory Pumping Station is not currently operational, as there is no operational power supply to the pumping station.

Without the Shad Factory Pipeline and Pumping Station, there is no redundant source water supply available to replenish the Kickemuit Reservoir from the BCWA's largest surface water source (Anawan Reservoir). The capacity of the Child Street WTP is severely limited, given this restriction, regardless of its available treatment capacity. According to BCWA staff, the Shad Factory Pipeline may be able to transport about 0.7 mgd of water by gravity to the Kickemuit Reservoir, but no documentation of this estimate was supplied to CDM. A report prepared for the BCWA in June 2001 by another consulting engineer evaluated the Shad Factory Pipeline condition, and

provided an analysis with various options to fully replace the pipeline and pumping station. Costs for the replacement of the pipeline in June 2001 ranged from about $4,900,000 to $7,900,000. In today's dollars, the replacement costs of the Shad Factory pipeline are escalated to about $6,700,000 to $10,800,000. Although repairs and upgrades have been evaluated and planned for the Shad Factory Pipeline and Pumping Station, BCWA officials stated that no repair work has been completed to-date due to interstate and permitting issues. Officials from both the BCWA and RIWRB indicated to CDM that work to restore the Shad Factory Pipeline is currently in the final design stages.

The Child Street WTP pumps raw water from an intake on the Kickemuit Reservoir. A picture of the Kickemuit Reservoir is presented in **Figure 2-3**. The Kickemuit Reservoir is divided to prevent salt water contamination from Mount Hope Bay. The reservoir water surface is only 4 feet above mean sea level, with a dam equipped with tide gates to prevent salt water intrusion from tides up to 8 feet. Over that height, sea water from Mount Hope Bay reaches the reservoir from low lands along its western shore, which has occurred during past hurricanes. The water is treated by the Child Street WTP and then pumped to the BCWA's distribution system network for consumption. The Child Street WTP has the capability of treating raw water directly from the Shad Factory Reservoir via the Shad Factory Pumping Station (assuming it is operational), Shad Factory Pipeline and piping and valves on the raw water lines at the WTP.

Because the Shad Factory Pumping Station currently is not currently operational and the pipeline is in need of significant repair, the Kickemuit Reservoir (and thus Child Street WTP) is currently limited to supply from only the Swansea and Kickemuit Reservoirs, which have a combined safe yield of 1.3 mgd. There may be some additional limited supply capacity currently available at the WTP by gravity flow through the Shad Factory Pipeline. However, as previously discussed, RIWRB and BCWA officials indicated to CDM that design plans and permitting to restore the capacity of the Shad Factory Pipeline are currently in progress.

The Child Street WTP currently provides about 30 percent of the total BCWA system demand, with the remaining demands supplied by the East Bay Pipeline connection. In the event that the Child Street WTP is offline, the East Bay Pipeline connection from the PWSB system supplies all of the BCWA current system demands.

Figure 2-3
Picture of the Kickemuit Reservoir in Warren, Rhode Island

2.1.2 Nayatt Road Well Field and Treatment Facility

The Nayatt Road Well Field is a groundwater source that the BCWA utilized from about 1952 to about 2001. The well field, located along Nayatt Road in Barrington, Rhode Island, consists of three 12-inch gravel packed wells and a treatment facility building. The wells are located in a sand and gravel aquifer interspersed with several clay layers. These clay lenses allow the water table to be drawn below sea level without significant sea water intrusion, but they also retard the recharging of the aquifer. The Nayatt Road treatment facility was built in 1952 and subsequently upgraded in 1978. It is located in a residential neighborhood in Barrington, near the Rhode Island Country Club, and in direct proximity to Narragansett Bay. The plant was designed to remove elevated iron and manganese from the gravel packed wells developed on this site. The treatment processes employed at the facility included aeration, oxidation, filtration and pH adjustment. The treatment facilities were originally designed to treat 2.0 mgd of water from the wells, and include a 150-kW propane generator for standby power supply. Pictures of the treatment facility and well field are presented in **Figures 2-4** and **2-5**.

Pertinent information regarding the Nayatt Road wells is presented in **Table 2-2**. All three gravel packed wells at this facility are approximately 80 feet deep. Well #1, originally drilled in 1952, was replaced around 1981, and in its current state is referred to as Well #1A. Well #2 was installed in 1952 and Well #3 was drilled in 1957. Well #3 has been subsequently capped and physically disconnected from the BCWA distribution system due to extremely high iron levels. The pumps installed at each

Figure 2-4
Picture of the Nayatt Road Treatment Facility

Figure 2-5
Picture of the Nayatt Road Well #1A

well were each capable of delivering about 600 gallons per minute (gpm). Original safe yield data indicated that each well had a maximum production rate of about 1 mgd, but problems associated with elevated iron and manganese as well as high sodium levels (from potential salt water intrusion) reduced the actual safe yield of these wells to about 0.65 mgd. BCWA officials suspect that the high sodium levels may have been from salt water intrusion from the nearby Narragansett Bay.

	Well #1A	**Well #2**	**Well #3**
Location	Barrington, RI	Barrington, RI	Barrington, RI
Status	Abandoned	Abandoned	Capped & Disconnected
Date Drilled	1981	1952	1957
Type	Gravel Packed	Gravel Packed	Gravel Packed
Pumping Capacity (gpm)	600	600	600
Diameter (inches)	12	12	12
Depth (feet)	83	81	75
Casing Material	Steel	Steel	Steel

Table 2-2
Summary of Nayatt Road Groundwater Sources

The well field and treatment facility still exists, but they have not been used since 2001, after the installation and activation of the East Bay Pipeline interconnection. By the late 1990s and in 2001, the average daily production of this well field and facility had decreased to a total average of about 0.29 mgd. Water quality sampling data provided by HEALTH indicated samples from the well field had high levels of iron, manganese, sodium and total dissolved solids (TDS), as well as other contaminants. Although this facility is abandoned, it is still routinely checked by BCWA staff to ensure that unauthorized personnel have not gained entry.

The Nayatt Road well field facilities would most likely need extensive rehabilitation work to be placed into service. In addition, our preliminary water quality analysis indicates poor water quality that would require further study, evaluation, and approval from HEALTH prior to use of the well field as an active source of supply to the BCWA system. The wells could still be minimally maintained for use under emergency situations.

2.1.3 East Bay Pipeline Connection

The installation and activation of the East Bay Pipeline from the PWSB system was completed in December 1998. The pipeline was built due to concerns about water supply shortages, redundant supply from the PWSB system to East Providence, degrading water quality from the Nayatt Road Well Field and decreased treatment capacity at the Child Street WTP. Previous engineering and economic studies recommended the construction of the East Bay Pipeline over other potential source options, since this was the best option to supply BCWA with adequate and good quality water. The East Bay Pipeline continues to serve as an active source of supply for the BCWA system, and can provide ample supply to the entire system. Treated surface water (from the Scituate Reservoir System) is purchased from the PWSB through this connection. Through a contract with the PWSB, this interconnection ensures that up to 7.5 mgd of water be available and provided to the BCWA system on a daily basis. Once the East Bay Pipeline was installed, the BCWA became less reliant on the Nayatt Road Well Field. In 2001, the BCWA stopped supplying water to its system from the Nayatt Road Well Field.

The East Bay Pipeline is a 24- and 30-inch pipe with a subaqueous crossing underneath the Providence River (Narragansett Bay), north of Fields Point and south of the Budlong Road connection to East Providence. The East Bay Pipeline connects the PWSB system at Virginia Avenue in Providence to the BCWA system. A 30-inch ductile-iron water main extends from Virginia Avenue to the Columbia Park meter vault in Providence. From this meter vault, the pipeline travels across Harbourside Boulevard and reduces to a 24-inch steel pipe. It then crosses under the Providence River (Narragansett Bay) and enters East Providence as a 30-inch pipe at a meter vault in a parcel of land along Pawtucket Avenue near the Village Green roadway. The East Bay Pipeline connects to both the BCWA and East Providence water systems at this location in East Providence. There is also an emergency pumping station on Pawtucket Avenue in East Providence, to be discussed later in this section.

After the Pawtucket Avenue vault, the 30-inch pipe continues to a booster pumping station in Nayatt Road in Barrington, where it supplies the BCWA distribution system. The pumping station is located on the same site and directly adjacent to the abandoned Nayatt Road Well Field treatment facility. The Barrington Booster Pumping Station maintains water supply to the BCWA distribution system. Water from the PWSB system is delivered to the BCWA at the Pawtucket Avenue vault with an average pressure of about 50 psi, which equates to a hydraulic grade line of about 225 feet.

One significant water quality difference between the PWSB and BCWA finished water is that PWSB solely uses chlorine as their primary and secondary disinfectant. Chlorine reacts with certain organic matter that may be in the source water to form the DBPs triholemethanes (THMs) and halocetic acids (HAAs). Since the Child Street WTP currently uses chlorine dioxide as a primary disinfectant and not chlorine, these DBPs will be slightly higher in the areas of the system supplied directly by the East Bay Pipeline than the areas supplied by the Child Street WTP.

Table 2-3 summarizes pertinent information relative to the East Bay Pipeline interconnection.

	East Bay Pipeline
Location	East Providence, RI
Status	Active
Date Installed	December 1998
Type	Gravity Supplied Connection
Supplied From	PWSB
Pipe Size (inches)	30
Capacity (mgd)	7.5
Hydraulic Grade Line (feet)	225

Table 2-3
Summary of East Bay Pipeline Connection

2.1.4 Emergency Interconnections

The BCWA has two 8-inch emergency interconnections with the City of East Providence, Rhode Island – one at Metropolitan Park Drive and the second at Richmond Avenue in Barrington (see **Figure 2-1** and **Figure 2-2**). Both of these emergency interconnections were established in 1987 and have meter vaults at their locations. Fire hydrants from both systems are directly adjacent to the vaults on each side. Both connections are capable of supplying about 0.5 mgd to the BCWA system, for a total of about 1.0 mgd.

The City of East Providence water system is supplied by a connection with the PWSB at Budlong Road, as previously discussed. This connection is supplied directly by the PWSB's main aqueduct system through a 42-inch pre-stressed concrete cylinder pipe (PCCP), beginning at Budlong Road in Cranston. The 42-inch PCCP main traverses through Cranston and then reduces to twin 30-inch mains just before the Providence River. To reach East Providence across the Providence River (Narragansett Bay), two parallel 30-inch mains cross the Providence River and terminate at a meter vault at Veterans Memorial Parkway in East Providence. These mains then branch off and supply the rest of East Providence's system, including the two interconnections to the BCWA system.

From about 1990 to 1998, the BCWA periodically obtained approximately 1.0 mgd from the two emergency interconnections with East Providence, when drought conditions persisted and BCWA supplies (surface and groundwater) were inadequate to provide the total system demands. Since the installation and activation of the East Bay Pipeline interconnection with the PWSB, the emergency interconnections have not been needed. However, they are still connected and active, and can be utilized if needed. BCWA staff stated that East Providence is responsible for the supply of water and metering, but that the BCWA must maintain the meter vaults and piping connections.

The installation of the East Bay Pipeline connection with the PWSB also included the installation of a new emergency booster pumping station on Pawtucket Avenue in East Providence. The East Bay Pipeline supplies the BCWA by gravity and includes connections to supply the emergency pump station. The pumping station is a prefabricated unit that is owned by the BCWA. However, the pump station was designed to provide water from the East Bay Pipeline connection to the City of East Providence in the event of an emergency. The pumping station includes two 6.0-mgd pumps (one duty, one standby) and there is also a diesel fueled generator on site to provide stand-by power. The station discharges to a 16-inch cast-iron pipe in Pawtucket Avenue. The current design was not intended to feed water from East Providence to the BCWA. A picture of the emergency pumping station site location along Pawtucket Avenue is presented in **Figure 2-6**.

The pump station was never successfully tested and remained inactive. Recently, in 2007, both the BCWA and East Providence officials expressed concern about potential water supply emergencies, including the possibility of losing their supplies from the connections with the PWSB system. The BCWA and City of East Providence entered into a joint agreement with CDM to assess possible emergency supply options, including the reactivation of the Pawtucket Avenue emergency pumping station.

Figure 2-6
Picture of the Pawtucket Avenue Emergency Pumping Station

In consultation with the BCWA and East Providence officials, CDM developed an operations protocol to place the emergency pumping station online and to evaluate the performance of the pumping station. The pumping station was successfully operated and tested by CDM on the night of July 8, 2008 and the morning of July 9, 2008. The results of this field test are documented in final letter reports prepared by CDM and delivered to the City of East Providence and the BCWA in August and September 2008, respectively. In general, the station was found to be in good condition. Given the fact that the station is ten years old and new instrumentation technology is now available, CDM and the station manufacturer provided recommendations for upgrading the station for active emergency service.

As part of the 2008 work, CDM evaluated the capability of East Providence's system to supply the BCWA system by gravity during a water supply emergency, since the BCWA expressed concerns about the potential emergencies that may limit their supply from the PWSB. Since CDM had constructed and calibrated a distribution system model for the City of East Providence, the BCWA requested that the model be used to assess the potential for emergency supply by gravity at the emergency pump station site on Pawtucket Avenue. This analysis determined that East Providence is only able to supply the BCWA under water supply conditions where the City's hydraulic grade line (HGL) is high (i.e., under lower demand conditions when the City's system is not stressed).

With this understanding, it was anticipated that both systems would coordinate water curtailment programs to improve hydraulic conditions in both systems, should East Providence supply the BCWA by gravity in an emergency situation. Under more favorable supply conditions in East Providence, as documented in CDM's August and

September 2008 evaluation, it was determined that the following flow rates and system pressures in Pawtucket Avenue adjacent to the emergency pump station site could be provided to the BCWA from East Providence under gravity flow conditions. It was recommended by CDM that the BCWA evaluate what impact, if any, would occur in their system if pressures were below what the BCWA historically records at the meter vault.

Flow Rates	Pump Station Pressures
1 mgd	42 psi
2 mgd	39 psi
3 mgd	34 psi

Table 2-4 summarizes pertinent information relative to all of BCWA's emergency interconnections.

	Metropolitan Park	Richmond Avenue	Pawtucket Avenue
Location	Barrington, RI	Barrington, RI	East Providence, RI
Status	Active	Active	Pending Full Activation
Date Installed	1987	1987	1998
Type	Gravity Pipeline	Gravity Pipeline	Booster Pumping Station / Potential Gravity*
Supplied From	East Providence, RI	East Providence, RI	PWSB via East Bay Pipeline
Pipe Size (inches)	8	8	16
Capacity (mgd)	0.5	0.5	6.0

*Depends upon East Providence system demands.

Table 2-4
Summary of Emergency Interconnections

2.2 Potential Water Sources

A number of potential water sources have been studied for the BCWA to supplement its existing supplies because of past droughts which caused its supply reservoirs to become nearly depleted and forced the BCWA to restrict its customers' water usage. These studies examined the feasibility of developing previously identified sources of supply, identified potential new sources and made recommendations for the BCWA to follow. Ultimately, the BCWA choose to construct the East Bay Pipeline connection with the PWSB, which guaranteed them up to 7.5 mgd of water. Numerous economic

impact evaluations determined that construction of the East Bay Pipeline connection was the most cost effective way for the BCWA to meet its existing system demands.

The paragraphs that follow summarize some of the potential water sources (reservoirs, wells, well sites and emergency connections) that have been examined, and discuss issues associated with interstate interconnections, should the BCWA deem this to be a future alternative.

2.2.1 Alternative Sources of Additional Supply

Some of the alternative sources of supply that the BCWA has looked at in the past include different combinations of reservoirs, wells, diversion structures, pumping stations and transmission mains. Previous studies identified sites near the BCWA's existing system that could be developed to provide additional storage capacity. Five of the original 20 sites studied were deemed to have sufficient potential storage capacity. These sites and options included:

- Palmer River Reservoir;
- Upper Palmer River Reservoir;
- Rocky Run Reservoir;
- Cole River Dam;
- Raise the Anawan Reservoir; and
- Raise the Swansea Reservoir.

Regarding potential groundwater sources, a potential groundwater aquifer extends approximately 2,000- to 4,000-feet in a north-south direction, east of the BCWA's Shad Factory Reservoir (in the Swansea, Massachusetts area), according to the United States Geological Survey (USGS). Previous studies by other consulting engineers indicated that favorable groundwater conditions may exist either east or north of the Shad Factory Reservoir. Overburden appeared to be the greatest in the southernmost part of this potential aquifer. However, the delineation of this aquifer was primarily based on limited information, including depths to rock as reported by drillers of domestic wells in the area. A lithologic log for a boring in this vicinity indicated that the bottom 50 feet appeared to be good aquifer material. However, the Palmer River is tidal over this part of the aquifer, and it was noted that salt water encroachment may result from pumping wells in this area. Since this aquifer was largely unexplored, no definitive conclusion was drawn as to the precise quantity of supply which may be available from it – only that the potential of supply may be able to be developed.

Another consulting engineer previously recommended to the BCWA that a groundwater exploration program, complete with geophysical survey, resistivity surveys, test wells to confirm pumping and water quality, long term pumping tests

and safe yield determination be conducted. Past reports indicated that the BCWA did commission a hydrogeological study in 1981 in an attempt to locate new groundwater sources in this area, but this effort did not locate any new potential groundwater sources of value.

2.2.2 Interstate Interconnections

The BCWA currently has emergency interconnections with only one community - the City of East Providence. Because East Providence is also supplied by the PWSB, any complication to the PWSB WTP or distribution system could potentially leave both systems susceptible to water shortages. Since the BCWA water system directly borders communities in Massachusetts, there may be potential interconnections available with these neighboring communities. However, interstate interconnections are a legally complex issue, which would require the BCWA to consult with its legal counsel. It does not appear that this issue has ever been studied for the BCWA in great detail. CDM has therefore described some issues associated with interstate interconnections in the following paragraphs.

As a precedent, there are presently a few interconnections that cross state lines throughout New England, both for routine and emergency supply. Interconnections between drinking water systems in neighboring states can provide benefits to both systems, including sharing water in times of drought or system failure (e.g., water main breaks, finished water quality upset, treatment complications, etc.). There are some issues associated with interstate connections which would need to be considered, should the BCWA look into this option further.

First, and perhaps most important, is that interconnections between municipalities or water systems in adjacent states must be properly legally addressed. Some attorneys contend that there is a potential that these agreements can be challenged and contested by concerned parties unless a proper legal agreement between the two systems is ratified by the United States Congress. Therefore, professional legal counsel should be sought to represent the BCWA's interests.

The design for physical infrastructure appurtenances (pipelines, pumping stations, etc.) for any potential interstate interconnection would need to be reviewed and approved by state agencies on each side of the border. In addition to industry accepted standards (i.e., American Water Works Association), there may be different and perhaps conflicting state-specific standards for design and construction.

Various permits would also be required to properly install and activate an interconnection between the BCWA system and neighboring communities in Massachusetts. There may be other, site specific issues regarding potential interstate interconnections that would need to be addressed with the regulating agencies of each state, which may constrain the actual amount of water that could be obtained through a potential connection. Each state may have different requirements for water conservation, water curtailment, declaring water supply emergencies, etc. If a

Massachusetts community needed to increase its source withdrawals to supply the BCWA through an interstate interconnection, a WMA permit application to allocate withdrawal volumes with MADEP would be required of that community. The applicable provisions of Rhode Island General Laws Title 46 (Waters and Navigation), including review and approval by the RIWRB, would also apply to any potential interstate connection for the BCWA.

The planning, permitting, design and construction processes for an interstate interconnection would therefore most likely require a significant amount of time and effort. The concept of an interstate interconnection between the BCWA and a neighboring community or water supplier in Massachusetts could potentially be feasible from a regulatory viewpoint, but would need more detailed and specific research should the BCWA wish to investigate this alternative. However, given the importance of adequate water supply, it may be worthwhile for the BCWA to perform some additional investigations for potential emergency supply from other communities or water suppliers that may be available.

Section 3
Water Quality Evaluation

Raw water treated by the Child Street WTP is supplied from the Kickemuit Reservoir intake located adjacent to the WTP, as discussed in **Section 2**. Water quality data was provided to CDM by the BCWA for both raw and finished water. CDM tabulated and evaluated this data to understand the BCWA's treatment objectives and design criteria necessary to meet current and potential regulatory requirements.

This section discusses regulatory requirements, reviews historical raw and finished water quality at the BCWA Child Street WTP, and establishes water quality objectives and design criteria in order to evaluate the potential increase in capacity at the Child Street WTP.

3.1 Regulatory Requirements

The United States Environmental Protection Agency (USEPA) promulgated regulations under the Safe Drinking Water ACT (SDWA) that drinking water suppliers must adhere to. Some of these regulations are mandatory and enforceable; others such as secondary standards are guidelines to minimize cosmetic and aesthetic effects. Present regulatory requirements that the BCWA are subject to are described in the following subsections.

3.1.1 Primary Drinking Water Standards (MCLs)

Many individual contaminants are regulated under the SDWA with set Maximum Contaminant Levels (MCLs). Regulated contaminants include inorganic chemicals such as mercury and nickel, organic chemicals such as synthetic organic compounds (SOCs), and volatile organic compounds (VOCs). **Table 3-1** lists the individual contaminants with their MCLs.

3.1.2 Secondary Drinking Water Standards (SMCLs)

In addition to the Primary Drinking Water Standards, the USEPA provides non-enforceable guidelines for contaminants that may cause cosmetic effects such as skin discoloration (silver), tooth discoloration (fluoride) or aesthetic effects such as taste and odor (chloride, iron, manganese), color (aluminum, color), and foaming (foaming agents). **Table 3-2** summarizes the SMCLs that should be met to minimize cosmetic and aesthetic effects. Source water and plant effluent manganese levels, as discussed earlier, are problematic at the Child Street WTP. The BCWA treatment process needs to reduce manganese levels, as manganese can accumulate in the distribution system and cause black water problems.

Inorganic Chemicals	Unit	MCL	Detection Limit
Antimony	mg/l	0.006	0.002
Asbestos	MFL	7	N/A
Barium	mg/l	2	0.02
Beryllium	mg/l	0.004	0.0002
Cadmium	mg/l	0.005	0.001
Chromium	mg/l	0.1	0.005
Cyanide	mg/l	0.2	0.01
Fluoride	mg/l	4	0.2
Mercury	mg/l	0.002	0.001
Nitrate	mg/l	10	0.02
Nitrite	mg/l	1	0.02
Selenium	mg/l	0.05	0.005
Thallium	mg/l	0.002	0.0005
Synthetic Organic Compounds			
2,3,7,8-TCDD	mg/l	0.00000003	N/A
2,4,5-TP (Silvex)	mg/l	0.05	0.00025
2,4-D	mg/l	0.07	0.00025
Acrylamide	N/A	TT	N/A
Alachlor	mg/l	0.002	0.0002
Atrazine	mg/l	0.003	0.0002
Carbofuran	mg/l	0.04	0.0005
Chlordane	mg/l	0.002	0.0001
Dalapon	mg/l	0.2	<.00031
Di(2-ethylhexyl) adipate	mg/l	0.4	0.0001
1,2-Dibromo-3-chloropropane (DBCP)	mg/l	0.0002	0.01
Di(2-ethylhexyl) phthalate (DEHP)	mg/l	0.006	0.0001
Dinoseb	mg/l	0.007	0.0005
Diquat	mg/l	0.02	N/A
Endothall	mg/l	0.1	<.0015
Endrin	mg/l	0.002	0.0001
Epichlorohydrin	N/A	TT	N/A
Ethylene Dibromide (EDB)	mg/l	0.00005	0.00005
Gylphosphate	mg/l	0.7	N/A
Heptachlor	mg/l	0.0004	0.0001
Heptachlor Expoxide	mg/l	0.0002	0.0001
Hexachlorobenzene	mg/l	0.001	0.0001
Hexachlorocyclopentadiene (HEX)	mg/l	0.05	0.0001
Lindane	mg/l	0.0002	0.0001
Methoxychlor	mg/l	0.04	0.0001
Oxamyl (Vydate)	mg/l	0.2	0.0005
PAHs (Benzo(a)pyrene)	mg/l	0.0002	0.0001
PCBs (Polychlorinated Biphenyls)	mg/l	0.0005	.00025-0.02
Pentachlorophenol	mg/l	0.001	0.0003
Picloram	mg/l	0.5	0.00075
Simazine	mg/l	0.004	0.0001
Toxaphene	mg/l	0.003	0.001
Volatile Organic Compounds			
1,1,1-Trichloroethane	mg/l	0.2	0.0005
1,1,2-Trichloroethane	mg/l	0.005	0.0005
1,1-Dichloroethylene	mg/l	0.007	0.0005
1,2,4-Trichlorobenzene	mg/l	0.07	0.0005
1,2-Dichloroethane	mg/l	0.005	0.0005
1,2-Dichloropropane	mg/l	0.005	0.0005
Benzene	mg/l	0.005	0.0005
Carbon Tetrachloride	mg/l	0.005	0.0005
Chlorobenzene	mg/l	0.1	0.0005
Cis-1,2-Dichloroethylene	mg/l	0.07	0.0005
Dichloromethane	mg/l	0.005	0.0005
Ethylbenzene	mg/l	0.7	0.0005
Othro-Dichlorobenzene	mg/l	0.6	0.0005
Para-Dichlorobenzene	mg/l	0.075	0.0005
Styrene	mg/l	0.1	0.0005
Tetrachloroethylene (PCE)	mg/l	0.005	0.0005
Toluene	mg/l	1	0.0005
Trans-1,2-Dichloroethylene	mg/l	0.1	0.0005
Trichloroethylene	mg/l	0.005	0.0005
Vinyl Chloride	mg/l	0.002	0.0005
Xylenes (total)	mg/l	10	0.00005

MCL = maximum contaminant level
Det. Limit. = detection limit of analytical method used
N/A = not applicable

Table 3-1
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Primary Drinking Water Standards (MCLs)

CDM

Contaminant	Unit	SMCL
Aluminum	mg/l	0.05-0.2
Chloride	mg/l	250
Color	color units	15
Copper	mg/l	1
Corrosivity		noncorrosive
Fluoride	mg/l	2
Foaming Agents	mg/l	0.5
Iron	mg/l	0.3
Manganese	mg/l	0.05
Odor	TON	3
pH		6.5-8.5
Silver	mg/l	0.1
Sulfate	mg/l	250
Total Dissolved Solids	mg/l	500
Zinc	mg/l	5

Table 3-2
Secondary Drinking Water Standards (SMCLs)

3.1.3 Surface Water Treatment Rule (SWTR)

The Surface Water Treatment Rule was promulgated in 1989. The key provisions of the SWTR that apply to the BCWA are as follows:

- *Giardia* – Minimum 3-log (99.9%) removal/inactivation of *Giardia* with performance requirements demonstrated through a combination of removal via filtration and inactivation via disinfection.

- *Enteric Viruses* – Minimum 4-log (99.99%) removal/inactivation of viruses with performance requirements demonstrated through a combination of removal via filtration and inactivation via disinfection.

- *Legionella/Heterotrophic Plate Count (HPC)* – Must maintain disinfectant residual above 0.2 mg/L entering the distribution system and a detectable residual level throughout the distribution system.

As outlined in the American Water Works Association (AWWA) *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, a well-operated conventional treatment plant receives 2.5-log removal/inactivation credit for *Giardia* and 2.0-log removal/inactivation credit for viruses. The required additional 0.5-log removal for *Giardia* and 2.0 -log removal for viruses must be achieved through disinfection.

3.1.4 Interim Enhanced Surface Water Treatment Rule (IESWTR)

In December 1998, USEPA promulgated the Interim Enhanced Surface Water Treatment Rule (IESWTR). The IESWTR became effective in January 2002. The portions of the IESWTR that apply to the Child Street WTP are as follows.

- *Turbidity* – Treatment effectiveness is demonstrated by combined filter effluent turbidity less than or equal to 0.3 NTU in 95% of measurements taken each month.

- *Cryptosporidium* – If the 0.3-NTU filtered water turbidity requirement is met, the WTP is assumed to achieve 2-log *Cryptosporidium* removal.

The IESWTR requires strict reporting of filter turbidity exceedances. If routine measurements demonstrate any of the characteristics listed in **Table 3-3**, systems must report individual filter turbidity measurements within 10 days after the end of each month the system serves water to the public.

In addition, as stated in the USEPA *Disinfection Profiling and Benchmarking Guidance Manual*, if a system is considering switching disinfectants to ozone, chloramines, or chlorine dioxide, the inactivation of viruses is not ensured by meeting a benchmark based on *Giardia*. Therefore, such systems are required to provide an additional disinfection profile and benchmark for viruses.

3.1.5 Total Coliform Rule (TCR)

The Total Coliform Rule (TCR) became effective in December 1990. The intent of the TCR is to protect water supply systems from disease-producing organisms, which present a health hazard to the public. Coliform is an indicator that such contamination may exist.

The TCR requires greater vigilance for secondary disinfection and addresses the microbial quality of water in the distribution system. The TCR established a total coliform Maximum Contaminant Level Goal (MCLG) of zero.

Members of the Total Coliform Rule Distribution System Advisory Committee (TCRDSAC) signed the "Agreement in Principle" (AIP) on September 18, 2008 that will become the basis for revision to the TCR expected in 2010. The intent of the rule is to reduce public alarm over indicator organisms while improving the focus on protecting public health. Potential changes to measured parameters are as follows:

- Fecal Coliform will not be allowed for regulatory compliance.

- There will no longer be an MCLG/MCL for Total Coliform (TC). Instead, a treatment technique (TT) will require a Level 1 Assessment and corrective action when more than 5% of monthly TC results are positive or when a system fails to take required repeats.

- An MCLG of zero will be required for *E. coli*. Exceedence of this limit or failure to take required repeats will trigger a Level 2 Assessment, corrective action and Tier 1 public notification. Primacy agency must be consulted within 24 hours.

Condition Measured	Reporting Required	Follow-up Action
Any individual filter having a measured turbidity level > 1.0 NTU in two consecutive measurements taken 15 minutes apart	Filter Number Turbidity Measurement Date(s) on which the exceedance occurred	Produce a filter profile for the filter within 7 days of the exceedance (if the system is not able to identify an obvious reason for the abnormal filter performance and report that the profile has been produced, **or** Report the obvious reason for the exceedance
Any individual filter having a measured turbidity level > 0.5 NTU in two consecutive measurements taken 15 minutes apart at the end of the first four hours of continuous filter operation after the filter has been backwashed or otherwise taken offline	Filter Number Turbidity Measurement Date(s) on which the exceedance occurred	Produce a filter profile for the filter within 7 days of the exceedance (if the system is not able to identify an obvious reason for the abnormal filter performance and report that the profile has been produced, **or** Report the obvious reason for the exceedance
Any individual filter having a measured turbidity level > 1.0 NTU in two consecutive measurements taken 15 minutes apart at any time in each of three consectueve months	Filter Number Turbidity Measurement Date(s) on which the exceedance occurred	Conduct a self-assessment of the filter
Any individual filter having a measured turbidity level > 2.0 NTU in two consecutive measurements taken 15 minutes apart at any time in each of two consectueve months	Filter Number Turbidity Measurement Date(s) on which the exceedance occurred	Contact the State or a third party approved by the State ot conduct a comprehensive performance evaluation.

Table 3-3
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Filter Performance Report Requirements
for IESWTR Compliance

CDM

The Level 1 Assessment is to be completed by the Public Water System (PWS) and reviewed by the primacy agency. It is intended to identify factors that would contribute to water quality changes observed by positive TCR samples. The Rhode Island Department of Health (HEALTH) is to implement the exact process which may involve a Level 1 Assessment Form.

