FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR THE CROTON WATER TREATMENT PLANT

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3. PROPOSED PROJECT AND ENGINEERING ALTERNATIVES

3.1. INTRODUCTION

This section provides a general description of the engineering design and process for the Croton water treatment plant (WTP). The general process is similar at all three site alternatives, but the process train layouts, chemical feed equipment, and residuals handling vary between sites. There are differences in the dimensions of the facilities at each potential site, since local site constraints have required the shape of the main process building to vary. Each site is at a different elevation above local grade and has different hydraulic grades. The site-specific details are described in Section 5.1, Introduction and Project Description for the Eastview Site, Section 6.1, Introduction and Project Description for the Mosholu Site, and Section 7.1, Introduction and Project Description for the Harlem River Site.

3.2. WATER TREATMENT PLANT CAPACITIES

3.2.1. Background

Based on analysis of NYCDEP records since 1960, the NCA has been operated at an annual average flow of 144 mgd, equal to approximately 10 percent of the City's supply (Table 3-1). During droughts, when use of Croton water is typically increased due to restrictions from and shortages in the Catskill/Delaware Systems, the NCA has provided as much as 30 percent of the City's supply, and is frequently operated at maximum aqueduct capacity.

TABLE 3-1. HISTORICAL NEW CROTON AQUEDUCT FLOWS

Category	Flow	Proportion of City Supply
Average	144 mgd	10 percent
Maximum year	252 mgd	19 percent
Maximum month	292 mgd (1)	23 percent
Maximum day	308 mgd (1)	22 percent

Notes:
(1) Recorded July 1985

The capacity of the proposed plant is related to the capacity of the NCA to convey water. Currently, the NCA has a maximum capacity of about 270 mgd. Without pressurization, the NCA capacity would be restored in 2004-2006 to 290 mgd by grouting leaks and other restoration and rehabilitation work from its present maximum capacity of about 270 mgd. NYCDEP also investigated the feasibility of increasing the NCA capacity by pressurization. Originally, it was thought that an NCA capacity of 450 mgd could be achieved through pressurization. It subsequently was determined that NCA capacities up to only 418 mgd could be achieved by pressurization. NYCDEP ultimately decided not to pressurize the NCA all the way from the Croton Lake Gate House to Jerome Park Reservoir in order to deliver 418 mgd, but to repair it and restore its capacity to 290 mgd. The following section describes this decision-making process.

3.2.2. Analysis of Water Treatment Plant Capacities

In order to identify alternative proposed plant capacities, the NYCDEP monthly flow records for the years 1960 through 1994 were compiled and analyzed. Data were disregarded for months in which unusual operations (such as construction-related shutdowns) occurred. Since 1992, Croton operation has been unusual due to construction or aqueduct inspections, and there have been frequent system shutdowns due to poor water quality. Some data after 1992 were therefore disregarded as well.

The remaining data (for 375 months) were separated into normal operation months (279 months) and drought operation months (96 months). Drought operation months were defined as when transfer pumping to the Intermediate and High Level systems occurred at a flow rate exceeding about 50 mgd. This pumping includes the Jerome and Mosholu Pumping Stations in the Bronx, and the Croton Falls and Cross River Hydraulic Pumping Stations in the Croton watershed, which transfer water directly to the Delaware Aqueduct upstream of Kensico Reservoir. A summary of the data is presented in Table 3-2. Flows from West Branch Reservoir discharged directly into the Delaware Aqueduct have been excluded, since these flows have filtration avoidance under the U.S. Environmental Protection Agency (USEPA) 1997 Filtration Avoidance Determination. The data show that use of Croton water could be increased during both normal and drought periods if facilities were constructed to treat and convey additional Croton water to the City, as needed.

TABLE 3-2. NORMAL AND DROUGHT USAGE OF CROTON WATER

	Normal Conditions	**Drought Conditions**
New Croton Aqueduct Flow	142 mgd (1)	202 mgd
To Delaware Aqueduct from upstate pumping	12 mgd	28 mgd
To in-watershed communities	3 mgd	4 mgd
Total Usage	157 mgd	234 mgd
Stream releases to downstream watercourses	22 mgd	0 mgd
Spill/wasted over dam spillway	184 mgd	56 mgd
Total available	363 mgd	290 mgd

Notes:
(1) This figure of 142 mgd differs slightly from the figure of 144 mgd reported in the section 3.3.1 because of the exclusion of data for months of unusual operation.

Four alternatives proposed plant capacities were developed and analyzed based on the transmission capacity of the NCA (Table 3-3)[1]. The analysis was performed using a computer model of system operation during a simulated eighteen-month drought, during which the reservoirs would be reduced from 100 percent full to 25 percent of capacity. While pressurization of the NCA to the New Croton Reservoir head would increase its flow capacity to about 418 mgd, this maximum capacity would only be available when the New Croton Reservoir was at maximum water level. As the reservoir level is lowered, as would occur during a

[1] Alternatives that do not use the full capacity of the NCA were not considered, since such alternatives would not meet NYCDEP's project objective of allowing the City to maximize the use of Croton water that can be conveyed down the NCA.

prolonged drought, the capacity of the aqueduct would be reduced significantly. The potential drought usage of Croton water in Table 3-3 reflects this reduction in aqueduct capacity as the reservoir level is lowered.

If the NCA is rehabilitated to 290-mgd capacity (pressurized to Eastview head or without pressurization) and no upstate transfers are used, potential drought usage of Croton water would be reduced to 290 mgd (Alternative 1). This alternative assumes that the Croton Falls and Cross River hydraulic pumping stations are not used. The estimated capital cost of this alternative is significantly lower than for full pressurization due to the elimination of the cost of full pressurization and the reduction in proposed plant capacity.

TABLE 3-3. NEW CROTON AQUEDUCT PRESSURIZATION

Condition	Aqueduct Capacity	Potential Drought Usage of Croton	Capital Cost Estimate (1)
Alternative 1 - rehabilitated aqueduct, no upstate transfers	290 mgd	290 mgd	$590 million
Alternative 2 - rehabilitated aqueduct plus upstate transfers to Delaware Aqueduct	290 mgd	413 mgd	$640 million
Alternative 3 - rehabilitated aqueduct plus upstate transfers to Catskill Aqueduct	290 mgd	413 mgd	$820 million
Alternative 4 - Pressurized aqueduct, no upstate transfers	418 mgd	335 mgd	$850 million

Notes:
(1) These estimated capital costs are valid for comparison purposes only, since the costs are based on conceptual and preliminary design work performed to support the Draft Environmental Impact Statement (DEIS) under preparation by NYCDEP in 1995 for the previously proposed 450-mgd Water Treatment Plant. This Draft EIS was never completed as the City decided to re-evaluate its future plans for the Croton System.

If upstate transfers were used in conjunction with a rehabilitated (but not fully pressurized) NCA, the potential drought usage of Croton water would be maximized. Alternative 2 assumes that upstate transfers would be made at Croton Falls and/or Cross River to the Delaware Aqueduct, but using larger capacity motor-driven pumping stations in place of the existing hydraulic pumping stations. Based on the analysis, these pumping stations have been preliminarily sized for a combined capacity of 123 mgd. Further, more-detailed analysis using daily, rather than monthly, flow records would be needed to confirm the optimum capacity for these pumping stations. The estimated capital cost of this alternative is significantly lower than for pressurization due to the elimination of the cost of pressurization and the reduced proposed plant capacity. A reduced treatment capacity has been assumed, since the New York State Department of Health (NYSDOH) has indicated that unfiltered use of these supplies would continue to be approved under emergency conditions, such as drought or the need to reduce usage of the Catskill/Delaware supplies for water quality or other concerns. NYSDOH approval for such use of the existing hydraulic pumping stations has been requested and granted promptly in the past and continuation of this procedure is anticipated by NYCDEP. Alternative 3 assumes that upstate transfers would be made at the New Croton Reservoir to the Catskill Aqueduct. Unlike Alternative 2, full treatment including filtration is anticipated to be necessary for water transferred from the New Croton Reservoir, and the estimated capital costs reflect this additional treatment capacity.

3.2.3. Analysis of Croton Usage

Alternative 1 would reduce the City's ability to use Croton water during drought periods and is not recommended. Alternatives 2 and 3 show clear advantages in increasing the potential usage of Croton water compared to pressurization of the NCA[2]. Analysis of "spare" capacity in the Catskill and Delaware Aqueducts, north of Kensico Reservoir at the general location where the upstate transfers would take place, indicates that the Catskill Aqueduct does not generally have sufficient spare capacity to accommodate these transfers, even during drought periods. The Delaware Aqueduct has ample spare capacity for the anticipated transfers. The Delaware Aqueduct at this location has a capacity of 1,000 mgd and rarely exceeds 900 mgd flow. During drought emergencies, flows from the Delaware system are required to be reduced to as little as approximately 500 mgd to permit adequate interstate transfers. Even with the Chelsea Pumping Station activated (100 mgd), there would be several hundred million gallons per day spare capacity in the Delaware Aqueduct north of Kensico Reservoir. Alternative 2 is therefore preferred over Alternative 3 for operational as well as economic reasons.

In addition to reducing the potential drought usage of Croton water, pressurization of the NCA to convey 418 mgd would take many years to complete. The City has many competing inspection, maintenance and construction needs on all three of its systems. Scheduled NCA shutdowns for inspection in order to confirm the feasibility and likely cost of restoration or pressurization have repeatedly been delayed for several years, due to more critical work needed elsewhere in the system (such as at Hillview Reservoir). Even if the NCA could be taken out of service for the duration of the improvements necessary for pressurization, the work would be anticipated to take 3 to 5 years. More likely, the work would have to be performed during multiple short duration (several months) shutdowns, to allow work to be performed elsewhere in the system and to avoid the risk of inadequate water supply to the City during peak summer months, particularly if drought conditions occurred, and would probably take 10 years or more to complete.

3.2.4. Summary and Recommended Water Treatment Plant Capacity

Pressurization of the entire NCA to support flows of 418 mgd is not proposed at this time. However, pressurization to the Eastview head for a water treatment plant at the Eastview Site is a viable alternative. The lower pressurization at the Eastview Site could be done without taking the Croton system off-line if the Croton water were to use the Delaware Aqueduct for the estimated five years it could take to complete the pressurization of the treated water section. In the future, irrespective of the decision on siting for the proposed water treatment plant, the NCA would be restored (rehabilitated) to 290-mgd capacity, and the proposed plant would be designed

[2] Pressurization of the entire aqueduct was an alternative intended to increase the potential to utilize the NCA. This is a different alternative than the pressurization of only the treated water portion downstream of the Eastview Site alternative. Treated water pressurization would be intended to prevent infiltration and potential contamination as well as to avoid additional in-City pumping of treated water.

and constructed at 290-mgd capacity to match the capacity of the NCA after its planned rehabilitation.

3.3. WATER TREATMENT PROCESS DESIGN AND ALTERNATIVES

3.3.1. Treated Water Quality Objectives

Water treatment goals and process design criteria were prepared in November of 2001[3] and were based on previous pilot studies and reports. The recommended process design includes dissolved air flotation (DAF) over filtration, with ultraviolet light (UV) for disinfection. This process was subsequently endorsed by the NYSDOH in the January 2002.

The primary goals of the proposed project are to meet the public water supply and public health needs of the City and to comply with State and Federal drinking water standards and regulations. The key treated water quality objectives considered in evaluating and selecting a treatment process for the Croton System focus on source water quality and current and anticipated water quality regulations.

