Section 2

Basic Planning Criteria

2.1 Introduction

This section documents the basic planning criteria used in the development and evaluation of alternative treatment solutions at the Water Pollution Control Association (WPCA), City of Bridgeport, West Side and East Side Wastewater Treatment Plants (WWTPs). In the development and evaluation of alternatives for the WWTPs CDM Smith followed good engineering practice, and the guidelines and recommendations of Design of Water Resource Recovery Facilities, MOP-8 (6th Edition, 2018) and New England Interstate Water Pollution Control Commission (NEIWPCC) TR-16 Guides for the Design of Wastewater Treatment Works (2016 Edition).

2.2 Planning Period

The planning period for this Wastewater Facilities Plan is 30 years (2020 – 2050). The purpose is to assess the broad needs of each facility, to assess the level of service provided and to continue to improve the receiving water quality through the year 2050. The intent of this Facilities Plan is to help WPCA invest wisely and move towards a scheme to “build-it-better” rather than “replace-in-kind” and move the facility toward a Utility of the Future which is sustainable and resilient. Improvements have been assessed and recommendations made herein to dovetail with the Combined Sewer Overflow Long-Term Control Plan (CSO LTCP) concepts to avoid sunk costs and missed opportunities.

2.3 Service Areas

Although the focus of this Facilities Plan is “inside the fence” at each of the WWTPs, in developing solutions for Bridgeport it is important to understand the potential for growth in the service area, assess the system holistically and assess opportunities within the system to determine the most cost-effective means to meet the Facilities Planning goals and objectives. As such, an evaluation of the CSO LTCP recommendations, collection system improvements, and plant capacity have been evaluated to uncover opportunities to enhance system performance.

Figure 2.3-1 provides an overview of the WPCA’s service area and treatment facilities, pumping stations, CSOs and water resources.

The service area for the East Side and West Side WWTPs currently includes Bridgeport, Trumbull, and portions of Stratford and Fairfield. A brief description of these service areas provided below.

2.3.1 Bridgeport

The City of Bridgeport is assumed to be completely sewered for the purposes of this report. In general, the service area west of the Pequonnock River flows to the West Side WWTP, and the service area to the East of the Pequonnock River flows to the East Side WWTP. There are a few interconnections between the two systems. Generally, the southern half of the City is served by combined sewers and the northern half by separated sewers. The sewershed boundaries are shown on Figure 2.3-1.

2.3.2 Trumbull

Since 1967 the Town of Trumbull has been discharging wastewater into the collection system in Bridgeport for treatment. In July 2016, the Agreement between the WPCA, City of Bridgeport, and the Town of Trumbull, was renewed for ten years and remains in effect through June 30, 2026. Under this Agreement the WPCA agrees to accept and treat up to a maximum monthly flow of 4.2 million gallons per day (mgd) from the Town of Trumbull. All flow from Trumbull is conveyed to the West Side WWTP. Trumbull has been steadily expanding its sanitary sewer system over the last few decades and it is estimated that the town is 65% sewered. The flow is metered at two interconnection points: the Beardsley Pump Station and the Sunnydale Road crossover. These two interconnections are described below and shown on Figure 2.3-1.

The Beardsley Pump Station, upgraded in 2020, is located at 129 White Plains Road in Trumbull. A 20-inch force main from the pump station travels south into the City of Bridgeport and ultimately discharges into a 30-inch interceptor in Bridgeport at the intersection of Pond Street and Summit Street. It is likely that the discharge point of the force main was selected in order to reach a point where the interceptor had enough capacity to receive the additional flow from Trumbull. The flow from the pump station is metered and recorded for billing purposes.

The Sunnydale Road crossover conveys flow through a 30-inch gravity pipe from Trumbull into the City of Bridgeport. This cross-country pipeline flows from the southern end of the Westfield Trumbull Shopping Center into the City of Bridgeport. The flow from this interconnection is also metered and recorded for billing purposes.

2.3.3 Fairfield and Stratford

The WPCA serves a limited number of customers from Fairfield (70 customers) and Stratford (100 customers) that border Bridgeport. Stratford customers discharge to the East Side plant and Fairfield customers discharge to the West Side plant. These customers are billed directly and there are no established agreements with either Towns. For the purposes of this report, these customers were accounted for in the WPCA's flows and loads. Since both communities have their own WWTPs, it is assumed that no new customer connections would be added in the future.

2.3.4 Monroe

The Town of Monroe is located north of Trumbull, CT. Monroe established their own WPCA. Monroe has been planning for more than 20 years to install sewers along their main roads to service commercial and industrial areas. If implemented, it is expected that the Monroe WPCA would install approximately three miles of sewer along two major roads; CT-25 and CT-111. These sewers would service approximately 300 acres of commercial and industrial land. This expansion of the collection system would be tributary to Trumbull, and ultimately Bridgeport. This planned future expansion of sewer service was included in the projected flows and loads.

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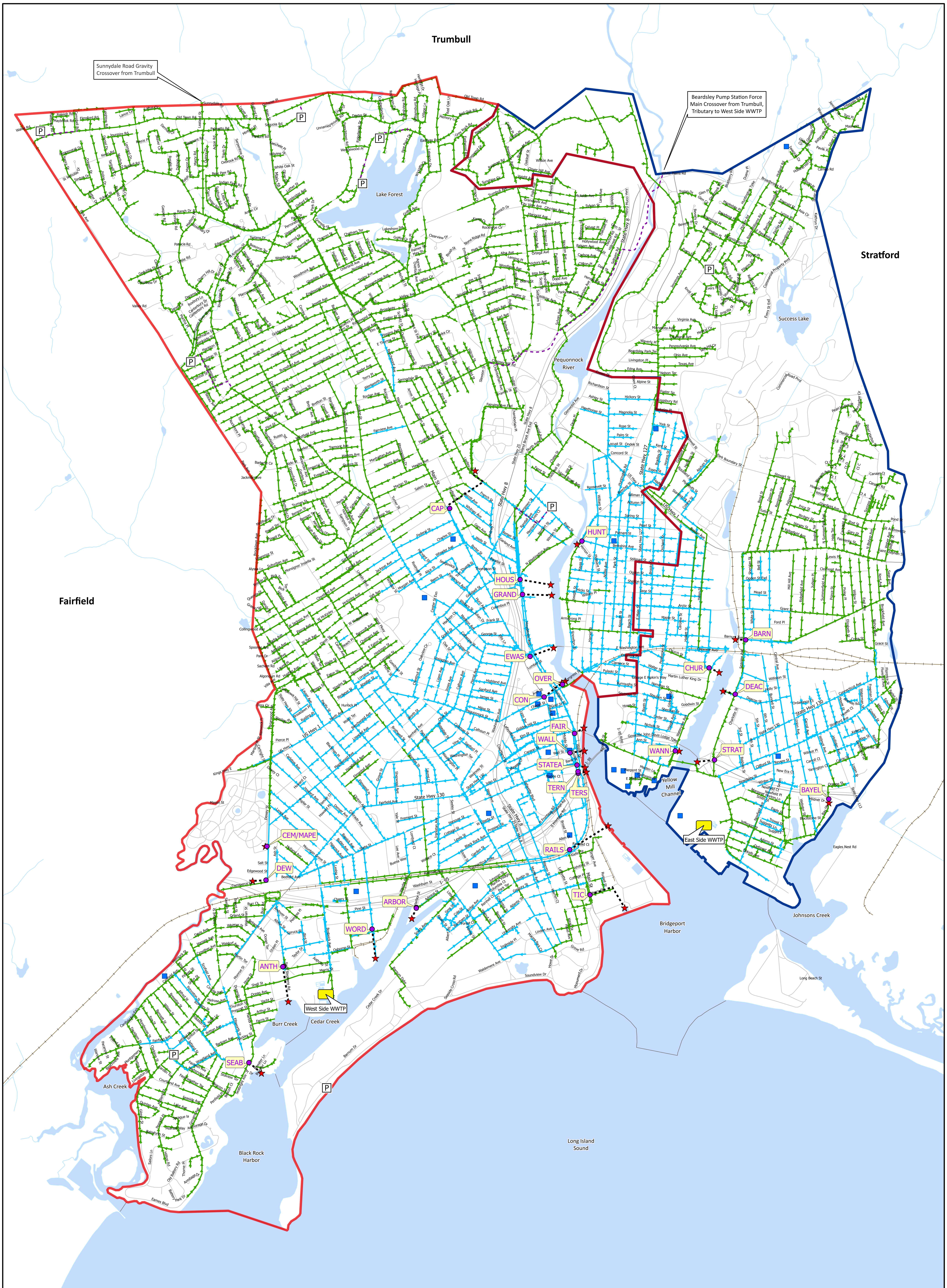

0 0.25 0.5 1 Miles

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Legend

- Combined Sewers
- Separated Sewers
- Roads
- Wastewater Treatment Plants
- CSO Outfalls
- CSO Outfall Pipes
- East Side Tributary Area
- West Side Tributary Area
- Railroad
- Force Mains
- Pump Stations
- Locations for Potential Redevelopment
- CSO Regulators