Based on the AIP, TC is an "indicator" organism not necessarily "a contaminant of public health significance." The revised TCR will reduce the number of "violations" (assuming TT compliance) and will require an assessment and corrective action instead of public notification one to two months after a hit.

A Level 1 Assessment is triggered if 5%of the monthly TC samples are positive or if there is failure to take all required repeat samples and will include the following:

- Inadequacies of site or protocol
- Atypical events
- Changes in operation
- Sanitary defects
- Corrective actions taken
- Timetable for actions not completed

The Level 2 Assessment is to be completed by the PWS provided the system has a certified operator with two years of experience. HEALTH is to implement the exact process which may involve a Level 2 Assessment Form. The Level 2 Assessment is more detailed and comprehensive than the Level 1 Assessment. A Tier 1 public notification is required for an *E. coli* positive as it is an acute violation. Level 2 Assessment is triggered if there is a violation of the *E. Coli* MCL, or monitoring violation or second Level 1 trigger within a rolling 12 month period.

It is probable that the TT allowed for regulatory compliance may change. The membrane filtration (MF) technique may only be allowed for informational purpose only. Chromogenic substrate tests (i.e. Coli-alert, coli-sure, etc.) may be required for compliance. TT triggers may include:

- Failure to perform a Level 1 or Level 2 Assessment
- Failure to correct all sanitary defects identified in an assessment
- Failure to correct sanitary defects according to agreed upon schedule

Consequences for a TT violation may include a Tier 2 public notification or repeat public notification every 3 months as long as violation persists.

A routine monitoring violation is triggered if the PWS does not take required routine or additional routine samples. If this occurs a Tier 3 public notification will be required.

A reporting violation is triggered if the PWS fails to submit a monitoring report or assessment form, or fails to submit a report by the required date. If this occurs a Tier 3 public notification will be required.

Monitoring flexibility may be allowed under the revised rule including:

- Point of Entry sampling
- Eliminate requirement for 5-up and 5-down requirement
- Large systems to develop SOP for repeats
- Repeat monitoring locations that may be representative of pathway for entry for contamination

3.1.6 Stage 1 Disinfectants/Disinfection Byproducts Rule (D/DBPR)

In December 1998, USEPA promulgated the Stage 1 Disinfectants/DBP Rule (D/DBPR). The Stage 1 D/DBP Rule became effective in January 2002. The portions of the Stage 1 D/DBPR applicable to the BCWA are as follows:

- *Disinfectants (MRDLs)* – The maximum disinfectant residual level (MRDL) for chlorine dioxide is 0.8 mg/L and chlorine is 4.0 mg/L. Compliance for chlorine dioxide is based on daily samples at the point of entry (POE). Compliance for chlorine is based on the running annual average (RAA) of the monthly averages taken at the same sampling locations as the TCR.
- *Total Organic Carbon (TOC)* – The Stage 1 D/DBPR also requires WTPs to remove a certain percentage of TOC based on the source water alkalinity and TOC level. Samples for TOC in the source water and the combined filter effluent are taken monthly and a TOC removal ratio is calculated. The TOC removal ratio is the ratio of the actual TOC removed divided by the required TOC removal. For each quarter (January – March, April – June, etc.), the quarterly average of the removal ratio is calculated. The RAA is then calculated based on the quarterly averages. Compliance with the TOC rule is based on the RAA being greater than 1.
- *Disinfection By-Products (THM/HAA5)* – The Stage 1 D/DBPR requires water systems to comply with a MCL for TTHMs of 80 ug/L. Stage 1 also regulates HAA5, which had not been previously regulated. The MCL for HAA5 is 60 ug/L. Compliance with both the TTHM and HAA5 MCLs is based on the RAA of all quarterly samples.

- *Disinfection By-Products (Chlorite)* - Stage 1 also includes an MCL for chlorite, a byproduct of disinfection with chlorine dioxide. The chlorite MCL is 1.0 mg/L measured daily at the POE to the distribution system and 1.0 mg/L based on the average of monthly samples at three specified locations in the distribution system. Compliance is based on the arithmetic average of the three monthly samples being less than the MCL.

3.1.7 Stage 2 Disinfectants/Disinfection Byproducts Rule (D/DBPR)

The Stage 2 D/DBPR final rule was promulgated January 5, 2006 and requires a new method of calculating compliance. The current system-wide RAA method was changed to a location-specific RAA (LRAA). The LRAA concept removed the ability to average DBP levels across locations that previously existed in Stage 1. Even though the MCLs remained at 80/60 ppb (TTHM/HAA5), the LRAA calculation method has the effect of being more stringent than the present RAA method.

Systems will have approximately six years from the final rule (approximately 2012) to comply with the 80/60-ppb (TTHM/HAA5) LRAA. The exact date that systems must comply with the Stage 2 DBP requirements is based on service population as listed below:

- Systems Serving ≥ 100,000: April 1, 2012
- Systems Serving 50,000-99,999: October 1, 2012
- Systems Serving 10,000-49,999: October 1, 2013

3.1.8 Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)

The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) applies to all public water systems supplied by a surface water source and public water systems supplied by a groundwater source under the direct influence of surface water (GWUDI). Systems subject to the LT2 must comply with the following general requirements:

- Source Water Monitoring - Conduct source water monitoring for each plant that treats surface water or GWUDI. Large systems must monitor for *Cryptosporidium*, *E. coli*, and turbidity.
- Filtered systems must determine their *Cryptosporidium* bin classification, based on these source water monitoring results.
- If additional *Cryptosporidium* treatment is required based on the foregoing bin classification, systems must implement "microbial toolbox options" as defined by this regulation. Systems must develop a disinfection profile and calculate

disinfection benchmarks. This is only applicable to those systems planning to make a significant change to their disinfection practice.

- Uncovered finished water storage facilities must be covered or the discharge must be treated.
- Comply with record keeping and reporting requirements as defined by this regulation.
- Address any significant deficiencies that may be identified in sanitary surveys conducted by the State/USEPA.

The first (initial) round of source water monitoring must begin no later than the month beginning October 1, 2006. The second round of source water monitoring must begin no later than the month beginning April 1, 2015. Both sampling rounds will require one sample to be collected and analyzed once a month for 24 months. Following the two years of monitoring, systems will be classified into a bin based on the concentrations of *Cryptosporidium* detected as listed in **Table 3-4**. Systems will have three years following bin classifications to meet the treatment requirements associated with the bin. Systems requiring capital improvements have an additional 2-year extension for compliance (approximately 2011).

To meet the additional removal requirements, the water system would select the appropriate tool(s) from the Microbial Toolbox provided under the rule and included in **Table 3-5**.

Bin Number	Average *Cryptosporidium* Concentration	Additional treatment requirements for systems with conventional treatment that are in full compliance with IESWTR
1	*Cryptosporidium* < 0.075/L	No action
2	0.075/L < *Cryptosporidium* < 1.0/L	1.0-log treatment (systems may use any technology or combination of technologies from toolbox as long as credit is at least 1.0-log)
3	1.0/L < *Cryptosporidium* < 3.0/L	2.0-log treatment (systems must achieve at least 1.0-log of the required 2.0-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)
4	*Cryptosporidium* > 3.0/L	2.5-log treatment (systems must achieve at least 1.0-log of the required 2.5-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)

Table 3-4
LT2ESWTR Cryptosporidium Bin Classification

Toolbox Option	Crytosporidium Treatment Credit with Design and Implementation Criteria
Source Toolbox Components	
Watershed control program	0.5-log credit for State approved program comprised of EPA specified elements. Specific criteria are in 40 CFR 141.725(a).
Alternative source/intake management	No presumptive credit. Systems may conduct simultaneous monitoring for LT2ESWTR bin classification at alternative intake locations or under alternative intake management strategies. See 40 CFR 141.725(b).
Pre-Filtration Toolbox Components	
Bank filtration	0.5 log credit for 25 foot setback; 1.0 log credit for 50 foot setback. Aquifer must be unconsolidated sand containing at least 10% fines. Average turbidity in wells must be < 1 NTU. Systems with existing wells must monitor well effluent to determine bin classification and are not eligible for presumptive credit. See 40 CFR 141.726(c).
Presedimentation basin with coagulation	0.5-log credit for new basins with continuous operation and coagulant addition. Basins must achieve 0.5 log turbidity reduction based on the monthly mean of daily measurements in 11 of the previous 12 months. All flow must pass through basins. Systems with pre-sed. basins must monitor after basins to determine bin classification and are not eligible for presumptive credit. See 40 CFR 141.726(a).
Two-stage lime softening	0.5-log credit for two-stage softening with coagulant addition. Coagulant must be present in both clarifiers and includes metal salts, polymers, lime, or magnesium precipitation. See 40 CFR 141.725(b)
Treatment Performance Toolbox Components	
Combined filter performance	0.5-log credit for combined filter effluent turbidity of 0.15 NTU in 95% of samples each month. See 40 CFR 141.727(a).
Individual filter performance	1.0-log credit for individual filter effluent turbidity of 0.10 NTU in 95% of daily maximum samples each month (excluding 15 minutes following backwash) and no filter >0.3 NTU in two consecutive measurements taken 15 minutes apart. See 40 CFR 141.727(b).
Demonstration of performance	Credit based on a demonstration to the State through State-approved protocol. See 40 CFR 141.727(c).
Additional Filtration Toolbox Components	
Bag filters	1.0-log credit with demonstration of at least 2.0 log removal efficiency in challenge test; Specific criteria are in 40 CFR 141.728(a).
Cartridge filters	2.0-log credit with demonstration of at least 3.0 log removal efficiency in challenge test; Specific criteria are in 40 CFR 141.728(a).
Membrane filtration	Log removal credit up to the lower value of the removal efficiency demonstrated during the challenge test if verified by direct integrity testing. See 40 CFR 141.728(b).
Second stage filtration	0.5-log credit for a second separate filtration stage; treatment train must include coagulation prior to first filter. No presumptive credit for roughing filters. See 40 CFR 141.728(c).
Slow sand filters	2.5-log credit for second separate filtration process. No disinfection residual present in influent. See 40 CFR 141.728(d).
Inactivation Toolbox Components	
Chlorine dioxide	Log credit based on demonstration of compliance with CT tables. See 40 CFR 141.729(b).
Ozone	Log credit based on demonstration of compliance with CT tables. See 40 CFR 141.729(c).
UV	Log credit based on demonstration of compliance with UV dose table ; reactor testing required to establish validated operating conditions. See 40 CFR 141.729(d).

Table 3-5
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
LT2ESWTR Microbial Toolbox

3.1.9 Lead and Copper Rule

The Lead and Copper Rule (LCR) was promulgated by the USEPA in June 1991 to reduce the soluble concentrations of copper and lead present in the water distribution system and at the consumer's tap. The LCR Minor Revisions (LCRMR) was promulgated on January 12, 2000.

The LCR requires that the 90% percentile of all sampling results be below the Action Level (AL) of 0.015 mg/L for lead and 1.3 mg/L for copper. If a system exceeded these action levels in initial rounds of sampling, the LCR requires water systems to determine and then implement optimal corrosion control.

3.1.10 Arsenic Rule

On October 31, 2001, the USEPA announced its decision to move forward in implementing the arsenic standard for drinking water at 0.01 mg/L. Reducing the MCL from 0.05 mg/L to 0.01 mg/L will provide additional protection to millions of Americans from cancer and other health problems, such as heart disease and diabetes. Water systems must meet this standard by January 2006.

3.1.11 Radionuclides Rule

The USEPA issued the final Radionuclides Rule in December 2000. The Radionuclides Rule became effective in November 2003. The Radionuclides Rule regulates uranium, radium-226 and radium-228, beta particles and photon emitters, and gross alpha particles in water supplies. The MCLs for radionuclides in drinking water are as follows.

- Radium-226 and radium-228 (combined) – MCL of 5 piC/L
- Beta/Photon Emitters – MCL of 4 mrem/yr with an initial monitoring RAA of 50 piC/L.
- Gross Alpha – MCL of 15 piC/L
- Uranium – MCL of 30 ug/L

3.1.12 Consumer Confidence Reports Rule

The Consumer Confidence Reports (CCR) Rule requires systems to prepare and distribute annual consumer confidence reports to their consumers every July. The CCR rule was promulgated in August 1998 with the first reports due in October 1999.

3.1.13 Unregulated Contaminant Monitoring Rule (UCMR)

As required by the 1996 Amendments to the SDWA, the USEPA published revisions to the UCMR establishing criteria for a program to monitor unregulated contaminants in drinking water, and published a list of contaminants to be monitored. The rule was

published on September 17, 1999 and supplemented on March 2, 2000 and January 11, 2001. From the USEPA fact sheet, the new rule includes the following.

- Three different lists of contaminants based on the availability of established analytical methods.
- Requirements for all large public water systems (PWS) and a representative sample of small PWS to monitor for those contaminants on List 1.
- Requirements for selected large and small PWS to monitor for those contaminants on List 2.
- Requirements to submit the monitoring data to USEPA and the States for inclusion in the National Drinking Water Contaminant Occurrence Database.
- Requirements to notify consumers of the availability of the results of monitoring.
- Requirements to include detected contaminants in Consumer Confidence Reports (CCRs).

3.1.14 Aldicarb Rule

Aldicarb is regulated as part of the primary drinking water standards. The Aldicarb rule became effective in July 1991. The short-term effects of aldicarb include nausea and relatively minor neurological symptoms. The long-term effects include sweating and leg weakness. The MCL for aldicarb is 0.003 mg/L.

3.1.15 Filter Backwash Recycling Rule (FBRR)

The Filter Backwash Recycling Rule (FBRR) applies to systems that use conventional or direct filtration treatment and that recycle spent filter backwash water, thickener supernatant or liquids from dewatering processes within the WTP. The rule requires the recycle flows to pass through all processes of the system's representative treatment. For most treatment plants this would be prior to the primary coagulant application point.

The FBRR requires systems that practice filtration and recycle spent filter backwash must notify the State in writing that they practice recycle. The notification to the State must include the following information:

- A plant schematic showing the origin, the hydraulic conveyance and the location where they are recycled back to in the plant
- Typical recycle flows, highest previous year flow, design flow and state approved operating capacity

Systems must collect and maintain the following information for review by the State:

- Copy of notification sent to the State
- List of all recycle flows and the frequency they are returned
- Average and maximum backwash flow rate through the filters and duration of the filter backwash process
- Typical filter run length and written summary on how it is determined
- Type of treatment provided for recycle flow
- Physical dimensions of treatment units, hydraulic loading rates, type and dose of chemical used, frequency at which solids are removed

3.1.16 Radon Rule

The regulation of radon was originally addressed under the "Radionuclides Rule" in July 1991. The "Radon in Drinking Water Rule" was proposed on November 2, 1999.

The key elements in USEPA's Radon Rule are as follows:

- Radon MCL – The radon MCL is 300 piC/L for community ground water systems that serve 10,001 or greater people.
- Multi-Media Mitigation (MMM) Programs – Establishes criteria for development and implementation of MMM programs. Applies to community public water systems. Where a state has an USEPA approved MMM program, water suppliers will be allowed to comply with an alternate MCL of 4000 pCi/L.

The effective date of the rule is August 2003 for states that don't have a USEPA approved MMM program and February 2005 for states with an approved MMM. Initial monitoring is conducted for one year after the effective date of the rule. For states without a USEPA approved MMM program, water suppliers must submit a local MMM plan for state approval one year after monitoring (August 2005), and must implement MMM program 6 months after submitting MMM program for state approval (February 2006). The rule applies to all community systems that use groundwater or mix ground water and surface water.

3.2 Child Street WTP Historical Water Quality

3.2.1 Raw Water Quality

CDM evaluated raw water quality data from January 2007 through mid-July 2009. CDM requested all historical data from the BCWA that was available on the raw water. BCWA provided daily measurements of pH, alkalinity, color, turbidity, chloride, total manganese and total iron. BCWA also provided HEALTH forms that included source water total organic carbon (TOC). The WTP was taken offline in July 2009 by the BCWA due to severe rain events resulting in high color, turbidity and

manganese concentrations. A summary of the raw water quality is included in **Table 3-6** and is described below.

The raw water pH is typical of most surface water reservoirs in New England. The average pH range of the raw water was 6.0 to 7.5. pH levels greater that 7.5 occurred during the spring and summer months with the increase of algae growth, as shown in **Figure 3-1**. Alkalinity ranged from less than 10 to 35 mg/L as $CaCO_3$ as shown in **Figure 3-2** and is influenced by seasonal changes. The increased spikes in pH and alkalinity require operators to provide adequate chemical addition to prevent upsetting the treatment process.

Apparent color is highly variable and ranged from 10 to 220, as shown in **Figure 3-3**. The wide variation in color can be attributed to increased levels in organics, minerals and seasonal fluctuations.

Turbidity is also highly variable and ranges from less than 1 to 13 NTU, as shown in **Figure 3-4**. Turbidity is severely impacted by rain events and upsets to the reservoir, as indicated in the early spring spikes. High levels in turbidity have negative impacts on the treatment process. If turbidity is not removed through the clarification process, the filter run times are reduced in order to meet regulatory requirements.

Chloride levels in the raw water are typically below 100 mg/L, as shown in **Figure 3-5**. However, in 2007 there were several occasions when the concentration was above 200 mg/L, which may be attributed to salt water intrusion from the brackish portion of the Kickemuit River. A combination of rain events and flooding during high tide may have attributed to increased chloride levels.

Manganese was usually less than 0.2 mg/L but can be elevated during spring time turnover as shown in **Figure 3-6**. Manganese typically increases in the spring up to 0.3 mg/L. The June 2009 extreme rain events caused manganese levels to increase to 1.0 mg/L and along with other extreme water quality issues forced the plant to be shutdown as regulatory requirements could not be met. The extreme June 2009 manganese concentration did not occur in any previous years and is considered an outlier.

Source water TOC was reported monthly on the HEALTH forms and was provided from February 2008 through June 2009. The organics in the source water ranged from 6.5 to 14 mg/L as shown in **Table 3-7**. Spikes in organics concentrations occur in November 2008, May 2008 and May 2009 and may be attributed to seasonal rain events as shown in **Figure 3-7**.

In general, all of the raw water quality parameters range widely due to rain events. The BCWA stated that the varying water quality is thought to be due to the flushing of the natural stream beds of the Kickemuit River that feed the Kickemuit Reservoir.

Month/Year	pH		Alkalinity		Apparent Color		NTU		Chloride		Total Mn		Total Fe	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
January-07	6.2	7.0	13	21	96	158	1.78	5.96	27	44	0.047	0.247	0.26	0.50
February-07	6.0	6.7	9	27	42	110	1.33	4.50	43	68	0.035	0.306	0.13	0.38
March-07	5.9	6.7	4	18	45	218	1.14	13.30	28	55	0.020	0.185	0.05	0.33
April-07	6.0	6.7	9	18	60	147	1.44	6.31	22	68	0.033	0.226	0.14	0.39
May-07	6.0	6.9	14	21	92	167	1.37	3.03	36	54	0.080	0.252	0.27	1.02
June-07	6.3	8.0	19	31	62	121	1.02	2.64	44	290	0.061	0.200	0.28	0.60
July-07	6.5	7.8	19	33	43	95	1.28	2.16	34	210	0.033	0.183	0.17	0.86
August-07	6.9	7.4	15	24	20	76	1.31	2.23	31	46	0.019	0.071	0.08	0.22
September-07	6.9	7.4	16	22	11	45	0.62	1.31	28	85	0.012	0.037	0.04	0.28
October-07	7.0	7.3	19	25	19	31	0.57	1.09	64	225	0.018	0.088	0.02	0.26
November-07	7.0	7.3	22	24	21	35	0.84	1.70	64	194	0.020	0.044	0.07	0.43
December-07	6.6	7.4	23	32	24	108	1.06	4.22	58	84	0.026	0.179	0.10	0.35
January-08	6.4	7.0	17	22	48	103	1.27	3.61	50	74	0.058	0.183	0.17	0.47
February-08	6.5	7.1	8	22	44	160	1.10	10.00	42	74	0.031	0.140	0.09	0.32
March-08	6.5	7.3	9	19	58	126	1.28	5.87	38	78	0.028	0.090	0.12	0.30
April-08	6.9	7.5	16	26	51	139	1.42	3.60	40	58	0.041	0.295	0.17	0.58
May-08	6.8	8.4	18	26	107	156	1.30	2.94	40	54	0.069	0.345	0.32	0.68
June-08	6.9	7.7	23	33	56	98	0.96	2.27	46	92	0.068	0.293	0.24	0.68
July-08	6.9	7.3	24	35	42	70	0.99	1.91	46	92	0.078	0.213	0.17	0.37
August-08	6.6	7.3	15	24	20	50	0.80	1.65	32	48	0.031	0.111	0.09	0.26
September-08	6.7	7.3	17	28	22	119	0.57	1.07	28	60	0.011	0.071	0.04	0.49
October-08	6.4	7.0	17	25	68	191	0.75	4.27	32	42	0.023	0.141	0.13	0.84
November-08	6.6	7.2	19	33	82	217	0.96	3.40	36	60	0.023	0.131	0.16	0.57
December-08	6.4	7.0	10	21	69	192	1.03	5.39	21	52	0.026	0.105	0.17	0.70
January-09	6.4	6.9	14	18	40	107	0.91	3.03	30	66	0.026	0.077	0.10	0.69
February-09	6.6	7.0	14	18	38	69	0.92	2.54	40	67	0.022	0.062	0.01	0.42
March-09	6.7	7.4	14	23	30	87	0.97	2.58	58	82	0.017	0.090	0.08	0.21
April-09	6.5	7.4	13	24	48	193	1.46	9.64	44	92	0.037	0.111	0.16	0.93
May-09	6.8	7.3	18	25	83	195	1.07	3.20	44	60	0.049	0.142	0.39	0.89
June-09	6.8	7.5	24	34	59	157	0.87	1.86	44	74	0.043	0.170	0.22	0.83
July-09[1]	6.6	7.1	22	36	148	207	1.80	3.30	26	54	0.182	1.000	0.87	1.30
MIN	5.9	6.7	4	18	11	31	0.57	1.07	21	42	0.011	0.037	0.0	0.2
MAX	7.0	8.4	24	35	107	218	1.78	13.30	64	290	0.080	0.345	0.4	1.0
AVE	6.6	7.3	16	25	50	125	1.08	3.91	40	88	0.036	0.160	0.1	0.5

1 - July 2009 data not included in statistical analysis as majority are considered outliers

Table 3-6
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Historical Raw Water Quality Data

CDM

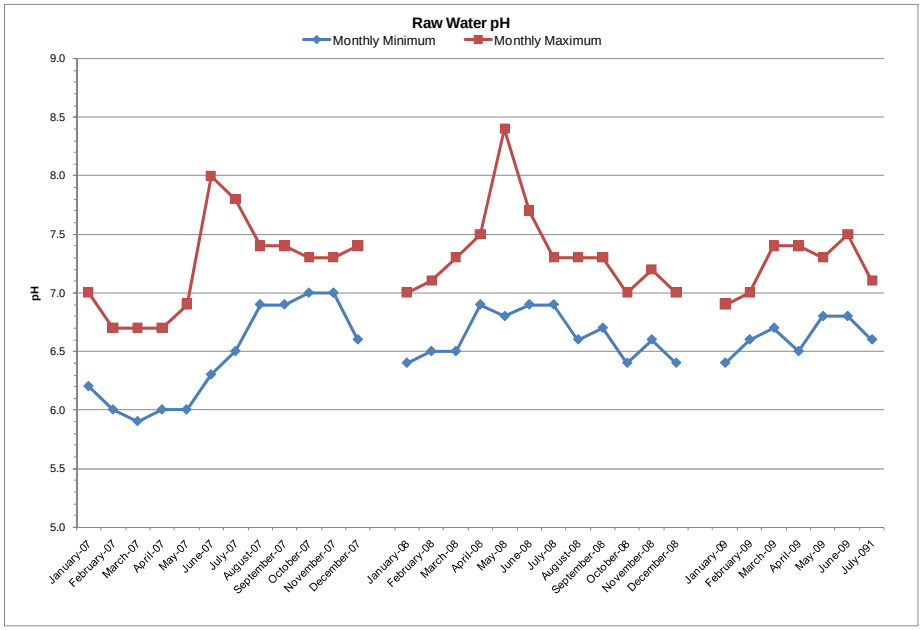


Figure 3-1
Historical Raw Water pH

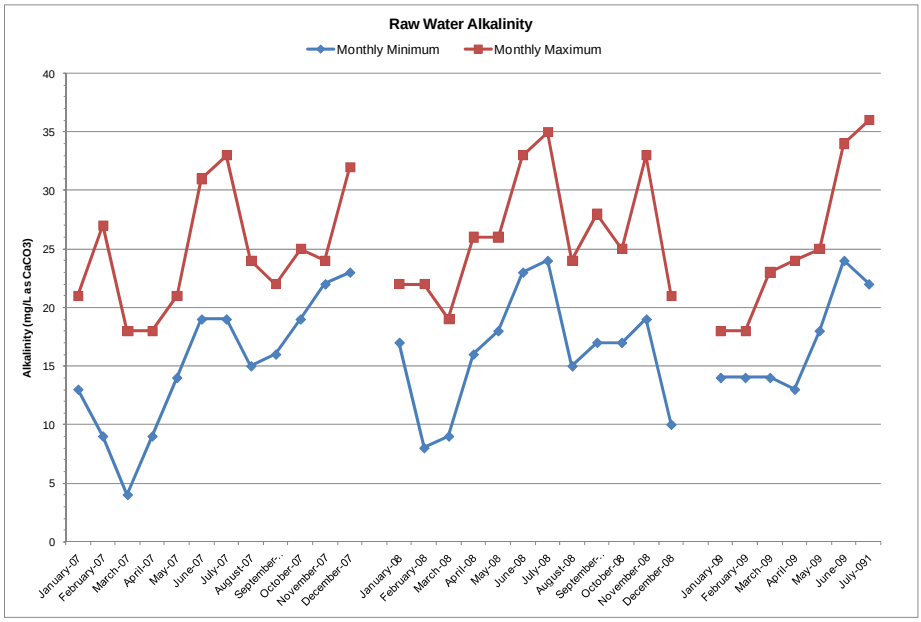


Figure 3-2
Historical Raw Water Alkalinity

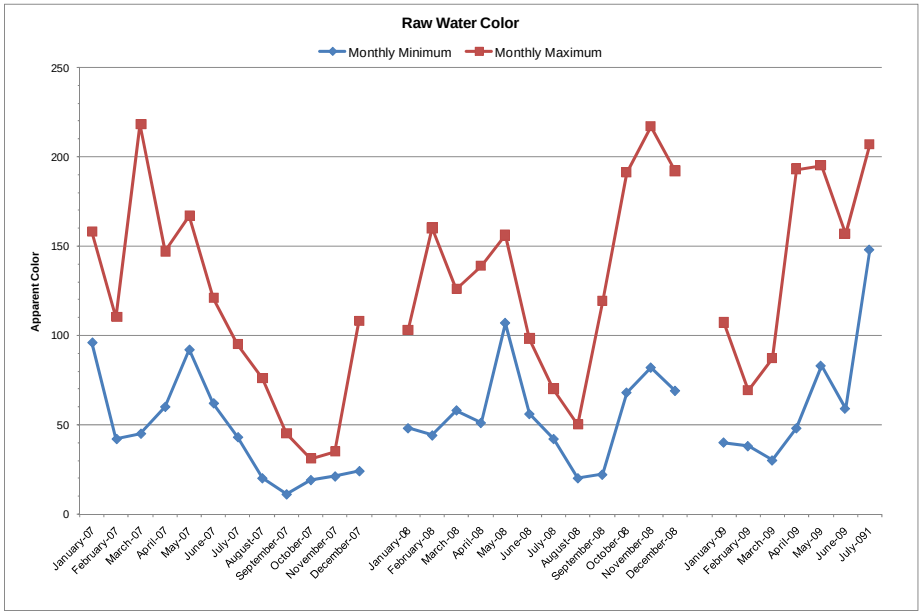


Figure 3-3
Historical Raw Water Color

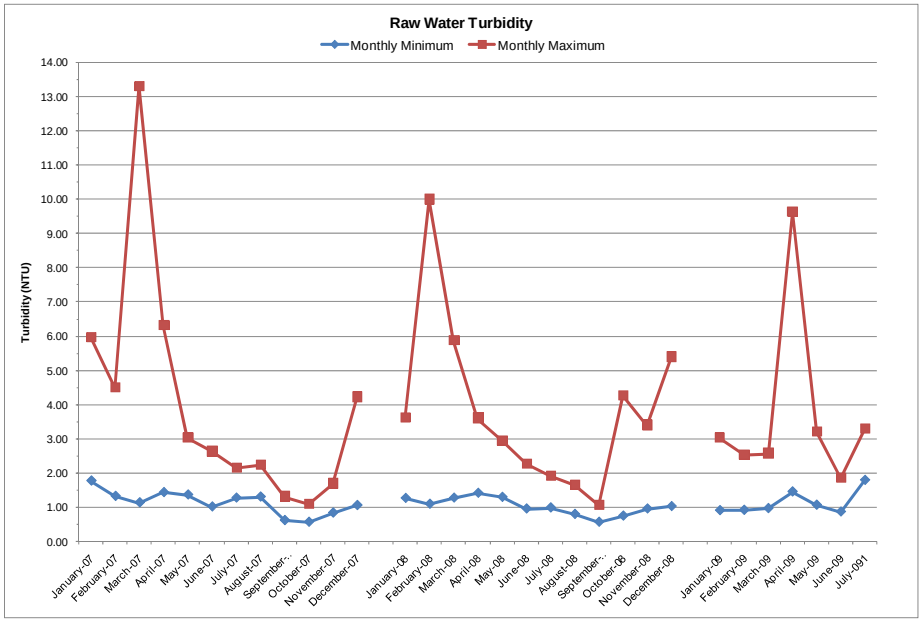


Figure 3-4
Historical Raw Water Turbidity

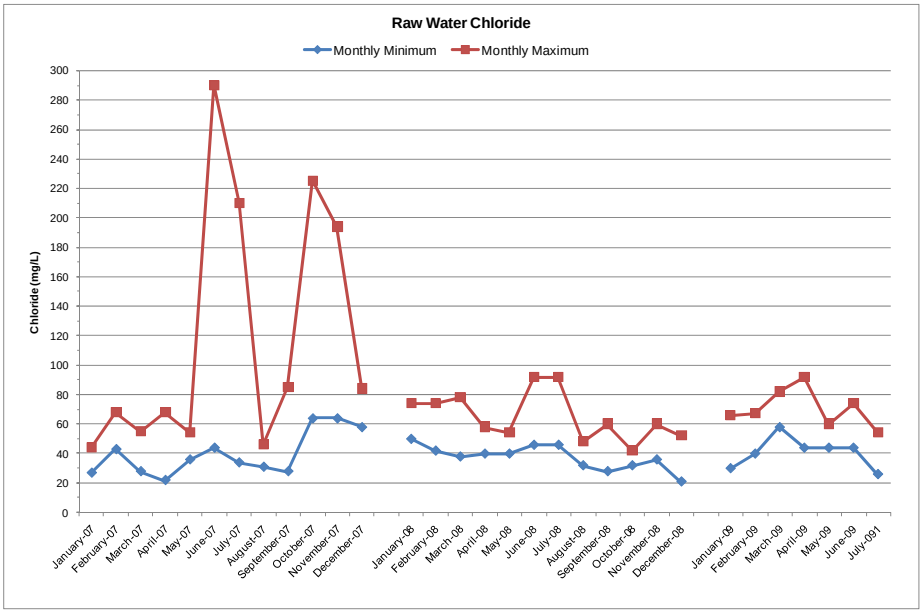


Figure 3-5
Historical Raw Water Chloride

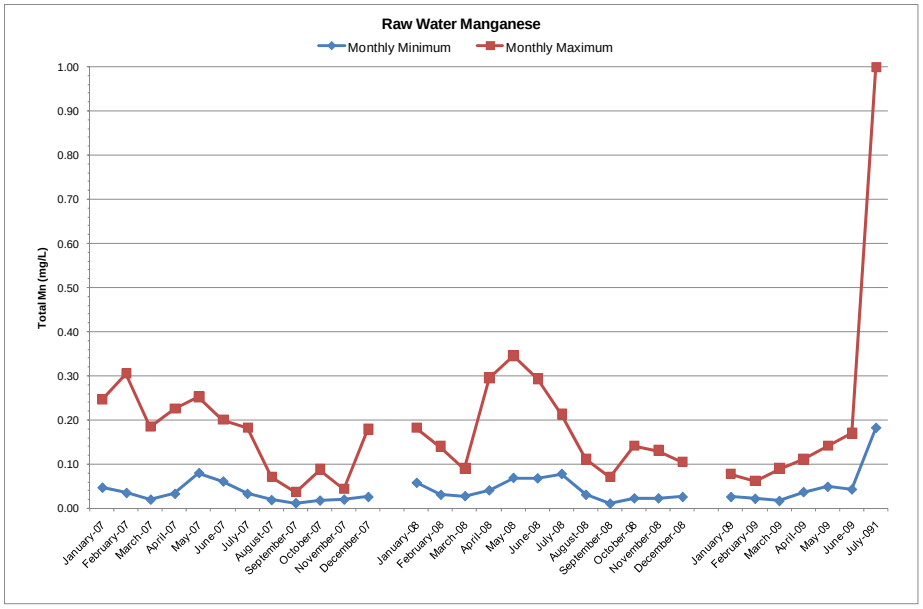


Figure 3-6
Historical Raw Water Manganese

Date	Raw Water TOC (mg/L)
2/13/2008	13.0
3/12/2008	10.0
4/9/2008	10.0
5/9/2008	14.0
6/11/2008	11.0
7/16/2008	8.4
8/13/2008	6.9
9/12/2008	7.7
11/26/2008	13.0
12/12/2008	11.0
1/19/2009	7.7
2/11/2009	8.0
3/12/2009	6.5
4/8/2009	7.6
5/13/2009	13.0
6/10/2009	9.0