Treated water quality goals are presented in Table 3-4. These goals are based on the USEPA regulations proposed or promulgated under the Safe Drinking Water Act, Part 5 of the State Sanitary Code (10NYCRR), and NYCDEP's own water quality goals. In addition to the specific goals listed below, the plant's treated water quality is anticipated to comply with all other regulated parameters – these other contaminants are generally not present in the Croton raw water at levels above regulated standards.

Treated water quality goals for microbiological parameters include 99.9-percent (3-log) removal/inactivation of *Giardia* cysts and *Cryptosporidium* oocysts. On-line particle measurements would be used to determine steady-state operation. Steady-state operation is defined as the condition when the particle counts reach a constant level, which is continued without variation over time. The absolute particle numbers are not as important as maintaining this steady state. No numerical goal is set for the particle counts since particle counts are not regulated at this time, and particle count measurements are not consistent between instruments provided by different manufacturers.

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[3] The Croton Water Treatment Plant Process Design Criteria Report – November 2001. New York City Department of Environmental Protection. New York, NY.

TABLE 3-4. TREATED WATER QUALITY GOALS

Constituent	Goal
Microbiological	
Giardia cysts	≥99.9percent removal and inactivation
Cryptosporidium oocysts	≥99.9percent removal and inactivation
Viruses	≥99.99percent removal and inactivation
Filtered water turbidity	≤0.10 ntu for 95percent of time
Particles (>2 µm)	Steady state operation
Regrowth potential	BDOC(1) not more than raw water levels (seasonally adjusted)
Disinfection By-Products	
Trihalomethanes (total)	≥64 µg/l (4-quarter RAA(2))
Haloacetic acids (HAA6)	≥48 µg/l (4-quarter RAA)
Bromate	≤5 µg/l
Inorganics	
Aluminum	≤0.05 mg/l
Corrosion control	Maintain finished water pH of 7.0-7.5
Iron	≤0.10 mg/l
Manganese	≤0.05 mg/l
Other	
Total organic carbon	>35percent removal, or <2 mg/l in filtered water
True color	≤5 scu
Tastes and odors	Treat to minimize

Notes:
(1) Biodegradable Dissolved Organic Carbon (BDOC)
(2) Running Annual Average (RAA)

3.3.2. Treatment Process and Design Criteria

To achieve the process goals, the treatment process would consist of dissolved air flotation stacked above filters. No pre- or intermediate-ozonation is included. Instead, inactivation of *Cryptosporidium* oocysts and *Giardia* cysts would be accomplished by Ultraviolet Light (UV) irradiation as the primary disinfection step. Recently, high intensity UV has been approved by the USEPA for inactivation of protozoan parasites. This technology offers lower costs and a smaller footprint of equipment than ozone disinfection. Chlorine would be added to treated water to provide the required chlorine residual in the distribution system.

In accordance with a letter sent to NYCDEP by the NYSDOH, additional piloting of the process modifications is not needed, for several reasons. Although the previous piloting for the Croton WTP focused primarily on DAF followed by ozonation in the process train, data were also collected for the DAF process without ozonation. Based on the data, the DAF process without ozonation was deemed a viable process for treating the Croton supply. More importantly, useful and directly applicable data are available from the BHC Company of Bridgeport, CT, which owns and operates a 50-mgd plant with a stacked DAF/filtration design. This facility, the William S. Warner WTP, is located on the Hemlocks Reservoir in Fairfield, CT and has been operational since 1997. The data from the Warner WTP are applicable to the Croton system, because the water quality in the Hemlocks Reservoir is similar to that in the New Croton Reservoir with respect to turbidity, temperature, iron, manganese, and organic carbon concentrations. Furthermore, the dose response of *Giardia* cysts and *Cryptosporidium* oocysts to UV is now well known, and no additional process design information could be gathered from the pilot testing of this technology. Refer to Table 3-5 for the water treatment design criteria.

TABLE 3-5. WATER TREATMENT DESIGN CRITERIA

Unit Process	Parameter	Proposed Design
Entire Plant	Maximum Flow Average Flow Minimum Flow	290 mgd 144 mgd 90 mgd
Pretreatment	Oxidant Contact Time	Potassium permanganate feed at Croton Lake Gate House or Gate House No. 5; NaOCl feed in plant >6 hrs in Aqueduct
Coagulation/ Rapid Mix	Metallic Coagulant pH Control Polymer Type Detention Time Mixing Intensity	Alum, PACl Seasonally Sulfuric Acid Cationic 2-Stage, 20 Sec / Stage 1000 Sec^{-1}
Flocculation	Flocculation HDT Mixing Intensity	2-stage, 2.4 min / stage (minimum) 100 sec^{-1}
Flotation	DAF Loading Rate	5.0 gpm / sf (with residual recycle flow and 1 in 12 tanks out of service)
Filtration	Media Type Filter Media Depth Filtration Rate Maximum Backwash Rate Filter-to-Waste Filter Aid Polymer	Dual Media 24" Anthracite / 12" Sand 6.5 gpm / sf (with 1 in 12 filters out of service) 25 gpm / sf Provided Anionic
Primary Disinfection	Type Maximum Dose	UV Light 40 mJ / cm^2
Residuals Handling	DAF Sludge Treatment Solids Dewatering Filter-to-Waste Treatment Waste Backwash Water Treatment	Skimmed solids sent to centrifuges for dewatering Centrifuge Equalization -recycle to head of plant without treatment Equalization – recycle to head of plant without treatment

Note: Design criteria based on a design flow of 290 mgd for the Croton WTP.

3.3.3. Process Design – Engineering Alternatives

Several engineering alternatives for various water treatment processes were evaluated. These processes were rapid mixing, flocculation, micro-bubble production for DAF, UV disinfection, UV chamber layout, and DAF layout.

3.3.3.1. Rapid Mixing

There are several alternative types of mixing methods that could be used to mix chemicals with the raw water. These include:

Hydraulic Mixing. This is a type of mixing which does not involve mechanical or moving parts. The mixing energy is obtained through head loss in the water, and is proportional to the square of the discharge velocity. As flow rates vary substantially, there is no positive control over the degree of mixing at low flow rates.

Static Mixers. Static mixers are in-line devices that do not have a motor, but rather require an outside source of energy. Static mixers are provided with a series of turning vanes that divide the flow and create turbulence in the flow stream, thereby mixing the chemical into the water. The decrease in line pressure across the static mixer provides the energy for mixing. Static mixers are frequently used in small plants, but are not typical for larger plants. Most manufacturers of static mixers provide standard sizes only up to about 36 inches, because the cost benefits of using static mixers decrease as the flow rate (and therefore mixer size) increases.

Injection Mixing. Mixing is accomplished by pressurized water jets that take water directly off the raw water line, upstream of chemical addition, raise its pressure, and discharge the water back into the raw water flow. An advantage of this type of mixing system over a mechanical mixing system is that power consumption is substantially reduced. One disadvantage of this system is the potential for debris to block the nozzles.

Mechanical Mixers. Mechanical mixing is accomplished by impellers, which are driven by motors. The main advantage of mechanical mixers is that the impeller drives are usually variable speed, which enables the mixing intensity to be adjusted with seasonal changes in temperature, coagulant type and dose, and water flow. However, the duration of mixing can often be too long at lower plant flows because the mixing basins are of a fixed size. Other disadvantages of mechanical mixing are a high capital cost and a high energy requirement.

Hydraulic mixing and static mixing were not selected for the reasons presented above. Injection mixing and mechanical mixing were both considered, and a cost analysis of these two methods was conducted. Although the economic analysis indicated that injection mixing would be more cost effective, installation and access of the pipe and nozzles would be difficult. Mechanical mixing would provide the required mixing for dispersion of the pretreatment chemicals and would be less difficult to operate and maintain. Thus mechanical mixing was the alternative selected.

3.3.3.2. Flocculation

Hydraulic flocculation and powered flocculation were both considered.

Hydraulic flocculation. This process uses perforated baffles to create shear energy. The baffles cause hydraulic headloss or energy dissipation, which are associated with velocity gradients.

Powered flocculation. This process is well established as an effective method of flocculation, and it was chosen for the Croton WTP design because it is effective and easy to control. Vertical impeller flocculator mixers are chosen over vertical paddle flocculator mixers, because vertical impeller flocculators turn the contents of the flocculation basin over two or more times before the water exits. Paddle flocculators were not chosen because they produce high, localized shear gradients.

3.3.3.3. Dissolved Air Floatation (DAF) Layout

DAF Layout. The traditional DAF treatment design utilizes separate basins for the DAF process and the filtration process. This layout requires a large footprint, and due to size constraints imposed for the Croton WTP, is not feasible at the proposed sites.

Stacked DAF/Filtration. Stacked DAF/Filtration, the chosen alternative for the Croton WTP, is a combined design of both the DAF process and the filtration process. The two separate process units are combined, and DAF is “stacked” above the filtration basin. Only one physical basin is required for the two processes, and the advantage of design is that the plant footprint is significantly reduced, and as a result, construction costs are also reduced.

3.3.3.4. Micro-bubble Production for DAF

There are three methods of producing DAF micro-bubbles:

Needle Valves. The most common method of DAF micro-bubble production is to use small needle valves, which reduce the pressure in order to introduce the recycle bubble stream into the water at the contact zone. The needle valves and diffusers are mounted at 1-ft. centers on horizontal manifolds, located in the contact zone at a depth of 6 ft. to 10 ft. The advantage of using needle valves is that they can be adjusted to allow for wear in the orifice and to adjust the recycle flow for given pressure conditions. The disadvantage of using needle valves is that floc or debris from the upstream pipe easily blocks the openings. Furthermore, the large numbers of needle valves required for a large capacity plant are considered impractical.

Orifice Nozzles. Another method considered is to use fixed orifice nozzles mounted at 1-ft. centers on horizontal manifolds. The advantage of fixed nozzles is that they are difficult to block. The nozzle system design can better handle changes in plant flows, DAF recycle flows, and operating pressure as compared to the needle valve system, but requires two or three separate manifolds of nozzles per DAF tank. Manifolded systems using fixed nozzles or needle valves may involve an energy penalty on larger plants, because the effective and most efficient operating recycle pressure and flow “windows” are small for a given manifold and number of nozzles or needle valves.

Globe Valves. In this method, rather than using hundreds of needle valves mounted on manifolds, the needle valves are replaced with six globe valves per tank. Each globe valve discharges into a parallel duct between the flocculation and DAF zones. The advantage of this concept is that the pressure at the saturator can be controlled continuously over a very wide recycle flow band. Also, the large opening of the globe valve annulus makes it difficult to block. A disadvantage of this arrangement is that it requires a valve access gallery that increases the footprint of the plant. In addition, the capital costs of the valves are much greater than the capital costs of the other methods.

The needle valve method of micro-bubble production was eliminated as an option for the Croton WTP due to the required maintenance involved as compared to the other two methods. The fixed orifice nozzle approach and the control valve methods require less maintenance. The main considerations for making a selection for these methods include space requirements, equipment costs, and operating costs. The globe valves would require additional gallery space (a larger footprint) than the fixed orifice nozzle system, and the equipment costs of the valves would be significantly higher than the equipment cost for the nozzle system. As a result, the fixed orifice nozzle approach to micro-bubble production was selected for the Croton WTP.

3.3.3.5. UV Disinfection

Two types of UV systems were considered for the Croton WTP Preliminary Design: low-pressure systems and medium-pressure systems. Both types of UV systems were evaluated for four alternative layouts.

