Section 7

Detailed Evaluation of Alternatives

7.1 Introduction

Given the preliminary screening of individual treatment process alternatives and the collection system analysis presented in Section 6, alternative treatment trains were developed for four different peak plant capacities for the West Side plant (90 million gallons per day (mgd), 140 mgd, 180 mgd and 200 mgd) and two different peak plant capacities for the East Side plant (40 mgd and 80 mgd). The cost and benefit to increasing the peak flow at the plants, can then be assessed against the estimated cost for collection system improvements to reduce combined sewer overflows (CSOs). The desire of the Water Pollution Control Authority (WPCA) to efficiently and effectively provide holistic, reliable wastewater treatment solutions, reduce CSOs in a timely fashion, and increase the resilience of the system is then assessed for each alternative.

This section first focuses on each treatment facility; the West Side Wastewater Treatment Plant (WWTP) followed by the East Side WWTP. Alternative site layouts using various combination of treatment technologies under varying peak flow scenarios have been developed. Treatment trains were developed to depict both conventional treatment technologies that can be more land intensive, and more innovative treatment technologies that result in a more compact site. Some alternatives include a separate treatment train to treat peak flows, while others provide dual-use primary treatment alternatives to be used in both dry weather and wet weather conditions. The alternatives assessed present some common features typically related to the preliminary treatment, disinfection, and residuals management, with the variation in alternatives portrayed in the varying primary and secondary treatment trains. Assessments of each alternative scenario, as well as estimated capital cost for the construction of each scenario for comparison is summarized herein. Refer back to Section 6 for a more detailed description of the technology.

This section then addresses the system holistically comparing ongoing and proposed improvements in the collection system, the cost, the expected timing, and the commensurate benefits of these improvements in terms of reduction in the frequency and volume of CSO discharges with the cost of increasing treatment plant capacity and the benefits achieved.

Based on this assessment the most viable alternatives are carried forward to Section 8 for an assessment of financial capability and the recommended plan, is further defined in Section 9.

7.2 West Side Wastewater Treatment Plant

For the West Side WWTP four peak flow scenarios were assessed and a total of thirteen different liquid treatment trains:

- Four (4) – 90 mgd treatment train options (the current peak flow of the existing facility),
- One (1) – 140 mgd treatment train option (an intermediate flow which provides a reasonable reduction in CSOs),

- Five (5) – 180 mgd treatment train options (doubling the current peak capacity and providing significant CSO reductions), and
- Three (3) – 200 mgd treatment train options (peak capacity analyzed)

As described previously, the West Side WWTP's current average daily flow is 22.1 mgd. The facility is designed to treat up to 58 mgd through the secondary treatment system. Flow in excess of 58 mgd, up to the peak treatment capacity, is treated through primary treatment and disinfected prior to discharge. However, based on current records it appears that flow is capped between 80 and 85 mgd currently. For all scenarios evaluated, we have maintained the maximum day design flow through the secondary treatment system at 58 mgd. This equates to a secondary treatment peaking factor of 2.25 at the design year (2050) average daily flow of 25.8 mgd.

The thirteen alternative liquid treatment trains include a combination of unit processes common to each alternative and unique processes that vary across alternatives.

7.2.1 Common Treatment Train Unit Processes

For each treatment train, a few unit processes remain consistent in all treatment trains including, a new headworks facility consisting of coarse screens, influent pumping, fine screens and stacked tray grit removal; and ultraviolet disinfection for all secondary effluent, and often for all flow, with effluent pumping. In addition, sludge management includes gravity thickening of primary sludge, rotary drum thickening of waste activated sludge, thickened sludge storage with thickened sludge hauled off-site for disposal.

Headworks. For the basis of evaluation for each West Side WWTP alternative, flow is redirected from the two upstream distribution boxes and redirected to the new headworks consisting of multi-rake 1-inch opening coarse screens ahead of the new influent pumps. New centrifugal pumps would draw from a trench style wet well and pump up to new multi-rake fine screens with ¼-inch openings. Washer compactors would be provided for both the coarse screens and fine screens and discharge to a roll-off container located at grade with the new building. Screened flow would then pass to the stacked tray (Headcell) grit removal system – 12-foot diameter, 12 tray units would be provided, each with a duty and standby grit pump. Collected grit would be conveyed to a grit washer for discharge to a roll-off container located within the building.

Disinfection and Effluent Pumping. For each West Side WWTP alternative (with the exception of W-140A and W-200A), disinfection would be provided through a ultraviolet (UV) disinfection system. The UV system would consist of multiple channels each with multiple lamp modules in series to treat all dry and wet weather flow. The system would automatically react to changes in flow and turn on additional modules or open additional channels as needed to provide proper disinfection. At average day flow, at least one channel would be offline. At peak flow, all channels would be online. Alternatives W-140A and W-200A feature UV only for dry weather flow and utilize new chlorine contact tanks to disinfect using sodium hypochlorite for flows over 58 mgd. Under average flow and sea level conditions, disinfected effluent would flow by gravity through existing effluent outfall and discharge to Cedar Creek. Under high flows in conjunction with high water in the harbor, effluent pumping would be required to pump flow out of the facility at all peak flows. New axial flow column pumps would draw from either a trench style or rectangular wet well and discharge through the existing outfall.

Sludge Handling Facilities. For each West Side WWTP alternative, two new gravity thickeners would be constructed for primary sludge thickening (except for W-90D which rehabilitates the existing gravity thickeners) and three rotary drum thickeners provided in a new Solids Handling Facility for waste activated sludge thickening. Two new waste activated sludge (WAS) storage tanks would be provided as well as two new thickened sludge storage tanks. Off-loading facilities would be provided to easily pump thickened sludge into tanker trucks for further processing and disposal off-site. Although the quantity and quality of sludge produced from the various primary and secondary treatment processes will differ, this evaluation assumes the same capital infrastructure would be installed. The percent solids achieved and/or the hours of operation of the rotary drum thickeners (RDTs) may vary slightly between alternatives.

Electrical and I&C Systems. In all options it is assumed that a new electrical distribution system as well as standby power would be provided. In addition, new instrumentation and control systems including a full plant supervisory control and data acquisition (SCADA) system.

Flow Metering. For reporting and to assist in process operation, flow metering would be performed under all alternatives. At a minimum, flow would be constantly measured at the influent, effluent, and upstream of the secondary treatment system. In general, the influent flow would be measured using a magnetic flow meter on the discharge piping of the influent pumps. The effluent flow would be measured using a Parshall flume downstream of disinfection, but upstream of the effluent pump station. Flow to the secondary treatment system would be measured using a magnetic flow meter on the buried piping between primary treatment and the aeration tanks. During wet weather events, the bypass flow rate would be determined by subtracting the secondary treatment flow from the influent flow while accounting for side stream inputs.

7.2.2 Unique Treatment Train Unit Processes

The unique treatment train unit processes that vary across the alternative liquid treatment trains are primary treatment, high flow management and the biological nutrient removal (secondary treatment) process.

Primary Treatment. The primary treatment trains analyzed consider either dual-use operation where the same technology is used for both dry weather and wet weather flow, or a separate treatment train for wet weather flow (flow above the capacity of the secondary treatment system). The various treatment trains employ one of three technologies: Traditional rectangular settling tanks, cloth disk filtration, or high rate clarification (HRC). Although the use of cloth disk filtration is new to the market for primary filtration, the benefits of small footprint and enhanced primary effluent quality are apparent. High rate clarification has been used at a number of facilities for wet weather treatment, but dual use of HRC for both dry weather and wet weather flow is less common. Traditional primary clarification is tried and true, however, the area required to achieve an appropriate level of primary treatment is far greater than that of the other alternatives. The detailed evaluation of primary treatment and high flow management alternatives is presented in Section 7.2.4.1.

Biological Nutrient Removal (BNR). In all treatment trains the existing process will be upgraded to a four-stage process (anoxic, aerobic, post-anoxic, re-aeration) to achieve year-round nitrogen removal under design year flows and loadings. This is accomplished either through expanding the bioreactor volume, increasing the capacity of the existing bioreactors by implanting integrated fixed film activated sludge (IFAS), and/or replacing secondary clarification with membrane filtration (MBR). In each case, the ability to add supplemental alkalinity (magnesium hydroxide) upstream of the BNR process, is included, the ability to add supplemental carbon to the post-anoxic zone, is included, and new process blowers to be housed in a new blower building constructed. The detailed evaluation of BNR alternatives is presented in Section 7.2.4.2.

7.2.3 Detailed Evaluation of WWTP's Peak Flowrate Alternatives

Four alternative peak flowrates were evaluated; 90 mgd, 140 mgd, 180 mgd, and 200 mgd. Each flowrate evaluated (greater than 90 mgd) represents significant CSO removal milestones throughout the West Side WWTP's collection system. Liquid treatment train options were developed and laid out on the WWTP's site for each flowrate. The sections, below, present and describe these various liquid treatment trains and site layouts for the alternative peak flow rates.

7.2.3.1 90 MGD Peak Flow Plant

The 90-mgd peak flow West Side plant alternatives maintain the current capacity of the West Side plant, which then inherently relies on collection system improvements to reduce the volume and frequency of CSOs during the one-year, 24-hour storm event. The following treatment trains were assessed:

- W-90A – 90 mgd, Dual-use traditional primary settling tanks and traditional suspended growth 4-stage BNR activated sludge treatment (West of the WWTP on the marina site)
- W-90B – 90 mgd, Dual-use primary filtration and 4-stage BNR activated sludge treatment with IFAS
- W-90C – 90 mgd, Dual-use primary filtration and 4-stage BNR activated sludge treatment with membrane filtration
- W-90D – 90 mgd, Dual-use traditional primary settling tanks and traditional suspended growth 4-stage BNR activated sludge treatment (on existing site)

Option W-90A

Option W-90A represents the traditional treatment train option, consistent with unit processes currently employed at the West Side plant for a 90 mgd peak flow facility. New and upgraded primary and secondary treatment tankage is appropriately sized to meet NPDES permit limits under design-year influent flows and loads. The option requires significant new infrastructure on the Marina Site. In order to maintain operation of the existing facility during construction, it is likely that these facilities would be constructed first, then, once up and running, existing facilities would be upgraded. In this option, nine new appropriately sized traditional rectangular primary settling tanks would be constructed on land currently occupied by the marina to treat up to 90 mgd. Primary effluent up to 58 mgd would pass to the BNR system consisting of the existing East battery and a new West battery. Primary effluent in excess of 58 mgd, up to 90 mgd would pass directly to disinfection. Three new four-stage BNR bioreactors would be constructed, to ensure year-round nitrogen removal at design flow, also on land currently occupied by the marina. The existing primary clarifiers would be re-purposed to serve as new anoxic zones for the East battery of bioreactors. The existing secondary clarifiers would be maintained and upgraded including all associated mechanical equipment. Odor control would be provided to serve the new headworks and sludge processing systems.

Table 7.2-1 and **Figure 7.2-1** summarize and depict Option W-90A.

Option W-90B

As opposed to Option W-90A, Option W-90B employs space saving technologies to result in a treatment facility that can be constructed within the footprint of the existing facility. In this case, the novel primary cloth disk filters would be used to provide primary treatment to all flows. Primary effluent up to 58 mgd would pass to the BNR system, primary effluent in excess of 58 mgd, up to 90 mgd would pass directly to disinfection. Seven cloth disk filter trains would be provided. It is expected that the quality of the primary effluent from the cloth filters will be superior to primary effluent from the traditional primary settling tanks. Upgrade of the existing bioreactors to a four-stage suspended growth BNR system with IFAS, will enable total nitrogen (TN) removal within the footprint of the existing bioreactors. The existing secondary clarifiers would be maintained and upgraded including all associated mechanical equipment. Odor control would be provided to serve the new headworks, primary filters and sludge processing systems.

Table 7.2-2 and **Figure 7.2-2** summarize and depict Option W-90B.

Option W-90C

Option W-90C also employs space saving technologies to result in a treatment facility that can be constructed within the footprint of the existing facility, however instead of IFAS to increase the BNR system capacity membrane filtration is employed. As in Option W-90B, primary cloth disk filters would be used to provide primary treatment to all flows. In this option new anoxic tanks would be constructed in the location of the existing chlorine contact tanks and the existing bioreactors upgraded to house the final three stages of the 4-stage suspended growth BNR system. New membrane filtration would also be constructed in the location of the existing chlorine contact tank and eliminating the need for the existing secondary clarifiers. The membrane filtration system allows the BNR system to operate at a higher mixed liquor suspended solids (MLSS) to allow for adequate treatment under all flow and load scenarios. It is expected that the effluent from the membrane filtration system will be superior to that provided by conventional secondary clarifiers. Odor control would be provided to serve the new headworks, primary filters and sludge processing systems.

Table 7.2-3 and **Figure 7.2-3** summarize and depict Option W-90C.

Option W-90D

Option W-90D is very similar to Option W-90A and represents the traditional treatment plant processes. However, this option attempts to construct the entire facility within the bounds of the existing treatment plant including the parcel to the north, thus avoiding construction within the marina occupied parcel.

Table 7.2-4 and **Figure 7.2-4** summarize and depict Option W-90D.

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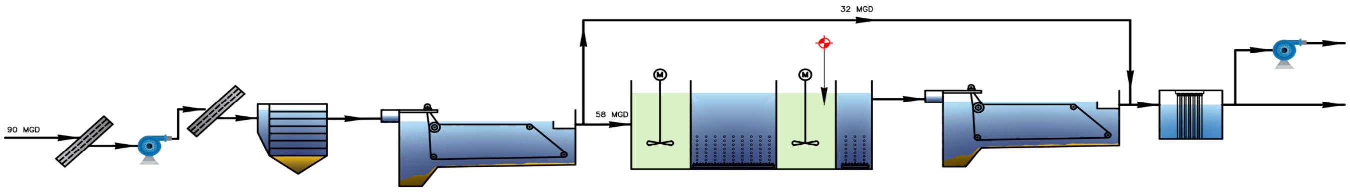
Table 7.2-1
Alternative W90A – 90 MGD, Dual-use Traditional Primaries and Traditional 4-stage Suspended Growth BNR Treatment



A new 90 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, four influent pumps (3 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Nine new traditional rectangular primary settling tanks constructed on land currently occupied by the marina. Upgrade of the existing 4-stage suspended growth BNR system with new 1st stage anoxic zone constructed in the location of the existing primary clarifiers, with new blower/control building, construction of three new BNR bioreactors on the marina parcel and upgrade of the existing secondary clarifiers. New 90 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Traditional systems used for treatment processes, similar to current treatment processes at existing facility and most common technologies used in the industry. Increased primary treatment and BNR treatment system capacity will enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The traditional plant requires a significant amount of land currently occupied by the existing marina.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. New facilities will first be constructed on land currently unoccupied by treatment facilities, prior to upgrade of existing facilities.
Ease of Operations	Technologies similar to that currently used at the plant, with the exception of stacked tray grit removal and UV disinfection, which are conventional treatment technologies in the industry. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Standard equipment maintenance required. UV lamps require periodic replacement.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant infringes on property currently occupied by the marina reducing the land available for boat storage. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved sites aesthetics.
Ability to Phase Implementation	New facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site which will reduce truck traffic. Higher solids capture will reduce impact of sidestream loads. Providing improved screening and grit removal will enhance sludge quality.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required.
	OPCC [(1)] = $214,100,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-1
Alternative W-90A

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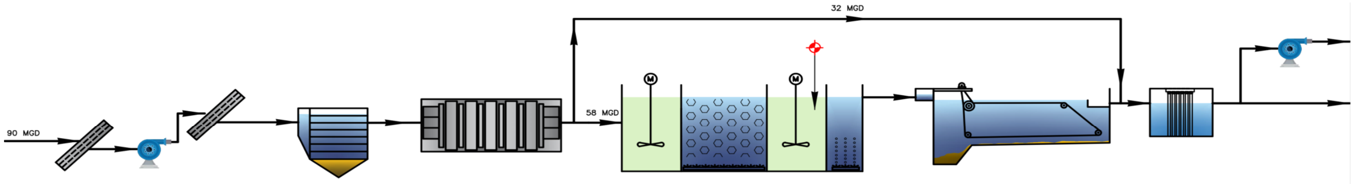
Table 7.2-2
Alternative W90B – 90 MGD, Dual-use Primary Filtration and 4-stage Suspended Growth BNR Treatment with IFAS



A new 90 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, four influent pumps (3 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Seven cloth disk filter trains for primary treatment constructed on land currently occupied by the influent pumping station. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system with IFAS, new blower/control building and upgrade of the existing secondary clarifiers. New 90 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary and primary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. IFAS has been used to increase the capacity of secondary treatment systems for a number of years. Improved primary treatment capacity as well as increased capacity of the BNR system will enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies, fits within the footprint of the existing plant site.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, IFAS and UV disinfection. However, once operators are trained, operation will not be more complex than existing. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Standard equipment maintenance required. Cloth filters and UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aesthetics.
Ability to Phase Implementation	New preliminary, primary, disinfection and sludge processing facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plant's energy efficiency. Improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required.
	OPCC [(1)] = $199,800,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-2
Alternative W-90B

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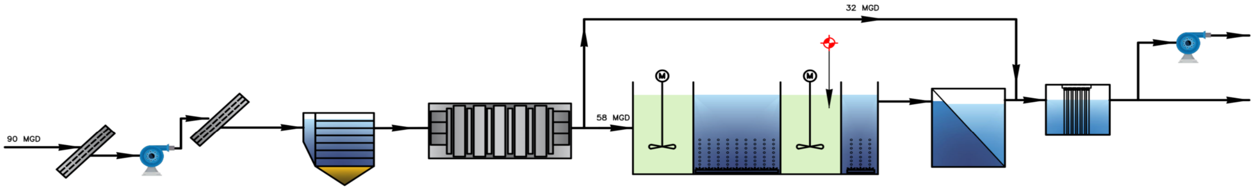
Table 7.2-3
Alternative W90C – 90 MGD, Dual-use Primary Filtration and 4-stage Suspended Growth BNR Treatment with MBR



A new 90 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, four influent pumps (3 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Seven cloth disk filters trains for primary treatment constructed on land currently occupied by the influent pumping station. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system, new blower/control building and new membrane filtration in lieu of the existing secondary clarifiers. New 90 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary and primary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. Membrane filtration is prevalent in the industry, more typically for reuse applications. Improved primary treatment and BNR treatment system capacity to enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies fits within the footprint of the existing plant site.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, membrane filtration and UV disinfection. Membrane filtration is a more complex operation as compared to secondary clarification. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	This option will likely be more complex to maintain given the advanced systems. Cloth filters, membranes and UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aesthetics.
Ability to Phase Implementation	Due to the intricate sequence of construction, phasing not warranted with this alternative.
Sludge Impacts	Primary filtration and membrane filtration will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site which will reduce truck traffic. Higher solids capture will reduce impact of sidestream loads. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plant's energy efficiency. Improved HVAC and odor control as well as membranes and UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site. Supplemental carbon to enhance BNR as necessary. Citric acid and NaOCl required for membrane cleaning. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required.
	OPCC [(1)] = $243,700,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-3
Alternative W-90C

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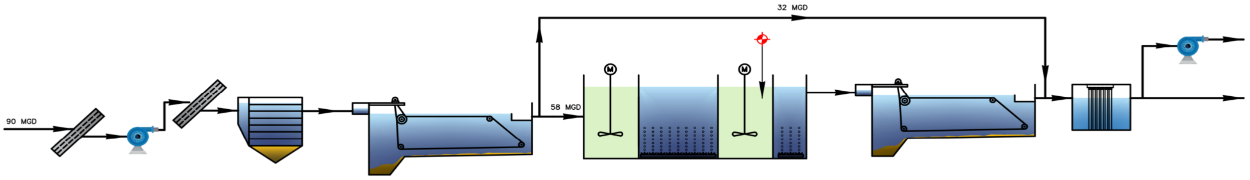
Table 7.2-4

Alternative W90D – 90 MGD, Dual-use Traditional Primaries and Traditional 4-stage Suspended Growth BNR Treatment



A new 90 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, four influent pumps (3 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units on the unoccupied parcel north of the site. Nine new traditional rectangular primary settling tanks constructed on the northwestern parcel. Reconfiguration of the existing bioreactors to 3 four-stage BNR bioreactors and construction of 3 new BNR bioreactors in the location of the existing influent pumping station, new blower building and upgrade of the existing secondary clarifiers. New 90 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Traditional systems used for treatment processes, similar to current treatment processes at existing facility and most common technologies used in the industry. Increased primary treatment and BNR treatment system capacity will enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The layout of this traditional plant requires a significant amount of land north and northwest of the existing plant site. Extremely congested site layout leaves limited space for parking, access, vehicular movement
Maintenance of Plant Operations	Detailed and complex sequencing plan required to maintain operation during construction, but can be accommodated. New facilities will first be constructed on land currently unoccupied by treatment facilities, prior to upgrade of existing facilities.
Ease of Operations	Technologies similar to that currently used at the plant, with the exception of stacked tray grit removal and UV disinfection, which are conventional treatment technologies in the industry. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Standard equipment maintenance required. UV lamps require periodic replacement.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant abuts directly against northern property line adjacent to housing units. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aesthetics.
Ability to Phase Implementation	Due to the intricate sequence of construction phasing not warranted with this alternative.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Providing improved screening and grit removal will enhance sludge quality.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required.
	OPCC [(1)] = $215,000,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-4
Alternative W-90D

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7.2.3.2 140 MGD Peak Flow Plant

The 140-mgd peak flow West Side plant alternative, increases the peak flow capacity at the West Side plant by 50 mgd over existing conditions. It was clear when evaluating the existing collection system that more flow can be conveyed to the West Side plant than it currently has the ability to pump and treat. By simply increasing the pumping and treatment capacity at the WWTP, under a 1-year, 24-hour storm event the volume of CSOs in the system is reduced by 9.4 million gallons (MG). This CSO flow, rather than being discharged untreated to local receiving waters, is conveyed to the plant and receives primary treatment and disinfection prior to discharge to Cedar Creek. CSOs identified as RAILS and TIC are controlled to a one-year level with this alternative. One treatment train was assessed for the 140 mgd alternative:

- W-140A – 140 mgd, Dual-use primary filtration and 4-stage BNR activated sludge treatment with membrane filtration, with traditional primary tanks for wet weather treatment.

Option W-140A

Option W-140A employs space saving technologies to result in a treatment facility that can be constructed within the footprint of the existing facility, including cloth disk filtration for primary treatment and membrane filtration in lieu of secondary clarifiers. The primary filtration system would be designed for a peak flow of 58 mgd, compatible with the secondary treatment system capacity. Flow in excess of 58 mgd up to the peak flow of 140 mgd would be directed to re-purposed secondary clarifiers to serve as an 82 mgd wet weather treatment. In addition, new chlorine contact tanks would be constructed within a portion of the decommissioned secondary clarifiers to disinfect the wet weather flow with sodium hypochlorite. In this option new anoxic tanks would be constructed in the location of the existing chlorine contact tanks and the existing bioreactors upgrade to house the final three stages of the 4-stage suspended growth BNR system. New membrane filtration would also be constructed in the location of the existing chlorine contact tank thus eliminating the need for the existing secondary clarifiers. The membrane filtration system allows the BNR system to operate at a higher MLSS to allow for adequate treatment under all flow and load scenarios. It is expected that the effluent from the membrane filtration system will be superior to that provided by conventional secondary clarifiers. Odor control would be provided to serve the new headworks, primary filters and sludge processing systems.

Table 7.2-5 and **Figure 7.2-5** summarize and depict this alternative.

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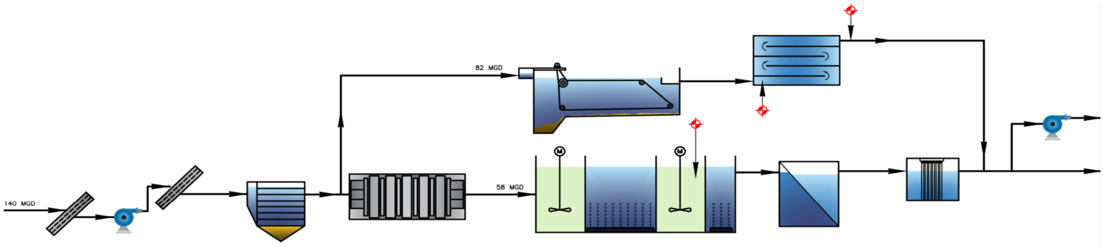
Table 7.2-5
Alternative W140A – 140 MGD, Primary Filtration with Traditional Primaries for Wet Weather, and 4-stage Suspended Growth BNR Treatment with MBR



A new 140 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), four (3 operating, one standby) 1/4-inch fine screens, and four stacked tray grit removal units. Seven cloth disk filter trains for dry weather primary treatment constructed on land currently occupied by the influent pumping station to treat up to 58 MGD. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system, new blower/control building and new membrane filtration in lieu of the existing secondary clarifiers. New 58 MGD UV system for disinfection of secondary effluent. Wet weather flow treated through re-purposed secondary clarifiers and disinfected with sodium hypochlorite. New 140 MGD effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment, disk filters and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. Membrane filtration is prevalent in the industry, more typically for reuse applications. Improved primary treatment and BNR treatment system capacity to enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies, fits within the footprint of the existing plant site.
Maintenance of Plant Operations	Detailed and complex sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, membrane filtration and UV disinfection. Membrane filtration is a more complex operation as compared to secondary clarification. This alternative also requires independent wet weather system to be brought on-line to manage high flows. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	This option will likely be more complex to maintain given the advanced systems. Cloth filters, membranes and UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant abuts directly against northern property line adjacent to housing units. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aesthetics.
Ability to Phase Implementation	Due to the intricate sequence of construction phasing not warranted with this alternative.
Sludge Impacts	Primary filtration and membrane filtration will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site which will reduce truck traffic. Higher solids capture will reduce impact of sidestream loads. Increased peak capacity will increase solids production. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as membranes and UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will reduce use of sodium hypochlorite and sodium bisulfite since only used for wet weather flow. Supplemental carbon to enhance BNR as necessary. Citric acid and NaOCl required for membrane cleaning. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required.
	OPCC [1] = $258,200,000

(1) OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-5
Alternative W-140A

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7.2.3.3 180 MGD Peak Flow Plant

The 180-mgd peak flow West Side plant alternatives double the current peak capacity of the West Side plant, as a means of further reducing the volume and frequency of CSOs upstream in the collection system. By increasing the pumping and treatment capacity at the WWTP, under a 1-year, 24-hour storm event the volume of CSOs is reduced by 17.5 MG as compared to the 90- mgd option. This CSO flow rather than being discharged untreated to the receiving waters is conveyed and receives primary treatment and disinfection prior to discharge. CSOs identified as RAILS, TIC, ANTH and SEAB can be controlled to a one-year level with this treatment plant capacity and some collection improvements. The following treatment trains were assessed:

- W-180A – Primary filtration and 4-stage BNR activated sludge treatment with IFAS, high rate clarification for wet weather treatment
- W-180B – Dual-use primary filtration and 4-stage BNR activated sludge treatment with membrane filtration
- W-180C – Traditional primary settling and 4-stage BNR activated sludge treatment, high rate clarification for wet weather treatment
- W-180D – Dual-use primary filtration and 4-stage BNR activated sludge treatment with IFAS
- W-180E – Traditional primary settling tank and 4-stage BNR activated sludge treatment with IFAS and high rate clarification for wet weather treatment

Option W-180A

Option W-180A uses space-saving primary filtration to treat dry weather flows up to 58 mgd and high rate clarification for influent flow greater than 58 mgd up to 180 mgd. The bioreactors are upgraded to a 4-stage system with IFAS, and the existing secondary clarifiers maintained and upgraded. Flows from the secondary system would be combined with flows from the HRC system and be disinfected in a common UV disinfection facility. This treatment train infringes on the Marina parcel and consumes the parcel to the north and northwest of the existing site.

Table 7.2-6 and **Figure 7.2-6** summarize and depict Option W-180A.

Option W-180B

Option W-180B uses dual-use primary filtration to treat up to 180 mgd, simplifying operations. Bioreactors are converted to a four-stage suspended growth system and the secondary clarifiers replaced with membrane filtration located where the primary clarifiers currently exist. The post-anoxic zones are constructed in the location of the former secondary clarifiers as well as a new sludge processing building. The new disinfection and effluent pumping structures infringe on the marina parcel.

Table 7.2-7 and **Figure 7.2-7** summarize and depict Option W-180B.

Option W-180C

Option W-180C presents the traditional treatment design for dry weather flow and high rate clarification for wet weather flow. In this option new traditional rectangular secondary clarifiers are constructed on the land currently occupied by the Marina and a new HRC system in the northwesternmost portion of the site. Similar to Option W-90A, three new four-stage BNR bioreactors would be constructed, to ensure year-round nitrogen removal at design flow, also on land currently occupied by the marina. The existing primary clarifiers would be re-purposed to serve as new anoxic zones for the East battery of bioreactors. The existing secondary clarifiers would be maintained and upgraded including all associated mechanical equipment. A new effluent pumping station and UV disinfection would be located on the southern end of the site, also within land currently occupied by the Marina. Odor control would be provided to serve the new headworks, primary filters and sludge processing systems.

Table 7.2-8 and **Figure 7.2-8** summarize and depict Option W-180C.

Option W-180D

Option W-180D stays within the footprint of the existing site and the northern parcel by employing dual use primary filtration and 4-stage bioreactors with IFAS. The existing secondary clarifiers are maintained and upgraded. UV disinfection and the effluent pumping station are constructed within the footprint of the existing primary settling tanks and the new sludge processing facility within the footprint of the existing influent pumping station. Odor control would be provided to serve the new headworks, primary filters and sludge processing systems.

Table 7.2-9 and **Figure 7.2-9** summarize and depict Option W-180D.

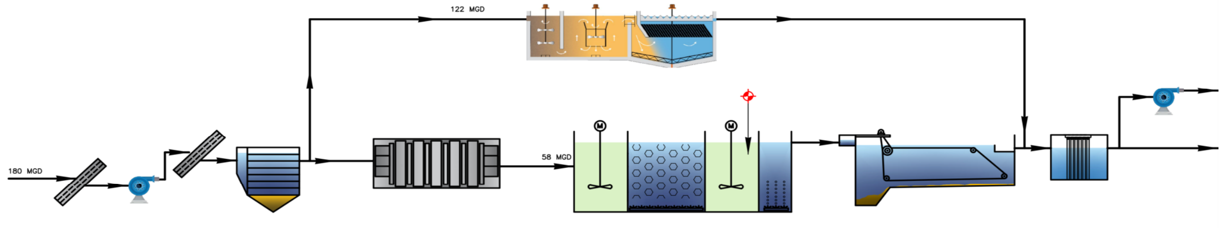
Option W-180E

Option W-180E is very similar to Option W-180D with the exception of primary treatment. In this case traditional primary clarifiers are designed to treat up to 58 mgd, and the balance of flow is treated through high rate clarification. Other components are identical to Option W-180D.

Table 7.2-10 and **Figure 7.2-10** summarize and depict Option W-180E.