Table 3-7
Raw Water Total Organic Carbon

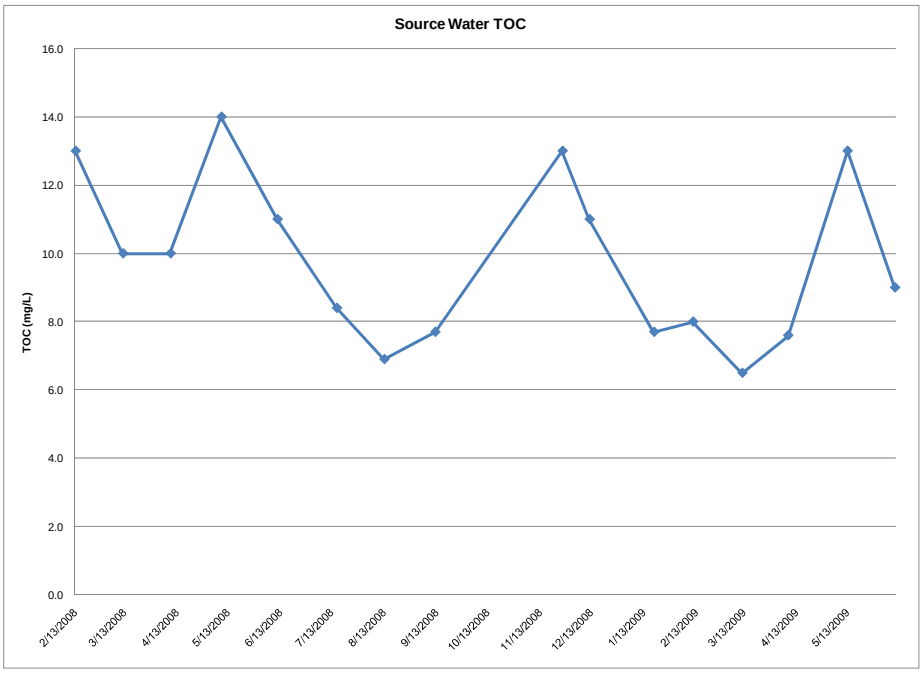


Figure 3-7
Raw Water Total Organic Carbon

More controlled flow during rain events to minimize the flushing of the brooks may reduce some of the wide ranges in water quality that the BCWA experiences. The reservoir is also very shallow, so seasonal and even daily changes can affect the reservoir very rapidly. For example, water temperature can have wide variations just over the course of the day due to the affect of sunlight.

The extreme rainfall that occurred during June 2009 continued to have affects on raw water quality into July, including increases in alkalinity, color, turbidity and manganese. These parameters increased to levels that exceeded all of the historical data that CDM analyzed. We therefore consider raw water quality data from June and July 2009 as outliers, which do not appear to be representative or typical of the normal range of expected raw water quality parameters.

The BCWA has recently completed testing of its raw water for the presence of the pathogen *Cryptosporidium*. Under currently accepted testing methods the BCWA indicated that they have not found *Cryptosporidium* in their source water. As will be discussed later in this section, the presence of *Cryptosporidium* in source water can play a major role in influencing the required disinfection.

3.2.2 Finished Water Quality

CDM requested all historical data from the BCWA that was available on the finished water. CDM evaluated finished water data at the Child Street WTP from HEALTH forms and daily summary tables provided by the BCWA. The monthly reporting HEALTH forms reported daily point of entry concentrations for free chlorine, chlorine dioxide, chlorite, turbidity, and source and finished water TOC from January through June of 2009. Free chlorine residual at the point of entry to the distribution system was consistent as the BCWA maintained a free chlorine residual between 0.20 to 0.65 mg/L and met regulations. Chlorine dioxide concentrations ranged from 0.01 to 0.26 mg/L. Chlorite concentrations ranged from 0.180 to 1.167 mg/L. The high concentration of chlorite indicates that these levels were elevated and ferrous chloride was not able to mitigate these levels prior to entry to the distribution system. Turbidity levels over this period ranged from 0.03 to 0.42 NTU.

Month	Free Chlorine (mg/L)	Chlorine Dioxide (mg/L)	Chlorite (mg/L)	Turbidity (NTU)
January	0.19-0.50	0.01-0.26	0.180-0.780	0.05-0.28
February	0.23-0.49	0.01-0.15	0.204-0.868	0.03-0.42
March	0.31-0.50	0.03-0.23	0.259-0.622	0.04-0.06
April	0.30-0.50	0.01-0.18	0.305-0.907	0.04-0.14
May	0.26-0.53	0.01-0.20	0.293-1.167	0.05-0.38
June	0.21-0.40	0.01-0.16	0.290-0.894	0.04-0.13
July	0.20-0.65	0.02-0.10	0.366-1.006	0.08-0.13

Table 3-8
Summary of Finished Water Data Reported to HEALTH in 2009

The majority of the turbidity exceedences occurred in May when spring rain events occurred. Turbidity levels exceeded the regulatory limit of 0.3 NTU on four days during this period, including:

Date	Samples Taken/Sample Exceeded	NTU
2/14/2009	12/1	0.42
5/14/2009	10/4	0.33
5/29/2009	12/3	0.35
5/31/2009	12/2	0.38

Finished water TOC removals were achieved over the period of data evaluated. Source, finished and removal ratio are tabulated in **Table 3-9**. A removal ratio of 1 indicates that the actual TOC percent removed was equal to the required TOC percent removed.

Date	Raw Water (mg/L)	Finished Water (mg/L)	Ratio Removed
2/13/2008	13.0	2.7	1.58
3/12/2008	10.0	2.4	1.52
4/9/2008	10.0	2.6	1.48
5/9/2008	14.0	2.7	1.61
6/11/2008	11.0	2.6	1.53
7/16/2008	8.4	2.2	1.48
8/13/2008	6.9	1.7	1.67
9/12/2008	7.7	2.6	1.47
11/26/2008	13.0	3.6	1.45
12/12/2008	11.0	3.3	1.40
1/19/2009	7.7	2.6	1.47
2/11/2009	8.0	2.6	1.50
3/12/2009	6.5	3.5	1.03
4/8/2009	7.6	2.7	1.43
5/13/2009	13.0	2.6	1.60
6/10/2009	9.0	2.8	1.38

Table 3-9
Finished Water Total Organic Carbon

As a result of using chlorine dioxide as the primary disinfectant, the DBPs of TTHMs and HAAs are safely below the regulatory requirements. From the third quarter in 2008 through third quarter in 2009, the TTHMs ranged from 30 to 56 ppm and HAAs ranged from 12 to 38 ppm, which were well within the regulatory requirements.

Additional finished water quality data was provided by the BCWA for January 2007 through mid July 2009 and included chloride, manganese, iron, aluminum and temperature. These water quality parameters are secondary contaminants that may

cause cosmetic or aesthetic effects. The secondary standards for these parameters are listed in **Table 3-2** and are described earlier in this section.

With the exception of manganese, all of the secondary finished water parameters typically met the secondary standard within the time periods that CDM evaluated. Manganese exceeded the secondary standard quite frequently during this time. At times, the finished water manganese exceeded the raw water manganese concentrations. CDM suspects that the increase in manganese indicates that manganese is being reintroduced within the treatment process.

Primary standards were typically met but under poor raw water quality conditions the WTP has been taken offline when it was expected regulations would not be achieved. These conditions are related primarily to high color, turbidity and organics under which the plant has difficulty meeting regulations, and plant production rates are impacted.

3.3 Water Quality Objectives & Design Requirements

The process evaluation and recommendations which will be described in the following sections are based on CDM's understanding of the raw and finished water quality at the BCWA Child Street WTP and the regulatory requirements that must be met, as presented herein. The raw water quality indicates that high color, turbidity, manganese and organics are problematic to the current treatment process.

CDM evaluated the ability for the WTP to operate at a theoretical maximum capacity of 5.0 mgd and a reliable capacity of 4.0 mgd and treat the source water when poor water quality conditions exist. The Child Street WTP needs to achieve simultaneous compliance between the SWTR, which dictates disinfection requirements "CT" and the D/DBPR, which dictates organics removal and places limits on byproduct formation. The current disinfection byproduct of alarm is chlorite which is formed by the use of chlorine dioxide as a disinfectant and oxidant. The major objectives of this evaluation are to reduce chlorite, improve treatment operations and increase capacity. Removing manganese (secondary contaminant of concern) is another major objective of our evaluation of the BCWA treatment process.

After reviewing the draft report, the RIWRB and BCWA requested that CDM develop potential improvements to maximize the existing WTP processes. CDM therefore evaluated the ability for the WTP to operate at theoretical maximum capacities less than its original design capacity. Although it may not be feasible to increase the reliable treatment capacity to the full design capacity of 5.0 mgd, both the RIWRB and BCWA felt that any potential gain in treatment capacity from current performance would be beneficial and provide the BCWA with added system reliability.

Section 4
Process Evaluation

The existing BCWA Child Street WTP was originally constructed in 1908, with many additions and improvements made throughout the years. The plant was originally designed and constructed with a reliable design capacity of 4.0 mgd and a maximum capacity of 5.0 mgd. Given the age of the facility and with the enactment of more stringent drinking water regulations, a comprehensive study was conducted in 2001 to evaluate the plant to ensure regulatory compliance with the USEPA Stage 1 D/DBP Rule and the IESWTR. This 2001 evaluation recommended several major improvements to the WTP at a design capacity of 3.5 mgd, in a phased approach, to ensure regulatory compliance.

As a result of this study and with funding provided by the RIWRB, the BCWA began rehabilitation to its Child Street WTP in 2001. This first phase of improvements were completed in 2004 and included:

- Installation of a new raw water Venturi flow meter
- Installation of a new in-line static mixer
- Relocation of chemical application points
- Installation of new axial flow flocculators in the primary clarifier
- Installation of new tube settlers in the primary clarifier
- Sand blasting and repainting the primary clarifier
- Filter media replacement in all filters
- New underdrains in all filters
- Installation of new air blowers and an air scouring system for filter backwash
- Installation of new backwash pumps
- Installation of new turbidimeters on the filter effluent lines
- Installation of a new chlorine dioxide generator
- Replacement of drain pipes in the filter gallery
- Structural repairs to the WTP concrete walls and floor slabs
- Replacement of WTP yard piping and valves
- Rehabilitation of the backwash water holding tank

Due to funding constraints, not all of the recommended improvements from this 2001 study were implemented. The recommended automatic sludge collection and removal system in the primary sedimentation basin, improvements to the chemical feed systems and various instrumentation upgrades were not constructed. To-date, these additional improvements have not yet been implemented.

After completion of this first phase of the recommended improvements in the summer of 2004, the Child Street WTP was operated in "pilot" mode through December 2005, with oversight from Weston & Sampson. During this time, it was determined that even with the improvements that were made, the WTP could only produce safe, reliable and regulatory compliant water at a flow rate of approximately 1.5 to 2.0 mgd. Flow rates higher than these amounts resulted in serious degradation of water quality throughout the treatment process and the plant could not meet all of the necessary regulatory requirements. Through correspondence (**Appendix B**) between Weston & Sampson, BCWA and HEALTH, the following reasons are likely for this reduced treatment capacity:

- Increased organics, turbidity and color resulted in an elevated chlorine dioxide demand. The elevated demand required an increase dose to maintain residual and CT requirements and resulted in chlorite concentrations that exceeded the regulatory limit. Ferrous chloride was not used at this time to mitigate chlorite.

- Without a tracer study at an increased flow rate, HEALTH limited the capacity of the WTP to 2.0 mgd.

- Without a fully operational Shad Factory Pipeline, the BCWA has a reduced available safe yield and therefore cannot run the WTP at its full design capacity at this time. To increase the WTP capacity to 4.0 to 5.0 mgd, it is essential to restore the full capacity of the Shad Factory Pipeline. Officials from both the BCWA and RIWRB indicated to CDM that plans to restore the capacity of the Shad Factory Pipeline are currently in the final design and permitting stages. However, no work has been completed to-date.

The intent of this section is to present an overview of the current treatment process used at the Child Street WTP, describe each treatment process in more detail and to assess and summarize current physical and treatment limitations. Treatment alternatives and recommended improvements to mitigate these limitations will be discussed later in this report.

4.1 Existing Treatment Process Overview

As discussed in **Section 2**, the intake of the Child Street WTP is on the shore of the Kickemuit Reservoir, directly adjacent to the WTP in Warren, Rhode Island. Water is pumped from the Kickemuit Reservoir by the WTP's raw water pumps through the intake, the chemical addition and to the primary clarifier. Chlorine dioxide is added in the primary clarifier for oxidation and to achieve the necessary "CT" to meet primary

disinfection requirements. The BCWA utilizes the sedimentation basin to add ferrous chloride to reduce the subsequent chlorite concentration. After the sedimentation basin, water flows through a smaller basin where pH is adjusted and then onto eight dual media filters. Sodium hypochlorite is added at the clearwell to maintain a secondary disinfectant residual as water is pumped from the WTP and enters the distribution system. Fluoride, polyphosphate and potassium hydroxide are also added in the clearwell. A copy of the Child Street WTP's current treatment process flow diagram is shown on **Figure 4-1**.

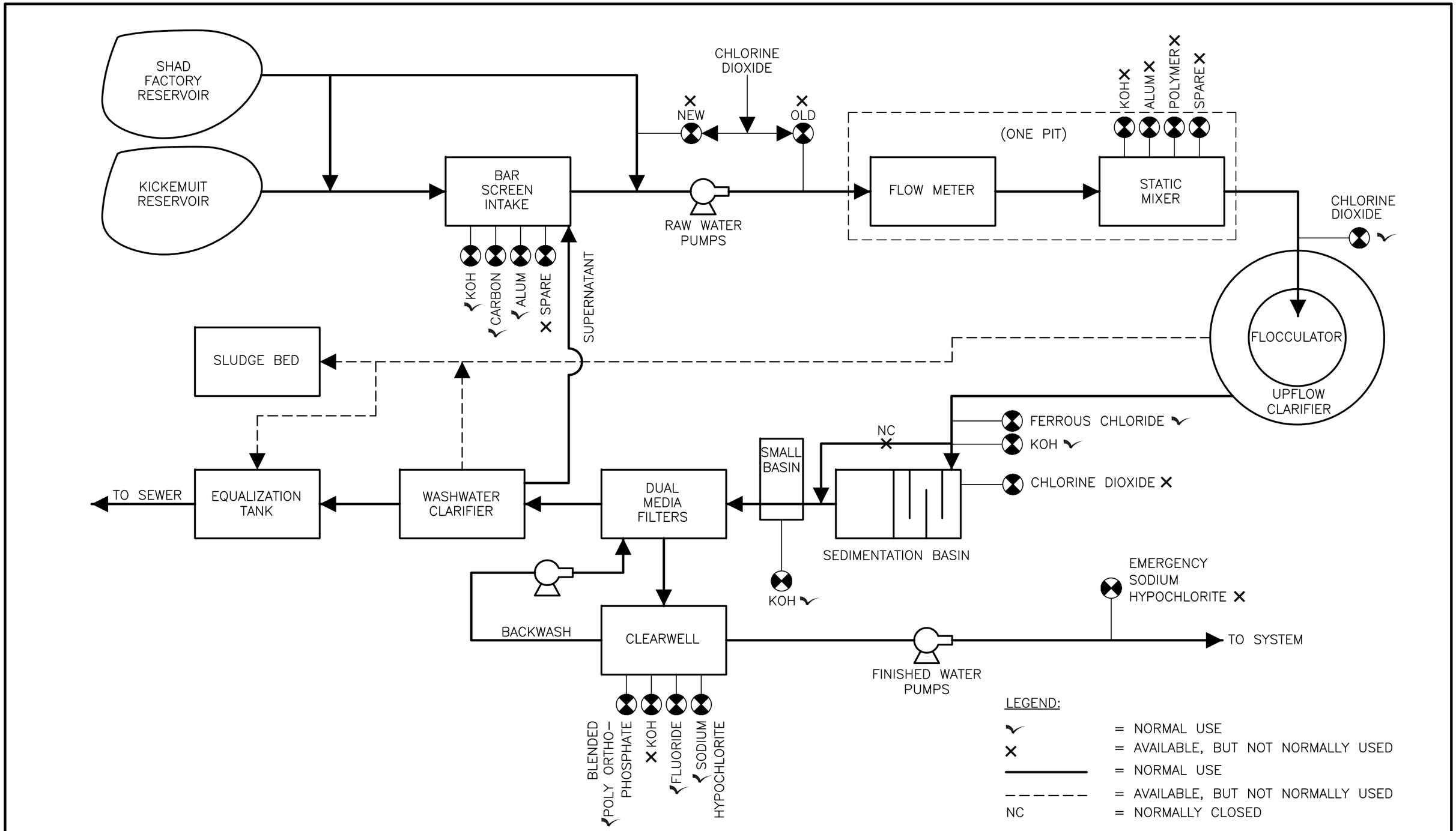
Waste solids from the WTP are generated primarily from three different locations – the filter backwash (backwash holding tank), settled solids in the circular clarifier and settled solids in the rectangular sedimentation basin. Solids can be pumped to sludge lagoons or to an equalization tank prior to discharge to the municipal sewer. Filter backwash is sent to a backwash holding tank, with a portion of the supernatant recycled back to the head of the WTP.

Each treatment process at the Child Street WTP is summarized and discussed in more detail in the following paragraphs. To monitor treatment plant performance, BCWA operators take grab samples every two hours at the center of the clarifier, clarifier effluent, sedimentation basin inlet, top of the filters and from the treatment plant effluent through the sample sink in the lab. Daily water quality data is kept in log books, which are maintained by the BCWA Superintendent.

4.2 Intake & Chemical Addition

The intake on the Kickemuit Reservoir is equipped with both bar and wire mesh screens to prevent solids from entering the WTP. Pictures of the intake are presented in **Figure 4-2** and **4-3**. However, CDM noted during site visits that these screens appear to be in poor condition and at times may not be preventing all solids from entering the WTP. Although the performance of the existing screens currently may not be affecting treatment capacity, the screens could be repaired or replaced to improve operations.

Directly after the intake, aluminum sulfate (alum), potassium hydroxide (KOH) and powder activated carbon (PAC) for taste and odor mitigation are added. Alum is added to the raw water at an injection point just after the intake. The piping between the intake and the primary clarifier is used to provide time for partial coagulation prior to flocculation in the primary clarifier. Depending on water quality, the BCWA's typical alum dose is 70 mg/L but varies significantly with changes in raw water quality. As discussed in **Section 3**, the water quality parameters vary widely and subsequently dictate coagulant dose. The source water is high in organics which must be removed prior to disinfection by coagulation, flocculation and clarification. According to BCWA staff, the alum dose must be increased significantly at times to provide enhanced coagulation due to poor raw water quality. The high alum dose results in increased chemical dose and solids removal. As discussed later in this section, solids disposal is limited at the plant site.



BCWA CHILD STREET WTP
WATER QUALITY EVALUATION

CDM

EXISTING PROCESS FLOW DIAGRAM

FIGURE 4–1

Figure 4-2
Picture of the Intake on the Kickemuit Reservoir

Figure 4-3
Picture of the Intake Mesh Screens

Potassium hydroxide is also added to the raw water at an injection point just after the intake, to maintain pH within optimum values for effective coagulation. Alum has the effect of lowering pH, as it consumes alkalinity, so the pH must be raised for effective coagulation. The potassium hydroxide dose varies based on alum dose. PAC is added on an as needed basis to mitigate taste and odor problems in the water.

The pipeline between the intake and primary clarifier is used to provide contact time prior to flocculation. At the current flow rate of 2.0 mgd, the pipe contact time is 4.5 minutes. At the original maximum design capacity of 5.0 mgd the contact time is 1.8 minutes. PAC typically should have approximately 20 minutes of contact time prior to coagulation and the rapid mix process to be the most effective.

During recent WTP upgrades, a new in-line static mixer was installed in a new vault between the intake and the primary clarifier to aid in mixing of chemicals. The mixer is a 14-inch wafer-style motionless static mixer and according to the manufacturer's information, fluids are injected and rapidly mixed by a combination of alternate vortex shedding and shear zone turbulence. However, BCWA staff question the ability of this mixer to effectively mix the alum and potassium hydroxide uniformly throughout the flow. The BCWA encountered difficulty feeding chemicals through the mixer's injection ports, and subsequently relocated the chemical applications points to alternative locations. CDM suspects that the chemical feed lines to this mixer may be undersized. It should also be noted that the mixer was recommended with a design flow of 3.5 mgd. At reduced flows (1.0 to 2.0 mgd), the pipeline velocity will be less than what the mixer was designed for and this may be the reason for less effective mixing. If the mixer does not perform as intended, a potential remedy would be to replace it with a new inline mechanical mixer. Since the BCWA currently achieves satisfactory clarification results, we do not consider this to be a high priority issue at this time. Flocculation and clarification are discussed in the following paragraphs.

Additional chemical application points exist between the intake and the flow meter, as well as at the static mixer, but these are not currently utilized.

4.3 Flocculation and Clarification

After the addition of alum, potassium hydroxide, PAC and subsequent mixing in the pipeline, flow travels to the primary clarifier, a circular flocculation and upflow clarification tank. Pictures of the primary clarifier are shown in **Figure 4-4** and **4-5**.

The circular clarifier has two separate but interconnected chambers (**Figure 4-5**), separated by a baffle wall. In the first chamber, two axial flow flocculators provide slow, gentle mixing to encourage particles to contact, stick together and grow to larger floc that will readily settle. The flocculation well is 38 feet in diameter, 10 feet deep and should provide 30 to 40 minutes of flocculation time. Because the reliable design flow rate of 4.0 mgd meets the industry standard, CDM finds the flocculation time is acceptable at increased flow rates.

The flocculation times at various flow rates are listed below:

Flow Rate	Flocculation Time
2.0 mgd (current)	60 minutes
3.5 mgd (2001 upgrade design)	40 minutes
4.0 mgd (1908 reliable design)	30 minutes
5.0 mgd (1908 maximum design)	24 minutes

Figure 4-4
Picture of the Primary Clarifier

Figure 4-5
Picture of the Primary Clarifier Flocculation and Upflow Clarification Chambers

After the flocculation chamber the water flows under the baffle wall and upwards through a 6-foot width of tube settlers in the sedimentation/ clarification chamber. The tube settlers improve the settling process, surface overflow rate and enhance the

ability to collect solids, since the settling distance that particles have to fall to enter the clarifier sludge zone is greatly reduced. The tubes promote laminar flow conditions, which enhance settling. The settled solids from the circular clarifier are continuously withdrawn to the equalization tank and discharged to the sewer. The sludge can also be pumped to the sludge beds if required.

The tube settlers were designed by Maguire Group, Inc. as documented in their June 2001 evaluation report. This report indicates that a 6-foot width of tubes will provide 1.87 gpm/square foot rise rate at a flow rate of 3.5 mgd. The typical design application rate for 2-foot deep tubes is 2.00 gpm/square foot. At a flow rate of 5.0 mgd, the 6-foot width of tubes would provide a 2.67 gpm/square foot rise rate which does not meet industry guidelines. In order to treat 5.0 mgd at a 2.00 gpm/square foot rise rate, additional tubes would need to be installed.

At the center of the inlet to this tank, the BCWA adds chlorine dioxide to the water. The chlorine dioxide is added both for oxidation of dissolved manganese in the raw water and to achieve the necessary "CT" to meet primary disinfection requirements which is described in detail in **Section 4.6**. Chlorine dioxide is also effective at oxidizing manganese, so that it subsequently precipitates out of solution and is removed from the water through settling or filtration. The reaction with manganese is relatively rapid, with the formation of manganese oxide particles (MnO_2). Industry guidelines indicate that about 2.5 mg/L of chlorine dioxide will oxidize 1.0 mg/L of dissolved manganese. A byproduct of chlorine dioxide is chlorite, which is a regulated DBP with a MCL of 1.0 mg/L. The current chlorine dioxide demand of the water increases the required dose and results in chlorites above the MCL which must be removed before entering the distribution system.

Chlorine dioxide is volatile and extremely unstable at high concentrations and temperatures or when exposed to light (i.e., sunlight). The BCWA has covered the circular clarifier with small white balls (also referred to as "bird balls"), shown on **Figure 4-5**, to limit the exposure to sunlight and the degradation chlorine dioxide. Degradation of the chlorine dioxide is also attributable to the PAC application upstream. Industry guidelines suggest the use of chlorine dioxide should be applied upstream of other chemicals such as alum and PAC. This will optimize the process and decrease the degradation of the chlorine dioxide.

4.4 Sedimentation

After exiting the clarifier through radial launders, flow from the primary clarifier enters the rectangular sedimentation basin through a serpentine inlet. Pictures of the rectangular sedimentation basin are shown in **Figures 4-6** and **4-7**. The BCWA adds ferrous chloride at the inlet of the sedimentation basin to reduce the elevated levels of chlorite to concentrations within accepted regulatory limits. The ferrous chloride dose is determined based on the chlorite concentration from the primary clarifier. This basin is intended to reduce chlorite concentrations and provide additional settling.

The large area of the sedimentation basin should provide low velocities necessary for particles to settle.

There is some baffling at the inlet of the rectangular sedimentation basin (**Figure 4-7**), but it is apparent that short circuiting is problematic in this basin. A baffling factor has not been determined but is most likely poor, increasing velocities considerably. There is a significant degradation of water quality in this basin, as noted by both CDM during site visits, water quality data and indications by BCWA staff.

The calculated detention time of this basin at various flow rates are presented below.

Flow Rate	Detention Time
2.0 mgd	540 minutes
3.5 mgd	310 minutes
4.0 mgd	270 minutes
5.0 mgd	216 minutes

Figure 4-6
Picture of the Rectangular Sedimentation Basin

Figure 4-7
Picture of the Rectangular Sedimentation Basin Inlet Zone

During site visits, CDM observed orange/reddish floc suspended in the water of the basin. This floc is a result of the application of ferrous chloride. Although the floc may be filterable, it does not appear to readily settle in this basin. The sedimentation basin's main purpose is to reduce the chlorite concentration using ferrous chloride as a result of the chlorine dioxide application in the primary clarifier.

The sedimentation basin does not have any means of automatic sludge removal, so settled solids resulting from the application of ferrous chloride are allowed to build up in the bottom of the basin until the BCWA can take the WTP offline and manually

pump or remove the solids from this basin. Operators indicated that sludge in this basin sometimes is not removed for a few years, and at times, the sludge has built up close to the water surface level. Although sludge collection improvements to this basin were recommended as part of the 2001 study they were never implemented due to apparent funding constraints.

With the addition of the ferrous chloride, additional precipitate is formed in this basin to remove the chlorites. The ferrous chloride floc and resuspended sludge particles combined with high sludge levels and increased velocities from short circuiting carry solids onto the filters. This water quality degradation has a direct effect on the filtration process, to be discussed in the following paragraphs. It appears that the sedimentation basin is currently the main limitation in the treatment process at the Child Street WTP. CDM suspects that if the ferrous chloride was not needed to reduce chlorite levels, this basin could be abandoned. However, the chlorine dioxide dose would need to be reduced or an alternate disinfectant utilized to achieve "CT". There is also a small vault/basin downstream of the rectangular sedimentation basin which currently provides a holding chamber for pH adjustment prior to water entering the filters.

4.5 Filtration

Water from the sedimentation basin flows to eight dual media filters, seven of which are operational. The BCWA indicated that there was a problem during the recent WTP upgrades with construction on the piping connection to the filter that is currently not operational. When this filter was placed back into service, the BCWA suspected that short circuiting was occurring, and promptly shut down this filter. It has remained inactive and is no longer used for treatment.

The filters were upgraded in 2004 with new dual media (12 inches of silica sand and 12 inches of anthracite coal), new underdrains and a new air scour system for backwashing. The silica sand media has an effective size of 0.45 to 0.55 millimeters (mm), a uniformity coefficient less than or equal to 1.6 and a specific gravity between 2.55 and 2.65. The anthracite coal media has an effective size of 1.0 to 1.2 mm a uniformity coefficient less than or equal to 1.4 and a specific gravity between 1.65 and 1.75. Although the effective grain size of the media is typical, the 12 inches of coal may be a limiting factor. Typically, 24 inches of coal would be designed to provide more storage space for solids. The sand layer is primary for polishing and does not provide very much overall solids removal. The filters could be modified by raising the troughs by about 1 foot and adding additional coal media.

The loading rate to the filters is acceptable for the various flow rates up to 5.0 mgd. With all seven filters operating the loading rate to the filters is as follows:

Flow Rate	Loading Rate
2.0 mgd	1.10 gpm/square foot
3.5 mgd	1.93 gpm/square foot
4.0 mgd	2.20 gpm/square foot
5.0 mgd	2.76 gpm/square foot

The filters remove remaining particles and turbidity after sedimentation within the filter media by gravity flow and solids entrapment. Turbidity is constantly monitored by turbidimeters connected to the effluent lines of each filter, in order to demonstrate compliance with the SWTR. The flow from each filter enters the clearwell individually – there is no combined filter effluent line. A picture of the filter gallery is shown in **Figure 4-8** and one of the individual filters is shown in **Figure 4-9**.