Low Pressure Mercury Lamps. Low-pressure lamps deliver UV primarily at 253.7 nanometers (nm), with a smaller component at 185 nm. Both of these wavelengths fall in the germicidal band as defined by the DNA absorbance spectrum. Low-pressure lamps are designed and operated to maximize output of light in the germicidal range and they operate at a wall temperature of 40 to 60°C. Efficiencies of 30-40 percent are typical for low-pressure lamps. A transfer efficiency of 36 percent is considered to be high as compared to other lamp types. The low operating temperature allows for long lamp lives compared to alternate lamp types. Replacement periods of up to 10,000 hours (>1 year) have been reported.

Medium-Pressure Mercury Lamps. In these types of lamps, the mercury inside the lamps is at five or six times higher pressure than as in the low-pressure lamps. Combined with a higher operating temperature, medium-pressure lamps emit a polychromatic spectrum, stretching from the far UV (185 nm) to the infrared (1387 nm). Within the effective germicidal range (230 to 300 nm), many peaks are emitted, allowing for effective inactivation of many different microorganisms. The lamps operate with wall temperatures between 500 and 850°C. With the high operating temperatures, the lamp life is considerably shorter than as compared to the low-pressure-high output lamps. Replacement periods of 2,000 to 5,000 hours (83 to 210 days) are typical. While the germicidal efficiency of the medium-pressure lamps is less than that of the low -pressure lamps (15 to 25 percent as compared with 30 to 40 percent), the output of the medium -pressure lamps is much higher (up to 20 kW compared to < 0.5 kW). Therefore, fewer lamps are required (and associated sensors, cleaning mechanisms, and maintenance requirement) and a smaller footprint can be anticipated. Thus, medium-pressure systems have the potential of being more cost effective for large systems.

The low -pressure UV system was chosen for the Croton WTP design. This system, compared to the medium -pressure UV system, has a lower cost, lower power consumption and lower operating temperatures. Also, lamp fouling is less prevalent and so there is a reduced need for mechanical wipers.

3.3.3.6. UV System Layout

Two general configurations were evaluated for the UV chamber arrangement and design. For the first configuration, the UV chambers were directly coupled to the filters (i.e., one chamber per one filter, or one chamber per two filters). For the second configuration, the UV chambers were not directly coupled to the filters (i.e., chambers fed from a filtered water header). Several alternative layouts for UV chambers arranged for each of these two configurations were investigated.

One UV Chamber Directly Coupled To One Filter. Under this alternative, one UV chamber would be directly coupled to each filter with a total of 48 UV chambers, each capable of treating 7.5 mgd. The filters and UV chambers cannot be operated independently under this alternative. If a UV chamber is taken offline for any reason (i.e., lamp replacement, cleaning, out-of-service), the coupled filter must then be taken off-line. Filter backwashing would interfere with the UV chamber operation and the UV chambers must be designed to accommodate the backwash cycle (i.e., chambers would either be shut off, or left on).

One UV Chamber Directly Coupled To Two Filters. Under this alternative, one UV chamber would be directly coupled to two filters, with a total of 24 UV chambers capable of treating 15 mgd each. The filters and UV chambers cannot be operated independently under this alternative either. If a UV chamber is taken offline, then both coupled filters must then be taken offline. Filter backwashing under this alternative would normally not interfere with the operation of the UV chamber beyond adjusting the power to the lamps to maintain the UV dose at the lower flow. This is the result of teaming two filters to the chamber, allowing one filter to be backwashed while the second filter would still be sending filtered water to the UV chamber.

Uncoupled 20-mgd UV Chambers. Under this alternative, the UV chambers would not be directly coupled to the filters. Each UV chamber would have a capacity of 20 mgd, with 16 duty UV chambers and 4 standby chambers. The filtered water header would convey water through each UV chamber train. Since the UV chambers are not directly coupled to the filters, the UV system can be operated independent of the filters. Therefore, if a UV chamber is taken off-line for any reason, the redundant chamber in the group can be turned on without losing any capacity in the system. For this alternative, filter backwashing would not impact the UV system. The chamber capacity for this alternative is 20 mgd, the industry's largest available validated chamber.

Uncoupled 40-mgd Chambers. Under this alternative, the UV chambers would not be directly coupled to the filters. Each UV chamber would have a capacity of 40 mgd, with a total of 8 duty UV chambers, and 4 standby chambers. Since the UV chambers are not directly coupled to the filters, the UV system can be operated independent of the filters.

The UV chamber alternative layouts were compared to determine the optimum configuration. The parameters used to compare alternatives include chamber capacity, chamber layout, and costs. The advantages of using 20 mgd UV chambers (or smaller) are that these chambers have been validated and are currently commercially available. The advantage of using 40 mgd chambers is that fewer chambers are required, resulting in a smaller footprint.

The uncoupled configuration would be used in the proposed plant, since it provides greater operational flexibility when compared to the coupled configuration. A 20 mgd UV chamber was chosen for the uncoupled configuration for the Croton WTP UV system design. The 20 mgd unit layout provides the benefit of being commercially available as well as being the largest validated unit available.

3.4. ANCILLARY SYSTEMS – ENGINEERING ALTERNATIVES FOR THE EASTVIEW SITE

3.4.1. Surge Analysis

The raw (untreated) water that would flow to a WTP at the Eastview Site would flow by gravity ten miles down the NCA, and then another 7,500 feet to the pump station below the WTP. In the event of an unanticipated system shutdown, water from the WTP, 200 ft. above the raw water tunnel, would back down the raw water tunnel and collide with water flowing from New Croton Reservoir. This would create a surge that could damage the aqueduct if the pressure were not relieved. The existing blow-off at Shaft No. 9 in the Village of Sleepy Hollow was designed to handle sudden discharges from the NCA, but it is not configured to handle the NCA flows combined with sudden backpressure from the water treatment plant. Five alternative solutions for alleviating surge conditions are discussed in this section.

3.4.1.1. Detention Tank at Shaft No. 9

One of the alternatives to handle surge conditions would be a detention tank at Shaft No. 9 in the Village of Sleepy Hollow. The water in the detention tank would flow by gravity through a sluice gate and drainage would absorb some of the peak flow and reduce the maximum overflow. The detention tank would reduce the overflow at Shaft No. 9, but would not reduce the maximum surge level at the plant wet well. Pressurization of the NCA would be required between Shaft No. 9 and the new raw water tunnel connection.

3.4.1.2. Pressurization of NCA Upstream of Raw Water Tunnel Connection

Pressurizing the NCA to the New Croton Reservoir is a potential hydraulic solution to the surge problem. Raw water would flow from the plant wet well up the NCA and be released to the New Croton Reservoir. A surge under these conditions would result in no environmental impacts. In this alternative, the NCA would require pressurization from the new raw water tunnel to the Croton Lake Gate House.

3.4.1.3. A New Relief Tunnel to the Hudson River

A new tunnel constructed from the new concrete plug in the NCA to the Hudson River is also one option to relieve surge. An overflow structure at the new concrete plug would be constructed connecting to a new tunnel to the Hudson River. An outfall structure would be constructed at the Hudson River. Overflow at Shaft No. 9 would thus be limited to 150 mgd and no pressurization of the NCA would be required.

3.4.1.4. A Detention Tank at Eastview

A detention tank at the proposed plant at the Eastview Site would reduce the maximum surge level at the wet well to 151 ft. MSL (Mean Sea Level) (149 ft. MSL at Shaft No. 9). The wet well would contain an overflow weir at Elevation 149.3 ft. MSL to the detention tank. The overflow at Shaft No. 9 would be rehabilitated and blow-off would be limited to a maximum of 290 mgd.

3.4.1.5. Overflow Structure to the NCA

An overflow structure at the new concrete plug would reduce the maximum surge level at the wet well and the overflow at Shaft No. 9. Minimal pressurization of the NCA from the plug to Shaft No. 9 would be necessary, similar to the baseline rehabilitation planned for the upstream portion of the NCA from Croton Lake Gate House to Shaft No. 9. The overflow would flow to the Jerome Park Reservoir. However, this requires that the NCA downstream of the raw water tunnel connection be available for surge releases and the Jerome Park Reservoir would serve as a blow-off. This alternative is only viable if the decision is made to use the Kensico-City Tunnel as the principal means of conveying Croton water to the City.

3.4.1.6. Recommended Surge Alternative

If the long-term treated water conveyance is the NCA then the recommended alternative to alleviate surge is the detention tank at Eastview coupled with the rehabilitation of the blow-off at Shaft No. 9. This alternative would require minimal pressurization of the NCA from Shaft No. 9 to the raw water tunnel and minimal construction work would be required at Shaft No. 9.

If the long-term treated water conveyance is the KCT then the recommended alternative to alleviate surge is the detention tank at Eastview coupled with the overflow structure to the NCA. Jerome Park Reservoir has adequate capacity to handle many hours of surge without overflowing to waste via existing drain lines to the sewer.

3.4.2. Emergency Bypass

If the proposed plant is taken out of service and Croton System was required to meet demand, an emergency bypass, subject to NYSDOH review and approval, would be available to convey Croton water downstream of the proposed plant. Different bypass plans would be implemented depending on the choice of treated water conveyance. If the KCT were selected for treated water, an overflow structure would be constructed in the NCA at the raw water tunnel connection. If the proposed plant were taken out of service, raw water would fill the wet well and detention tank at the raw water pump station. The water would rise to a maximum level and cause the water to reverse direction and overflow at the weir located in the NCA. Water would flow to the NCA, at Low Level, and flow downstream from the proposed plant. Low Level water could be conveyed through the NCA to Manhattan.

If the design for pressurizing the NCA to convey treated water is selected, no overflow structure at the raw water tunnel would be constructed. Instead, a plug would be installed upstream from the treated water tunnel connection to the NCA and the overflow structure would be sealed. Subject to NYSDOH approval, a connection at the proposed plant from the raw water shaft to the treated water shaft would serve as a bypass and allow untreated Croton water to be conveyed to the NCA downstream of Shaft No. 10. Due to the loss of power, no raw water pumping would be available and Low Level raw water would be distributed to the new Shaft Chamber at Jerome Park Reservoir. The sleeve valves to the Low Level service connections at the new Shaft Chamber could be opened to allow up to 190 mgd to be distributed to the Low Level Service areas in the Bronx and Manhattan.

3.4.3. Dewatering Alternatives

Treatment of Croton water would result in the production of residuals throughout the treatment process. Separating, handling, and managing these residuals would allow reclamation of usable water and minimization of waste disposal. The following three primary streams of residuals would be generated from the main water treatment processes:

Water from the DAF units would pass through granular media filters (filters) to capture additional solids not removed with the floated solids. Solids captured by the filters would be removed with the waste backwash water (WBW) during backwash cycles. WBW would flow by gravity to the WBW equalization tanks and then recycled to the head of the plant upstream of the coagulation process. Settled solids from the bottom of the WBW equalization tanks would be pumped to the floated solids storage tanks.

Filter-to-Waste (FTW) water generated before and/or after each filter backwash cycle would flow by gravity to the FTW equalization tanks and then recycled back to the head of the plant upstream of the coagulation process. It is assumed that solids in the FTW would be negligible and would eventually be removed in the DAF units.

DAF units would remove approximately 90 percent of the solids produced during the flocculation stage of the treatment process. Floated solids from the DAF units would be conveyed by gravity to the floated solids buffer tanks and then pumped to the floated solids storage tanks.

Alternative dewatering processes for the solids and their key advantages and disadvantages are discussed below.

3.4.3.1. Centrifuges

Centrifuges are used frequently and successfully in both water and wastewater industries for dewatering various types of sludge. Solid bowl centrifuges would be considered over basket centrifuges for this application, since they would allow continuous operation and offer operational flexibility. Solids removal and cake dryness can also be enhanced, as with other dewatering technologies, by the addition of polyelectrolytes and other coagulants.