Figure 2.3-1

Sewer Service Collection System Map
City of Bridgeport, CT

May 2020

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2.4 Vertical Datum

The base elevation used in the Facilities Plan for the WWTPs is the Bridgeport City Datum. All historic construction drawings on the plant site are based on this datum, and in accordance with Bridgeport's Engineering Department, plans submitted for site review must use this datum. The Flood Insurance Rate Maps base their maps on the North American Vertical Datum of 1988 (NAVD88). Conversion from NAVD88 to the City of Bridgeport Datum is as follows:

$$City\ of\ Bridgeport\ Datum\ (ft) = NAVD88\ (ft) + 14.60\ ft$$

In the event an existing resource references the National Geodetic Vertical Datum of 1929 (NGVD 29), the elevations will be converted to City of Bridgeport Datum using the following equations:

$$NAVD88\ (ft) = NGVD29\ (ft) - 1.09\ ft$$

$$City\ of\ Bridgeport\ Datum\ (ft) = NGVD29\ (ft) + 13.51\ ft$$

Datums are depicted graphically on **Figure 2.4-1.**

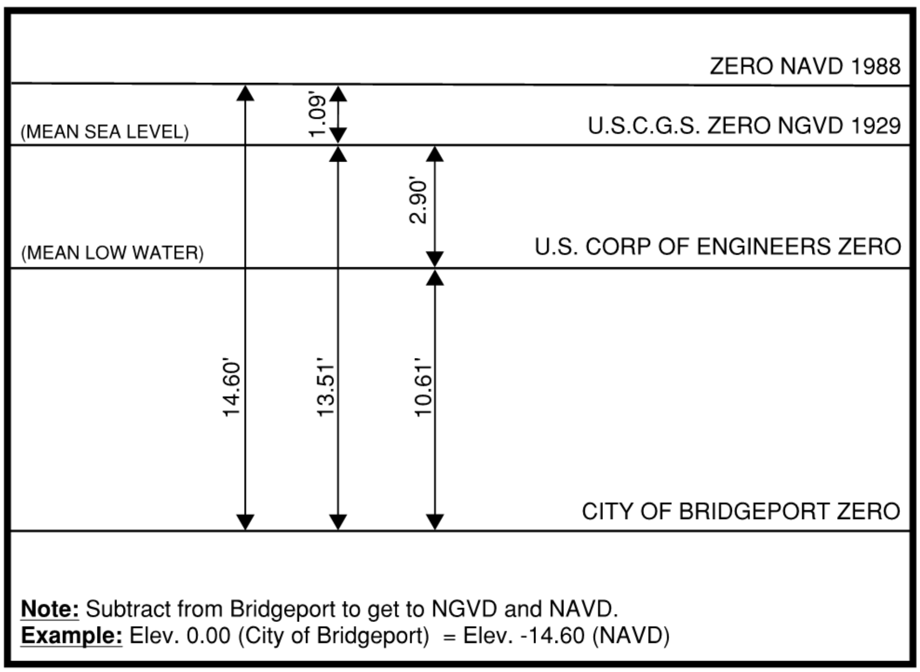

Figure 2.4-1
Bridgeport Datum Conversions

Although the conversion from the City of Bridgeport Datum to NAVD88 is defined above as a difference of 14.60 feet, this conversion **could not** be established at the East or West Side WWTPs despite recent extensive survey activities. Two benchmark discs stamped with an elevation were located at each WWTP. These benchmarks are believed to be on the City of Bridgeport Datum, but the conversion between these physical benchmarks and NAVD88 was surveyed in the field and resulted in a conversion from NAVD88 of 14.80 feet, which is inconsistent with the value stated by the City of Bridgeport conversion of 14.60 feet. Ultimately the site surveys of the WWTPs were completed based on these stamped benchmarks at each plant, and match well to historical drawings.

All elevations in this report refer to the City of Bridgeport Datum, unless noted.

2.5 Flood Protection Requirements

Due to both the treatment plants' proximity to the Long Island Sound, tidal flooding occurs at the plant sites during intense storms and hurricanes. Tidal flooding is typically the result of several factors such as tidal fluctuation, intense rainfall (which cannot drain from the sites when tides are high) and wind driven coastal storm surge. In the case of Bridgeport, tidal floods are conveyed from Long Island Sound to the Cedar Creek (Black Rock Harbor) and Bridgeport Harbor.

Tidal flood elevations were delineated by the Federal Emergency Management Agency (FEMA) via a Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM). The most current FIS and FIRM for Bridgeport, Connecticut were produced in 2013. **Table 2.5-1** presents flood elevations for each site based on FEMA mapping. The FIRMs used for each plant are included in **Appendix C**.

Table 2.5-1 Bridgeport FEMA Flood Insurance Study Flood Elevations

	East Side Wastewater Treatment Plant[1]	West Side Wastewater Treatment Plant[2]
10-Percent (10-Year) Annual Chance Stillwater Flood Elevation	22.35	22.40
2-Percent (50-Year) Annual Chance Stillwater Flood Elevation	23.90	23.90
1-Percent (100-Year) Annual Chance Stillwater Flood Elevation	24.55	24.60
1-Percent (100-Year) Annual Chance Base[3] Flood Elevation	27.60	26.60
0.2-Percent (500-Year) Annual Chance Stillwater Flood Elevation	25.85	25.90

[1] East Side Treatment Plant Stillwater Flood Elevations derived from the average of elevations at Long Island Sound Coastal Transects 45 and 46.
[2] West Side Treatment Plant Stillwater Flood Elevations taken from Long Island Sound Coastal Transect 45.
[3] Base flood elevations defined by FEMA include effects of wave setup while stillwater flood elevations do not.

As first presented in the 1973 EPA Redundancy Criteria, and subsequently incorporated into several other treatment plant design guidelines, including TR-16, treatment facilities are to be designed to provide for uninterrupted operation of all units during conditions of a 25-year (4% annual chance) flood and be placed above or protected against structural, process and electrical equipment damage that might occur in a 100-year (1% annual chance) flood elevation. With the current threat of sea level rise, TR-16 design guidelines were revised in 2016 to incorporate significant modifications to flood protection and resiliency. This includes requiring existing treatment plants that are planned for upgrade or expansion be improved to the maximum extent possible to meet the following flood protection criteria:

1. Provide for uninterrupted operation of all units during conditions of a 100-year (1% annual chance) flood, and

2. Be placed above or protected against the structural, process and electrical equipment damage that might occur in an event that results in a water elevation above the 100-year (1% annual chance) flood.

    a. Critical equipment should be protected against damage up to a water surface elevation that is three feet above the 100-year flood elevation

    b. Non-critical equipment should be protected against damage up to a water surface elevation that is two feet above the 100-year flood elevation

Critical equipment is defined as all electrical, mechanical, and control systems associated with pump stations and treatment facilities that are responsible for the primary treatment and disinfection during a flood event. TR-16 notes, *"existing facilities may present significant challenges to implementing increased levels of protection. The possible vulnerability and the differential cost of increasing the level of protection above the 100-year flood elevations for uninterrupted operation and protection from damage, respectively should be weighed against replacement cost in selecting the level of flood protection implemented when upgrading existing facilities."*

The State of Connecticut Department of Energy and Environmental Protection (DEEP) has indicated that the guidance provided in TR-16 should be followed unless it proves impractical to do so, and states that projects shall meet the requirements of Clean Water Fund (CWF) Memorandum 2017-001, Storm Resiliency of Municipal Wastewater Infrastructure.

The Connecticut Institute for Resilience & Climate Adaptation (CIRICA) suggests planning efforts assume 20 inches of sea level rise in Long Island Sound by 2050. This projected future sea level rise will impact the 100-year flood elevation which is why critical and non-critical equipment will be placed at three and two feet above the flood elevation providing an additional level of conservatism beyond the 20 inches projected by CIRCA. Figures from CIRCA showing projected water levels during a 100-year flood with 20 inches of sea level rise at both WWTPs are included in **Appendix C**.

To meet the requirements of CWF Memo 2017-001, planning efforts have assumed uninterrupted operation of the treatment plants up to the 100-year flood elevation. This elevation is 26.60 and 27.60 for the West Side and East Side WWTPs, respectively.

To meet the requirements of CWF Memo 2017-001 and provide protection from future sea level rise, planning efforts will assume protection of processes and equipment using the Freeboard Value Approach. All critical equipment and processes (influent pumping, preliminary treatment, primary treatment, disinfection and effluent pumping, if required) will be protected up to an elevation of three feet above the 100-year flood plain elevation. This is equal to 29.60 and 30.60 at the West Side and East Side WWTPs, respectively. Non-critical equipment and processes will be protected up to an elevation of two feet above the 100-year flood. This is equal to 28.60 and 29.60 at the West Side and East Side WWTPs respectively.

Table 2.5-2 presents a summary of flood elevations to be used in planning efforts of the West Side and East Side WWTPs.

Table 2.5-2 Flood Elevations for Facilities Planning

	East Side Wastewater Treatment Plant	West Side Wastewater Treatment Plant
Uninterrupted Hydraulic Operation Flood Elevation (100-year flood)	27.60	26.60
Critical Process and Equipment Flood Elevation (100-year flood plus three feet)	30.60	29.60
Non-Critical Process and Equipment Flood Elevation (100-year flood plus two feet)	29.60	28.60

Figures 2.5-1 through 2.5-4 present a plan view of the West Side and East Side WWTPs with the 100-year flood elevation and the 100-year flood elevation plus 3-feet delineated.

Figures 2.5-5 and 2.5-6 represent the hydraulic profile of the West Side and East Side plants, respectively. These figures were based on the hydraulic profiles presented in the August 1992 West Side Wastewater Treatment Plant Modification and Improvements and August 1995 Rehabilitation of the East Side Wastewater Treatment Plant drawings. As presented, during a 100-year flood event plus 3-feet, the chlorine contact tanks, a critical structure, are submerged at both plants which will likely require a complete rebuild in order to meet the current criteria.

All new facilities will be designed and constructed to meet the updated requirements, and all existing structures to be maintained will be protected against flooding unless impracticable.

2.6 Equipment and Tankage Reliability

All new pumps and mechanical equipment will be provided with a minimum firm capacity that can manage peak conditions with at least the largest unit out of service (n+1). Specific equipment will be assessed to determine if a higher level of redundancy is required based on criticality of the equipment and consequence of failure. It is assumed that all tankage, primary clarifiers, aeration tanks, secondary clarifiers, and chlorine contact tanks will be on-line during peak flow events. During low flow periods operators should drain tanks and inspect and service equipment in the tanks to improve reliability of the system.

