8.0 INFRASTRUCTURE-BASED CONTROL MEASURES

8.1 IDENTIFICATION AND DESCRIPTION OF CONTROL MEASURES

Table 8-1 lists the infrastructure-based options being considered for implementation in the initial screening stage. Descriptions of these options follow.

Table 8-1 Infrastructure-Based Options

					Goals Addressed							
Number	Category	Option	Required	IWMP	Dry Weather WQ	Solids/Floatables	Recreation	Tributary Habitat	Tidal Habitat	Water Balance	Wet Weather WQ	Stewardship
I.1	Nine Minimum Controls	Nine Minimum Controls	X	X	X	X					X	X
I.2	Operation and Maintenance	Inspection and Cleaning of Combined Sewers	X	X	X	X					X	
I.3	Operation and Maintenance	Combined Sewer Rehabilitation		X	X							
I.4	Operation and Maintenance	Regulator/Pump Station Inspection/Maintenance/Repairs	X								X	
I.5	Operation and Maintenance	Outfall Maintenance Program				X					X	
I.6	Operation and Maintenance	House Lateral Repairs										X
I.7	Sewer Separation	Permitted Discharge to Receiving Water for Waterfront Properties				X					X	
I.8	Sewer Separation	Separation of Sanitary Sewage and Stormwater on Development Sites				X					X	
I.9	Sewer Separation	Separate Street Runoff from Combined System				X					X	
I.10	Sewer Separation	Complete Separation into Sanitary and Storm Sewer Systems				X					X	
I.11	Sewer Separation	Permitted Discharge to Receiving Water for Waterfront Interstate Highways				X					X	
I.12	Outfall Consolidation/Elimination	Outfall and Regulator Consolidation				X					X	
I.13	Storage	Instream Storage Technologies				X					X	
I.14	Storage	In-Line Storage in Interceptor or Trunk Sewer				X					X	
I.15	Storage	Earthen Basins				X					X	
I.16	Storage	Offline Covered Storage Basins				X					X	
I.17	Storage	Offline Open Storage Basins				X					X	
I.18	Storage/Transmission	Deep Tunnels				X					X	
I.19	Storage/Transmission	Real Time Control		X		X					X	
I.20	Transmission	Parallel Interceptors				X					X	
I.21	Transmission	Remove Flow Bottlenecks				X					X	
I.22	Transmission	Diversion of Trunk Flow Directly to WPCP				X					X	
I.23	Treatment at Discharge Point	Vortex Separators				X					X	
I.24	Treatment at Discharge Point	Swirl Concentrators				X					X	

					Goals Addressed							
Number	Category	Option	Required	IWMP	Dry Weather WQ	Solids/Floatables	Recreation	Tributary Habitat	Tidal Habitat	Water Balance	Wet Weather WQ	Stewardship
I.25	Treatment at Discharge Point	Disinfection				X					X	
I.26	Treatment at Discharge Point	High Rate Treatment				X					X	
I.27	Treatment at Discharge Point	Screens				X						
I.28	Treatment at Discharge Point	Netting				X						
I.29	Treatment at Discharge Point	Booms				X						
I.30	Treatment at Discharge Point	Baffles				X						
I.31	Treatment in Receiving Water	Debris Skimming Vessels		X		X						
I.32	Treatment at Existing WPCP	Expand Primary Treatment Capacity				X					X	
I.33	Treatment at Existing WPCP	Expand Secondary Treatment and Disinfection Capacity				X					X	
I.34	Treatment at Existing WPCP	Flow Equalization				X					X	
I.35	Treatment at Existing WPCP	Expansion of Wet Weather Treatment Capacity				X					X	

I.1 Nine Minimum Controls

In the first phase of the PWD's CSO strategy, and in compliance with its NPDES permits, the PWD submitted CSO Documentation: Implementation of Nine Minimum Controls to the Pennsylvania Department of Environmental Protection on September 27, 1995. The nine minimum controls are low-cost actions or measures that can reduce CSO discharges and their effect on receiving waters, do not require significant engineering studies or major construction, and can be implemented in a relatively short time frame. To provide information needed for the development of the Nine Minimum Controls (NMC) program, the PWD instituted a $6.5 million project to upgrade its comprehensive system flow monitoring network. This program provides information necessary to identify and eliminate dry weather overflows, monitor system performance and operation, and configure and calibrate computer hydraulic models needed to develop the NMCs and long-term CSO control plans. This information provided the basis for the System Hydraulic Characterization Report that was submitted to the PADEP in June 1995 and provided the technical basis for the development of the NMC plan.

Extensive data from the PWD's Geographic Information System (GIS), flow monitoring system, the U.S. Army Corps of Engineer's Storage, Treatment, Overflow, Runoff Model (STORM), and the EXTRAN and RUNOFF blocks of the EPA Stormwater Management Model (SWMM) were used to support each phase of the CSO program. These tools were developed to support concept engineering through implementation and post-construction monitoring. The monitoring system, models, and GIS will serve as the basis for planning improvements and enhancing operation of the sewerage system over the long-term.

Using the above tools, the PWD's NMC program includes comprehensive, aggressive measures to maximize water quality improvements through the following measures:

NMC1. Review and improvement of on-going operation and maintenance programs

CSO Regulator Inspection & Maintenance Program
PWD has committed to demonstrating an improved follow-up response to sites experiencing a dry weather overflow. PWD has instituted a policy of next day follow-up inspection at sites that experience an overflow. PWD will conduct an evaluation of the effectiveness of twice-weekly inspections.
A database has been developed to document the maintenance performed on each CSO site. This system will ensure that proper regulator settings are maintained and system changes are documented. This database can also store scanned plan view and profile view drawings of CSO regulator and hydraulic control point chambers for inclusion in the field inspection report forms.

Additional components of the O&M program include:

- Pumping Station Maintenance
- Sewer Cleaning Contracts
- Inflow Prevention Program
- Tide Gate Inspection and Maintenance Program
- Emergency Overflow Weir Modification

NMC2. Measures to maximize the use of the collection system for storage

Use of the collection system for storage has long been recognized as a potentially cost-effective means to mitigate the occurrence and impacts of CSOs. PWD has been implementing in-system storage in Philadelphia's combined sewer system for nearly twenty years, using a variety of technologies.

- Reducing tidal inflows at regulators along the Southwest Main Gravity and the Lower Schuylkill West Side interceptors can reduce CSO overflows to Cobbs Creek by increasing available treatment capacity at the SWWPCP.
- A program to install tide gates or other backflow prevention structures at Cobbs Creek regulators to protect these regulators from potential inundation.
- Another approach that can be implemented to gain additional in-system storage is to raise the overflow elevation by physically modifying the overflow structure (*e.g.* raising an overflow weir). However, this approach must be implemented cautiously, since raising the overflow elevation also raises the hydraulic grade line in the combined trunk sewer during storm flows, and therefore increases the risk of basement and other structural flooding within the upstream sewer system due to backup or surcharge problems.

NMC3. Review and modification of PWD's industrial pretreatment program

Over the years, PWD has implemented a rigorous industrial pretreatment program. The effectiveness of this program has allowed the City to develop one of the largest and most successful biosolids beneficial reuse programs in the nation.

NMC4. Measures to maximize flow to the wastewater treatment facilities

As a minimum control, maximizing flow to the water pollution control plant (WPCP) means making simple modifications to the sewer system and treatment plant to enable as much wet weather flow as possible to reach the treatment plant and receive treatment. The secondary capacity of the treatment plant should be maximized, and all flows exceeding the capacity of secondary treatment should receive a minimum of primary treatment – and disinfection, when necessary. The most effective way to determine the ability of the WPCP to operate acceptably at incremental increases in wet weather flow, and to estimate the effect of the WPCP's compliance with its permit requirement, is to perform stress testing to determine optimum flows, loads, and operations of the plant's unit processes. Please refer to Supplemental Documentation Volumes 6, 7 and 8 (Stress Testing of the Northeast WPCP, Stress Testing of the Southeast WPCP and Stress Testing of the Southwest WPCP).