Centrifuges would provide a relatively clean, continuously operating, and flexible process that would require less operator attention than other alternatives. Additionally, fewer units would be required, resulting in both cost and footprint savings.

3.4.3.2. Vacuum Filters

The type of vacuum filter required for aluminum hydroxide sludge generated in the water treatment would be the rotary drum vacuum filter, specifically, a pre-coat media filter. The primary disadvantage of this technology for dewatering aluminum hydroxide sludge would be the necessity of a diatomaceous earth pre-coat. This would add a significant amount of solids that would require disposing.

Another disadvantage of vacuum filters would be the large number of units required to process this quantity of sludge. This greatly increases operational requirements, and also requires considerably more spatial area. Given this, vacuum filters would not be considered further.

3.4.3.3. Belt Filter Presses

Belt filter presses are more commonly used, and are more efficient, for dewatering wastewater sludge. However, extensive lime conditioning would be required and consistently high cake solids concentrations would be difficult to achieve with aluminum hydroxide sludge. Another major disadvantage of this technology would be the need for a large quantity of belt wash water during operation. This would significantly increase the quantity of residuals streams to be managed and processed. In general, this process is a messy, open operation requiring a high level of maintenance. Given these considerations, belt filter presses would not be considered further.

3.4.3.4. Membrane Presses

Membrane plate filter presses dewater thickened sludge, and would be capable of producing higher cake solids than vacuum filters, belt presses, or centrifuges. The membrane filter press would be a batch operation that would include a fill cycle, and a final dewatering cycle. Every other press plate in the filter would be fitted with a flexible membrane that would squeeze the sludge during the dewatering cycle. The membranes would be pressurized with water for final dewatering of sludge. An advantage of the membrane press would be achieving higher cake solids production. However, disadvantages of using membrane presses would be high cost, batch operations, potential cake release problems, and higher operator attention.

3.4.3.5. Recommended Dewatering Process

The solid bowl centrifuge would be the recommended dewatering process alternative for the following reasons:

Solid Bowl Centrifuges:

- Capture more than 90 percent of the solids entering the centrifuge (normal operation would yield a capture of 96 percent to 98 percent),
- Provides highly flexible process for dewatering sludge,
- Are a cleaner process since the sludge is contained in the bowl during dewatering,
- Provide for a continuous flow process,
- Require little operator attention after start-up and fewer staff to maintain, and
- Require fewer units to produce the desired sludge cake concentration.

3.4.4. Dewatered Solids Conveyance Alternative

Dewatered solids would be transferred from the dewatering process system to tractor-trailers for off-site disposal. The following dewatered solids conveying alternatives were considered:

3.4.4.1. Screw Conveyors

Screw conveyors would convey dewatered solids through a long trough by a rotating screw. Control of sludge distribution within the screw conveyor systems would be achieved with slide gates mounted under each of the conveyors. Sludge conveying flexibility would be dependent on the quantity, arrangement, and operation of the conveyors. Primary maintenance on screw conveyors would be simple, requiring periodic replacement of the wear bars in the conveyor trough.

The primary advantage to screw conveyors for conveying dewatered solids would be that they are low cost, simple and reliable to operate and maintain, and are commonly used at water treatment plants. The main disadvantage would be limited flexibility.

3.4.4.2. Sludge Pumping

Conveying dewatered solids via a positive displacement pump and piping system would provide increased flexibility in sludge routing and space utilization. Inspection and maintenance of pump and piping systems would only require access to pumps and valves and are generally cleaner to operate than screw conveyor systems. However, pump systems are more complex and require a higher level of operation maintenance than screw conveyor systems.

3.4.4.2.1. Hydraulic Piston Pumps

Hydraulic piston pumps are positive displacement pumps powered by a hydraulic cylinder, and are typically capable of handling pressures in excess of 500 psi. These pumps are typically used to pump dewatered wastewater solids. Their operation has been characterized as “messy and maintenance intensive” and are mechanically more complex than progressing cavity pumps.

3.4.4.2.2. Progressing Cavity Pumps

Progressing cavity pumps are positive displacement pumps that exhibit a smooth continuous flow. As the rotor turns, the cavities progress and pull the solids through. An open throat progressing gravity pump would be recommended for pumping dewatered solids. The progressing cavity pumps would be multiple stage units. For aluminum hydroxide sludge a four or six stage progressing cavity pump would be required.

3.4.4.3. Recommended Dewatered Solids Conveyance

Screw conveyors would be recommended for conveying the dewatered solids because they would be simpler to operate, require less maintenance, and are more commonly used in water treatment plants for this application than either of the pump alternatives.

One dedicated screw conveyor would be provided for each of the four centrifuges. The entire screw conveyor/sludge storage system would be comprised of four individual screw conveyors and four sludge storage bins.

3.4.5. Floated Solids Conveyance Alternatives

Solids from the floated solids storage tanks would be conveyed to a dewatering process to remove additional water. Two feed system alternatives for conveying and distributing solids from the floated solids storage tanks to the centrifuge dewatering process were considered:

3.4.5.1. Direct Centrifuge Feed System

In the direct centrifuge feed system alternative, centrifuge feed pumps would withdraw floated solids from the floated solids storage tanks and pump directly to individual centrifuges. Each centrifuge would have a dedicated pump, for which separate flow meters would be set to monitor and control the sludge feed. This would allow the centrifuges to be operated individually.

3.4.5.2. Feed Loop Recirculation System

In the feed loop recirculation system alternative, feed loop pumps would withdraw floated solids from the floated solids storage tanks through a suction manifold connected to two recalculating feed loops. Flow meters on the feed loops to direct centrifuge feed lines would monitor the flow rates in the lines for controlling the speed of the feed loop pumps and adjusting the centrifuge feed control valves. The feed loop recirculation alternative would be more complex than the direct feed alternative, requiring coordination and control between the feed loop recirculation pumps, backpressure valves, and centrifuge feed flow control valves. While the feed loop pumps would provide a constant flow to the centrifuge feed lines, the centrifuge feed control valves would maintain the flow required for each of the centrifuges.

3.4.5.3. Recommended Centrifuge Feed System

The recommended centrifuge feed system would be the direct centrifuge feed system alternative. This alternative is recommended over the feed loop recirculation system because it would be less complex, easier to operate and control, and a more flexible and stable system.

The direct centrifuge feed system would consist of six centrifuge feed pumps that would withdraw floated solids from any of the six floated solids storage tanks through a suction manifold and pump directly to four individual centrifuges. Each centrifuge would have a dedicated feed pump, with a common spare pump provided for each pair of dedicated pumps.

The centrifuge feed pumps would be of the progressing cavity type. Progressing cavity pumps are positive displacement pumps that provide smooth discharge and allow for flow metering to the centrifuges.

The basic elements of the system include:

- Six floated solids storage tanks divided into two sets of three.
- Common suction manifold connecting the floated solids storage tanks to the centrifuge feed pumps allowing independent operation of the two floated solids storage tank.

3.4.6. Treated Centrate to Sewer

Centrate treatment would only be necessary if the quality of the raw centrate did not meet the permissible sewer discharge concentrations for regulated pollutants as required by the Westchester County Facilities Act (Governing Code for Residuals Management in Westchester County). If the direct discharge of centrate did not meet the requirement for the Westchester County sewer system, treatment would consist of settling additional solids in the centrate. It would be assumed that this method of treatment would be sufficient to address the removal of any pollutants that would cause raw centrate to exceed the Westchester County's requirements.

The primary advantage of this alternative would be that the treated centrate would be permitted to the Westchester County sewer system for disposal. The primary disadvantage of this alternative would be that the installation of additional treatment equipment would be necessary thereby adding to spatial requirements, operation maintenance, and equipment/chemical costs.

3.5. ANCILLARY SYSTEMS – ENGINEERING ALTERNATIVES FOR THE MOSHOLU SITE

3.5.1. Emergency Bypass

If the proposed Croton WTP were taken out of service (electrical or other failure) and Croton water is required to meet the demand, an emergency bypass would be used to convey untreated Croton water to the distribution system. Subject to NYSDOH approval, a connection at the proposed plant pump station from the raw water inlet piping to the treated water discharge piping would serve as a bypass.

3.5.2. Raw Water Alternative

The 1999 design for the Croton WTP at the Mosholu Site had all of the raw water conveyed directly from the NCA to the proposed plant. The lower portion of the NCA was to be used for Low Level water. This alternative would reduce the total amount of tunneling, but it would take Jerome Park Reservoir off-line. With Jerome Park Reservoir off-line, the only way to vary input to the water treatment plant would be to adjust flows at the New Croton Lake Gate House, 21 miles away. This would make it very difficult to respond to diurnal changes in demand, and it was decided to use the current plan of supplying water to Jerome Park Reservoir via the Branch Aqueduct and then to back feed the proposed plant from the NCA.

The current design would divert the raw water in the NCA at Gate House No. 1 to the New Croton Branch Aqueduct (NCBA), which feeds Jerome Park Reservoir. Raw water in Jerome Park Reservoir would flow via the New Croton Aqueduct to the raw water tunnel connection west of the water treatment plant. During periods of peak demand, when the NCBA could not deliver full flows, the sluice gates at Gate House No. 1 would be partially opened, allowing water to flow south along the NCA from Gate House No. 1 to the raw water tunnel as well as north along the NCA from Jerome Park Reservoir.

3.5.3. Dewatering

Sources of solids that would require dewatering are described in Section 3.4.3 for the Eastview Site and are applicable at the Mosholu Site. The two options for the treatment of the residuals produced by the Croton WTP would be either on-site or off-site treatment.

3.5.3.1. On-Site Treatment of Residuals

The solids would be dewatered via one of the processes described above in Section 3.4.3; the water removed during the dewatering process would be discharged to the sewer and the centrate would be pumped to a sewer interceptor at the Mosholu Site. From there the centrate would be discharged to the head of the NYCDEP's Wards Island Water Pollution Control Plant (WPCP), loaded on to tractor-trailers and removed from the plant for off-site disposal.

The effect of conveying mixed solids to the head of the treatment process at the Wards Island WPCP was considered. The primary impact on the Wards Island WPCP would be an increase in inert settled solids load to the primary settling tanks. The increase of inert solids from the proposed plant would result in a decreasing solids retention time in the secondary treatment process, which currently would not have a significant effect on Wards Island WPCP's secondary treatment process. However, if the Wards Island WPCP implements carbon addition to enhance nitrogen removal in its secondary treatment, the increase of inert solids and decrease of solids retention time may hinder this process.