2.7 Effluent Requirements

The current NPDES permit requirements are presented in Section 1. In order to ensure that the proposed treatment facilities are designed with the flexibility to meet or be modified to meet potential future permit limits an assessment of potential future permit limits are presented. As previously noted, both treatment facilities receive combined sewage flows so during high flow events, when the capacity of the secondary treatment facility is exceeded, excess flow receives primary treatment and disinfection. Currently, during a bypass event, the WPCA is required to monitor and report effluent quality; however, the maximum daily concentration for five-day

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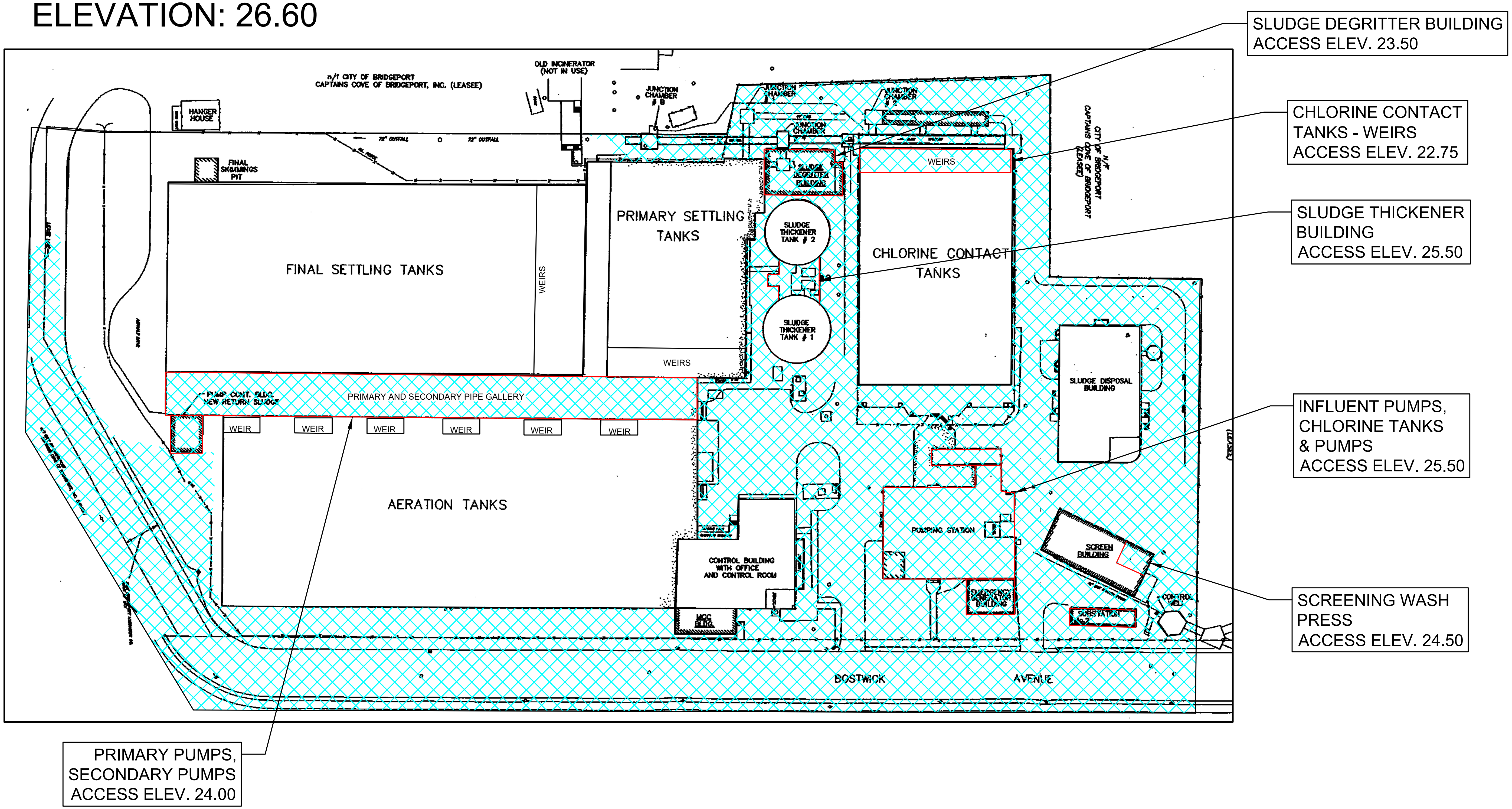
100-YEAR FLOOD

ELEVATION: 26.60



ALL ELEVATIONS REFER TO BRIDGEPORT DATUM

Figure 2.5-1
West Side WWTP 100-Year Flood

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100-YEAR (+3) FLOOD

ELEVATION: 29.60

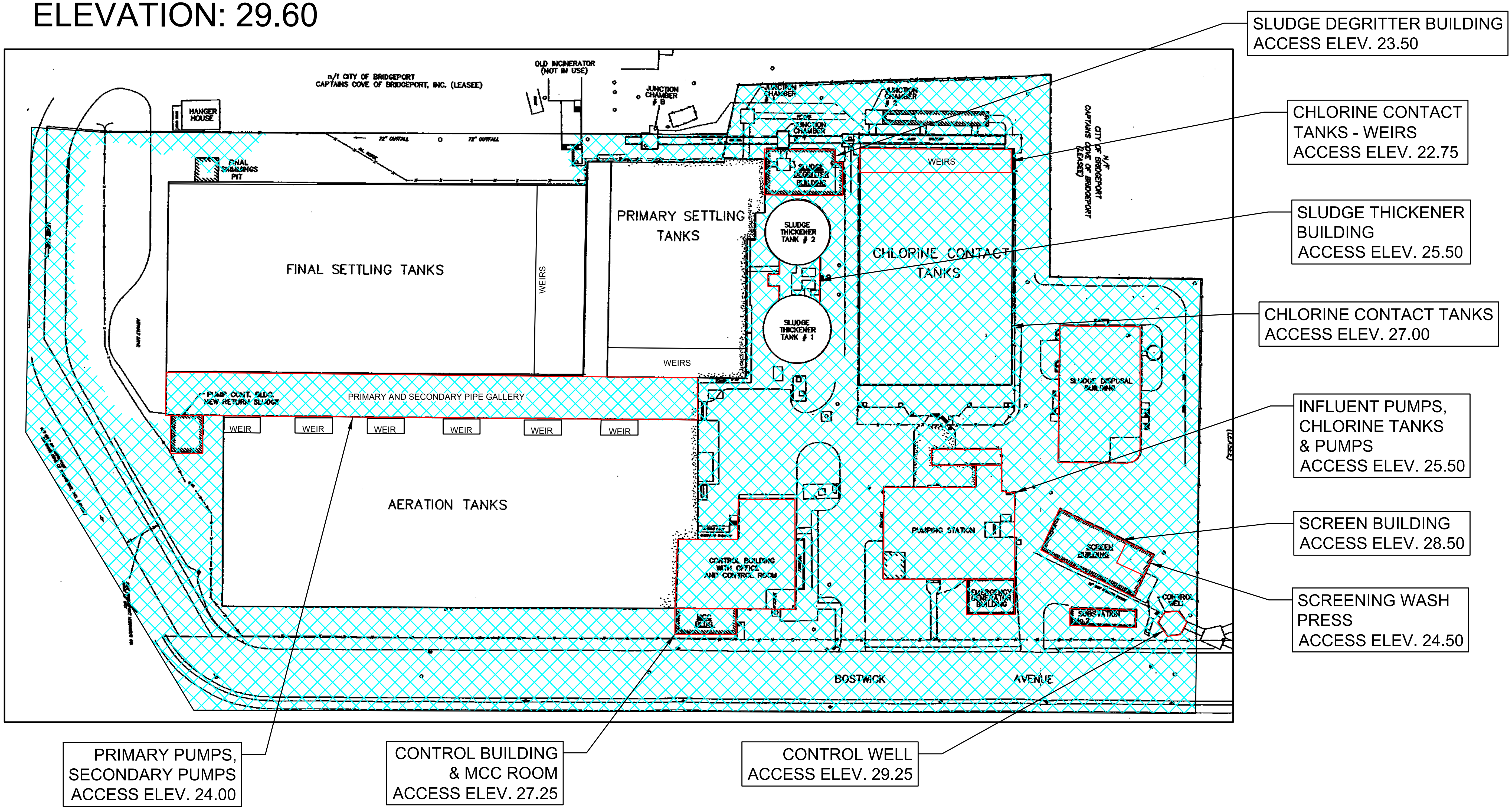

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Figure 2.5-2
West Side WWTP 100-Year (+3 Feet) Flood