NMC5. Measures to detect and eliminate dry weather overflows

The operations and maintenance options discussed later in this section include ongoing measures to prevent dry weather discharges from the combined sewer system.

NMC6. Control of the discharge of solid and floatable materials

Solids are waterborne waste material and debris consisting of sand, gravel, silts, clay, and organic matter. Significant concentrations of solids are not only a visual nuisance, but can affect turbidity, dissolved oxygen, and carry pathogens in the receiving water. In addition, excessive amounts of solids can affect the combined sewer system by decreasing hydraulic capacity, thus increasing the frequency of overflows. Solids can enter the system through domestic and industrial wastewater, and debris washed from streets.

Floatables are waterborne waste material and debris (*e.g.*, plastics, polystyrene, and paper) that float at or below the water surface. Floatables seen in significant quantities are aesthetically undesirable and can cause beach closings, interfere with navigation by fouling propellers and water intake systems, and impact wildlife through entanglement and ingestion.

Floatables and solids control measures consist of non structural and structural technologies.

Non structural technologies include combined sewer system maintenance procedures such as sewer flushing, street sweeping, and catch basin cleaning. Public education, land

use planning and zoning, and ordinances are also considered non-structural technologies implemented to reduce solids and floatables entering the combined sewer system. These technologies are discussed under separate subsections and therefore will not be discussed further here.

Structural controls typically consist of abatement devices that would be constructed near the point of discharge. Technologies used for removing solids and floatables from CSOs include: Baffles, Booms, Catch Basin Modifications, Netting Systems, Swirl Concentrators, Screens, and Trash Racks. Modification of storm and combined sewer inlets for solids control, as well as catch basin and storm inlet maintenance are discussed under separate subsections.

Solids and floatables discharged from CSOs may represent a potentially significant impact to Philadelphia's creeks and streams. PWD currently expends considerable effort to minimize the potential discharge of solids and floatables.

- PWD performs over 50,000 inlet cleanings each year preventing many tons of street surface-related materials from discharging to waterways through CSOs. The significant pipe cleaning and grit removal activities conducted by the department also remove a great deal of material that otherwise might discharge through CSO outlets during wet weather.

- The continued practice of regularly cleaning and maintaining grit pockets at critical locations in the trunk and interceptor system is an important part of the CSO control strategy. Grit buildup reduces the hydraulic capacity of the interceptor both by constricting its cross sectional area, and by increasing its frictional resistance. For example, quarterly cleaning of the 100-foot deep siphon grit pocket located at the Central Schuylkill wastewater pumping station is a major undertaking requiring specialized equipment and the commitment of significant labor resources. This practice has been shown to reduce the hydraulic grade surface at the siphon, increasing the wet weather flow capacity to the SWWPCP. Prior to the institution of this cleaning practice, the grit pit at this location had not been cleaned regularly in over 40 years.

- Operation condition inspections of regulator chamber and backflow prevention devices are conducted for each structure approximately weekly, resulting in more than 10,000 inspections conducted each year. Additionally, comprehensive structural and preventative maintenance inspections are performed annually.

- Floatables will be monitored. If additional floatables control is warranted, then structural technologies will be considered. Structural technologies that would be considered first are catch basin modifications, including further enhancement of inlet grating and submerged outlet installations, netting systems, and static screens. More structurally intensive controls would be considered only if the application of the controls mentioned above proved not to be feasible under specific site requirements.

NMC7. Implementation of programs to prevent generation and discharge of pollutants at the source

Most of the city ordinances related to this minimum control are housekeeping practices that help to prohibit litter and debris from actually being deposited on the streets and within the watershed area. These options are discussed under Target A, including litter ordinances and illegal dumping policies and enforcement. If these pollutants eventually accumulate within the watershed, practices such as street sweeping and regular maintenance of catch basins can help to reduce the amount of pollutants entering the combined system and ultimately, the receiving water.

NMC8. Measures to ensure that the public is informed about the occurrence, location and impacts of CSOs

PWD has developed and will continue to develop a series of informational brochures and other materials about its CSO discharges and the potential effect on the receiving waters, in addition to information regarding dry weather flows from its stormwater outfalls. The brochures provide phone contacts for additional information. Also, the opportunity to recruit citizen volunteers to check or adopt CSO outfalls in their watersheds (*i.e.*, notifying the PWD of dry weather overflows, etc.) will be explored through the watershed partnership framework. Brochures and other educational materials discuss the detrimental effects of these overflows and request that the public report these incidences to the department. In addition, PWD has enlisted watershed organizations to assist it with this endeavor and to raise the level of awareness in its citizens about the function of combined and stormwater outfalls through a variety of educational mediums. The watershed partnerships are important for this kind of public/private effort to protect stream water quality. Lastly, the department's Waterways Restoration Team will investigate the feasibility of installing signs that can withstand nature and vandals at the department's outfalls.

A more recent development was discussion among the state, PWD and the Delaware Estuary Program, to begin a marina best management practices education program that, in addition to alerting recreational users of the Delaware and Schuylkill Rivers regarding questionable water quality following rain storms, will also provide tips and information to marina operators to ensure their practices are environmentally sound. To complement this effort, the PWD has completed RiverCast for the Schuylkill River due to the number of recreational activities that take place on the river year around. This system's educational message is similar to that of the marina program as the advisories are based upon rainfall, CSOs and upstream influences on water quality.

NMC9. Comprehensive inspection and monitoring programs to characterize and report overflows and other conditions in the combined sewer system.

Monitoring and characterization of CSO impacts from a combined wastewater collection and treatment system are necessary to document existing conditions and to identify water quality benefits achievable by CSO mitigation measures. Tables are compiled annually to represent average annual CSO overflow statistics as required in the NPDES Permit.

I.2 Operation and Maintenance: Inspection and Cleaning of Combined Sewers

Maintenance of sewers includes activities required to keep the system functioning as it was originally designed and constructed. Any reinvestment in the system, including routine maintenance, capital improvements for repair or rehabilitation, inspection activities, and monitoring activities are generally classified as maintenance.

An inspection program is vital to proper maintenance of a wastewater collection system. Without inspections, a maintenance program is difficult to design, since problems cannot be solved if they are not identified. Sewer inspections identify problems such as blocked, broken, or cracked pipes; tree roots growing into the sewer; sections of pipe that settle or shift so that pipe joints no longer match; and sediment and other material building up and causing pipes to break or collapse. The elements of an inspection program include flow monitoring, manhole inspections, smoke/dye testing, closed circuit television inspection, and private sector inspections. Private sector building inspection activities include inspection of area drains, downspouts, cleanouts, sump discharges and other private sector inflow sources into the system.

In addition to inspection, routine maintenance must also include sewer cleaning, root removal/treatment, cleaning of mainline stoppages, cleaning of house service stoppages, and inspections and servicing of pump stations.

I.3 Operation and Maintenance: Combined Sewer Rehabilitation

An inspection program may identify sections of sewer that are in poor condition and in need of major repair or replacement. Under the traditional method of sewer relief, a replacement or additional parallel sewer line is constructed by digging along the entire length of the existing pipeline. While these traditional methods of sewer rehabilitation require unearthing and replacing the deficient pipe (the dig-and-replace method), trenchless methods of rehabilitation use the existing pipe as a host for a new pipe or liner. Trenchless sewer rehabilitation techniques offer a method of correcting pipe deficiencies that requires less restoration and causes less disturbance and environmental degradation than the traditional dig and-replace method.