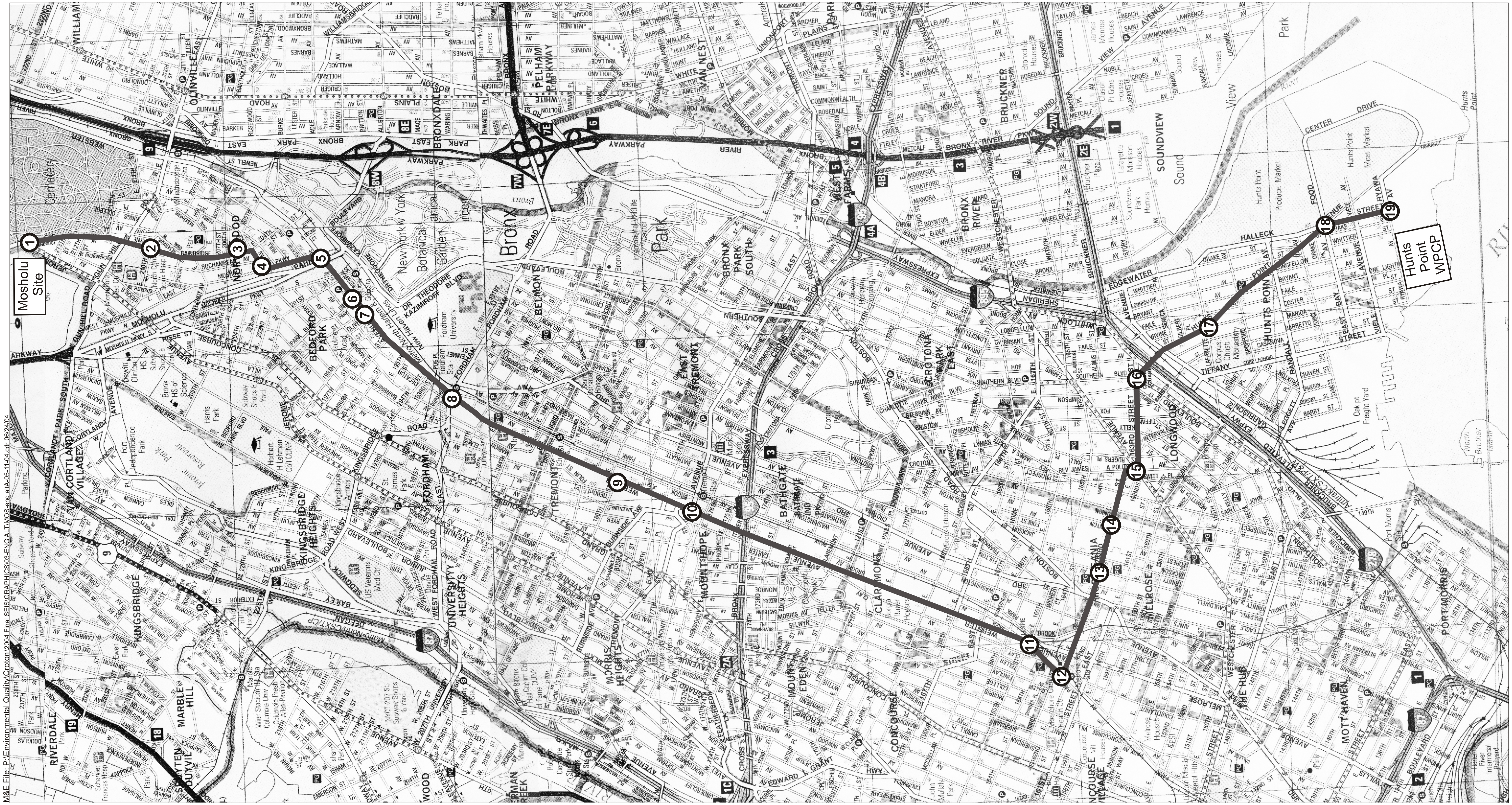
In addition to impacting the Wards Island WPCP's primary and secondary treatment processes, the solids may affect other areas within the Wards Island system:

- Aluminum accumulating in the biosolids may reduce land application availability.
- Increased polymer dosages may be required for Wards Island's centrifuge dewatering.
- Solids may accumulate in low velocity points within the sewer system.

Due to the potential impacts to the treatment process at the Wards Island WPCP, this alternative was eliminated from further consideration.

3.5.3.2. Off-Site Treatment of Residuals

Conveying mixed solids to the dewatering facility at the Hunt's Point WPCP was evaluated. The mixed solids (waste backwash settled solids and floated solids) from the floated solids storage tanks would be pumped off-site for dewatering and disposal. Further treatment of the mixed solids would be handled by the Hunt's Point WPCP. It has been determined that the Hunts Point WPCP has adequate surplus capacity to handle the flows from the Croton WTP without the construction of any new equipment or additional staffing. This could result in the reduction of several staff positions at the water treatment plant site. This alternative has been selected as preferred because it saves footprint at the Croton WTP and simplifies operations.



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Proposed Alignment of Residuals Pipeline from the Mosholu Site to the Hunts Point WPCP

The 8-mile route to the Hunts Point WPCP would be entirely in streets. Two (one standby) 10-12-inch pressure conduits would be placed in the roadway right-of-way. The proposed alignment is shown in Figure 3-1.

3.6. ANCILLARY SYSTEMS – ENGINEERING ALTERNATIVES FOR THE HARLEM RIVER SITE

3.6.1. Emergency Bypass

If the proposed Croton WTP is taken out of service and Croton water is required to meet the demand, an emergency bypass would be used to convey untreated Croton water to the distribution system. Subject to NYSDOH approval, a connection at the proposed plant pump station from the raw water inlet piping to the treated water discharge piping would serve as a bypass.

One of the emergency bypasses reviewed would be constructed from the NCA just downstream of the new raw water tunnel connection to the proposed plant, to the NCA downstream of Shaft No. 22. The bypass would be a below-grade chamber and would be capable of delivering untreated Croton water to the Low Level Service in Manhattan in an emergency.

A bypass at Shaft No. 22 would almost certainly be more expensive than a proposed plant bypass because it would be off-site and because it would have to be well below grade.

3.6.2. Turbine Energy Recovery

Raw water would be conveyed to the proposed plant by gravity from the NCA through a new tunnel. This water would be at a hydraulic grade approximately 110 feet above the operating level of the water treatment plant. Turbines could be used to lower the pressure of the raw water. Two alternatives were evaluated: 1) turbine generators, and 2) turbine pumps.

1. Electric generators could be driven by turbines. Recovered energy from the turbine generators could be utilized anywhere within the plant. Two pressure-reducing valves would be installed to reduce the pressure of the flow when the turbines are off-line.

2. Hydraulic turbines could be installed to recover energy and reduce the pressure. The hydraulic turbines would be directly coupled to finished water pumps and could pump some of the finished water to the Low Level Service. The amount of energy recovery and the pressure losses by the turbines would limit the amount of water pumped to the Low Level system. This method provides less operational flexibility when compared to turbines that would reduce the pressure of raw water, drive electric generators to generate electricity, and run in parallel with the plant's electrical system.

Electric turbine generators were selected as the preferred means of lowering the water pressure of the raw water. If the turbine driven Low Level pumps were out-of-service there would be no energy recovered. The construction costs for turbine driven Low Level pumps would also be higher than turbine generators.

3.6.3. Dewatering

Dewatering options for the Harlem River Site are similar to those described in Section 3.4.3 for the Eastview Site alternative. A sewer interceptor near the Harlem River Site could accommodate the centrate, which would be conveyed to the Wards Island WPCP. For all the reasons described in Section 3.5.3, the off-site treatment via a new conveyance to the Hunts Point WPCP would be the preferred alternative for dewatering of solids.

The pipeline alternative to the Hunts Point WPCP is different for the Harlem River Site and is shown in Figure 3-2 below. As stated above, conveying mixed solids to the dewatering facility at the Hunt's Point WPCP could result in the reduction of several staff positions at the water treatment plant site. Detailed staffing plans would be available at the Final Design stage; a conservative estimate of 53 staff positions was utilized for the analyses presented in this Final SEIS.

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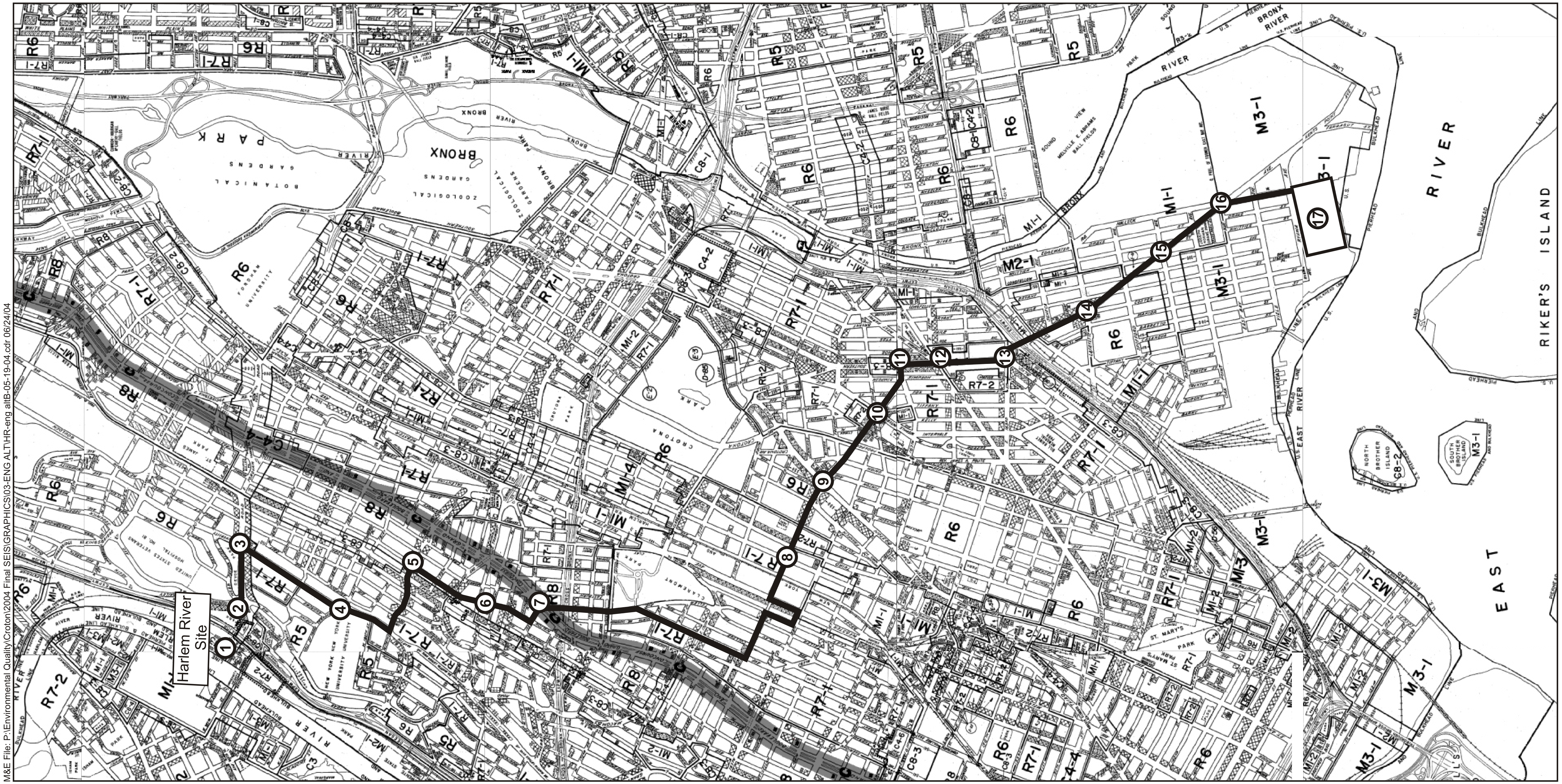

Proposed Alignment of Residuals Pipeline from the Harlem River Site to the Hunts Point WPCP

3.7. PROTECTION OF TREATED WATER IN THE NEW CROTON AQUEDUCT

The NCA currently conveys raw water by gravity flow from the 1994 Croton Lake Gate House adjacent to the New Croton Reservoir about 20 miles south to NCA Shaft No. 20, near the Van Cortlandt Park in the Bronx. Downstream of NCA Shaft 20, a further eight miles of the NCA is pressurized and conveys raw water to NCA Shaft No. 33 in Manhattan. If the proposed plant is located at the Eastview Site, the NCA downstream of the proposed plant could be used to convey treated water to the Bronx and Manhattan Low Level Service. Croton water can be pumped from the Low Level Service to the Intermediate Level Service at the Jerome Pumping Station and to the High Level Service from the Mosholu Pumping Station. Additional protection against infiltration of contaminants into the NCA downstream of the proposed plant may be required to protect the treated water.