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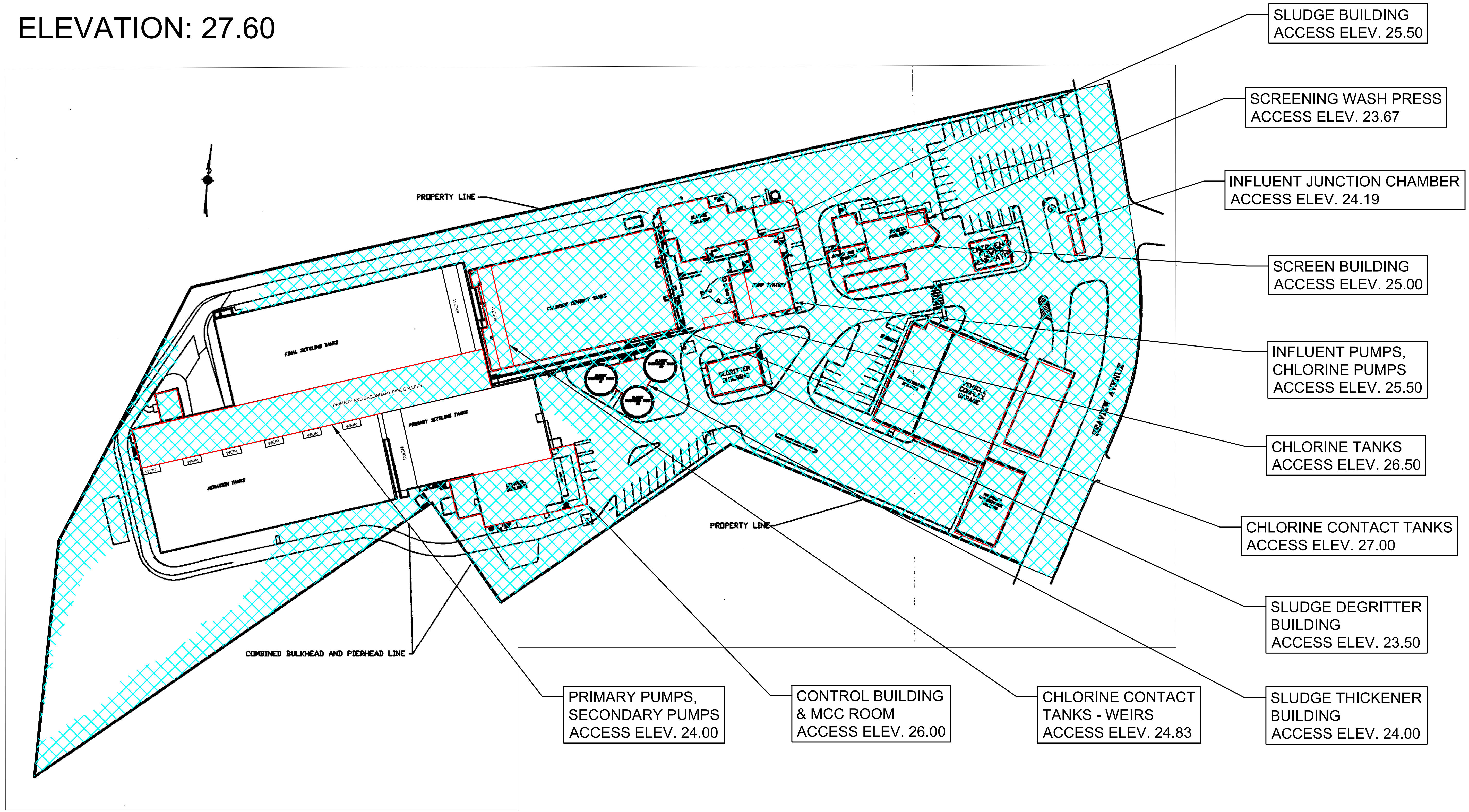
100-YEAR FLOOD

ELEVATION: 27.60



ALL ELEVATIONS REFER TO BRIDGEPORT DATUM

Figure 2.5-3
East Side WWTP 100-Year Flood

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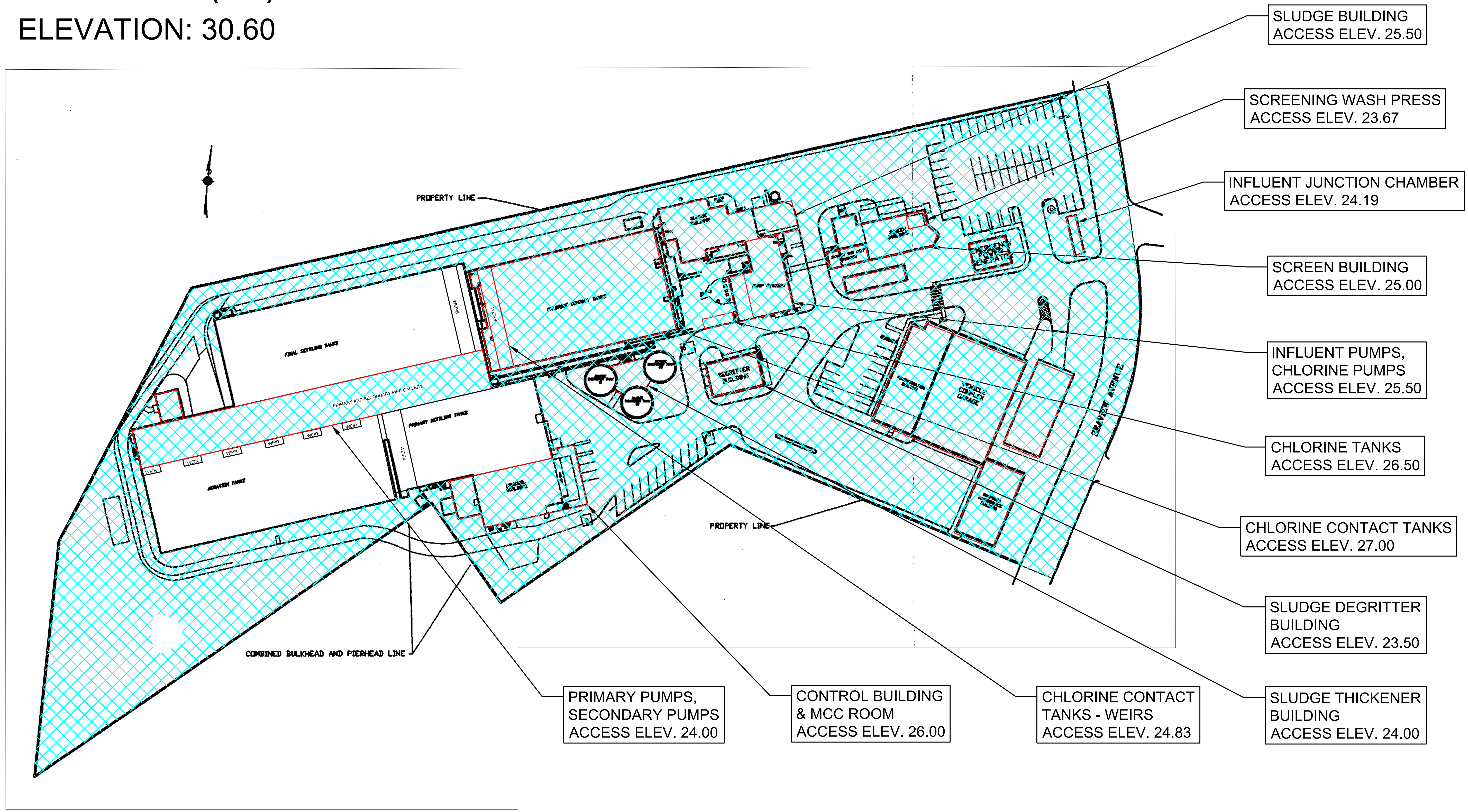
100-YEAR (+3) FLOOD

ELEVATION: 30.60



ALL ELEVATIONS REFER TO BRIDGEPORT DATUM

Figure 2.5-4
East Side WWTP 100-Year (+3 Feet) Flood

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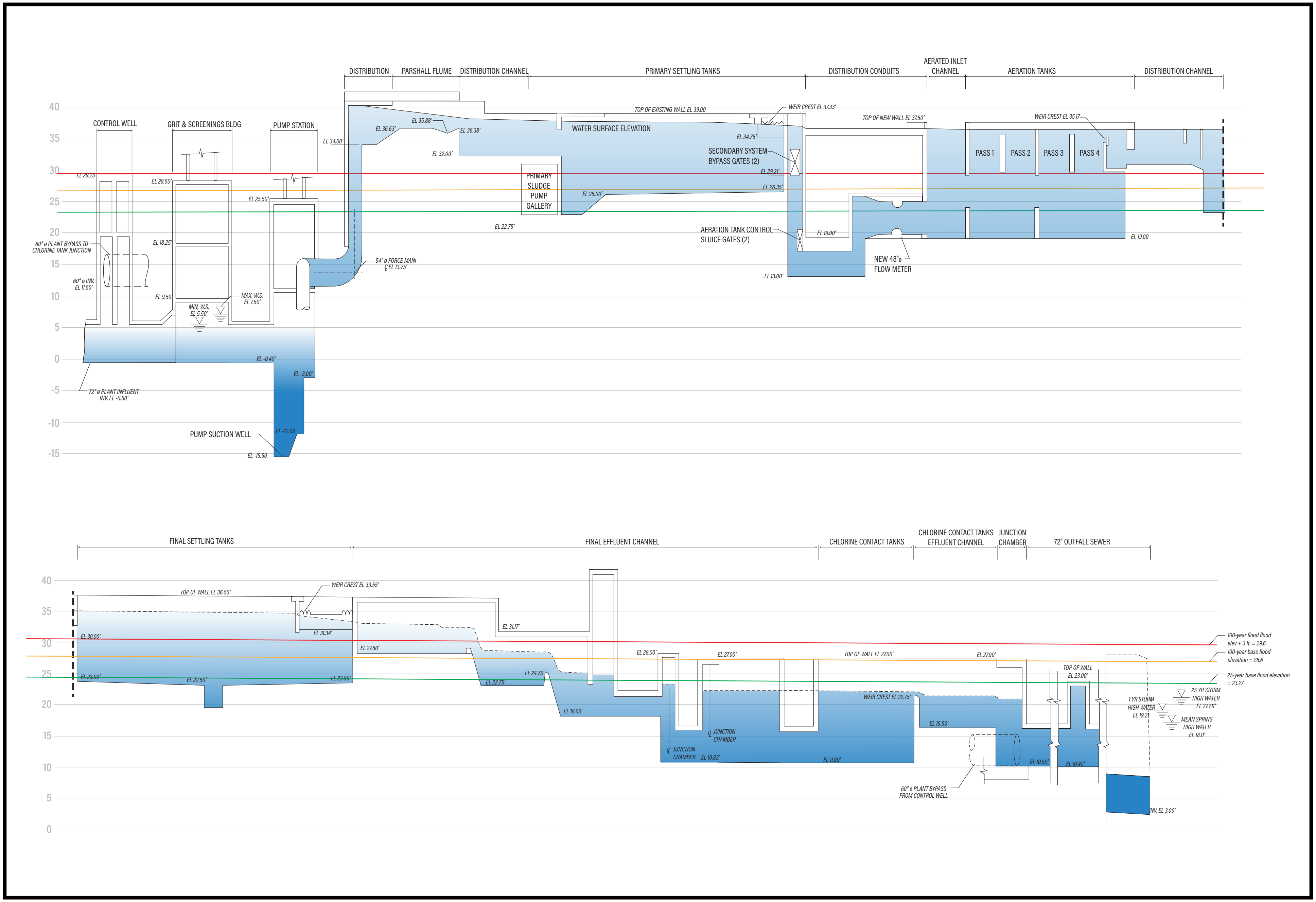