I.4 Operation and Maintenance: Regulator/Pump Station Inspection/Maintenance/ Repairs

In order to keep the regulator and pumping stations optimized it is necessary to have routine site inspections and maintenance performed. It is not uncommon for debris and grit to interfere with regulator and pump operations and therefore, expansion and continuation of the current regulator and pumping station inspection and maintenance programs will allow for efficient detection of malfunctioning regulator and/or pumping stations. Presently, the maintenance and repair program relies on site inspections to identify faulty mechanisms, grit or debris build-up and/or damage to the regulator or pumping structure itself. The observations are documented and updated in a database to track repairs.

I.5 Operation and Maintenance: Outfall Maintenance Program

Because of the debris normally present in combined sewage, regulators are particularly susceptible to the accumulation of materials that cause clogging and blockages. Trash blockages at the entrance to the orifice of the interceptor increase head loss through the orifice and cause the majority of unnecessary overflows in passive regulators. Other causes of unnecessary diversions at regulators include weir plates or dams that are improperly set, damaged, or broken off. Similarly, tide gate failure can often be attributed to trash or debris becoming lodged in the gate, or corrosion of the gate or deterioration of the gate gaskets. Tide gate failure allows the receiving water to enter the CSS, reducing the storage and flow capacity.

Pump stations should be maintained to operate at the design conditions. Wet wells should be routinely cleaned because grit and solids deposition in the wet well can damage the pump or restrict the flow of wastewater into the pump.

I.6 Operation and Maintenance: House Lateral Repairs

The City of Philadelphia requires homeowners to maintain and repair lateral connections up to the point where the lateral connects to the city's sewer line. To facilitate prompt attention to failing laterals and to mitigate the financial strain of lateral repairs, PWD offers a homeowner's assistance program, the Homeowner's Emergency Loan Program (HELP). The homeowner must meet certain program requirements and may repay the city in interest free installments.

I.7 Sewer Separation: Permitted Discharge to Receiving Water for Waterfront Properties

Implementation of the LTCPU will coincide with a number of long-term planning efforts for Philadelphia's riverfronts. Redevelopment of these riverfronts provides a once-in-a-lifetime opportunity to modify and retrofit water resources infrastructure at minimal marginal cost while providing new amenities to the community. Since 2006, redevelopment sites have been required to separate sanitary sewage and stormwater in separate laterals prior to connection to public infrastructure. Sewer separation is the practice of separating the combined, single pipe system into separate sewers for sanitary and stormwater flows. In a separate system, stormwater is conveyed to a stormwater outfall for discharge directly into the receiving water. To free wet weather capacity in the combined sewer system, separate storm laterals can be connected to storm sewers built in conjunction with highway expansion projects (see Option I.11), or on large waterfront development sites discharged directly to a receiving water through a permitted outfall. Sanitary sewage can be conveyed to a WPCP for treatment.

Tidal Schuylkill River Master Plan: The Tidal Schuylkill River Master Plan was completed by the Schuylkill River Development Corporation in 2003. It includes a long-term vision for the tidal Schuylkill including stormwater management, water quality improvement, and habitat restoration; streetscaping, trails and greenways, marinas, boat launches, and docks; improved transportation and connections between neighborhoods and the river; a "sustainable riverfront" including new wetlands, restored wetlands, and treatment wetlands; protection and restoration of forest, native species, and buffers; modern shoreline stabilization best management practices; and public and private development

The North Delaware Riverfront Planning Process: The North Delaware Riverfront represents one of the City's unique assets with its spectacular views and amenities, convenient public transportation access and tremendous potential for growth in the form of new recreational opportunities, new riverfront neighborhoods, and ecological habitat restoration. The riverfront offers a prime site for the creation of a public greenway along the river's edge that would complement the distinctive riverfront features and bridges, broad river views, tidal flats and estuarine habitat, and fishing and boating facilities present. The Greenway would provide walking and bike trails, river road access, active recreational opportunities and overlooks, marinas and restaurants, with inland sites developed as new residential and mixed-use riverfront communities. The City's Vision Plan for the North Delaware – eleven miles from Penn Treaty Park to Glen Ford – is to transform much of the vacant, former industrial properties along the riverfront into a destination frontage that will bring new distinction and identity to the City and stimulate the economy and culture of the entire City.

Central Delaware Riverfront Planning Process: A Civic Vision for the Central Delaware. The process was led by PennPraxis of the School of Design of the University of Pennsylvania and authorized by executive order of Philadelphia Mayor John F. Street on October 12, 2006. The charge was to "create a civic vision for the central Delaware that balances the public good, access to the waterfront, open space and quality urban development." The hallmark of the work has been the civic-engagement process, which was designed and facilitated in collaboration with the Penn Project on Civic Engagement.

I.8 Sewer Separation: Separation of Sanitary Sewage and Stormwater on Development Sites

Incorporating sewer separation into all development sites allows for a cost-effective means to detach from the combined sewer design practice. The current stormwater development guidelines require sewer separation from all private development projects and at the very least, separation of sewer lines must be implemented to the trap line.

I.9 Sewer Separation: Separate Street Runoff from Combined System

Separating street runoff from the combined sewer system would require construction of a separate stormwater conveyance pipe to capture and convey captured runoff from surface streets only and would not be combined with sanitary flow conveyed by the existing CSS.

I.10 Sewer Separation: Complete Separation into Sanitary and Storm Sewer Systems

Based on a comprehensive review of a community's sewer system, separating part or all of its combined systems into distinct storm and sanitary sewer systems may be feasible. Communities that elect for partial separation typically use other CSO controls in the areas that are not separated.

I.11 Sewer Separation: Permitted Discharge to Receiving Water for Waterfront Interstate Highways

Currently, stormwater runoff from the two interstate highways (I-95 and I-76) along Philadelphia's riverfronts is discharged to the combined sewer system, taking up wet weather capacity and increasing overflow from sewersheds along the waterfronts. The area represented by I-95 is approximately 2.1% of impervious area in the Delaware River Watershed. Currently, the PADOT has plans to expand the capacity of a portion of I-95 by adding new lanes. This major construction project provides an opportunity to incorporate a stormwater management component concurrently with the transportation component (Figure 8-1). In this concept, stormwater runoff from new and existing lanes will be diverted from the combined sewer system. New separate storm sewers will be constructed from I-95 to the waterfront, with stormwater quality treatment included as appropriate. This infrastructure can be sized to accommodate not just runoff from the highway, but runoff from future redevelopment projects along the waterfront. A similar concept will be considered along waterfront portions of I-76, although there are no current plans to expand this roadway.

I.12 Outfall and Regulator Consolidation

Where several outfalls are near each other, municipalities should investigate whether to consolidate them to a single location for storage and/or treatment. Consolidation can provide more cost-effective control of CSOs, minimizing the number of sites necessary for abatement facilities, and providing the institutional benefit of reducing the number of permitted outfalls. In waterfront areas where redevelopment is taking place and new public amenities are being created, elimination outfalls can remove an impediment to public use and enjoyment of the waterfront.

I.13 Storage: Instream Storage Technologies

The instream storage method involves using floating pontoons and flexible curtains to create an in-receiving water storage facility. CSO flows fill the facility by displacing the receiving water that normally occupies the storage facility. The CSO flows are then pumped to the collection system following a storm. The technology has been used for CSO control in Brooklyn, New York. This alternative involves permanently installing the floating pontoons in the receiving water near the CSO outlets. The feasibility of this technology, therefore, depends in part on whether the structure would be a hindrance to navigation. Other site-specific concerns include the availability of volume due to tidal variations in coastal waters and the need for protection from damage due to high winds or wave action.