Table 7.2-6

Alternative W180A – 180 MGD, Primary Filtration and 4-stage Suspended Growth BNR Treatment with IFAS, HRC for Wet Weather



A new 180 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), five (4 operating, one standby) 1/4-inch fine screens, and four stacked tray grit removal units. Seven cloth disk filter trains for primary treatment constructed on land currently occupied by the influent pumping station. New 122 MGD high rate clarification (HRC) system for wet weather treatment. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system with IFAS, new blower/control building and upgrade of the existing secondary clarifiers. New 180 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. IFAS has been used to increase the capacity of secondary treatment systems for a number of years. High rate clarification for wet weather treatment commonly used. Improved primary treatment and BNR treatment system capacity will enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies, however consumes the northern and northwestern parcel and infringes marginally on the property currently occupied by the marina.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, IFAS, HRC and UV disinfection. However, once operators are trained operation will not be much more complex than existing. This alternative employs an independent wet weather system that must be brought on-line to manage high flows. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Unique treatment systems require unique maintenance procedures including cloth filters, HRC, IFAS, and UV disinfection. Cloth filters and UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant abuts against northern property line adjacent to housing units and infringes on marina parcel. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aesthetics.
Ability to Phase Implementation	New preliminary, primary, HRC, disinfection and sludge processing facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Increased peak capacity may increase solids production. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required. HRC will require use of coagulant and polymer.
	OPCC [1] = $258,100,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-6
Alternative W-180A

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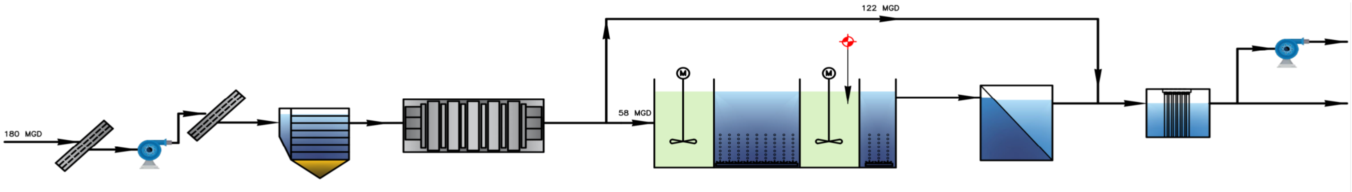
Table 7.2-7
Alternative W180B – 180 MGD, Dual-use Primary Filtration and 4-stage Suspended Growth BNR Treatment with MBR



A new 180 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), five (4 operating, one standby) 1/4-inch fine screens, and four stacked tray grit removal units. Ten cloth disk filter trains for primary treatment constructed on land currently occupied by the influent pumping station. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system, new blower/control building and new membrane filtration in lieu of the existing secondary clarifiers. New 180 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. Membrane filtration is prevalent in the industry, more typically for reuse applications. Improved primary treatment and BNR treatment system capacity will enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies, however consumes the northern and north western parcel and infringes marginally on the property currently occupied by the marina.
Maintenance of Plant Operations	Detailed and complex sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, membrane filtration and UV disinfection. Membrane filtration is a more complex operation as compared to secondary clarification. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	This option will likely be more complex to maintain given the advanced systems. Cloth filters, membranes and UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant abuts against northern property line adjacent to housing units and infringes on marina parcel. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aesthetics.
Ability to Phase Implementation	Due to the intricate sequence of construction phasing not warranted with this alternative.
Sludge Impacts	Primary filtration and membrane filtration will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Increased peak capacity may increase solids production slightly. Higher solids capture will reduce impact of sidestream loads. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as membranes and UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site. Supplemental carbon to enhance BNR as necessary. Citric acid and NaOCl required for membrane cleaning. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required.
	OPCC [1] = $276,000,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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West Side WWTP
205 Bostwick Ave, Bridgeport CT

Scale: 1" = 150'

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0 75 150 Feet

CDM Smith

Figure 7.2-7
Alternative W-180B

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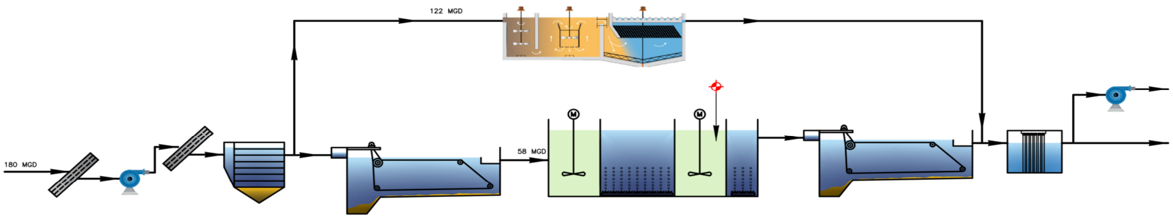
Table 7.2-8
Alternative W180C – 180 MGD, Traditional Primary Settling Tanks and 4-stage Suspended Growth BNR Treatment, HRC for Wet Weather Flow



A new 180 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), five (4 operating, one standby) 1/4-inch fine screens, and four stacked tray grit removal units. Six new traditional rectangular primary settling tanks constructed on land currently occupied by the marina. New 122 MGD high rate clarification (HRC) system for wet weather treatment. Upgrade of the existing 4-stage suspended growth BNR system with new 1st stage anoxic zone constructed in the location of the existing primary clarifiers, with new blower/control building, construction of three new BNR bioreactors on the marina parcel and upgrade of the existing secondary clarifiers. New 180 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Upgrade of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Traditional systems used for treatment processes, similar to current treatment processes at existing facility and most common technologies used in the industry. High rate clarification for wet weather treatment commonly used. Increased primary treatment and BNR treatment system capacity will enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The traditional plant requires a significant amount of land currently occupied by the existing marina.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. New facilities will first be constructed on land currently unoccupied by treatment facilities, prior to upgrade of existing facilities.
Ease of Operations	Technologies similar to that currently used at the plant, with the exception of stacked tray grit removal, HRC and UV disinfection, which are conventional treatment technologies in the industry. This alternative employs independent wet weather system that must be brought on-line to manage high flows. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Standard equipment maintenance required for the dry weather treatment train. HRC system will require more unique maintenance requirements. UV lamps require periodic replacement.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant abuts against northern property line adjacent to housing units and consumes a significant footprint on property currently occupied by the marina reducing the land available for boat storage. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aesthetics.
Ability to Phase Implementation	New preliminary, primary, secondary systems, HRC, disinfection and sludge processing facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Increased peak capacity may increase solids production slightly. Providing improved screening and grit removal will enhance sludge quality.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required. HRC will require use of coagulant and polymer.
	OPCC [1] = $266,000,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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West Side WWTP
205 Bostwick Ave, Bridgeport CT

Scale: 1" = 150'

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CDM Smith

Figure 7.2-8
Alternative W-180C

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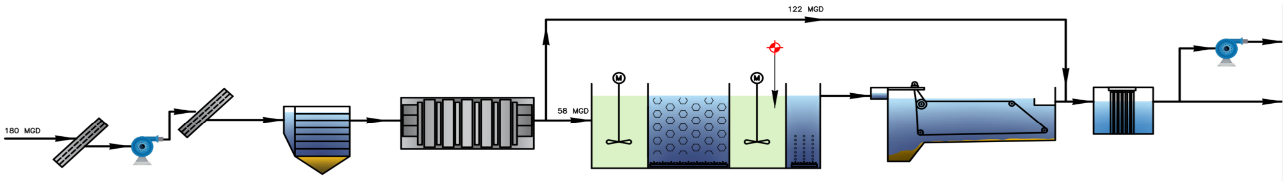
Table 7.2-9

Alternative W180D – 180 MGD, Dual-use Primary Filtration and 4-stage Suspended Growth BNR Treatment with IFAS



A new 180 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), five (4 operating, one standby) 1/4-inch fine screens, and four stacked tray grit removal units. Ten cloth disk filter trains for primary treatment constructed on the northwestern parcel. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system with IFAS, new blower/control building and upgrade of the existing secondary clarifiers. New 180 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. IFAS has been used to increase the capacity of secondary treatment systems for a number of years. Improved primary treatment and BNR treatment system capacity will enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies, however consumes the northern and northwestern parcel.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, IFAS, and UV disinfection. However, once operators are trained operation will not be much more complex than existing. Wet weather flows managed simply by bringing more units on-line. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Unique treatment systems require unique maintenance procedures including cloth filters, IFAS, and UV disinfection. Cloth filters and UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant abuts against northern property line adjacent to housing units. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling, improved effluent quality and improved aesthetics.
Ability to Phase Implementation	New preliminary, primary, disinfection and sludge processing facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Increased peak capacity will increase solids production. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required.
	OPCC [(1)] = $243,300,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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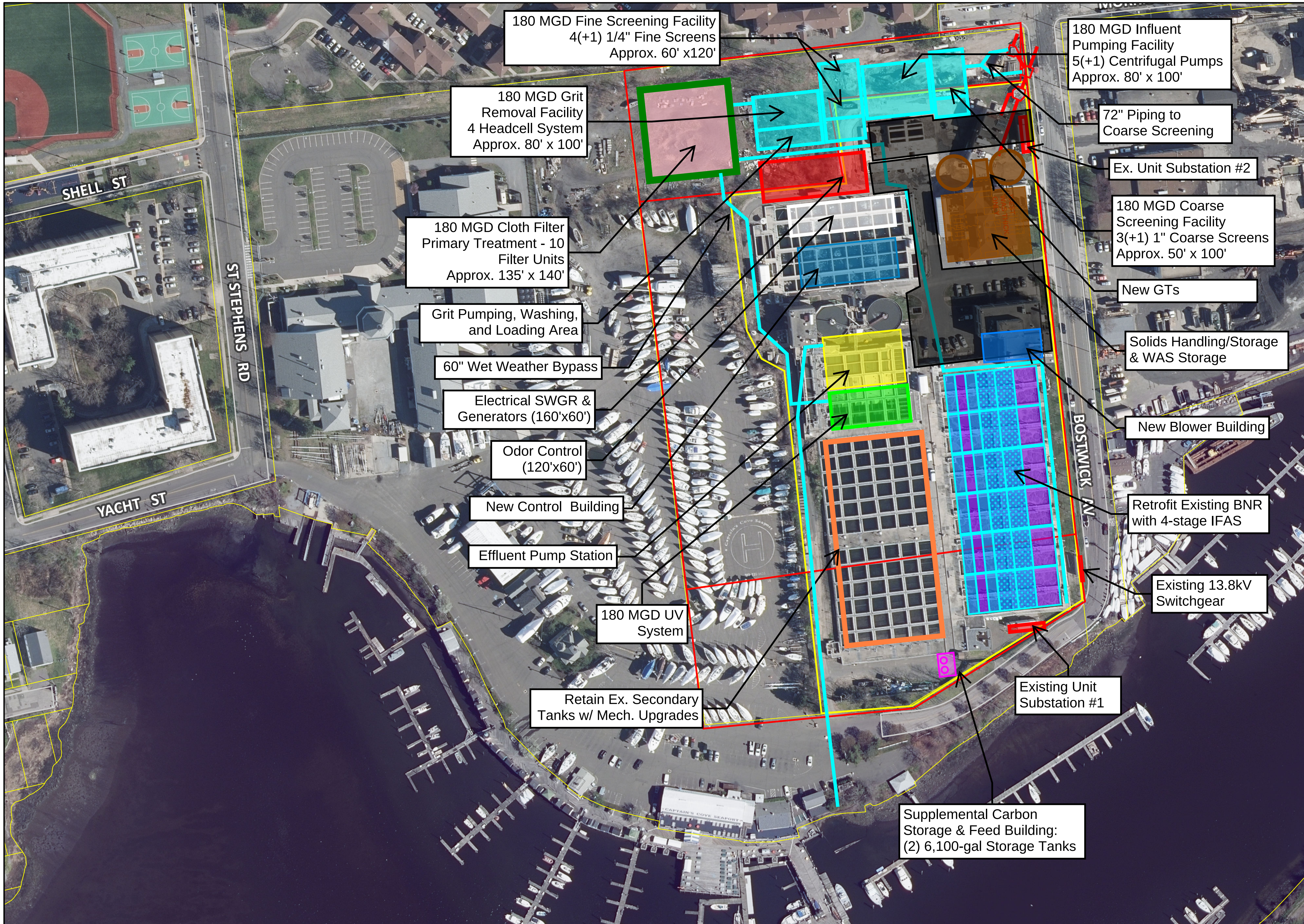

West Side WWTP
205 Bostwick Ave, Bridgeport CT

Scale: 1" = 150'

Feet
0 75 150

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CDM Smith

Figure 7.2-9
Alternative W-180D

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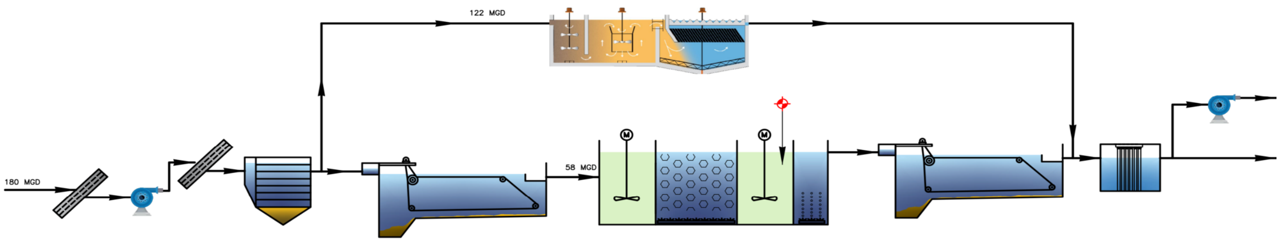
Table 7.2-10

Alternative W180E – 180 MGD, Traditional Primary Settling Tanks and 4-stage Suspended Growth BNR Treatment with IFAS, HRC for Wet Weather Treatment



A new 180 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), five (4 operating, one standby) 1/4-inch fine screens, and four stacked tray grit removal units. Six traditional primary settling tanks constructed on the northwestern parcel. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system with IFAS, new blower/control building and upgrade of the existing secondary clarifiers. 122 MGD high rate clarification (HRC) to manage wet weather flows. New 180 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Traditional systems used for dry weather treatment processes, with the addition of IFAS to BNR system. High rate clarification for wet weather treatment commonly used. Increased primary and BNR treatment system capacity will enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The plant consumes the northern and north western parcel and infringes marginally on the property currently occupied by the marina.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, IFAS, HRC and UV disinfection. However, once operators are trained operation will not be much more complex than existing. Traditional primaries easy to operate. This alternative employs independent wet weather system that must be brought on-line to manage high flows. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Unique treatment systems require unique maintenance procedures including HRC, IFAS, and UV disinfection. Cloth filters and UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant butts up against northern property line adjacent to housing units. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling, improved effluent quality and improved aesthetics.
Ability to Phase Implementation	New preliminary, primary, HRC, disinfection and sludge processing facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Increased peak capacity may increase solids production slightly. Providing improved screening and grit removal will enhance sludge quality.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required. HRC will require use of coagulant and polymer.
	OPCC [1] = $256,400,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-10
Alternative W-180E

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7.2.3.4 200 MGD Peak Flow Plant

The 200-mgd peak flow West Side plant alternatives, more than doubles the current peak capacity of the West Side plant, as a means of further reducing the volume and frequency of CSOs. Although, based on modeling, this treatment capacity does not result in the control of any additional CSOs over and above those identified with the 180 mgd capacity, modeling indicates that up to 200 mgd could be conveyed to the treatment facility with existing infrastructure during a 10-year storm event. As piping improvements are made within the collection system it is likely that 200 mgd could be conveyed to the plant under smaller storm events. The following treatment trains were assessed for the 200 mgd peak plant flow. Due to space constraints, no traditional systems were investigated at this capacity:

- W-200A – 200 mgd, Dual-use high rate clarification for primary treatment, IFAS, UV for disinfection of secondary effluent, sodium hypochlorite for disinfection of primary effluent
- W-200B – 200 mgd, Dual-use high rate clarification for primary treatment, IFAS, UV disinfection of all effluent
- W-200C – 200 mgd, Dual-use primary filtration, IFAS, UV disinfection of all effluent

Option W-200A

Option W-200A is the first to employ dual-use high rate clarification for primary treatment. Subsequent to primary treatment, the BNR system is identical to options W-180A, D and E, with a 4-stage system with IFAS, and the existing secondary clarifiers maintained and upgraded. In this case, however, dry weather flow up to 58 mgd is disinfected with UV disinfection, and wet weather flow is disinfected with sodium hypochlorite in rehabilitated chlorine contact tanks. This option consumes a footprint just slightly larger than option W-180D.

Table 7.2-11 and **Figure 7.2-11** summarize and depict Option W-200A.

Option W-200B

Option W-200B also employs dual-use high rate clarification for primary treatment and is identical to Option W-200A with the exception of disinfection which employs UV disinfection for the entire 200 mgd flow.

Table 7.2-12 and **Figure 7.2-12** summarize and depict Option W-200B.

Option W-200C

Option W-200C employs dual-use primary filtration for primary treatment, the same BNR treatment system as the other 200 mgd alternatives and employs UV disinfection for the entire 200 mgd flow.

Table 7.2-13 and **Figure 7.2-13** summarize and depict Option W-200C.

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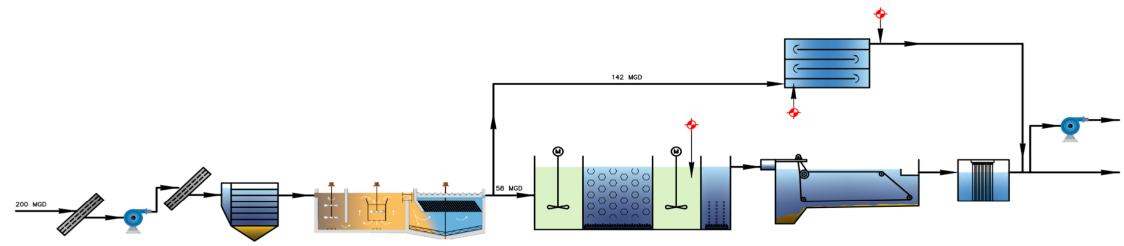
Table 7.2-11

Alternative W200A – 200 MGD, Dual-use High Rate Clarification (HRC) and 4-stage Suspended Growth BNR Treatment with IFAS, Both UV Disinfection and Sodium Hypochlorite



A new 200 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, seven influent pumps (6 operating, one standby), five (4 operating, one standby) 1/4-inch fine screens, and five stacked tray grit removal units. New 4 to 7 train high rate clarification (HRC) system for primary treatment in dry and wet weather constructed on the north western parcel. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system with IFAS, new blower/control building and upgrade of the existing secondary clarifiers. New 58 MGD UV system for disinfection of secondary effluent and new chlorine contact tank for disinfection of wet weather flow. New 200 MGD effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	High Rate Clarification (HRC) for primary treatment for dry weather flow not standard, but has been done. HRC for wet weather treatment commonly used. IFAS has been used to increase the capacity of secondary treatment systems for a number of years. Improved primary treatment and BNR treatment system capacity will enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies, however consumes the northern and north western parcel.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, HRC, IFAS, and UV disinfection. However, once operators are trained operation will not be much more complex than existing. Wet weather flows managed simply by bringing more HRC units on-line, however, chlorination system needs to be brought on-line for wet weather disinfection. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Unique treatment systems require unique maintenance procedures including HRC, IFAS, and UV disinfection. Two disinfection schemes require attention. UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant butts up against northern property line adjacent to housing units. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling, improved effluent quality and improved aesthetics.
Ability to Phase Implementation	New preliminary, primary, disinfection and sludge processing facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Increased peak capacity may increase solids production slightly. Providing improved screening and grit removal will enhance sludge quality. Thin sludge off of HRC.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of sodium hypochlorite and sodium bisulfite on-site for wet weather flow disinfection and dechlorination. Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required. Chemical coagulant and polymer for HRC.
	OPCC [1] = $261,100,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-11
Alternative W-200A

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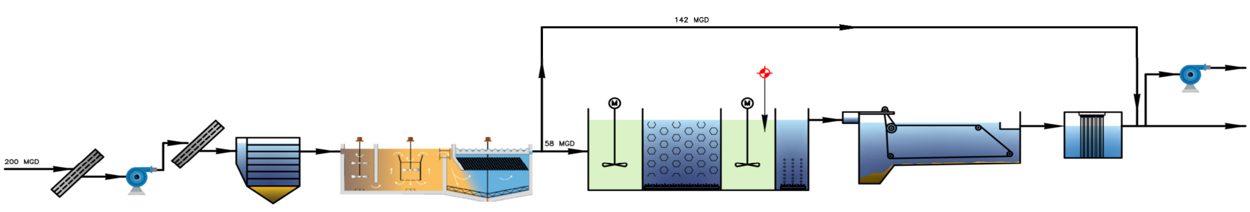
Table 7.2-12

Alternative W200B – 200 MGD, Dual-use High Rate Clarification (HRC) and 4-stage Suspended Growth BNR Treatment with IFAS, UV Disinfection



A new 200 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, seven influent pumps (6 operating, one standby), five (4 operating, one standby) 1/4-inch fine screens, and five stacked tray grit removal units. New 4 to 7 train high rate clarification (HRC) system for primary treatment in dry and wet weather constructed on the north western parcel. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system with IFAS, new blower/control building and upgrade of the existing secondary clarifiers. New 200 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	High Rate Clarification (HRC) for primary treatment of dry weather flow not standard, but has been done. HRC for wet weather treatment commonly used. IFAS has been used to increase the capacity of secondary treatment systems for a number of years. Improved primary and BNR treatment system capacity will enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies, however consumes the northern and north western parcel.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, HRC, IFAS, and UV disinfection. However, once operators are trained operation will not be much more complex than existing. Wet weather flows managed simply by bringing more units on-line. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Unique treatment systems require unique maintenance procedures including HRC, IFAS, and UV disinfection. UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant butts up against northern property line adjacent to housing units. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling, improved effluent quality and improved aesthetics.
Ability to Phase Implementation	New preliminary, primary, disinfection and sludge processing facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Increased peak capacity may increase solids production slightly. Providing improved screening and grit removal will enhance sludge quality. Thin sludge off of HRC.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as HRC and UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required. Chemical coagulant and polymer for HRC.
	OPCC [1] = $261,400,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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West Side WWTP
205 Bostwick Ave, Bridgeport CT

Scale: 1" = 150'

0 75 150 Feet

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Figure 7.2-12
Alternative W-200B

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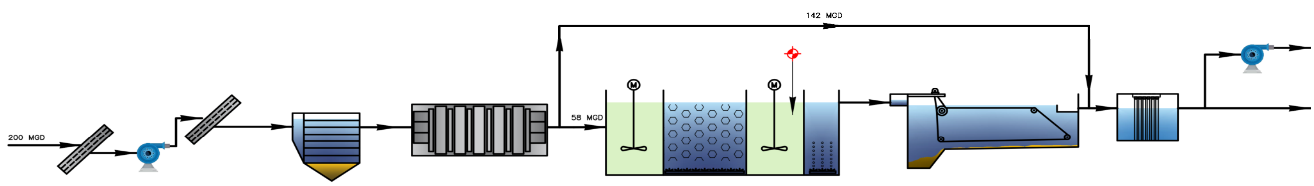
Table 7.2-13
Alternative W200C – 200 MGD, Dual-use Primary Filtration and 4-stage Suspended Growth BNR Treatment with IFAS



A new 200 MGD preliminary treatment facility consisting of four (3 operating, one standby) 1-inch coarse screens, seven influent pumps (6 operating, one standby), five (4 operating, one standby) 1/4-inch fine screens, and five stacked tray grit removal units. Eleven cloth disk filter trains for primary treatment constructed on the north western parcel. Upgrade of the existing bioreactors to a 4-stage suspended growth BNR system with IFAS, new blower/control building and upgrade of the existing secondary clarifiers. New 200 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. New gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. New electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. IFAS has been used to increase the capacity of secondary treatment systems for a number of years. Improved primary and BNR treatment system capacity will enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies, however consumes the northern and north western parcel.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, IFAS, and UV disinfection. However, once operators are trained operation will not be much more complex than existing. Wet weather flows managed simply by bringing more units on-line. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Unique treatment systems require unique maintenance procedures including cloth filters, IFAS, and UV disinfection. Cloth filters and UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. New plant butts up against northern property line adjacent to housing units. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling, improved effluent quality and improved aesthetics.
Ability to Phase Implementation	New preliminary, primary, disinfection and sludge processing facilities could be constructed in first phase and upgrade to the existing bioreactors and secondary clarifiers could be implemented in a second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Increased peak capacity will increase solids production. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased pumping capacity, improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use.) Supplemental carbon to enhance BNR as necessary. If chemical scrubbers employed for odor control, storage of NaOCl and NaOH required.
	OPCC [1] = $257,000,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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Figure 7.2-13
Alternative W-200C

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7.2.4 Detailed Evaluation of Unique Unit Process Alternatives

The unique treatment train unit processes that differ across the liquid treatment train alternatives presented throughout Section 7.2.3 are primary treatment, high flow management, and the biological nutrient removal (secondary treatment, BNR) process. While preferred treatment trains will be evaluated holistically from a plantwide and collection system perspective for each flow rate later in this section, detailed evaluation of individual primary treatment alternatives and BNR alternatives on a non-economic and economic basis is warranted because of the major differences between alternative technologies related to footprint, success at other facilities, ease of operation and maintenance, capital costs, annual operation and maintenance (O&M) costs, present worth costs, etc. This detailed evaluation of unique unit process alternatives will help to develop the preferred alternative for each of the flow rates under consideration.

7.2.4.1 Primary Treatment Alternatives Detailed Evaluation

This section presents the non-economic evaluation of the most viable primary treatment alternatives identified in the previous section: traditional primary settling tanks, cloth media disk filters, and high-rate clarification. The detailed evaluation of unit processes considers both cost and non-economic and economic criteria. Non-economic criteria are based on a number of items, as defined in Section 2 of this report. As presented, economic criteria will carry a weight of 60% and non-economic criteria will carry a weight of 40%.

The results of this non-economic and economic evaluation were used to inform the recommended improvements, summarized at the end of this section.

Primary Treatment Alternatives Non-Economic Evaluation

Section 6 presented descriptions of the various primary treatment alternatives that were considered. **Table 7.2-14** presents the rankings for each of the criteria of the three primary treatment alternatives. As presented in **Section 2**, non-cost factors and the relative importance of those factors vary based on project objectives. A rating of 5 indicates the most favorable rating, while a rating of 1 indicates least favorable, and a rating of 3 indicates that either a criterion is neutral. The weighted score represents the points awarded for criterion based on rating.

The sum of each alternative's weighted scores for each criterion represents the total non-economic weighted score which is out of a total possible 40 points.

Table 7.2-14 Non-Economic Primary Treatment Alternative Rankings

Rating Legend *5= favorable* *3= neutral* *1= unfavorable*	**Alternative Process Description**	**Traditional Primary Settling Tanks**		**Cloth Media Disk Filters**		**High-Rate Clarification**	
	Maximum Score for Criteria	**Rating**	***Weighted Score***	**Rating**	***Weighted Score***	**Rating**	***Weighted Score***
Site Utilization	10	1	*2.0*	5	*10*	5	*10*
Success at Other Installations/ Reliability	8	3	*4.8*	1	*1.6*	3	*4.8*
Neighborhood Impacts	4	1	*0.8*	5	*4.0*	3	*2.4*
Energy Efficiency	4	3	*2.4*	3	*2.4*	1	*0.8*
Ease of Operations	3	3	*1.8*	3	*1.8*	1	*0.6*
Ease of Maintenance	3	3	*1.8*	1	*0.6*	1	*0.6*
Maintenance of Plant Operations	2	5	*2.0*	5	*2.0*	5	*2.0*
Ability to Phase Implementation	2	3	*1.2*	5	*2.0*	3	*1.2*
Sludge Impacts	2	3	*1.2*	3	*1.2*	1	*0.4*
Chemical Handling/Hazards	2	5	*2.0*	3	*1.2*	1	*0.4*
Non-Economic Total Weighted Score	**40**	--	***20***	--	***27***	--	***23***

Table 7.2-15 includes the detailed evaluation used to determine the rankings for each of the alternatives.

Table 7.2-15 Detailed Evaluation of Primary Treatment Alternatives Non-Economic Criteria

Alternative Process Description Non-Economic Criteria	Traditional Primary Settling Tanks	Cloth Media Disk Filters	High-Rate Clarification
Site Utilization	Largest process footprint. Traditional primary tanks would require three times the footprint of the existing tanks and the cloth filtration option, requiring construction on adjacent boat yard parcel. System sized for peak wet weather flows would be largely oversized for average design flows.	Smallest process footprint. "Space-saving" option, allows for improved layout of other facilities and less encroachment onto surrounding properties.	Compact process footprint. Allows for improved layout of other facilities, but would still require expansion onto surrounding properties.
Success at Other Installations/ Reliability	Conventional process used with success at similarly sized facilities to achieve primary treatment when appropriately sized according to industry guidelines.	Cloth media filtration technology proven, but application in primary treatment is still emerging. No existing installations at large-scale CSO facilities comparable to the West Side WWTP. Cloth media is a filter, or a physical barrier that reliably produces high quality effluent which decreases solids washout and reduces load to the downstream BNR process.	Ballasted flocculation technology proven, including CSO applications. Application as traditional primary treatment is emerging. Several existing primary treatment installations at large scale facilities. Higher quality effluent compared to traditional primary settling.
Neighborhood Impacts	New, large, above grade settling tanks would be constructed on adjacent land (north parcel and partial boat yard). Nuisance odors and tank visuals from primary treatment may cause neighborhood disturbance to the north of the plant and south at Captain's Cove area. Covering influent/effluent channels may be warranted.	Rotating filter units are installed in open tanks. Cover system over the tanks or a full building over the tank area would be constructed. Containing odors under covers or within a facility would reduce aesthetic impacts to the surrounding neighborhood. Minimal chemical usage and higher quality effluent are other positive neighborhood impacts.	Cover system over the tanks or a full building over the tank area would be constructed. Containing odors under covers or within a facility would reduce aesthetic impacts to the surrounding neighborhood. Chemical storage and chemical truck deliveries (coagulant, polymer, and microsand ballast) and access roads also required, potentially impacting neighborhood.
Energy Efficiency	New settling tanks would require more sludge/scum collection mechanisms and primary sludge pumps (more motors). New equipment will be more efficient than existing equipment, but energy consumption is likely to increase compared to current operations.	Each filter unit has a filter drive along with a backwash pump and solids wasting pump (20 hp each). Backwash and solids wasting pump operation is intermittent, not continuous.	Fewer overall tanks/units necessary but more energy-intensive compared to other alternatives due to extra mechanical equipment, including coagulation mixers, maturation mixers, sludge scraper mechanisms, sand recirculation pumps, sludge pumps, and chemical feed systems.
Ease of Operations	Operations would be similar to current operations. Main operating components including sludge and scum collection systems and primary sludge pumps will be fully automated.	Individual operating filter units (trains) switch between filtration, backwash, and solids wasting modes automatically through vendor supplied control panel. Filter units are brought on/offline automatically as needed based on plant flow rate. Idle/standby tanks to be drained or kept full with disinfected water when not in use.	Although fully automated, the number of ancillary systems required to operate HRC process adds operational complexity (coagulant feed systems, polymer feed systems, sand recirculation systems, hydrocyclones, sludge pumps, mixers, clarifier drives, and sand replenishment systems). Trains brought on/offline manually or automatically as needed based on plant flow rate - chemical feed started, sand recirculation started. Idle/standby tanks to be kept full with plant water. Idle equipment to be run for 20 minutes every 2 weeks.
Ease of Maintenance	Maintenance similar to what operators currently experience. Main maintenance items are chain/flight sludge collectors, scum collectors, and sludge pumps.	Cloth media needs to be cleaned at regular intervals for several hours to maintain backwash efficiency. Requires soaking cloth media in sodium hypochlorite every 3 mo - 1 yr (depending on FOG accumulation). Replacement of cloth media necessary after 4-7 years, requires 2-3 staff to remove each disc from tank. Routine maintenance of chemical storage/feed equipment, backwash pumps, and sludge pumps. Idle/standby tanks to be drained or kept full with disinfected water when not in use.	More complex system with several chemical feed systems and mechanical components. Routine maintenance of chemical storage/feed equipment, tank mixers/motors, sludge scrapers/motors, sand recirculation pumps and sand hydrocyclone separators, and sludge pumps. Periodic sand replenishment. Idle equipment to be run for 20 minutes every 2 weeks.
Maintenance of Plant Operations	New settling tanks would be constructed on currently open/undeveloped land, no current operations would be interrupted. Primary treatment would be completed as first phase of construction to allow existing primary tank area to be demolished and the area repurposed.	Cloth filter facility would be constructed on currently open/undeveloped land, no current operations would be interrupted. Primary treatment would be completed as first phase of construction to allow existing primary tank area to be demolished and the area repurposed.	High rate clarification facility would be constructed on currently open/undeveloped land, no current operations would be interrupted. Primary treatment would be completed as first phase of construction to allow existing primary tank area to be demolished and the area repurposed.
Ability to Phase Implementation	Potential to phase if plan is to design for a lower flow now and expand flow in future. Potential to build an initial battery and then additional tanks in future.	Potential to phase if plan is to design for a lower flow now and expand flow in future. Potential to build filter tanks in present and add mechanical filter equipment in the future as flows to the WWTP increase. Or potential to add filter tanks/units and add on to/expand the building in the future.	Potential to phase if plan is to design for a lower flow now and expand flow in future. Potential to add trains and add on to/expand the building in the future.
Sludge Impacts	Dry weather and wet weather sludge production rates anticipated to be typical of primary settling tanks sized according to industry guidelines. Greater production at design flows compared to current process as current tanks are undersized and under performing.	Primary sludge production (dry and wet weather flows) would be higher because the process removes more TSS than other alternatives. Increased primary sludge flow rate and volume due to increased flow from backwash, impacting sludge thickening process. Increased sludge production reduces load to secondary processes. Carbon rich sludge has value to disposal facilities for energy production, digestion, incineration.	Primary sludge production (dry and wet weather flows) would be higher due to higher performing process. Thinner sludge generated, would require more intensive processing. Metal-laden sludge would also contain small amounts of microsand ballast that is not separated by the hydrocyclone.
Chemical Handling/Hazards	Process does not require the use of chemicals.	Hypochlorite storage required for routine cleaning of cloth media.	Coagulant, polymer, microsand are required to operate the HRC process. Chemical storage and feed facility/equipment, delivery area, and piping required.