Figure 2.5-5
West Side WWTP Hydraulic Profile

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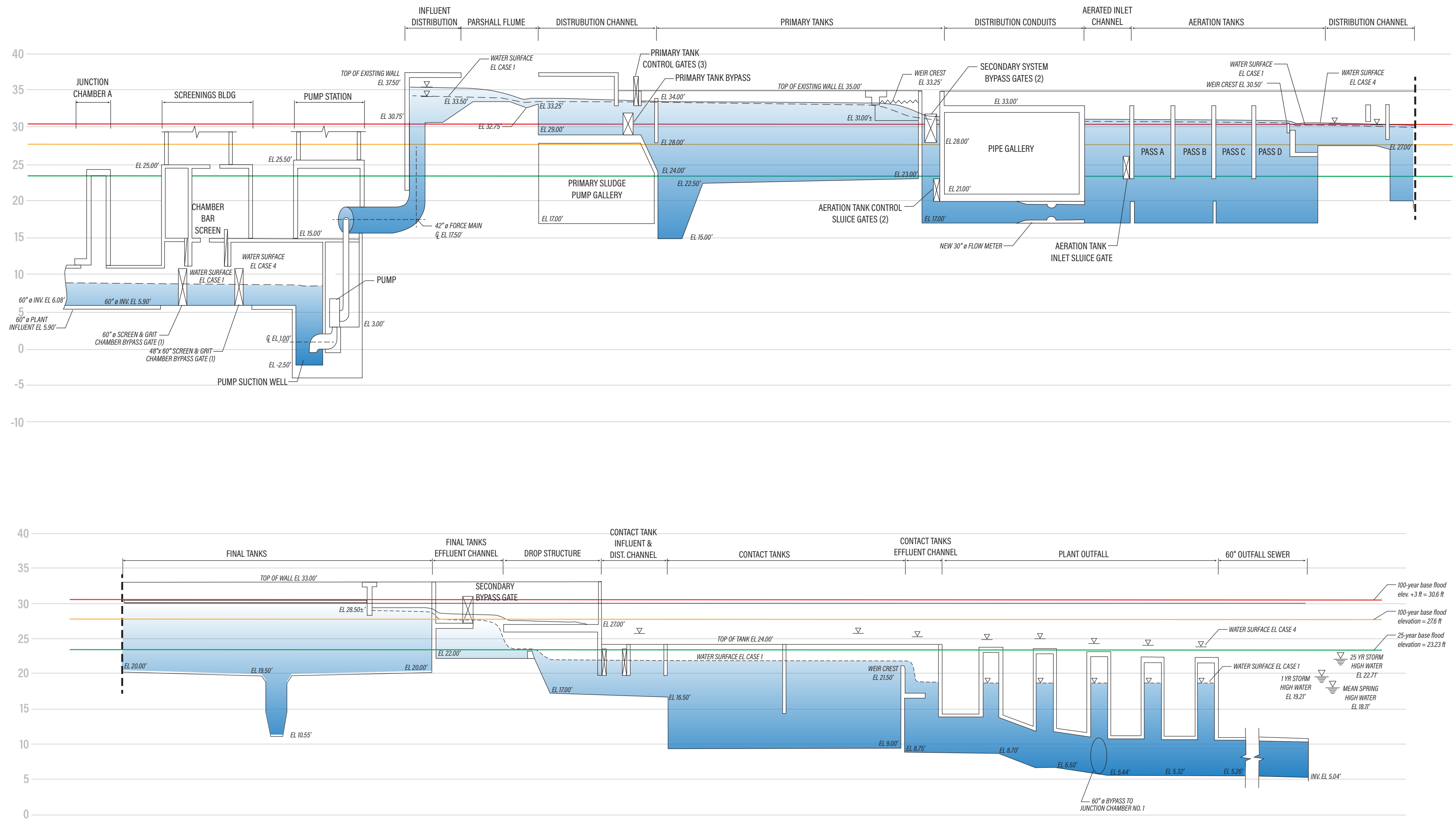

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Figure 2.5-6
East Side WWTP Hydraulic Profile

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biochemical oxygen demand (BOD_5) and total suspended solids (TSS) is waived. For the purpose of this analysis, we have assumed the current maximum daily limit of 50 milligrams per Liter (mg/L) for BOD_5 and TSS, the fecal coliform and *E. coli* requirements, as well as total residual chlorine would have to be achieved. Although a well-designed and operated secondary treatment system with nitrogen removal should be able to achieve average daily BOD_5 and TSS concentrations less than 15 mg/L, we have assumed that the permit limit for average daily concentrations will not change.

With respect to total nitrogen (TN), CT DEEP is currently reassessing the nitrogen loads to Long Island Sound. Currently, as defined by the General Permit for Nitrogen Discharges, the West Side plant must achieve an average annual TN load of 1,041 pounds per day (lb/day) and the East Side plant must achieve an average annual TN load of 362 lb/day. If these levels are not achieved, the WPCA must purchase nitrogen credits. For the purposes of this analysis, we have designed facilities to achieve the current nitrogen effluent loading limits for the estimated design year (2050) influent flows. Should more stringent TN effluent limits be established, the nitrogen removal facilities will be designed with the flexibility to achieve more stringent limits with the addition of supplemental carbon.

It is not expected that either plant would be subject to total phosphorus limits given the discharge into Long Island Sound; however, if phosphorus limits are imposed, it is presumed this could be accomplished in the future through multi-point chemical addition with a metal salt (assuming a total phosphorus limit greater than or equal to 0.5 mg/L).

2.8 Siting Considerations

The West Side WWTP is located at 205 Bostwick Avenue along the shores of Cedar Creek, south of Interstate 95. As shown of **Figure 2.8-1** the plant occupies parcels totaling 11.1 acres owned by the City of Bridgeport, bounded by Bostwick Avenue to the east and south, Morris Street (discontinued) to the north, and Bird Street (reported to council) to the west. The site is bounded on the west and south by a 14.9-acre parcel owned by the City of Bridgeport which is currently occupied by the Aquaculture school, the marina, and Captain's Cove restaurant. The marina's boat storage, in fact, infringes on the parcel east of Bird Street. A 14.9-acre parcel to the north is owned by the City of Bridgeport Housing Authority and is occupied by high density residential housing units. Across Bostwick Ave to the east is a parcel owned by O&G Industries which houses an asphalt plant. The treatment plant site is currently zoned as I-L: Industrial Light Zone according to the June 2018 Zoning Map of the City. The site available for plant upgrades and expansion to the north and west presents some challenges, so vacant parcels in the vicinity of the treatment facility were assessed as presented in **Figure 2.8-2**. As presented, the most amenable parcel would be the adjacent Marina parcel for expansion which sits above the 100-year flood plain. FEMA flood mapping was assessed to identify other parcels at or above the 100-year flood plain plus 3-feet. On the West Side, a new plant would have to be relocated at least 0.5 miles inland to escape the 100-year flood plain and over a mile to be above the 100-year flood plain plus 3-ft, generally north of I-95 and the railroad line. The planning, permitting and cost of relating the entire facility was not deemed feasible.

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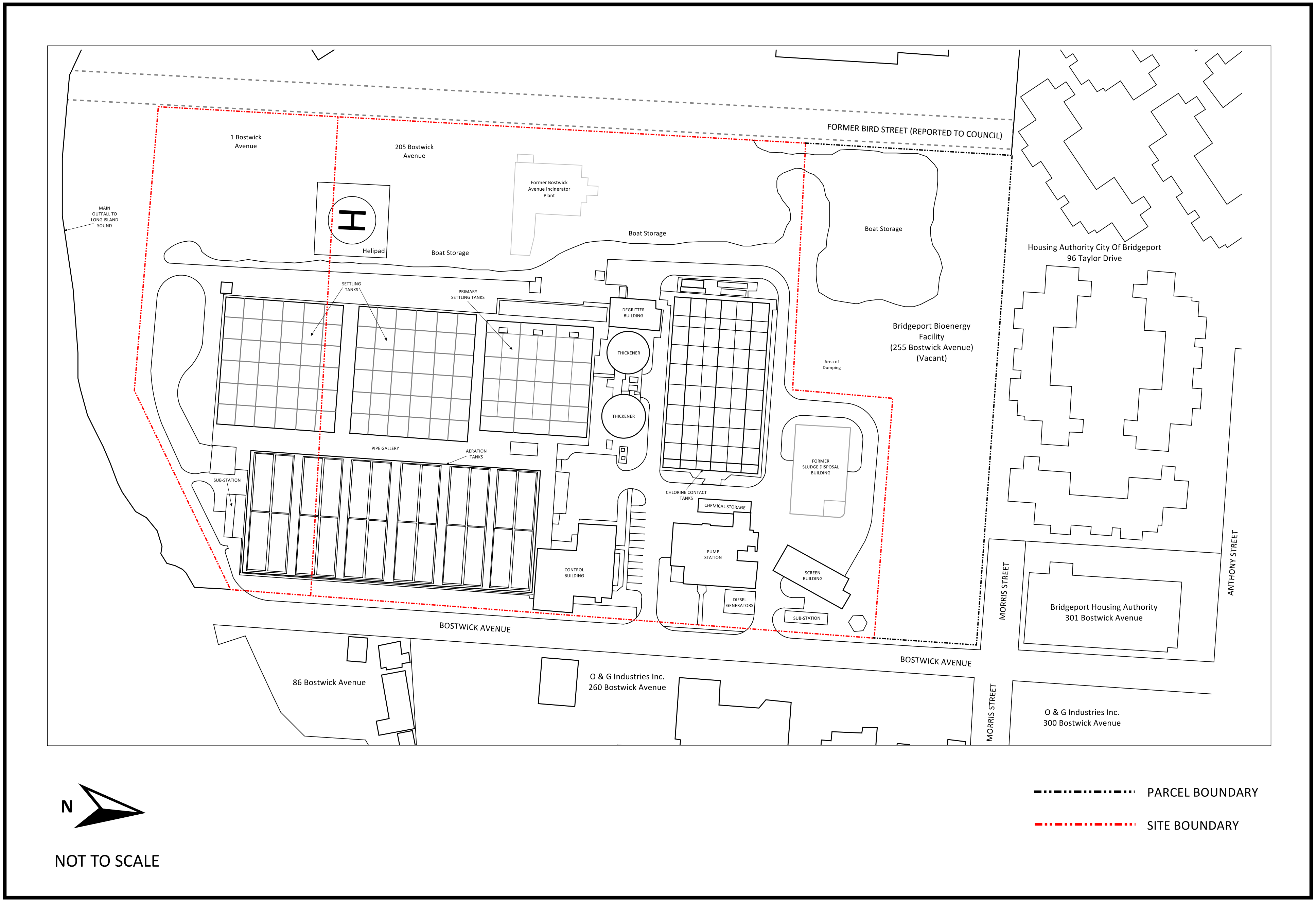