I.14 Storage: In-Line Storage in Interceptor or Trunk Sewer

In-line storage is storage in series with the sewer (Urbonas and Stahre, 1993). In-line storage can be developed in two ways: (1) construction of new tanks or oversized conduits to provide storage capacity or (2) construction of a flow regulator to optimize storage capacity in existing conduits. The new tanks or oversized conduits are designed to allow dry weather flow to pass through, while flows above design peaks are restricted, causing the tank or oversized conduit to fill. A flow regulator on an existing conduit functions under the same principle, with the existing conduit providing the storage volume. Developing in-line storage in existing conduits is typically less costly than other, more capital-intensive technologies, such as offline storage/sedimentation, and is attractive because it provides the most effective utilization of existing facilities. The applicability of in-line storage, particularly the use of existing conduits for storage, is very site-specific, depending on existing conduit sizes and the risk of flooding due to an elevated hydraulic grade line. Examples of flow regulating technologies used to develop in-line storage were discussed previously.

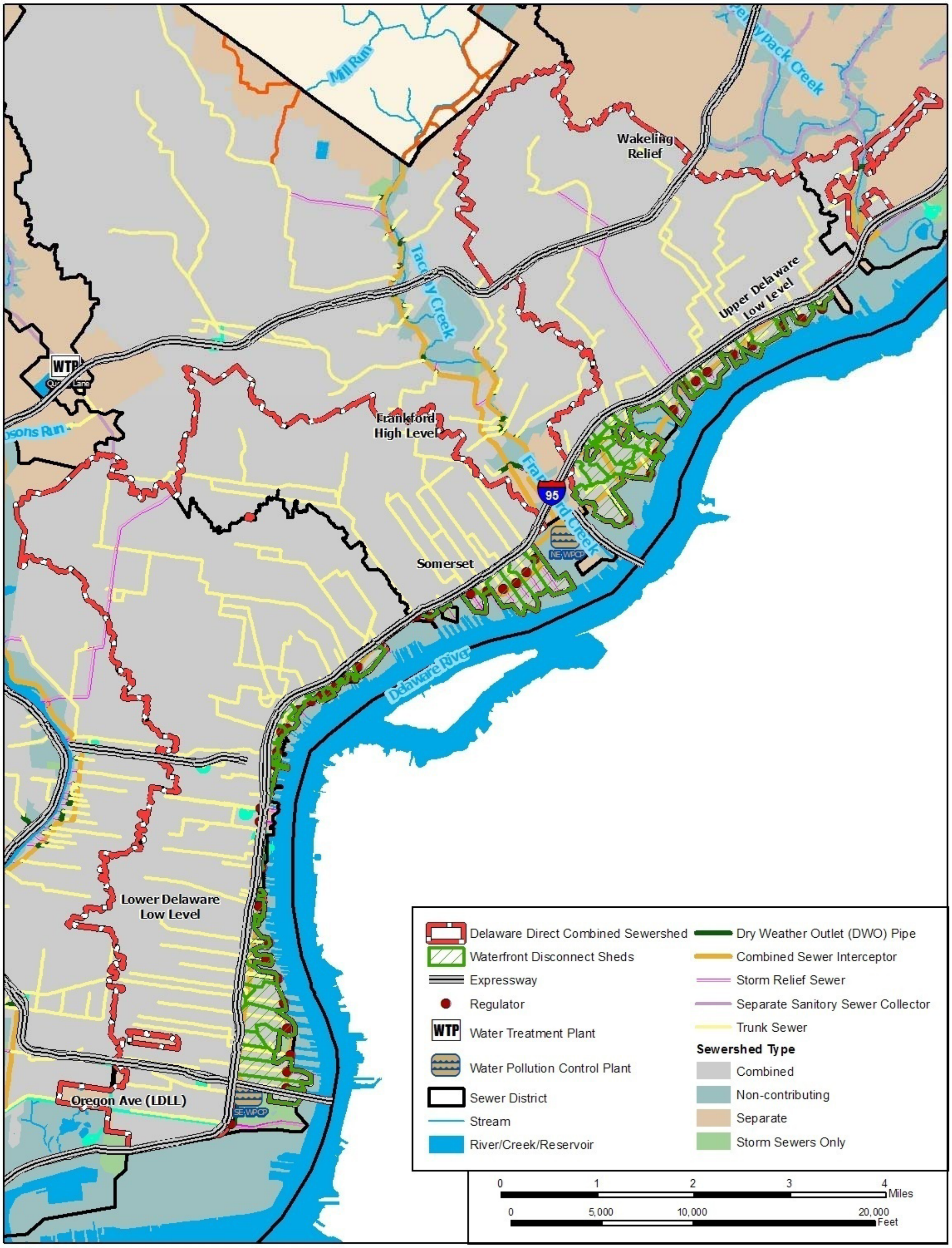

Figure 8-1 I-95 and Delaware Waterfront Combined-Sewered Areas

I.15 Storage: Earthen Basins

Generally, there are three types of earthen basins used in stormwater management design: Detention, Wet-Weather Retention and Infiltration. All basins are supplemented with some form of underdrain and emergency overflow structure to manage flow into the combined system. Detention basins are large areas of depression within a pervious location that remains dry except during wet-weather events. The detention basins capture wet-weather runoff during storm events and detain the runoff to attenuate peak flows into the combined system. Wet-weather retention basins always have a small pond of water and generally are vegetated. The retention pond allows for greater nutrient and solids removal than that of the detention basin. Infiltration basins are constructed with a more intricate underdrain system to facilitate nutrient and solids removal as well as infiltration and groundwater recharge of captured stormwater.

Earthen basins, as described above, may be implemented in a variety of sizes and locations to help meet stormwater management needs for large or small drainage areas. The flexibility of earthen basins allow for them to be used in conjunction with other stormwater management practices to reduce CSOs into receiving waters.

I.16 Storage: Offline Covered Storage Basins

Offline covered storage basins are concrete tanks that are connected in parallel to the combined sewer and receive flows only during wet weather periods. Covered basins are preferred over earthen basins or uncovered tanks because they provide better odor control and better safety conditions. Offline storage is more costly than online storage because parallel lines must be constructed and facilities for pumping the stored wastewater back to the sewer are usually required. However, offline storage is required where head loss in the downstream sewer is a concern and sedimentation or other treatment methods are desired.

Offline basins may be located at upstream or downstream locations in the combined sewer system. Advantages of upstream control include greater flexibility in selecting sites for facilities and more efficient control of flows to the downstream treatment facility. The primary advantage of downstream storage is that fewer facilities are required, resulting in lower construction and operation and maintenance costs. It may be possible to minimize costs further if storage capacity is available at the wastewater treatment plant.

I.17 Storage: Offline Open Storage Basins

Offline open storage basins are typically earthen. Offline storage is more costly than online storage because parallel lines must be constructed and facilities for pumping the stored wastewater back to the sewer are usually required. However, offline storage is required where head loss in the downstream sewer is a concern and sedimentation or other treatment methods are desired.

Offline RBs may be located at upstream or downstream locations in the combined sewer system. Advantages of upstream control include greater flexibility in selecting sites for facilities and more efficient control of flows to the downstream treatment facility. The primary advantage of downstream storage is that fewer facilities are required, resulting in lower construction and operation and maintenance costs. It may be possible to minimize costs further if storage capacity is available at the wastewater treatment plant.

I.18 Storage/Transmission: Deep Tunnels

Philadelphia has multiple outfalls and limited available space for near-surface facilities, making consolidation of outfalls on a regional basis using deep tunnels or other appropriate technologies a potentially cost effective storage and transmission approach. Depending on the geographic distribution of outfalls, subsurface geological conditions, and other factors, a deep tunnel alternative can include near-surface consolidation conduits or satellite near-surface storage/treatment facilities for remotely located outfalls. Alternatives involving deep tunnels should consider whether the tunnels will serve primarily as storage facilities to be pumped out to the WPCP at the end of a storm event or whether they will also serve to convey wet weather flows to the WPCP for treatment during a storm event.