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Traditional Primary Settling Tanks

The major disadvantage with traditional primary tanks is their size. They require substantial footprint in order to maintain acceptable surface overflow rates to achieve adequate settling of solids. While this can be accommodated at some plants, the restricted site footprint at the West Side WWTP presents challenges with this technology. An appropriately sized system for the dry weather peak flow would be approximately twice the footprint of the existing tanks. And a system sized for the minimum peak flow of 90 MGD to function as both dry and wet weather treatment would be even larger, over 300 feet long and 150 feet wide. Coupling tanks this large with other required new processes for preliminary treatment utilizes the majority of the open parcels at the plant and even begins to expand onto the marina property. This siting challenge only gets exacerbated if trying to utilize traditional primary treatment for dual-use dry and wet weather flows at the higher flow of 180 mgd and 200 mgd, with these scenarios likely impossible even with substantial land acquisition, which is likely not available. For this reason, this alternative was assigned an *unfavorable* rating.

Traditional primary settling tanks are the most common alternative for primary treatment found at plants all throughout the country, consisting of large open tanks with minimal operating equipment. It is a simple system that relies only on gravity settling for the removal of sludge, with any floating scum or other solids rising to the surface. The only associated equipment are the sludge and scum collection mechanisms, and the settled sludge pumps to convey solids to the solids processing processes. Traditional primary settling tanks rely solely on sludge settling velocities and do not enhance settling characterizes. For these reasons, this alternative was assigned a *neutral* with respect to success at other installations and reliability.

The large open tanks can also be a major source of odor issues. While the influent and effluent channels can be covered and tied into the odor control system to contain and treat some of the sources, fully covering the tanks is feasible, but very costly and makes access to the tanks difficult. Having such a large odor source, and such a large physical tank structure, in such close proximity to residential neighborhoods and commercial properties could be problematic, which is why it received an *unfavorable* rating.

Traditional primary settling tanks utilize sludge and scum collection mechanisms utilizing small HP motors and primary sludge pumps. There are no specific energy efficient features with traditional primary settling tanks, so it was assigned a *neutral* rating with respect to energy efficiency.

The West Side WWTP currently utilizes traditional primary settling tanks that operations staff would already be familiar with. Traditional primary settling tanks require routine mechanical maintenance of equipment and the mechanical equipment would run in a mostly automatic mode through the plant control system. This alternative was assigned a *neutral* rating for both ease of operations and maintenance criteria.

New settling tanks would be constructed on currently open/undeveloped land, no current operations would be interrupted. Primary treatment would be completed as first phase of construction to allow existing primary tank area to be demolished and the area repurposed. Traditional primary settling tanks were assigned a *favorable* rating for maintenance of plant operations (MOPO).

Primary treatment will be designed for the selected WWTP flow to treat both dry weather and peak wet weather flows. While not a straightforward effort, a traditional primary settling tank process could be built for an initial lower peak flow rate with the potential to construct additional tanks in future to increase treatment capacity. This alternative received a *neutral* rating.

Traditional primary clarification does not utilize any chemicals that would increase sludge production. For this reason, traditional primary clarifiers received a *neutral* rating with respect to sludge impacts. Because there is also no chemical usage associated with the process, which is why it received a *favorable* score with respect to chemical handling/hazards.

Cloth Media Disk Filters

Cloth media filters are a common process in the wastewater industry, with the bulk of their applications as tertiary treatment for advanced nutrient and solids removal. However, they are starting to be utilized more for primary treatment and in some installations as standalone wet weather/CSO treatment. They are a simple filtration process, with wastewater passing through the cloth media, 10 micron for primary applications, and the solid retained on the outside. The filters are periodically backwashed to remove the solids which collect at the bottom of the bank for removal.

The main advantage with cloth media filters is their small footprint. As this a filtering process, large process tanks are not needed to provide for gravity settling. A single filter unit, with a footprint of about 10 feet by 35 feet, with 24 cloth rotating disks could treat up to 11 mgd when operating as a traditional primary clarifier with dry weather flows, and approximately 18 mgd when treating a combined dry/wet weather CSO flow (because of the higher allowable hydraulic loading rate). For comparison purposes, a 90 mgd cloth filter facility, when including space for support pumps and equipment, could have a facility footprint of about 70 feet by 195 feet, compared to a footprint of over 300 feet by 150 feet for 90 mgd traditional primary tanks, less than one third the total area. This becomes very advantageous for the West Side WWTP for the potential 180 and 200 mgd treatment scenarios. Cloth filters facilities sized for these flows are less of a challenge to integrate into the available land area. For this reason, this alternative was assigned a *favorable* rating for site utilization.

The main disadvantage with the cloth media filters is their limited use for primary and CSO treatment. There are only a handful of plants in operation or under construction in the U.S. that utilize cloth media filters for primary, standalone wet weather, or combined influent flows and the largest of these installations is only 168 mgd, smaller than the 180 and 200 mgd scenarios being considered for the West Side WWTP. However, cloth filter technology is a proven successful technology for tertiary filtration. And the cloth media also serves as a physical barrier that filters particulates which makes them a reliable process, potential risk of process upsets, and also will provide better wet weather effluent quality. Despite the advantage of filtration technology, this alternative was assigned an *unfavorable* rating for success at other installations and reliability due to its limited usage.

The cloth filter assemblies are installed in concrete tanks. For protection of the filters, the tanks would have a cover system over them, or would be installed within a building, allowing odors to be controlled, collected and treated. The influent and effluent channels would also be covered or located within the building. The process does not require routine chemical use which eliminates the need for frequent chemical truck deliveries, and also will provide a better wet weather effluent quality. Being able to capture and collect odorous air, reducing chemical deliveries to the plant, and providing a better quality wet weather effluent allows this to have a *favorable* rating for neighborhood impacts.

The cloth filter assembly rotates via a small drive motor. Additionally, each filter/tank also includes a backwash pump (approximately 20 hp) for cleaning the cloth media and also a sludge wasting pump (approximately 20 hp) to remove solids that have settled to the bottom of the tank, but these pumps are not in continuous operation and continuous loads. This option therefore receives a *neutral* rating for energy efficiency.

The cloth filters also do require more ancillary equipment than traditional primary tanks, along with increased maintenance. There are backwash pumps and valve systems to maintain, and the cloth media does require routine cleaning every few months, and then eventually cloth replacement every four to seven years. The system does operate largely in an automatic mode with minimal operator input. This alternative was assigned a *neutral* rating for ease of operation, and an *unfavorable* rating for ease of maintenance.

A new cloth media filter facility would be constructed on currently open/undeveloped land, no current operations would be interrupted. Primary treatment would be completed as first phase of construction to allow existing primary tank area to be demolished and the area repurposed. Cloth media filters were assigned a *favorable* rating for MOPO.

Primary treatment will be designed for the selected WWTP flow to treat both dry weather and peak wet weather flows. The tanks in which the cloth filter assembles are installed are small in comparison to traditional primary tanks and HRC trains. While not a straightforward effort, a filter facility could be built for an initial lower peak flow rate with the potential to construct additional filter tanks in future to increase treatment capacity. Alternatively, spare tanks could be included as part of the initial facility construction with the filter assembly mechanical equipment and associated backwash and sludge pumps added in the future. Therefore, this alternative received a *favorable* rating.

Cloth media filters do not utilize any chemicals as part of the filtration process that would affect sludge composition, however the fine cloth would increase primary sludge production and sizing of downstream solids processing. This increase in primary sludge production has the benefit of reducing the loading to the secondary treatment process. The primary sludge would also be a more carbon rich sludge which has value to disposal facilities for energy production, digestion, incineration. For this reason, cloth media filters received a *neutral* rating with respect to sludge impacts.

The cloth media fabric requires periodic cleaning with a sodium hypochlorite solution, but does not require chemical addition for normal operations, which is why it received a *neutral* score with respect to chemical handling/hazards.

While cloth media filters for primary and CSO treatment is still an emerging application, they will be considered as a viable treatment alternative for the West Side WWTP. Their advantageous small facility footprint would allow for primary treatment of dry and peak wet weather CSO flows for the largest flow scenarios being considered while staying within the available site constraints.

High Rate Clarification

The main benefit with HRC is its compact footprint. With surface overflow rates orders of magnitude greater than traditional primary settling, HRC facilities have footprints that are greatly reduced even when accounting for all the ancillary support equipment. For comparison purposes, a 200 mgd dual use primary/wet weather facility would be one third smaller than a 90 mgd traditional primary system. Similar to the cloth media filter technology, HRC would allow for primary treatment of dry and peak wet weather CSO flows for the largest flow scenarios being considered while staying within the available site constraints. For this reason, this alternative was assigned a *favorable* rating for site utilization.

HRC is a common process in the wastewater industry for applications in wet weather treatment and tertiary treatment for advance nutrient and solids removals, and less common for use in primary treatment. There are installations throughout the country up to flows of 250 mgd for the largest CSO applications. This alternative was assigned a *neutral* rating for success at other installations and reliability.

The HRC system is installed in concrete tanks. The tanks can largely be covered, or more likely the entire process would be installed within a building, allowing odors to be controlled, collected, and treated. The influent and effluent channels would also be covered or located withing the building. The process requires chemical use for normal operation, which will lead to the need for frequent chemical truck deliveries. Being able to capture and collects odorous air, but requiring chemical truck deliveries and truck traffic results in this alternative having a *neutral* rating for neighborhood impacts.

The HRC system has multiple pieces of operating equipment including coagulation and maturation tank mixers, settling tank collector drive, sand recirculation pumps, and chemical metering pumps that are in continuous operation. This option therefore receives an *unfavorable* rating for energy efficiency.

A disadvantage with HRC is the system complexity and increased level of operation and maintenance. There are many operating components in the system including coagulation and maturation tanks mixers, settling tank collectors and drive, tube or lamella plate settlers, ballast/sand recirculation pumps, and sand separation hydro-cyclones, all leading to increased O&M costs. The system also requires chemical use, a metal salt and polymer, to promote the formation of heavy flocs required for rapid settling. This necessitates a sizable ancillary storage facility with multiple tanks and feed pumps. The system does however operate largely in an automatic mode with minimal operator input but would require operator input to bring trains on and offline as flows fluctuate. This alternative was assigned an *unfavorable* rating for ease of operation, and an *unfavorable* rating for ease of maintenance.

A new HRC facility would be constructed on currently open/undeveloped land, no current operations would be interrupted. Primary treatment would be completed as first phase of construction to allow existing primary tank area to be demolished and the area repurposed. HRC was assigned a *favorable* rating for MOPO.

Primary treatment will be designed for the selected WWTP flow to treat both dry weather and peak wet weather flows. While not a straightforward effort, an HRC process could be built for an initial lower peak flow rate with the potential to construct additional system trains in future to increase treatment capacity. This alternative received a *neutral* rating.

HRC utilizes a coagulant, polymer, and sand ballast as part of the rapid settling process that will affect sludge composition and increase primary sludge production. For this reason, cloth media filters received an *unfavorable* rating with respect to sludge impacts and also an *unfavorable* score with respect to chemical handling/hazards.

While a complex system, HRC is considered as a viable treatment alternative for the West Side WWTP. Their advantageous smaller facility footprint would allow for primary treatment of dry and peak wet weather flows, or for standalone treatment of excess CSO flows only in conjunction with an alternate dry weather primary train, for the largest flow scenarios being considered while staying within the available site constraints.

Primary Treatment Non-Economic Evaluation Summary

Cloth media disk filtration received the highest economic score of the three alternatives. Both traditional primary settling tanks and HRC received the same non-economic evaluation. Because non-economic scores for the three technologies were so similar, each of the technologies was brought forward to the economic evaluation.

Primary Treatment Alternative Economic Evaluation

This section presents further evaluation of the primary treatment alternatives on an economic basis, including planning-level cost estimates for capital cost, annual O&M cost, and 20-year life cycle cost.

Economic Evaluation Assumptions

Opinions of probable construction cost (OPCCs) were developed in order to assess the differences in lifecycle costs between the various primary treatment alternatives, and they include contractor's overhead and profit (OH&P), construction contingency, and engineering and implementation. For the purposes of this economic evaluation and technology comparison, the OPCCs reflect each 90 mgd alternative as not all the technologies are feasible for implementation at the higher proposed peak flow rates. The OPCCs established for each alternative include allowances for site remediate and disposal of materials likely to be encountered during construction of the new facilities, based on site investigations previously conducted. The costs also include other site work allowances and demolition.

The following list includes a summary of the major assumptions that were common to each annual O&M estimate. Specific items related to each system are defined later in this section.

- All costs were calculated on an annual average basis, assuming average daily flows.
- All costs associated with chemical addition for high rate clarification are based on 365 days of operation.

- Annual maintenance costs for all new equipment were roughly estimated to be 5% of the equipment cost.

The only primary treatment alternative that requires considerable ancillary consumable storage and feed facilities is the high rate clarification alternative. The cloth media disk filter system only requires a modest amount of sodium hypochlorite for periodic cleaning of the media fabric. **Table 7.2-16** identifies the chemical storage and feed facilities assumed for the high rate clarification facility and where they are assumed to be located. These assumptions were used to develop the opinions of probable cost for the high rate clarification alternative.

Table 7.2-16 Ancillary Facility Assumptions for High Rate Clarification

Primary Treatment Alternative	Ancillary System(s)	Location	Additional Structures/Structure Modifications
High Rate Clarification	Coagulant, Polymer, Microsand (ballast)	Coagulant, polymer and microsand storage and feed systems to be located within the new high rate clarification facility in the NW corner of the site.	New high rate clarification facility to be constructed.

Table 7.2-17 presents the total OPCC for the main components associated with each primary treatment alternative (sized for a maximum flow of 90 mgd) the O&M costs, and the life cycle cost (as present worth). The present worth was calculated using the methodology described in **Section 2**.

Table 7.2-17 Estimated Costs for Primary Treatment Alternatives for 90 mgd

	Traditional Primary Settling Tanks	Cloth Media Disk Filters	High Rate Clarification
Total OPCC	$40,050,000	$34,340,000	$35,950,000
Annual O&M Cost Estimate	$480,000	$680,000	$1,030,000
Present Worth of 20-year Life Cycle Costs	**$35,300,000**	**$38,500,000**	**$47,000,000**

Of the three alternatives, the traditional primary settling tanks were the most costly in terms of OPCC, largely due to amount of concrete required to construct adequately sized primary settling tanks. The OPCCs for cloth media disk filters and high rate clarifiers are similar. The high rate clarification process has the highest estimated O&M costs, due to the number of consumables required to operate the process (coagulant, polymer, and microsand ballast). On a present worth of 20-year life cycle cost comparison, high rate clarification was the greatest. Traditional primary settling tanks and cloth media disk filters have similar present worth costs (<10% difference).

Primary Treatment Alternatives Overall Evaluation

Table 7.2-18 presents the non-economic weighted scores (from Table 7.2-16) and the economic rankings and weighted scores (based on the costs from Table 7.2-17) for the three primary treatment alternatives.

Table 7.2-18 Overall (Economic and Non-Economic) Evaluation of Primary Treatment Alternatives

Criteria	Maximum Score	Traditional Primary Settling Tanks	Cloth Media Disk Filters	High Rate Clarification
Non-Economic				
Weighted Non-Economic Score	40	20	27	23
Economic				
Weighted Economic Score	*60*	60	55	45
Overall Evaluation Score	**100**	**80**	**82**	**68**

The primary cloth filters received the highest non-economic score of the three alternative technologies. Because the traditional primary settling tanks were the lowest cost option on a present worth basis due to low O&M costs, it received the highest economic score. Because they received both highest non-economic and economic evaluation scores, the cloth media disk filters received the highest combined score. Traditional primary settling tanks received the second highest combined score.

Selection of the primary treatment technology needs to take into account this economic and non-economic evaluation, but it also needs look at how the process integrates into the overall treatment plant improvements plan from a holistic standpoint. While the traditional primary settling tank alternative does present some distinct benefits, the sheer size of the process makes this system a significant challenge to site for dry weather flows (58 mgd), and virtually unfeasible to site for the higher dry/wet peak flows up to 200 mgd while also siting other new required treatment processes and facilities within that available footprint.

For these reasons, traditional primary settling is not recommended for implementation at the West Side WWTP, and cloth media disk filtration is the preferred alternative for primary treatment at all flow scenarios. Additional benefits with this system is that it will function as a single, dual-use dry and wet weather process by varying the number of filter units in service, it will produce a quality primary effluent that will reduce the loading on the downstream BNR process, and will produce a better effluent quality when the secondary system is bypassed. It can also be a fully enclosed facility easing maintenance and control odors.

Because cloth media filters are a relatively new technology for use in primary and high flow management applications (cloth media filtration technology has been used successfully for tertiary treatment for over 20 years), an onsite pilot study of the technology should be conducted. The function of the pilot study will be to confirm system performance, confirm the design criteria used in the final design (e.g. hydraulic and solids loading rates), assess percent five day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) removal through the system to aid in the design of the downstream BNR and disinfection systems, and assess system backwash requirements and estimated solids generation rates/quantities to aid the design of the sludge management systems (gravity thickeners).

7.2.4.2 Biological Nutrient Removal Alternatives- Detailed Evaluation

This section presents the non-economic and economic evaluations of the most BNR alternatives identified in the Section 6: conventional four-stage Bardenpho, IFAS, and MBRs. Based on the results of the nutrient removal evaluation, the recommended nutrient removal improvements are summarized at the end of this section.

Biological Nutrient Removal Non-Economic Evaluation

Table 7.2-19 presents the rankings for each of the criteria for the three BNR alternatives. A rating of 5 indicates the most favorable rating, while a ranking of 1 indicates least favorable. The weighted score represents the points awarded for criterion based on rating.

Table 7.2-19 Non-Economic Biological Nutrient Removal Alternative Rankings

Rating Legend *5= favorable* *3= neutral* *1= unfavorable*	Alternative Process Description	Alternative Suspended Growth Activated Sludge Configuration: Four-Stage Bardenpho		Integrated Activated Sludge Process: Integrated Fixed Film Activated Sludge (IFAS)		Membrane Bioreactors (MBRs)	
	Maximum Score for Criteria	Rating	*Weighted Score*	Rating	*Weighted Score*	Rating	*Weighted Score*
Site Utilization	10	1	*2.0*	5	*10*	3	*6.0*
Success at Other Installations/ Reliability	8	3	*4.8*	3	*4.8*	5	*8.0*
Neighborhood Impacts	4	1	*0.8*	5	*4.0*	5	*4.0*
Energy Efficiency	4	3	*2.4*	5	*4.0*	1	*0.8*
Ease of Operations	3	3	*1.8*	5	*3.0*	1	*0.6*
Ease of Maintenance	3	3	*1.8*	5	*3.0*	1	*0.6*
Maintenance of Plant Operations	2	3	*1.2*	1	*0.4*	5	*2.0*
Ability to Phase Implementation	2	3	*1.2*	5	*2.0*	1	*0.4*
Sludge Impacts	2	3	*1.2*	3	*1.2*	1	*0.4*
Chemical Handling/Hazards	2	3	*1.2*	3	*1.2*	1	*0.4*
Non-Economic Total Weighted Score	**40**	--	***18***	--	***34***	--	***22***

Table 7.2-20 includes the detailed evaluation used to determine the rankings for each of the alternatives.

Table 7.2-20 Detailed Evaluation of Biological Nutrient Removal Alternatives Non-Economic Criteria

Alternative Process Description	Alternative Suspended Growth Activated Sludge Configuration	Integrated Activated Sludge Process: Integrated Fixed Film Activated Sludge (IFAS)	Membrane Bioreactors (MBRs)
Non-Economic Criteria	**Four-Stage Bardenpho**	**Kruger AnoxKaldnes**	**Suez ZeeWeed**
Site Utilization	Largest process footprint. Requires additional BNR tankage in addition to existing BNR basins. The existing primary settling tanks are required for repurposing into pre-anoxic volume and a new West Battery of aeration tanks to be constructed in the boat yard is required to achieve process volume.	Smallest process footprint. Can be implemented within the existing BNR basins. IFAS would not require the construction of any additional tankage nor large, supporting facilities.	New post-anoxic tanks need to be constructed in addition to the new MBR facility on site. New facilities cannot be built in the footprint of the existing secondary clarifiers because the secondary clarifiers must remain operational until the MBR facility is fully operational.
Success at Other Installations/ Reliability	Common process used at large-scale BNR facilities to achieve nitrogen removal. Fully conventional, suspended growth activated sludge process performance is largely susceptible to cold temperatures and changing flow and loading conditions, which can negatively impact effluent quality.	Technology has been successfully implemented at other large-scale BNR facilities. There have been numerous process upsets related to media loss, but Kruger has made process design adjustments to minimize process upsets. Including attached growth with suspended growth promotes a more robust system less susceptible to process upsets.	System has been successfully implemented at other large-scale facilities. The process relies on physical separation (ultrafiltration) which reliably produces high quality effluent, minimizing potential process upsets.
Neighborhood Impacts	The new West Battery of BNR basins is to be constructed in the boat yard, which is in close proximity to a restaurant. Exposed aeration tanks abutting this public space leaves the area susceptible to unappealing aesthetic conditions and odors during process upset conditions.	The process can be implemented within the existing BNR tankage, which should not negatively impact the surrounding neighborhood.	The MBR facility and post anoxic tanks can be located within the existing property line, so there is no additional site requirements associated with the MBR BNR alternative. Additionally, the MBR facility will eliminate the need for the large secondary clarifiers (large, open tanks abutting the boat yard).
Energy Efficiency	The construction of an additional BNR basin requires more mixing energy, pumping energy, and aeration energy compared to the existing MLE process.	IFAS is the least energy-intensive process of the BNR alternatives evaluated.	Most energy intensive process evaluated. MBRs are not considered to be a sustainable process due to the continuous permeate pumping required along with high recycle flow (RAS) pumping rates (5X the design ADF).
Ease of Operations	A second battery of BNR basins to be operated in parallel to the existing BNR basins increases operational complexity. Although it is a conventional activated sludge process, operating two basins on opposite sides of the site of dissimilar geometry (e.g. number of trains) increases operational complexity and flow splitting challenges.	There would be no increase in operational complexity compared to operating the existing MLE process.	The three-stage activated sludge process would be no more operationally intensive than the current operating MLE system. However, operating the MBR system will be more complex than conventional, secondary clarifiers.
Ease of Maintenance	Three additional BNR basins requires more aeration piping, fine bubble diffusers, control valves, instrumentation, IR pumps, RAS pumps, mixers and long stretches of carbon feed piping that require routine mechanical maintenance. This alternative also requires a deep distribution box equipped with a large submersible mixer and motor-actuated gates which will also require routine mechanical maintenance.	Process includes most of the equipment currently used in the plant's MLE process; submersible IR pumps and mixers. New media retention screens used to keep plastic media within dedicated zones is routinely cleaned with automated air sparge systems. The process utilizes coarse/medium bubble aeration which requires less frequent maintenance compared to fine bubble diffused aeration.	A three-stage activated sludge process (submersible mixers, IR pumps, aeration equipment, and instrumentation) will require routine mechanical maintenance, in addition to the equipment that makes up the MBR system, itself. MBRs require routine chemical cleanings: maintenance cleanings twice per week with sodium hypochlorite (200 mg/L dose) and once per week with citric acid (2,000 mg/L) dose. Mechanical equipment requiring routine mechanical maintenance include air scour blowers, permeate pumps, WAS pumps, and large RAS pumps.
Maintenance of Plant Operations	The distribution box and new West Battery can be constructed in the boat yard without disrupting plant operations. Primary treatment must be accomplished elsewhere on site before the existing primary clarifiers can be converted to pre-anoxic zones for the East Battery. A complex hydraulic structure used to join and condition flow from the West and East Battery's upstream of the existing secondary clarifiers will be difficult to construct while keeping the secondary clarifiers operational.	To minimize hydraulic flux through the process, IFAS manufacturer needs to eliminate the horseshoe flow path through the existing BNR basins and needs to utilize the channel currently used for step feed operation as the BNR influent channel. Because the internals of the BNR basins need to be completely demolished, two basins will need to be offline at a time because each pair of basins is tied to a secondary clarifier. One BNR basin's internals will be demolished as the second BNR basin is being upgraded with the IFAS system.	New post-anoxic tanks and MBR facility are to be built onsite when existing facilities are demolished and space becomes available. The existing MLE process should undergo basic mechanical upgrades, but does not require substantial modifications be made to the BNR basins, themselves. When the post-anoxic tanks and MBR facility is constructed, flow can be diverted from the MLE process without disrupting other plant operations.
Ability to Phase Implementation	Converting primary clarifiers to pre-anoxic volume will immediately increase nitrogen removal through the existing process. It is also possible to construct the new BNR basins in the West Side Battery one basin at a time, as loads to the secondary system increase. If the West battery is constructed one basin at a time, flow split through the distribution box will become more complex.	With reconfiguration of existing BNR basins complete, vendor can fill IFAS zones to lesser fraction of media and increase fill fraction as flows and loads increase.	Existing MLE process requires post anoxic tanks to convert to the three stage process upstream of MBRs. Because MBRs are a clarification process, they are sized primarily based on hydraulics. Because the secondary system's existing capacity of 58 mgd will be maintained, there is no way to phase MBR implementation.
Sludge Impacts	Overall process improvement with respect to nitrogen removal should improve thickening characteristics due to decreasing the amounts of filamentous bacteria present in the current activated sludge. Despite better settling characteristics, it is not anticipated that sludge production would decrease.	Properly configured pre-anoxic zone should reduce filamentous bacteria growth currently observed in the WWTP's existing MLE process. Attached growth biofilm that sloughs off of the plastic media carriers typically results in improved settling characteristics compared to traditional suspended growth (only) activated sludge processes.	Because MBRs reduce effluent TSS levels to single-digits, more TSS will be removed from the process which will increase sludge production.
Chemical Handling/Hazards	Magnesium hydroxide would be required to maintain neutral pH in primary effluent, which would replace the existing sodium hydroxide system. Supplemental carbon may be required during certain times of the year to drive denitrification through winter months.	Magnesium hydroxide would be required to maintain neutral pH in primary effluent, which would replace the existing sodium hydroxide system. Supplemental carbon may be required during certain times of the year to drive denitrification through winter months.	Magnesium hydroxide would be required to maintain neutral pH in primary effluent, which would replace the existing sodium hydroxide system. Supplemental carbon may be required during certain times of the year to drive denitrification through winter months. Preliminary design data indicates that membrane cleanings would require 27,100 gallons/year of sodium hypochlorite and 21,700 gallons/year of citric acid.

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Four-Stage Bardenpho

The four-stage Bardenpho process is a completely conventional suspended growth activated sludge process that requires the largest volume of additional tankage to be constructed to accomplish treatment objectives. This alternative requires the construction of a West Battery that can only fit in the footprint of the land currently occupied by the boat yard. It also requires the construction of a distribution box to split primary effluent flow between the new West Battery and the existing East Battery. To reconfigure the East Battery, the primary settling tanks must be converted to pre-anoxic volume. Because of the large footprint associated with this conventional process, this was assigned an *unfavorable* rating for site utilization.

The four-stage Bardenpho process is a common process used at BNR facilities of all sizes to achieve nitrogen removal. The process is a conventional, suspended growth activated sludge process. Process performance is susceptible to changing flows, loads, and temperatures. Nitrogen removal is particularly susceptible to fluctuating temperatures, like the cold winter temperatures experienced throughout New England. This alternative was assigned a *neutral* for the first criterion.

The new West Battery of BNR basins is to be constructed in the boat yard, which is adjacent to the marina and a restaurant. This alternative more than doubles the amount of exposed process tankage compared to the existing WWTP. Exposed aeration tanks abutting this public space leaves the area susceptible to unappealing aesthetic conditions during process upset conditions. This alternative received an *unfavorable* rating with respect to neighborhood impacts.

The second battery of BNR basins will increase pumping, mixing, and aerating energy consumption. The construction of a deep distribution box will need to be continuously mixed by a large mixer. Because of this, it was assigned a *neutral* rating for energy efficiency.

A second battery of BNR basins to be operated in parallel to the existing BNR basins will increase operational complexity. Although it is a conventional activated sludge process, operating two batteries on opposite sides of the site of dissimilar geometry (e.g. number of trains) increases operational complexity. Because of these reasons, this alternative was awarded a *neutral* rating with respect to ease of operations.

With the construction of the new West Battery, there will be more mixers, IR pumps, RAS pumps, large fine bubble aeration grids with diffusers, two sets of aeration piping and instrumentation that will all require routine mechanical maintenance. In addition to the new equipment associated with the new West Battery, a deep distribution box required to split primary effluent flow to the West or East Batteries will have a large hyperbolic mixer and motor-actuated gates that will require routine mechanical maintenance. For these reasons, the four-stage Bardenpho as assigned a *neutral* rating with respect to ease of maintenance.

The distribution box and new West Battery can be constructed offsite, in the footprint of the existing boat yard without disrupting current plant operations. Before the existing primary settling tanks are converted to pre-anoxic zones for the East Battery, primary clarification must be achieved elsewhere on site. A complex hydraulic structure will need to be constructed that will co-mingle and condition flow from each BNR battery upstream of the existing secondary clarifiers. Constructing this structure would be challenging while keeping all three clarifiers operational. The four-stage Bardenpho process was awarded *neutral* with respect to maintenance of plant operations.

Converting primary clarifiers to pre-anoxic volume will immediately increase nitrogen removal through the existing process. It is also possible to construct the new BNR basins in the West Side Battery one basin at a time, as loads to the secondary system increase. If the West battery is constructed one basin at a time, flow split through the distribution box would become more complex. The four-stage Bardenpho received a *neutral* rating with respect to ability to phase implantation.

Properly configured pre-anoxic zones should improve sludge settling characteristics compared to the present-day configuration of the Modified Ludzack Ettinger (MLE) configuration. Despite improvement in sludge settling characteristics, it is not anticipated that sludge production will reduce significantly. This alternative received a *neutral* rating with respect to sludge impacts.

The four-stage process will require supplemental alkalinity to maintain neutral pH in primary effluent, which would replace the existing sodium hydroxide system. In addition to supplemental alkalinity, provisions for supplemental carbon addition will be supplied to be used throughout certain times of the year to increase denitrification. This alternative received a *neutral* rating with respect to chemical handling/hazards.

AnoxKaldnes IFAS

The IFAS process was developed to intensify biological processes and can be implemented within the existing BNR basins on site and has the smallest process footprint of the alternatives evaluated. It does not require the construction of any additional tankage nor large supporting facilities, and thus it was assigned a *favorable* rating for site utilization.

IFAS has been successfully implemented at other large-scale facilities throughout the country, notably, similarly sized Fields Point Plant owned and operated by the Narragansett Bay Commission which achieves very low nitrogen limits (<5 mg/L) throughout the year. There have been numerous IFAS process upsets reported throughout the country related to media loss. As a leader in IFAS technology, Kruger has implemented added safety precautions into the current design to reduce the risk of media loss through the system (notably by minimizing hydraulic flux through the IFAS reactors). IFAS combines conventional suspended growth activated sludge with fixed-film activated sludge which intensifies secondary treatment and is considered to be a more robust process compared to conventional suspended growth (only) activated sludge processes. Because of these reasons, IFAS received a *neutral* rating with regards to success at other installations and reliability.

IFAS can be implemented within the existing BNR basins, which should not negatively impact the surrounding neighborhoods, nor public spaces. For this reason, IFAS was awarded a *favorable* rating for neighborhood impacts.

The IFAS alternative was determined to be the least energy intensive process of the evaluated alternatives. Because of this, the IFAS system was awarded a *favorable* rating with respect to energy efficiency.

The process will be fully automated and should require the least amount of operator attention compared to other alternatives. Operators at the Narragansett Bay Commission's Fields Point noted that the system is easy to operate. For this reason, the IFAS technology was awarded a *favorable* for the ease of operations criterion.

The IFAS process consists of similar equipment currently used in the existing MLE process including submersible internal recycle (IR) pumps and mixers. The IFAS process does include new media retention screens that are used to keep the IFAS plastic media within the dedicated IFAS zones. The IFAS process utilizes medium or coarse bubble aeration, which is simpler to maintain, compared to fine bubble diffused aeration which requires routine membrane cleaning and replacement. For those reasons, the IFAS process was awarded a *favorable* rating for ease of maintenance.

Kruger requires substantial modifications to the existing BNR basins be completed to create the most robust IFAS design. Kruger needs to eliminate the horseshoe pattern through the existing BNR basins, in order to minimize the hydraulic flux through the process to eliminate the risk for media carryover towards media retention screens. To accomplish this, the channel currently used during step feed operations shall become the BNR influent channel. Internal baffle and partitioning walls within each BNR basin require demolition Two basins should be taken offline during construction, since each pair of BNR basins is tied to a secondary clarifier, which would temporarily reduce secondary treatment to 66 percent. When a pair of BNR basins is offline, mechanical upgrades can be completed in the dedicated secondary clarifier. One BNR basin will be being demolished as the second basin is being constructed. Temporary piping from primary treatment and bulkheads installed to isolate portions of the influent/effluent channel will be required to maintain secondary treatment throughout construction. Because of the complexity of construction sequencing required to implement the IFAS system, it received an *unfavorable* rating with regards to maintenance of plant operations.