Figure 4-8
Picture of the Filter Gallery at the Child Street WTP

Figure 4-9
Picture of a Filter Unit at the Child Street WTP

Unfortunately, settled water with high suspended solids leaving the sedimentation basin puts an excessive load on the filters to reduce turbidity to regulatory limits in the finished water. The filters have a tendency to rapidly clog during poor raw water quality conditions or at high flows. The solids carry over from the sedimentation basin to the filters is one of the reasons that the WTP capacity has been reduced, as filtered water turbidity limits cannot be met at increased flow rates. Filtration also generates excess solids that are backwashed and sent to the backwash holding tank.

The BCWA indicated that they do not operate the filters based on terminal head loss or turbidity breakthrough – the turbidity is monitored but filter backwash occurs based on a schedule set by the BCWA. BCWA operators stated that the number of backwashes per day is limited by the backwash water holding tank capacity and the solids content that they are allowed to discharge to the sewer. The BCWA currently backwashes one filter every five hours, so one backwash cycle of all seven filters takes

about 35 hours. With the high solids content trapped in the filters, the frequency of backwashing is greatly increased. Without the high solids loading, CDM expects that the BCWA would achieve longer filter runs, reducing solids and volume of backwash.

During the recent WTP upgrades, the main piping to send backwash water up through the filters for cleaning was upgraded to 16 inches, but the individual lines connecting to each filter were left unchanged at 8 inches. CDM therefore believes that because of this hydraulic restriction, backwashing may not be properly cleaning the filters and restoring the full clean bed filtering capacity. Theoretically, it may be possible to replace the individual backwash lines to each filter, but any potential solution to this issue may not be practically achievable and could be quite expensive. There is minimal room in the existing pipe gallery and the structural integrity of the existing concrete walls surrounding the pipe gallery is unknown. Increasing the size of these individual backwash lines to each filter would also come with added risk to avoid compromising the structural integrity of the pipe gallery walls.

4.6 Disinfection

Chlorine dioxide is formed on-site by combining sodium chlorite, sodium hypochlorite and hydrochloric acid. The chlorine dioxide solution is typically generated within the range of 1800 to 2000 mg/L concentration. The BCWA installed a new chlorine dioxide generator as part of the recent WTP improvements, shown in the picture presented in **Figure 4-10**. The chlorine dioxide dose is not recorded automatically. Operators test the solution strength and based on the WTP flow rate the solution feed rate is adjusted accordingly. BCWA and CDM performed this test when on-site in September 2009 and determined on that day that the solution strength was 1940 mg/L, the WTP flow rate was 1.4 mgd, and the solution feed rate was 1.2 gpm, resulting in a chlorine dioxide dose of 2.8 mg/L. However, per conversations with the BCWA staff, the solution feed rate can be increased to 3.0 gpm providing a chlorine dioxide dose of 7.0 mg/L.

Figure 4-10
Picture of the Chlorine Dioxide Generator at the Child Street WTP

If the chlorine dioxide generator is not operating efficiently excess chlorite and chlorates can be produced in the product solution, which is subsequently injected into the water. Research has indicated that about 50 to 70 percent (by mass) of the chlorine dioxide applied during drinking water treatment is converted to chlorite. This formation can limit the chlorine dioxide dose that can be applied to water for treatment, in order to comply with the 1.0-mg/L regulatory limit for chlorite.

The application point for chlorine dioxide is limited at the WTP due to the need to both disinfect and oxidize. To effectively oxidize manganese, chlorine dioxide needs to be applied at the head of the plant so it can coagulate, precipitate and settle solids in the primary clarifier. In terms of disinfection, the chlorine dioxide needs to be added prior to the primary clarifier so that the "CT" can be achieved. The WTP clearwell contact time is not adequate to meet "CT" requirements. Because the chlorine dioxide is added before removal of NOM, the chlorine dioxide demand is greater and requires a high dose. As a primary disinfectant, chlorine dioxide has the ability to inactivate pathogens with the primary advantage being that it does not form TTHMs and HAAs from NOM precursor material as free chlorine does. Based on the data provided to meet "CT" requirements, the chlorine dioxide residual at the clarifier effluent launders is typically less than 0.2 mg/L.

As outlined in the AWWA *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, the Child Street WTP receives 2.5-log removal credit for *Giardia* and 2.0-log removal for virus for being a well-operated conventional treatment plant. The required additional 0.5-log inactivation of *Giardia* and 2.0-log inactivation of virus must be achieved through disinfection. The Child Street WTP provides inactivation as defined by "CT" (the product of disinfectant residual "C" and contact time "T_{10}") for both *Giardia* and viruses by disinfection with chlorine dioxide at the inlet to the primary clarifier. T_{10} is defined by the USEPA as the detention time within a basin or treatment unit at which 90 percent of the water passing through the unit is retained within the basin or unit. A total "CT" is calculated from the sum of the contact time for the primary clarifier and clearwell.

The required "CT" at 0.5°C is 10 for Giardia and 8.4 for Virus, and at 10°C are 4 for Giardia and 4.2 for Virus. The ratio of calculated "CT" (concentration x T_{10}) to required "CT" must be equal to or greater than one for compliance. The baffle factor for the primary clarifier is 0.5. The corresponding T_{10} is 168 minutes at 2.0 mgd and 70 minutes at 5.0 mgd. Assuming a 0.2-mg/L residual, the calculated "CT" at 2.0 mgd is 33.68, which results in a ratio of calculated/required "CT" much greater than 1. This is attributable to the high T_{10} at a flow rate that is less than the design flow rate of 3.5 mgd. However, at a flow rate of 5.0 mgd the calculated "CT" is 14.06, which results in a ratio of 1.4 for Giardia at 0.5°C.

The long contact time through the clarifier provides enough calculated "CT" to exceed the required "CT" for disinfection. With the low chlorine dioxide residual as reported in the collected data, it is not feasible that the chlorine dioxide dose could be reduced to minimize the DBP formation of chlorite. The current dose is necessary to provide a residual to meet "CT" requirements, as most of the chlorine dioxide is consumed by the oxidation of manganese and organics as well as the inactivation of pathogens.

Since chlorine dioxide does not maintain a free chlorine residual long enough to be useful as a distribution system disinfectant, the BCWA adds sodium hypochlorite to the water in the 52,000 gallon clearwell downstream of the filters to maintain a residual as water enters the distribution system. The BCWA maintain a free chlorine residual of at least 0.2 mg/L. Since the volume of the clearwell is very small and has a 0.1 baffle factor, the T_{10} is only 3.7 minutes at 2.0 mgd and provides only minor additional "CT" credits. Each filter has its own individual effluent line to the clearwell, which is located directly below. The finished water pumps withdraw water from the east side of the basin. Because there is no combined filter effluent line with finished water pumping from the opposing side of the clearwell, the water does not move in a plug flow pattern. The backwash water is withdrawn from the same side of the clearwell as the finished water pumps and therefore reduces the contact time even more when a filter is in backwash mode. The clearwell is not designed to provide any significant "CT" credits.

Because of the configuration of the existing clearwell and lack of space in the pipe gallery, we do not believe that there are any improvements (e.g., baffling or combined filter effluent pipe) that could be made to improve flow patterns and contact time. Even with additional baffles, the flow pattern would not be improved enough to warrant any baffling upgrades because of the existing clearwell's small volume.

4.7 Sludge Disposal and Wash Water Recycle

Waste solids from the WTP are generated primarily from three different locations – the filter backwash, settled solids in the circular clarifier and settled solids in the rectangular sedimentation basin. Filter backwash is sent to a backwash holding tank (wash water clarifier), with the supernatant sent back to the head of the WTP. The solids from the primary clarifier are either sent to sludge beds or a holding tank which is ultimately pumped to the sewer. The solids from the rectangular sedimentation basin are manually pumped every few years to the two lagoons (sludge beds) on-site.

Treatment and proper disposal of sludge from the treatment process can be a complex and costly operation. The sludge is largely comprised of water (which can contain dissolved contaminants), but the solids in sludge contain particles, organic compounds, chemical precipitates and pathogens which must be properly disposed of. The Child Street WTP is currently at the limit of the amount of daily solids they can discharge to the sewer. The agreement that the BCWA has with the Town of Warren allows for up to 33,000 gpd at no more than 4,000 parts per million (ppm) of solids to be disposed of to the town sewer system. This limitation may prevent any increase in treatment plant capacity unless additional solids handling is incorporated in the treatment process. Additional sludge generated would be in proportion to the increased treatment capacity. Although not part of the scope of this evaluation, CDM feels that this issue should be noted, as it will have direct impacts on any potential increase in treatment capacity unless it is addressed.

4.8 Summary of Physical & Process Limitations

Throughout the course of this evaluation, CDM has noted several limitations, both physically and with the treatment process, at the existing Child Street WTP facility. These limitations are summarized below, and include:

- As discussed in **Section 2**, the total source water available to the Child Street WTP is currently restricted without a fully operational Shad Factory Pipeline and Pump Station. In order to increase the Child Street WTP's reliable design capacity, it is first necessary to restore the capacity of the Shad Factory Pipeline and Pump Station.

- The intake screens on the Kickemuit Reservoir appear to be in poor condition, and may not be efficiently preventing solids from entering the WTP.

- The sequence of chemical application is not correct for efficient and optimum treatment process performance. Chemical application should be rearranged in the following order: chlorine dioxide, PAC, alum, potassium hydroxide.

- The new tube settlers added to the primary clarifier have been designed for 3.5 mgd, which would limit the maximum treatment capacity of the entire plant should greater plant capacities be desired.

- The chlorine dioxide is added at the primary clarifier to oxidize manganese and to achieve the required contact time for primary disinfection. The dose is based on the chlorine dioxide demand, quality of the raw water and the ability to maintain a residual. In order to meet the "CT" requirements for primary disinfection the chlorine dioxide dose cannot be reduced which results in a chlorite concentration that exceeds the regulatory limit.

- With an elevated chlorite concentration the sedimentation basin must be utilized for ferrous chloride addition. With short circuiting and lack of sludge removal there is a significant deterioration of water quality in the sedimentation basin. This water quality degradation has a direct effect on the filtration process.

- High turbidity levels leaving the sedimentation basin puts excessive load on the filters to reduce turbidity to within regulatory limits. With the high solids content trapped in the filters, the frequency of backwashing and the amount of solids generated from backwashing is increased.

- Since the clearwell has minimal detention time and cannot be effectively baffled, only minor credits are received for "CT" requirements for disinfection.

- The WTP sludge discharge to the sewer is limited to 33,000 gpd at no more than 4,000 ppm. An increase in sludge production may require additional solids handling.

- The current drain piping configuration (a 16-inch pipe feeds individual 8 inch pipes) in the filter gallery restricts the total amount of backwash water that can be used for properly backwashing the filters.

Section 5
Treatment Alternatives

Based on CDM's review of historical water quality data and the treatment processes at the BCWA Child Street WTP, as well as current and future regulatory requirements, potential treatment alternatives were developed to increase the reliable treatment capacity of the WTP. This section presents a disinfection analysis, provides a summary of alternate disinfectants, discusses CDM's bench and full scale testing, provides alternatives evaluations for treatment options, and provides a summary matrix of feasible treatment alternatives with advantages, disadvantages and preliminary estimates of probable construction and engineering costs.

The alternatives evaluation for treatment options is presented for two primary objectives. The original intent and scope of this analysis is to increase the capacity of the WTP to its original full design capacity of 5.0 mgd. CDM developed two alternatives that would reduce the DBP chlorite, meet disinfection requirements, oxidize and remove manganese, improve operations, and meet all regulatory requirements. These two alternatives are based upon an alternative means of primary disinfection.

After reviewing the draft report, the RIWRB and BCWA requested that CDM develop potential improvements to maximize the existing WTP processes. This evaluation specifically required determining the maximum capacity of the existing sedimentation basin. CDM also re-evaluated the disinfection alternatives at a reduced flow rate for a means of present worth comparison.

5.1 Disinfection Analysis

CDM evaluated, in-depth, the current disinfection practices and process implications at the WTP for both primary and secondary disinfection. Based on process and hydraulic limitations, alternative disinfectants were evaluated for implementation at the WTP.

5.1.1 Existing Disinfection Practices

As discussed in **Section 3**, the SWTR requires a minimum 3-log removal of *Giardia* and a 4-log removal of viruses through a combination of removal via filtration and inactivation via disinfection. A disinfectant residual above 0.2 mg/L entering the distribution system and a detectable residual level throughout the distribution system must be maintained to minimize heterotrophic plate counts (HPCs).

As discussed in **Section 4**, the Child Street WTP receives 2.5-log removal credit for *Giardia* and a 2.0-log removal for viruses for being a well-operated conventional treatment plant with removal through filtration. The additional required 0.5-log inactivation for *Giardia* and 2.0-log inactivation for viruses must be achieved through disinfection.

The Child Street WTP currently provides inactivation as defined by "CT" (the product of disinfectant residual "C" and contact time "T") for both *Giardia* and viruses by disinfection with chlorine dioxide. As discussed in **Section 4**, chlorine dioxide is added to the center of the primary clarifier for primary disinfection. Sodium hypochlorite is added to the clearwell to provide a disinfection residual in the distribution system. The chlorine disinfection with sodium hypochlorite provides minimum "CT" credit. The total "CT" is calculated by adding the individual chlorine dioxide and sodium hypochlorite "CTs".

Based on monthly reporting forms that the BCWA submitted to HEALTH and provided copies to CDM, they currently use a baffling factor of 0.5 for the primary clarifier and 0.1 for the clearwell. The baffling factor for the primary clarifier has not been verified since before the tube settlers were installed.

With a residual of 0.2 mg/L at a flow rate of 2.0 mgd, the T_{10} is 176 minutes and the calculated "CT" ratios are about 4 at 0.5°C and 8 at 10°C. In order to determine that proper disinfection has been achieved, the ratio of the calculated "CT" to the required "CT" (per USEPA regulations) must be equal to or greater than 1. Currently, the BCWA's "CT" ratio ranges based on temperature and flow from 4 to 30, which is a result of the very high contact time in the primary clarifier and not the chlorine dioxide residual. The high contact time in the clarifier is a result of the low capacity that the plant is currently being operated at and the volume of the primary clarifier, 1.5 to 2.0 mgd and approximately 480,000 gallons, respectively.

CDM also evaluated the BCWA's existing disinfection practices at potential increased treatment capacities. If the current disinfection practices were to occur at an increased rate of 5.0 mgd, then the T_{10} would be reduced to 70 minutes. The "CT" ratio would be 1.4 with a residual of 0.2 mg/L at 0.5°C. As the "CT" ratio would be close to 1, the chlorine dioxide dose and residual would have to be monitored very closely. The use of chlorine dioxide at the primary clarifier is possible assuming that the baffling factor is indeed 0.5 and a residual of 0.2 mg/L is maintained. A tracer study would need to be performed at high flow rates to confirm. High chlorite concentrations resulting from the chlorine dioxide would still need to be treated with ferrous chloride at increased flow rates.

The BCWA currently adds sodium hypochlorite just prior to the clearwell as a secondary disinfectant. The clearwell is undersized to provide primary disinfection, with a small volume of 52,000 gallons. The contact time of the clearwell is reduced even more by its low baffling factor, providing only mere minutes towards the "CT" disinfection requirement. The BCWA therefore adds sodium hypochlorite for the sole purpose of meeting the 0.2-mg/L distribution residual requirement per SDWA regulations. As discussed in **Section 4**, additional baffling will not provide significant improvement and is not acceptable for meeting "CT" requirements.

5.1.2 Alternative Primary and Secondary Disinfectants

One of the primary objectives of this evaluation is to reduce the chlorite formation and improve treatment operations. In order to reduce chlorite formation, the chlorine dioxide would need to be reduced. CDM therefore assessed alternative disinfectants so that the BCWA could use the chlorine dioxide for oxidation of manganese only, and greatly reduce the required dose since it would no longer be needed as a disinfectant. The following paragraphs discuss each alternative disinfectant in more detail.

5.1.2.1 UV Disinfection

One alternative primary disinfectant is ultraviolet (UV) disinfection. To-date, UV has had a wide variety of applications for disinfection of wastewater, and is becoming far more prevalent for potable water disinfection. UV light is the name used to describe electromagnetic radiation having a wavelength between 100 and 400 nanometers (nm). A portion of this spectrum, known as the "germicidal range" is the part that is effective for disinfection. UV inactivates microorganisms by transforming their DNA and altering their genetic code as UV light is absorbed. This prevents the microorganisms from replicating. Current UV disinfection used in drinking water applications employs different types of lamp technologies – low pressure, low intensity; low pressure, high intensity; and medium pressure, high intensity.

The primary advantage of UV disinfection is that it does not require any chemical addition and therefore does not produce DBPs. UV disinfection can be added at the end of the treatment process for the inactivation of *Giardia* and *Cryptosporidium*. However, UV disinfection has been found to be relatively ineffective at inactivating viruses. The genetic makeup of viruses differs from other pathogens, and because of this, they are less sensitive to UV light. An additional 2-log removal for virus by sodium hypochlorite would still be required. This sodium hypochlorite application would also suffice as the secondary disinfectant to provide a distribution residual, which would be required anyway.

The existing clearwell at the Child Street WTP would not provide enough "CT" for virus inactivation. Applying chlorine at the top of the filters would provide the required time to meet the "CT" requirements. Testing would be required to confirm the contact time and ensure that TTHMs would not become an issue. An alternative to this option would be to construct a new well baffled clearwell downstream of the UV reactors.

5.1.2.2 Sodium Hypochlorite

Another alternative primary and secondary disinfectant is sodium hypochlorite. Sodium hypochlorite could be used to provide the 0.5-log *Giardia* and 2-log virus inactivation along with providing the required distribution residual. However, the existing clearwell is not sized or configured appropriately to accomplish the "CT" requirements and a new, larger clearwell would need to be constructed. The primary

advantages of chlorine as a primary disinfectant are that it is the most widely used compound for disinfection of water in the United States and is fairly easy for treatment plant operators to use. The major disadvantage is that it reacts with natural organic matter (NOM) in water to form chlorinated DBPs that are regulated by the USEPA. Simulated Distribution System (SDS) testing would first be required to determine the formation potential of TTHMs under this treatment scenario.

5.1.2.3 Ozone

Ozone is a third option for primary disinfection and it is also a strong oxidant. Several issues exist with the use of ozone. Ozone must be piloted to ensure effectiveness with the specific source water and is also expensive (both capital and operating costs) when compared to other disinfectants. Ozone typically tends to oxidize organics first followed by manganese. In the case of BCWA, the goal of oxidization is primarily for manganese while organics oxidation is a secondary goal. Chlorine dioxide, which the BCWA currently uses, is better suited for initial manganese oxidation. CDM determined from the review of the BCWA's historical water quality data and through our own on-site water quality analysis that chlorine dioxide does effectively oxidize manganese and should continue to be used solely for this purpose.

5.2 Bench Scale Testing

CDM conducted bench scale testing on September 23rd and 24th, 2009 to assess the effect that chlorine dioxide has on the clarification process in terms of manganese oxidation and organics removal in the event that the chlorine dioxide dose was reduced. The original intent was to collect water with chlorine dioxide from the treatment process prior to any other chemical applications. The clarified water with chlorine dioxide would be compared to clarified water without chlorine dioxide to determine the impact on organics removal. However, the chlorine dioxide is currently added at the primary clarifier after coagulant addition. Typically, chlorine dioxide is fed at the head of a plant for immediate oxidation without interference from other chemicals. BCWA staff indicated to CDM that chlorine dioxide could not be applied at the head of the plant at this time.

Therefore, CDM altered its approach for the bench scale testing in an attempt to determine any negative impact on organics/manganese oxidation with reduced chlorine dioxide doses. Two sets of coagulation jar tests were completed as follows:

- Raw water, aluminum sulfate and potassium hydroxide
- Raw water, aluminum sulfate, potassium hydroxide and chlorine dioxide.

CDM originally planned to conduct this testing during the summer month of August when water quality is typically poorer and manganese levels are elevated. But, due to unforeseen distribution regulatory issues that the BCWA encountered in late August, the jar testing had to be rescheduled for the end of September 2009. In September 2009, the source water quality of the Kickemuit Reservoir had improved and CDM

found that it had very low levels of manganese. In fact, the dissolved manganese was below regulatory requirements and did not require any further removal. Because manganese can be quite problematic for the BCWA with their current treatment process, CDM felt that it was important to assess the oxidation potential of manganese with chlorine dioxide.

The BCWA provided several samples of raw water from different locations in their source water system. After analyzing all the raw water, CDM used the water sample collected from the head of the Kickemuit Reservoir for jar tests. This water had the highest manganese concentration of all the source waters and was more influenced by the Kickemuit River, which provides water to the Kickemuit Reservoir. CDM felt that this water was therefore more representative of that withdrawn by the Child Street WTP through the intake of the Kickemuit Reservoir and provided a conservative analysis for elevated manganese levels.

Because the raw water was not identical to that being treated by the WTP during the bench scale testing, six different doses of alum were applied to the jars to determine the optimized coagulant dose for this particular water. Alum was applied for coagulation and potassium hydroxide for pH adjustment. The appropriate combination that CDM determined was 70 mg/L of alum with a pH adjustment to 6.1 for optimal coagulation for turbidity and organics removal.

Once CDM determined the optimum coagulant dose, a second set of jar tests was performed with the optimized coagulant dose and various chlorine dioxide doses. The chlorine dioxide doses that CDM applied to the jars were based on current WTP practices and incrementally smaller doses to determine the effect that the chlorine dioxide has on oxidizing organics and manganese. The data collected by CDM during these bench scale jar tests is summarized in **Table 5-1. Table 5-1** includes raw water quality, the clarified effluent without chlorine dioxide and five jars each with different doses of chlorine dioxide. It should be noted that dosing chlorine dioxide in a jar for oxidation does not exactly simulate the dose that would be applied full scale.

All of the results from the jar tests indicated a similar turbidity removal. The turbidity of the raw water was 3.0 NTU and clarified water from all of the jar tests was less than 0.3 NTU, as shown in **Figure 5-1**. The total manganese measured in the raw water during the jar tests was 0.337 mg/L. Based on the monthly maximum historical data we would not typically expect manganese levels higher that 0.3 mg/L except during extreme weather conditions. The total manganese measured in the raw water was comprised significantly of dissolved manganese and therefore can effectively be oxidized by chlorine dioxide.

Figure 5-2 shows the high level of manganese in the raw water and various levels of oxidization that occurred in each jar during the bench scale testing. The dissolved manganese in Jar 1 that is greater than the raw water appears to be a result of the sampled water not being uniform or a field error in sampling or filtering. Regardless,

	Raw Water	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
CHEMICALS							
1 Alum(mg/L)	0	70	70	70	70	70	70
2 KOH (mg/L)	0	10	10	10	10	10	10
3 ClO2 (mg/L)	0	0.0	2.4	1.0	0.8	0.6	0.4
Coagulation pH		6.1	6.1	6.1	6.1	6.1	6.1
ANALYSIS OF SETTLED WATER							
pH	7.1	6.5	6.5	6.6	6.6	6.6	6.6
Alkalinity (mg/L)	47	25	29	29	32	32	32
Apparent Color	43	0	1	1	0	0	0
True Color	6						
Turbidity (NTU)	3.00	0.24	0.26	0.16	0.15	0.20	0.23
UV 254	0.042	0.011	0.005	0.003	0.000	0.004	0.001
Aluminum (mg/L)		0.135	0.214				
Total Manganese (mg/L)	0.337	0.291	0.033	0.085	0.068	0.088	0.101
Dissolved Manganese (mg/L)	0.242	0.274	0.013	0.075	0.062	0.069	0.094
Total Iron (mg/L)	0.239	0.040	0.015				0.014
Dissolved Iron (mg/L)	0.056					0.02	
Chlorine Dioxide (mg/L)			0.16	0.02	0.02	0.02	0.02
Chlorite (mg/L)			1.599	0.704	0.605	0.493	0.553
TOC	3.10	2.00	1.40	1.40	1.30	1.20	1.30
DOC	3.00	1.80	1.30	1.30	1.20	1.30	1.20
SUVA	1.400	0.611	0.385	0.231	0.000	0.308	0.083

Date: September 24, 2009

Sample Temperature: 22.7 ºC

WTP Flow Rate = 1.4-mgd

ClO_2 dose = 2.8-mg/L

Table 5-1
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Bench Scale Testing Data and Results

CDM

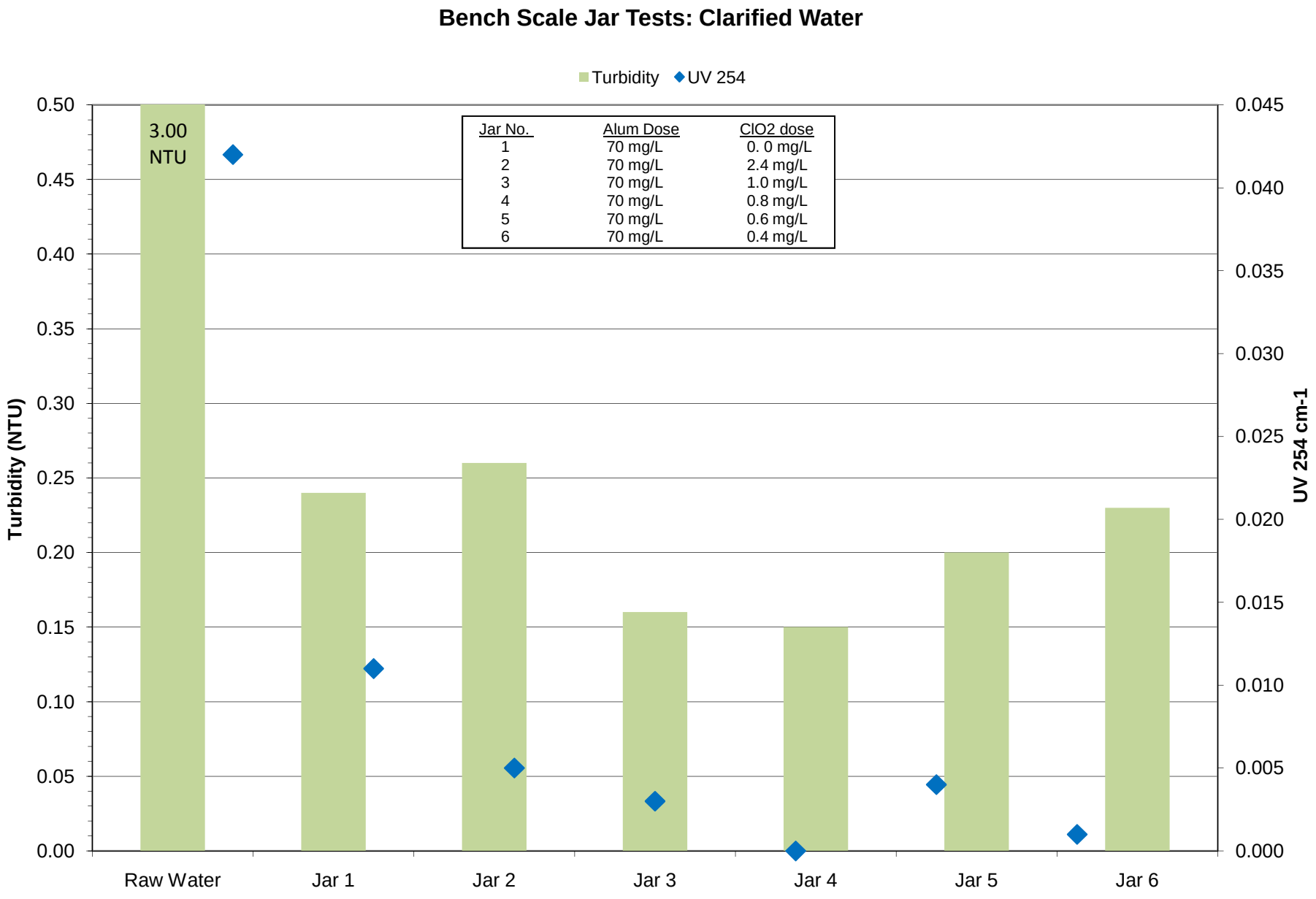


Figure 5-1
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Bench Scale Jar Test Results: Clarified Water Turbidity and UV254

CDM

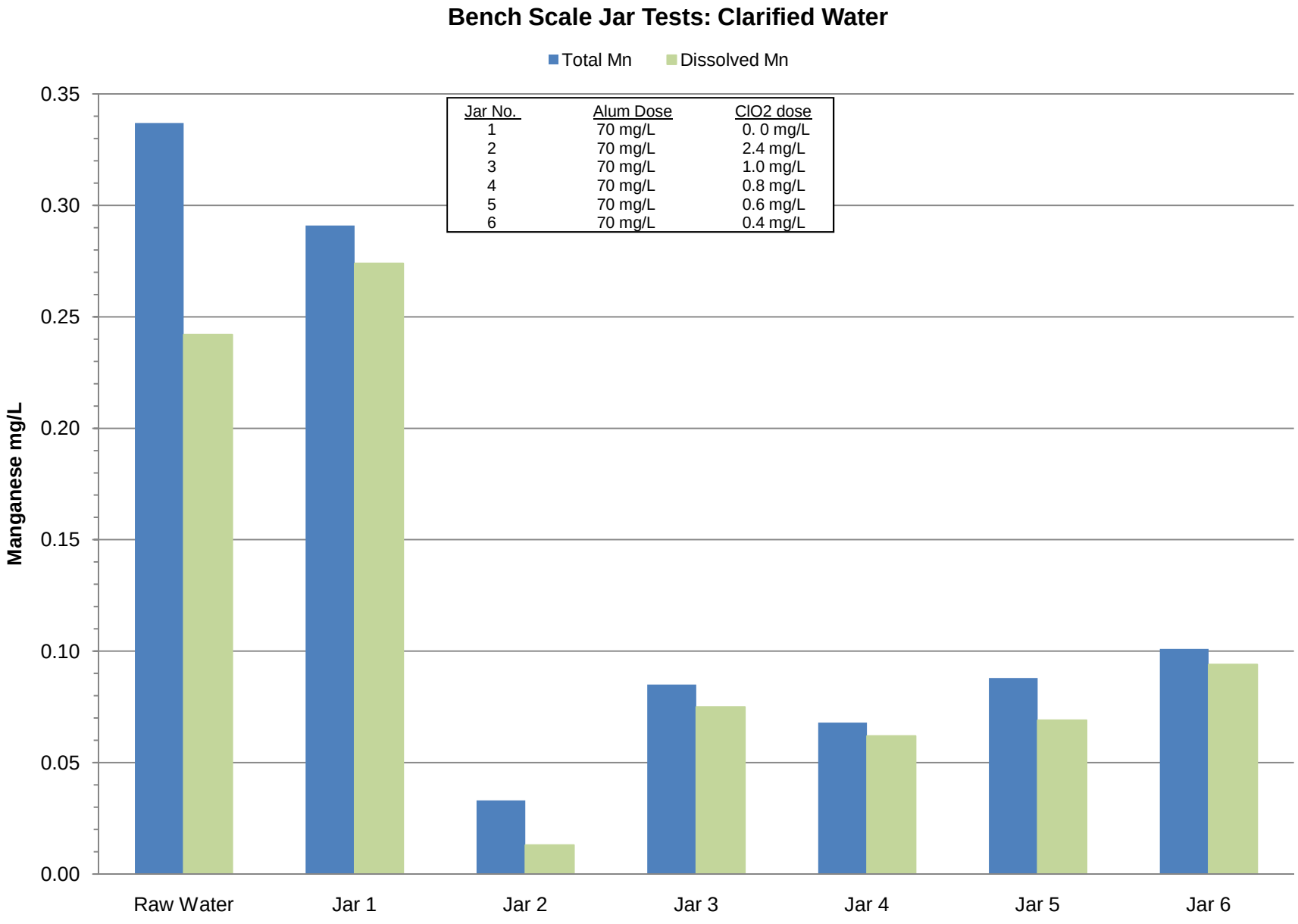


Figure 5-2
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Bench Scale Jar Test Results: Clarified Water Manganese

CDM

these jar tests indicate the oxidizing power of chlorine dioxide for the removal of manganese. **Figure 5-3** compares the organic content of the raw water with the treatment of each jar test. In general, the chlorine dioxide appears to also be oxidizing some of the organic material, by a reduction of about 0.6 mg/L. It should be noted that the organics in the raw water provided by the BCWA for the bench scale testing are much less than that at the intake of the WTP. The jar test data therefore indicates that chlorine dioxide does oxidize some organics, but not a significant amount. A reduced chlorine dioxide dose for oxidation of manganese will also aid in some oxidation of organics and the remainder should be removed through the coagulation/clarification process.