I.19 Storage/Transmission: Real Time Control

PWD has been evaluating and implementing computer controlled CSO outfall/regulator gate facilities that use level monitors to control the position of the dry-weather outlet (DWO) gate and tide gate at each location for maximizing the utilization of in-system storage in the combined sewer system. These computer controlled outfall facilities apply real-time control (RTC) mechanisms to maximize in-system storage. The use of RTC allows the capture and delivery to the treatment works of flow at the maximum rate at which it can be treated. This approach is attractive in terms of optimizing the use of the existing sewer system to capture combined wastewater and minimize CSOs.

I.20 Transmission: Parallel Interceptors

Parallel interceptors provide increased transmission capacity to bring flows to a WPCP.

I.21 Transmission: Remove Flow Bottlenecks

PWD's collection system includes some localized instances where infrastructure does not have the capacity to convey the full flow from upstream. Examples include siphons and pipes of smaller diameter than upstream pipes. In these cases, localized replacement may be a cost-effective way to increase transmission capacity to the WPCP.

I.22 Transmission: Diversion of Trunk Flow Directly to WPCP

For a limited number of small sewersheds close to the WPCP, it may be possible to divert all trunk flow to the WPCP without regulation.

I.23 Treatment at Discharge Point: Swirl Concentrators

Swirl concentrators provide flow regulation and solids separation by inducing a swirling motion within a vessel. Solids are concentrated and removed through an underdrain, while clarified effluent passes over a weir at the top of the vessel. Types of swirl devices include the EPA swirl concentrator. Conceptually, the EPA swirl concentrator is designed to act as an in-line regulator device. In addition to flow routing or diversion, it removes heavy solids and floatables from the overflow. Each type of swirl unit has a different configuration of depth/diameter ratio, baffles, pipe arrangements, and other details designed to maximize performance.

I.24 Treatment at Discharge Point: Vortex Separators

The commercial vortex separators are based on the same general concept as the EPA swirl concentrator but include a number of design modifications intended to improve solids separation. The commercial designs have been applied as offline treatment units. Vortex separators placed at discharge points are intended for inorganic solids separation and removal prior to discharging. Separation is facilitated by a swirling motion similar to a centrifuge and the solids are settled out at the bottom of the unit. Vortex Separators are available for both in-line and offline treatment, are available in varying sizes and designs, which are based on the peak flow design event and on-site configuration requirements.

I.25 Treatment at Discharge Point: Disinfection

This process destroys or inactivates microorganisms in overflows, most commonly through contact with forms of chlorine. Various disinfection technologies are available both with and without chlorine compounds. Some of the more common technologies include gaseous chlorine, liquid sodium hypochlorite, chlorine dioxide, ultraviolet radiation, and ozone. For disinfection of CSOs, liquid sodium hypochlorite is the most common of the above technologies.

Dechlorination: A major disadvantage of chlorine-based disinfection systems is that the residual chlorine concentration can have a toxic effect on the receiving waters, due either to the free chlorine residual itself or to the reaction of the chlorine with organic compounds present in the effluent. With the relatively short contact times available at many CSO control facilities, disinfection residuals can be of particular concern and can require consideration of dechlorination alternatives. Two of the more common means for dechlorinating treated effluent are application of gaseous sulfur dioxide or liquid sodium bisulfite solution.

I.26 Treatment at Discharge Point: High Rate Treatment

High Rate Clarification

High rate clarification (HRC) processes have surface overflow rates greater than 20 gallons per minute per square foot (gpm/ft^2). Both the DensaDeg® and Actiflo® processes utilize ballasted flocculation to achieve these overflow rates.

DensaDeg® Ballasted Flocculation

The DensaDeg® process is a ballasted flocculation process that recirculates settled sludge as the ballast to achieve excellent TSS removal at a standard design surface overflow rate of 40 gpm/ft2 for wet-weather flow. The process consists of a rapid mix zone, reactor zone, and a clarifier/thickening zone. Wastewater enters the rapid mix zone along with a coagulant where flash mixing occurs. Polymer is added as a flocculating agent as the wastewater flows to the reactor zone, which is equipped with an axial flow impeller/ draft tube arrangement.

The water and flocculated sludge enter the clarification zone where most of the solids settle. The clarifier contains a lamella settling zone where most of the remaining solids are removed. The settled sludge is thickened, and part of the thickened sludge is recirculated back to the reactor zone to serve as a ballasting agent and nucleus for floc growth for improved settleability. The remaining sludge is wasted. The process is well suited for enhanced primary treatment of wet-weather flows in combined sewer systems. Suspended solids removal in excess of 90% of influent concentrations can be achieved consistently, and COD and BOD removal are often better than 60% depending on influent characteristics. Optimal treatment is typically achieved approximately 30 to 45 minutes after start-up. The start-up time is necessary to build up adequate sludge.

Advantages: The DensaDeg® process provides high removal efficiencies and is stable at variable influent flows and loads.

Disadvantages: Pilot testing is recommended for design optimization.

Actiflo® Ballasted Flocculation

The Actiflo® process is a ballasted flocculation process that utilizes microsand as the ballast to achieve excellent TSS removal at a standard design surface overflow rate of 60 gpm/ft^2 for wet-weather flow. The process consists of a coagulation zone, injection zone, maturation zone, and clarification zone. Wastewater enters the coagulation chamber along with a coagulant for flash mixing. Wastewater then flows to the injection tank where microsand and polymer are added. Microsand interacts with the destabilized particles and the polymer. The maturation tank is a gentle mixing zone that allows the formation of floc. The polymer promotes the formation of strong flocs around the microsand. The water and floc then flow to the clarification zone where the flocculated solids settle. Most of the solids settle at the bottom of this compartment. Lamella plate or tube settlers may be used to enhance removal of suspended solids. Solids that accumulate at the bottom of the clarification compartment are recycled to a hydrocyclone, where the lower density sludge is separated from the higher density microsand. The microsand is recycled to the injection tank, and the sludge leaves the system.

Advantages: The Actiflo® process provides high removal efficiencies and is stable at variable influent flows and loads.

Disadvantages: Actiflo® requires a 5 to 15 minute startup time since startup flows must be stored and fed back through unit or to the conventional treatment headworks. A minimum 4:1 turndown ratio (minimum flow through unit is 25% of capacity) is available for lower flows.

Biologically Enhanced High Rate Clarification (Bio HRC)

Biologically and chemically enhanced clarification (Bio CEC) incorporates a short duration biological contact tank upstream of chemically enhanced clarification (CEC) to achieve rapid uptake of soluble organic matter that would not be removed by only CEC. In this process, activated sludge from a plant's secondary process (RAS or WAS) is routed to a short-duration (5-10 minutes) contact basin where it blends with excess wet weather flows to achieve rapid uptake of soluble organic matter into the biomass. This mixture of biomass and influent wastewater is then treated through CEPT or HRC. The resulting CEPT or HRC sludge may be returned to the aeration basins or wasted. The nonproprietary technology is Bio CEPT, and the current proprietary technology is BioActiflo®.

Advantages: Soluble BOD uptake, Bioadsorption of colloidal and particulate matter, Potential reduction of CEPT and HRC chemical requirements, Lower foaming potential and Higher UV Transmittance.

Disadvantages: It is a relatively new process thus is relatively unproven at full-scale and little operational information is available.