Upon reconfiguration of the existing BNR basins, the vendor can fill the IFAS zones to a lesser fill fraction of media to treat present day loads and can add media as required in the future to maximize biological treatment. Because of this flexibility, IFAS was awarded a *favorable* rating with respect to process flexibility and ability to phase implementation.

The process will produce similar sludge quantities to the conventional activated sludge process. A newly configured pre-anoxic zone should improve sludge settling characteristics compared to the current pre-anoxic zone configuration of the MLE system. It has been documented that the sludge produced from IFAS process can exhibit better settling characteristics (SVI) compared to sludge from conventional plants, likely attributed to extracellular polymeric substances (EPS) within attached growth biofilms that regularly slough off the plastic media carriers. IFAS received a *neutral* rating with respect to sludge impacts.

Like the four-stage Bardenpho process, IFAS may require supplemental carbon to increase denitrification during certain periods throughout the year and will require alkalinity addition/pH adjustment with magnesium hydroxide to primary effluent. This alternative received a *neutral* rating with respect to chemical handling/hazards.

Membrane Bioreactors (MBRs)

The MBR alternative requires the construction of new post-anoxic tanks and a large MBR facility. The MBR facility needs to be constructed outside of the footprint of the existing secondary clarifiers because those clarifiers need to remain operational until the MBR facility is brought online. Because the MBR replaces the function of the secondary clarifiers, it allows the secondary clarifiers to be demolished when the MBR system is fully functional, which frees up appreciable space for other unit processes. Because of these reasons, it was assigned a *neutral* rating with respect to site utilization.

MBR technology has been implemented at many similarly sized WWTPs throughout the world. MBRs rely on ultrafiltration to remove particles from the wastewater, thereby discharging a very high-quality effluent with low effluent TSS, and low effluent particulate and colloidal nitrogen. For these reasons, MBRs have been used to achieve very low effluent nitrogen concentrations. MBRs are a physical barrier which filter particulates which makes them a reliable process and reduces risk of process upsets. Because of this, MBRs received a *favorable* rating with respect to success at other installations and reliability.

The MBR facility and post anoxic tanks can be located within the existing property line, so there is no additional site requirements associated with the MBR BNR alternative. Additionally, the MBR facility will eliminate the need for the large secondary clarifiers (large, open tanks abutting the boat yard). Because the process will be mostly enclosed, the MBR alternative as assigned a *favorable* with respect to neighborhood impacts.

MBR technology was determined to be the least energy efficient BNR process. MBRs are not considered to be a sustainable technology because of the energy required to operate the process. Continuous permeate pumping is required along with high recycle flow (RAS) rates. Because of these energy intensive items, MBRs received an *unfavorable* rating with respect to energy efficiency.

The MBR system will need to be operated in addition to the three-stage activated sludge process located upstream of the MBRs. This increases operational complexity, since operating a MBRs system is far more complex than operating conventional secondary clarifiers. For this reason, MBRs were assigned an *unfavorable* rating with respect to ease of operations.

MBRs require substantial maintenance. In addition to the MBR facilities, the three-stage activated sludge process upstream of the MBRs have mechanical equipment that will need to be maintained. MBRs require routine (twice per week) sodium hypochlorite cleanings (200 mg/L dose) to reduce biofouling through the membrane and periodically (once per week) require soaks in citric acid (2,000 mg/L) to increase flux through the membranes. In addition to the routine cleanings, the automated air scour blower systems that will be used to keep the membranes clean and aerate the system is another aeration system to maintain. Because RAS rates with MBR systems are so high (500% of forward flow), large RAS pumping system will require routine mechanical maintenance. Other pieces of equipment that require routine mechanical maintenance (specific to the MBR system, itself) include permeate pumps, WAS pumps, and chemical feed systems. For these reasons, the MBR was assigned an *unfavorable* rating with respect to ease of maintenance.

The MBR facility and post-anoxic tanks can be constructed as land becomes available after demolishing existing facilities. The MBR will need to be fully operational before the secondary clarifiers are decommissioned and demolished. The existing MLE configuration will go through general mechanical upgrades but does not require substantial modifications to the existing tankage. When the MBR facility and post-anoxic tanks are constructed, flow can be diverted from the MLE process to the new facilities. Because of the ease of construction sequencing without needing to take processes offline, the MBR alternative received a *favorable* rating with respect to maintenance of plant operations.

As a clarification process, MBRs are designed to treat hydraulic flows. Because the secondary system's capacity will be maintained at existing 58 mgd capacity, there will be no additional flow to treat under future conditions, and no way to phase MBR implementation. For this reason, MBRs received an *unfavorable* rating for phased implementation.

Because MBRs reduce effluent TSS to low, single-digit concentrations, more TSS will be consistently removed throughout the year, which will result in increased sludge production. Because of this, it received an *unfavorable* rating with regards to sludge impacts.

MBRs require routine chemical cleanings with sodium hypochlorite and citric acid to reduce biofouling and increase flux through the membranes themselves. In addition to the chemicals associated with the MBRs, the three-stage process upstream of the membranes will require supplemental alkalinity addition for pH adjustment with magnesium hydroxide and supplemental carbon addition to increase denitrification throughout certain times of the year. MBRs received an *unfavorable* rating with respect to chemical handling/hazards.

Biological Nutrient Removal Non-Economic Evaluation Summary

The IFAS system received the highest non-economic rating of the three alternatives. Despite it receiving the highest non-economic rating, all three alternatives were brought forward to be evaluated on an economic basis.

Biological Nutrient Removal Economic Evaluation

This section presents further evaluation of the nitrogen removal alternatives on an economic basis, including planning-level cost estimates for capital cost, annual O&M cost, and 20-year life cycle cost.

Economic Evaluation Assumptions

OPCCs were developed in order to assess the differences in lifecycle costs between the various alternative, and they include OH&P, construction contingency and engineering and implementation. The OPCCs established for each alternative include allowances for site remediation and disposal of materials likely to be encountered during construction of the new facilities, based on site investigations previously conducted. The costs also include other site work allowances and demolition.

The following list includes a summary of the major assumptions that were common to each annual O&M estimate. Specific items related to each system are defined later in this section.

- All costs were calculated on an annual average basis, using average daily flow.

- All costs associated with chemical addition for nitrogen removal and the add-on nitrogen removal alternative are based on 365 days of operation.
- All costs associated with the BNR tank operation (mixers) are assumed to apply 365 days per year.
- Annual maintenance costs for all new equipment were roughly estimated to be 5% of the equipment cost.

Table 7.2-21 identifies the chemical storage and feed facilities assumed for each alternative and where they are assumed to be located. Any additional structures or major structure modifications required for each alternative are also identified. These assumptions were used to develop the opinions of probable cost for each nutrient removal alternative.

Table 7.2-21 Ancillary Facility Assumptions for Biological Nutrient Removal Alternatives

BNR Alternative	Ancillary Systems	Location	Additional Structures/Structure Modifications
Four-Stage Bardenpho	MicroC 2000, Magnesium Hydroxide	Supplemental carbon storage tanks located outside of Blower Building, supplemental alkalinity storage tanks to be located within Blower Building along with carbon and alkalinity feed systems, north of existing BNR Basin #1	Primary effluent distribution box; West Battery of BNR basins, flow conditioning structure in FST influent channels
Integrated Fixed Film Activated Sludge (IFAS)	MicroC 2000, Magnesium Hydroxide	Supplemental carbon storage tanks located outside of Blower Building, supplemental alkalinity storage tanks to be located within Blower Building along with carbon and alkalinity feed systems, north of existing BNR Basin #1	Eliminate BNR internal baffle walls and reinforce channel currently used during step feed operation
Membrane Bioreactors	MicroC 2000, Magnesium Hydroxide, Citric Acid, Sodium Hypochlorite	Supplemental carbon storage tanks located outside of Blower Building, supplemental alkalinity storage tanks to be located within Blower Building along with carbon and alkalinity feed systems, north of existing BNR Basin #1; citric acid and sodium hypochlorite storage and feed equipment located in new MBR facility	New post-anoxic tanks, MBR facility to be constructed

Table 7.2-22 presents the total OPCC for the main components associated with each nitrogen removal alternative, the O&M costs, and the life cycle cost (as present worth). The present worth was calculated using the methodology described in **Section 2**.

Table 7.2-22 Estimated Costs for Biological Nutrient Removal Alternatives

	Alternative Suspended Growth Activated Sludge Configuration	Integrated Activated Sludge Process: Integrated Fixed Film Activated Sludge (IFAS)	Membrane Bioreactors (MBRs)
	Four-Stage Bardenpho	Kruger AnoxKaldnes	Suez ZeeWeed
Total OPCC	$57,540,000	$44,380,000	$81,230,000
Annual O&M Cost Estimate	$2,220,000	$2,140,000	$4,130,000
Present Worth of 20-year Life Cycle Costs	**$81,900,000**	**$76,800,000**	**$146,100,000**

The MBR alternative had a substantially higher OPCC and annual O&M costs compared to the other two alternatives. The annual O&M estimated costs for the four-stage Bardenpho and IFAS systems are similar. Similarly, the present worth of the four-stage Bardenpho and IFAS system are relatively similar but on a life cycle cost basis, the IFAS systems is the least costly.

Biological Nutrient Removal Alternatives Overall Evaluation

Table 7.2-23 presents the non-economic weighted scores (from Table 7.2-16) and the economic rankings and weighted scores (based on the costs from Table 7.2-17) for the three biological nutrient removal alternatives.

Table 7.2-23 Overall (Economic and Non-Economic) Evaluation of Biological Nutrient Removal Alternatives

Criteria	Maximum Score	Alternative Suspended Growth Activated Sludge Configuration	Integrated Activated Sludge Process: Integrated Fixed Film Activated Sludge (IFAS)	Membrane Bioreactors (MBRs)
		Four-Stage Bardenpho	Kruger AnoxKaldnes	Suez ZeeWeed
Non-Economic				
Weighted Non-Economic Score	40	18	34	23
Economic				
Weighted Economic Score	*60*	56	60	33
Overall Evaluation Score	**100**	**74**	**94**	**56**

The IFAS alternative received the highest non-economic score due to a combination of site utilization and neighborhood impacts, energy efficiency, ease of operations, ease of maintenance, and ability to phase implementation. The IFAS alternative also received the highest economic score due to the lowest present worth of 20-year life cycle costs. The IFAS system received an overall evaluation score of 94 out of 100. Thus, implementation of the IFAS system (with continued use of the existing secondary clarifiers) is recommended to ensure permit compliance with the current annual effluent nitrogen loading permit.

7.2.5 Summary and Recommendation

Treatment summaries, conceptual layouts, and OPCCs for each of the West Side WWTP alternatives were presented in Table 7.2-1 though Table 7.2-13 and Figure 7.2-1 through Figure 7.2-13. A complete cost summary included as **Table 7.2-24** presents the OPCCs for all the West Side WWTP alternatives. This table breaks the total construction cost into individual work areas, and adds engineering, contingency and land acquisition to arrive at a total project cost. All costs are in 2020 dollars and do not include escalation to the midpoint of construction.

Of the unique unit processes evaluated, cloth filtration was determined to be the most preferred primary/wet weather treatment technologies because of their compact size. Similarly, IFAS was determined to be the most preferred BNR alternative.

Of the four 90 mgd treatment options, Option W-90B, is the preferred option from the combined cost and non-cost criterion. The option has the lowest cost and includes both preferred primary treatment and BNR alternatives. Despite cloth disk filtration being relatively new for primary and wet weather treatment applications, the saving in real estate enables the system to be constructed within the footprint of the existing plant.

The 140 mgd option has been eliminated from consideration as the 180 mgd options offer improved benefits for a similar cost.

Of the five 180 mgd treatment options, Option W-180D, is the preferred option from the combined cost and non-cost criterion. The option is the lowest cost, and again, although the cloth disk filtration technology is new to primary treatment and wet weather treatment applications, the saving in real estate enables the system to be constructed within the footprint of the existing plant. Similarly, Option W-200C is the preferred option which represents the same treatment train as W-180D, but increased capacity of preliminary, primary, disinfection, and effluent pumping systems.

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Table 7.2-24: West Side WWTP - Preliminary Construction Costs

Item	90 MGD				140 MGD	180 MGD					200 MGD		
	W-90A	W-90B	W-90C	W-90D	W-140A	W-180A	W-180B	W-180C	W-180D	W-180E	W-200A	W-200B	W-200C
	Trad. Primary & 4 Stage	Dual Use Primary Filter & IFAS	Dual Use Primary Filter & MBR	Trad. Primary & 4 Stage (Alt.)	Trad. Primary & MBR	Primary Filter, HRC & IFAS	Dual Use Primary Filter & MBR	Trad. Primary, Trad. 4-Stage, HRC	Dual Use Primary Filter & IFAS	Trad Primary, IFAS, & HRC	Dual Use HRC, IFAS, UV & Cl2 Dis.	Dual Use HRC, IFAS, 200 MGD UV	Dual Use Pri. Filter, IFAS, 200 MGD UV
Site Work & Yard Piping	$ 22,700,000	$ 22,500,000	$ 25,100,000	$ 22,700,000	$ 24,100,000	$ 22,000,000	$ 22,200,000	$ 23,700,000	$ 22,900,000	$ 23,600,000	$ 22,800,000	$ 22,900,000	$ 22,900,000
Demolition	$ 5,000,000	$ 6,300,000	$ 9,600,000	$ 5,000,000	$ 6,300,000	$ 6,300,000	$ 9,600,000	$ 5,000,000	$ 6,300,000	$ 6,300,000	$ 6,300,000	$ 6,300,000	$ 6,300,000
Headworks	$ 36,200,000	$ 36,200,000	$ 36,200,000	$ 36,200,000	$ 52,400,000	$ 58,600,000	$ 58,600,000	$ 58,600,000	$ 58,600,000	$ 58,600,000	$ 65,100,000	$ 65,100,000	$ 65,200,000
Primary Treatment	$ 32,800,000	$ 28,200,000	$ 28,200,000	$ 32,800,000	$ 26,500,000	$ 26,500,000	$ 38,100,000	$ 23,200,000	$ 38,100,000	$ 23,200,000	$ 47,200,000	$ 47,200,000	$ 42,900,000
Wet Weather Treatment	$ -	$ -	$ -	$ -	$ 2,200,000	$ 27,300,000	$ -	$ 27,300,000	$ -	$ 27,300,000	$ -	$ -	$ -
BNR	$ 41,000,000	$ 30,200,000	$ 21,900,000	$ 41,000,000	$ 21,900,000	$ 30,200,000	$ 14,000,000	$ 41,000,000	$ 30,200,000	$ 30,200,000	$ 30,200,000	$ 30,200,000	$ 30,200,000
Final Settling	$ 6,300,000	$ 6,300,000	$ 52,600,000	$ 6,300,000	$ 52,600,000	$ 6,300,000	$ 52,600,000	$ 6,300,000	$ 6,300,000	$ 6,300,000	$ 6,300,000	$ 6,300,000	$ 6,300,000
Disinfection	$ 8,000,000	$ 8,000,000	$ 8,000,000	$ 8,000,000	$ 8,400,000	$ 13,700,000	$ 13,700,000	$ 13,700,000	$ 13,700,000	$ 13,700,000	$ 14,800,000	$ 15,000,000	$ 15,000,000
Effluent Pumping Station	$ 7,500,000	$ 7,500,000	$ 7,500,000	$ 7,500,000	$ 9,700,000	$ 10,000,000	$ 10,000,000	$ 10,000,000	$ 10,000,000	$ 10,000,000	$ 11,200,000	$ 11,200,000	$ 11,200,000
Solids Processing	$ 27,700,000	$ 27,700,000	$ 27,700,000	$ 27,700,000	$ 24,600,000	$ 27,700,000	$ 27,700,000	$ 27,700,000	$ 27,700,000	$ 27,700,000	$ 27,700,000	$ 27,700,000	$ 27,700,000
Odor Control	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000	$ 5,300,000
Site Electrical	$ 12,100,000	$ 12,100,000	$ 12,100,000	$ 12,100,000	$ 14,700,000	$ 14,700,000	$ 14,700,000	$ 14,700,000	$ 14,700,000	$ 14,700,000	$ 14,700,000	$ 14,700,000	$ 14,700,000
Control Building	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000	$ 9,500,000
Total Construction Cost	$ 214,100,000	$ 199,800,000	$ 243,700,000	$ 214,100,000	$ 258,200,000	$ 258,100,000	$ 276,000,000	$ 266,000,000	$ 243,300,000	$ 256,400,000	$ 261,100,000	$ 261,400,000	$ 257,000,000
Engineering (Des. & Const. Svcs.) (22%)	$ 47,100,000	$ 43,900,000	$ 53,600,000	$ 47,100,000	$ 56,800,000	$ 56,800,000	$ 60,700,000	$ 58,500,000	$ 53,500,000	$ 56,400,000	$ 57,400,000	$ 57,500,000	$ 56,500,000
Overall Project Contingency (10%)	$ 21,400,000	$ 20,000,000	$ 24,400,000	$ 21,400,000	$ 25,800,000	$ 25,800,000	$ 27,600,000	$ 26,600,000	$ 24,300,000	$ 25,600,000	$ 26,100,000	$ 26,100,000	$ 25,700,000
Land Acquisition, Easements, ROW	$ 500,000	$ -	$ -	$ 500,000	$ -	$ 250,000	$ 250,000	$ 500,000	$ -	$ 250,000	$ 250,000	$ 250,000	$ 250,000
Total Project Cost (Rounded)	$ 283,000,000	$ 264,000,000	$ 322,000,000	$ 283,000,000	$ 341,000,000	$ 341,000,000	$ 365,000,000	$ 352,000,000	$ 321,000,000	$ 339,000,000	$ 345,000,000	$ 345,000,000	$ 339,000,000

Notes

- Costs in 2020 Dollars
- Costs do not include escalation to the midpoint of construction
- Overall Project Contingency carried is 10%. Typical contingency ranges from 10% to 25%.

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7.3 East Side Wastewater Treatment Plant

For the East Side WWTP two peak flow scenarios were assessed and a total of eight different liquid treatment trains:

- Four (4) – 40 mgd treatment train options (the current peak flow of the existing facility),
- Four (4) – 80 mgd treatment train option (doubling the current peak capacity and providing significant CSO reductions),

As described previously, the East Side WWTP current average daily flow is 5.7 mgd. The facility is designed to treat up to 24 mgd through the secondary treatment system. Flow in excess of 24 mgd, up to 40 mgd, is treated through primary treatment and disinfected prior to discharge. Today it appears that flow to the East Side plant is controlled to a peak of about 35 mgd by throttling the influent gates. For the scenarios evaluated, we have maintained the maximum day design flow through the secondary treatment system at 24 mgd. For the 40 mgd options the preliminary treatment systems (pumping, screening and grit removal), the primary treatment system and disinfection are designed for a peak flow of 40 mgd. For the 80 mgd options the preliminary treatment systems (pumping, screening and grit removal), the primary treatment system and disinfection are designed for a peak flow of 80 mgd, unless a separate wet weather treatment system is incorporated, in which case the wet weather treatment system and associated disinfection is designed for 40 mgd, to supplement the dry weather system also designed to treat 40 mgd.

The eight alternative liquid treatment trains include a combination of unit processes common to each alternative and unique processes that vary across alternatives.

7.3.1 Common Treatment Train Unit Processes

For each treatment train, a few unit processes remain consistent in all treatment trains including, a new headworks facility consisting of coarse screens, influent pumping, fine screens and stacked tray grit removal; and ultraviolet disinfection for all secondary effluent, and often for all flow, with effluent pumping. In addition, sludge management includes gravity thickening of primary sludge, rotary drum thickening of waste activated sludge, thickened sludge storage with thickened sludge hauled off-site for disposal.

Headworks. For each East Side WWTP alternative, flow is redirected to a new headworks facility through a new 54-inch sewer line. The new headworks is similar for the two flow schemes consisting of multi-rake 1-inch opening coarse screens ahead of the new influent pumps. New centrifugal pumps would draw from a trench-style wet well and pump up to new multi-rake fine screens with ¼-inch openings. Washer compactors would be provided for both the coarse screens and fine screens and discharge to a roll-off container located at grade within the new building. Screened flow would then pass to the stacked tray (Headcell) grit removal system, each with a duty and standby grit pump. Collected grit would be conveyed to a grit washer for discharge to a roll-off container located within the building.

Disinfection and Effluent Pumping. For each East Side WWTP alternative disinfection would be provided through a UV system. The UV system would consist of multiple channels each with multiple lamp modules in series to treat all dry and wet weather flow. The system would automatically react to changes in flow and turn on additional modules or open additional channels as needed to provide proper disinfection. At average day flow, at least one channel would be offline. At peak flow, all channels would be online. Under average flow and sea level conditions, disinfected effluent would flow by gravity through existing effluent outfall and discharge to Bridgeport Harbor. Under high flows in conjunction with high water in the harbor, effluent pumping would be required to pump flow out of the facility. New axial flow column pumps would draw from either a trench style or rectangular wet well and discharge through the effluent outfall. The disinfection and effluent pumping facilities would be located in the southwestern portion of the site, so these facilities could be constructed and put into operation, prior to demolition of the existing chlorine contact tanks.

Sludge Handling Facilities. For each East Side WWTP alternative, the three existing gravity thickeners would be maintained and upgraded for primary sludge thickening. Similar to the West Side plant, two rotary drum thickeners provided for waste activated sludge thickening in a new Solids Handling Facility. New WAS storage tanks would be provided as well as thickened sludge storage tanks. Off-loading facilities would be provided to easily pump thickened sludge into tanker trucks for further processing and disposal off-site. Although the quantity and quality of sludge produced from the various primary and secondary treatment processes will differ, this evaluation assumes the same capital infrastructure would be installed. The percent solids achieved and/or the hours of operation of the RDTs may vary slightly between alternatives.

Electrical and I&C Systems. In all options it is assumed that a new electrical distribution system as well as standby power would be provided. In addition, new instrumentation and control systems including a full plant SCADA system would also be provided.

Flow Metering. For reporting and to assist in process operation, flow metering would be performed under all alternatives. At a minimum, flow would be constantly measured at the influent, effluent, and upstream of the secondary treatment system. In general, the influent flow would be measured using a magnetic flow meter on the discharge piping of the influent pumps. The effluent flow would be measured using a Parshall flume downstream of disinfection, but upstream of the effluent pump station. Flow to the secondary treatment system would be measured using the existing Parshall flume upstream of the existing primary tanks. During wet weather events, the bypass flow rate would be determined by subtracting the secondary treatment flow from the influent flow while accounting for side stream inputs.

7.3.2 Unique Treatment Train Unit Processes

The unique treatment train unit processes that vary across the alternative liquid treatment trains are primary treatment, high flow management and the biological nutrient removal (secondary treatment) process.

Primary Treatment. The primary treatment trains analyzed consider either dual-use operation where the same technology is used for both dry weather and wet weather flow, or a separate treatment train for wet weather flow (flow above the capacity of the secondary treatment system). The various treatment trains for dual-use employ one of three technologies: Traditional rectangular settling tanks, traditional rectangular settling tanks with chemically enhanced primary treatment (CEPT), and cloth disk filtration. At this facility, HRC is assessed for wet weather treatment only. Although the use of cloth disk filtration is new to the market for primary filtration, the benefits of small footprint and enhanced primary effluent quality are apparent. High rate clarification has been used at a number of facilities for wet weather treatment. Traditional primary clarification is tried and true. Due to the space available this site is more amenable to the use of traditional primary clarification. A detailed evaluation of primary treatment alternatives is presented in Section 7.3.4.1.

BNR Treatment. In all treatment trains the existing process will be upgraded to a four-stage process (anoxic, aerobic, post-anoxic, re-aeration) to achieve year-round nitrogen removal under design year flows and loadings. This is accomplished either through expanding the bioreactor volume, increasing the capacity of the existing bioreactors by implementing IFAS, and/or replacing secondary clarification with MBR. In each case, the ability to add supplemental alkalinity (magnesium hydroxide) upstream of the BNR process, is included, the ability to add supplemental carbon to the post-anoxic zone, is included, and new process blowers to be housed in a new blower/control building constructed. A detailed evaluation of primary treatment alternatives is presented in Section 7.3.4.2.

7.3.3 Detailed Evaluation of WWTP's Peak Flowrate Alternatives

Two alternative peak flowrate scenarios were evaluated; 40 mgd and 80 mgd. The 80 mgd flowrate evaluated represent significant CSO removal milestones throughout the East Side WWTP's collection system. Liquid treatment train options were developed and laid out on the WWTP's site for each flowrate. The sections, below, present and describe these various liquid treatment trains and site layouts for the alternative peak flowrates.

7.3.3.1 40 MGD Peak Flow Plant

The 40-mgd peak flow East Side plant alternatives maintain the current capacity of the East Side plant, which then inherently relies on in-system improvements to reduce the volume and frequency of CSOs during the one-year, 24-hour storm event. The following treatment trains were assessed:

- E-40A – 40 mgd, Dual-use traditional primaries and traditional 4-stage secondary treatment
- E-40B – 40 mgd, Dual-use traditional primaries with CEPT and IFAS
- E-40C – 40 mgd, Dual-use primary filtration and traditional 4-stage secondary treatment
- E-40D – 40 mgd, Dual-use primary filtration and membrane bioreactors

Option E-40A

Option E-40A provide a traditional treatment train for the East Side plant consisting of traditional rectangular primary settling tanks constructed in the location of the existing solids and influent pump station buildings, and a traditional 4-stage BNR suspended growth system with additional volume provided by constructing new pre-anoxic zones in the location of the existing primary settling tanks. The existing secondary clarifiers would be maintained and upgraded including all associated mechanical equipment. Odor control would be provided, likely using a biofilter, for treatment of odorous air off the headworks and sludge processing building.

Table 7.3-1 and **Figure 7.3-1** summarize and depict Option E-40A.

Option E-40B

Option E-40B maintains the existing primary settling tanks and provides the option to add chemicals (CEPT) to improve settling under high flow conditions. In addition, this option employs IFAS within the footprint of the existing bioreactors to ensure TN removal under design year flow and load conditions year-round. The existing secondary clarifiers would be maintained and upgraded including all associated mechanical equipment. Odor control would be provided, likely through biofiltration, for treatment of odorous air collected from the headworks and sludge processing building.

Table 7.3-2 and **Figure 7.3-2** summarize and depict Option E-40B.

Option E-40C

Option E-40C provides dual-use primary filtration in lieu of traditional primary settling tanks. The bioreactors are configured similar to Option E-40A and secondary clarifiers are maintained and upgraded. The biofilter for odor control would not only treat air flow from the headworks and sludge processing, but also from primary filtration.

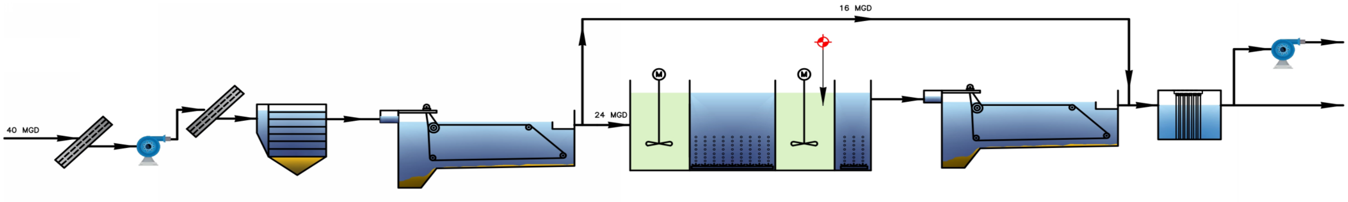
Table 7.3-3 and **Figure 7.3-3** summarize and depicts Option E-40C.

Option E-40D

Option E-40D, consumes the least amount of space on-site as it employs dual use primary filtration and membrane filtration. Because a high MLSS can be carried in the bioreactors, all 4-stages can be constructed within the footprint of the existing bioreactors.

Table 7.3-4 and **Figure 7.3-4** summarize and depict Option W-40D.

Table 7.3-1
Alternative E40A – 40 MGD, Dual-use Traditional Primaries and Traditional 4-stage Suspended Growth BNR Treatment



A new 40 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. New traditional rectangular primary settling tanks constructed in the location of the existing sludge processing building and influent pumping station. Upgrade of the existing 4-stage suspended growth BNR system with new 1st stage anoxic zone constructed in the location of the existing primary clarifiers, with new blower/control building, and upgrade of the existing secondary clarifiers. New 40 MGD UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Rehabilitation of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. Installation of new electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Traditional systems used for treatment processes, similar to current treatment processes at existing facility and most common technologies used in the industry. Increased capacity of the primary and BNR treatment system will enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The upgraded plant fits within the footprint of the existing facility and utilizes existing tankage when possible.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated.
Ease of Operations	Technologies similar to that currently used at the plant, with the exception of stacked tray grit removal and UV disinfection, which are conventional treatment technologies in the industry. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Standard equipment maintenance required. UV lamps require periodic replacement and cleaning.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved effluent quality, improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), and improved aesthetics, and improved aesthetics.
Ability to Phase Implementation	Construction could be phased with preliminary, primary, disinfection and sludge processing in first phase and bioreactor and secondary clarifier work in the second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site which will reduce truck traffic. Providing improved screening and grit removal will enhance sludge quality.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity of NaOCl for occasional RAS disinfection and for plant water use. Supplemental carbon to enhance BNR as necessary. Biofilter for odor control would not require chemicals.
	OPCC [(1)] = $110,700,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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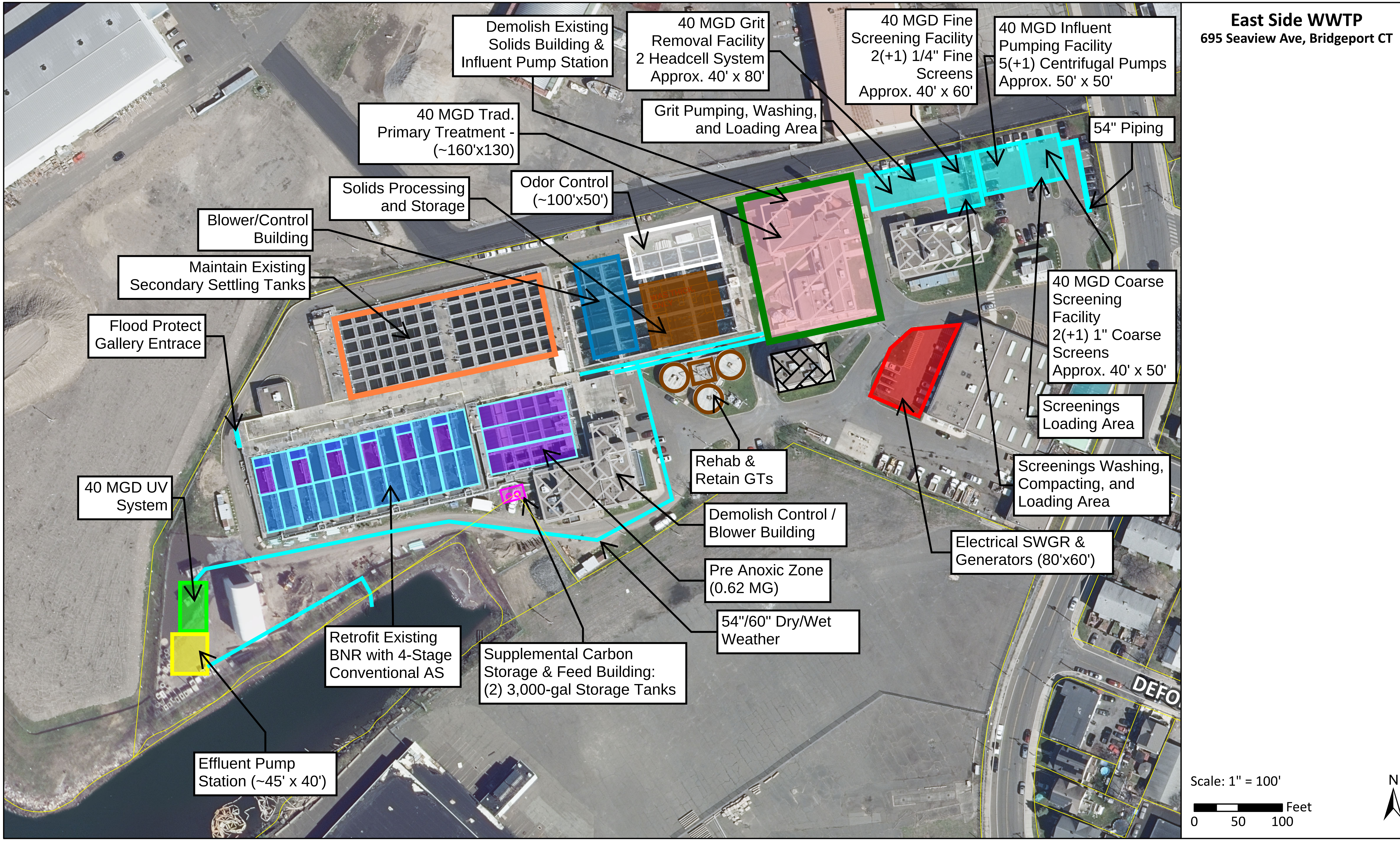