The brick-lined structure of the NCA was originally designed to relieve hydrostatic pressure on the outside by allowing the infiltration of groundwater. Estimates indicate that approximately 2 mgd currently enters the NCA from surrounding groundwater. This represents 0.75 percent of the average flow volume in the aqueduct. When the NCA is running full less water would infiltrate.

A study was completed in October 2001[4] that developed a plan to identify and control risks of contamination of treated water in the NCA downstream of the proposed plant.

This *Plan for the Protection of the NCA* (Plan) comprises the following main elements:

1. Identification and assessment of potential sources and means of contamination of the NCA.

2. Identification of portions of the aqueduct that are susceptible to ground water infiltration.

3. Development of recommendations for improvement of aqueduct integrity and control of the risks of contamination of ground water around the treated water portion of the NCA from identified potential sources.

4. Monitoring of water quality in the NCA.

5. Performing regular inspections of the treated water portion of the NCA.

Specific actions to accomplish the main elements of the plan are described in more detail as follows:

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[4] NYCDEP. 2001. *Plan for the Protection of the New Croton Aqueduct.*

3.7.1. Identification of Sources and Means of Contamination

- Identify, compile and map potential sources of contaminants along the NCA including gas stations, fuel storage areas, dry cleaning establishments, auto repair and sales lots, landfills, etc. Assessment would consist of compilation of existing databases of such potential sources and a new, on the ground survey of potential sources within 500 feet of the centerline of the NCA. Each Town over the NCA should have a database relative to: surveys of sources of contaminants; land use and assessors maps of the area over and adjacent to the aqueduct; registration of the location of hazardous materials. NYCDEP may have additional data on potential sources.

- Identify zones of influence of ground water affecting the NCA. Conduct limited ground water modeling to identify approximate zones of influence.

- Identify Federal/ State/ local laws requiring replacement of Underground Storage Tanks (USTs). Determine local entities regarding enforcement of these laws. Identify location of existing, reported USTs. Determine UST replacement programs for commercial and private residential tanks. Identify construction of new USTs.

- Assess impact of highway drainage, any agricultural and residential runoff, into any recharge areas that could impact water quality in the aqueduct.

- Identify limits of watershed and sub-watershed areas, which could influence recharge of contaminated water over the aqueduct.

- Identify and assess highway spill emergency containment programs in place.

- Assess feasibility of having restricted truck access at critical areas along the aqueduct.

- Research existing information and data regarding previous known occurrences of aqueduct contamination and monitoring of water quality in the NCA.

3.7.2. Susceptibility of NCA to Infiltration

The NCA is lined in brick for most of its length and has been in service for over 100 years. The NCA is constructed under deep ground cover from the New Croton Lake Gate House as far as Shaft 10, in Tarrytown. NYCDEP engaged a consultant, Parsons Brinckerhoff/Montgomery Watson Harza, to inspect the NCA, assess its condition and prepare recommendations for rehabilitation of the aqueduct for extended use as a raw water aqueduct[5]. The consultant's Phase III Report was submitted to NYCDEP in December 2000 following several years of detailed internal inspection of the gravity portion of the NCA from Croton Lake Gate House to Shaft 20. This report identifies portions and features of the aqueduct that are most susceptible to ground water infiltration and leakage and makes general recommendations for rehabilitation of the aqueduct for continued conveyance of raw water.

The portions and features of the NCA identified in The Phase III Report as most susceptible to infiltration and leakage are as follows:

- Weep holes along the invert of the existing gravity flow portion of the aqueduct. The gravity portion of the aqueduct was apparently designed to facilitate infiltration of ground water through these weep holes. Significant ground water infiltration was noted through weep holes in portions of the NCA south of Shaft 10 during inspection of the aqueduct.

- Shafts connecting the NCA to the ground surface penetrate the NCA along its length. These consist of known service shafts, most of which are still in use, and construction shafts, which were filled in after construction.

- Portions of the NCA constructed with shallow ground cover or constructed using cut-and-cover methods. Significant ground water infiltration was noted in these portions of the NCA during inspection.

- Portions of the NCA in weak ground such as Gould's Swamp or under the Sawmill River.

- Other portions of the unpressurized aqueduct where significant infiltration of ground water was evident while unwatered[6] during inspection. Significant ground water infiltration was noted in some portions where ground water is present and the existing NCA masonry structure is deteriorating.

- The pressurized portion of the NCA between Shafts No. 20 and No. 33 has not yet been inspected in detail. However, some leaks are visible and some contamination has been recently reported while this portion of the aqueduct has been unwatered.

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[5] Parsons Brinckerhoff/Montgomery Watson Harza. 1998-2001. *Inspection and Rehabilitation of the New Croton Aqueduct. Phases I-IV*.

[6] Unwatering refers to the removal of water from the NCA for purposes of inspection and repair.

3.7.3. Implementation Progress

Since this plan was prepared, the risk assessment has been completed. Hundreds of sites within the one-quarter mile study area along the NCA were found that legally store and use hazardous materials. Many spills have been recorded since mandatory reporting was required.

Coordination procedures with NYSDEC have been developed so that NYCDEP is now notified when a spill occurs that could threaten the NCA. Monitoring wells have been put in place and groundwater has been sampled near the aqueduct.

Plans for the next phase of inspection of the NCA are underway, and these inspections would further guide the design of the proposed rehabilitation work[7].

3.7.4. Risk Prevention Recommendations

Based on the results of the identification of potential risks, four options were proposed:

1. Grout and seal weep holes in the NCA. Apply deep consolidation grouting to plug large sources of infiltration.

2. Apply the grout treatment as described above in areas where the NCA was above the water table, but line the NCA with concrete or steel in areas where the water table was higher than the hydraulic grade line in the adjacent aqueduct.

3. Fully line the entire gravity portion.

4. Abandon the NCA as a treated water conveyance and use the KCT.

NYCDEP determined that the inspection and baseline rehabilitation (Option 1 above) to protect the NCA should proceed irrespective of the site selection for the Croton WTP. This work would be started in 2004 and would be the subject of an independent environmental review.

Option 2 was rejected as it would not provide the protection for treated water that would be provided at relatively low additional cost of that provided by the third option. If the proposed plant were located at the Harlem River or Mosholu Sites, no additional work beyond the baseline rehabilitation would be necessary for the gravity portion of the NCA. This work would include structural improvements, security enhancements, cleaning, and miscellaneous improvements as needed for the reliable transport of untreated water through the NCA to the proposed plant in the Bronx. The baseline work would proceed irrespective of the choice of water treatment plant site or treated water conveyance alternative, and would be the subject of an independent environmental review.

If the proposed plant is located at the Eastview Site, complete rehabilitation that includes fully lining the NCA downstream of the proposed plant to (Option 3) convey the treated water to the

[7] This inspection work is part of a baseline rehabilitation project that would be subject to an independent environmental review.

City at the same hydraulic pressure as the water in the other aqueducts or Option 4, the abandonment of the NCA and the use of the KCT would be used for treated water conveyance. Potential environmental impacts of Option 3, the pressurization of the NCA, are described in this Final SEIS. Potential impacts of the KCT project are described at a generic level in this Final SEIS; because this project is not yet designed this possible project would not be on-line until after the Croton WTP is finished. It would be the subject of independent decision-making and a future environmental review when sufficient design detail is available.

3.8. TREATED WATER CONVEYANCE ALTERNATIVES FOR THE EASTVIEW SITE

During conceptual design, several engineering alternatives were identified for conveying treated water from the proposed plant to the City's distribution system. Section 5.1, Introduction and Project Description presents the two selected engineering alternatives for treated water conveyance still under consideration. This section reviews the two alternatives currently under consideration and presents those engineering alternatives not selected.

3.8.1. Gravity Flow in the NCA

This alternative would convey by gravity (Low Level) treated water from the proposed plant to the NCA. Excess hydraulic head would be converted to electrical energy in a hydraulic turbine station. The NCA would require modifications to protect the quality of the treated water during transmission to the High and Low Level service areas in City.

New facilities would be constructed at Jerome Park Reservoir to distribute High and Low Level treated water to the distribution system. Upgrades to the existing facilities at Jerome Park Reservoir and along the NCA would also be performed to integrate the facilities to the distribution system.

Gravity Flow in the NCA was eliminated as a treated water conveyance because it would provide less operational flexibility to the overall system. NYCDEP's operating staff would prefer all Croton treated water to be delivered at the High Level service pressure (Hillview gradient). This would eliminate the need for pumping treated water at Jerome Pumping Station and constructing a new turbine generator facility at the proposed plant. The Low Level service would be provided through the High Level service using the existing in-City regulators.

This alternative was also eliminated because the required construction would increase the potential traffic impacts to the Jerome Park Reservoir area and increase the construction schedule. The construction would consist of a new Distribution Chamber in Jerome Park Reservoir, a new Shaft Chamber in Harris Park Annex, and upgrades to the existing facilities at Jerome Park Reservoir.

3.8.2. Alternative C

Long-term Alternative C would convey treated water from the proposed plant to the Delaware Aqueduct Shaft No. 19, subject to review and approval by the NYSDOH. After the proposed plant is in operation, treated water would continue to be conveyed to the connection at Shaft No. 19. A new pipeline would be constructed to serve as the permanent back-up system (for redundancy). The NCA would be taken off-line downstream of the raw water connection to the proposed plant, the New Croton Branch Aqueduct, and the Jerome Park Reservoir facilities would also be taken off line but would be retained for NYCDEP BWSO use under this alternative. The Mosholu and Jerome Pumping Stations would be taken off line, and the Microstrainer would be dismantled.

It has been determined that a connection to the Catskill Aqueduct in addition to the connection to the Delaware Aqueduct, at Shaft No. 19, would bring no additional benefits while adding cost. Such connection would limit supply and operational flexibility. The benefits of power generation at Kensico Reservoir from the Catskill flow would be reduced since, because there is a lack of spare capacity in the Catskill Aqueduct, the Catskill flow leaving Kensico would no longer be constant.

It is also anticipated that this connection would have a significant environmental impact, as a large area of dense vegetation must be destroyed for its construction. In building this new treated water aqueduct, the Catskill Aqueduct would become more vulnerable to contamination due to infiltration. Additionally, there would be significant extra costs associated with the connection. For these reasons, no Catskill Aqueduct connection is proposed for further consideration.

3.8.3. Pressurized Flow in the NCA

This alternative would convey water by gravity from the water treatment plant at the Eastview Site but the hydraulic head at the Eastview Site would be preserved. The NCA would be plugged between the raw water intake and the connection with the finished water tunnel from the water treatment plant. The height of the proposed water treatment plant at the Eastview Site is sufficient to pressurize the water to the High Level Service pressure. The NCA would be fully lined from the treated water connection to the existing pressurized portion south of Gate House No. 1 in the Bronx. All the water would arrive at a new underground Shaft Chamber near Gate House No. 5. The High Level water would be distributed from the new Shaft Chamber near, and sleeve valves in this Shaft Chamber would reduce the pressure of some of the water to the Low Level Service pressure. One new pipeline would feed Low Level water to the Bronx via existing nearby connections from the Shaft Chamber and another pipeline would supply the Manhattan Low Level service from Shaft No. 21 in Jerome Park Reservoir.