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Figure 2.8-1
Site Extents - West Side WWTP

Water Pollution Control Authority, City of Bridgeport
Facilities Plan

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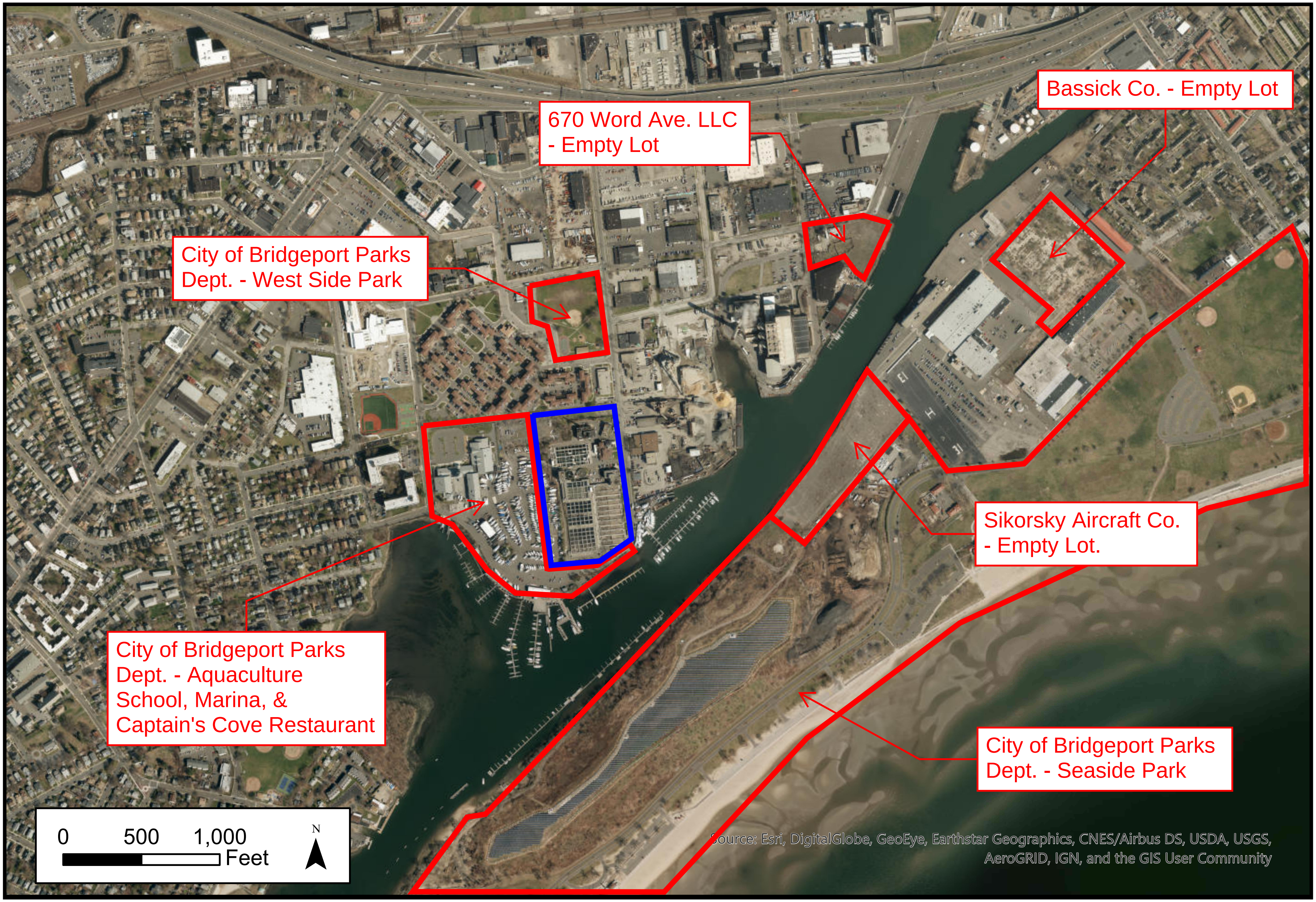

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Figure 2.8-2
West Side Open Land

Water Pollution Control Authority, City of Bridgeport
Facilities Plan

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As shown on **Figure 2.8-3**, the East Side facility is located at 601 Seaview Avenue and sits on an 8.8 acre parcel along the shore of Bridgeport Harbor downstream of the confluence of the Yellow Mill

Channel and Pequonnock River, just south of Exit 29 off the Connecticut Turnpike (Interstate 95). The plant site is currently zoned as I-H: Industrial Heavy Zone according to the June 2018 Zoning Map of the City. Two and three family residential zone exists just to the east of the treatment facility. Constructing plant upgrades and expansion to the existing facility within the footprint of the existing plant site will be challenging and so vacant parcels in the vicinity of the treatment facility were assessed as presented in **Figure 2.8-4**. As presented, if necessary, acquiring land or easements from adjacent parcels would be the most practical if required. With respect to the 100-year flood plain, the Port Authority parcel to the north of the East Side plant is out of the 100-year flood plain and would be the most feasible area to relocate the plant if deemed desirable.

Future waterfront development will encroach upon the buffers surrounding each WWTP, which will heighten scrutiny around the plants' aesthetics (odor generation, noise pollution, truck traffic, etc.).

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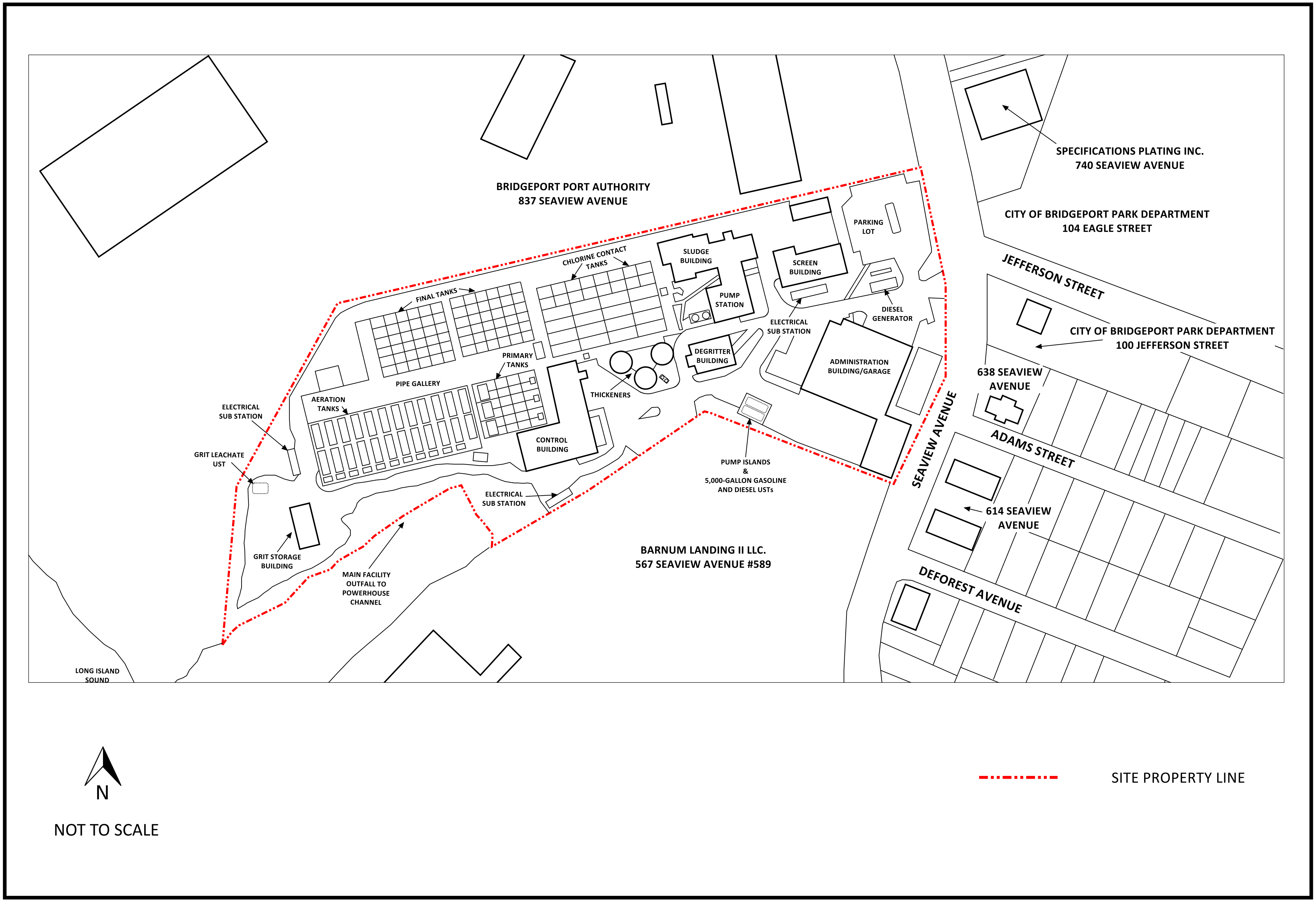

Figure 2.8-3
Site Extents - East Side WWTP

Water Pollution Control Authority, City of Bridgeport
Facilities Plan

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Figure 2.8-4
East Side Open Land

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2.9 Evaluation Framework

The evaluation process for this facilities plan encompasses not only the evaluation of alternative treatment technologies at the plant site, but looks for opportunities for resource recovery, sustainable development and community enhancement while concurrently assessing the capacity of the treatment facility which, if increased, could cost-effectively address combined sewer overflows. **Figure 2.9-1** schematically presents the evaluation process.