5.3 Full Scale Testing

While CDM was conducting the jar tests, samples were collected at each stage in the full scale WTP process. The raw water from the Kickemuit Reservoir was different than that used for the jar tests, so the water quality parameters were not fully comparable. However, the data collected provided further insight into the existing treatment process. The full scale data that CDM collected is summarized in **Table 5-2**. The sample collected to represent filter effluent was taken from the common drain of the individual filter turbidimeters. Typically, a sample port is available from one main turbidimeter that measures combined filter effluent. But, since there is no combined filter effluent pipe at the Child Street WTP, this was the only means to take a representative sample from the filter effluent. Since all the filters flow individually to the clearwell, this was the only available way to assess the filter effluent in the full scale process.

The turbidity removal through the treatment process indicates removal by the primary clarifier and the filters. As shown in **Figure 5-4**, the recycle stream and the sedimentation basin turbidity levels are significantly greater than the raw water. The additional turbidity added by the use of ferrous chloride to reduce chlorites and the excessive sludge in the sedimentation basin must also be removed by the filters. The clarifier performs quite well at removing turbidity, but additional solids and particulates are reintroduced in the sedimentation basin and increase the turbidity, which carry over to the filters. These solids are captured in the filters and essentially returned to the process through the recycle stream.

The total and dissolved manganese concentrations throughout the treatment process are presented in **Figure 5-5**. This data provides further insight into CDM's suspicions regarding the historical water quality data where higher manganese levels were detected in the plant effluent than in the raw water. There are two sources of manganese within the treatment plant – the filter backwash recycle and the sedimentation basin. Manganese in the sedimentation basin is reintroduced by both the ferrous chloride and the sludge. The manganese in the sedimentation basin is carried onto the filters. The filters remove a portion of the manganese which is eventually backwashed and returned through the recycle stream.

Jar No.	Alum Dose	ClO2 dose
1	70 mg/L	0. 0 mg/L
2	70 mg/L	2.4 mg/L
3	70 mg/L	1.0 mg/L
4	70 mg/L	0.8 mg/L
5	70 mg/L	0.6 mg/L
6	70 mg/L	0.4 mg/L

Figure 5-3
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Bench Scale Jar Test Results: Clarified Water TOC and DOC

CDM

Source	Raw	Recycle	Clarifier Effluent	Sedimentation Basin Effluent	Filter Effluent	Plant Effluent
	RAW	RECYCLE	CE	SBE	CFE	PE
pH	7.1	7.3	5.7	7.7	7.6	7.4
Alkalinity (mg/L)	26.0		55.0	23.5	23.0	22.5
Apparent Color	47	55	6	33	2	1
True Color	39		2	2	3	2
Turbidity (NTU)	0.75	2.40	0.44	1.45	0.45	0.09
UV 254 (cm-1)	0.273	0.105	0.091	0.049	0.054	0.045
Aluminum (mg/L)			0.186			
Total Manganese (mg/L)	0.044	0.091	0.033	0.050	0.028	0.014
Dissolved Manganese (mg/L)	0.024	0.062	0.033	0.037	0.025	0.014
Total Iron (mg/L)	0.232					0.080
Dissolved Iron (mg/L)	0.192					
Chlorine Dioxide (mg/L)			0.06	0.02	0.02	0.04
Total Chlorine (mg/L)						0.48
Free Chlorine (mg/L)			0.03			0.35
Chlorite (mg/L)			1.188			0.373
ORP (mv)	243		625	417	395	685
Temp (deg C)	21.9	24.6	22.2	22.5	22.6	22.6
TOC (mg/L)	8.2		3.5	3.2	2.9	2.8
DOC (mg/L)	8.2		3.1	2.9	2.7	2.6
Recycle (On/Off)	On		On	On	On	On
SUVA	3.329		2.935	1.690	2.000	1.731

Date: September 23, 2009

Table 5-2
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Full Scale Testing Water Quality Data and Results

CDM

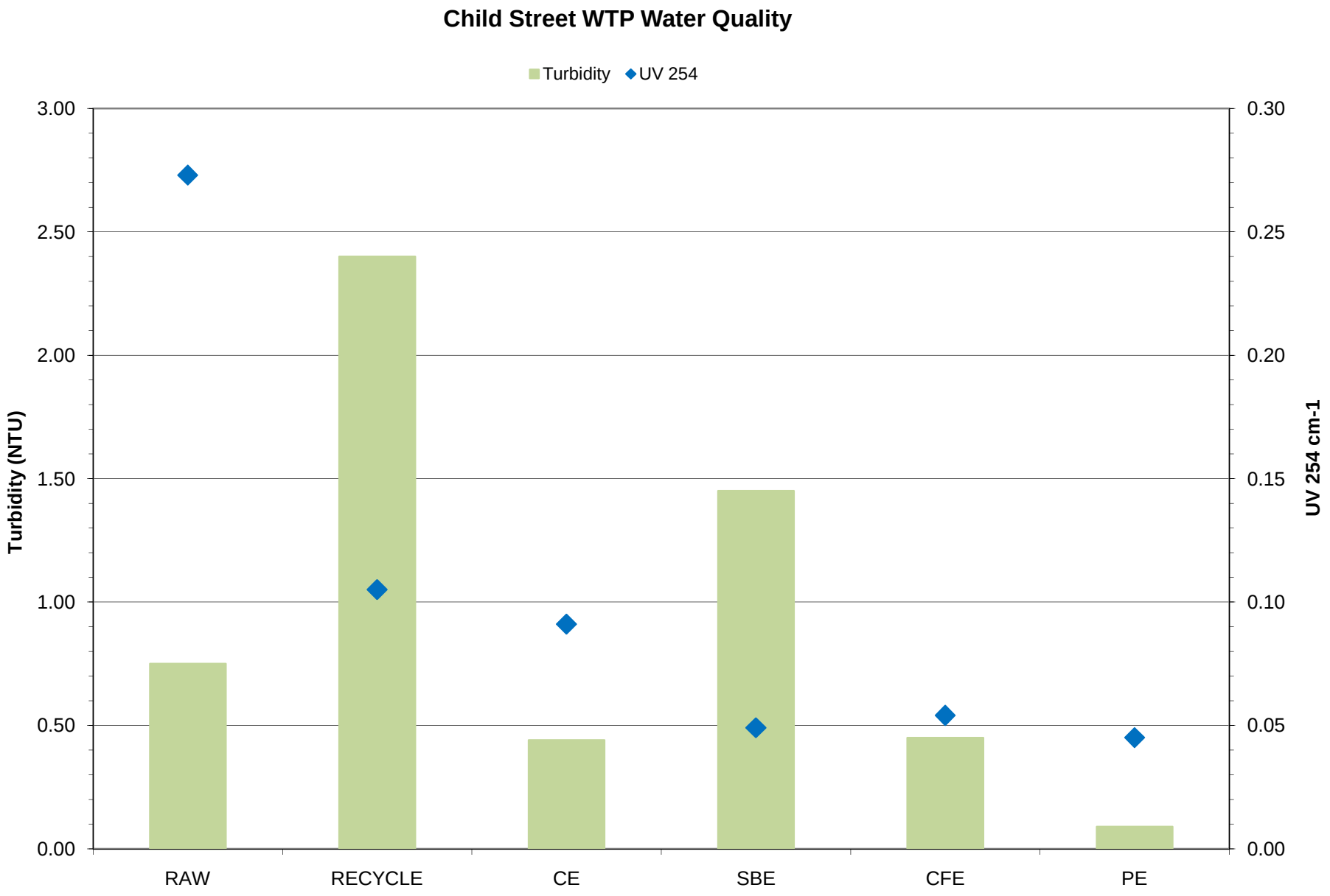


Figure 5-4
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Child Street WTP Water Quality: Turbidity and UV254

CDM

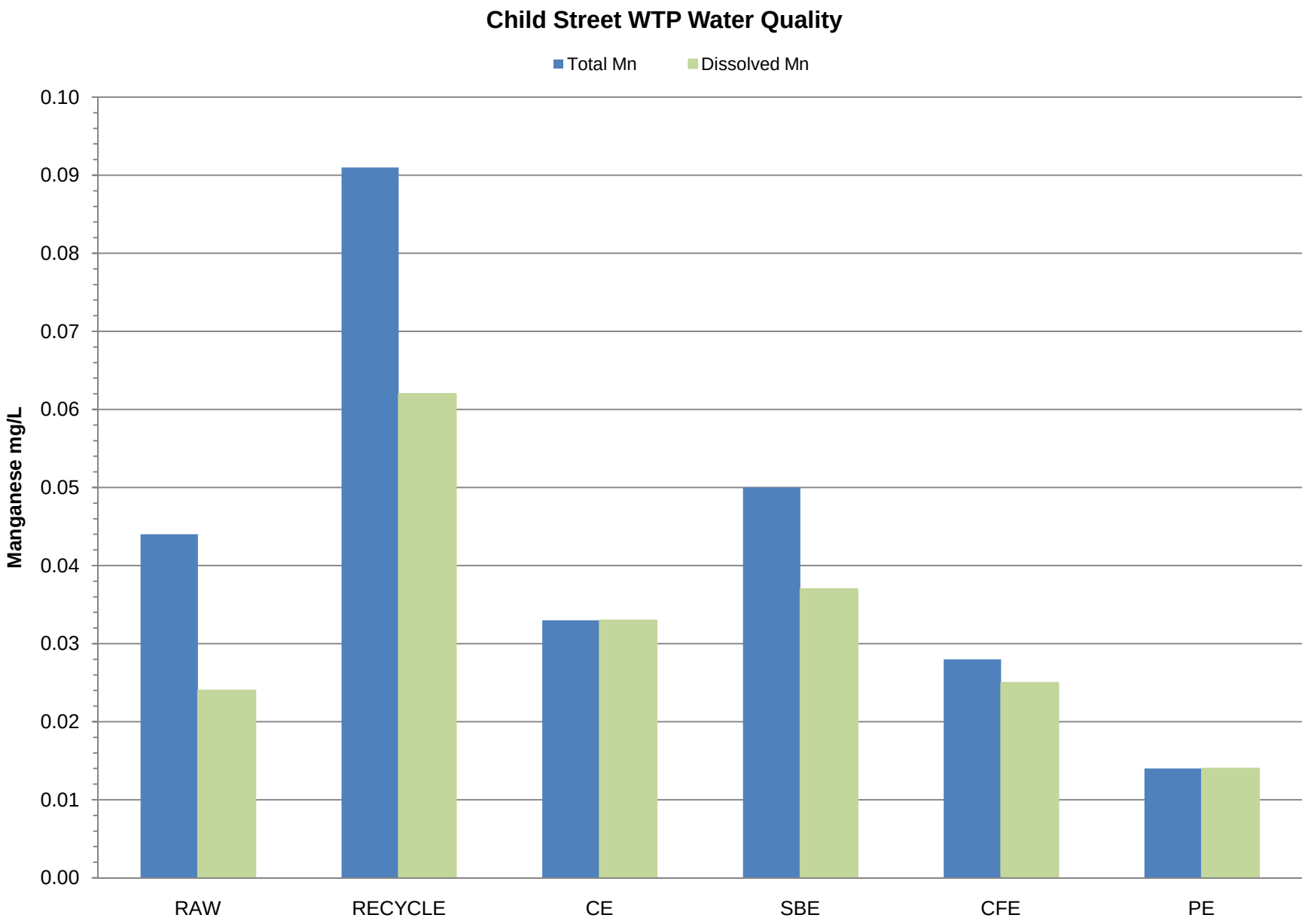


Figure 5-5
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Child Street WTP Water Quality: Manganese

CDM

CDM also measured the UV254 for each step in the process. The results indicate that organics are primarily removed in the circular clarifier and are not reintroduced by any downstream processes. The results also indicate that TOC and DOC appear to be removed in the primary clarifier, as displayed in **Figure 5-6**. Also of interest was that the chlorite formed in the primary clarifier was only slightly above the limit of 1.0 mg/L at a concentration of 1.188 mg/L. The concentration of chlorite in the plant effluent was 0.373 mg/L, indicating the ferrous chloride dose was more than necessary as the concentration was well below the regulatory limit. Although the primary clarifier removed most of the color in the water, the color is increased again to levels close to the raw water because of the use of ferrous chloride. The color increase is subsequently removed by the filters.

The results of the full scale laboratory measurements indicate that the addition of ferrous chloride in the sedimentation basin is significantly complicating the operation of the treatment process. The sedimentation basin effluent has significantly worse water quality than the clarifier effluent with regards to color, turbidity and manganese. The sedimentation basin dissolved manganese is similar to that of the clarifier effluent but the total or particulate manganese increased. The increase in all these parameters is most likely due to the lack of solids removal and the addition of ferrous chloride, which can also be a source of manganese.

To exacerbate this problem, additional solids are stirred up in the sedimentation basin due to a lack of automatic sludge collection. These solids are then discharged onto the filters, limiting the total available filtering capacity. When the filters are backwashed, the solids are discharged to the washwater clarifier. The supernatant from the washwater clarifier is returned as recycle to the head of the process. Eliminating the solids carryover from the sedimentation basin effluent would improve the operation of the filters and recycle.

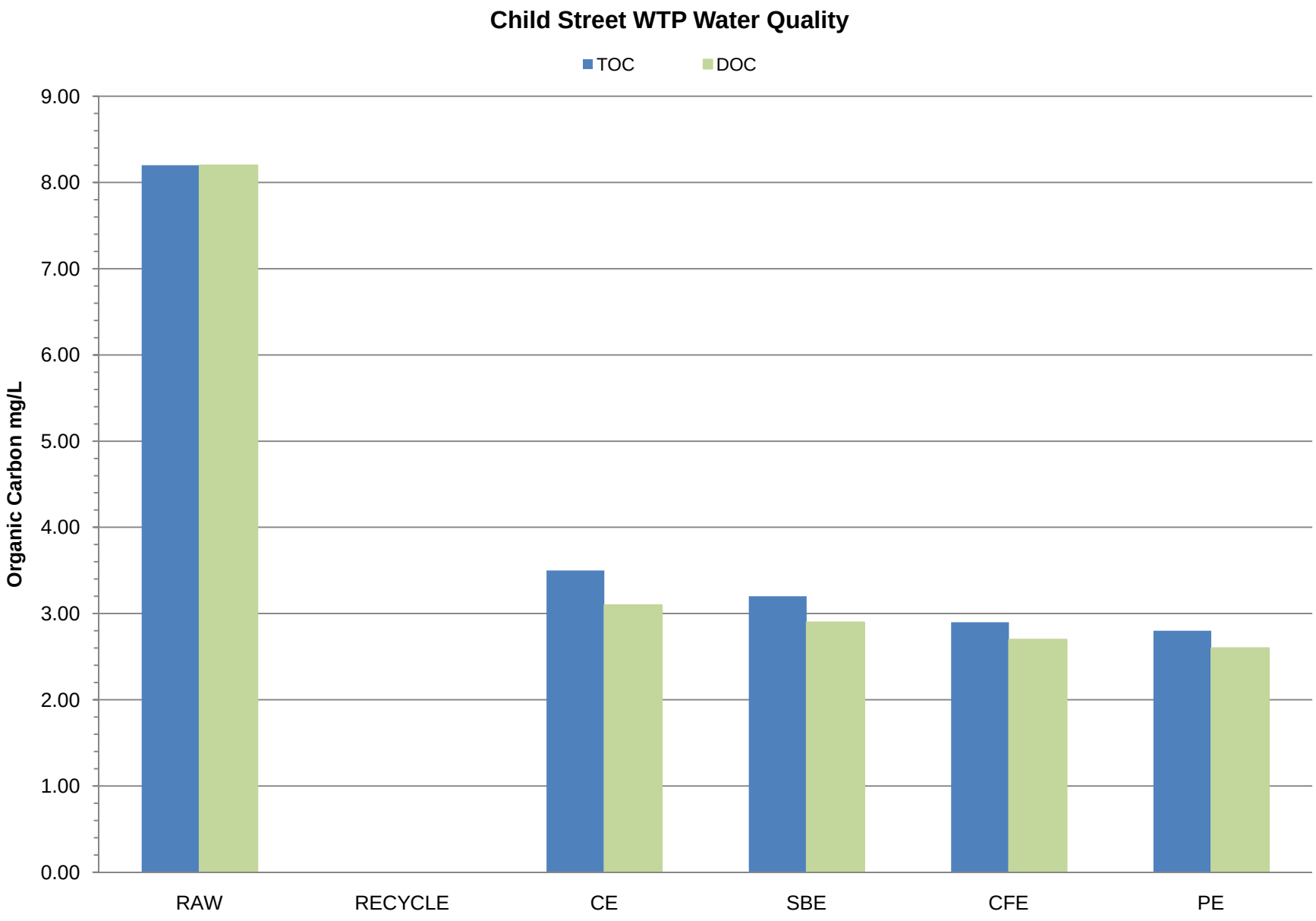


Figure 5-6
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Child Street WTP Water Quality: TOC and DOC

CDM

5.4 Treatment Alternatives – 5.0 MGD WTP Capacity

Based on CDM's review of the historical water quality data, plant performance, bench and full scale testing results, various treatment alternatives were developed to increase the reliable capacity of the WTP to its original capacity of 5.0 mgd. The alternatives are to address the limitations discussed herein and to increase current capacity and improve operations at the Child Street WTP. Since we considered reducing the chlorine dioxide demand in order to reduce chlorite formation, we considered alternative means of disinfection (discussed earlier in this section) paramount to developing the treatment alternatives for a 5.0 mgd capacity. Since oxidation of manganese in the source water will still be required, and CDM's bench scale testing indicates that chlorine dioxide effectively removes manganese, the chlorine dioxide will still be needed as an oxidant, albeit at a much reduced dose.

5.4.1 Pretreatment

Regardless of the primary disinfection employed, chlorine dioxide will still be required for manganese oxidation. In order to optimize the oxidation capabilities of chlorine dioxide, the chemical application point should be relocated to the head of the plant prior to any other chemical addition. If PAC is required for taste and odor issues it should be added after chlorine dioxide, as it will consume some of the chlorine dioxide. In order to fully optimize the use of PAC, 20 minutes of contact time would be required. A new, baffled 50,000 gallon contact tank for PAC with approximate dimensions of 18 feet by 18 feet by 20 feet deep would provide this contact time up to 5 mgd. Alum and potassium hydroxide can then be added with mixing to provide coagulation in the primary clarifier.

5.4.2 Primary Clarifier

The primary clarifier, described in **Section 4**, currently serves several purposes – flocculation, clarification and application of chlorine dioxide for oxidation and primary disinfection. As discussed earlier, a 6-foot width of tube settlers were designed by Maguire Group, Inc. in their 2001 evaluation for 3.5 mgd. In order to treat up to 5.0 mgd, an additional 3 feet of tube settlers would be required.

5.4.3 Sedimentation Basin

Based on the water quality evaluation, process evaluation, bench and full scale testing, the primary factor limiting the treatment capacity of the WTP is the addition of ferrous chloride in the sedimentation basin. The sole purpose for the sedimentation basin is to reduce the DBP chlorite with ferrous chloride to meet regulatory requirements. The ferrous chloride, resuspension of solids, and short circuiting in the sedimentation basin cause solids to carry over onto the filters. The solids cause the filters to become limited by reducing the run time and requiring frequent backwashing.

In order for the WTP to operate at an increased capacity with the existing process, adequate settling of the ferrous chloride floc will be required in the sedimentation

basin. The surface overflow rate of the sedimentation basin is too high at 5 mgd to provide adequate settling even if improvements were made to the basin. At an increased flow rate the ferrous floc would still impact the filters and in turn limit the treatment capacity. The existing treatment process is therefore not adequate for an increased capacity of 5 mgd.

With an alternative primary disinfection practice (to be discussed in the following paragraphs) and the use of chlorine dioxide for only manganese oxidation, CDM anticipates that the chlorite concentration would be less than the regulatory requirement of 1 mg/L. Since chlorites would no longer need to be mitigated by applying ferrous chloride, the sedimentation basin would not be needed for this proposed process at 5.0 mgd.

5.4.4 Filters

The existing filter media could be replaced with granular activated carbon (GAC) to utilize the existing treatment process at increased capacities. GAC will remove any excess chlorite and ferrous chloride would no longer be required. CDM evaluated the current filter underdrain system, which was upgraded in 2004/2005, and has concluded that this option is not feasible because they are constructed of Type 304SS, which would be damaged by direct contact with GAC. In order to install GAC filters, the entire filter system would need to be rebuilt. CDM does not feel that this would be cost effective, given that the filters were recently upgraded.

In the event the treatment capacity is increased to 5.0 mgd, the filters may be limited due to the depth of filter media. The troughs could be raised 1 foot and additional 12 inches of anthracite coal media could potentially be added.

5.4.5 Disinfection Alternatives

An alternative to the existing disinfection process is to provide a different form of primary disinfection, as previously discussed. To reduce chlorite concentration, we recommend only using a chlorine dioxide dose to provide oxidation of manganese and not to be used as a primary disinfectant. Under this scenario, industry guidelines indicate that the chlorite would be less than 1.0 mg/L and subsequent removal of the chlorites would not be required. However, a new primary disinfectant method would be needed to achieve the necessary "CT" per regulatory requirements.

There are two options that have been considered as an alternative means for primary disinfection – UV light and sodium hypochlorite. Both of these methods for primary disinfection will require additions and upgrades to the Child Street WTP.

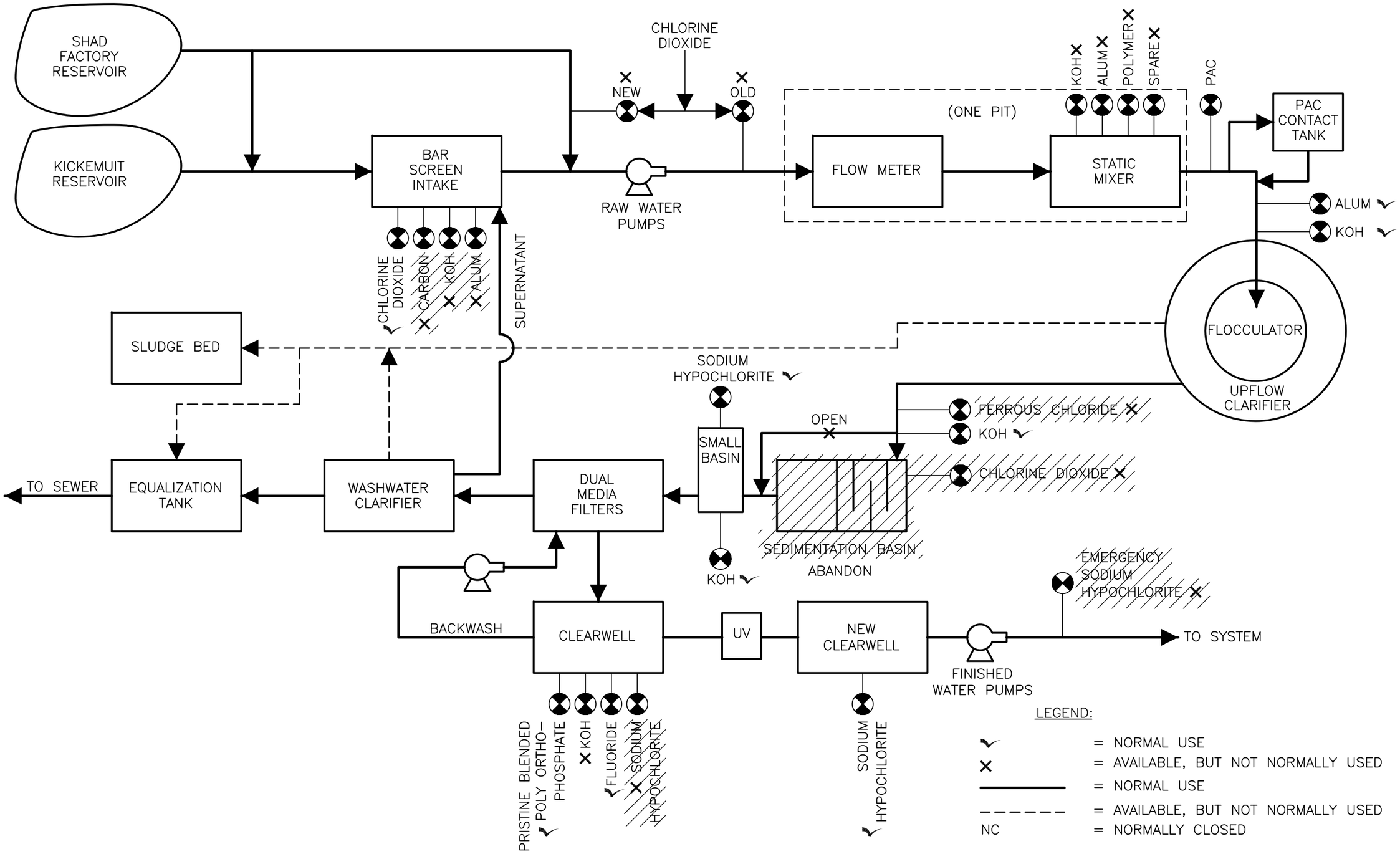
UV disinfection requires a new building to house the UV reactors. The UV building would require an approximate 25-feet square footprint and two levels. Associated piping connections and electrical supply would also be required. The reactors would provide the proper log removals for *Giardia* and *Cryptosporidium*. Sodium hypochlorite would still be required for virus inactivation but would require

substantially less contact time than that needed for *Giardia*. To achieve the required "CT" for virus inactivation of 6 at 0.5°C and 3 at 10°C, the sodium hypochlorite would need to be added to the top of the filters to provide enough contact time. Testing would be required to ensure that TTHM levels and contact time are acceptable. A process flow diagram of this alternative is included in **Figure 5-7**. If testing indicated that sodium hypochlorite could not be added to the top of the filters then a new, well baffled, 70,000 gallon clearwell would need to be constructed downstream of the UV reactors. The improvements to the Child Street WTP site plan are shown schematically in **Figure 5-8**. The process flow diagram and site plan includes the relocated chemical application points, PAC contact tank, upgrading the primary clarifier and the UV building.

In order to meet CT requirements using sodium hypochlorite as a primary disinfectant, a new, larger and well baffled clearwell would need to be constructed. Assuming a 0.5 baffling factor for a conservative design approach, a "CT" of 46 and 22 would be required at 0.5°C and 10°C, respectively. To treat 5.0 mgd, we estimate that a new 210,000 gallon underground concrete clearwell with a gravity flow pipeline from the existing clearwell would need to be constructed. The new clearwell would have approximate dimensions of 50 feet by 80 feet by 10 feet deep and will require baffle walls. Three new vertical turbine pumps would be located at the end, each estimated to have a design capacity of 1,750 gpm at 85 psi, 90 horsepower (hp) (based on current operations). A process flow diagram of this alternative is included in **Figure 5-9**. The improvements to the site plan are shown in **Figure 5-10**. The process flow diagram and site plan includes the relocated chemical application points, PAC contact tank, upgrading the primary clarifier and the new clearwell (for 5.0 mgd).

5.4.6 Solids Handling

Increased sludge volumes from the primary clarifier are expected if treatment capacity is increased. Since it appears that the BCWA is currently at the maximum limit of what can be discharged to the sewer, additional solids handling will need to be added to the treatment plant. There are several options that can be evaluated further, if required. A thickener could be installed to optimize the solids being discharged to the sewer so that the maximum flow and percent solids are discharged. Additional solids that still need to be removed can be discharged to the lagoons. An alternative to this approach is to install dewatering equipment that can be used to process sludge from the treatment process such as a plate and frame filter press. The processed sludge would then need to be hauled to an outside facility. The filter press would require a new building to be housed in with access for a tanker truck for loading of process sludge.