Retention Treatment Basins (RTBs)

Retention treatment basins (RTBs) are satellite high rate treatment facilities designed to provide screening, settling, skimming (with a fixed baffle) and disinfection of combined sewer flows before discharge to a receiving water. Since RTBs are empty between wet-weather events, they also provide storage, which can completely capture combined sewer flows from small wet weather events for later dewatering and conveyance to the WPCP for treatment. RTBs can be designed with a variety of screen types, disinfection methods and basin geometries. The surface loading rates can also vary but are typically higher than rates used for design of primary clarifiers. RTBs can be constructed above or below grade but typically require at least an above grade process/control building. If pumping of the combined sewer flow is required, the pump station may be integral to the RTB facility or constructed as a separate structure.

Advantages: Relatively simple to operate and maintain.

Disadvantages: Large footprint of the structure occupies waterfront land that could otherwise provide public amenities.

I.27 Treatment at Discharge Point: Screens

Screens and trash racks consist of a series of vertical and horizontal bars or wires that trap floatables while allowing water to pass through the openings between the bars or wires. Screens can be installed at select points within a CSS to capture floatables and prevent their discharge in CSOs. Screens used for CSO control include mechanically cleaned permanent screens, static screens, traveling screens, or drum screens. Screens can also be divided into three categories according to the size of floatable material they are designed to capture. These are:

- Bar screens (> 2.5 centimeter [1 inch] openings)
- Coarse screens (0.5 - 2.5 centimeter [0.19 - 1 inch] openings)
- Fine screens (0.01 - 0.5 centimeter [0.004 - 0.19 inch] openings)

The screens most commonly used to control CSOs are trash racks (a type of bar screen primarily used as an end-of-pipe control) and coarse screens.

I.28 Treatment at Discharge Point: Netting

Two types of netting systems can be used to collect floatables in a CSS: in-line netting, and floating units. In-line netting can be installed at strategic locations throughout the CSS. The nets would be installed in underground concrete vaults containing one or more nylon mesh bags and a metal frame and guide system to support the nets. The mesh netting is sized according to the volume and types of floatables targeted for capture. The CSO flow carries the floatables into the nets for capture. Bags are replaced after every storm event. Floating units consist of an in-water containment area that funnels CSO flow through a series of large nylon mesh nets. Mesh size depends on the volume and type of floatables expected at the site. This system is passive and relies on the energy of the overflow to carry the floatables to the nets. However, nets must be located some distance from the outfall (often 15 meters [50 feet] or more) to allow floatables entrained in the turbulent CSO flow to rise to the flow surface and be captured. The nets are single use, and after an overflow, the nets are typically removed and taken to a disposal area.

I.29 Treatment at Discharge Point: Booms

Booms are containment systems that use specially fabricated floatation structures with suspended curtains designed to capture buoyant materials. Booms can also be designed to absorb oils and grease. They are typically anchored to a shoreline structure and the bottom, and they can be located downstream of one or more outfalls. Booms are sized based upon the expected volume of floatables released during a design-storm event. After a storm event, material captured in the boom can be removed manually, or with a vacuum truck or a skimmer vessel.

I.30 Treatment at Discharge Point: Baffles

Baffles are simple floatables control devices that are typically installed at flow regulators within the CSS. They consist of vertical steel plates or concrete beams that extend from the top of the sewer to just below the top of the regulating weir. During an overflow event, floatables are retained by the baffles while water passes under the baffles, over the regulator, and into the receiving water body. When the flow recedes below the bottom of the baffle, floatable material is carried downstream to the wastewater treatment plant.

I.31 Treatment in Receiving Water: Debris Skimming Vessels

Skimmer vessels are a very visible floatables control method that are easy for the general public to understand and support. Skimmer vessels are typically used to clean broad areas of open water. As a result, the floatable debris and litter collected comes from a variety of sources including CSOs, separate stormwater systems, and upstream sources. Financial assistance from sources other than the owner and operator of the CSS may be warranted.

I.32 Treatment at Existing WPCP: Expand Primary Treatment Capacity

Expansion of the primary treatment capacity of the WPCPs in all districts must take into account the average daily flow, the peak instantaneous flow and the maximum daily average flow that could potentially be delivered to each plant. Using this information the feasibility of expanding the plant to apply primary treatment to all flow being delivered must be evaluated with regard to spatial limitations of the plant expansion footprint, costing and a list of design options.

I.33 Treatment at Existing WPCP: Expand Secondary Treatment and Disinfection Capacity

Secondary treatment essentially has the primary effluent bypass primary treatment and either receives treatment at the existing secondary treatment structure (*e.g.* the chlorine contact basin) or at a new secondary treatment structure downstream of the existing chlorine contact unit. The bypass flowrate value, necessary WPCP improvements and cost considerations are assessed when evaluating this option.

I.34 Treatment at Existing WPCP: Flow equalization

Flow equalization within WPCPs is a technique in which the velocity of water to be treated is reduced and stabilized as it moves through each treatment process in the plant. The reduced velocity allows for maximum settling of floatables and reduces the adverse effects produced from high velocity inflow surges that could disrupt the efficiency of the wastewater treatment processes, such as thorough chemical mixing and settling processes.

I.35 Treatment at Existing WPCP: Expansion of Wet Weather Treatment Capacity

Expansion of the WPCP to increase Wet Weather treatment capacity requires defining a target treatment capacity for each district's WPCP. This target is determined from analyzing the maximum flow that may be delivered by the contributing collection of interceptor systems to that plant. Using this target value, a list of improvements necessary for the WPCP to meet the target is required. Finally, a conceptual design, cost estimate and construction timeline needs to be generated for each item in the list of improvements. For this LTCPU plant expansion was analyzed for each district and a number of different treatment capacity scenarios.

Stress testing was conducted for all three WPCPs and reports were completed in 2001; reports are available in Supplemental Documentation Volumes 6, 7 and 8 (Stress Testing of the Northeast WPCP, Stress Testing of the Southeast WPCP and Stress Testing of the Southwest WPCP). The following section briefly describes the above studies for each of the WPCPs.

Northeast Wastewater Treatment Plant Stress Testing Summary and Capital Improvement Options

The Northeast WPCP (NEWPCP) is located at Wheatsheaf Lane and Richmond Street in Philadelphia and is permitted to treat an average daily flow of 210 mgd, a maximum daily average flow of 350 mgd, and an instantaneous peak flow of 420 mgd. Since 2001, PWD has been actively planning and evaluating options to increase the capacity of the NEWPCP to treat wet-weather flows.

A hydraulic model of the NEWPCP was used to evaluate the feasibility of conveying additional wastewater through the primary treatment process during high-flow events. A SWMM model of the collection system was used to determine the maximum conveyance capacity of the FHL sewer. This maximum flow rate was carried forward to establish the maximum flow rate for analysis in the plant hydraulic model. This analysis showed that rehabilitation of the FHL sewer between the NEWPCP pre-treatment building (PTB) and an upstream point at regulator R18 would increase the potential flow delivery to NEWPCP through the FHL from 80 mgd to 205 mgd. This maximum FHL flow rate was used as the basis of all further hydraulic and process analysis resulting in a total target plant flow of 545 mgd.

A process design model (Pro2D) was used to evaluate predicted plant performance and determine maximum allowable flows without exceeding permit limits. The process model assumed a peak wet-weather flow rate of 435 mgd through secondary treatment. Flow greater than 435 mgd would receive only primary treatment and disinfection.