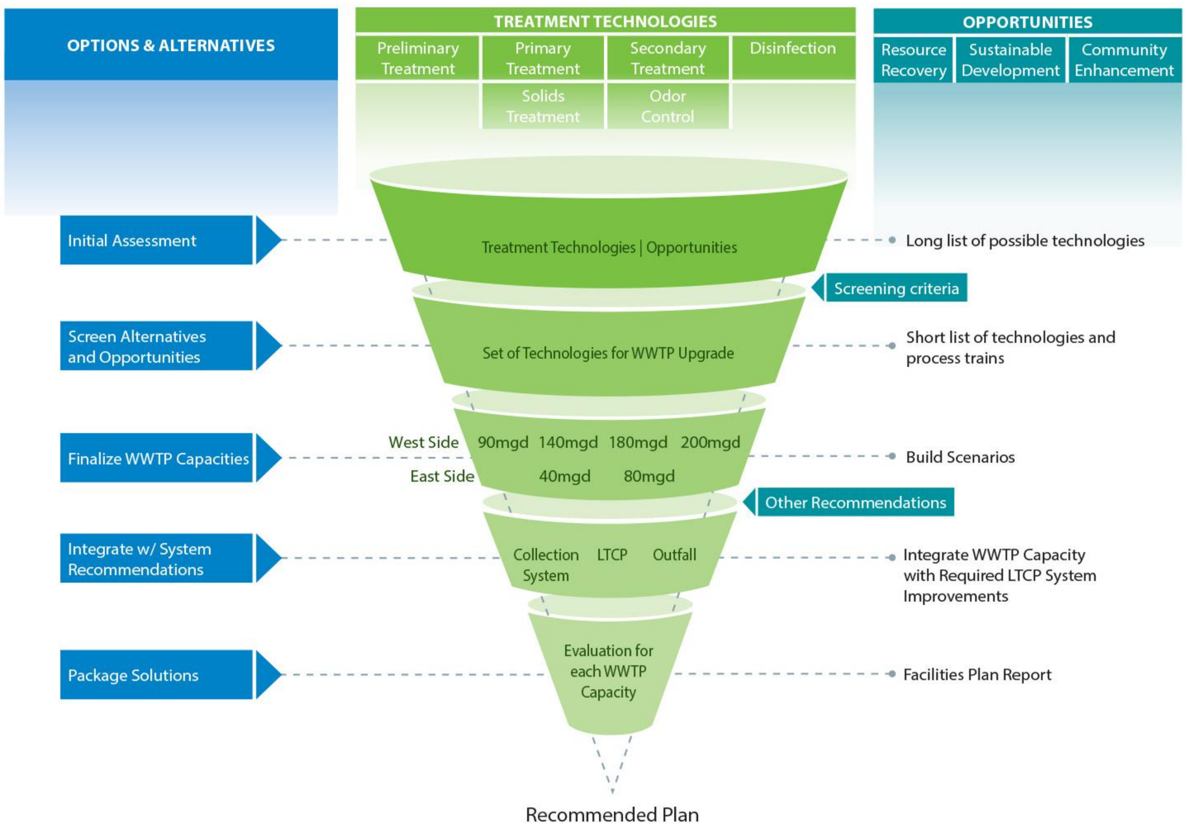

Figure 2.9-1
Evaluation Process

The initial screening of alternative treatment technologies and equipment to improve the efficiency of operations at the treatment facility considers the ability to meet permit limits, the operational complexity of the system and the area requirements of the system is presented in Section 6. If any of the initial screening criteria precluded the technology or equipment it was eliminated from the evaluation.

The detailed evaluation of unit processes, presented in Section 7, considers both cost and non-cost factors. Cost criteria is based on both capital cost and operation and maintenance (O&M) costs, normalized through a 20-year present worth analysis as described in the following section. Non-cost criteria are based on a number of items as defined below. Cost criteria will carry a weight of 60% and non-cost criteria will carry a weight of 40%.

Subsequent to the evaluation of unit processes, preferred treatment trains are developed, and the evaluation of plant size and high flow management is assessed against other recommendations included in the CSO LTCP.

2.9.1 Non-Economic Evaluation

Each treatment process is evaluated on the basis of site utilization, experiences at other similar municipal wastewater treatment facilities, reliability, neighborhood impacts, and other criteria defined below. Numerical scores (1, 3 or 5) are applied for each criterion using the following rating system:

5 Favorable

3 Neutral

1 Unfavorable

A non-economic evaluation is more subjective in nature than an economic evaluation. **Table 2.9-1** lists the non-economic criteria to determine the overall rating of each unit process for a maximum total score of 40 points. The maximum score of 40 points is broken down by the non-economic criteria as shown in Table 2.9-1. Non-economic factors and the relative importance of those factors vary by project. If a treatment process was awarded the maximum rating of 5 (favorable) for a particular criterion, that process would receive the maximum score assigned for that criterion. For treatment processes awarded 3 (neutral) or 1 (unfavorable) for a particular criterion, that process would receive the fraction (3 out of 5, or 1 out of 5) of the criterion's maximum score.

Table 2.9-1 Non-Economic Unit Process Evaluation Criteria

Criterion	Maximum Score
Site Utilization	10
Success at Other Installations/Reliability	8
Neighborhood Impacts	4
Energy Efficiency	4
Ease of Operations	3
Ease of Maintenance	3
Maintenance of Plant Operations	2
Ability to Phase Implementation	2
Sludge Impacts	2
Chemical Handling/Hazards	2
Non-Economic Total Weighted Score	**40**

The evaluation criteria are described in detail below.

2.9.1.1 Site Utilization

Land area within the fence line of both facilities is limited. Parcels of land surrounding the facilities may be available through purchase or lease; however, this is not a preferred option. Required area was estimated for each alternative. Processes that require less area than others being evaluated were rated “favorable”. Those that require an average amount of area compared to other alternatives and require some additional land outside of the fence line were considered “neutral”. Those alternatives that require more expansive area outside of the fence line are considered “unfavorable”.

2.9.1.2 Success at Other Installations and Reliability

Each alternative’s experience and performance at similarly sized municipal wastewater treatment facilities was considered pertinent information, including the number of years in operation, size of facilities, history of operation and maintenance, issues with the operation, ability to handle peak flows including significant spikes in flow, performance as measured by process effluent quality, and cold weather experience. Also considered was the level of assurance that unit process will consistently achieve the required degree of treatment under the expected range of operating conditions.

Unit process ranked “favorable” have consistently achieved or exceeded the required treatment under similar climatic conditions at similarly sized facilities and thus can be expected to do so at the East and West Side WWTPs. A unit process ranked “neutral” may not have the experience at a similarly sized facility but has a track record at a smaller facility and/or can be expected to have occasional process upsets but will continuously achieve process standards. A unit process considered “unfavorable” may have potential but has limited experience in the marketplace and could be considered new and unproven. A process that has a record of poor reliability is eliminated from further review.

2.9.1.3 Neighborhood Impacts

Neighborhood impacts consider odor generation, noise pollution, truck traffic, safety and aesthetic impacts associated with construction and operation of each alternative. Unit processes that have minimal neighborhood impacts than other alternatives were “favorable”. Alternatives with similar neighborhood impacts similar to other processes were “neutral,” and those with a more significant negative neighborhood impact were “unfavorable”.

2.9.1.4 Ease of Operations

The difficulty of operating a process alternative was considered. Some processes are complex and require a lot of attention for proper operation. In some cases, processes require operators to have special skills and extensive training. Merely adding types of unit operations also increases complexity as it likely would require additional staff that must be trained and managed. A high number of individual units or pieces of equipment within a process also increases complexity since it would require more operator attention. The least complex processes were “highly favorable”. Those that require average attention and some additional staff and training were “neutral”. Processes deemed difficult to maintain were “highly unfavorable”.

2.9.1.5 Ease of Maintenance

The difficulty in maintaining a process, both routine and infrequent maintenance, was considered. Some processes require a lot of attention to maintain working equipment which can require frequent or arduous plant staff intervention. The systems requiring the least amount of maintenance (both in terms of time and frequency) and least intensive maintenance were “highly favorable”. Those that require average maintenance and some additional staff and training were “neutral”. Processes deemed difficult to maintain were “highly unfavorable”.

2.9.1.6 Maintenance of Plant Operations

Any alternative that is implemented will need to be constructed while full operation of the WWTP is maintained. Maintenance of plant operations (MOPO) requires that all systems, including conveyance, treatment, chemical feed systems and residuals management, not be interrupted during construction. A “favorable” alternative can be implemented with a limited impact or manageable impact to plant operations. A “neutral” alternative has a higher level of impact at a reasonable cost, such as manageable by-pass pumping. An “unfavorable” alternative has major impact to operations with a significant cost to implement.

2.9.1.7 Ability to Phase Implementation

This criterion assessed the potential of a unit process or treatment alternative to be implemented in phases to increase the system capacity over time as flows and/or loads are increased. Unit processes that can be implemented in phases have the advantage of spreading out capital cost over a longer time. A unit process was “favorable” if it had the greatest potential for phased implementation compared with the other processes, “neutral” if it had similar potential, and “unfavorable” if it had no potential for phased implementation.

2.9.1.8 Sludge Impacts

Liquid unit processes affect generation, collection, processing, and disposing of residuals. Thus, alternatives are evaluated for their impact on residuals unit processes. Processes that increase sludge quantities or impact sludge quality will adversely impact the WPCA’s sludge management facility requirements. This criterion considers both the quality and quantity of residuals produced and their impact on the sludge management system.