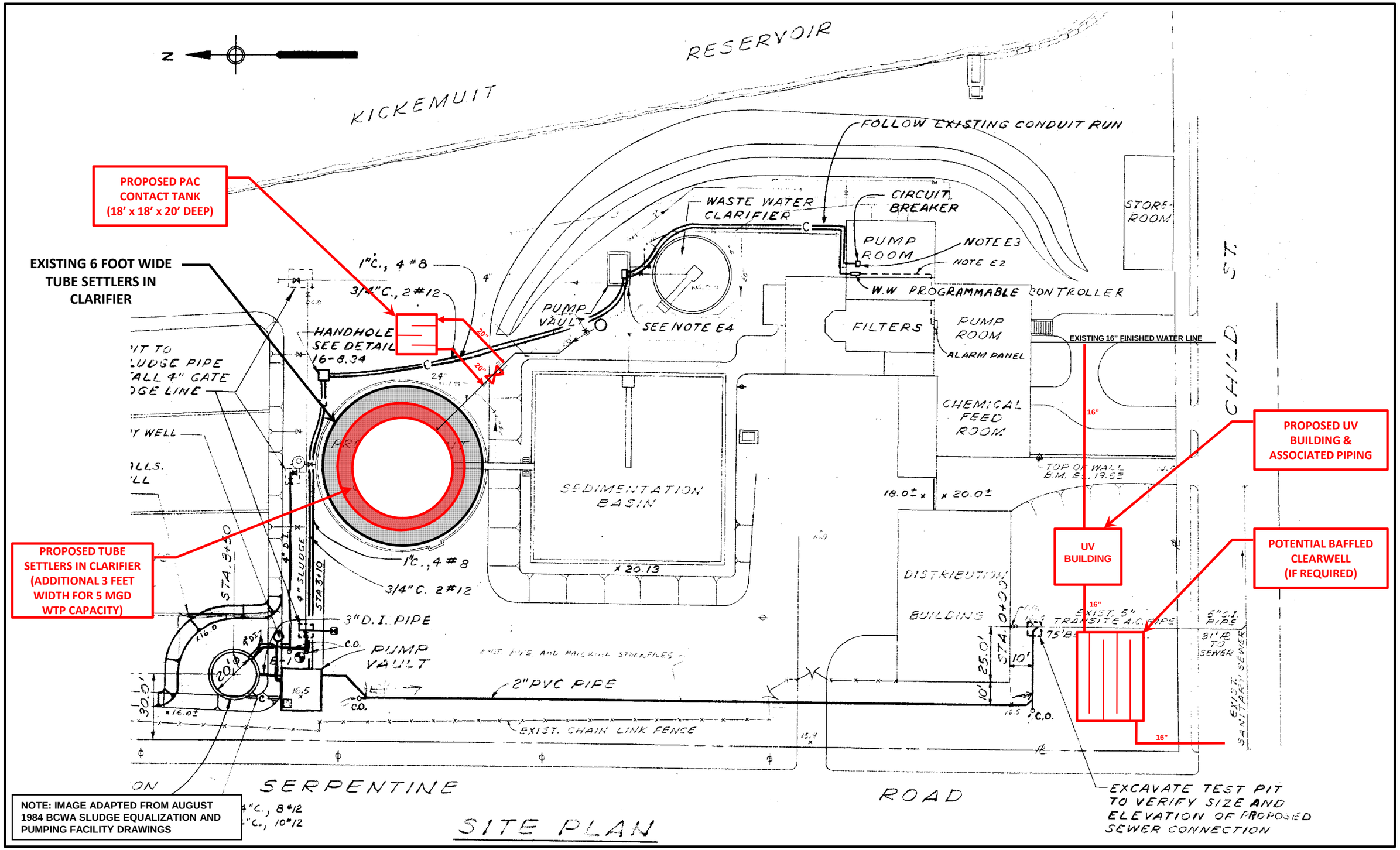


CDM

BCWA CHILD STREET WTP
WATER QUALITY EVALUATION

PROCESS FLOW DIAGRAM FOR UV DISINFECTION

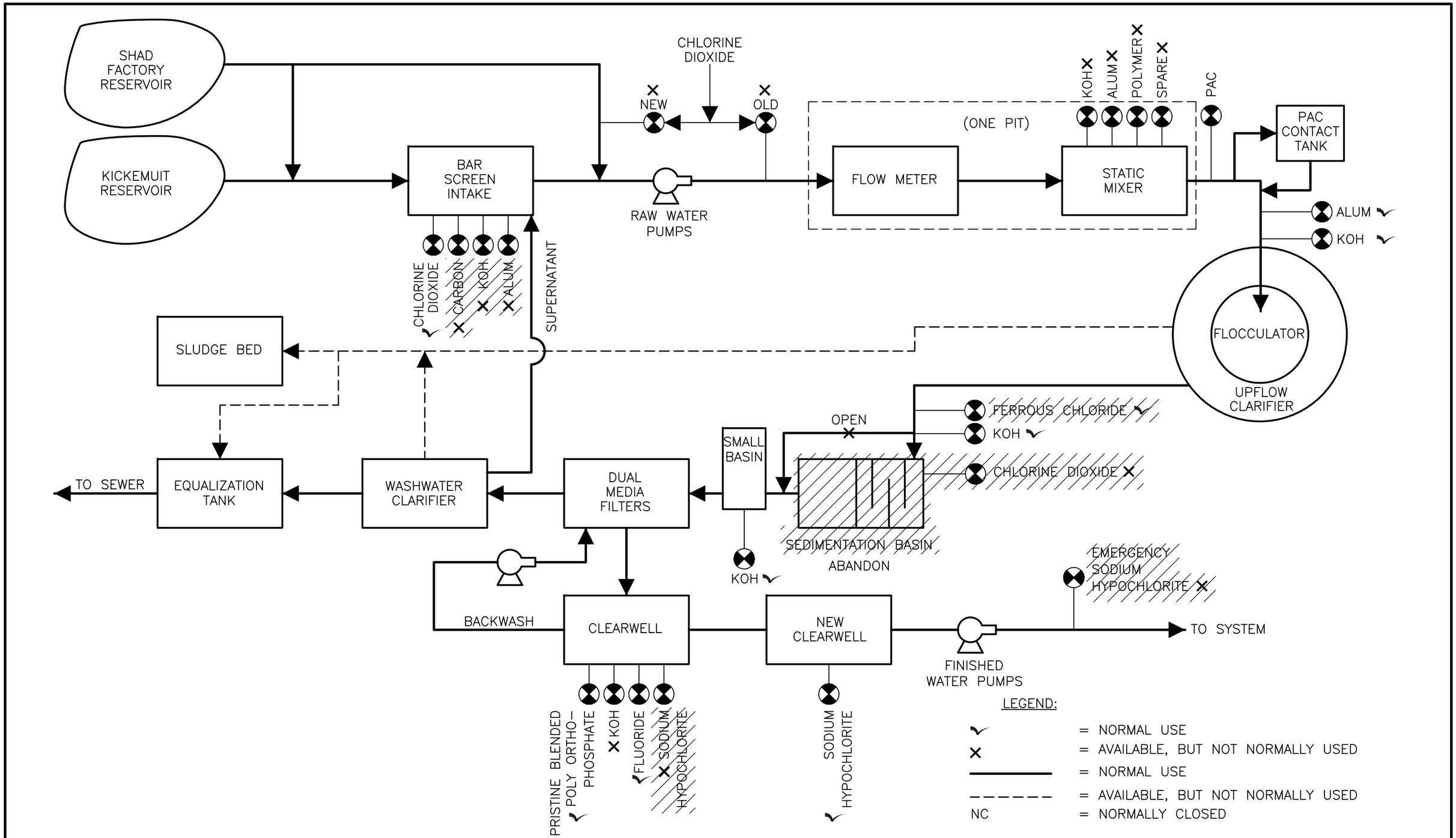
FIGURE 5–7



PLAN
SCALE: 1 INCH = 40 FEET

CDM

FIGURE 5-8
BRISTOL COUNTY WATER AUTHORITY
CHILD STREET WTP WATER QUALITY EVALUATION
UV DISINFECTION ALTERNATIVE WTP SITE PLAN

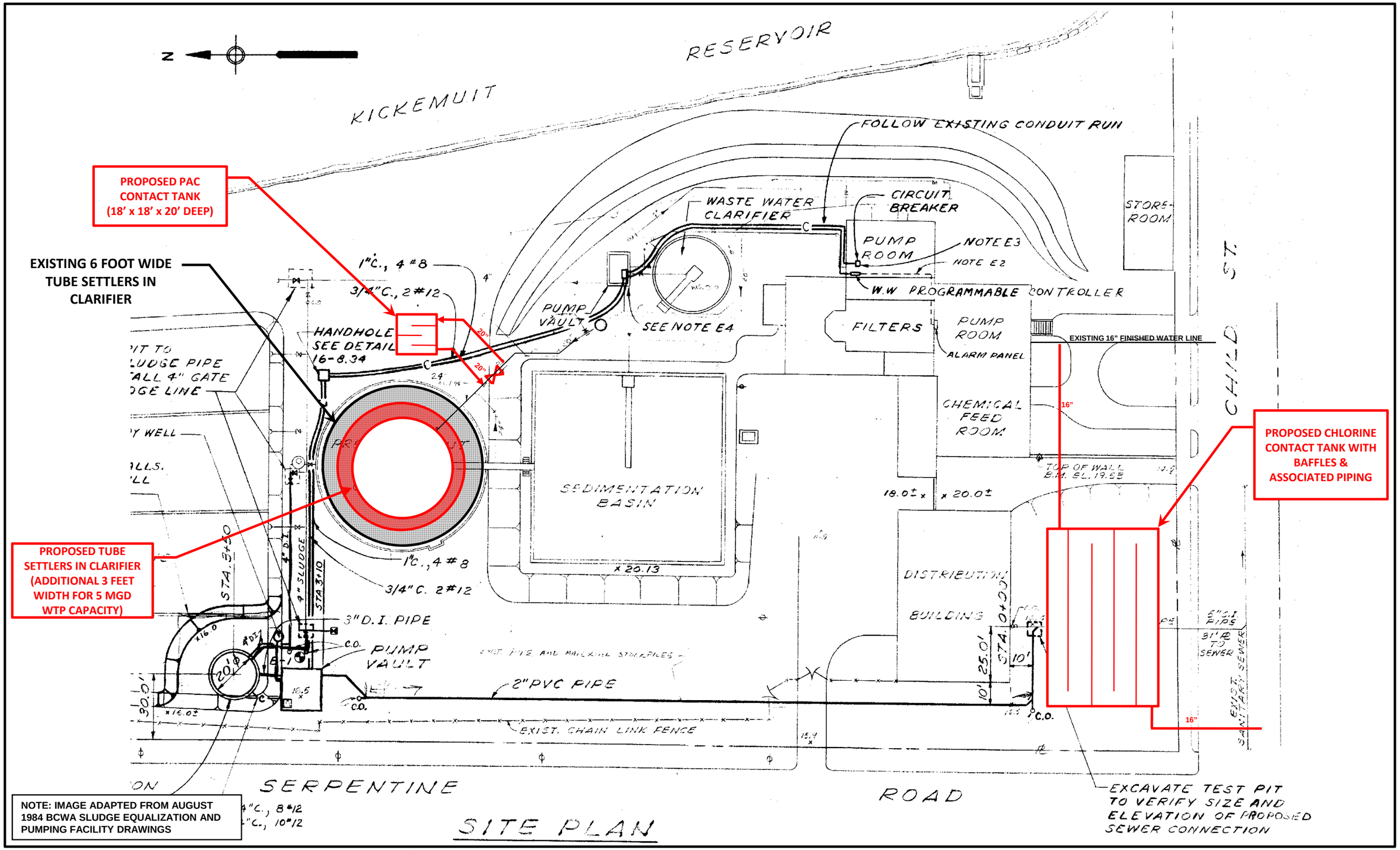


CDM

BCWA CHILD STREET WTP
WATER QUALITY EVALUATION

PROCESS FLOW DIAGRAM FOR NEW CLEARWELL

FIGURE 5–9



NOTE: IMAGE ADAPTED FROM AUGUST 1984 BCWA SLUDGE EQUALIZATION AND PUMPING FACILITY DRAWINGS

PLAN
SCALE: 1 INCH = 40 FEET

CDM

FIGURE 5-10
BRISTOL COUNTY WATER AUTHORITY
CHILD STREET WTP WATER QUALITY EVALUATION
NEW CLEARWELL ALTERNATIVE WTP SITE PLAN

5.5 Treatment Alternatives – 3.5 MGD WTP Capacity

The RIWRB and BCWA requested that CDM develop potential improvements to maximize the existing WTP process. CDM also re-evaluated the disinfection alternatives at a reduced flow rate for a means of present worth comparison. Although it may not be feasible to increase the reliable treatment capacity to the full design capacity of 5.0 mgd, both the RIWRB and BCWA felt that any potential gain in treatment capacity from current performance would be beneficial and provide the BCWA with added system reliability.

As previously discussed, the primary clarifier was upgraded with tube settlers to treat up to 3.5 mgd. CDM determined that the "CT" disinfection requirement can be met in the primary clarifier with chlorine dioxide at a maximum capacity of 3.5 mgd, provided that a minimum chlorine dioxide residual concentration of 0.10 mg/L is maintained leaving the clarifier at all times. Based on reporting forms submitted by the BCWA to HEALTH, it appears that the BCWA typically maintains this 0.10 mg/L chlorine dioxide residual concentration leaving the clarifier. There are a few occasions where the chlorine dioxide residual was less than 0.10 mg/L. The BCWA staff and operators would need to be aware of the required minimum 0.10 mg/L chlorine dioxide residual should the existing process be used to treat up to 3.5 mgd.

In order to continue using the existing treatment process at an increased capacity, ferrous chloride would still be required in the sedimentation basin to reduce the chlorite concentration. CDM determined that the surface overflow rate of the sedimentation basin is adequate to treat 3.5 mgd with some improvements.

Therefore, with improvements to the sedimentation basin, the maximum reliable capacity of the Child Street WTP could be increased to 3.5 mgd. Three primary disinfection options were evaluated at 3.5 mgd, including chlorine dioxide, UV disinfection and sodium hypochlorite. The alternative disinfectants (UV and sodium hypochlorite) meet the overall objective of reducing the DBP chlorite and improving operations. Utilizing the existing process would not reduce the DBP chlorite, but may improve operations.

For all three cases, many of our recommendations previously presented for a 5.0 mgd WTP capacity still apply for a 3.5 mgd capacity, including relocation of the chlorine dioxide application to the head of the plant, contact time for PAC after chlorine dioxide, additional 12-inches of filter media, and potential solids handling.

5.5.1 Existing Treatment Process

To compare cost feasibility, the RIWRB and the BCWA requested that CDM evaluate utilizing the existing treatment process with appropriate improvements to increase capacity. CDM therefore looked at potential alternatives to utilize the existing process and meet all regulatory requirements. Utilizing the existing treatment process requires that chlorine dioxide would still need to be applied for both primary disinfection and manganese oxidation. The primary clarifier was retrofitted with tube

settlers to treat up to 3.5 mgd. Based on the detention time at this flow rate the "CT" requirement for primary disinfection can still be achieved with chlorine dioxide, provided that a minimum chlorine dioxide residual of 0.10 mg/L is maintained at all times leaving the clarifier in order to meet the minimum required "CT" ratio.

As discussed in **Section 4**, the sedimentation basin is currently the main limitation in the treatment process at the Child Street WTP. The surface loading rate of the sedimentation would be acceptable at 3.5 mgd. However, due to the short circuiting, lack of sludge removal and ferric floc carryover to the filters, the treatment capacity is limited. In order to utilize the current treatment process at an increased flow rate the sedimentation basin would need to be retrofit with new equipment to improve treatment and operations. Structural modifications may also be required in order to install new equipment in the sedimentation basin. It is important to note that although upgrades to the sedimentation basin would improve operations, the addition of ferrous chloride would still be an operation challenge.

A schematic of the proposed improvements to the sedimentation basin is presented later in this section. To increase the treatment plant capacity utilizing the existing process, the following improvements would be necessary:

1. Install a new, inline mechanical mixer in an underground concrete vault to mix the ferrous chloride and mitigate chlorite in the sedimentation basin.

2. Construct a new inlet connection to the sedimentation basin to provide an even flow split to two new flocculation compartments.

3. Construct new flocculation compartments with flocculator mixers and weir walls in the sedimentation basin to promote ferrous chloride floc particles to agglomerate and subsequently settle. Existing wood baffles in the sedimentation basin will need to be removed. CDM estimated the approximate size of the flocculation compartments to provide a minimum flocculation detention time of 30 minutes, as recommended by industry guidelines.

4. Install new tube settlers with required structural support system and baffle walls after a quiescent zone. The tube settlers will promote efficient settling in the sedimentation basin. In a horizontal basin, a minimum length of one-third of the basin length must be provided before tube settlers as a quiescent settling zone. The quiescent settling zone's purpose is to minimize turbulence, prevent short circuiting, and maintain gradual velocities into the tube settler area. CDM determined the required tube settler surface area in the sedimentation based on industry guidelines for typical design application rates.

5. Construct new effluent troughs in the sedimentation basin and relocate the sedimentation basin effluent piping connection. New effluent troughs will uniformly collect treated water across the width of the entire sedimentation

basin and maintain acceptable effluent velocities to prevent solids carryover to the filters.

6. Install automatic sludge collection and removal equipment beneath all of the settling zones in the sedimentation basin. This equipment will automatically facilitate sludge removal from the sludge zones in the sedimentation basin and prevent solids build-up.

By eliminating short circuiting, including sludge removal, and enhancing settling of the ferrous floc, the solids carryover from the sedimentation basin to the filters should be greatly reduced and we expect that overall treatment capacity could be increased up to 3.5 mgd.

The BCWA would need to first dewater and remove the existing sludge in the sedimentation basin for the new equipment to be installed. Construction of these upgrades would require that the WTP be taken offline during the entire construction period.

5.5.2 UV Primary Disinfection

Many of the same improvements previously discussed for UV disinfection at a flow rate of 5.0 mgd would also apply to the WTP capacity of 3.5 mgd. Therefore, the process flow diagram and site plans presented in **Figures 5-7** and **5-8** are also applicable for UV disinfection at a rate of 3.5 mgd. Chlorine dioxide would no longer be used as the primary disinfectant and would solely be used for manganese oxidation.

A new building would be required to house the UV reactors. The size of the building and associated piping and electrical supply would be the same as discussed for 5.0 mgd. The only change would potentially be the UV reactor size. CDM would recommend that the building and power supply be sized to accommodate any potential future increases in WTP capacity up to the original design capacity of the WTP (5.0 mgd).

Sodium hypochlorite would still be required as a disinfectant for viruses and to provide a minimum residual for the distribution system. The sodium hypochlorite may need to be added to the top of the filters to provide enough contact time. Testing would still be required to ensure that TTHM levels and contact time are acceptable. If testing indicated that sodium hypochlorite could not be added to the top of the filters, than a new, well baffled clearwell would need to be constructed downstream of the UV reactors. CDM estimates that a new, well baffled, 50,000-gallon clearwell would be required for the sodium hypochlorite disinfection. It is important to note that although the existing WTP clearwell volume is 52,000 gallons, CDM feels that additional baffling will not provide significant improvement and is not acceptable for meeting "CT" requirements in this tank, based on the current tank's configuration.

Therefore, a new, well-baffled clearwell would be needed if testing confirmed that sodium hypochlorite could not be added at the top of the filters.

CDM anticipates that with UV primary disinfection, the chlorite concentration leaving the primary clarifier would be within acceptable levels, since chlorine dioxide would only be used for manganese oxidation. Therefore the dose of chlorine dioxide used solely for manganese oxidation would be drastically reduced. Since chlorites would no longer need to be mitigated by applying ferrous chloride, the sedimentation basin would not be needed for this proposed process alternative.

5.5.3 Sodium Hypochlorite Primary Disinfection

Sodium hypochlorite primary disinfection at a WTP capacity of 3.5 mgd would require that a new, larger, and well-baffled clearwell be constructed. To treat 3.5 mgd, we estimate that at minimum, a new 150,000-gallon underground concrete clearwell with a gravity flow pipeline from the existing clearwell would need to be constructed. Three new vertical turbine pumps would be required to pump from the clearwell to the distribution system. The process flow diagram and site plan presented in **Figures 5-9** and **5-10** are also applicable for sodium hypochlorite disinfection at a WTP capacity of 3.5 mgd.

Again, CDM anticipates that with sodium hypochlorite primary disinfection, the chlorite concentration leaving the primary clarifier would be within acceptable levels, since chlorine dioxide would only be used for manganese oxidation. Therefore the dose of chlorine dioxide used solely for manganese oxidation would be drastically reduced. Since chlorites would no longer need to be mitigated by applying ferrous chloride, the sedimentation basin would not be needed for this proposed process alternative.

5.6 Summary Matrix of Feasible Treatment Alternatives

The options identified as effective treatment alternatives are evaluated further for their advantages, disadvantages and estimated probable costs in the following paragraphs. The following paragraphs summarize this evaluation matrix, which is presented in **Table 5-3**. Planning level cost estimates for these alternatives are presented in **Section 6**.

5.6.1 Advantages

Disinfection by UV light or sodium hypochlorite has many of the same advantages, including meeting the overall project objectives of decreasing chlorite and increasing the capacity of the WTP. By decreasing the chlorite concentration, there is no longer a need for ferrous chloride addition, thus eliminating the need for the sedimentation basin. The primary clarifier alone can provide treatment capacity for clarification at 3.5 mgd, and with some modifications, it can provide a 5.0 mgd treatment capacity. The filter operation and recycle will in turn be improved by reducing the solids carry

Technology	UV Disinfection	Sodium Hypochlorite Disinfection	Existing Treatment Process
Advantages	Inactivation of Giardia & Cryptosporidium Reduced ClO_2 dose Reduced chlorite formation Eliminates ferrous chloride in sedimentation basin Eliminates need for sedimentation basin Low TTHMs / HAAs Improves recycle (reduced solids and Mn) Meets future LT2ESWTR disinfection requirements	Inactivation of Giardia & Viruses Reduced ClO_2 dose Reduced chlorite formation Eliminates ferrous chloride in sedimentation basin Eliminates need for sedimentation basin Improves recycle (reduced solids and Mn) Ease of operations / familiarity with treatment	Inactivation of Giardia & Viruses Familiarity with existing treatment process Improvements limited to existing sedimentation basin
Disadvantages	No inactivation of Viruses Hypochlorite required for viruses & distribution residual SDS testing recommended New building & electrical supply	No inactivation of Cryptosporidium Potential DBPs (TTHMs and HAAs) SDS testing required New clearwell & finished water pumps	ClO_2 still required for primary disinfection Chlorite formation is not reduced Ferrous chloride in sedimentation basin is not eliminated SDS testing required No inactivation of Cryptosporidium May be operationally challenging WTP offline for entire time improvements are constructed

Table 5-3
Bristol County Water Authority
Child Street WTP Water Quality Evaluation
Treatment Alternatives Evaluation

over to the filters. However, there are also some major differences between the two alternative disinfectants. UV disinfection has the ability to inactivate *Giardia* and *Cryptosporidium.* The BCWA has conducted the required sampling to determine its bin classification for *Cryptosporidium* and has not found any represented in the source water. However, if *Cryptosporidium* were to be found in the future, UV disinfection is the most viable means of inactivation. UV disinfection also does not produce any DBPs. TTHMs and HAAs similar to current conditions would be expected from the sodium hypochlorite addition for virus and distribution residual but not at the concentration that would be expected with its use as a primary disinfectant. Although a new building will be required to house the UV reactors, the footprint is relatively small.

Sodium hypochlorite as a primary disinfectant provides log removals for *Giardia* and viruses. The chlorine disinfection practice is a conventional method and operation will be similar to the current practice. Regulatory reporting would also be quite similar to what is currently required. A properly baffled clearwell does not require significant maintenance and would be fairly simple operation.

The primary advantage of utilizing the existing process is that the WTP would continue to operate as it presently does. If manganese concentrations exceed the historical data, the chlorine dioxide dose can be increased as long as enough ferrous chloride can be added to mitigate high chlorite levels. Construction and modifications would be limited to the existing sedimentation basin.

5.6.2 Disadvantages

There are also disadvantages to each of the alternatives that have been presented in the preceding paragraphs.

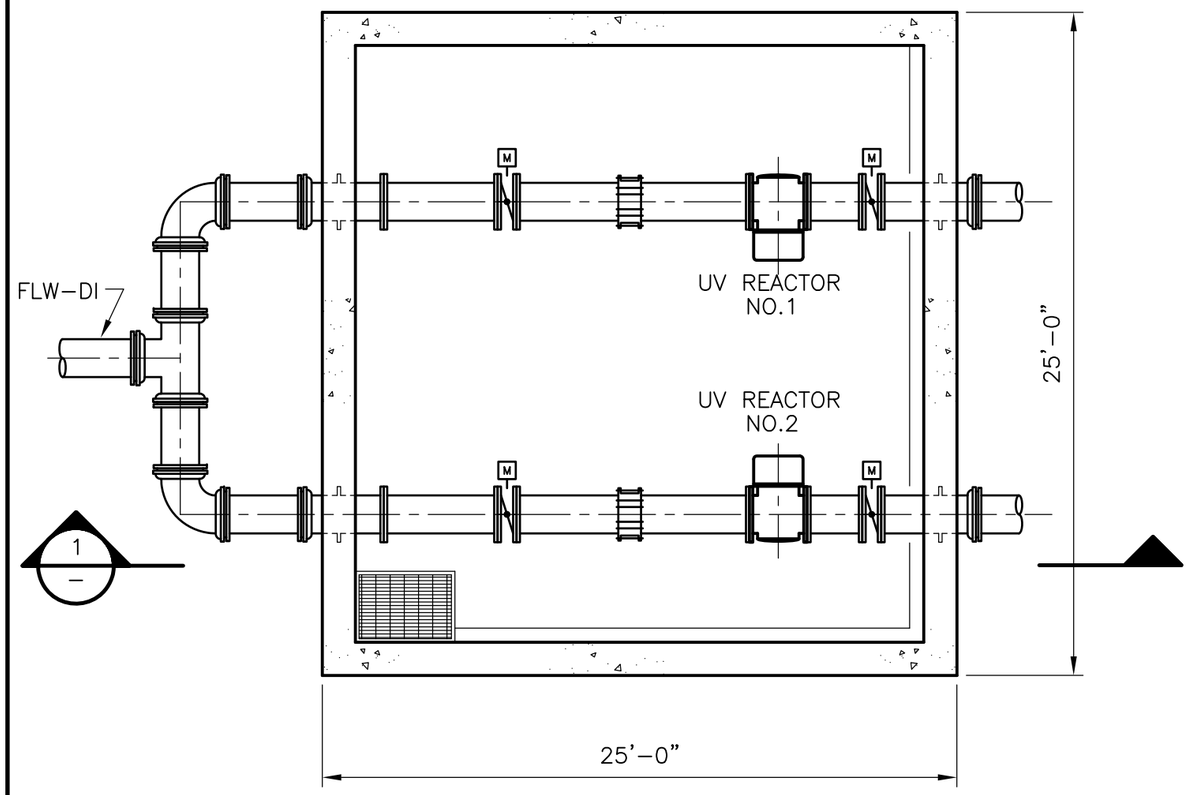
Although UV disinfection has the ability to inactivate *Giardia* and *Cryptosporidium* it does not inactivate viruses. Sodium hypochlorite would still be required to provide a 2-log inactivation for viruses and to provide a disinfection residual in the system. Because the existing clearwell contact time is so minimal, the sodium hypochlorite will have to be applied at the top of the filters and testing would be required to confirm contact time and TTHM formation. If these tests show that this application is not acceptable, a new well baffled clearwell will be required. A new building for UV and electrical supply will be a significant upgrade. Without the ability to add ferrous chloride to reduce chlorite, chlorine dioxide will need to monitored so that the dose not result in a chlorite level greater than 1 mg/L.

A new clearwell for disinfection with sodium hypochlorite does not provide inactivation of *Cryptosporidium* if it becomes present in the source water in the future. If this alternative was chosen, and *Cryptosporidium* was identified in the future, future plant improvements would again be required, which may ultimately require that UV be installed. The formation potential of TTHMs and HAAs with chlorine is elevated with concentration, time and temperature. An increase in these DBPs is probable and

SDS testing would be required to determine the impact of these concentrations. The size of the new clearwell is significant and requires a much larger footprint than the UV building. Construction of this size tank and the tight site constraints would require very controlled construction. The water table would also have to be evaluated to provide adequate design of a clearwell to provide water quality protection and prevent against tank buoyancy/flotation. Without the ability to add ferrous chloride to reduce chlorite, chlorine dioxide will need to monitored so that the dose not result in a chlorite level greater than 1 mg/L.

Utilizing the existing process has many disadvantages. This option does not meet the overall objective of reducing the DBP chlorite to improve operations. At an increased flow rate, more chlorine dioxide and ferrous chloride will be required. During poor raw water quality periods the chlorine dioxide demand will be higher and will require an increased chlorine dioxide dose. An alternative disinfectant (UV of sodium hypochlorite) downstream of the filters eliminates the need to increase disinfectant dose based on raw water demand. Close monitoring of chlorine dioxide to meet "CT" and ferrous chloride to meet chlorite regulatory requirements complicates operations. To construct these upgrades, the entire WTP would need to be taken offline so that the sedimentation basin could be retrofit with new equipment. A significant increase in chemical costs for chlorine dioxide and ferrous chloride would also be expected.

Figures 5-11, 5-12 and **5-13** show preliminary engineering schematics for each of the alternatives discussed in this section.



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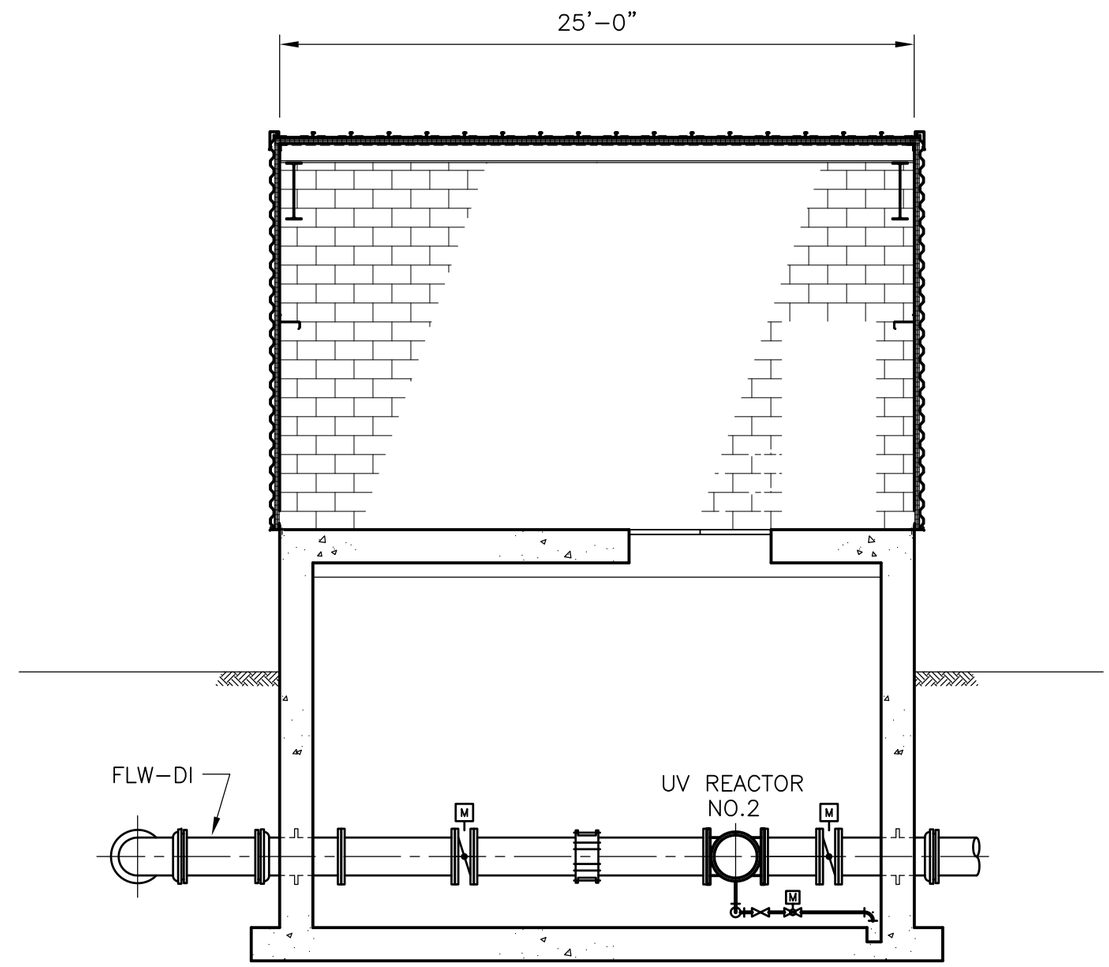