This alternative would avoid having to pump any water in the Bronx. However, it would require the full lining of the NCA, a project that would take five years after the water treatment plant was completed, and add considerable cost to the project. It also would require Shaft No. 9 in Sleepy Hollow to carry surplus flows if the water treatment plant would shut down unexpectedly. This alternative was carried forward into the preliminary design.

3.8.4. Kensico-City Tunnel

This alternative for the conveyance of treated Croton water to the City involves the construction of an entirely new tunnel from the Kensico Reservoir to the Eastview Site and from there to the City's water distribution system. This new tunnel could potentially be sized to accommodate all of the City's flows, be able to bypass Hillview Reservoir, and provide system redundancy for future maintenance of the other conveyances. If the Croton System were to use this new tunnel, the NCA would be used for emergencies and for system overflows.

The proposed KCT is still at the stage of a feasibility study[8]. Its primary purpose would be to provide system flexibility for the Catskill/Delaware water supplies. The KCT would be sized to accommodate between 1,600 and 2,400 mgd of treated water, 24 ft. to 29 ft. in diameter, and 12.5 to 16 miles long.

The feasibility study describes three alternative alignments, including three possible intake locations alongside Kensico Reservoir. Two of the alignments include uptake and downtake chambers on the Eastview Site and connections to the Catskill and Delaware aqueducts. The tunnel alignments consider the geology of the rock strata in which the aqueduct would be bored and the hydraulic profile of the proposed routes. In addition to the constraints from the geology, the choice of shaft sites may also affect the final alignment. No specific shaft sites are recommended, but all the alternatives under consideration terminate at the distribution system connections at the Van Cortlandt Valve Chamber in the Bronx.

The feasibility study assumes that the subsurface work would take place 24-hours a day. Work on the surface shaft sites would have to comply with local zoning, which generally restricts night work. Shaft sites would have to be at least 2 acres in area to allow for equipment and staging. Each shaft would have parking, ventilation equipment, construction trailers, a crane, electrical substation, and materials laydown areas. During operations the shaft sites would occupy about half an acre. The shaft sites would have to accommodate up to 140 workers and would generate truck traffic from the removal of tunnel spoils. This truck traffic would be less than 120 trucks per day. The total spoil to be removed would be approximately 2,500,000 cubic yards for the largest diameter tunnel under consideration.

The tunneling would encounter groundwater, and the groundwater would have to be treated to remove sediment and discharged to one of the rivers that pass over the alignment. In addition, some or all of the shafts would be used as a dewatering point to empty the aqueduct for maintenance. Dewatering would require discharges of up to 10 cfs (4,600 gpm). This could represent a significant flow into some of the possible discharge points. These possible discharge points could be the Hutchinson River, Bronx River, or the Sawmill River, depending on the shaft location. The average annual discharge of the Hutchinson River is only 4 cfs, so dewatering would more than triple the average flow (from 4 cfs to 14 cfs) and bring the river to high, but not flood, condition. If dewatering took place at flood conditions, the flood would be worsened. Average annual flow to the Bronx River is 47 cfs, and the Sawmill River is even more. These rivers could accommodate the 10 cfs of water from the aqueduct with much less impact. Siting of the shafts and intake structures would require a thorough environmental impact analysis.

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[8] NYCDEP. 2003. *Feasibility Study: Kensico-City Tunnel*

The environmental impact statement for the KCT would analyze flood control, scouring, and other impacts of this action. The long duration of the construction (about 15 years) would require a detailed analysis of the impacts of this proposed work on all environmental parameters. The long duration would require a very thorough consideration of the neighborhoods if any construction would take place near residences or commercial operations that could be sensitive to the long-term trucking of spoils and associated impacts.

In addition to the shafts, the new intake structure at Kensico Reservoir would be a substantial construction project, about 300 ft. by 400 ft. and three levels high. Impacts to Kensico Reservoir would be assessed very carefully. This facility would house chemical addition facilities.

Another project component would be a surge tank that would be a low concrete structure about five acres in size. This would have to be downstream of the Ultraviolet Light (UV) Disinfection Facility. One site that has been considered is the City-owned property in Greenburgh, south of the proposed site of the UV Facility. This site is forested with mature trees and has wetland areas that could be impacted.

Finally, after the aqueduct would be finished, the City may seek additional in-City treated water storage. This would require a site up to 25 acres in size. The existing Richmond tanks or the Silver Lake tanks in Staten Island might be modified for this use, but this component is in the very early planning stages.

Construction of the KCT would not start before 2009. There could be a year's overlap in construction between the Croton WTP and the KCT start-up work. The Croton work effort would be past peak in 2009, and it is not anticipated that the combined effect of these two projects would create impacts as large as the impacts during the peak construction period for the Croton WTP alone. The tunnel would be completed in 2019, but other features of this new system would be built for years afterward.

The KCT design is still in the future, and if it is adopted it would be subject to a separate and thorough public environmental review process. If a decision were made to advance the proposed Kensico-City Tunnel and utilize it as the treated water conveyance, the pressurization of the NCA would not have to proceed. Croton water would be blended with treated Catskill and Delaware water and the entire City's water would be conveyed at the same pressure to the distribution system. Existing boundary valves and regulators would supply the Intermediate and Low Level service areas in the City. This would add full redundancy to the conveyances and allow for much greater operational flexibility. The new tunnel would result in the NCA being taken off-line. This section of the NCA would be retained for use as a bypass during surge occurrences, subject to review and approval by the NYSDOH. The Jerome Park Reservoir and the Gate Houses would also be taken off line and retained for NYCDEP Bureau of Water Supply and Sewer Operations (BWSO) use. The Mosholu and Jerome Pumping Stations would be taken off line, and the Microstrainer Building and Demonstration Water Treatment Plant would be dismantled.

A feasibility study released in December 2003 determined that this KCT is feasible and recommended additional design. The design is currently under procurement.

3.9. TREATED WATER CONVEYANCE ALTERNATIVES FOR THE MOSHOLU SITE

During conceptual design, several engineering alternatives were identified for conveying treated water from the proposed plant to the City's distribution system. This section presents all the engineering alternatives that were evaluated.

3.9.1. Alternative 1

Alternative 1 would convey treated water from the proposed plant through two tunnels. One tunnel would convey water to the Manhattan Low Level service area via a 3,710 ft. long 9-ft. diameter tunnel from the water treatment plant site to a new Shaft Chamber north of Gate House No. 5. A short (650 ft.) tunnel would connect the Low Level service to the NCA south of Shaft No. 21 in Jerome Park Reservoir. The other 9-ft. tunnel would convey water at high pressure approximately 3,700 ft. from a pump station at the water treatment plant to the new Shaft Chamber at the Jerome Park Reservoir. From there water would be distributed to the City Water Tunnels.

This treated water system would avoid pumping of up to 150 mgd of water that would be conveyed by gravity to the Low Level service via the New Croton Aqueduct. This is the preferred alternative described in Section 6.1, Introduction and Project Description.

3.9.2. Alternative 2

Alternative 2 would convey treated water from the proposed plant through a single tunnel. The tunnel would lead to a new Shaft Chamber at Jerome Park Reservoir, and would convey water to the High Level Service area. Under this alternative, no treated water would be conveyed from the proposed plant to the Low Level Service area.

This treated water conveyance alternative does not allow the proposed plant to use gravity flow directly to the Low Level Service. Pumping all treated water to the High Level Service would increase annual electrical and operation costs. Alternative 2 would not supply redundancy to the Croton system, and constrains the quantity of deliverable water if City Tunnel No. 1 is taken off-line.

This alternative was rejected because it would have higher operating costs, reduces system flexibility, and does not reduce any environmental impacts.

3.10. TREATED WATER CONVEYANCE ALTERNATIVES FOR THE HARLEM RIVER SITE

During conceptual design, several engineering alternatives were identified for conveying treated water from the proposed plant to the City's distribution system. Section 7.1, Introduction and Project Description, presents the selected engineering alternative for treated water conveyance. This section presents all the engineering alternatives that were evaluated.

3.10.1. Alternative 1

Alternative 1 would convey treated water from the proposed plant through two tunnels. One tunnel would convey water to the Manhattan Low Level service area. The other tunnel would convey water at the High Level Service to a new shaft chamber at the Jerome Park Reservoir.

This treated water conveyance alternative does not allow for flexibility and convenience of operating this part of the City's Water Supply System. In the event the NCA downstream of the proposed plant is taken out of service, the proposed plant would be limited to treating that water delivered to the new shaft chamber at Jerome Park Reservoir, and pumping the treated water to the High Level service. This alternative would not permit flexibility of being able to pump all treated water to the High Level Service, which could simply the operation of the City's Water Supply System. This alternative would limit that capability.

3.10.2. Alternative 2

Alternative 2 would convey treated water from the proposed pant through a single tunnel. The tunnel would extend to a new Shaft Chamber at Jerome Park Reservoir, and would convey water to the High Level Service area. Under this alternative, no treated water would be conveyed from the proposed plant to the Low Level Service area.

This treated water conveyance alternative does not allow the proposed plant to pump directly to the Low Level Service. Pumping all treated water to the High Level Service would increase annual electrical and operation costs. Alternative 2 would not supply redundancy to the Croton system, constrains the quantity of deliverable water if City Tunnel No. 1 is taken off-line, and increases the cost due to a need to locate the bypass at Shaft No. 22.

In addition to this bypass location problem, Alternative 2 might present a water quality problem, since the raw water bypassing the plant under this alternative would be conveyed into an aqueduct (the NCA south of Shaft No. 22) that was not normally in service.

3.10.3. Alternative 3

Alternative 3 would convey the Low Level service directly to the NCA through a short tunnel. A second tunnel would convey the High Level Service to a new Shaft Chamber at Jerome Park Reservoir. This High Level Service tunnel would be sized to accommodate all of the Croton WTP treated water.

This water maximizes operational flexibility, and permits the cost saving of pumping some of the water at a lower pressure. However, it has the complexity of two finished water tunnels and pumping at two pressures. This was the alternative selected for this site alternative and is described in detail in Section 7.1.

3.11. ALTERNATIVE TREATMENT CHEMICALS

3.11.1. Sodium Hypochlorite (NaOCl) Generation

To reduce the amount of hazardous materials delivered to and stored at the proposed plant, the NYCDEP investigated the use of on-site sodium hypochlorite (NaOCl) generation as an alternative to commercially purchased, 12.5 percent sodium hypochlorite. The process of on-site generation is a simple and proven method by which common table salt, sodium chloride (NaCl) is electrolytically converted to a safe, dilute sodium hypochlorite solution. Therefore, the major bulk material necessary for on-site generation of NaOCl is salt.

If on-site generation of NaOCl were utilized, the NYSDOH would require the proposed plant to have 15-days storage of salt. In addition to bulk storage for brine, space would be necessary for finished product storage, water softeners, generators and hydrogen ventilation system for the product storage tank. Secondary containment would not be required for the brine tank or the finished product storage tank.

Advantages of on-site sodium hypochlorite generation would be the reduction of risks associated with the transport of sodium hypochlorite, reduced deterioration in storage, and the elimination of off-gassing problems. Disadvantages include the necessity to operate and maintain the facility, space requirements for storage of salt, the generation equipment, and sodium hypochlorite, and the ability of the City to purchase sodium hypochlorite from bulk suppliers at a wholesale rate. After a review of the operational complexity involved in generating sodium hypochlorite, costs, and the size of the facility, it was decided to purchase the concentrated 12.5 percent solution from an off-site supplier. Purchasing the liquid sodium hypochlorite would result in a smaller facility, less operations and maintenance costs, and less potential for service disruptions due to equipment failure.