A "favorable" unit process either has little impact on other unit processes and mechanical equipment and/or generates similar sludge quantities or residuals that are no more difficult to collect, process, and dispose of than existing conditions. A "neutral" process generates less than 10 percent more sludge with quality similar to existing conditions or only minimally more challenging, and an "unfavorable" unit process generates significantly more residuals or residuals more difficult to collect, process, or dispose of than existing conditions.

2.9.1.9 Energy Efficiency

Some alternatives may require significantly more power to operate, necessitating the construction of more substantial electrical supply systems, incurring higher operational costs and generating more greenhouse gas emissions. Annual energy usage is estimated for each alternative in kilowatt hours per year (kWh/year). Alternatives that have minimal estimated energy usage are “favorable,” those with median energy usages are “neutral” and those with high energy requirements are “unfavorable”.

2.9.1.10 Chemical Handling/Hazards

Certain alternatives require chemicals such as ferric chloride, sodium hypochlorite, supplemental carbon sources, or polymer to facilitate their function. Storage and handling of these chemicals can increase risk to plant personnel, and some chemicals require more onerous handling procedures and safety precautions than others. A unit process is "favorable" if it uses no chemicals or if it uses a substantially lower number and amount of different chemicals than other unit processes. An alternative is rated "neutral" if it uses an average number of different chemicals with typical handling requirements. An "unfavorable" unit process uses an excessive amount of chemicals in terms of the number of different chemicals and/or requires challenging handling procedures.

2.10 Cost Estimating Standards

Cost estimates prepared for this Facilities Plan are considered screening or feasibility level, Class 5 estimates, as defined by the American Association of Cost Engineering (AACE) International system for classifying cost estimates with a project definition of 0% to 2%. The economic evaluation includes consideration of capital, O&M, and life-cycle costs. It is important to consider all of these cost components since some alternatives may be capital cost intensive and yet require minimal annual O&M expenditures, and other alternatives may be less capital cost intensive but require high annual O&M expenditures. Alternatives can be equitably compared by using a life-cycle cost analysis to convert all capital and O&M costs for the 20-year planning period into a net present worth. The following sections describe the methodology used in the economic evaluation.

2.10.1 Capital Cost

Capital costs generated for this facilities plan were developed based on vendor quotes, quantity take-offs and CDM Smith's extensive database of construction projects in the Northeast. **Table 2.10-1** presents the contingencies applied to the cost estimates. The planning-level cost estimates contain allowances for construction and project contingency to account for unknowns in the construction requirements or pricing at the facilities planning stage – for example, site-specific and season specific costs of construction or construction market conditions during bidding. As a project becomes better defined, there are fewer unknowns and therefore the contingency decreases. The construction cost with contingency included is referred to as the Opinion of Probable Construction Cost (OPCC). An additional project contingency is added to the OPCC depending on the level of planning and design completed, the level of difficulty of the project, risks associated with unknown underground site conditions, and requirements for the inclusion of contingencies for State Revolving Fund (SRF) or other loan and grant programs. The project contingency applied for this Facilities Plan is 10%. Engineering and implementation costs are added as a percentage to the total of all costs described above. The value of 22% is used herein to cover the following typical costs: permitting, engineering design, bidding and services during construction, public participation, and general legal costs. The cost of land acquisition and easements and right of ways have not been included herein for the evaluation of alternatives, but will be developed, as necessary for the recommended plan.

Table 2-10.1 Contingencies Used for Cost Estimating

Contingency	Value
Contractor's General Conditions and Overhead & Profit (OH&P)	20%
Construction Contingency	25%
Project Contingency	10%
Engineering and Implementation Costs	22%

The OPCC of the recommended plan will be escalated to the expected estimated midpoint of construction based on the recommended construction schedule. However, the project costs plus engineering costs in 2020 dollars will be used for the present worth lifecycle cost comparison. In general, planning studies, such as this one, include order-of-magnitude estimates of costs.

2.10.2 Operation and Maintenance Costs

Annual costs were estimated using unit costs for labor, energy, and chemicals obtained from Bridgeport based on current operational costs (2020). **Table 2.10-2** presents the unit costs that were assumed in this analysis.

Table 2.10-2. Unit Costs for Power, Chemicals and Residual Disposal

Item	Unit Cost
Power	\$0.14 per kWh
Liquid Polymer	\$1.25 per lb delivered
Microsand (Ballast)	\$0.15 per lb
Sodium Hypochlorite	\$0.991 per gal delivered
Sodium Bisulfite	\$2.24 per gal
Ferric Chloride (40%)	\$1.22 per gallon
Magnesium Hydroxide	\$1.15 per gallon
Supplemental Carbon (MicroC 2000)	\$2.50 per gallon
Citric Acid (50%)	\$7.04 per gallon

An annual labor cost (including fringe benefits) of \$95,000 per employee was assumed for the comparison of alternatives, understanding that the plant currently uses contract operations. Annual preventive maintenance costs, including lubrication oils and replacement parts, were assumed to be five percent of the equipment capital costs. Where appropriate, major consumable replacements were also included at major intervals during the planning period.

2.10.3 Present Worth Analysis

The calculation of present worth costs includes the effective discount rate, equipment life expectancies, base year of analysis, and planning period. The following paragraphs describe the methodology for how the present worth is calculated.

2.10.3.1 Effective Discount Rate

The interest rate used to convert future annual costs to present day costs includes both the current discount rate to borrow money and the current inflation rate. The two rates are combined to determine an effective discount rate, as follows:

$$Effective\ discount\ rate = \frac{(\text{discount rate} - \text{inflation rate})}{(1 + \text{inflation rate})}$$

For this analysis, the discount rate published annually in the Federal Register by the Department of the Interior for Federal Water Resources Planning is used. The most recent discount rate is 2.75 percent, which was published December 2019 for fiscal year 2020.

Assuming a 2.0 percent inflation rate, the effective discount rate is 0.74 percent and is used for the present worth analysis. Note that by including inflation in the estimate of the effective discount rate, the present day annual O&M cost can be used for the present worth calculation (described below).

2.10.3.2 Equipment Life Expectancy

The average life expectancy is assumed to be 20 years for equipment, unless noted otherwise for specific equipment or systems. The following relationships are used to estimate replacement cost and remaining value:

$$Replacement\ Cost = \frac{(\text{Planning period} - \text{Years to end of planning period})}{\text{Total Service life}} * (\text{Initial Cost})$$

$$Remaining\ Value = \frac{\text{Remaining Service Life}}{\text{Total Service life}} * (\text{Initial Cost})$$

The following subsections describe how the replacement costs and remaining values are incorporated into the calculation of present worth.

2.10.3.3 Present Worth Factors for Equipment Costs

Equipment replacement costs are estimated on those occasions when equipment service life is shorter than the 20-year planning period. Using the equation above, the equipment replacement cost when replaced equals 1.0 times the present-day equipment cost (C_e).

Equipment remaining value is then estimated because in these occasions, the replacement equipment will not have exceeded its useful life at the end of the planning period. Using the above equation, where the replacement equipment will have no remaining service life at the end of the planning period, the remaining value in year 20 will equal 1.0 times the present-day equipment cost (C_e).

Assuming the present equipment cost is initially incurred in 2025 (n = 5), replacement costs are incurred in 2045 (n = 25), and there is no remaining value to recover in 2045 (n = 25), the present worth factor for equipment is calculated as follows:

$$Present\ Worth\ of\ Equipment = \frac{C_e}{(1.0074)^5} + \frac{1.0 * C_e}{(1.0074)^{25}} - \frac{1.0 * C_e}{(1.0074)^{25}}$$

$$= 0.96 * C_e + 0.83 * C_e - 0.83 * C_e = \mathbf{0.96 * C_e}$$

2.10.3.4 Present Worth Factors for Structure Costs

Structure replacement costs do not apply in this case because any new structures will have 30 years of remaining service life at the end of the planning period. However, a structure's remaining value in year 20 is estimated using the above equation to be 0.6 times the initial structure cost.

Assuming the present structure cost is initially incurred in 2025 (n=5) and the remaining value is recovered in 2045 (n=25), the present worth factor for structures is calculated as follows:

$$Present\ Worth\ of\ Structures = \frac{C_s}{(1.0074)^5} - \frac{0.6 * C_s}{(1.0074)^{25}}$$

$$= 0.96 * C_s - 0.50 * C_s = \mathbf{0.46 * C_s}$$

2.10.3.5 Present Worth Factors for Annual O&M Costs

The present worth factor for annual O&M costs is calculated as follows, assuming that the annual O&M costs (A) begin to be incurred in 2025 (n = 5) and are incurred annually through 2045 (n = 25):

$$Present\ Worth\ of\ Annual\ O\&M Costs = \left(\left[\frac{1}{0.0074 * (1.0074)^{(5-1)}}\right] - \left[\frac{1}{0.0074 * (1.0074)^{25}}\right]\right) * A$$

$$= (\mathbf{131.21} - \mathbf{112.39}) * \boldsymbol{A} = \mathbf{18.82} * \boldsymbol{A}$$

2.10.3.6 Present Worth Calculation

Using the factors estimated above, which account for the effective discount rate of 0.74 percent, the replacement cost of equipment at year 20, the remaining value of equipment at year 20, the remaining value of structures at year 20, and annual O&M costs, the present worth is calculated as follows:

$$\boldsymbol{Present\ Worth} = \mathbf{0.96} * \boldsymbol{C_e} + \mathbf{0.46} * \boldsymbol{C_s} + \mathbf{18.82} * \boldsymbol{A}$$

where C_e = present day equipment construction cost

C_s = present day structures construction cost

A = annual O&M cost

2.10.4 Economic Evaluation

The present worth of 20-year lifecycle cost is the most important evaluation criteria as it assigned a weight of 60 maximum points. The lowest present-worth of 20-year lifecycle costs that satisfies project objectives will score the maximum 60 points. Each alternative that exceeds the lowest cost will score a percentage of the maximum points equal to the incremental difference between its cost and the lowest cost.

A total score for each alternative was developed by combining the results of the economic evaluation (economic score out of a possible 60 points)and non-economic evaluation(non-economic score out of a possible 100 points) for a total score out of a possible 100 points.