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Figure 7.3-1
Alternative E-40A

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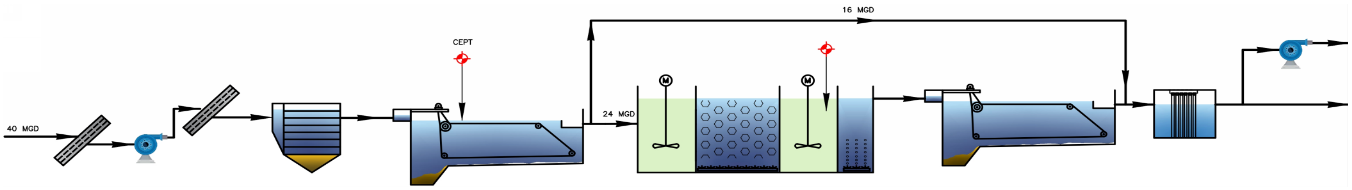
Table 7.3-2

Alternative E40B – 40 MGD, Dual-use Traditional Primaries with CEPT and 4-stage Suspended Growth BNR Treatment with IFAS



A new 40 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Upgrade of the existing traditional rectangular primary settling tanks incorporating the ability for chemically enhanced primary treatment (CEPT). Upgrade of the existing BNR system to a 4-stage suspended growth BNR system with IFAS, with new blower/control building, and upgrade of the existing secondary clarifiers. New UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Rehabilitation of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. Installation of new electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Traditional systems used for treatment processes, similar to current treatment processes at existing facility with the exception of CEPT and IFAS. Increased capacity of the BNR system offered by IFAS will enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The upgraded plant fits within the footprint of the existing facility and utilizes existing tankage when possible.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	Technologies similar to that currently used at the plant, with the exception of stacked tray grit removal CEPT, IFAS and UV disinfection, which are conventional treatment technologies in the industry. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	Standard equipment maintenance required. UV lamps require periodic replacement and cleaning. Some additional equipment associated with CEPT and IFAS
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved effluent quality, improved operable odor control and improved scum and residuals handling (likely reduced truck traffic)
Ability to Phase Implementation	Construction could be phased with preliminary, primary, disinfection and sludge processing in first phase and bioreactor and secondary clarifier work in the second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site which will reduce truck traffic. Providing improved screening and grit removal will enhance sludge quality. CEPT will increase sludge production.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity for occasional RAS disinfection and for plant water use. CEPT requires addition of chemical coagulant. Supplemental carbon to enhance BNR as necessary. Biofilter for odor control would not require chemicals.
	OPCC [(1)] = $100,000,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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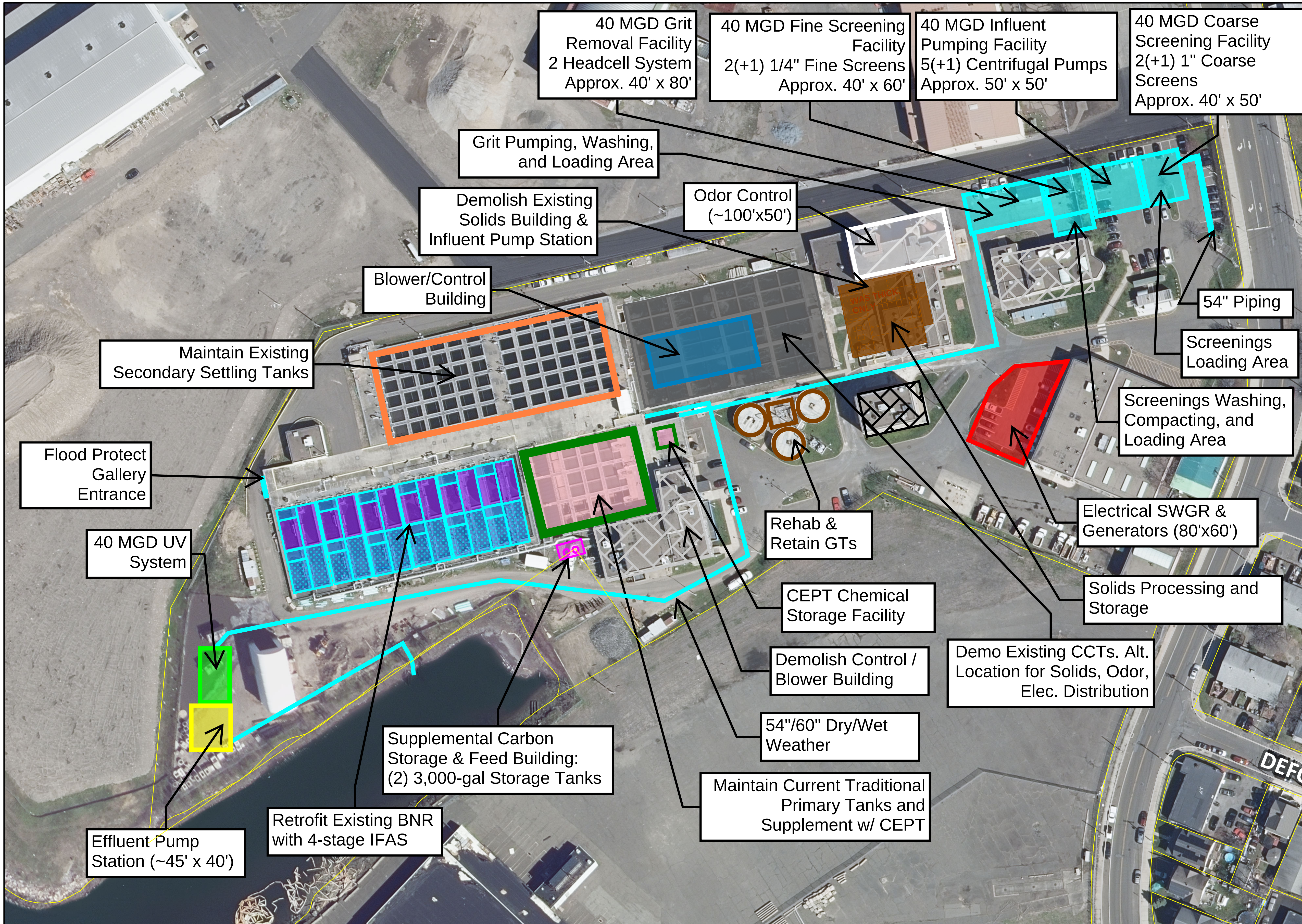

East Side WWTP
695 Seaview Ave, Bridgeport CT

Scale: 1" = 100'

0 50 100 Feet

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Figure 7.3-2
Alternative E-40B

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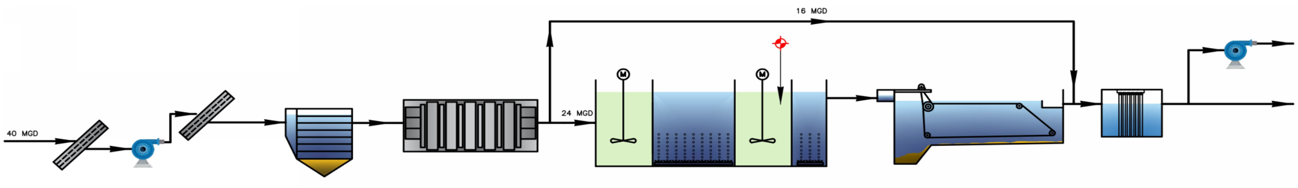
Table 7.3-3

Alternative E40C – 40 MGD, Dual-use Primary Filtration and Traditional 4-stage Suspended Growth BNR Treatment



A new 40 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Four new cloth disk primary filtration units constructed in the location of the existing chlorine contact tanks. Upgrade of the existing 4-stage suspended growth BNR system with new 1st stage anoxic zone constructed in the location of the existing primary clarifiers, with new blower/control building, and upgrade of the existing secondary clarifiers. New UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Rehabilitation of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary and primary treatment and sludge processing. Installation of new electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. Effluent from the primary treatment system is expected to be better than that of a conventional primary clarification system. The suspended growth BNR treatment system is similar to current process at existing facility, simply expanded, and most common technologies used in the industry. The increased capacity of the primary and BNR treatment systems will enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The upgraded plant fits within the footprint of the existing facility and utilizes existing tankage when possible.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated.
Ease of Operations	It is expected that the proposed primary filtration system will require more attention than a conventional primary clarification system. The BNR system is similar to that currently used at the plant, and will be enhanced with new instrumentation and controls. The proposed stacked tray grit removal and UV disinfection, will be new to the operations staff but are now considered conventional treatment technologies in the industry.
Ease of Maintenance	Maintenance of the cloth filtration system includes periodic cleaning and change-out of cloths. UV lamps require periodic replacement and cleaning. Other maintenance requirements are similar to existing facility.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved operable odor control, improved effluent quality, improved scum and residuals handling (likely reduced truck traffic), and improved aesthetics
Ability to Phase Implementation	Construction could be phased with preliminary, primary, disinfection and sludge processing in first phase and bioreactor and secondary clarifier work in the second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity for occasional RAS disinfection and for plant water use. Supplemental carbon to enhance BNR as necessary. Biofilter for odor control would not require chemicals.
	OPCC [(1)] = $109,400,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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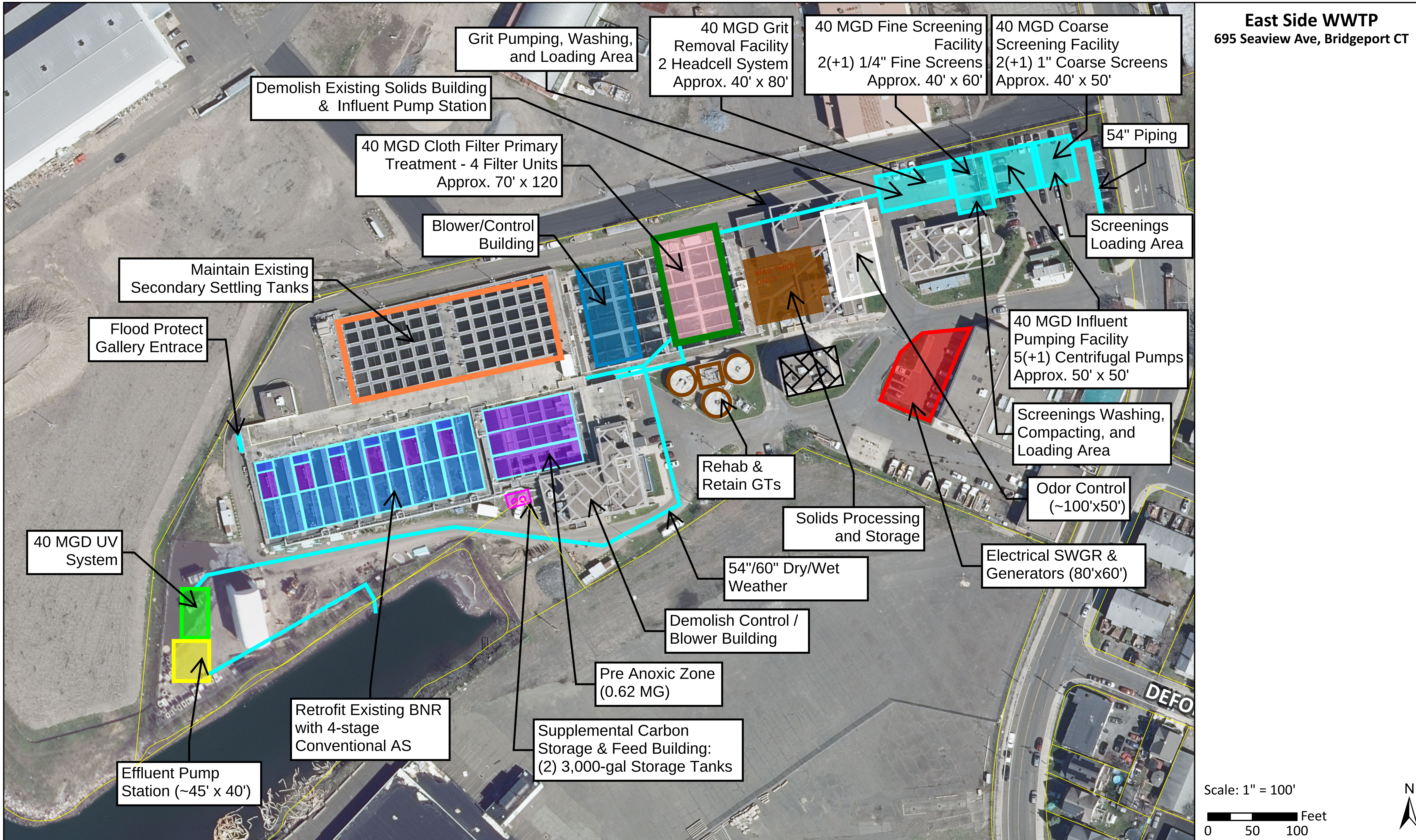

Figure 7.3-3
Alternative E-40C

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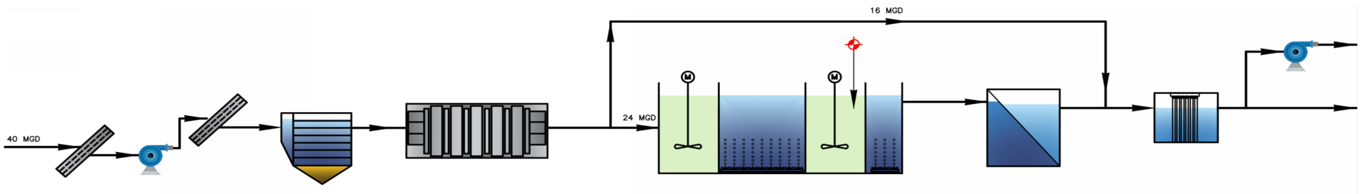
Table 7.3-4
Alternative E40D – 40 MGD, Dual-use Traditional Primaries and 4-stage Suspended Growth BNR Treatment with MBR



A new 40 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. New dual use primary filtration constructed in the location of the existing sludge processing building and influent pumping station. Upgrade of the existing 4-stage suspended growth BNR system, with new blower/control building, and membrane filtration in lieu of the existing secondary clarifiers. New UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Rehabilitation of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. Installation of new electrical distribution and emergency power system.

Criterion	**Comments**
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. Membrane filtration is prevalent in the industry, more typically for reuse applications. Improved primary treatment capacity as well as increased capacity of the BNR system to enable reliable TN removal year-round under future flow and load conditions.
Site Utilization	The plant, using space saving technologies fits within the footprint of the existing plant site.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, membrane filtration and UV disinfection. Membrane filtration is a more complex operation as compared to secondary clarification. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	This option will likely be more complex to maintain given the advanced systems. Cloth filters, membranes and UV lamps require periodic cleaning and replacement.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aesthetics.
Ability to Phase Implementation	Construction could be phased with preliminary, primary, disinfection and sludge processing in first phase and bioreactor and membrane filtration in the second phase.
Sludge Impacts	Primary filtration and membrane filtration will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as membrane filtration and UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and significantly reduce need for sodium hypochlorite on-site. Supplemental carbon to enhance BNR as necessary. Citric acid and NaOCl required for membrane cleaning.
	OPCC [(1)] = $134,200,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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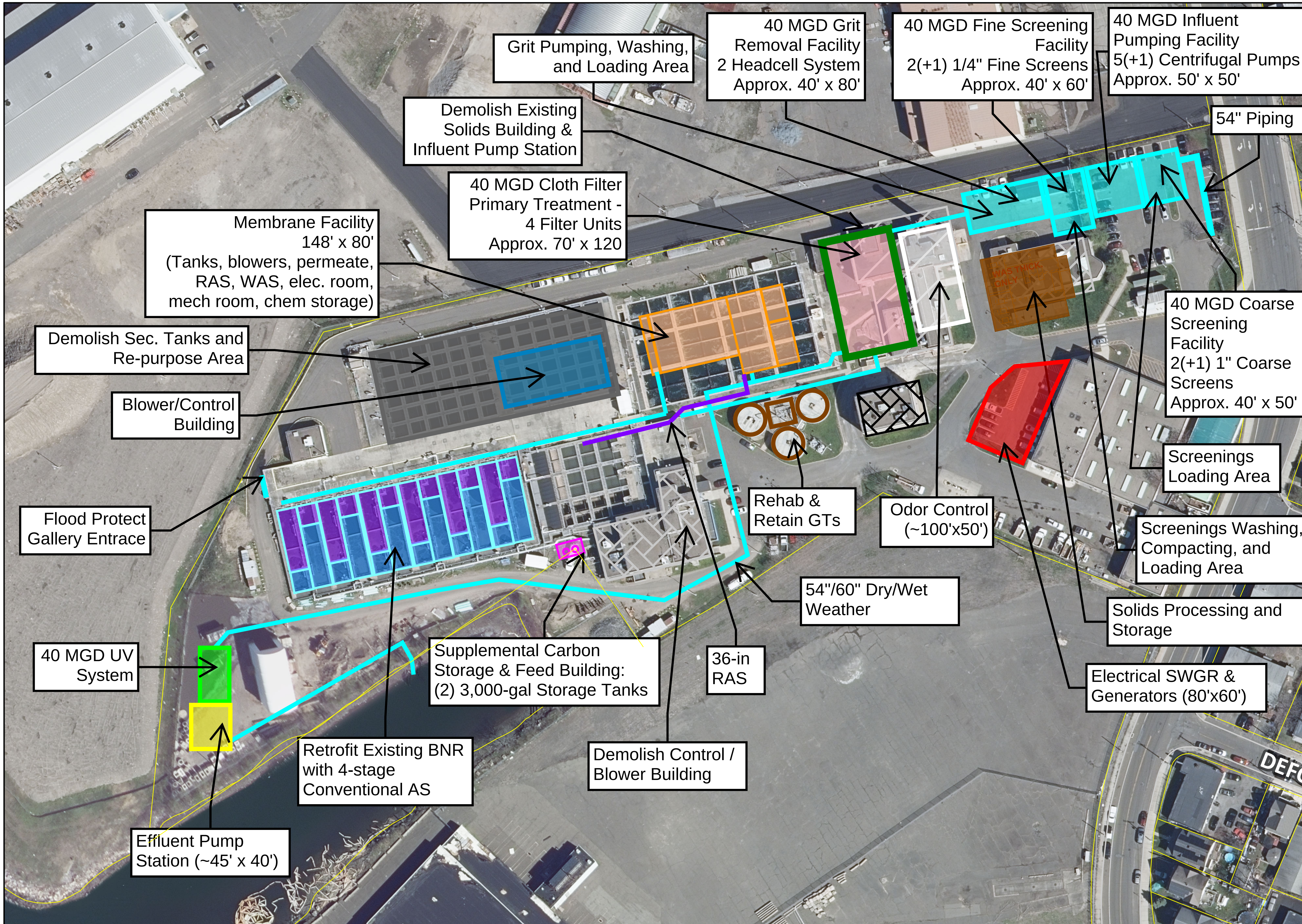

East Side WWTP
695 Seaview Ave, Bridgeport CT

Scale: 1" = 100'
Feet
0 50 100
N

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Figure 7.3-4
Alternative E-40D

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7.3.3.2 80 MGD Peak Flow Plant

The 80-mgd peak flow East Side plant alternatives doubles the current capacity of the East Side plant, which reduces the volume of CSOs during the one-year, 24-hour storm event from 4.1 MG to 1.0 MG as compared to a 40 mgd capacity plant – a 75% reduction in CSO volume for the 1-year design storm. With collection system improvements it is expected that the following CSOs would be controlled during a one-year event: DEAC, WANN and STRAT. In addition, modeling shows that without collection system improvements 69 mgd could be conveyed to the East Side plant during a 1-year, 24-hour storm event and 78 mgd during a 2-year, 24-hour event. The following 80 mgd treatment trains were assessed:

- E80A – 80 mgd, Traditional primary treatment, wet weather high rate clarification and membrane bioreactor
- E80B – 80 mgd, Traditional primary treatment, wet weather high rate clarification and IFAS
- E80C – 80 mgd, Dual-use primary filters and membrane bioreactors
- E80D – 80 mgd, Dual-use primary filters and traditional 4-stage secondary treatment

Option E-80A

Option E-80A maintains and upgrades the existing traditional primary settling tanks for dry weather flow up to 24 mgd and incorporates HRC for up to 56 mgd. The existing bioreactors are upgraded to a four-stage system within their existing footprint and membrane filtration provided in lieu of traditional secondary clarification. A biofilter would be provided to treat odorous air captured from the headworks, HRC and sludge processing facilities.

Table 7.3-5 and **Figure 7.3-5** summarize and depict Option E-80A.

Option E-80B

Option E-80B also maintains and upgrades the existing traditional primary settling tanks for dry weather flow up to 24 mgd and incorporates HRC for up to 56 mgd. This option however incorporates IFAS into the BNR system to increase its capacity and maintains and upgrades the existing secondary clarifiers. A biofilter would be provided for headworks, HRC and sludge processing odorous air flows.

Table 7.3-6 and **Figure 7.3-6** summarizes and depicts Option E-80B.

Option E-80C

Option E-80C is also a space savings alternative that incorporates dual-use primary filtration (avoiding the need to startup a second system under high flows) and provides the necessary BNR treatment capacity with membranes. In this alternative the bioreactors have adequate volume to incorporate a 4-stage system within the existing footprint. A biofilter would be provided for headworks, primary filtration and sludge processing odorous air flows.

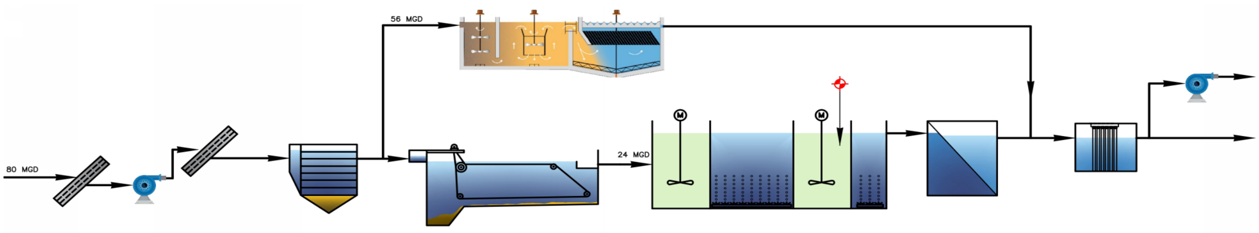
Table 7.3-7 and **Figure 7.3-7** summarize and depict Option E-80C.

Option E-80D

Option E-80D also employs dual-use primary filtration in the location of the existing chlorine contact tanks, converts the existing primary tanks to pre-anoxic zone, modifies the existing bioreactors, and maintains and upgrades the existing secondary clarifiers. A biofilter would be provided for headworks, primary filtration and sludge processing odorous air flows.

Table 7.3-8 and **Figure 7.3-8** summarize and depict Option E-80D.

Table 7.3-5
Alternative E80A – 80 MGD, Traditional Primaries plus HRC for Wet Weather, 4-stage Suspended Growth BNR Treatment with MBR



A new 80 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Upgrade to existing rectangular primary settling tanks. High rate clarification (HRC) for wet weather flow. Upgrade of the existing 4-stage suspended growth BNR system, with new blower/control building, and membrane filtration (MBR) in lieu of the existing secondary clarifiers. New UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Rehabilitation of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. Installation of new electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Traditional primaries and bioreactors used for dry weather treatment processes, similar to current treatment processes with the exception of the MBR filtration. Membrane filtration is prevalent in the industry, more typically for reuse applications. Increased capacity of the BNR system to enable reliable TN removal year round under future flow and load conditions. High rate clarification for wet weather treatment commonly used.
Site Utilization	The upgraded plant fits within the footprint of the existing facility and utilizes existing tankage when possible.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated.
Ease of Operations	Many new technologies including stacked tray grit removal, HRC, MBR and UV disinfection, which are conventional treatment technologies in the industry, but new to Bridgeport. This alternative requires independent wet weather system to be brought on-line to manage high flows. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	This option will likely be more complex to maintain given the advanced systems such as HRC, membranes and UV disinfection. UV lamps and membranes require periodic cleaning and replacement.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved effluent quality, operable odor control and improved scum and residuals handling. HRC generates thin sludge.
Ability to Phase Implementation	Due to the intricate sequence of construction phasing not warranted with this alternative.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Providing improved screening and grit removal will enhance sludge quality.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as membranes and UV disinfection system will increase energy demand for those systems
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on site and significantly reduce need for sodium hypochlorite on-site. Supplemental carbon to enhance BNR as necessary. Citric acid and NaOCl required for membrane cleaning. Biofilter for odor control would not require chemicals. HRC will require use of coagulant and polymer.
	OPCC [(1)] = $154,100,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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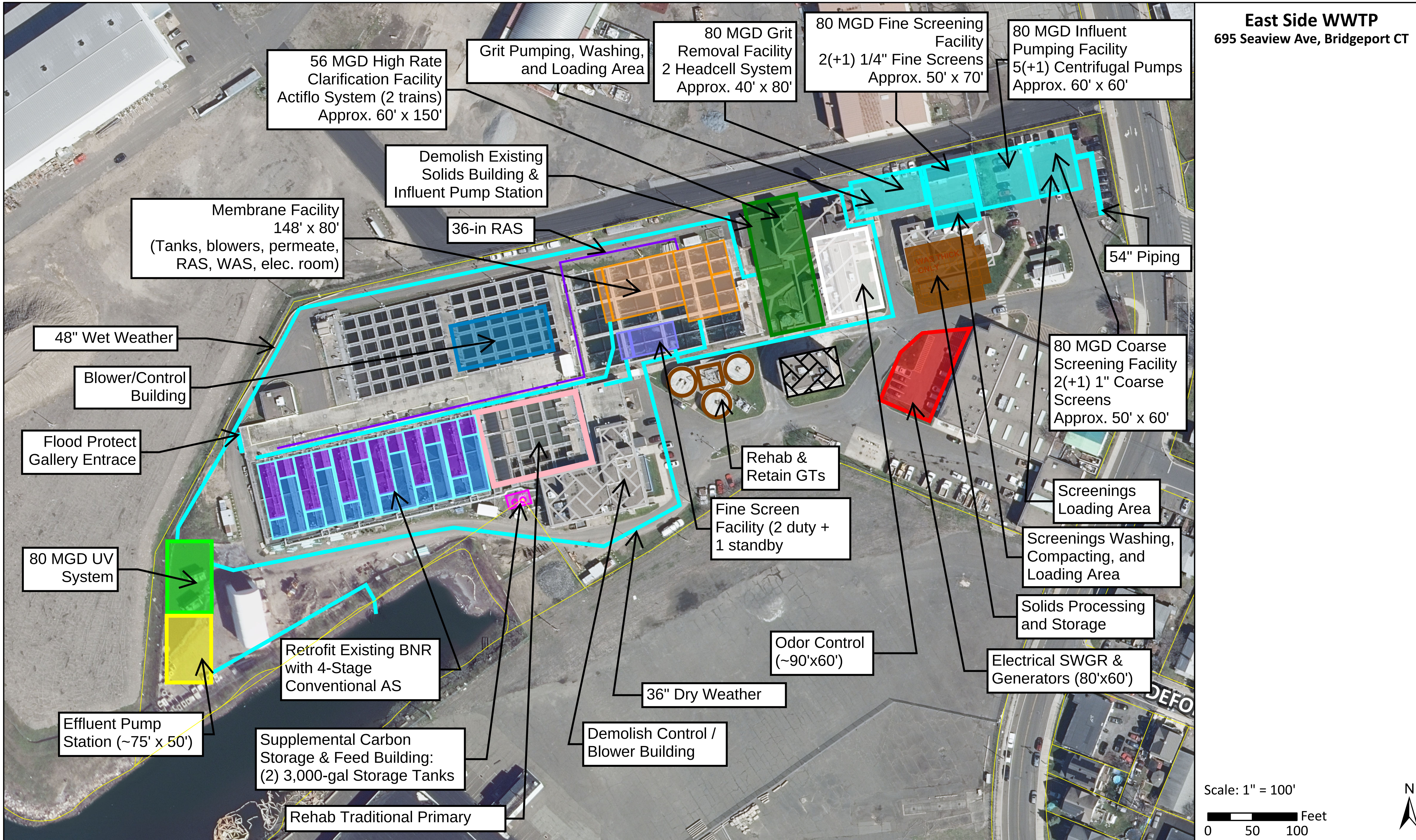

Figure 7.3-5
Alternative E-80A

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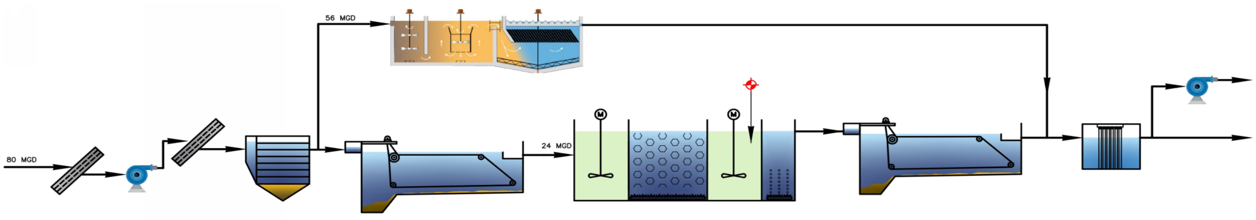
Table 7.3-6
Alternative E80B – 80 MGD, Traditional Primaries plus HRC for Wet Weather and 4-stage BNR Treatment with IFAS



A new 80 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Upgrade to existing rectangular primary settling tanks. 56 MGD high rate clarification (HRC) for wet weather flow. Upgrade of the existing 4-stage BNR system with IFAS. New blower/control building, and upgrade to the existing secondary clarifiers. New UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Rehabilitation of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. Installation of new electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Traditional primaries and bioreactors used for dry weather treatment processes, similar to current treatment processes with the exception of IFAS. Increased capacity of the BNR system to enable reliable TN removal year round under future flow and load conditions. High rate clarification for wet weather treatment commonly used.
Site Utilization	The upgraded plant fits within the footprint of the existing facility and utilizes existing tankage when possible.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated.
Ease of Operations	New technologies include stacked tray grit removal, IFAS, HRC and UV disinfection, which are conventional treatment technologies in the industry, but new to Bridgeport. This alternative requires independent wet weather system to be brought on-line to manage high flows. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	This option will likely be more complex to maintain given the advanced systems HRC, IFAS and UV disinfection. UV lamps require periodic cleaning and replacement.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved effluent quality, operable odor control and improved scum and residuals handling.
Ability to Phase Implementation	Potential to phase construction with new headworks, disinfection, HRC and sludge management in first phase and upgrade to existing primaries, bioreactors and secondary clarifiers in second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Providing improved screening and grit removal will enhance sludge quality. HRC produces thin sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Increased peak flow, improved HVAC and odor control as well as membranes and UV disinfection system will increase energy demand for those systems
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on site and significantly reduce need for sodium hypochlorite on-site. Supplemental carbon to enhance BNR as necessary. Biofilter for odor control would not require chemicals. HRC will require use of coagulant and polymer.
	OPCC [(1)] = $129,400,000