Maximizing flow to the WPCP is intended to ensure that optimum use is made of existing plant capacity. The National CSO Control Policy states that ". . . the long-term control plan should also consider expansion of WPCP secondary and primary capacity in the CSO abatement alternative analysis " (II.C.4). In some cases, it might be more cost-effective to expand existing WPCP facilities than to site separate facilities for CSO control. The National CSO Control Policy addresses the specific case where existing primary treatment capacity at a WPCP exceeds secondary treatment capacity and it is not possible to utilize the full primary treatment capacity without overloading the secondary facilities. For such cases, the National CSO Control Policy states that at the request of the municipality, EPA may allow an NPDES permit ". . . to authorize a CSO-related bypass of the secondary treatment portion of the WPCP for combined sewer flows in certain identified circumstances " (II.C.7). Under this provision, flows to the WPCP within the capacity of primary treatment facilities but in excess of the capacity of secondary treatment facilities may be diverted around the secondary facilities, provided that "... all wet weather flows passing the headworks of the WPCP will receive at least primary clarification and solids and floatables removal and disposal, and disinfection, where necessary, and any other treatment that can reasonably be provided" (II.C.7). In addition, the CSO-related bypass should not cause exceedance of WQS.

The results of the process model analysis recommend the wet-weather capacity upgrades be limited to a maximum of 550 mgd based on predicted process performance versus effluent limits. This demonstrates the ability of the plant process to handle the projected flow of 545 mgd and meet permitted effluent limits within the existing treatment process footprint.

Conceptual designs were developed for 11 capital improvement options (Table 8-2), each providing increased treatment or hydraulic capacity to achieve the 545 mgd target flow rate. Different combinations of the improvement options can be implemented to reach, first, the peak flow through secondary treatment (435 mgd) and, second, the peak flow through primary treatment (545 mgd), as described below.

Table 8-2 Improvement Options Summary

Improvement Number	Improvement Description
1	Frankford Grit Chamber Bypass Replacement
2	Frankford High Level Second Barrel Rehabilitation
3	New Conduit from Div B to Pre-Treatment Building (PTB)
4A	Additional Pretreatment at Northeast Side of PTB with Detritor grit removal technology -
4B	Additional Pretreatment at Southeast Side of PTB with Detritor grit removal technology
5	New Conduit from PTB to Set-1 PSTs
6A	New Conduit from PTB to Set-2 PSTs in Conjunction with 4A
6B	New Conduit from PTB to Set-2 PSTs in Conjunction with 4B
7	Reactivate Bypass Conduit from Div B to Set-2 PSTs with New Bar Screen and Grit Removal
8	New Influent Baffles in Set-2 PSTs
9	Remove Double Deck Effluent Channel in FST Set-2
10A	New Bypass Conduit from Set-1 PSTs to Plant Outfall with Disinfection Upstream of CCC
10B	New Bypass Conduit from Set-1 PSTs to Plant Outfall with Disinfection Downstream of CCC
11	High-Rate Treatment System

To achieve 435 MGD:

- Remove double-decker effluent channel in Set 2 Final Sedimentation Tanks (FSTs) (Improvement 9)
- Install new conduit between Preliminary Treatment Building (PTB) and one set of Primary Sedimentation Tanks (PSTs) - either Set 1 or Set 2 (Improvement 5 or 6A or B)

To achieve 545 MGD:

- Replace Frankford Grit Chamber Bypass (Improvement 1)
- Rehabilitate second barrel of the Frankford High Level Sewer (Improvement 2)
- Install new conduit between Diversion Chamber B and PTB area (Improvement 3)
- Install bypass from Primary Treatment to the Chlorine Contact Chamber (Improvement 10A or B

Either:

- Build High Rate Treatment facility (Improvement 11)

Or:

- Implement improvements within existing plant that could include a combination of the following:
  - Install new influent baffles in Set 2 PSTs (Improvement 8)
  - Reactivate bypass from Diversion Chamber B to Set 2 PSTs and build new preliminary treatment system for diverted flow (Improvement 7)
  - Expand PTB capacity by adding new bar screen and grit chamber (Improvement 4A or B)
  - Install new conduit between PTB and the other set of PSTs (Improvement 5 or 6A or B)

More details may be found in Supplemental Documentation Volumes 6 and 9.

In order to achieve a peak plant flow rate of 545 mgd, 110 mgd of the flow must be bypassed around secondary treatment, disinfected, and discharged to the plant outfall. This could be achieved by bypassing a portion of the primary effluent either to the existing Chlorine Contact Chamber or through a new additional Chlorine Contact Unit to points downstream of the existing Chlorine Contact Chamber.

Southeast Wastewater Treatment Stress Testing Summary

In order to increase the flow capacity of the SE WPCP for wet weather conditions, the potential of maximizing flow through the existing plant was evaluated. According to stress testing results, the SE WPCP currently has a flow capacity of 240 mgd (Supplemental Documentation Volume 7 :Stress Testing of the Southeast WPCP.). With several process and hydraulic modifications, the SEWPCP's flow capacity can potentially reach 330 mgd (Table 8-3). The necessary improvements to achieve this flow were identified in the Stress Testing Report and are based on results of stress tests on unit processes, long-term monitoring of the plant, hydraulic modeling, and input from SEWPCP plant staff.

Table 8-3 Improvement Options Summary

Improvement Number	Improvement Description
1	Provide facilities for phosphorous addition to wastewater
2,3	Resolve capacity limitations associated with having one coarse bar rack out of service and hydraulic bottleneck at existing influent pump station
4	Replace existing primary clarifier effluent launders with new launders running parallel to flow to increase hydraulic capacity
5	Provide two gravity thickeners to perform offline sludge thickening and improve performance of the primary clarifiers
6	Provide an additional 71-MGD effluent pump at the effluent pumping station
8	Resolve hydraulic limitation between primary clarifiers and the aeration basins by adding pumps to pass greater flow and increase available head.

The current configuration of the influent wet wells limits the plant flow to 200 mgd when one coarse screen is out of service. To provide redundancy, Improvements 2 and 3 include the addition of two new bar screens and influent pumps with a capacity of 130 mgd. Due to the configuration and space limitations of the existing influent pump station, a new pump station will be needed for this new equipment. Since any new wet weather treatment facility will also require influent screening and pumping, a single building can be constructed to house all the new equipment. This new preliminary treatment building (PTB) will include the two new bar screens and influent pumps for the existing plant, as well as the additional units needed for the wet weather treatment train alternatives. A new conduit will be constructed from the new PTB to the head of the existing grit channels, carrying up to 130 mgd to the existing plant for treatment during either dry or wet weather conditions.

To increase the capacity of the existing primary clarifiers, Improvement 5 provides for the addition of offline sludge thickening. Currently, primary sludge is thickened in the clarifiers. The thickened sludge is pumped from the clarifiers to sludge storage tanks, which store the sludge until it is pumped to the Southwest WPCP for further treatment. The addition of separate gravity thickeners on site will eliminate the need to carry a sludge blanket in the primary clarifiers. This will eliminate scour of the solids from the sludge blanket during high surface overflow rates, allowing the clarifiers to maintain removal efficiencies during peak flows. The sizing of these gravity thickeners is based on a 55 percent removal efficiency in the existing clarifiers, a 0.5 percent solids concentration, and a solids loading rate of 30.7 $lb/ft^2/day$ for the thickeners. These assumptions are consistent with those for the wet weather treatment trains. Since the majority of the proposed wet weather treatment trains require gravity thickening also, all gravity thickeners for both the existing plant and the wet weather treatment facility will be located in the same area on site.

Southwest Wastewater Treatment Plant Stress Testing Summary

In order to increase the flow capacity of the SWWPCP for wet weather conditions, the potential of maximizing flow through the existing plant was evaluated. From 2004 to 2007, the SWWPCP treated an average daily flow of 193 mgd, a maximum daily flow of 432 mgd, and an instantaneous peak flow of 489 mgd. The maximum plant flow sustained over 12 hours was 466 mgd. According to stress testing results and recommendations, the SWWPCP's flow capacity can potentially reach 540 mgd with several process and hydraulic modifications (Table 8-4). The necessary improvements to achieve this flow were identified in the 2001 Stress Testing Report and are based on results of stress tests on unit processes, long-term monitoring of the plant, hydraulic modeling, and input from SWWPCP plant staff . The improvements should lead to increasing the plant's capacity to a minimum of 540 mgd (Supplemental Documentation Volume 8: Stress Testing of the Southwest WPCP.).