SECTION 1 –

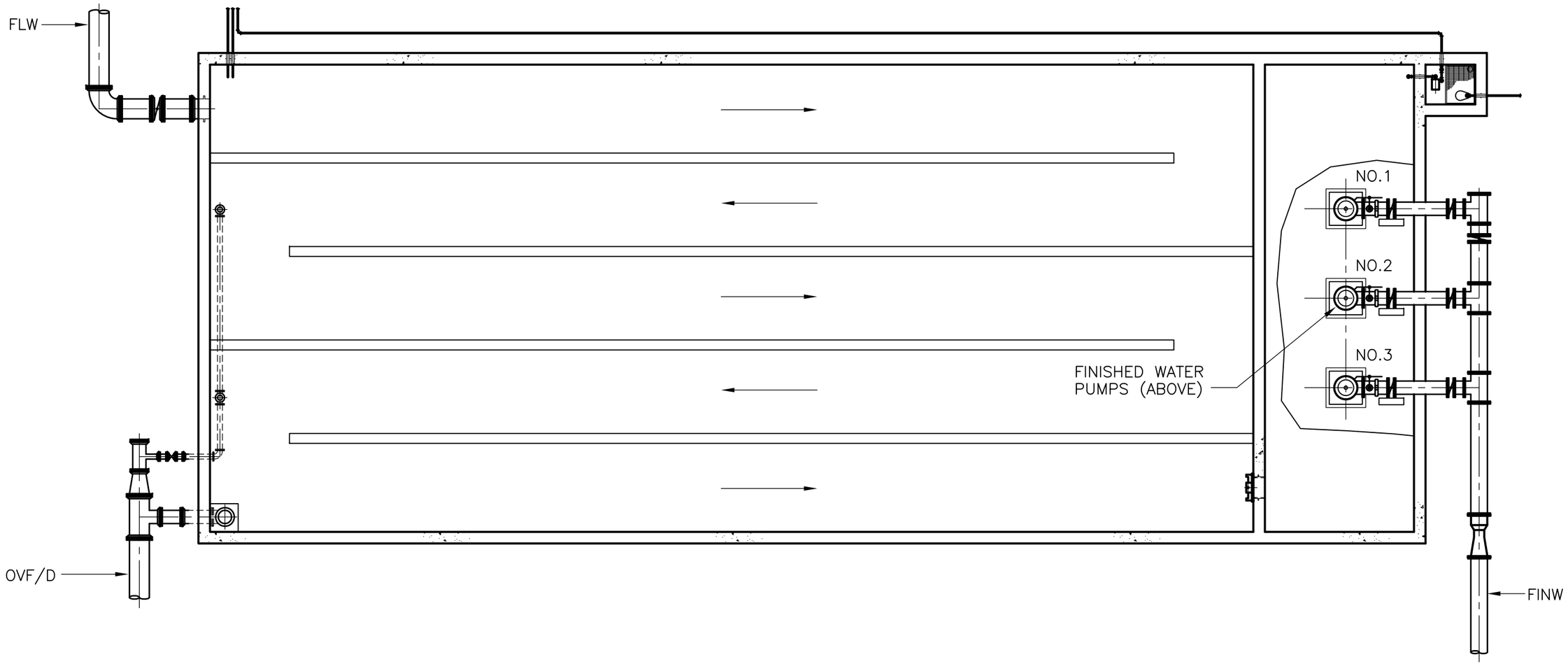
NTS

BCWA CHILD STREET WTP
WATER QUALITY EVALUATION

CDM

UV DISINFECTION BUILDING
SCHEMATIC

FIGURE 5–11



PLAN

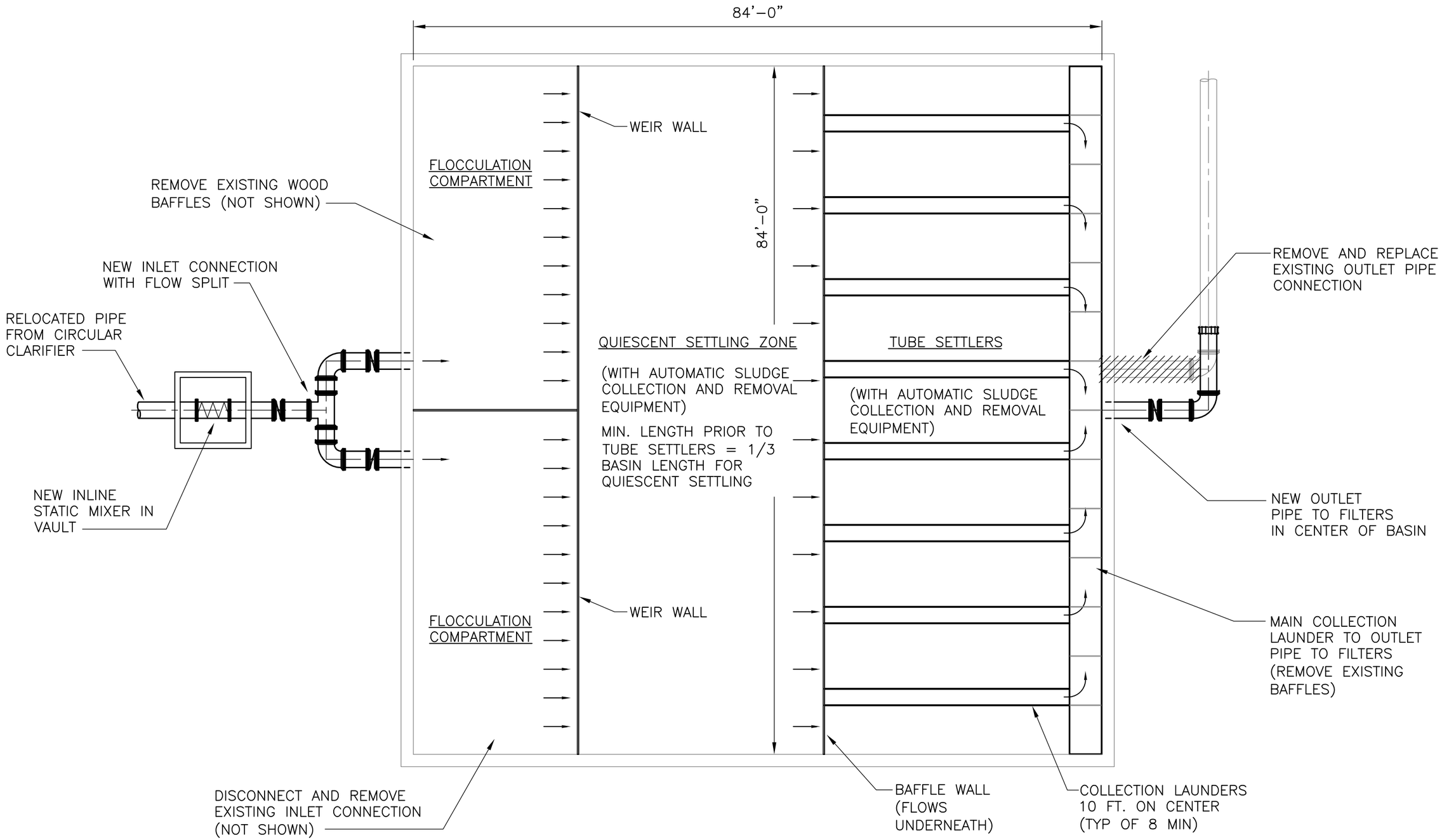
NTS

BCWA CHILD STREET WTP
WATER QUALITY EVALUATION

CDM

CLEARWELL SCHEMATIC

FIGURE 5–12



PLAN

NTS

CDM

BCWA CHILD STREET WTP
WATER QUALITY EVALUATION

SEDIMENTATION BASIN IMPROVEMENTS SCHEMATIC

FIGURE 5–13

Section 6
Conclusions and Recommendations

The previous sections of this report have discussed the BCWA supply sources, interconnections and Child Street WTP. The BCWA strives to provide a continuous, reliable and redundant supply of high quality, safe and aesthetically pleasing drinking water for all of its customers. To continue to provide this source of high quality water, CDM developed treatment alternatives to increase the reliable capacity of the WTP while meeting all regulatory requirements.

The original intent and scope of this analysis is to increase the capacity of the WTP to its original full design capacity of 5.0 mgd. CDM developed two alternatives that would meet the objectives of reducing the DBP chlorite, meet disinfection requirements, oxidize and remove manganese, improve operations, meet all regulatory requirements, and increase the reliable capacity of the WTP to 5.0 mgd. These two alternatives are based upon an alternative means of primary disinfection.

As discussed in **Section 5**, the RIWRB and BCWA subsequently requested that CDM develop potential improvements to maximize the existing WTP processes. CDM therefore determined the maximum increase in treatment capacity at the WTP utilizing the existing processes to be 3.5 mgd. Accordingly, we evaluated treatment alternatives and the existing process to formulate recommended improvements for a 3.5 mgd WTP capacity.

The following paragraphs discuss CDM's conclusions and recommendations for the preferred alternatives and approach; presents estimated planning level probable costs associated with engineering and construction for facility upgrades, rehabilitation and/or replacement; presents a present worth analysis of all the potential WTP improvement options for comparative purposes; discusses our recommended staged approach; provides conceptual engineering sketches; and provides a general summary of some of the permits and applicable project reviews that may be required to construct improvements at the WTP.

6.1 Sources and Interconnections

Given CDM's review of the BCWA's existing sources, interconnections and potential water sources, CDM has made the following conclusions and recommendations that the BCWA may wish to consider.

- The total safe yield of the BCWA source water system is currently 1.3 mgd without a fully operational Shad Factory Pipeline and Pumping Station. With a fully operational Shad Factory Pipeline and Pumping Station, the total safe yield would be 3.4 mgd. Although it does not seem feasible to repair the existing Shad Factory Pipeline, RIWRB and BCWA officials indicated to CDM that the design and permitting of a replacement pipeline is in the final design stages. To-date, no construction work has been completed on this new pipeline.

- CDM recommends that the BCWA investigate additional emergency interconnections with neighboring communities, including in Massachusetts. Additional emergency interconnections would be beneficial in the event that the East Bay Pipeline and Child Street WTP are not operational.

- CDM recommends routine inspections and preventative maintenance (e.g., pipe condition assessments, routine valve exercising, etc.) on the East Bay Pipeline. There are several specialty contractors that CDM has experience with that have the ability to perform internal pipe condition assessments, using a variety of different inspection methods and technologies.

- The Nayatt Road well field facilities would most likely need extensive rehabilitation work to be placed into service. In addition, our preliminary water quality analysis indicates poor water quality that would require further study, evaluation, and approval from HEALTH prior to use of the well field as an active source of supply to the BCWA system. The wells could still be minimally maintained for use under emergency situations.

- There are several potential contamination risks that pose threats to the water quality in the Kickemuit Reservoir. Source water protection measures should be investigated to reduce runoff from farms, nurseries and other sources of potential contamination and implemented if feasible. A source water assessment report was completed for the BCWA in 2003, including a description of various source water protection tools and strategies.

- To minimize the flushing of the natural stream beds of the Kickemuit River that feed the Kickemuit Reservoir, CDM recommends further investigation to identify and study potential remedies that could reduce some of the fluctuations in water quality that the BCWA currently experiences.

- The interconnections with the City of East Providence all seem to be active and viable emergency interconnections that the BCWA can rely on in an emergency supply situation. Modifications to the Pawtucket Avenue Emergency Pump Station should be implemented as documented in CDM's 2008 letter report to adequately prepare the station for emergency supply and develop a full operations protocol.

6.2 Child Street Water Treatment Plant

Based on our evaluation of the water quality data, process evaluation and water quality testing, CDM developed treatment options and corresponding improvements to meet the following objectives:

- Reduce the DBP chlorite while meeting disinfection requirements

- Oxidize and remove manganese

- Improve operations
- Increase the reliable treatment capacity
- Meet all regulatory requirements

The alternative treatment options are presented and discussed in detail in **Section 5**. Regardless of the reliable capacity selected for the WTP (3.5 or 5.0 mgd), the following recommendations all cumulatively need to be made in order to achieve these desired objectives should the BCWA choose to increase treatment capacity:

1. Perform a complete Facility Assessment and WTP Audit.
2. Construct the required improvements for the desired WTP capacity and process.
3. Relocate chemical application points to optimize and improve operations.
4. Reduce solids loading to the filters to increase capacity.
5. Add additional solids handling associated with increased capacity.

All of the recommendations presented in the preceding paragraphs are based on the assumption, as indicated by both RIWRB and BCWA officials, that the Shad Factory Pipeline will be repaired or replaced to increase raw water supply capacity at the Child Street WTP. CDM evaluated capital costs, O&M costs and 20-year present worth values to determine the economic feasibility of each of the treatment alternatives that have been identified and evaluated.

6.2.1 Opinion of Probable Improvements Costs

Table 6-1 presents our estimated probable capital costs, differential annual operation and maintenance (O&M) costs and 20-year present worth values for the various upgrades of the treatment alternatives discussed in **Section 5**. These capital costs are presented in 2009 dollars (ENR Index of 8596) and include construction, engineering and general services/resident engineering (GS/RE) during construction. The following paragraphs discuss our planning level estimates for capital costs, differential annual O&M costs, and 20-year present worth values in more detail.

WTP Capacity (MGD)	Proposed Improvement	Capital Cost	Differential Annual O&M Cost	20-Year Present Worth
5.0	UV Disinfection	$2,800,000	$80,000	$3,800,000
	Clearwell Disinfection	$2,400,000	$47,000	$2,900,000
3.5	UV Disinfection	$2,400,000	$68,000	$3,200,000
	Clearwell Disinfection	$1,700,000	$33,000	$2,100,000
	Sedimentation Basin Upgrades	$2,000,000	$340,000	$6,200,000

Table 6-1
Summary of Probable Costs and Present Worth for WTP Improvements

6.2.1.1 Capital Costs

The estimated construction and engineering costs apply only to process improvements and do not include a complete facility assessment or potential costs for additional solids handling that may be required. All of the options include relocating the chlorine dioxide application point to the head of the plant at the intake. However, cost estimates for the relocation of the chemical application points was not included, as multiple unused chemical application points are currently available.

In order to increase the treatment capacity to 5.0 mgd, additional tube settlers will be required in the primary clarifier in addition to the alternative disinfectant improvements and these are included in the cost estimate. Additional tube settlers in the primary clarifier are not required to increase the treatment capacity to 3.5 mgd. The sedimentation basin can be upgraded to a maximum capacity of 3.5 mgd and includes an inline mechanical mixer, new inlet connection, flocculation compartments, tube settlers, new effluent troughs, new effluent connection, automatic sludge collection and removal equipment, and an allowance for structural upgrades to this basin. Support work specific to the upgrade (e.g., electrical, site work, etc.) are also included in the cost estimate.

The improvements to upgrade the treatment capacity to 5.0 mgd require upgrades to multiple areas of the WTP and therefore increase the total capital cost. The UV disinfection improvements will require a new building and electrical upgrade to supply power to the UV reactors, which makes this alternative slightly more expensive than the new clearwell option.

The improvements to upgrade the treatment capacity to 3.5 mgd limit the upgrades to one area of the WTP, as improvements to the primary clarifier are not required. The costs are fairly similar for each alternative, with the clearwell being the least expensive. The sedimentation improvement costs are slightly more than the option for a new clearwell due to structural improvements and unknown construction conditions in this basin.

It is important to note that the capital costs presented in **Table 6-1** do not include a PAC contact tank or a new, well-baffled clearwell for virus disinfection for the UV alternatives (if testing indicated that sodium hypochlorite could not be added to the top of the filters). If PAC is required for taste and odor mitigation issues, a new 50,000 gallon baffled contact tank would cost an additional $800,000 in engineering and construction costs. At 5.0 mgd, a new 70,000 gallon well-baffled clearwell for virus disinfection for the UV treatment alternative would cost an estimated $800,000 (engineering and construction costs). At 3.5 mgd, a new 50,000 gallon well-baffled clearwell for virus disinfection for the UV treatment alternative would cost an estimated $600,000 (engineering and construction costs). These estimates are also current in 2009 dollars.

6.2.1.2 Operation and Maintenance Costs

Comparative annual O&M costs were estimated for each alternative, as summarized in **Table 6-1**, and indicate primarily the differences in power and chemical usage as well as maintenance hours required. The O&M costs are comparative of the alternatives only, and are meant to establish differences among the options, and are not meant to represent the total cost of operating a treatment plant that incorporates these options. The power consumption is estimated based on the average power draw while operating 8,760 hours annually. We included electrical power, based on the BCWA's typical unit costs for electricity ($0.14/kW-hour), and the different chemical costs for chlorine dioxide (hydrochloric acid, sodium chlorite, and sodium hypochlorite), ferrous chloride, and sodium hypochlorite (for both primary and secondary disinfection) for all of the options. We did not include PAC, alum, potassium hydroxide, fluoride or power of other support systems in the cost estimates, as we assumed these would all increase the same proportionally at the relative increased treatment capacities.

The BCWA provided CDM with historical chemical usage and associated unit costs for 2009. Based on this historical usage, we estimated annual chemical use for each of the increased treatment capacities and alternatives. For the alternative primary disinfectants, chlorine dioxide will only be needed for oxidation of manganese and ferrous chloride will not be needed for chlorite mitigation; this will reduce chemical costs significantly. The O&M costs to continue using chlorine dioxide as a primary disinfectant and ferrous chloride to mitigate chlorite is significantly more than the alternative disinfectant options. This is specifically related to quantity and cost of sodium chlorite for chlorine dioxide generation and the addition of ferrous chloride. Reducing or eliminating these chemicals will significantly affect the O&M costs.

6.2.1.3 Present Worth Analysis

The 20-year present worth costs associated with upgrading the existing sedimentation basin to continue utilizing the existing process at 3.5 mgd is significant. The equipment modifications required and the unknown structural condition of this basin contribute to the engineering and construction costs to implement this option. The

increase in use of chlorine dioxide for primary disinfection, and thus ferrous chloride to mitigate chlorides, results in significant annual chemical costs.

6.2.2 Recommended Improvements

The following paragraphs describe our recommendations for the preferred approach in detail based on our evaluation of advantages, disadvantages and estimated probable costs.

6.2.2.1 Raw Water Quality

The raw water quality from the Kickemuit Reservoir varies substantially due to shallow depth, seasonal changes and rain events. Upon review of historical raw water data, the color, turbidity, organics and manganese can be quite high impacting treatment. Treatment for manganese should be based on a maximum concentration of 0.3 mg/L, as this has been the historical high. Control measures should still be continued to manage seasonal algae blooms.

6.2.2.2 Pretreatment

Chlorine dioxide should still be applied for manganese oxidation regardless of primary disinfectant. In order to optimize the oxidation capabilities of chlorine dioxide, the chemical application point should be relocated to the head of the plant prior to any other chemical addition. This will allow the chlorine dioxide to first quickly oxidize any dissolved manganese before it is consumed by other reactions, so that the manganese is precipitated out of solution. Based on the historical raw water manganese concentrations, oxidation should be achievable to SMCLs the majority of the time while maintaining chlorite levels less than 1.0 mg/L.

If PAC is required for taste and odor issues it should be added after chlorine dioxide, as it will consume some of the chlorine dioxide. It is recommended that a new, separate tank for PAC application be added. To fully optimize the PAC, a new 50,000 gallon tank to provide 20 minutes of contact time is required for a treatment capacity of 5 mgd. The alum and potassium hydroxide should then be relocated downstream of the PAC contact tank prior to the primary clarifier.

6.2.2.3 Primary Clarifier

The water quality as it leaves the primary clarifier is acceptable with the exception of elevated chlorite levels which must be reduced in the remaining treatment process. Results indicate that organics and turbidity are primarily removed in the primary clarifier. The primary clarifier currently has 6 feet of tube settlers that were sized to provide a theoretical treatment capacity of 3.5 mgd. If a reliable WTP capacity of 5.0 mgd is desired, then an additional 3-foot width of tube settlers would need to be added to treat up to 5.0 mgd. No improvements are necessary for a WTP capacity of 3.5 mgd.

6.2.2.4 Sedimentation Basin

The major limitation in the current treatment process is the sedimentation basin. The current purpose for the sedimentation basin is to reduce the DBP chlorite to acceptable levels with ferrous chloride. The ferrous chloride, deep sludge deposits and short circuiting in the sedimentation basin cause solids to resuspend and carry over to the filters, limiting treatment capacity and affecting the recycle flow to the plant.

To utilize the existing process at an increased capacity of 3.5 mgd, the sedimentation basin would still be required to apply ferrous chloride to mitigate the DBP chlorite. The sedimentation basin would need to be upgraded with new equipment to improve treatment. The 20-year present worth costs associated with this process far exceed the implementation cost of the alternative disinfectants. CDM recommends that the sedimentation basin be abandoned as alternative disinfectants meet the original project scope and minimize the 20-year present worth costs.

With changes to the disinfection practice, the chlorine dioxide dose will be applied solely for manganese oxidation, at a much reduced dose, and the ferrous chloride will no longer be needed.

6.2.2.5 Disinfection

CDM recommends that the BCWA discontinue the use of chlorine dioxide for primary disinfection. CDM identified two options for alternative treatment - UV light and sodium hypochlorite. Advantage and disadvantage of each are discussed in **Section 5**. CDM recommends that testing (SDS testing) be completed to determine the TTHM formation potential for both of these options.

A new clearwell at a capacity of 3.5 mgd is the most economical alternative that was evaluated for capital, O&M and present worth costs. SDS testing will confirm if this disinfection method is a viable option for the BCWA. In the event that sodium hypochlorite is not a viable option for primary disinfection than the BCWA should investigate UV primary disinfection. Testing should then be completed to determine if "CT" for virus inactivation can be achieved through the existing clearwell and filters while meeting DBP requirements prior to the UV disinfection. In the event that this application point is not acceptable, a new clearwell for virus disinfection would be required, in addition to the new UV building. For a WTP capacity of 5.0 mgd, a 70,000-gallon clearwell would be necessary; for 3.5 mgd, a 50,000-gallon clearwell would be needed. If a clearwell is required, the capital cost for UV would increase but the present worth cost would still be less than using chlorine dioxide for primary disinfection.

6.2.2.6 Solids Handling

Increased sludge volumes from the process are expected if treatment capacity is increased. In the event that solids are greater than what can be discharged to the sewer, solids handling will need to be added to the treatment process. CDM

recommends this be investigated further to determine if thickening can optimize solids discharge or if a dewatering facility would be required.

6.2.2.7 Facility Assessment

CDM recommends that the BCWA conduct a complete facility assessment and audit to verify additional upgrades required to support the process improvements. It is expected that to operate the WTP at 5.0 mgd, the raw water pumps, finished water pumps, chemical feed systems (storage, containment and pumping) and electrical equipment may also require upgrades. Some of these same systems may also need to be upgraded at a capacity of 3.5 mgd. Based on the extent of upgrades required, the WTP may require additional work to meet current Rhode Island State Building Codes. This may require structural, HVAC, plumbing/fire protection and electrical upgrades. The economic feasibility of completing these upgrades needs to be evaluated by the BCWA and compared to the cost of solely supplying the entire BCWA system from the PWSB East Bay Pipeline connection.

6.2.3 CDM's Staged Approach

As previously mentioned, RIWRB and BCWA officials indicated to CDM that the Shad Factory Pipeline will be repaired or replaced to restore its full capacity and the full raw water supply capacity to the Child Street WTP. The recommendations and approach presented herein is predicated on the full capacity of the Shad Factory Pipeline being restored. CDM recommends the following staged approach based on the process evaluation and present worth analysis:

Stage 1 – Conduct SDS testing to determine TTHM formation potential from the use of sodium hypochlorite for primary disinfection of virus and *Giardia* and for disinfection of virus only (with UV for *Giardia* inactivation). Also conduct a facility assessment to determine additional WTP needs to support desired design capacity.

Stage 2 – Determine from Stage 1 testing if sodium hypochlorite is viable for either improvement alternative. If yes, discuss findings with RIDOH and obtain approval for change of primary disinfection. If no, continue with chlorine dioxide as primary disinfectant and conduct tracer test of primary clarifier to confirm baffling factor.

Stage 3 – Based on Stage 3 results, select and construct required facility improvements.

Stage 4 – Complete start-up operations of facility improvements.

Stage 5 – Evaluate filter performance and capacity at increased treatment capacities. If filter capacity is limited, raise troughs 12 inches and add 12 inches of additional anthracite coal media.

Stage 6 – Evaluate solids handling at increased flow rates and determine if thickening to maximum solids concentration for sewer discharge is feasible with additional solids to lagoons.

With any increase in treatment capacity from the Child Street WTP, CDM also recommends that the BCWA further study what impacts (e.g., hydraulics, change in flow patterns, etc.), if any, would occur in their distribution system.

6.2.4 Permits

Table 6-2 provides a general summary of some of the permits and applicable project reviews that may be required to construct any improvements at the BCWA Child Street WTP, as recommended in this section. This list is preliminary only and will be subject to change once the final design of any improvements progresses further.

Permit	Agency	Estimated Duration to Obtain	Purpose
Rhode Island Pollutant Discharge Elimination System (Construction General Permit - Notice of Intent to Discharge)	Rhode Island Department of Environmental Management (RIDEM)	1 month	For disturbance of more than 1 acre but less than 5 acres
Correspondence with the Rhode Island Historical Preservation and Heritage Commission (RIHPHC)	RIHPHC	1 to 2 months	Determination of any impacts to potentially sensitive archeological/ historical resources
Request for Preliminary Determination with RIDEM	RIDEM	1 month	For any disturbance to wetland resource areas
Correspondence with Rhode Island Natural Heritage Program (RINHP)	RINHP	1 month	Determination of any impacts to endangered species
Correspondence with Rhode Island Water Resources Board (RIWRB) and Rhode Island Department of Health (HEALTH)	RIWRB and HEALTH	1 to 2 months	To complete project site plan review
Customary local construction permits (trench opening, electrical, building, etc.)	Local municipality, building and zoning departments	1 to 2 months	To complete project site plan review
Correspondence with local zoning board and building department	Local building and zoning department	1 to 2 months	To complete project site plan review

Table 6-2
Summary of Potential Permits and Site Reviews for WTP Improvements

Appendix A

Massachusetts Water Management Act Registration

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

DEVAL L. PATRICK
Governor

TIMOTHY P. MURRAY
Lieutenant Governor

IAN A. BOWLES
Secretary

LAURIE BURT
Commissioner

December 31, 2007

PASQUALE DeLISE
BRISTOL COUNTY WATER AUTHORITY
PO BOX 447
WARREN, RI 02885

Dear Registrant:

Please find the attached documents:

- A description of the Massachusetts Water Management Act Registration Statement Contents and Conditions for 2008-2017; and
- The Water Management Act Registrant Statement #**42624705** for 2008-2017;
- The 2007 Annual Report Form to be completed and returned by February 28, 2008.

If you have any questions regarding the Registration Statement, please contact Duane LeVangie at (617) 292-5706 or Beth McCann at (617) 292-5901.

Sincerely,

Glenn Haas
Acting Assistant Commissioner
Bureau of Resource Protection

Enclosures
Cc: Duane LeVangie, MassDEP-WMA Program, Boston

Y:\DWP Archive\SERO\SWANSEA-WMA-Registration #42624705 2007-12-31

This information is available in alternate format. Call Donald M. Gomes, ADA Coordinator at 617-556-1057. TDD Service - 1-800-298-2207.

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Massachusetts Water Management Act Registration Statement
Content and Conditions for 2008-2017

The enclosed renewed Water Management Act Registration Statement authorizes continued withdrawals from January 1, 2008 through December 31, 2017. This Registration Statement reflects your documented water withdrawals from January 1, 1981 through December 31, 1985, and the source locations from which this water was withdrawn. While the initial Water Management Registration Statements had to be filed with the Massachusetts Department of Environmental Protection (the Department) by January 1, 1988, existing registrants have the opportunity to renew the Statements every ten years thereafter. Earlier this year you requested that your Registration be renewed, and the attached Registration Statement confirms your authorized registered withdrawal volumes and sources.

As noted in the Department's August 2007 Registration Renewal Request, the Department has evaluated including water conservation measures in registrations that are consistent with the State Water Conservation Standards approved by the Water Resources Commission (WRC) in July 2006. To better achieve a balance between competing water withdrawals and uses mandated by the Act, to protect the natural environment, and to provide continued and sustainable economic growth in the Commonwealth, the Department is including water conservation measures in Public Water Supply (PWS) Registration Statements pursuant to M.G.L. c. 21G, §§(5) and (6), that include:

- a requirement that PWSs meet the WRC's performance standards of 65 residential gallons per capita day water use (RGPCD) and 10% unaccounted for water loss (UAW) by December 31, 2017;
- a requirement that those not meeting specific performance milestones must develop and implement compliance plan(s) in advance of December 31, 2017;
- a prohibition on the use of decreasing block rates in establishing service charges (M.G.L. c.40, § 39L);
- a requirement that PWSs begin implementing by May 1, 2009 a Seasonal Demand Management Plan that, at a minimum, restricts nonessential outdoor water use between May 1st and September 30th when the Massachusetts Drought Management Task Force declares a drought level of "Advisory", "Watch", "Warning" or "Emergency" for the region in which the PWSs withdrawals are located. Restrictions on outdoor water use shall remain in force until the drought level is declared to be "Normal" by the Drought Management Task Force.
    - PWS with surface water sources who have a Department-approved Drought Management Plan that includes restrictions based on system storage, operational concerns and environmental considerations, may implement restrictions consistent with their plan rather than restrictions triggered by the Drought Management Task Force declaration.

RGPCD and UAW Performance Standards

The Registration Statements include steps that PWSs will need to take if they are having difficulty meeting the performance standards. The Registration Statement outlines a timetable for PWSs to develop and implement their own plans for bringing their system into compliance with the performance standards. Alternatively, a PWS can implement the MassDEP Model Conservation Plans for RGPCD or UAW at any time and then be considered to have met the functional equivalent of the performance standards.

The MassDEP Model Conservation Plans have not been completed at this time. The Department is committed to working with interested stakeholders, particularly the Massachusetts Water Works Association, to develop model conservation plans that provide a menu of best management practices for registrants to refer to and to use as they develop their own compliance plans. We anticipate developing a water management toolbox over the next several months that will meet the needs of suppliers and meet the Department's commitment to protect water resources while we balance human and environmental needs.

The Department plans to engage interested parties in discussions on rate structures, the experiences of water suppliers and other utilities incorporating rates into their conservation programs, and the impact of conservation on revenues. The Department anticipates incorporating the findings of our discussions into the water management toolbox. We look forward to your input on these matters.

Seasonal Demand Management

PWSs will be required to develop a Seasonal Demand Management Plan to reduce nonessential outdoor water use from May 1st to September 30th. The Department will be working in the coming months with the Massachusetts Water Works Association and the Water Management Advisory Committee to develop an outline of the minimum elements that will be required in a Seasonal Demand Management Plan. The Department will forward the Seasonal Demand Management Plan outline to registrants by May 1, 2008. Registrants will be required to forward a draft of their proposed Seasonal Demand Management Plan to the Department for its review and approval by August 1, 2008. The Department anticipates that many PWSs will already have developed and implemented seasonal water use restrictions that meet the minimum requirements in this Registration Statement. Suppliers can always implement stricter restrictions than those required by the Department. For more information on the Massachusetts Drought Task Force and drought declarations, please see
http://www.mass.gov/dcr/waterSupply/rainfall/drought.htm

In addition, the Department has included more information that was submitted by Registrants in 1988 and updated the documents to include changes that have occurred since 1988, including:

- A detailed list of ground and surface water sources, including the PWS source ID, for all registered withdrawal points. The Department has added this information to reflect the withdrawal points registered in 1988; and
- Replacement wells and/or satellite wells, if applicable.

Finally, the Department has included the following administrative language:

- Enforcement language that reserves the Department's rights in any case where there is an ongoing proceeding, or may be a future proceeding; and
- Appeal language that explains how the registrant can seek review of the Registration Conditions in the Renewal Registration Statement in an adjudicatory proceeding.

Many registered PWSs also hold Water Management Act permits. If the Registrant holds a Water Management Act permit, then the conditions in the permit, including all applicable deadlines, shall supersede the corresponding conditions in this Registration Statement.

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

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Commissioner

RENEWAL REGISTRATION STATEMENT FOR VERIFIED WATER WITHDRAWAL

The Massachusetts Department of Environmental Protection ("the Department") hereby accepts the Registration Renewal Request filed by the following Registrant pursuant to 310 CMR 36.10 for the water withdrawal described below. The Registrant is hereby authorized to withdraw up to the registered volume of water from the registered withdrawal point(s) until the expiration date, as set forth below, in compliance with M.G.L. c. 21G and 310 CMR 36.00, subject to the Registration Conditions set forth below.

GENERAL INFORMATION

Registration Number**: 42624705** River Basin: NARRAGANSET BAY

Registrant: BRISTOL COUNTY WATER AUTHORITY
PO BOX 447
WARREN, RI 02885

Number of registered withdrawal points: 3
Groundwater: 0 Surface water: 3

Type	Source Name
SW	ANAWAN RESERVOIR, REHOBOTH, MA
SW	SHAD FACTORY RESERVOIR, REHOBOTH, MA
SW	SWANSEA RESERVOIR, SWANSEA, MA

Use: Public Water Supply

Average Volume per Day (MGD): 2.7 Total Annual Volume (MGY): 985.5

Days of Operation: 365

Effective Date: January 1, 2008 Expiration Date: December 31, 2017

This information is available in alternate format. Call Donald M. Gomes, ADA Coordinator at 617-556-1057. TDD Service - 1-800-298-2207.