[(1)] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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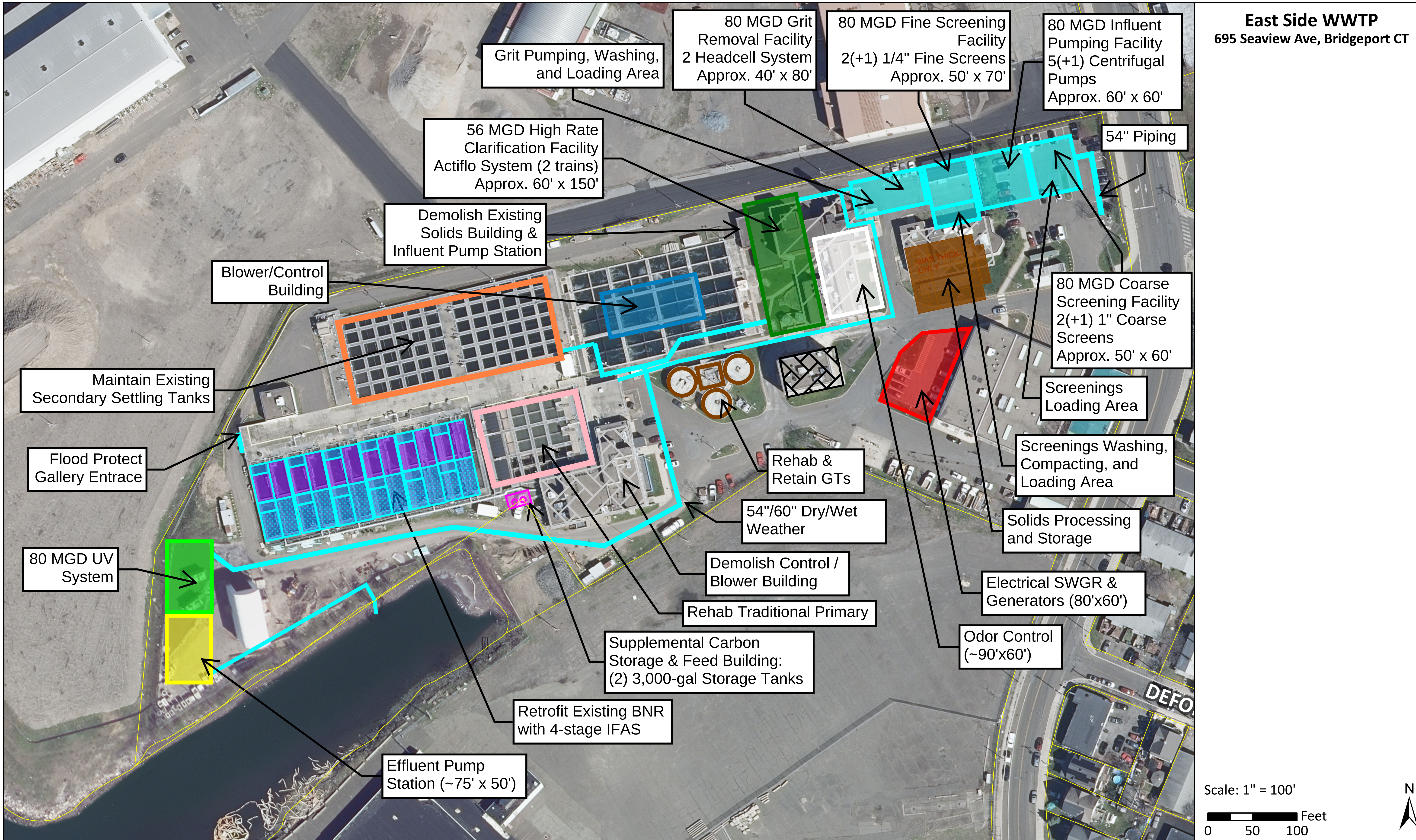

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Figure 7.3-6
Alternative E-80B

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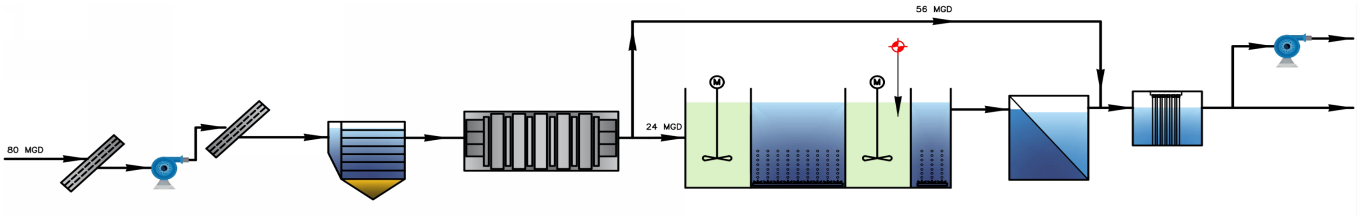
Table 7.3-7
Alternative E80C – 80 MGD, Dual-use Primary Filtration and 4-stage Suspended Growth BNR Treatment with MBR



A new 80 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Five new dual use primary cloth disk filtration trains constructed in the location of the existing sludge processing building and influent pumping station. Upgrade of the existing 4-stage suspended growth BNR system, with new blower/control building, and membrane filtration in lieu of the existing secondary clarifiers. New UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Rehabilitation of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary treatment and sludge processing. Installation of new electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Cloth disk filtration for primary treatment is new to the industry in this application although cloth disk filtration has been used for tertiary treatment for over 20 years. Improved primary effluent quality expected with cloth filters. Membrane filtration is prevelant in the industry, more typically for reuse applications. Improved primary treatment capacity as well as increased capacity of the BNR system to enable reliable TN removal year-round under future flow and load conditions.
Site Utilitization	The plant, using space saving technologies fits within the footprint of the existing plant site.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accomodated. Will lose some secondary treatment capacity during construction.
Ease of Operations	A number of new technologies will be used in this option, including stacked tray grit removal, primary filtration, membrane filtration and UV disinfection. Membrane filtration is a more complex operation as compared to secondary clarification. Improved instrumentation and controls will facilitate and optimize operations.
Ease of Maintenance	This option will likely be more complex to maintain given the advanced systems. Cloth filters, membranes and UV lamps require periodic cleaning and replacement.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved operable odor control and improved scum and residuals handling (likely reduced truck traffic), improved effluent quality and improved aethetics.
Ability to Phase Implementation	Due to the intricate sequence of construction phasing not warranted with this alternative.
Sludge Impacts	Primary filtration and membrane filtration will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site. Higher solids capture will reduce impact of sidestream loads. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as membrane filtration and UV disinfection system will increase energy demand for those systems.
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on-site and signficantly reduce need for sodium hypochlorite on-site. Supplemental carbon to enhance BNR as necessary. Citric acid and NaOCl required for membrane cleaning.
	OPCC [1] = $153,500,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land aquistion and easements or escalation to the midpoint of construction

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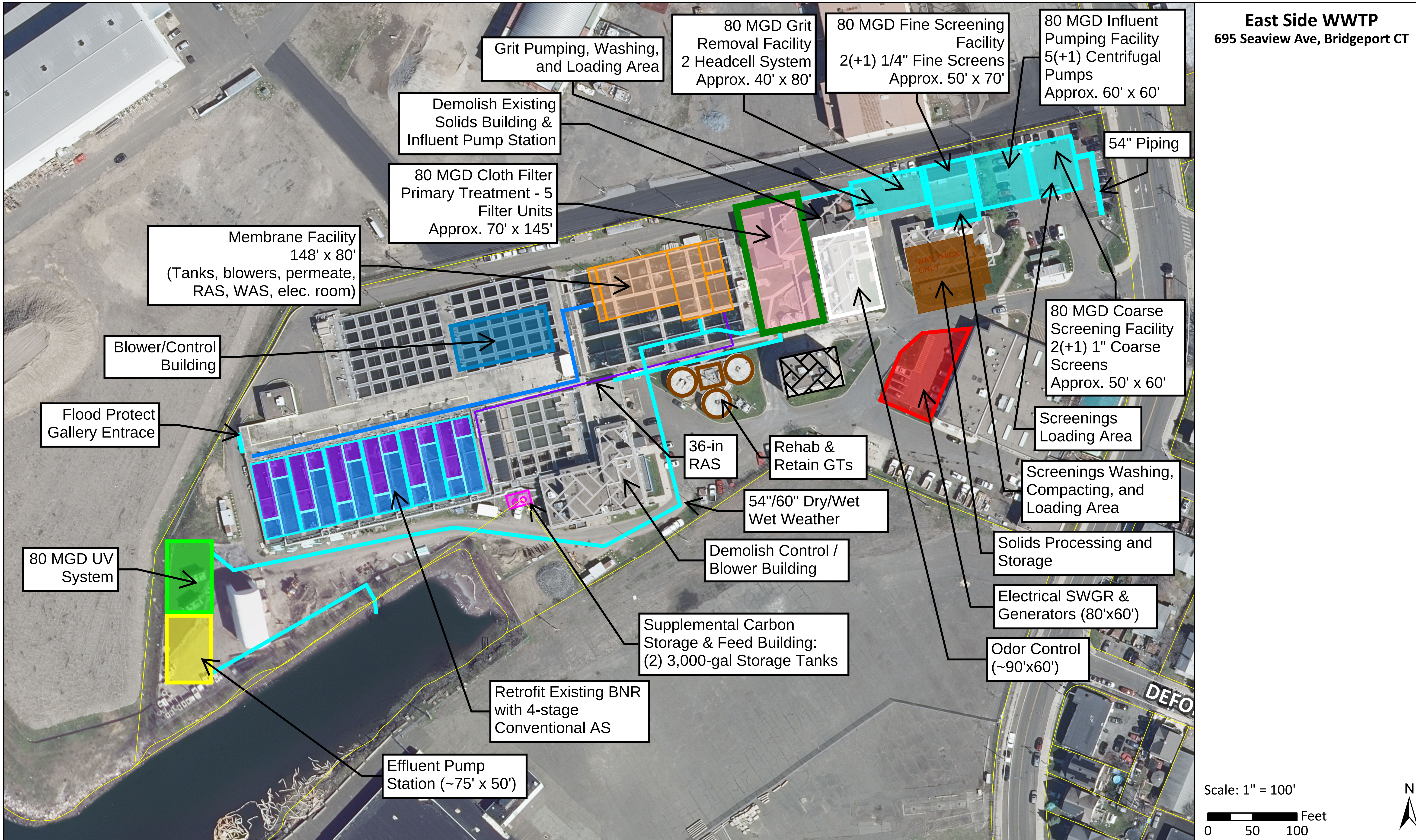

Figure 7.3-7
Alternative E-80C

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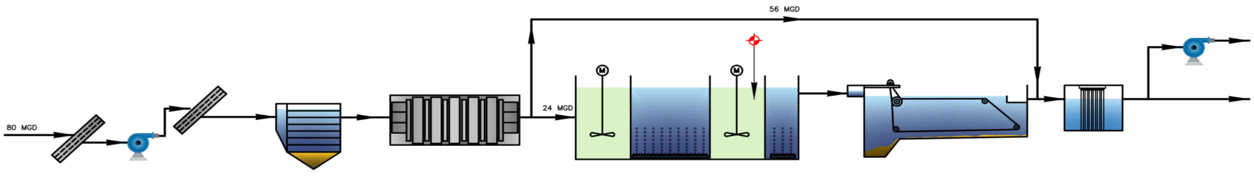
Table 7.3-8
Alternative E80D – 80 MGD, Dual-use Primary Filtration and Traditional 4-stage Suspended Growth BNR Treatment



A new 80 MGD preliminary treatment facility consisting of three (2 operating, one standby) 1-inch coarse screens, six influent pumps (5 operating, one standby), three (2 operating, one standby) 1/4-inch fine screens, and two stacked tray grit removal units. Five new cloth disk primary filtration trains constructed in the location of the existing chlorine contact tanks. Upgrade of the existing 4-stage suspended growth BNR system with new 1st stage anoxic zone constructed in the location of the existing primary clarifiers, with new blower/control building, and upgrade of the existing secondary clarifiers. New UV system for disinfection and new effluent pumping station to protect against rising seas and discharge against 100-year flood. Rehabilitation of existing gravity thickeners and new sludge storage and processing building. Odor control provided for preliminary and primary treatment and sludge processing. Installation of new electrical distribution and emergency power system.

Criterion	Comments
Success at Other Installations/Reliability	Primary cloth filtration new application in the industry, however the cloth filtration technology has been employed for tertiary treatment for over 20 years. Effluent from the primary treatment system is expected to be better than that of a conventional primary clarification system. The suspended growth BNR treatment system is similar to current process at existing facility, simply expanded, and most common technologies used in the industry. The increased capacity of the BNR system to enable reliable TN removal year round under future flow and load conditions.
Site Utilization	The upgraded plant fits within the footprint of the existing facility and utilizes existing tankage when possible.
Maintenance of Plant Operations	Detailed sequencing plan required to maintain operation during construction, but can be accommodated.
Ease of Operations	It is expected that the proposed primary filtration system will require more attention than a conventional primary clarification system. The BNR system is similar to that currently used at the plant, and will be enhanced with new instrumentation and controls. The proposed stacked tray grit removal and UV disinfection, will be new to the operations staff but are now considered conventional treatment technologies in the industry.
Ease of Maintenance	Maintenance of the cloth filtration system includes periodic change-out of cloths. UV disinfection will require periodic cleaning and replacement of lamps. Other maintenance requirements are similar to existing facility.
Neighborhood Impacts	Neighborhood impacts associated with construction of the new facility. Overall operations of new facility will improve neighborhood impacts with improved operable odor control, improved effluent quality and improved scum and residuals handling (likely reduced truck traffic)
Ability to Phase Implementation	Potential to phase construction with new headworks, primary treatment, disinfection, and sludge management in first phase and upgrade to existing bioreactors and secondary clarifiers in second phase.
Sludge Impacts	Improved primary and secondary treatment will enhance sludge removal and new sludge storage and improved thickening will likely result in higher percent solids of sludge hauled off-site which will reduce truck traffic. Providing improved screening and grit removal will enhance sludge quality. Primary filtration will increase carbon content in primary sludge.
Energy Efficiency	New aeration blowers and more efficient influent pumps should substantially improve plants energy efficiency. Improved HVAC and odor control as well as UV disinfection system will increase energy demand for those systems
Chemical Handling/Hazards	Use of UV disinfection will eliminate need for sodium bisulfite on site and significantly reduce need for sodium hypochlorite on-site (may maintain small quantity for occasional RAS disinfection and for plant water use. Supplemental carbon to enhance BNR as necessary. Biofilter for odor control would not require chemicals.
	OPCC [1] = $128,600,000

[1] OPCC = Opinion of Probable Construction Cost in 2020 dollars, and does not include engineering and contingency, land acquisition and easements or escalation to the midpoint of construction

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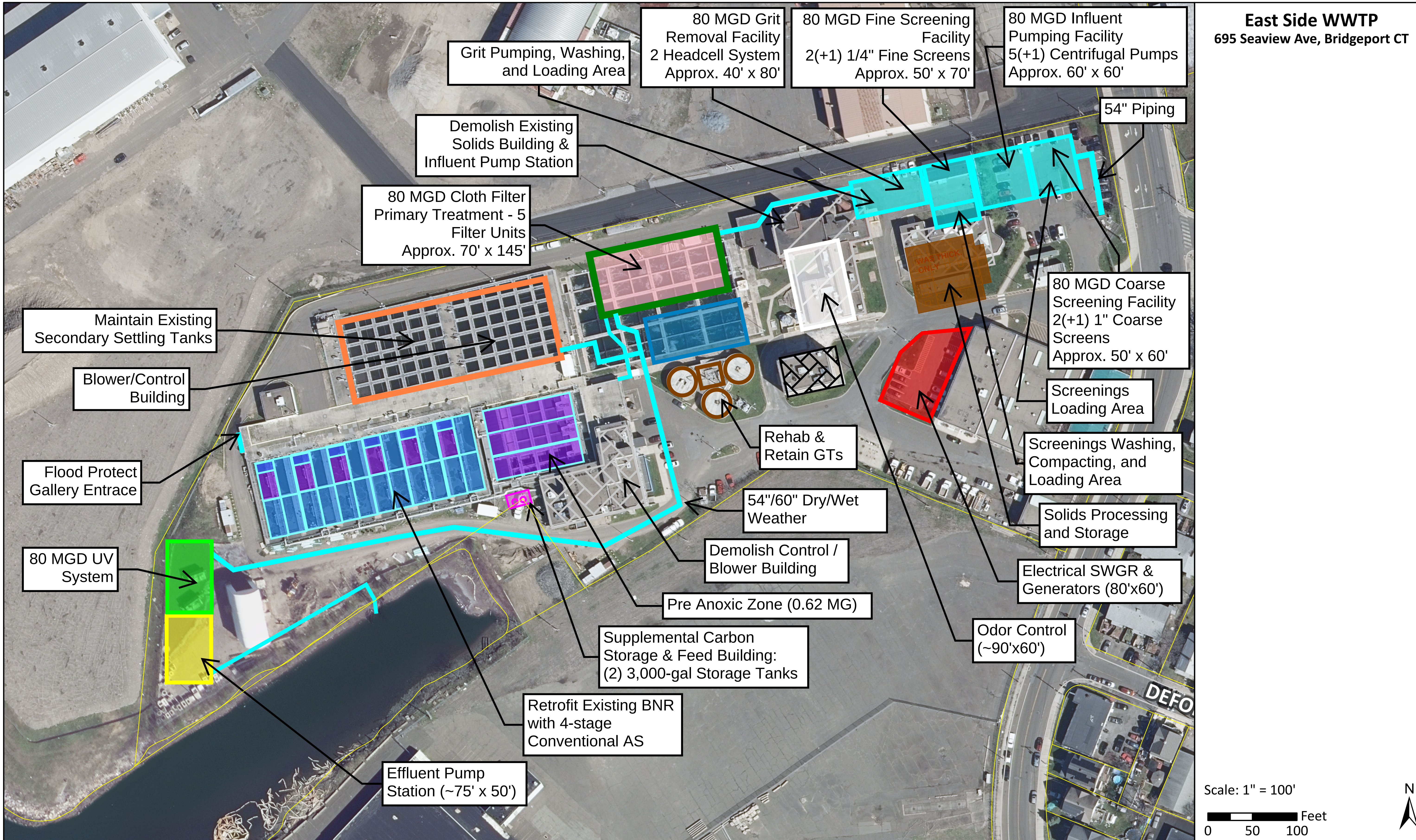

Figure 7.3-8
Alternative E-80D

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7.3.4 Detailed Evaluation of Unique Unit Process Alternatives

The unique treatment train unit processes that differ across the liquid treatment train alternatives presented throughout Section 7.2.3 are primary treatment, high flow management, and the biological nutrient removal (secondary treatment, BNR) process. While preferred treatment trains will be evaluated holistically from a plantwide and collection system perspective for each flow rate later in this section, detailed evaluation of individual primary treatment alternatives and BNR alternatives on a non-economic and economic basis is warranted because of the major differences between alternative technologies related to footprint, success at other facilities, ease of operation and maintenance, capital costs, annual O&M costs, present worth costs, etc. This detailed evaluation of unique unit process alternatives will help to develop the preferred alternative for each of the flow rates under consideration.

7.3.4.1 Primary Treatment Alternatives Evaluation

This section presents the detailed evaluation of the most viable primary treatment alternatives identified in the previous section for the East Side WWTP, traditional primary settling tanks, CEPT, cloth media disk filters, and high-rate clarification. Based on the results of the primary treatment evaluation, the recommended improvements are summarized at the end of this section.

Primary Treatment Non-Economic Evaluation

Section 6 presented descriptions of the various primary treatment alternatives that were considered. **Table 7.3-9** presents the rankings for each of the criteria of the four primary treatment alternatives. A rating of 5 indicates the most favorable rating, while a rating of 1 indicates least favorable. The weighted score represents the points awarded for criterion based on rating.

Table 7.3-9 Non-Economic Primary Treatment Alternative Rankings

Rating Legend *5= favorable* *3= neutral* *1= unfavorable*	Alternative Process Description	Traditional Primary Settling Tanks		Chemically-Enhanced Primary Treatment (CEPT)[1]		Cloth Media Disk Filters		High-Rate Clarification	
	Maximum Score for Criteria	Rating	*Weighted Score*	Rating	*Weighted Score*	Rating	*Weighted Score*	Rating	*Weighted Score*
Site Utilization	10	1	*2.0*	3	*6.0*	5	*10.0*	5	*10.0*
Success at Other Installations/ Reliability	8	3	*4.8*	3	*4.8*	1	*1.6*	3	*4.8*
Neighborhood Impacts	4	1	*0.8*	1	*0.8*	5	*4.0*	3	*2.4*
Energy Efficiency	4	3	*2.4*	3	*2.4*	3	*2.4*	1	*0.8*
Ease of Operations	3	3	*1.8*	1	*0.6*	3	*1.8*	1	*0.6*
Ease of Maintenance	3	3	*1.8*	3	*1.8*	1	*0.6*	1	*0.6*
Maintenance of Plant Operations	2	3	*1.2*	5	*2.0*	3	*1.2*	3	*1.2*
Ability to Phase Implementation	2	3	*1.2*	3	*1.2*	5	*2.0*	3	*1.2*
Sludge Impacts	2	3	*1.2*	1	*0.4*	3	*1.2*	1	*0.4*
Chemical Handling/Hazards	2	5	*2.0*	1	*0.4*	3	*1.2*	1	*0.4*
Non-Economic Total Weighted Score	**40**	**--**	***19***	**--**	**20**	**--**	***26***	**--**	***22***

Notes:

1. **CEPT evaluated for 40 mgd flowrate only (not 80 mgd).**

Table 7.3-10 includes the detailed evaluation used to determine the rankings for each of the alternatives.

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Table 7.3-10 Detailed Evaluation of Primary Treatment Alternatives Non-Economic Criteria

Alternative Process Description / Non-Economic Criteria	Traditional Primary Settling Tanks	Traditional Primary Settling Tanks with Chemically-Enhanced Primary Treatment	Cloth Media Disk Filters	High-Rate Clarification
Site Utilization	Largest process footprint. Traditional primary tanks would require several times the site space compared to the existing tanks and the cloth filter option, requiring construction on adjacent boat yard parcel. System sized for peak wet weather flows would be greatly oversized for average design flows.	Large process footprint, but more space-efficient than traditional primary settling. Likely requires construction on adjacent boat yard parcel. Requires construction of chemical (coagulant and polymer) storage/feed facility for storage tanks and metering pumps adjacent to the settling tanks.	Smallest process footprint. "Space-saving" option, allows for improved layout of other facilities and less encroachment onto surrounding properties.	Compact process footprint. Allows for improved layout of other facilities, but would still require expansion onto surrounding properties.
Success at Other Installations/ Reliability	Conventional process used with success at small and large-scale facilities similarly sized to Bridgeport to achieve primary treatment when sized according to industry guidelines.	Technology successfully implemented at other small and large-scale facilities similarly sized to Bridgeport for primary treatment, including wet weather CSO flow. Less common than traditional primary.	Cloth media filtration technology proven, but application in primary treatment is still emerging. No existing installations at large-scale CSO facilities comparable to the East Side WWTP. Cloth media is a filter, or a physical barrier that reliably produces high quality effluent which decreases solids washout and reduces load to the downstream BNR process.	Ballasted flocculation technology proven, including CSO applications. Application as traditional primary treatment is emerging. Several existing primary treatment installations at large scale facilities. Higher quality effluent compared to traditional primary settling.
Neighborhood Impacts	New, large, above grade settling tanks would be constructed on adjacent land (north parcel and partial boat yard). Nuisance odors and tank visuals from primary treatment may cause neighborhood disturbance to the north of the plant and south at Captain's Cove area. Covering influent/effluent channels may be warranted.	New, large, above grade settling tanks would be constructed on adjacent land (north parcel and northern portion of boat yard). Nuisance odors from primary treatment may cause neighborhood disturbance to the north of the plant. Covering influent/effluent channels may be warranted. Chemical storage and chemical truck deliveries and access roads also required, potentially impacting neighborhood.	Rotating filter units are installed in open tanks. Cover system over the tanks or a full building over the tank area would be constructed. Covers or building would help contain odors compared to large open tanks, positive neighborhood impact. Minimal chemical usage and higher quality effluent are other positive neighborhood impacts.	Cover system over the tanks or a full building over the tank area would be constructed. Covers or building would help contain odors compared to large open tanks, positive neighborhood impact. Chemical storage and chemical truck deliveries and access roads also required, potentially impacting neighborhood.
Energy Efficiency	Additional settling tanks (compared to CEPT) would require more sludge/scum collection mechanisms and sludge pumps (greater # of motors). Equipment efficiency would be similar compared to current operation, but on larger scale.	Fewer settling tanks would require fewer sludge/scum collection mechanisms and sludge pumps compared to traditional primary. Additional electrical load for chemical mixers and feed systems and potential mechanical injectors/mixers.	Each filter unit has a filter drive and a backwash pump and solids wasting pump (20 hp each). Backwash and solids wasting pump operation is intermittent, not continuous.	Fewer overall tanks/units necessary but more energy-intensive, extra mechanical equipment required including mixers, sludge scrapers, sand recirculation pumps, sludge pumps. Additional load for chemical feed systems and mixers.
Ease of Operations	Operation would be on a larger scale but otherwise similar to current operation. Sludge and scum collection system and sludge pumps are major operating components, starting and stopping through SCADA.	Operation would be similar, but more involved than current operation. Sludge and scum collection system and sludge pumps are major operating components, starting and stopping through SCADA. Process involves starting/stopping intermittent chemical feed pumps during wet weather flow events and monitoring dosages. Chemical systems incrementally brought online as flows increase.	Individual operating filter units (trains) switch between filtration, backwash, and solids wasting modes automatically through vendor supplied control panel. Filter units are brought on/offline automatically as needed depending on wet weather flow and total plant flow rate. Idle/standby tanks to be drained or kept full with disinfected water when not in use.	More complex operations with multiple system components: coagulant feed pumps, polymer feed pumps, sand recirculation pumps/piping, sand recovery cyclones, sludge pumps, mixers, clarifier drives, sand replenishment. System highly automated. Trains brought on/offline manually or automatically as needed depending on wet weather flow and/or total plant flow rate - chemical feed started, sand recirculation started. Idle/standby tanks to be kept full with plant water. Idle equipment to be run for 20 minutes every 2 weeks.
Ease of Maintenance	Maintenance similar to what operators currently experience. Main maintenance items are chain/flight sludge collectors, scum collectors, and sludge pumps.	Maintenance of the settling tanks would be similar to traditional primary tanks and similar to what operators currently experience. Added maintenance of coagulant and polymer storage, mixing, and feed pump equipment would be necessary.	Cloth media needs to be cleaned at regular intervals for several hours to maintain backwash efficiency. Requires soaking cloth media in sodium hypochlorite every 3 mo - 1 yr (depending on FOG accumulation). Replacement of cloth media necessary after 4-7 years, requires 2-3 staff to remove each disc from tank. Routine maintenance of chemical storage/feed equipment, backwash pumps, and sludge pumps. Idle/standby tanks to be drained or kept full with disinfected water when not in use.	More complex system with several chemical feed systems and mechanical components. Routine maintenance of chemical storage/feed equipment, tank mixers/motors, sludge scrapers/motors, sand recirculation pumps and sand hydrocyclone separators, and sludge pumps. Periodic sand replenishment. Idle equipment to be run for 20 minutes every 2 weeks.
Maintenance of Plant Operations	New settling tanks would be constructed on currently utilized land. Existing processes would need to be replaced and demolished prior to construction. Primary treatment would be completed as secondary phase of construction.	CEPT considered for 40 mgd flow options only. CEPT includes supplementing existing primary tanks with chemical use for wet weather, allowing existing primary tanks to be reused and rehabilitated.	Cloth filter facility would be constructed on currently open/undeveloped land, no current operations would be interrupted. Primary treatment would be completed as first phase of construction to allow existing primary tank area to be demolished and the area repurposed.	High rate clarification facility would be constructed on currently open/undeveloped land, no current operations would be interrupted. Primary treatment would be completed as first phase of construction to allow existing primary tank area to be demolished and the area repurposed.
Ability to Phase Implementation	Potential to phase if plan is to design for a lower flow now and expand flow in future. Potential to build an initial battery and then additional tanks in future.	Potential to phase if plan is to design for a lower flow now and expand flow in future. Potential to build an initial tank battery and then additional tanks in future.	Potential to phase if plan is to design for a lower flow now and expand flow in future. Potential to build spare filter tanks in present and add mechanical filter equipment in the future. Or potential to add filter tanks/units and add on to/expand the building in the future.	Potential to phase if plan is to design for a lower flow now and expand flow in future. Potential to add trains and add on to/expand the building in the future.
Sludge Impacts	Dry weather and wet weather sludge production rates anticipated to be typical of primary settling tanks sized according to industry guidelines. Greater production at design flows compared to current process as current tanks are undersized and under performing.	Dry weather sludge production rates anticipated to be typical of primary settling tanks sized according to industry guidelines. Wet weather sludge production rates would be greater due to chemical addition and increased solids removal rates.	Primary sludge production (dry and wet weather flows) would be higher because the process removes more TSS than other alternatives. Increased primary sludge flow rate and volume due to increased flow from backwash, impacting sludge thickening process. Increased sludge production reduces load to secondary processes. Carbon rich sludge has value to disposal facilities for energy production, digestion, incineration.	Primary sludge production (dry and wet weather flows) would be higher due to higher performing process. Thinner sludge generated, would require more intensive processing. Metal-laden sludge would also contain small amounts of microsand ballast that is not separated by the hydrocyclone.
Chemical Handling/Hazards	Process does not require the use of chemicals.	Metal salt and/or polymer addition is required to increase particle size and settling rates in CEPT. Requires storage and feed facility, delivery area, and piping.	Hypochlorite storage required for routine cleaning of cloth media.	Coagulant, polymer, microsand are required to operate the HRC process. Chemical storage and feed facility/equipment, delivery area, and piping required.

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Traditional Primary Settling Tanks

The major disadvantage with traditional primary tanks is their size. They require a substantial footprint in order to maintain acceptable surface overflow rates to achieve adequate settling of solids. While this can be accommodated at some plants, the restricted site footprint at the East Side WWTP presents challenges with this technology. An appropriately sized system for the dry weather peak flow of 24 mgd would be slightly larger than the existing primary tanks. And a system sized for the minimum peak flow of 40 mgd to function as both dry and wet weather treatment would be larger, approximately 160 feet long and 130 feet wide. Incorporating tanks this large with other required new processes for preliminary treatment would likely require an existing process to be replaced and removed first as there are minimal open available parcels at the East Side WWTP. This siting challenge only gets exacerbated if trying to utilize traditional primary treatment for dual-use dry and wet weather flows at the higher flow of 80 mgd, with this scenario likely impossible. For this reason, this alternative was assigned an *unfavorable* rating.

Traditional primary settling tanks are the most common alternative for primary treatment found at plants all throughout the country, consisting of large open tanks with minimal operating equipment. It is a simple system that relies only on gravity settling for the removal of sludge, with any floating scum or other solids rising to the surface. The only associated equipment are the sludge and scum collection mechanisms, and the settled sludge pumps to convey solids to the solids processing processes. Traditional primary settling tanks rely solely on sludge settling velocities and do not enhance settling characterizes. For these reasons, this alternative was assigned a *neutral* with respect to success at other installations and reliability.

The large open tanks can also be a source of odor issues. While the influent and effluent channels can be covered and tied into the odor control system to contain and treat some of the sources, fully covering the tanks is feasible, but very costly and makes access to the tanks difficult. Having such a large odor source could be problematic, which is why it received an *unfavorable* rating.

Traditional primary settling tanks utilize sludge and scum collection mechanisms utilizing small HP motors and primary sludge pumps. There are no specific energy efficient features with traditional primary settling tanks, so it was assigned a *neutral* rating with respect to energy efficiency.

The East Side WWTP currently utilizes traditional primary settling tanks that operations staff would already be familiar with. Traditional primary settling tanks require routine mechanical maintenance of equipment and the mechanical equipment would run in a mostly automatic mode through the plant control system. This alternative was assigned a *neutral* rating for both ease of operations and maintenance criteria.

New settling tanks would be constructed on land that is currently occupied by existing process(es), but the existing processes will be replaced by new processes located elsewhere. Primary treatment would be completed after other new processes have been constructed and put into operation, but the MOPO can be accommodated. Traditional primary settling tanks were assigned a *neutral* rating.

Primary treatment will be designed for the selected WWTP flow to treat both dry weather and peak wet weather flows. While not a straightforward effort, a traditional primary settling tank process could be built for an initial lower peak flow rate with the potential to construct additional tanks in future to increase treatment capacity. This alternative received a *neutral* rating.

Traditional primary clarification does not utilize any chemicals that would increase sludge production. For this reason, traditional primary clarifiers received a *neutral* rating with respect to sludge impacts. Because there is also no chemical usage associated with the process, which is why it received a *favorable* score with respect to chemical handling/hazards.

Chemically Enhanced Primary Treatment

CEPT is similar to traditional primary settling, except chemicals (a metal salt coagulant and a polymer) are added during times of high flows to allow for the tanks to operate at higher surface overflow rates, reducing their footprint. When used in a dual-use setup, the system would be designed to allow peak dry weather flows to be treated without chemical addition, with just the intermittent wet weather high flows requiring chemicals. Sludge and scum collection and sludge pumping are similar to traditional primary settling.

An advantage with CEPT is that it marginally reduces the size of the overall primary process compared to traditional primary tanks, as the large wet weather peak flows are processed at a higher overflow rate through the chemical addition. While CEPT does occupy a smaller footprint when compared to traditional primary systems, it still does require a substantial footprint when compared to the other higher performance primary alternatives under consideration, and is not considered a “space saving” alternative. At the East Side WWTP, CEPT could be integrated into the existing primary tanks to allow them to function as dual use dry/wet weather tanks, but only for the 40 mgd alternatives. A CEPT process sized for a peak flow of 80 mgd to function as both dry and wet weather treatment would require new tanks and could be approximately double footprint of the existing tanks, and also much larger than the higher performing processes. Siting tanks this large with other required new processes for preliminary treatment would present a challenge. For this reason, this alternative was assigned a *neutral* rating.

While traditional primary settling tanks are the most common alternative for primary treatment found at plants all throughout the country, consisting of large open tanks with minimal operating equipment, CEPT is less common. It also does require the use of chemicals to treat the peak wet weather flows, but coagulants and polymers are common in the wastewater industry. For these reasons, this alternative was assigned a *neutral* rating with respect to success at other installations and reliability.