3.11.2. Alternative Disinfection Techniques

Alternative means of achieving disinfection have been examined repeatedly during the planning process for the Croton WTP. Drinking water regulations require that a residual of chlorine is maintained in the distribution system, but primary disinfectants that do not use chlorine are applicable at the intake to the proposed plant. The following alternatives to gaseous chlorination were considered:

3.11.3. Chloramination

Chlorine would still be the primary disinfectant, but chloramines, produced by the reaction of ammonia with chlorine prior to discharge to the distribution system, and would reduce the formation of Disinfection Byproducts (DBPs). This alternative would require the storage and transport of liquid ammonia. Chloramination would not further reduce raw water color, iron or manganese levels beyond that achieved by chlorine, and chloramines are not effective against *Giardia* or *Cryptosporidium*.

Chloramination could change the taste of Croton water; this could result in increased customer complaints. Some literature suggests that chloramines are more effective than free chlorine in lessening distribution system regrowth problems because of their ability to penetrate biofilms. Other literature suggests that chloramines may be a cause of distribution system regrowth problems due to nitrification, although this problem occurs primarily with water that is warmer than the Croton supply. The addition of ammonia would require choramination of the entire NYC water supply to allow the waters to be blended. The modest reduction in DBPs, no benefit to color, and additional complexity argued against this alternative.

3.11.4. Chlorine Dioxide

Because of intense public interest in this alternative, a section on chlorine dioxide as a disinfectant alternative to filtration is presented in Section 2.3.2.1. Much of that discussion is repeated here. Chlorine dioxide does not contribute to the formation of THMs and HAAs. However, other regulated disinfection byproducts are formed i.e., chlorite and chlorate. It is only after primary disinfection, when chlorine is then added as the secondary disinfectant that HAA and THM would begin to form.

The evaluation of the use of chlorine dioxide includes determining the amount of chlorine dioxide needed to meet chlorine contact time requirements in all seasons, as well as the associated levels of byproducts formed. Chlorine dioxide is not as effective in cold water and extremely high doses may be needed. These high doses would be precluded by the resulting formation of chlorite and chlorate, so chlorine dioxide would not be suitable as a replacement of chlorine but it could be used in combination with other disinfectants to lower disinfection byproducts during parts of the year. There would remain periods of the year when chlorine dioxide would either create chorites and chlorates in excess of standards, so this is not a long-term alternative to filtering the Croton Supply and reducing the DBP precursors prior to disinfection.

Since the Draft SEIS was published, additional information is available in a report called *Investigation of Interim Measures to Control HAA Formation in the Croton System* (NYCDEP, February 2004). This study completed the bench scale testing that was proposed above in the Draft SEIS. The main drivers for filtering the Croton Supply (in addition to the regulations) include removing particulate matter (including pathogenic microorganisms), reducing color, and controlling disinfection byproducts. Although chlorine dioxide provides some protection against microorganisms, it does not reduce color to acceptable levels and does not adequately control haloacetic acids (HAA). In addition, chlorine dioxide cannot be used to achieve a minimum of 2-log *Cryptosporidium* inactivation that will be required by the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). The required chlorine contact time (CT) values for two and three log inactivation per the proposed LT2ESWTR follow:

CT for 2 log Cryptosporidium:
at 20°: 232 mg-min/L
at 1°: 1220 mg-min/L

CT for 3 log Cryptosporidium:
at 15°: 347 mg-min/L
at 1°: 1830 mg-min/L

Even though the travel time in the NCA is 20 hours (1200 minutes), a sufficient chlorine dioxide residual cannot persist for the entire length without exceeding the MCL for chlorite (a regulated compound) or the maximum residual disinfectant level (MRDL) for upstate communities.
A major disadvantage of chlorine dioxide is the formation of chlorite, a byproduct of chlorine dioxide treatment. The maximum contaminant level (MCL) for chlorite is 1.0 mg/L. This MCL was promulgated in December 1998 as part of the Stage 1 Disinfectants/Disinfection Byproduct Rule. Another significant disadvantage of chlorine dioxide is the formation of obnoxious cat-urine or kerosene odors in homes with new carpets and drapes. The cause of these odors is the release of chlorine dioxide (formed in the distribution system from the reaction between chlorine and residual chlorite) that then reacts with volatile chemicals in the air that are released from such sources as carpets and drapes. Experience suggests that this can be controlled by limiting chlorite residuals to approximately 0.4 to 0.5 mg/L. Chlorite removal strategies can be employed to eliminate this problem; however, the application of ferrous-based chemicals would require large feed facilities along the aqueduct or in the vicinity of Jerome Reservoir. In addition, sediment would accumulate in the aqueduct or in the reservoir, which could cause adverse water quality conditions. Because of these limitations, the regulations and the consent order requiring filtration, chlorine dioxide is not an acceptable approach for treating the Croton Water Supply.

Nevertheless, as part of a response for violating the Stage 1 HAA MCL in the Croton System, bench testing of chlorine dioxide treatment as a means of controlling HAAs was conducted by the University of Toronto during late 2003. The results show that chlorine dioxide treatment did not reduce color to the goal of 10 color units (to be comparable to Cat/Del water). More importantly, the application of chlorine dioxide did not consistently reduce the formation of HAAs. While under one set of conditions a modest reduction in HAA (up to 25%) was observed, when tests were repeated HAA levels increased. The study concluded that the application of chlorine dioxide did not consistently reduce the formation of HAAs. There was a wide variation in results based on the test and analytical conditions. In all cases after-treatment with chlorine would still be required. These tests concluded that there would be little or inconsistent benefit and a serious increase in complexity if this disinfection strategy is adopted.

Based on these data, there is doubt that the use of chlorine dioxide would allow the Croton System to meet the current Stage 1or proposed Stage 2 D/DBP levels.

3.11.5. Ozonation

Ozone, combined with secondary disinfection, is a powerful disinfectant that does not produce regulated DBPs. It can form aldehydes, epoxides, and (in the presence of bromide) bromate, These compounds are all regulated and could pose human health risks at dosages that are generally much higher than those that would occur from the disinfection of drinking water. It would be generated on site from oxygen. The oxygen could either be delivered in cryogenic form by truck or generated on site with a small oxygen generation plant. It was extensively pilot tested and shown to be effective. It is effective against *Giardia* and *Cryptosporidium*. When Ultraviolet light treatment was made available ozonation was dropped as the preferred alternative because of its complexity, potential formation of disinfection byproducts, large space requirements, and cost.

3.11.6. Sodium hypochlorite

Sodium hypochlorite is a liquid chemical that forms free chlorine in water. It has all the advantages and some of the disadvantages of chlorine gas including the creation of DBPs if organic precursors remain in the water. It is safer to handle and transport, and was selected as the secondary disinfectant for the Croton WTP.

3.11.7. Ultraviolet Disinfection

Ultraviolet light at high intensities can inactivate most pathogens, including *Giardia* and *Cryptosporidium*. The light sources are similar to conventional ultraviolet lamps. They are fitted into vessels inside glass tubes with the water flowing around the outside. Treatment is by exposure to light, with no chemical treatment. They do require replacement and cleaning of the vessels, so maintenance is higher than some alternatives. Ultraviolet light was chosen as the primary disinfectant for the Croton System.

3.12. THE REASON THERE IS NO FEASIBLE NO ACTION ALTERNATIVE

The NYCDEP has been mandated by the New York State Department of Health (NYSDOH) and the U.S. Environmental Protection Agency (USEPA) to filter its Croton System to comply with the standards set forth in Sub-Part 5.1 of Chapter 1 of the New York State Sanitary Code and the USEPA Surface Water Treatment Rule, a National Primary Drinking Water Regulation promulgated under the Safe Drinking Water Act. It is under this mandate (which is outlined in the 1998 Consent Decree[9] as well as the 2001 Supplement to the Consent Decree[10] between the City of New York, the United States of America, and the State of New York) that the NYCDEP proposes to design, construct, and place into operation a 290-million-gallon-per-day (mgd) water treatment plant. The consent decree states that the City has "violated and continue[s] to violate the Safe Drinking Water Act ("SDWA"), … and the Surface Water Treatment Rule ("SWTR") … by failing to install filtration treatment for its Croton Water Supply System; and … WHEREAS, the Parties agree that settlement of this matter, without adjudication of facts or law, is in the public interest and that entry of this Consent Decree … is an appropriate way to resolve the dispute." Subsequent to this ruling NYCDEP identified a site in the Bronx, the Mosholu Golf Course Site, as being preferred for construction of a water treatment plant. While the City's choice of site was disputed, Federal and State agencies continued to support the need to filter Croton Water.

A June 11, 2001 ruling by Magistrate Gold[11] required the City to identify one site in Westchester County and one site in the Bronx that could be used as alternatives to the previously favored Mosholu Golf Course Site. According to this ruling the City had to "submit [a] letter detailing its efforts to achieve passage of Mosholu Site legislation" before identifying these alternate sites.

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[9] United States District Court Eastern District of New York. United States of America, Plaintiff, State of New York and Barbara Debuono, M.D., as Commisioner of the New York State Department of Health, Plaintiffs-Intervenors, against City of New York and New York City Department of Environmental Protection, Defendants. Civil Action No. CV 97-2154 (Gershon, J.) (Gold, M.J.) 1998.

[10] Federal Register: December 20, 2001. Volume 66, Number 245. wais.access.gpo.gov.

[11] United States of America –v- City of New York et al. Docket No: CV-97-254 (NG). Steven M. Gold, United States Magistrate Judge. June 11, 2001.

NYCDEP identified two site alternatives (Eastview Site, in the Town of Mount Pleasant, Westchester County, New York and the Harlem River Site, in the Borough of the Bronx, New York).

Following the February 8, 2001 determination that legislative approval was required for the City to build the Croton WTP at the Mosholu Site, the City made a request for the necessary legislative approval. A home rule message was passed by the New York City Council on June 13, 2003. On June 20, 2003 the State Legislature passed a bill authorizing park alienation of certain land within Van Cortlandt Park and such legislation was signed into law by Governor Pataki on July 22, 2003. The legislation provides for temporary alienation of portions of Van Cortlandt Park during construction of the Croton WTP and permanent alienation of portions of the Park to operate and maintain the Croton WTP and related facilities.

The 1996 Safe Drinking Water Act Amendments and the rules and regulations that were promulgated subsequent to the Safe Drinking Water Act Amendments placed further regulatory burdens on the Croton System. The Interim Enhanced Surface Water Treatment Rule (1998) increased required protection from microorganisms, lowered the turbidity standard, and required the covering of all new treated water reservoirs. One of the Safe Drinking Act Amendments, the Disinfectants and Disinfection Byproducts Rule has rendered the filtration of Croton water a necessity. Stage 1 of this Rule limits certain by-products of chlorination. Stage II of this Rule went on to require measuring the disinfection byproducts as a quarterly running average and to change the points of measurement in the distribution system. As a result of these changes the Croton water is very close to violating the Stage 2 Disinfectants and Disinfection Byproducts Rule (Figure 2-2) much of time and did exceed the allowable level for Haloacetic Acids on one occasion in 2003. The Croton water further violated turbidity in 2002, requiring the notification of all users that the water exceeded standards.

Throughout the court proceedings the USEPA, NYSDOH, and the court have confirmed that the City must filter the Croton Supply. Environmental regulations require the consideration of a No Action Alternative in all Environmental Impact Statements (EIS). For the proposed Croton Water Treatment Plant project, the No Action Alternative is defined by the terms of the federal court Consent Decree that requires the construction of a Croton Water Treatment Plant. Because of the documented water quality problems, the lack of a plan that provides the same level of water quality protection as filtration, and the court-ordered requirement to filter the Croton Supply, the No Action alternative is not viable for this project.