MassDEP on the World Wide Web: http://www.mass.gov/dep
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REGISTRATION CONDITIONS

The Registrant shall comply at all times with M.G.L. c. 21G, 310 CMR 36.00 and all other applicable state and federal statutes and regulations.[1] In addition, the Registrant shall comply with the following conditions, provided, however, that if the Registrant holds a currently valid Water Management Act permit, then the conditions in the permit, including all applicable deadlines, shall supersede the corresponding conditions in this Renewal Registration Statement.

Metering:
The Registrant shall install and maintain source meter(s) for each withdrawal point(s).
The Registrant shall calibrate all source meter(s) annually.

Records:
The Registrant shall maintain withdrawal records in sufficient detail to timely provide the information necessary to accurately complete each Annual Statistical Report (ASR) it files with the Department.

Performance Standards for Residential Water Use and Unaccounted-for Water:
The Registrant shall comply with the 65 Residential Gallons per Capita Day (RGPCD) and 10 % Unaccounted-for Water (UAW) performance standards included in the Massachusetts Water Resources Commission's State Water Conservation Standards (July 2006) as soon as feasible but no later than **December 31, 2017**. The Registrant shall annually document its actual RGPCD and UAW in the ASRs it files with the Department, commencing with its ASR for calendar year 2008. The Registrant's ASRs shall document that it is making demonstrable progress towards meeting the performance standards for RGPCD and UAW. Commencing with its ASR for calendar year 2017, and for each year thereafter, the Registrant shall document that it is in full compliance with the performance standards for both RGPCD and UAW.

If the Registrant's ASR for calendar year 2009 indicates that the Registrant is exceeding 80 RGPCD and/or 15% UAW, then the Registrant shall develop and implement an annual compliance plan(s) designed to meet the 65 RGPCD and 10% UAW performance standards by December 31, 2017. The Department will make the MassDEP Model Conservation Plan(s), including a menu of best management practices (BMPs), available to the Registrant for adoption or consideration in developing its own compliance plan(s). The Registrant shall submit a copy of its first compliance plan(s) to the Department by December 31, 2010, and begin implementation upon submittal.

If the Registrant's ASR for calendar year 2012 indicates that the Registrant is exceeding 65 RGPCD or 10% UAW, then the Registrant shall develop and implement an annual compliance plan(s) designed to meet the 65 RGPCD and 10% UAW performance standards by December 31, 2017, unless it has done so already. The Registrant shall submit a copy of its first compliance plan(s) to the Department by December 31, 2013, and begin implementation upon submittal.

The Department reserves the right to commence enforcement against the Registrant if it is not making demonstrable progress towards meeting these performance standards, or if it has not developed and implemented an annual compliance plan(s) that is reasonably designed to meet the 65 RGPCD and 10% UAW performance standards by December 31, 2017. In exercising its enforcement discretion, the Department will consider the Registrant's past efforts to come into compliance with these requirements.

[1] Regulations may change from time-to-time. The Registrant is responsible for complying with the most current version of the applicable regulations, unless the regulations expressly provide otherwise.

Note: Those registrants with RGPCD above 65 or UAW above 10% may choose to adopt the MassDEP Model Conservation Plan(s) at any time before December 31, 2017. Those registrants that have adopted the MassDEP Model Conservation Plan(s), and have made appropriate arrangements to finance, implement and enforce its provisions, will not be subject to enforcement for exceeding the 65 RGPCD and 10% UAW performance standards provided that they are continuing to make reasonable efforts to implement and enforce their compliance plan(s). Those registrants that have not adopted the MassDEP Model Conservation Plan(s) prior to December 31, 2017, and/or that are not making reasonable efforts to finance, implement and enforce their compliance plan(s) provisions, may be subject to enforcement for exceeding the 65 RGPCD and/or 10% UAW performance standards and may be required to adopt the MassDEP Model Conservation Plan(s), if they have already not done so.

Seasonal Demand Management – May 1 through September 30:

The Registrant shall submit a Seasonal Demand Management Plan by August 1, 2008 for the Department's review and approval. The Plan must begin by May 1, 2009, and restrict at a minimum nonessential outdoor water use from May 1st through September 30th, consistent with the following:

If the Registrant's RGPCD is 65 or less on the ASR for the previous year, then the Registrant shall, at a minimum, restrict outdoor water use according to its Department-approved Seasonal Demand Management Plan when the Massachusetts Drought Management Task Force declares a Drought Advisory, Drought Watch, Drought Warning or Drought Emergency for the region where the Registrant's withdrawals are located. Restrictions on outdoor water use shall remain in place until the drought level is returned to "Normal."

-or-

If the Registrant's RGPCD is 66 or greater on the ASR for the previous year, then the Registrant shall, at a minimum, restrict nonessential outdoor water use to one day per week outside the hours of 9:00 a.m. to 5:00 p.m. when the Massachusetts Drought Management Task Force declares a Drought Advisory, Drought Watch, Drought Warning or Drought Emergency for the region where the Registrant's withdrawals are located. The restrictions on nonessential outdoor water use shall remain in place until the drought level is returned to "Normal."

-or-

If the Registrant withdraws from surface water supplies and has a Department-approved Drought Management Plan that includes restrictions based on system storage, operational concerns and/or environmental considerations, then the Registrant shall implement outdoor water use restrictions in accordance with its Drought Management Plan.

Nonessential Water Use: As used herein, "nonessential outdoor water use" means uses that are not required: (a) for health or safety reasons; (b) by regulation; (c) for the production of food and fiber; (d) for the maintenance of livestock; or (e) to meet the core functions of a business.

Examples of nonessential outdoor water uses include: the irrigation of lawns or landscaping, except by means of a hand-held hose outside the hours of 9:00 a.m. to 5:00 p.m.; washing vehicles other than by means of a commercial car wash or except as necessary for operator safety; and washing of exterior building surfaces, parking lots, driveways and/or sidewalks, except as necessary to apply paint, preservatives, stucco, pavement, cement, or the like.

Examples of acceptable outdoor water uses outside the hours of 9:00 a.m. to 5:00 p.m. include: irrigation to establish a new lawn during the months of May and September; irrigation for the production of food and fiber or the maintenance of livestock; irrigation by plant nurseries as necessary to maintain stock; irrigation by golf courses as necessary to maintain greens and tees, and limited fairway watering; and irrigation of public parks and recreational fields.

Nothing in this Registration Statement shall be construed to prohibit or prevent the Registrant from implementing any water use restrictions stricter than those contained herein.

Note: 310 CMR 22.15(8) requires that all public water systems establishing mandatory restrictions on water use notify the Department in writing within 14 days of the effective date of such restrictions. Notice must include a description of the regulations, bylaws or ordinances imposing the restriction. Registrants may also be required to document implementation and enforcement of the restrictions in their ASRs.

For the most up-to-date information on the drought status in your region, the Registrant should monitor the Department's website at www.mass.gov/dep and MassDCR's website at http://www.mass.gov/dcr/waterSupply/rainfall/drought.htm.

SERVICE CHARGES

The Registrant shall not charge for water services on a descending unit rate basis (i.e. decreasing block rates). Descending unit rate basis that charge lower unit prices as water use increases during the billing period are prohibited by M.G.L. c. 40, § 39L.

REPORTING

The Registrant shall file an annual statement of withdrawal, as required by 310 CMR 36.11, for each year that this registration is in force, on forms provided and by the deadline specified by the Department. At the request of the Department, the Registrant may be required to report withdrawal volumes monthly or daily in accordance with 310 CMR 36.08.

EFFECT ON ANY PENDING AND FUTURE ACTIONS

The withdrawal registration program is intended to provide a procedure and deadline for persons making existing withdrawals above the threshold quantity to file a registration statement with the Department for their existing withdrawals to enable the Department to document baseline water use to manage the surface and groundwater of the Commonwealth. Except as expressly provided herein, this Renewal Registration Statement shall not be construed or operate as barring, diminishing, adjudicating or in any way affecting any legal or equitable right of the Department with respect to any pending administrative or judicial action, or any such future action, including without limitation any pending enforcement action or permit appeal, or any legal or equitable right of the Department to pursue any claim, action, suit, cause of action, or demand that the Department may have with respect to any matter covered by this Renewal Registration Statement.

REGISTRATION RENEWAL

This Registration Statement expires on January 1, 2018, unless the Registrant files a registration renewal request with the Department prior to that date in accordance with 310 CMR 36.10. Failure to file a registration renewal request by the expiration date shall result in the loss of the Registrant's right to withdraw the water volumes authorized by this Renewal Registration Statement until a permit for such withdrawal has been obtained from the Department.

REGISTRATION TRANSFER

The transfer of Registration Statements is governed by 310 CMR 36.09. Except as provided in 310 CMR 36.09(2), this Renewal Registration Statement may be transferred, in whole or in part, by the Registrant to another person if (1) the Department is notified of the proposed transfer at least 30 days in advance of the proposed transfer date, (2) the notice includes a written agreement between the parties to the transfer, (3) the notice provides the date that the proposed transfer is to take place, and (4) the notice describes the registration to be transferred. A transfer request must be accompanied by the applicable fee established in 310 CMR 4.00. This Renewal Registration Statement shall be surrendered to the Department upon transfer of any withdrawal authorized by this document.

APPEALS

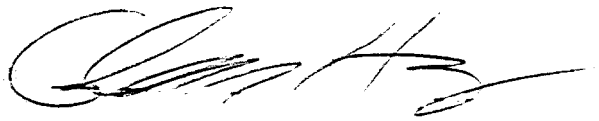
The Registrant may request an adjudicatory hearing on this Renewal Registration Statement by timely filing a Notice of Claim for an Adjudicatory Appeal ("Notice of Claim") in accordance with M.G.L. c. 30A, § 10 and 310 C.M.R. 1.00 within twenty-one (21) days of its receipt of this Renewal Registration Statement. The Notice of Claim shall state specifically, clearly and concisely the facts that are grounds for the appeal, the relief sought, and any additional information required by applicable law or regulation. A copy of this Renewal Registration Statement shall be included with a Notice of Claim. The Notice of Claim and supporting documentation must be sent to:

Case Administrator
Office of Appeals and Dispute Resolution
Department of Environmental Protection
One Winter Street, Second Floor
Boston, MA 02108

In addition, a valid check made payable to the Commonwealth of Massachusetts in the amount of $100 for the appeal filing fee, if required, must be mailed to:

Commonwealth of Massachusetts Lock Box
Department of Environmental Protection
P.O. Box 4062
Boston, MA 02211

The Notice of Claim may be dismissed if the filing fee is not paid, unless the appellant is exempt or granted a waiver. The filing fee is not required if the appellant is a city, town (or municipal agency), county, district of the Commonwealth of Massachusetts, or a municipal housing authority. The Department may waive the adjudicatory filing fee for a person who shows that paying the fee will create an undue financial hardship. A person seeking a waiver must file, along with the hearing request, an affidavit setting forth the facts believed to support the claim of undue financial hardship.



_____ 12/31/07

Glenn Haas, Acting Assistant Commissioner — Date
Bureau of Resource Protection

Appendix B

Correspondence from HEALTH

Weston & Sampson
SERVICES

5 Centennial Drive
Peabody MA 01960

October 17, 2005

Ms. Susan H. Rabideau, P.E.
Senior Sanitary Engineer
Rhode Island Department of Health
Office of Drinking Water Quality
3 Capital Hill, Room 209
Providence, Rhode Island 02908

RECEIVED
OCT 19 2005
R.I. DEPARTMENT OF HEALTH
DRINKING WATER QUALITY

Re: Child Street Water Treatment Plant
Process Changes

Dear Ms. Rabideau,

I am writing on behalf of our client, the Bristol County Water Authority. Please accept this letter and its attachments as the subsequent information discussed in our letter to you dated October 3,2005.

Attached to this letter are the analytical and bacteriological results of our Raw, Settled and Finished Water.

We are aware of your request for a disinfection profile of the area that we will be utilizing to meet the Chlorine Contact Time requirements. We propose that Health allow the Bristol County Water Authority, (BCWA), to conditionally resume operations of the Child Street Water Treatment Plant. The terms of the conditions are that BCWA will perform a tracer study on the clarifier and the Clearwell. The study shall be done at two flow rates that include 1 MGD and 3 MGD. Under current operations we are unable to continuously operate at a sustained flow rate to complete this task. The study will be presented to Health in writing and the actual task performed jointly by Weston & Sampson and BCWA. The results of these studies shall be presented to Health within 30 days of Health's approval of the written tracer study procedure.

Thank you in advance for your consideration. I may be reached through the BCWA or at (978) 423-1512 to answer any questions you may have.

Sincerely,

Jack Mitchell, General Manager
Weston & Sampson Services

Attachments
Cc: P. DeLise, BCWA
D. Soignoli, BCWA
R. Fouch, WSE

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

DEPARTMENT OF HEALTH

Safe and Healthy Lives in Safe and Healthy Communities

February 6, 2006

Mr. James F. Finegan, P.E., Project Manager
Weston & Sampson Engineers, Inc.
Five Centennial Drive
Peabody, MA 01960-7985

Re: BCWA Child Street Water Treatment Plant, PWSUD # 1647515

Dear Mr. Finegan:

The Rhode Island Department of Health, Office of Drinking Water Quality (HEALTH) has received your request for an extension of the deadline for completing the tracer study for the clarifier basin at the Child Street Water Treatment Plant. The deadline is herby extended to March 10, 2006. The tracer study should determine the baffling factor for the current basin configuration at all anticipated flow rates. Subsequently, a table should be generated that can be used to determine the detention time in the basin at various flow rates for use in preparing the monthly CT reports for the plant.

If you have any questions regarding this review, feel free to contact me at 222-7784.

Sincerely,

Susan H Rabideau

Susan Rabideau, P.E.
Senior Sanitary Engineer

Cc: June Swallow, HEALTH DWQ
Pasquale DeLise, Domenic Soignoli, BCWA
Jack Mitchell, Weston & Sampson

Weston & Sampson Engineers, Inc.
Five Centennial Drive
Peabody, MA 01960-7985
www.westonandsampson.com
Tel: 978-532-1900 Fax: 978-977-0100
Innovative Solutions since 1899

Bristol County Water Authority
WSE Project No. 2060095

April 7, 2006

Ms. Susan Rabideau, P.E.
Senior Sanitary Engineer
Department of Health
Cannon Building
Three Capitol Hill
Providence, RI 02908-5097

Re: Bristol County Water Authority
Tracer Study

Dear Ms. Rabideau:

On behalf of the Bristol County Water Authority, Weston & Sampson Engineers, Inc. (WSE) has prepared this letter report summarizing the findings of the tracer study conducted on the clarifier at the Child Street Water Treatment Plant (WTP). The purpose of the tracer study was to measure the relationship between the clarifier's actual detention time (T_{10}) and WTP flow rate in order to determine the disinfection contact time (CT) values in accordance with the requirements of Rhode Island Department of Health, Drinking Water Division.

Background

The tracer study was conducted to evaluate if the CT baffling factor in the clarifier is greater than 0.5, which was originally determined by a tracer study completed by CDM. Since CDM's 1992 determination, tube settlers have been installed in the clarifier which may have increased the baffling factor and detention time.

Tracer Study

The *Guidance Manual for the Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources* (AWWA 1991) describes the methodology to be used for determining contact time with water treatment plant process units. This methodology uses a tracer study to determine the contact time through development of a profile of the concentration of a constant dose of tracer chemical as a function of time. The following conditions are recommended for an accurate tracer study:

- Flow rate should be constant through the units tested.
- The test flow rate should be 91 percent or greater than the highest flow rate through the units.

- The water level in the basin should be equal to or slightly below the normal operating level.
- The tracer chemical needs to be dosed at a level to permit a residual to be measured in the unit discharge throughout the test.
- Tracer recovery of 90 percent should be achieved.

The tracer study was conducted utilizing the step-dose method. The step-dose method entails feeding a tracer chemical in the clarifier influent and maintaining a constant dose throughout the test. The tracer chemical utilized for the tracer study was 21% strength hydrofluorosilicic acid, which was fed at a rate of approximately 1.0 milligram per liter (mg/L) as fluoride. The background fluoride content of the water was 0.08 mg/L.

The existing fluoride chemical feed pump was utilized to inject fluoride solution into the influent piping to the clarifier. The chemical feed pump was set to dose at a rate of 27 ml/min, 0.43 gallons per hour. The pumping rate was confirmed by timed discharge into a measured graduated cylinder.

The tracer test was continued past the point where C_{10} was obtained. C_{10} is the measured fluoride concentration equal to 10-percent of the fluoride concentration being added plus the fluoride background concentration. The time corresponding to C_{10} is T_{10}. The time (T_{10}) paired with the flow rate at which the tracer test was conducted determines the available detention time. The tracer study was conducted at a flow rate of 2.5 mgd, which is higher than the plants current operating flow rate of 1.5 MGD. The water level in the clarifier was maintained at a constant rate equal to the normal operating level at the 2.5 mgd flow rate.

The data for the tracer test is attached in Table 1. This includes the sampling time intervals, background fluoride concentration, measured fluoride concentrations, actual fluoride concentration (C_0), C/C_0. The actual fluoride, C, was calculated by subtracting the background fluoride from the measured fluoride. C/C_o is the ratio of actual fluoride residual to applied dose concentration. Figure 1 is a graphical representation of the results from the tracer study.

Fluoride Testing and Calibration Equipment

Fluoride testing and calibration equipment was used to measure fluoride during the tracer tests. A Hach DR/5000 was used to measure the fluoride content of the water. A fluoride free deionized water sample was used throughout the test to zero the spectrophotometer.

Sampling Time Intervals

Water samples were obtained and tested in the WTP laboratory from the clarifier effluent. Fluoride levels were measured at 30 minute intervals for the first hour and a half. The sampling frequency was increase to every 5 minutes until after C_{10} was obtained. After T_{10} was reached, fluoride levels were measured every five minutes for the next half hour. Fluoride samples were

then taken every half-hour until the test had been conducted for over 11 hours. The data collected from the tracer study is present in Figure 1 and Table 1. Tracer recovery of 90-percent was not achieved during this test. It is suspected that the coagulant may have interacted with the fluoride, preventing full recovery of the tracer chemical.

Conclusions of Tracer Study

The results of the tracer study conducted on March 22, 2006 were inconclusive because of the apparent interference from the coagulant in the water. Tracer recovery of 90-percent was not achieved as recommended by the AWWA guidance manual. At this time it is recommended that BCWA continue to use the baffle factor of 0.5 for the CT calculations through the flocculator/clarifier that was established in previous tracer study done by CDM 1992.

Other Issues

In your email dated March 31, 2006 requested that several other issues be addressed. These included:

1. CT may not be able to met during all times of the year as noted in the February 21, 2006 from Jack Mitchell of this office because of raw water quality and the demand on the chlorine dioxide. When the demand increases on the chlorine dioxide in the raw water, the chlorite levels also increase. At certain times of year, especially during the summer months when the water is warm and the level of organic material in the water increases, the chlorite levels resulting from higher chlorine dioxide doses may approach the MCL, and require that the plant be temporarily shut down.

2. The addition of the plastic balls in the clarifier was meant to try to minimize the impact of the sun on water quality in the clarifier, and try to stabilize the rapid changes in water quality that were being experienced during different times of the day. The plastic balls would not have any impact on the raw water quality entering the plant.

3. Documentation of inactivation at the plant, based on two months of operation will be provided directly from BCWA. Per your phone conversation with Jack Mitchell on April 6, 2006 no additional documentation is required.

If you have any questions or comments, please contact myself or Margaret McCarthy.

Very truly yours,

WESTON & SAMPSON ENGINEERS, INC.

James F. Finegan, P.E.
Project Manager

Attachments

cc: Mr. Pasquale DeLise, P.E. – Bristol Count Water Authority
Mr. John Mitchell – Weston & Sampson Services

JFF/mam

O:\BCWA RI\TRACER STUDY\RESULTS.DOC

Fluoride Sample Tested

Table 1: Child Street WTP Tracer Study Results
March 22, 2006

Sample #	Time Taken	Time Tested	Temperature Tested	pH	Fluoride Residual	C Tracer Fluoride (mg/L)	C/Co	Cumulative Time (min)
Base	10:50 AM	11:20 AM	21 C	5.9	0.08			
1	11:00 AM	11:35 AM	21 C	5.9	0.08	0	0	0
2	11:30 AM	12:30 PM	21 C	5.9	0.03	-0.05	0	30
3	12:00 PM	12:38 PM	21 C	5.9	0.05	-0.03	0	60
4	12:30 PM	2:05 PM	22 C	5.8	0.09	0.01	0.01	90
5	12:45 PM	2:00 PM	22 C		0.13	0.05	0.05	105
6	12:50 PM	1:56 PM	22 C		0.14	0.06	0.06	110
7	12:55 PM	1:17 PM	22 C		0.16	0.08	0.08	115
8	1:00 PM	1:52 PM	22 C	5.6	0.17	0.09	0.09	120
9	1:05 PM	1:46 PM	22 C		0.11	0.03	0.03	125
10	1:10 PM	1:30 PM	22 C		0.14	0.06	0.06	130
11	1:15 PM	1:40 PM	22 C		0.12	0.04	0.04	135
12	1:20 PM	1:35 PM	22 C		0.17	0.09	0.09	140
13	1:25 PM	2:25 PM	22 C		0.2	0.12	0.12	145
14	1:30 PM	2:30 PM	22 C		0.17	0.09	0.09	150
15	1:35 PM	2:34 PM	22 C		0.18	0.1	0.1	155
16	1:40 PM	3:25 PM	22 C	5.7	0.18	0.1	0.1	160
17	1:45 PM	3:18 PM	22 C		0.18	0.1	0.1	165
18	1:50 PM	2:20 PM	22 C		0.22	0.14	0.14	170
19	1:55 PM	2:09 PM	22 C		0.2	0.12	0.12	175
20	2:00 PM	3:08 PM	22 C	5.8	0.2	0.12	0.12	180
21	2:30 PM	3:12 PM	22 C		0.22	0.14	0.14	210
22	3:00 PM	3:55 PM	22 C		0.2	0.12	0.12	240
23	3:30 PM	4:25 PM	22 C	5.8	0.24	0.16	0.16	270
24	4:00 PM	4:38 PM	22 C		0.25	0.17	0.17	300
25	4:30 PM	4:38 PM	22 C	5.7	0.22	0.14	0.14	330
26	5:00 PM	5:10 PM	22 C		0.19	0.11	0.11	360
27	5:30 PM	5:40 PM	22 C		0.23	0.15	0.15	390
28	6:00 PM	6:05 PM	22 C	5.6	0.28	0.2	0.2	420
29	6:30 PM	6:50 PM	22 C	5.5	0.31	0.23	0.23	450
30	7:00 PM	7:05 PM	22 C		0.34	0.26	0.26	480
31	7:30 PM	7:38 PM	22 C	5.7	0.35	0.27	0.27	510
32	8:00 PM	8:10 PM	22 C		0.32	0.24	0.24	540
33	8:30 PM	8:35 PM	22 C	5.5	0.27	0.19	0.19	570
34	9:00 PM	9:05 PM	22 C		0.3	0.22	0.22	600
35	9:30 PM	9:35 PM	22 C	5.5	0.3	0.22	0.22	630
36	10:00 PM	10:05 PM	22 C		0.3	0.22	0.22	660
37	10:30 PM	10:35 PM	22 C	5.5	0.25	0.17	0.17	690

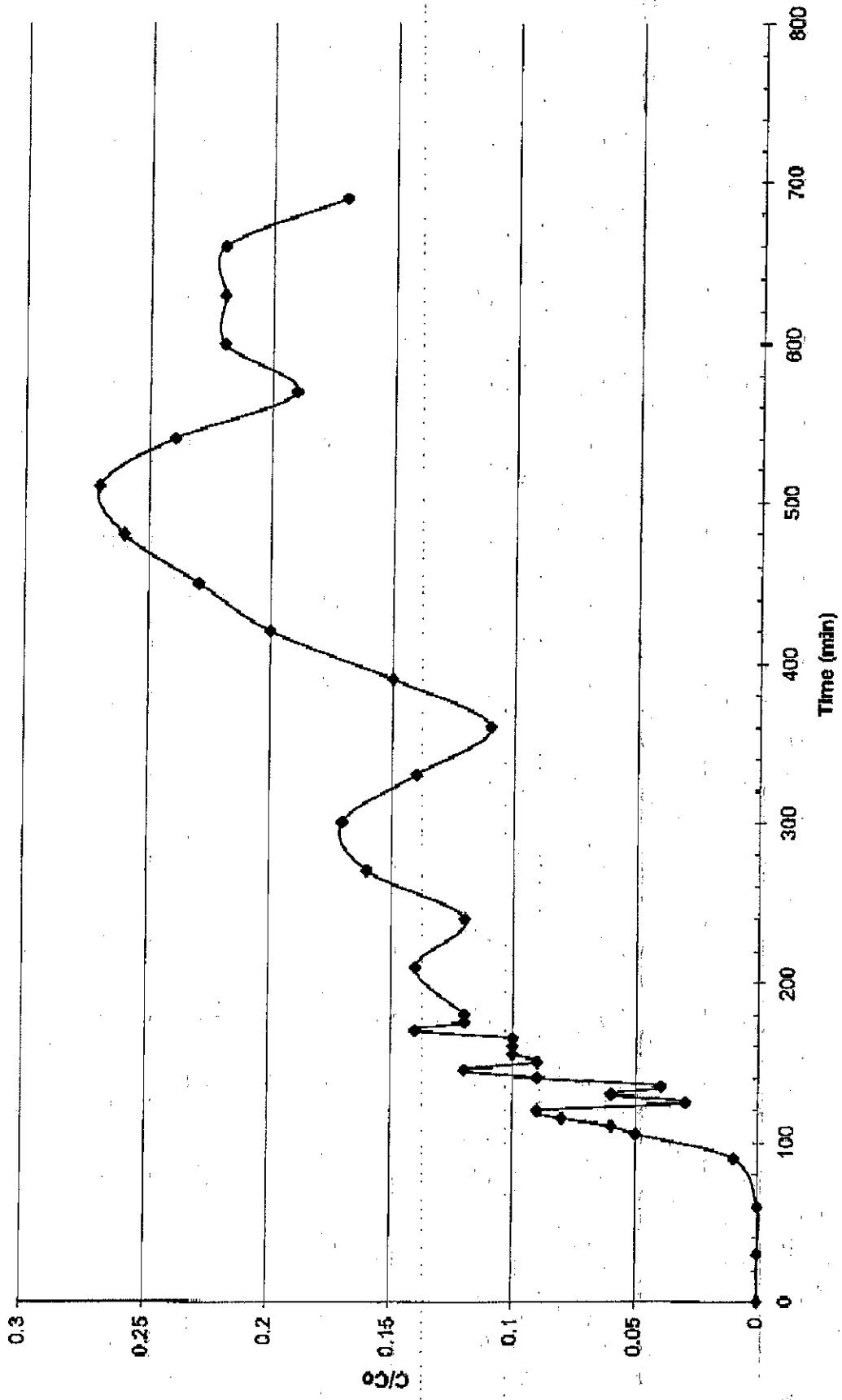


Figure 1: Child Street WTP Tracer Study

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

DEPARTMENT OF HEALTH

Safe and Healthy Lives in Safe and Healthy Communities

May 5, 2006

Mr. Pasquale DeLise, Executive Director
Bristol County Water Authority
450 Child Street
Warren, RI 02885

Re: BCWA Clarifier Tracer Study, PWSID # 1647515

Dear Mr. DeLise:

The Rhode Island Department of Health, Office of Drinking Water Quality (HEALTH) has reviewed the Tracer Study submitted on your behalf by Weston & Sampson Engineers, Inc. The study was performed to determine the amount of contact time being achieved in the clarifier basin at the Child Street Water Treatment Facility. The most recent tracer study done on this basin was performed by CDM in 1992. That study recommended a baffling factor of 0.5 for the basin. Since that time, physical modifications have been made to the basin, as well as changes to disinfectant chemical concentrations, application points and to the flow rate of the plant, warranting a new study.

Weston & Sampson performed a tracer study on March 22, 2006. The summary report submitted to HEALTH stated that the results of that test were inconclusive due to interference from coagulant in the water. It is unclear why coagulant was being added to the water source while the tracer study was being conducted since the plant was offline from 9am on 3/20 to 2pm on 3/24. It is also unclear why the test was not halted on the 22nd when it became clear that tracer recovery of 90 % was not being achieved and restarted the following day. In any event, the results are not acceptable.

The tracer study must be redone after any treatment chemicals have been flushed from the basin. Also, per the proposal submitted to HEALTH on October 17, 2005 (attached), "BCWA will perform a tracer study on the clarifier and the clearwell. The study shall be run at 1 MGD and 3 MGD." This proposal was approved and should be followed.

Also, once completed and approved, the results of the tracer study should be used to generate a table that can be used to determine the contact time in each basin under different flow rates. (see my attached letter dated February 6, 2006.) This table will be used in preparing the monthly CT reports for the plant.

If you have any questions regarding this review, feel free to contact me at 222-7784.

Sincerely,

Susan H Rabideau

Susan Rabideau, P.E.
Senior Sanitary Engineer

Cc: Domenic Soignoli, BCWA
James Finegan, Jack Mitchell, Weston & Sampson

BCW
BRISTOL COUNTY WATER AUTHORITY

October 30, 2006

Ms. Susan Rabideau, P.E.
Drinking Water Quality
Department of Health
3 Capitol Hill
Providence, RI 02908

Via Telefax and
First Class Mail

Dear Ms. Rabideau:

Per our phone discussion this morning it was agreed that a Tracer Study is not necessary at this time. The Study will be conducted when we are able to run the plant at 3 MGD or higher rates of production, which will not be possible until the Phase II improvements are implemented to the Plant.

A Tracer Study is therefore postponed and a future date for it will be established by Health and BCWA at the time of Phase II improvements.

Please do not hesitate to call me if you have and questions or desire more information.

Sincerely,
BRISTOL COUNTY WATER AUTHORITY

Pasquale DeLise, P.E.
Executive Director

PD:ch
cc: D. Soignoli
J. Mitchell
J. Finnegin

450 Child St. • P.O. Box 447 • Warren, Rhode Island 02885-0447 • www.bcwa-ri.com • Fax: 401-245-2004 • Tel: 401-245-2022
A Public Agency

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

D E P A R T M E N T O F H E A L T H

Safe and Healthy Lives in Safe and Healthy Communities

November 22, 2006

Mr. Pasquale DeLise, Executive Director
Bristol County Water Authority
450 Child Street
Warren, RI 02885

Re: BCWA Clarifier Tracer Study, PWSID # 1647515

Dear Mr. DeLise:

The Rhode Island Department of Health, Office of Drinking Water Quality has received your letter dated October 30, 2006 regarding the tracer study that will confirm contact time being achieved in the clarifier and clearwell. HEALTH concurs that the study is not required at this time since the plant is achieving adequate "CT" or disinfection inactivation time due to the low flow rate of 1.5 MGD.

The tracer study is required prior to increasing flow rate of the plant to greater than 2 MGD. Results of the new tracer studies must be submitted to this office. If you have any questions regarding this review, feel free to contact me at 222-7784.

Sincerely,

Susan H Rabideau

Susan Rabideau, P.E.
Senior Sanitary Engineer

Cc: Domenic Soignoli, BCWA

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