The large open tanks can be a major source of odor issues. While the influent and effluent channels can be covered and tied into the odor control system to contain and treat some of the sources, fully covering the tanks is feasible, but very costly and makes access to the tanks difficult. Having such a large odor source could be problematic, which is why it received an *unfavorable* rating.

CEPT tanks utilize sludge and scum collection mechanisms utilizing small HP motors and primary sludge pumps, along with small HP chemical feed pumps. There are no specific energy efficient features with CEPT, so it was assigned a *neutral* rating with respect to energy efficiency.

The East Side WWTP currently utilizes traditional primary settling tanks that operations staff would already be familiar with. CEPT tanks require routine mechanical maintenance of equipment and the mechanical equipment would run in a mostly automatic mode through the plant control system. The chemical storage and feed systems would also require routine mechanical maintenance of equipment. The feed and mixing equipment would run in a mostly automatic mode, but they would require operator input to put them into operation during wet weather events and also to shut them off after event to avoid wasting chemical. Chemical dosing would also have to be monitored to avoid overdosing. This alternative was assigned an *unfavorable* rating for ease of operations and a neutral rating for ease of maintenance criteria.

CEPT for 40 mgd would occur in the existing primary tanks, new tanks would not be required. CEPT was therefore assigned a *favorable* rating for MOPO.

Primary treatment will be designed for the selected WWTP flow to treat both dry weather and peak wet weather flows. There is the potential to upgrade the existing primary treatment system with new collection mechanisms and sludge pumps and then add the chemical systems at a later date if deemed necessary with increased flows. This alternative received a *neutral* rating.

CEPT utilizes a coagulant and polymer as part of the rapid settling process during wet weather operations that will affect sludge composition and increase primary sludge production. For this reason, CEPT received an *unfavorable* rating with respect to sludge impacts and also an *unfavorable* score with respect to chemical handling/hazards.

Cloth Media Filters

Cloth media filters are a common process in the wastewater industry, with the bulk of their applications as tertiary treatment for advanced nutrient and solids removal. However, they are starting to be utilized more for primary treatment and in some installations as standalone wet weather/CSO treatment. They are a simple filtration process, with wastewater passing through the cloth media, 10 micron for primary applications, and the solid retained on the outside. The filters are periodically backwashed to remove the solids which collect at the bottom of the tank for removal. Every three or four backwash cycles are followed by a solids removal cycle that remove solids that settle and collect at the bottom of the filter tank.

The main advantage with cloth media filters is their small footprint. As this is a filtering process, large process tanks are not needed to provide for gravity settling. A single filter unit, with a footprint of about 10 feet by 35 feet, with 24 cloth rotating disks could treat up to 11 mgd when operating as a traditional primary clarifier with dry weather flows, and approximately 18 mgd when treating a combined dry/wet weather CSO flow. For comparison purposes, a 40 mgd cloth filter facility, when including space for support pumps and equipment, could have a facility footprint of about 70 feet by 120 feet, compared to a footprint approximately 160 feet by 130 feet for 40 mgd traditional primary tanks, less than one half the total area. This becomes very advantageous for the East Side WWTP for the potential 80 mgd treatment scenarios. Cloth filters facilities sized for these flows are less of a challenge to integrate into the available land area. For this reason, this alternative was assigned a *favorable* rating for site utilization.

The main disadvantage with the cloth media filters is their limited use for primary and CSO treatment. There are only of handful of plants in operation or under construction in the U.S. that utilize cloth media filters for primary, standalone wet weather, or combined influent flows. However, cloth filter technology is a proven successful technology for tertiary filtration. And the cloth media also serves as a physical barrier that filters particulates which makes them a reliable process, reduces potential risk of process upsets, and also will provide better wet weather effluent quality. Despite the advantage of filtration technology, this alternative was assigned an *unfavorable* rating for success at other installations and reliability due to its limited usage.

The cloth filter assemblies are installed in concrete tanks. For protection of the filters, the tanks would have a cover system over them, or would be installed within a building, allowing odors to be controlled, collected and treated. The influent and effluent channels would also be covered or located within the building. The process does not require routine chemical use which eliminates the need for frequent chemical truck deliveries, and also will provide a better wet weather effluent quality. Being able to capture and collect odorous air, reducing chemical deliveries to the plant, and providing a better-quality wet weather effluent allows this to have a *favorable* rating for neighborhood impacts.

The cloth filter assembly rotates via a small drive motor. Additionally, each filter/tank also includes a backwash pump (approximately 20 hp) for cleaning the cloth media and also a sludge wasting pump (approximately 20 hp) to remove solids that have settled to the bottom of the tank, but these pumps are not in continuous operation and continuous loads. This option therefore receives *a neutral* rating for energy efficiency.

The cloth filters also do require more ancillary equipment than traditional primary tanks, along with increased maintenance. There are backwash pumps and valve systems to maintain, and the cloth media does require routine cleaning every few months, and then eventually cloth replacement every four to seven years. The system does operate largely in an automatic mode with minimal operator input. This alternative was assigned a *neutral* rating for ease of operation, and an *unfavorable* rating for ease of maintenance.

A new cloth media filter facility would be constructed on land that is currently occupied by existing process(es), but the existing processes will be replaced by new processes located elsewhere. Primary treatment would be completed after other new processes have been constructed and put into operation, but the MOPO can be accommodated. Cloth media filters were assigned a *neutral* rating.

Primary treatment will be designed for the selected WWTP flow to treat both dry weather and peak wet weather flows. The tanks in which the cloth filter assembles are installed are small in comparison to traditional primary tanks and HRC trains. While not a straightforward effort, a filter facility could be built for an initial lower peak flow rate with the potential to construct additional filter tanks in future to increase treatment capacity. Alternatively, spare tanks could be included as part of the initial facility construction with the filter assembly mechanical equipment and associated backwash and sludge pumps added in the future. Therefore, this alternative received a *favorable* rating.

Cloth media filters do not utilize any chemicals as part of the filtration process that would affect sludge composition, however the fine cloth would increase primary sludge production and sizing of downstream solids processing. This increase in primary sludge production has the benefit of reducing the loading to the secondary treatment process. The primary sludge would also be a more carbon rich sludge which has value to disposal facilities for energy production, digestion, incineration. For this reason, cloth media filters received a *neutral* rating with respect to sludge impacts.

The cloth media fabric requires periodic cleaning with a sodium hypochlorite solution, but does not require chemical addition for normal operations, which is why it received a *neutral* score with respect to chemical handling/hazards.

While cloth media filters for primary and CSO treatment is still an emerging application, they will be considered as a viable treatment alternative for the East Side WWTP. Their advantageous small facility footprint would allow for primary treatment of dry and peak wet weather CSO flows for the largest flow scenarios being considered while staying within the available site constraints.

High Rate Clarification

The main benefit with HRC is its compact footprint. With surface overflow rates orders of magnitude greater than traditional primary settling and also CEPT, HRC facilities have footprints that are greatly reduced even when accounting for all the ancillary support equipment. For comparison purposes, an 80 mgd dual use primary/wet weather facility would be 40 to 50 percent smaller than a 40 mgd traditional primary system. Similar to the cloth media filter technology, HRC would allow for primary treatment of dry and peak wet weather CSO flows for the 80 mgd scenarios being considered while staying within the available site constraints. For this reason, this alternative was assigned a *favorable* rating for site utilization.

HRC is a common process in the wastewater industry for applications ranging from wet weather treatment to primary treatment to tertiary treatment for advance nutrient and solids removals. There are installations throughout the country up to flows of 250 mgd for the largest CSO applications. This alternative was assigned a *neutral* rating for success at other installations and reliability.

The HRC system is installed in concrete tanks. The tanks can largely be covered, or more likely the entire process would be installed within a building, allowing odors to be controlled, collected and treated. The influent and effluent channels could also be covered or located within the building. The process requires chemical use for normal operation, which will lead to the need for frequent chemical truck deliveries. Being able to capture and collect odorous air, but requiring chemical truck deliveries and truck traffic results in this alternative having a *neutral* rating for neighborhood impacts.

The HRC system has multiple pieces of operating equipment including coagulation and maturation tank mixers, settling tank collector drive, sand recirculation pumps, and chemical metering pumps that are in continuous operation. This option therefore receives an *unfavorable* rating for energy efficiency.

A disadvantage with HRC is the system complexity and increased level of operation and maintenance. There are many operating components in the system including coagulation and maturation tanks mixers, settling tank collectors and drive, tube or lamella plate settlers, ballast/sand recirculation pumps, and sand separation hydro-cyclones, all leading to increased

O&M costs. The system also requires chemical use, a metal salt and polymer, to promote the formation of heavy flocs required for rapid settling. This necessitates a sizable ancillary storage facility with multiple tanks and feed pumps. The system does however operate largely in an automatic mode with minimal operator input but would require operator input to bring trains on and offline as flows fluctuate. This alternative was assigned an *unfavorable* rating for ease of operation, and an *unfavorable* rating for ease of maintenance.

A new HRC facility would be constructed on land that is currently occupied by existing process(es), but the existing processes will be replaced by new processes located elsewhere. Primary treatment would be completed after other new processes have been constructed and put into operation, but the MOPO can be accommodated. Cloth media filters were assigned a *neutral* rating.

Primary treatment will be designed for the selected WWTP flow to treat both dry weather and peak wet weather flows. While not a straightforward effort, an HRC process could be built for an initial lower peak flow rate with the potential to construct additional system trains in future to increase treatment capacity. This alternative received a *neutral* rating.

HRC utilizes a coagulant, polymer, and sand ballast as part of the rapid settling process that will affect sludge composition and increase primary sludge production. For this reason, HRC received an *unfavorable* rating with respect to sludge impacts and also an *unfavorable* score with respect to chemical handling/hazards.

While a complex system, HRC will be considered as a viable treatment alternative for the East Side WWTP. Their advantageous smaller facility footprint would allow for primary treatment of dry and peak wet weather flows, or for standalone treatment of excess CSO flows only in conjunction with an alternate dry weather primary train, for the largest flow scenarios being considered while staying within the available site constraints.

Primary Treatment Non-Economic Evaluation Rating Summary

CEPT received the highest non-economic score of the primary treatment technologies. Cloth media disk filtration scored one less point than CEPT, and HRC and conventional secondary clarifiers received three less points than CEPT. Because each of these technologies received very similar non-economic ratings, they were all brought forward to the economic evaluation.

Primary Treatment Alternative Economic Evaluation

This section presents further evaluation of the primary treatment alternatives on an economic basis, including planning-level cost estimates for capital cost, annual O&M cost, and 20-year life cycle cost.

Economic Evaluation Assumptions

OPCCs were developed in order to assess the differences in lifecycle costs between the various alternative, and they include contractor's OH&P, contingency, and engineering and implementation. The OPCCs established for each alternative include allowances for site remediate and disposal of materials likely to be encountered during construction of the new facilities, based on site investigations previously conducted. The costs also include other site work allowances and demolition.

The following list includes a summary of the major assumptions that were common to each annual O&M estimate. Specific items related to each system are defined later in this section.

- All costs were calculated on an annual average basis, assuming average daily flows.
- All costs associated with chemical addition for chemically enhanced primary treatment are based on 50 days of operation (wet weather).
- All costs associated with chemical addition for high rate clarification are based on 365 days of operation.
- Annual maintenance costs for all new equipment were roughly estimated to be 5% of the equipment cost.

The primary treatment alternatives that require considerable ancillary consumable storage and feed facilities is the chemically enhanced primary treatment and the high rate clarification alternative. The cloth media disk filter system only requires a modest amount of sodium hypochlorite for periodic cleaning of the media fabric. **Table 7.3-11** identifies the chemical storage and feed facilities assumed for the high rate clarification facility and where they are assumed to be located. These assumptions were used to develop the opinions of probable cost for the high rate clarification alternative.

Table 7.3-11 Ancillary Facility Assumptions for Primary Treatment Alternatives

Primary Treatment Alternative	Ancillary Systems	Location	Additional Structures/Structure Modifications
Chemically Enhanced Primary Treatment	Coagulant and Polymer	Coagulant and polymer storage and feed facilities to be housed in a stand-alone facility to be located next to existing primary settling tanks.	Existing primary settling mechanical equipment to be upgrade and chemical storage and feed facility structure.
High Rate Clarification	Coagulant, Polymer, Microsand (ballast)	Coagulant, polymer and microsand storage and feed systems to be located within the new high rate clarification facility in the NW corner of the site.	New high rate clarification facility to be constructed.

Table 7.3-12 presents the total OPCC for the main components associated with each primary treatment alternative, the O&M costs, and the life cycle cost (as present worth). The OPCCs for this section include construction contingency but do not include project contingency or engineering and implementation costs. The present worth was calculated using the methodology described in Section 2.

Table 7.3-12 Estimated Costs for 40 mgd Primary Treatment Alternatives

	Traditional Primary Settling Tanks	Chemically Enhanced Primary Treatment	Cloth Media Disk Filters	High-Rate Clarification
Total OPCC	$22,210,000	$3,970,000	$20,350,000	$17,160,000
Annual O&M Cost Estimate	$300,000	$480,000	$370,000	$560,000
Present Worth of 20-year Life Cycle Costs	**$20,500,000**	**$13,500,000**	**$22,000,000**	**$23,600,000**

Because each technology is not feasible at different flowrates, as an 80 mgd CEPT system and an 80 mgd traditional primary system would be a challenge to site, 80 mgd primary treatment alternatives were limited to cloth media disk filters and high-rate clarification. **Table 7.3-13** presents the OPCC for the main components associated with each preferred alternative.

Table 7.3-13 Estimated Costs for 80 mgd Primary Treatment Alternatives

	Cloth Media Disk Filters	High-Rate Clarification
Total OPCC	$24,810,000	$24,320,000
Annual O&M Cost Estimate	$370,000	$560,000
Present Worth of 20-year Life Cycle Costs	**$25,500,000**	**$28,400,000**

Primary Treatment Alternatives Overall Evaluation

Table 7.3-14 presents the non-economic weighted scores (from Table 7.3-1) and the economic rankings and weighted scores (based on the costs from Table 7.3-5) for the four primary treatment alternatives at a 40 mgd WWTP plant flow.

Table 7.3-14 Overall (Economic and Non-Economic) Evaluation of 40 mgd Primary Treatment Alternatives

Criteria	Maximum Score	Traditional Primary Settling Tanks	Chemically-Enhanced Primary Treatment	Cloth Media Disk Filters	High-Rate Clarification
Non-Economic					
Weighted Non-Economic Score	40	19	20	26	22
Economic					
Weighted Economic Score	*60*	40	60	37	34
Overall Evaluation Score	**100**	**59**	**80**	**63**	**57**

For the 40 mgd options, the primary cloth filters received the highest non-economic score of the four alternative technologies. Because the CEPT option was the lowest cost option on a present worth basis due to low O&M and capital costs, it received the highest economic score. Overall, CEPT received the highest combined score, and traditional primary settling tanks and cloth media disk filters received nearly the identical second highest combined scores of 59 and 63, respectively.

Selection of the primary treatment technology needs to take into account this economic and non-economic evaluation, but it also needs to look at how the process integrates into the overall treatment plant improvements plan from a holistic standpoint. While CEPT allows for continued use of the existing primary tanks, its operation in wet weather is heavily reliant on chemical (coagulant and a polymer) usage for treatment of elevated flows. And while the traditional primary settling tank alternative does present some distinct benefits and attains a favorable overall ranking, the sheer size of the process makes this system a significant challenge to site while also siting other new required treatment processes and facilities within that available footprint.

For these reasons, CEPT and traditional primary settling are not recommended for implementation at the East Side WWTP for the 40 mgd flow scenarios, with cloth media disk filtration being the preferred alternative for primary treatment. Additional benefits with this system is that it will function as a single, dual-use dry and wet weather process by varying the number of filter units in service, it will produce a quality primary effluent that will reduce the loading on the downstream BNR process, and result in a higher quality effluent during a secondary system bypass. The system can be a fully enclosed facility easing maintenance and odor control, and the technology will be similar to the recommended primary technology for the West Side WWTP.

Table 7.3-15 presents the non-economic weighted scores (from Table 7.3-1) and the economic rankings and weighted scores (based on costs from Table 7.3-6) for the two primary treatment alternatives at an 80 mgd WWTP flow.

Table 7.3-15 Overall (Economic and Non-Economic) Evaluation of 80 mgd Primary Treatment Alternatives

Criteria	Maximum Score	Cloth Disk Filters	High Rate Clarification
Non-Economic			
Weighted Non-Economic Score	40	26	22
Economic			
Weighted Economic Score	*60*	60	54
Overall Evaluation Score	**100**	**86**	**76**

For the 80 mgd analysis, the primary cloth filters received the highest non-economic score of the two alternative technologies. Because the cloth filter option was the lowest cost option on a present worth basis, it received the highest economic score. Overall, cloth filters received the highest combined score over the HRC alternative.

Based on this higher overall ranking score, and for similar reasons to the 40 mgd scenarios, cloth media disk filtration is the preferred alternative for primary treatment for the 80 mgd scenarios.

Similar to the West Side WWTP, since cloth media filters are a relatively new technology for use in primary and high flow management applications, an on-site pilot study of the technology should be conducted to confirm system performance, confirm the design criteria used in the final design (e.g. hydraulic and solids loading rates), assess percent BOD_5 and TSS removal through the system to aid in the design of the downstream BNR and disinfection systems, and assess system backwash requirements and estimated solids generation rates/quantities to aid the design of the sludge management systems (gravity thickeners).

7.3.4.2 Biological Nutrient Removal Alternatives- Detailed Evaluation

This section presents the non-economic and economic evaluations of the most viable nitrogen removal alternatives identified in the previous section. Based on the results of the nitrogen removal evaluation, the recommended nutrient removal improvements are summarized at the end of this section.

Biological Nutrient Removal Non-Economic Evaluation

Table 7.3-16 presents the rankings for each of the criteria for the three BNR alternatives. A rating of 5 indicates the most favorable rating, while a ranking of 1 indicates least favorable. The weighted score represents the points awarded for each rating based on criterion weight.

Table 7.3-16 Non-Economic Biological Nutrient Removal Alternative Rankings

Rating Legend *5= favorable* *3= neutral* *1= unfavorable*	Alternative Process Description	Alternative Suspended Growth Activated Sludge Configuration: Four-Stage Bardenpho		Integrated Activated Sludge Process: Integrated Fixed Film Activated Sludge (IFAS)		Membrane Bioreactors (MBRs)	
	Maximum Score for Criteria	Rating	*Weighted Score*	Rating	*Weighted Score*	Rating	*Weighted Score*
Site Utilization	10	3	*6.0*	5	*10.0*	3	*6.0*
Success at Other Installations/ Reliability	8	3	*4.8*	3	*4.8*	5	*8.0*
Neighborhood Impacts	4	5	*4.0*	5	*4.0*	5	*4.0*
Energy Efficiency	4	5	*4.0*	5	*4.0*	1	*0.8*
Ease of Operations	3	5	*3.0*	5	*3.0*	1	*0.6*
Ease of Maintenance	3	3	*3.0*	3	*1.8*	1	*3.0*
Maintenance of Plant Operations	2	3	*1.2*	1	*0.4*	5	*0.4*
Ability to Phase Implementation	2	3	*1.2*	5	*2.0*	1	*0.4*
Sludge Impacts	2	5	*1.2*	3	*1.2*	1	*0.4*
Chemical Handling/Hazards	2	3	*1.2*	3	*1.2*	1	*0.4*
Non-Economic Total Weighted Score	**40**	**--**	***30***	**--**	***32***	**--**	***23***

Table 7.3-17 includes the detailed evaluation used to determine the rankings for each of the alternatives.

Table 7.3-17 Detailed Evaluation of Biological Nutrient Removal Alternatives Non-Economic Criteria

Alternative Process Description	Alternative Suspended Growth Activated Sludge Configuration	Integrated Activated Sludge Process: Integrated Fixed Film Activated Sludge (IFAS)	Membrane Bioreactors (MBRs)
Non-Economic Criteria	**Four-Stage Bardenpho**	**Kruger AnoxKaldnes**	**Suez ZeeWeed**
Site Utilization	Implementing the four-stage process requires the volume of existing primary settling tanks to be converted to pre-anoxic volume along with the volume of existing BNR tankage.	Smallest process footprint. Can be implemented within the existing BNR basins and does not require the construction of any additional tankage nor large, supporting facilities.	Largest process footprint. Three-stage process upstream of MBRs can be constructed within existing BNR tankage. New MBR facility will need to be constructed. The MBR facility cannot be built in the footprint of the existing secondary clarifiers because the secondary clarifiers must remain operational until the MBR facility is fully operational.
Success at Other Installations/ Reliability	Common process used at large-scale BNR facilities to achieve nitrogen removal. Fully conventional, suspended growth activated sludge process performance is largely susceptible to cold temperatures and changing flow and loading conditions, which can negatively impact effluent quality.	Technology has been successfully implemented at other large-scale BNR facilities. There have been numerous process upsets related to media loss, but Kruger has made process design adjustments to minimize process upsets. Including attached growth with suspended growth promotes a more robust system less susceptible to process upsets.	System has been successfully implemented at other similarly-sized facilities. The process relies on physical separation (ultrafiltration) which reliably produces high quality effluent, minimizing potential process upsets.
Neighborhood Impacts	The process does not add additional open tankage compared to the existing process, so alternative is not expected to have added neighborhood impacts.	The process can be implemented within the existing BNR tankage, so alternative is not expected to have added neighborhood impacts.	The MBR facility can be located within the existing property line, so there is no additional site requirements associated with the MBR BNR alternative. Additionally, the MBR facility will eliminate the need for the large secondary clarifiers.
Energy Efficiency	Least energy intensive process of the alternatives.	Second least energy intensive process of the alternatives.	Most energy intensive process of the alternatives. MBRs are not considered to be a sustainable process due to the continuous permeate pumping required along with high recycle flow (RAS) pumping rates (5X the design ADF).
Ease of Operations	There would be no increase in operational complexity compared to operating the existing MLE process.	There would be no increase in operational complexity compared to operating the existing MLE process.	The three-stage activated sludge process would be no more operationally intensive than the current operating MLE system. However, operating the MBR system will be more complex than conventional, secondary clarifiers.
Ease of Maintenance	There would be no substantial increase in maintenance requirements compared to operating the existing MLE process. The only added piece of equipment to be maintained is a submersible mixer in the second anoxic zone.	Process includes most of the equipment currently used in the plant's MLE process; submersible IR pumps and mixers. New media retention screens used to keep plastic media within dedicated zones is routinely cleaned with automated air sparge systems. The process utilizes coarse/medium bubble aeration which requires less frequent maintenance compared to fine bubble diffused aeration.	A three-stage activated sludge process (submersible mixers, IR pumps, aeration equipment, and instrumentation) will require routine mechanical maintenance, in addition to the equipment that makes up the MBR system, itself. MBRs require routine chemical cleanings: maintenance cleanings twice per week with sodium hypochlorite (200 mg/L dose) and once per week with citric acid (2,000 mg/L) dose. Mechanical equipment requiring routine mechanical maintenance include air scour blowers, permeate pumps, WAS pumps, and large RAS pumps.
Maintenance of Plant Operations	Primary treatment must be achieved elsewhere on site before the existing primary clarifiers can be converted to pre-anoxic zones. Would require temporary bypassing to aeration tanks while converting primary tanks to pre-anoxic zones.	IFAS manufacturer needs to modify internal baffle walls/partitions within the basins to create individual media zones. A portion of the channel currently utilized for step feed operation will be converted to a transfer channel. Two basins will need to be offline at a time since each pair of BNR basins is tied to a secondary clarifier.	New post-anoxic tanks and MBR facility can be constructed as demolition occurs and space becomes available. The existing MLE process will undergo basic mechanical upgrades, but does not require substantial modifications be made to the BNR basins, themselves. When the post-anoxic tanks and MBR facility is constructed, flow can be diverted from the MLE process without disrupting other plant operations.
Ability to Phase Implementation	No ability to phase implementation; four-stage process is required to achieve present day treatment objectives. Primary settling tanks must be constructed at once.	With reconfiguration of existing BNR basins complete, vendor can fill IFAS zones to lesser fraction of media and add media when flows and loads increase.	Existing MLE process requires post anoxic tanks to convert to the three stage process upstream of MBRs. Because MBRs are a clarification process, they are sized based on hydraulics. Because the secondary system's existing capacity of 58 mgd will be maintained, there is no way to phase MBR implementation.
Sludge Impacts	Overall process improvement with respect to nitrogen removal (and pre-anoxic some configuration) should improve thickening characteristics due to decreasing the amount of filamentous bacteria present in the current activated sludge. Despite improvement sludge settling characteristics, sludge production quantities would not be reduced.	Attached growth biofilm that sloughs off of the plastic media carriers typically results in improved settling characteristics compared to traditional suspended growth (only) activated sludge processes.	Because MBRs reduce effluent TSS levels to single-digits, more TSS will be removed from the process which will increase sludge production.
Chemical Handling/Hazards	Magnesium hydroxide would be required to maintain neutral pH in primary effluent, which would replace the existing sodium hydroxide system. Supplemental carbon may be required during certain times of the year to drive denitrification through winter months.	Magnesium hydroxide would be required to maintain neutral pH in primary effluent, which would replace the existing sodium hydroxide system. Supplemental carbon may be required during certain times of the year to drive denitrification through winter months.	May require supplemental carbon to increase denitrification in certain months to drive average annual effluent nitrogen loading down. The process, similar to each of the processes, will also require supplemental alkalinity/pH adjustment using magnesium hydroxide to be fed to primary effluent. MBRs require routine cleanings with sodium hypochlorite and citric acid. Initial preliminary design data estimates 14,900 gal/year of sodium hypochlorite and 11,900 gallons/year of citric acid.

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Four-Stage Bardenpho

The four-stage Bardenpho process is a completely conventional suspended growth activated sludge process. This alternative requires the primary settling tanks to be converted to pre-anoxic volume. This was assigned a *neutral* rating for site utilization.

The four-stage Bardenpho process is a common process used at facilities of all sizes to achieve nitrogen removal. The process is a conventional, suspended growth activated sludge process. Process performance (notably nitrogen removal) is susceptible to changing flows and loads, and particularly susceptible to cold New England winter temperatures. This alternative was assigned a *neutral* for the first criterion.

The four-stage Bardenpho process does not require any additional tankage to be constructed on site. General upgrades to the existing tanks should improve process performance and should also reduce present-day neighborhood impacts. For these reasons it was awarded a *favorable* rating with respect to neighborhood impacts.

This alternative is the least energy intensive process of the three alternatives, so it received a *favorable* rating with respect to energy efficiency.

The four-stage Bardenpho process would not increase operational complexity. This was assigned a *favorable* rating with respect to ease of operations. Similarly, converting the existing MLE process to a four-stage process would not increase ease of maintenance, as the equipment with a four-stage process is no different than the equipment used with the existing MLE process. This was assigned a *favorable* rating with respect to ease of maintenance.

Before the existing primary settling tanks are constructed, primary clarification must be achieved elsewhere on site before those tanks are converted to pre-anoxic volume. The four-stage Bardenpho process was awarded *neutral* with respect to maintenance of plant operations.

To convert existing primary clarifiers to pre-anoxic tanks, a primary treatment will need to be accomplished elsewhere onsite before modifications to the existing primary settling tanks can begin.

There is no practical way to phase implementation since all pre-anoxic tanks must be online to reliably accomplish treatment objectives. Because of this, this alternative was awarded a *neutral* rating with respect to ability to phase implementation.

By achieving more nitrogen removal, the process improvements will result in sludge production with better settling characteristics compared to present day operation, with a properly configured pre-anoxic zone. Despite improving sludge settling characteristics, sludge production should not change from present-day conditions, so it received a *neutral* rating with respect to sludge impacts.

The four-stage process may require supplemental carbon to increase denitrification during certain months throughout the year to improve denitrification. The process, similar to each of the processes, will also require supplemental alkalinity/pH adjustment using magnesium hydroxide to be fed to primary effluent. This alternative received a *neutral* rating with regards to chemical handling/hazards.

AnoxKaldnes IFAS

The IFAS process can be implemented within the existing BNR basins and does not require the construction of any additional tankage nor large supporting facilities, and thus it was assigned a *favorable* rating for site utilization.

IFAS has been successfully implemented at other similarly-sized facilities throughout the country. There have been numerous IFAS process upsets reported throughout the country related to media loss. As a leader in IFAS technology, Kruger has implemented added safety precautions into the current design to reduce the risk of media loss through the system (notably by minimizing hydraulic flux through the IFAS reactors). IFAS combines conventional suspended growth activated sludge with fixed-film activated sludge which intensifies secondary treatment and is considered to be a more robust process compared to conventional suspended growth (only) activated sludge processes. Because of these reasons, IFAS received a *neutral* rating with regards to success at other installations and reliability.

IFAS can be implemented into the existing BNR basins, which should not negatively impact the surrounding neighborhood. For this reason, IFAS was awarded a *favorable* rating for neighborhood impacts.

The IFAS system was awarded a *neutral* rating with respect to energy efficiency since it is the second least energy intensive alternative.

There would be no increase in operational complexity compared to operating the existing MLE process. For this reason, the IFAS technology was awarded a *favorable* for the ease of operations criterion.

The IFAS process includes most of the equipment that is currently used in the existing MLE process, including submersible IR pumps and mixers. The IFAS process does include new media retention screens that are used to keep the IFAS plastic media within the dedicated IFAS zones. The IFAS process utilizes medium or coarse bubble aeration which is simpler to maintain, compared to fine bubble diffused aeration which requires routine membrane cleaning and replacement. For those reasons, the IFAS process was awarded a *neutral* rating for ease of maintenance.

Modifications to the existing BNR basins will be required to compartmentalize individual zones within the existing BNR basins and will require a portion of the step feed channel to be converted to a transfer channel. Two basins will need to be offline during demolition and construction because each pair of reactors is tied to a secondary clarifier. When two trains are offline, the dedicated secondary clarifier can undergo mechanical upgrades. Because of the complexity of construction sequencing required to implement the IFAS system, it received a *unfavorable* rating with regards to maintenance of plant operations.

Upon reconfiguration of the existing BNR basins, the vendor can fill the IFAS zones to a lesser fill fraction of media to treat present day flows and loads and can add media as required in the future to maximize biological treatment. Because of this flexibility, IFAS was awarded a *favorable* rating with respect to process flexibility and ability to phase implementation.

With a newly configured pre-anoxic zone, sludge settling characteristics should improve compared to current sludge characteristics. Furthermore, the sludge produced from IFAS process typically exhibits better settling characteristics (SVI) compared to sludge from conventional plants, likely attributed to extracellular polymeric substances (EPS) within attached growth biofilms that regularly slough off the plastic media carriers. Despite improved sludge settling characteristics afforded by implementing IFAS, sludge generation is not anticipated to change. For these reasons, IFAS received a *neutral* rating with respect to sludge impacts.

Like the four-stage Bardenpho process, IFAS may require supplemental carbon to increase dentification in certain months of the year to drive the average annual effluent nitrogen loading down. The process, similar to each alternative, will also require supplemental alkalinity/pH adjustment using magnesium hydroxide to be fed to primary effluent. For these reasons, this alternative received a *neutral* rating with respect to chemical handling/hazards.

Membrane Bioreactors

Although the three-stage process upstream of the MBRs can be implemented within the footprint of the existing BNR basins, a large new MBR facility must be constructed. The MBR facility cannot be built in the footprint of the existing secondary clarifiers because the secondary clarifiers must remain operational until the MBR facility is fully operational. However, because the MBR replaces the function of the secondary clarifiers, it allows the secondary clarifiers to be demolished, which can free up space for other processes. For these reasons, it was assigned a *neutral* rating with respect to site utilization.

MBR technology has been implemented at many similarly sized WWTPs throughout the world. MBRs rely on ultrafiltration to remove particles from the wastewater, thereby discharging a very high-quality effluent with low effluent TSS, and low effluent particulate and colloidal nitrogen. For these reasons, MBRs have been used to achieve very low effluent nitrogen concentrations. MBRs are a physical barrier which filter particulates which makes them a reliable process and reduces risk of process upsets. Because of this, MBRs received a *favorable* rating with respect to success at other installations and reliability.

As discussed previously, truck deliveries of citric acid will be needed for the MBR process. The MBR alternative as assigned a *neutral* with respect to neighborhood impacts.

MBRs were determined to be the most energy intensive process evaluated. MBRs are not considered to be a sustainable technology because of the energy required to operate the process. Continuous permeate pumping is required along with high recycle flow rates. Because of these energy intensive items, MBRs received an *unfavorable* rating with respect to energy efficiency.

The MBR process will need to be operated in addition to the three-stage activated sludge process upstream of the MBRs. This increases operational complexity, since operating MBRs is more challenging compared to operating conventional secondary clarifiers. For this reason, MBRs were assigned an *unfavorable* rating with respect to ease of operations.

MBRs require substantial maintenance. In addition to the MBR facilities, the three-stage activated sludge process upstream of the MBRs have mechanical equipment that will need to be maintained. MBRs require routine sodium hypochlorite cleanings to reduce biofouling through the membrane and periodically require soaks in citric acid to increase membrane flux. In addition to the routine cleanings, the automated air scour blower systems will be used to keep the membranes clean and introduce air into the process. Because return rates are so high with MBR's, large RAS and WAS pumps will be required that will require routine mechanical maintenance. For these reasons, the MBR was assigned an *unfavorable* rating with respect to ease of maintenance.

The MBR facility and post-anoxic tanks will need to be constructed on site before the secondary clarifiers are taken offline. The existing MLE configuration will go through general mechanical upgrades but does not require substantial modifications to the existing tankage. When the MBR facility and post-anoxic tanks are constructed, flow can be diverted from the MLE process to the new facilities. Because of the ease of construction sequencing without needing to take processes offline, MBR alternative received a *favorable* rating with respect to maintenance of plant operations.

As a clarification process, MBRs are designed to treat hydraulic flows. Because the secondary system's capacity will be maintained at existing 24 mgd capacity, there will be no additional flow to treat under future conditions, and no way to phase MBR implementation. For this reason, MBRs received an *unfavorable* rating for phased implementation.

Because MBRs reduce effluent TSS to low, single-digit concentrations, more TSS will be consistently removed throughout the year, which will result in increased sludge production. Because of this, it received an *unfavorable* rating with regards to sludge impacts.

MBRs require routine chemical cleanings with sodium hypochlorite and citric acid to reduce biofouling and increase flux through the membranes themselves. In addition to the chemicals associated with the MBRs, the three-stage process upstream of the membranes will require supplemental alkalinity addition for pH adjustment with magnesium hydroxide and supplemental carbon addition to increase denitrification throughout certain times of the year. MBRs received an *unfavorable* rating with respect to chemical handling/hazards.

Non-Economic Evaluation Rating Summary

The IFAS system received the highest non-economic rating of the three alternatives. Despite it receiving the highest non-economic rating, all three alternatives were brought forward to be evaluated on an economic basis.

Biological Nutrient Removal Economic Evaluation

This section presents further evaluation of the nitrogen removal alternatives on an economic basis, including planning-level cost estimates for capital cost, annual operations and maintenance (O&M) cost, and 20-year life cycle cost.

Economic Evaluation Assumptions

OPCCs were developed in order to assess the differences in lifecycle costs between the various alternative, and they include contractor's OH&P, construction contingency, and escalation to the midpoint of construction. The OPCCs established for each alternative include allowances for site remediation and disposal of materials likely to be encountered during construction of the new facilities, based on site investigations previously conducted. The costs also include other site work allowances and demolition.

The following list includes a summary of the major assumptions that were common to each annual O&M estimate. Specific items related to each system are defined later in this section.

- All costs were calculated on an annual average basis, assuming an average daily design flow.
- All costs associated with chemical addition for nitrogen removal and the add-on nitrogen removal alternative are based on 365 days of operation.
- All costs associated with the BNR tank operation (mixers) are assumed to apply 365 days per year.
- Annual maintenance costs for all new equipment were roughly estimated to be 5% of the equipment cost.

Table 7.3-18 identifies the chemical storage and feed facilities assumed for each alternative and where they are assumed to be located. Any additional structures or major structure modifications required for each alternative are also identified. These assumptions were used to develop the opinions of probable cost for each nutrient removal alternative.

Table 7.3-18 Ancillary Facility Assumptions for Biological Nutrient Removal Alternatives

BNR Alternative	Ancillary Systems	Location	Additional Structures/Structure Modifications
Four-Stage Bardenpho	MicroC 2000, Magnesium Hydroxide	Supplemental carbon storage tanks located outside of Blower Building, supplemental alkalinity storage tanks to be located within Blower Building along with carbon and alkalinity feed systems	NA
Integrated Fixed Film Activated Sludge (IFAS)	MicroC 2000, Magnesium Hydroxide	Supplemental carbon storage tanks located outside of Blower Building, supplemental alkalinity storage tanks to be located within Blower Building along with carbon and alkalinity feed systems	Reconfigure internal baffle walls and channel currently used for step feed operation
Membrane Bioreactors (MBRs)	MicroC 2000, Magnesium Hydroxide, Citric Acid, Sodium Hypochlorite	Supplemental carbon storage tanks located outside of Blower Building, supplemental alkalinity storage tanks to be located within Blower Building along with carbon and alkalinity feed systems; citric acid and sodium hypochlorite storage and feed equipment located in new MBR facility	MBR facility to be constructed

Table 7.3-19 presents the total OPCC for the main components associated with each nitrogen removal alternative, the O&M costs, and the life cycle cost (as present worth). The OPCCs for this

section include construction contingency but do not include project contingency or engineering and implementation costs. The present worth was calculated using the methodology described in Section 2.

Table 7.3-19 Estimated Costs for Biological Nutrient Removal Alternatives

	Alternative Suspended Growth Activated Sludge Configuration	Integrated Activated Sludge Process: Integrated Fixed Film Activated Sludge (IFAS)	Membrane Bioreactors (MBRs)
	Four-Stage Bardenpho	Kruger AnoxKaldnes	Suez ZeeWeed
Total OPCC	$11,270,000	$15,140,000	$49,660,000
Annual O&M Cost Estimate	$ 600,000	$960,000	$2,460,000
Present Worth of 20-year Life Cycle Costs	**$21,120,000**	**$32,060,000**	**$90,860,000**

The MBR alternative had a substantially higher OPCC and annual O&M costs compared to the other two alternatives. Both the OPCC and annual O&M estimated costs for the four-stage Bardenpho were the lowest of the three alternatives. Because of this, the present worth of the four-stage Bardenpho was the lowest of the three alternatives evaluated.

Biological Nutrient Removal Alternatives Overall Evaluation

Table 7.3-20 presents the non-economic weighted scores (from Table 7.3-10) and the economic rankings and weighted scores (based on the costs from Table 7.3-19) for the three biological nutrient removal alternatives.

Table 7.3-20 Overall (Economic and Non-Economic) Evaluation of Biological Nutrient Removal Alternatives

Criteria	Maximum Score	Alternative Suspended Growth Activated Sludge Configuration	Integrated Activated Sludge Process: Integrated Fixed Film Activated Sludge (IFAS)	Membrane Bioreactors (MBRs)
		Four-Stage Bardenpho	Kruger AnoxKaldnes	Suez ZeeWeed
Non-Economic				
Weighted Non-Economic Score	40	30	32	23
Economic				
Weighted Economic Score	*60*	60	40	14
Overall Evaluation Score	**100**	**90**	**72**	**37**

The IFAS alternative received a slightly higher non-economic score than the four-stage Bardenpho alternative. Despite similar non-economic scores, the four-stage Bardenpho alternative had the lowest present worth of 20-year life cycle cost because it had the lowest OPCC and annual O&M estimates, and therefore received the highest economic score. The overall evaluation score for the four stage Bardenpho alternative was 90 out of 100. Thus, implementation of the four-stage Bardenpho system is recommended to ensure permit compliance with the current average annual effluent nitrogen loading limit at the East Side WWTP.

7.3.5 Summary and Recommendation

Treatment summaries, conceptual layouts, and OPCCs for each of the East Side WWTP alternatives were presented in Table 7.3-1 though Table 7.3-8 and Figure 7.3-1 through Figure 7.3-8. A complete cost summary included as **Table 7.3-21** presents the OPCCs for all the East Side WWTP alternatives. This table breaks the total construction cost into individual work areas, and includes engineering, contingency and land acquisition to arrive at a total project cost. All costs are in 2020 dollars and do not include escalation to the midpoint of construction.

Of the unique unit processes evaluated, cloth filtration was determined to be the most preferred primary/wet weather treatment technologies at 40 mgd and 80 mgd largely because of its compact size, ease of operation, lack of chemical requirement, and high performance. Of the biological nutrient removal alternatives, the conventional four-stage Bardenpho process was determined to be the more preferred alternative largely because if its present worth cost.

Of the four, 40 mgd treatment options, Option E-40C, is the preferred option from the combined cost and non-cost criterion. The option has one of the lower costs and includes the preferred primary treatment and BNR alternatives. Although the cloth disk filtration technology is relatively new for primary and wet weather treatment applications, the saving in real estate helps keep capital costs down while minimizing the footprint of new facilities.

Of the four 80 mgd treatment options, Option E-80D, is the preferred option from the combined cost and non-cost criterion. This option is the lowest cost and includes the preferred primary treatment and BNR alternatives. With a higher peak flowrate of 80 mgd, space becomes more limited. Utilizing the compact primary filters eases the siting of other required treatment processes and ancillary infrastructure.

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Table 7.3-21: East Side WWTP - Preliminary Construction Costs

Item	40 MGD				80 MGD			
	E-40A Trad Primary & 4-Stage	E-40B Dual Use CEPT & IFAS	E-40C Dual Use Primary Filter & 4-Stage	E-40D Dual Use Primary Filter & MBR	E-80A Trad Primary, HRC & MBR	E-80B Trad Primary, HRC & IFAS	E-80C Dual Use Primary Filter & MBR	E-80D Dual Use Primary Filter & 4-Stage
Site Work & Yard Piping	$ 16,000,000	$ 16,400,000	$ 16,200,000	$ 16,700,000	$ 18,800,000	$ 18,100,000	$ 18,200,000	$ 17,600,000
Demolition	$ 4,700,000	$ 4,700,000	$ 4,700,000	$ 6,700,000	$ 6,700,000	$ 4,700,000	$ 6,700,000	$ 4,700,000
Headworks	$ 23,000,000	$ 23,000,000	$ 23,000,000	$ 23,000,000	$ 29,500,000	$ 29,500,000	$ 29,500,000	$ 29,500,000
Primary Treatment	$ 18,200,000	$ 3,300,000	$ 16,700,000	$ 16,700,000	$ 2,700,000	$ 2,700,000	$ 20,300,000	$ 20,300,000
Wet Weather Treatment	$ -	$ -	$ -	$ -	$ 14,100,000	$ 14,100,000	$ -	$ -
BNR	$ 4,700,000	$ 8,500,000	$ 4,700,000	$ 5,900,000	$ 9,400,000	$ 8,500,000	$ 5,900,000	$ 4,700,000
Final Settling	$ 4,500,000	$ 4,500,000	$ 4,500,000	$ 25,600,000	$ 25,600,000	$ 4,500,000	$ 25,600,000	$ 4,500,000
Disinfection	$ 4,800,000	$ 4,800,000	$ 4,800,000	$ 4,800,000	$ 8,000,000	$ 8,000,000	$ 8,000,000	$ 8,000,000
Effluent Pumping Station	$ 4,900,000	$ 4,900,000	$ 4,900,000	$ 4,900,000	$ 7,900,000	$ 7,900,000	$ 7,900,000	$ 7,900,000
Solids Processing	$ 12,600,000	$ 12,600,000	$ 12,600,000	$ 12,600,000	$ 12,600,000	$ 12,600,000	$ 12,600,000	$ 12,600,000
Odor Control	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000	$ 2,700,000
Site Electrical	$ 10,000,000	$ 10,000,000	$ 10,000,000	$ 10,000,000	$ 11,500,000	$ 11,500,000	$ 11,500,000	$ 11,500,000
Control Building	$ 4,600,000	$ 4,600,000	$ 4,600,000	$ 4,600,000	$ 4,600,000	$ 4,600,000	$ 4,600,000	$ 4,600,000
Total Construction Cost	$ 110,700,000	$ 100,000,000	$ 109,400,000	$ 134,200,000	$ 154,100,000	$ 129,400,000	$ 153,500,000	$ 128,600,000
Engineering (Des. & Const. Services (22%)	$ 24,400,000	$ 22,000,000	$ 24,100,000	$ 29,500,000	$ 33,900,000	$ 28,500,000	$ 33,800,000	$ 28,300,000
Overall Project Contingency (10%)	$ 11,100,000	$ 10,000,000	$ 10,900,000	$ 13,400,000	$ 15,400,000	$ 13,000,000	$ 15,400,000	$ 12,900,000
Land Acquisition, Easements, ROW	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Project Cost (Rounded)	$ 146,000,000	$ 132,000,000	$ 144,000,000	$ 177,000,000	$ 203,000,000	$ 171,000,000	$ 203,000,000	$ 170,000,000

Notes

- Costs in 2020 Dollars
- Costs do not include escalation to the midpoint of construction
- Overall Project Contingency carried is 10%. Typical contingency ranges from 10% to 25%.

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7.4 Detailed Evaluation of Plant Capacity

In order to assess various alternatives holistically across the community we must weigh the cost of increased capacity at the WWTPs against the cost of in-system improvements to reduce and/or eliminate CSOs. As presented in the treatment plant analyses above, there is obvious economy of scale with increased plant capacity, but also, with a larger facility, an expanded plant footprint that must be accommodated. In some cases, collection system improvements must be undertaken to enable full conveyance of flow to the WWTP during the 1-year, 24-hour storm. Alternatively, in-system improvements can capture CSOs at the source but could require remote storage tanks or a tunnel that must be constructed, operated and maintained (resulting in a higher overall cost).

In all alternatives, the baseline collection system recommendations described in **Section 3.6** should be implemented. These recommendations include; cleaning sewers, storage conduits, and siphons, continuing capacity, management, operations, and maintenance (CMOM) activities, and the repair of inoperable tide gates. Repair or replacement of any inoperable tide gates is recommended to reduce the amount of tidal inflow which not only increases extraneous flow to the treatment but can also adversely impact the operation of the biological system due to increased salinity. These baseline projects will help improve collection system conveyance and reduce CSOs. Sewer separation, green infrastructure projects, and infiltration and inflow (I/I) removal projects all contribute to reducing extraneous flows into the system and should move forward when viable.

7.4.1 CSO Reduction

The benefits of increased plant capacity were presented in **Section 6.2.** By increasing the capacity of the plants, a significant CSO volume can be captured in a 1-year, 24-hour storm event and associated CSO outfalls are controlled to the 1-year level, assuming some level of collection system improvements.

An alternative way to represent this information is to assess actual versus modeled flow to the treatment plants for the historic period of record January 2017 through December 2019, assuming no pipe replacement or cleaning. This information was used to produce **Figures 7.4-1 and 7.4-2.** These figures show observed maximum flow at the two treatment facilities versus simulated flow assuming no restrictions on plant influent. The area between the curves is representative of the flow that could be conveyed to the plant today if the capacity existed.

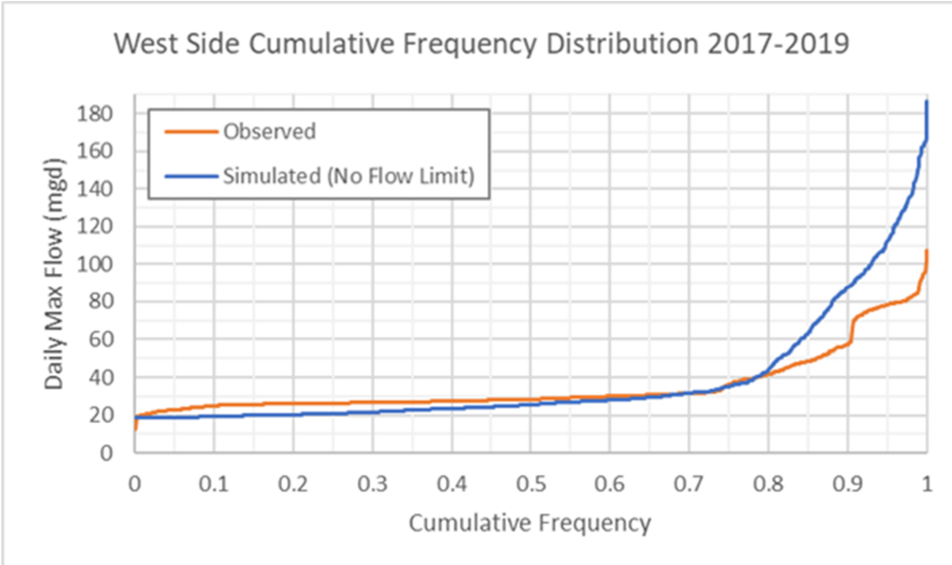

Figure 7.4-1
Observed versus Simulated Influent Flow to West Side WWTP

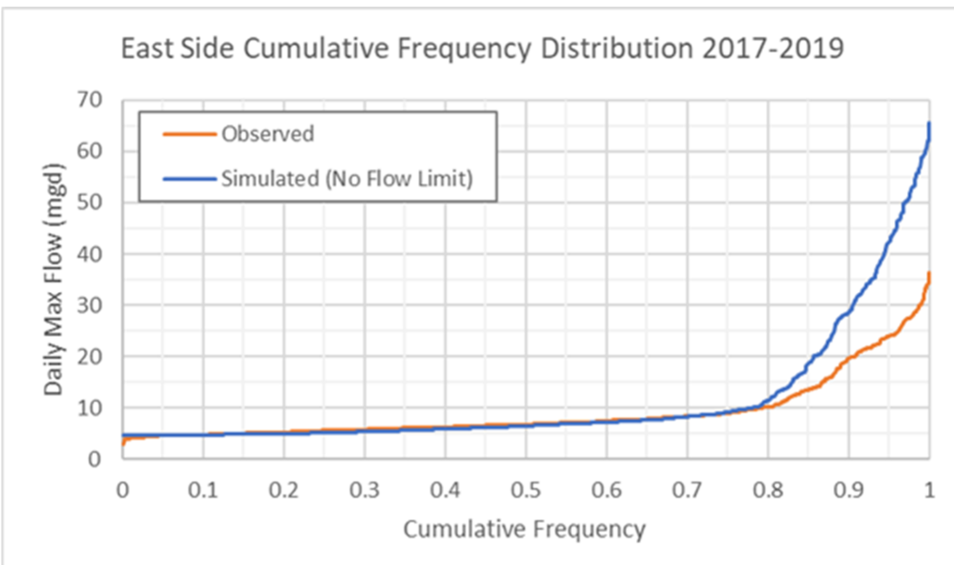

Figure 7.4-2
Observed versus Simulated Influent Flow to East Side WWTP

As presented, at the West Side plant, if influent flow was unrestricted, a peak flow of 186 mgd could have been conveyed to the plant. At the East Side a peak flow of 65 mgd could have been conveyed to the WWTP. Simulating the historic three-year period it is estimated that the CSO volume could be reduced by 20% simply by increasing the plant capacity. This equates to a range of 70 to 100 million gallons annually across the system. Cleaning of the interceptors, siphons, etc. could further increase the flow to the plant and reduce CSO volume. Implementing targeted recommended collection system improvements to limit pinch points in the system could potentially eliminate the need for remote storage tanks.

Based on this information, there is a clear benefit in increasing the capacity to the treatment facility since infrastructure currently exists to convey flow to the plants. For the West Side plant as shown in **Figure 7.4-3** (and discussed previously in Section 6.2), designing the plant to 180 mgd or 200 mgd (including conveyance improvements) results in the ability to meet the 1-year, 24-hour control level at 7 CSOs and produces a significant reduction in the volume of CSO discharged. On an annual basis using the three years of historic data as a guide, about 55 MG reduction in CSOs would be expected in the West Side collection system in a typical year and over 80 MG in a wet year. Much of this reduction comes through the reduction of CSOs designated ANTH and ARBOR, which are in close proximity to the treatment plant and responsible for the highest volume of CSOs in a 1-year, 24-hour event. For the East Side collection system, between 13 and 15 MG of CSO could be controlled on an annual basis representing a reduction of 35 to 45% in volume, with the CSOs responsible for the highest discharges (DEAC, STRAT and WANN) being controlled. Again, with additional pipeline cleaning and targeted conveyance improvements to eliminate bottlenecks, this CSO benefit could be increased.

Figure 7.4-3 and **Figure 7.4-4** depict the significant system wide CSO benefits (West Side and East Side respectively) for the 1-year, 24-hour storm as plant capacities are increased.

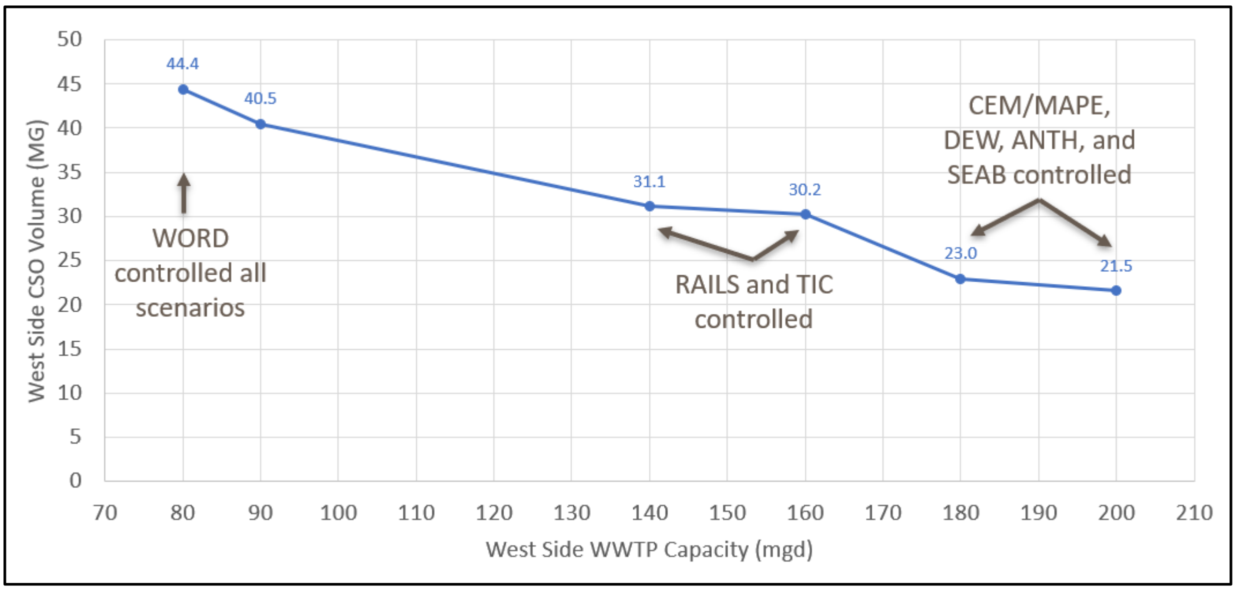

Figure 7.4-3
Simulated West Side WWTP Capacity vs CSO Volume during the 1-year, 24-hour Design Storm

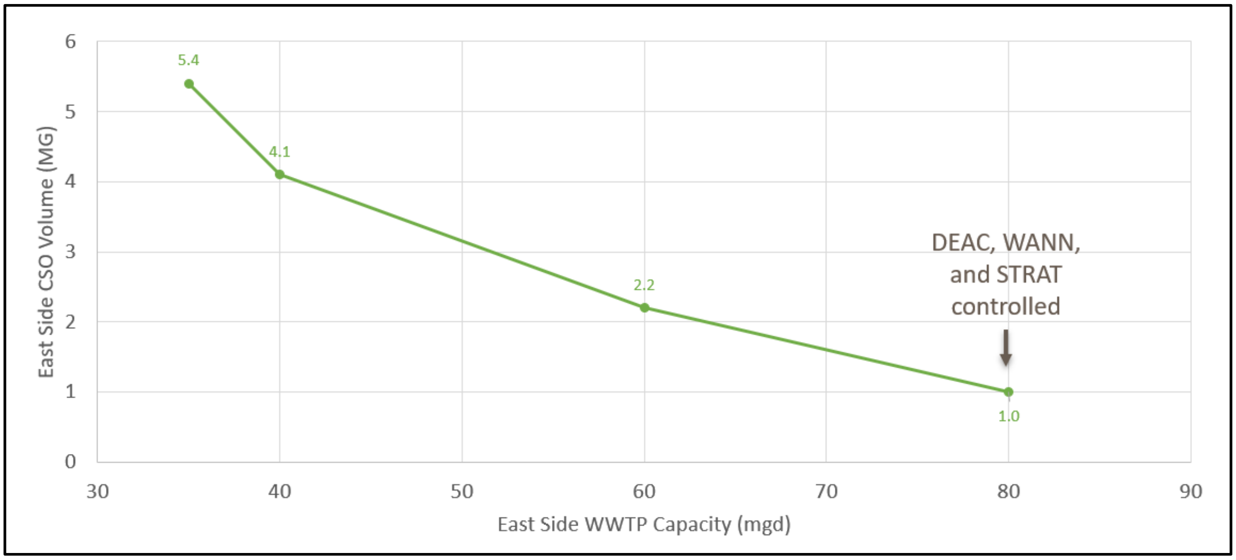

Figure 7.4-4
Simulated East Side WWTP Capacity vs CSO Volume during the 1-year, 24-hour Design Storm

As shown in Figures 7.4-3 and 7.4-4, increasing flow to the WWTPs results in the treatment of significant volumes of otherwise untreated flows that would be discharged into the receiving waters. Treated flows will receive (at a minimum) primary treatment and disinfection prior to discharge, thereby improving overall water quality in the local streams and harbors.

In 1995, EPA issued the guidance document Combined Sewer Overflows: Guidance for Nine Minimum Controls (NMCs). The intent of NMCs is not to completely eliminate CSOs, but to provide some CSO reduction while control plans are developed and implemented. One of the nine minimum controls is the maximization of flow to the WWTP for treatment. Expansion of the WWTP peak capacities at both plants will maximize the conveyance of flow to the WWTPs as recommended in the NMCs and reduce CSOs while additional controls are developed to control the remaining CSOs.

The collection system has the capacity to convey additional flow, and CSO volume can be greatly reduced if the WWTPs can accept the flow. Constructing the treatment plants to a lower peak capacity than the available conveyance of the collection system leaves the potential CSO and environmental benefits unrealized.

7.4.2 Recommended Improvements – Economic Evaluation

The design and construction of WWTP improvements to address the aging infrastructure and accommodate future flows and loadings are eligible for grant/loan funding through Connecticut's Clean Water Fund (CWF). This program, administered by Connecticut's Department of Energy and Environmental Protection (CT DEEP), has long provided financial assistance to Connecticut municipalities for projects addressing wastewater needs. Primary sources of funding for the CWF programs are state revolving fund revenue bonds and state general obligation bonds as managed by the Office of the State Treasurer, and federal capitalization grants through the Clean Water Act with annual appropriations through the U.S. Environmental Protection Agency (EPA). General improvements to address deficiencies and aging infrastructure are eligible for a 20 percent grant, nitrogen reduction facilities are eligible for a 30 percent grant, CSO reduction components are eligible for a 50 percent grant and the balance of project costs are eligible for a 2 percent 20-year loan.

DEEP has issued guidance documents for the nitrogen and CSO funding so that a clear and consistent methodology is used in determining CWF grant percentages. The guidance includes: <u>Clean Water Fund Memorandum 4 (CWFM-4) – Thirty percent (30%) Grant for construction costs related to BNR removal</u> and <u>Clean Water Fund Memorandum 2015-002 (CWFM-2015-002) – Combined Sewer Overflow Treatment Plant Project Grant / Loan Eligibility</u>. Both memos are included in **Appendix J**. Applying the various component eligibility criteria yields project grant eligibility ranging from about 21 to 23 percent for the baseline upgrade projects (i.e. no CSO capacity increase), and 30 to 40 percent for the expanded treatment capacity alternatives. To represent conservative assumptions for the financial capability analysis presented in Section 8 of this report, assumed aggregate grant percentages of 21 percent (for non CSO capacity increases) and 30 percent (for alternatives with CSO capacity increases will be carried forward.

As the plant size increases, more costs are associated with CSO management and therefore provide a benefit in the reduction in the share of the cost by the WPCA. This variation in the assumed aggregate grant percentages between the higher flow and baseline flow WWTP alternatives reduces the cost differential to construct a WWTP for a higher peak flow. The fraction of the cost to be paid by the WPCA for the low and high flow alternatives becomes closer, and the high flow plant alternatives provide a significant CSO benefit not seen with the lower flow options.

As presented in Section 6, various collection system improvements are required to optimize conveyance of flow to the treatment facilities for the higher peak flow alternatives. Cost of the improvements are summarized in **Table 7.4-1**. These collection system improvements are required to provide the stated levels of conveyance during the 1-year, 24-hour storm. As described in Section 6, the WWTP peak capacities of 180 and 200 mgd at the West Side WWTP and 80 mgd at the East Side WWTP can be achieved in storms greater than the 1-year, 24-hour design storm. This illustrates that higher flow WWTP options will still be utilized and can still be effective prior to construction of any collection system improvements.

Table 7.4-1 Recommended Collection System Improvement Project Costs

Collection System Alternative	Estimated Project Cost $2020
ESP2: East Side WWTP to 80 mgd	$10-12 Million
WSP3: West Side WWTP to 180 mgd[1]	$20-60 Million
WSP4: West Side WWTP to 200 mgd[1]	$20-60 Million

Note: 1) WSP3 and WSP4 include the same collection system improvements, but vary in WWTP peak capacity

The WPCA's 2011 Long-Term Control Plan (LTCP) evaluated a number of collection system alternatives for the control of CSOs to the one-year, 24-hour storm event. The LTCP recommended a combination of separation, relief sewers, storage tanks, and a storage tunnel to control the 1-year, 24-hour storm in the West Side collection system. The estimated capital cost of these improvements in 2010 was approximately $385 million (2010 dollars), escalated to today's dollars that program cost is approximately $496 million (2020 dollars). CSO reduction in the East Side collection system was not considered as a part of the 2011 LTCP.

At the West Side WWTP, the total project cost differential to increase the WWTP capacity from the most cost effective 90 mgd WWTP alternative (W-90B) to the most cost effective 200 mgd WWTP alternative (W-200C) is approximately $75 million (2020 dollars). Additionally, the high range of the WSP4 collection system improvements to convey 200 mgd during the 1-year, 24-hour storm is approximately $60 million (2020 dollars).Therefore, the total cost to increase the West Side WWTP from 90 mgd to 200 mgd and gain the full CSO benefit of the improvement is approximately $135 million. When CWF grants are considered the cost differential between the 90 and 200 mgd alternatives is even less because the CSO components of the 200 mgd alternative are eligible for a 50-percent grant. Constructing the West Side WWTP to 200 mgd and completing the collection system improvements outlined in WSP4 eliminates over half of the West Side CSO volume, and controls seven regulators during the 1-year, 24-hour storm. This significant CSO benefit can be provided for approximately 27% of the total 2011 LTCP program cost, and this benefit will be achieved more than 10 years sooner than the 2039 LTCP completion date. Following a LTCP update, the remaining CSO volume can be cost-effectively planned for and abated, including additional collection system metering and modeling to assess the true impacts of the increased plant capacity on the collection system.

At the East Side WWTP, the total project cost differential to increase the WWTP capacity from the most cost effective 40 mgd alternative (E-40B) to the most cost effective 80 mgd alternative (E-80D) is approximately $38 million (2020 dollars). When CWF grants are considered the cost differential between the 40 and 80 mgd alternatives is even less because the CSO components of the 80 mgd alternative are eligible for a 50-percent grant. The required ESP2 collection system improvements to convey 80 mgd during the 1-year, 24-hour storm are anticipated to cost approximately $12 million (2020 dollars). Therefore, the total cost differential to increase the East Side WWTP from 40 mgd to 80 mgd and obtain the complete CSO benefit is approximately $50 million (2020 dollars). These improvements are projected to reduce East Side CSO volumes by more than 80%, and control three of the six East Side regulators during the 1-year, 24-hour storm, again, 10 years sooner than improvements under the LTCP. Conveyance of 80 mgd to the East Side WWTP is expected to be similarly cost effective to the West Side WWTP, although the LTCP did not consider the cost of CSO control on the East Side.

The collection system improvements recommended in this report were developed with the best available information at the time the report was completed. Completing collection system alternatives WSP4 and ESP2 (for maximum conveyance at both WWTPs) and upgrading the WWTPs to 200 mgd (West Side WWTP) and 80 mgd (East Side WWTP) removes over half of the system wide CSO during the 1-year, 24-hour storm and is expected to control 10 of the 26 CSO regulators to the 1-year level of control.

7.5 Summary and Recommended Plan

Based on the analysis presented above, Option W-200C and Option E-80D are carried forward as the recommended plans for WWTP upgrade and expansion. These alternatives provide cost-effective treatment systems, in conjunction with holistic, cost-effective measures to control CSOs in the City by eliminating or reducing in size the remote facilities in the system as planned in the 2011 LTCP. By increasing plant capacity, additional flow can be conveyed to each facility for treatment. This benefit occurs immediately at plant start up and doesn't require the in-system improvements, although these improvements would further increase the flow to be treated. By providing the hydraulic capacity at the plant, as system improvements are implemented the higher peak flows could be accepted. It is recommended that subsequent to the startup of the expanded facilities, additional system flow monitoring should be undertaken to further refine system modeling and calibration, to determine the necessity and scope of further collection system improvements.

Section 8 develops a financial capability analysis for the WPCA to implement the recommended plan at each WWTP, factors in the time value of money and how inflation will affect these projects over time, and uses this to explore the impacts of the construction schedule for these projects.

Section 9 further develops the recommended plan for each facility and includes ideas for cost savings in the implementation of the improvements.

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