Table 8-4 Improvement Options Summary

Improvement Number	Improvement Description
1	Replace caulking on secondary clarifier launders to improve flow distribution[1]
2	Provide preliminary treatment for the BRC centrate that is recycled to the plant
3	Modify existing RAS system in the secondary clarifiers
4	Provide four gravity thickeners for thickening of primary sludge (tentative location west of the Final Sedimentation Tanks)
5	Resolve hydraulic limitations between primary clarifiers and aeration basin
6	Provide an additional effluent pump at the effluent pumping station

[1]Represents a re-occurring continued maintenance procedure on launders to keep performance efficient

Wet Weather Treatment Alternatives

PWD also conducted a set of studies for each of the three WPCPs to study the cost effectiveness of further wet weather treatment expansion at the WPCPs and a report was generated in 2009. These reports can be found in Volumes 9, 10 and 11 (Analysis of Wet Weather Treatment Alternatives for Northeast WPCP, Analysis of Wet Weather Treatment Alternatives for Southeast WPCP and Analysis of Wet Weather Treatment Alternatives for Southwest WPCP). The following section briefly describes the above studies for each of the WPCPs.

Studies of various conceptual designs and corresponding costs for Wet Weather Treatment Alternatives have been developed. These studies were performed for all the three plants. The following sections provide a brief summary of the plant expansion analyses that were performed.

Northeast Wet Weather Treatment Alternatives

The wet weather treatment technologies for the SWWPCP evaluated are as follows:

1. Vortex Swirl Concentrators
2. Conventional Clarifiers
3. Chemically Enhanced Primary Treatment (CEPT) with Conventional Clarifiers
4. Ballasted Flocculation (includes fine screening)

Conceptual treatment trains were developed for each treatment technology at various wet weather flows ranging from 69 million gallons per day (mgd) to 1100 mgd and cost curves for capital, operations and maintenance (O&M), and lifecycle costs were generated for each treatment train alternative. Currently, the NEWPCP has a flow capacity of 435 mgd. With several process and hydraulic modifications, as identified in the 2001 Stress Testing Report and the NEWPCP Flow Study, the capacity of the existing plant can potentially reach 650 mgd (Volumes 6 and 9 : Stress Testing of the Northeast WPCP and Analysis of Wet Weather Treatment Alternatives for Northeast WPCP). This work includes the construction of a 250-mgd secondary bypass from the existing primary sedimentation tanks to the chlorine contact chamber.

In sizing the wet weather treatment trains, it was assumed that these upgrades, costing $147 Million, will have been completed, increasing the plant’s capacity to a minimum of 650 mgd. Any wet weather flow in excess of 650 mgd would be diverted to the new wet weather facility. To expand the flow capacity of NEWPCP beyond 650 mgd for the treatment of wet weather flows, a separate wet weather treatment train will be required. Wet weather flows in excess of 650 mgd will be diverted to one of the new treatment trains, listed above, eventually blending with effluent from both the secondary system and the bypass from the existing plant. Conceptual designs and cost estimates were performed for each treatment train at various design flows.

Conceptual designs and cost estimates were developed at several design flows for each wet weather treatment train under evaluation (Table 8-5). These flows were selected based on the ability to meet permit requirements, the land area available onsite, and the maximum expected flow from the upgraded collection system. The Vortex/Swirl and Conventional Clarification trains were both flow-limited by permit requirements.

Table 8-5 Design Flows Evaluated for each Wet Weather Treatment Train

Treatment Train	Design Flows Evaluated (mgd)
#1 - Vortex/Swirl Concentrators	69, 183
#2 - Conventional Clarifiers	160, 376
#3 - CEPT w/ Conventional Clarifiers	150, 300, 1000
#4 - Ballasted Flocculation	150, 500, 1100

While each flow scenario for each treatment train evaluated is sized to produce blended effluent concentrations compliant with permit limits, the resulting water quality differs widely between different scenarios. The TSS and BOD concentrations of the blended effluent for each treatment train and flow scenario is presented under Tables 8-6 and 8-7. In general, ballasted flocculation achieves the lowest TSS and BOD concentrations after treatment and can operate an unlimited number of times during the month while allowing the NEWPCP to continue to meet permit limits.

Table 8-6 TSS Concentrations for each Treatment Train and Flow Value.

Treatment Train	Wet Weather Treatment Train Effluent Conc. (mg/L)	Blended Effluent TSS Concentration (mg/L)								
		Wet Weather Treatment Train Flow (mgd)								
		69	***150***	***160***	***183****	***300***	***376****	***500***	***1000***	***1100***
#1) Vortex/Swirl Concentrators	221	83			87					
#2) Conventional Clarifiers	142			83			82			
#3) CEPT w/ Conventional Clarifiers	63		67			66			65	
#4) Ballasted Flocculation	30		61					51		44

Notes: Based on the 95th percentile wet weather TSS concentration of 68 mg/L and a maximum of 650 MGD through the existing plant. Allowable daily blended effluent TSS concentration on wet weather days is 99 mg/L to meet monthly TSS permit limits.
The Vortex-183 mgd and CEPT-376 mgd flow scenarios are only allowable assuming no secondary bypass at the plant. Thus, these concentrations assume a 95th percentile wet weather TSS concentration of 31 mg/L and a maximum of 435 MGD through the existing plant.

Table 8-7 BOD Concentrations for each Treatment Train and Flow Value.

Treatment Train	Wet Weather Treatment Train Effluent Conc. (mg/L)	Blended Effluent cBOD Concentration (mg/L)								
		Wet Weather Treatment Train Flow (mgd)								
		69	***150***	***160***	***183****	***300***	***376****	***500***	***1000***	***1100***
#1) Vortex/Swirl Concentrators	117	37			49					
#2) Conventional Clarifiers	91			41			53			
#3) CEPT w/ Conventional Clarifiers	66		36			41			51	
#4) Ballasted Flocculation	55		34					40		45

Notes: Based on the 95th percentile wet weather cBOD concentration of 29 mg/L and a maximum of 650 MGD through the existing plant.
*The Vortex-183 mgd and CEPT-376 mgd flow scenarios are only allowable assuming no secondary bypass at the plant. Thus, these concentrations assume a 95th percentile wet weather cBOD concentration of 20 mg/L and a maximum of 435 MGD through the existing plant.

As shown in Figure 8-2, the capital costs for Trains #2 through#4 track each other very closely, with CEPT being slightly more expensive. Train #1, the vortex/swirl, appears least expensive and most cost effective as flows increase. Train #3, CEPT, appears slightly less cost effective than Train #4, Ballasted Flocculation, due to greater cost for piles due to its larger footprint (Figure 8-3).

The comparison of O&M costs for each treatment train is shown in Figure 8-4. As expected, the O&M costs for vortex swirls and conventional clarifiers, which do not require chemical settling aids, are the lowest. Ballasted Flocculation has the highest O&M costs due to the use of chemicals and the complexity of its system.

Taking construction, non-construction, and O&M costs into consideration, Figure 8-5 shows the present value of the total cost of each wet weather treatment train. This graph suggests that there is negligible cost difference between Train #3, CEPT, and Train #4, Ballasted Flocculation at this plant. As expected, Trains #1 and #2 are least expensive due to its low chemical usage and minimal O&M costs.

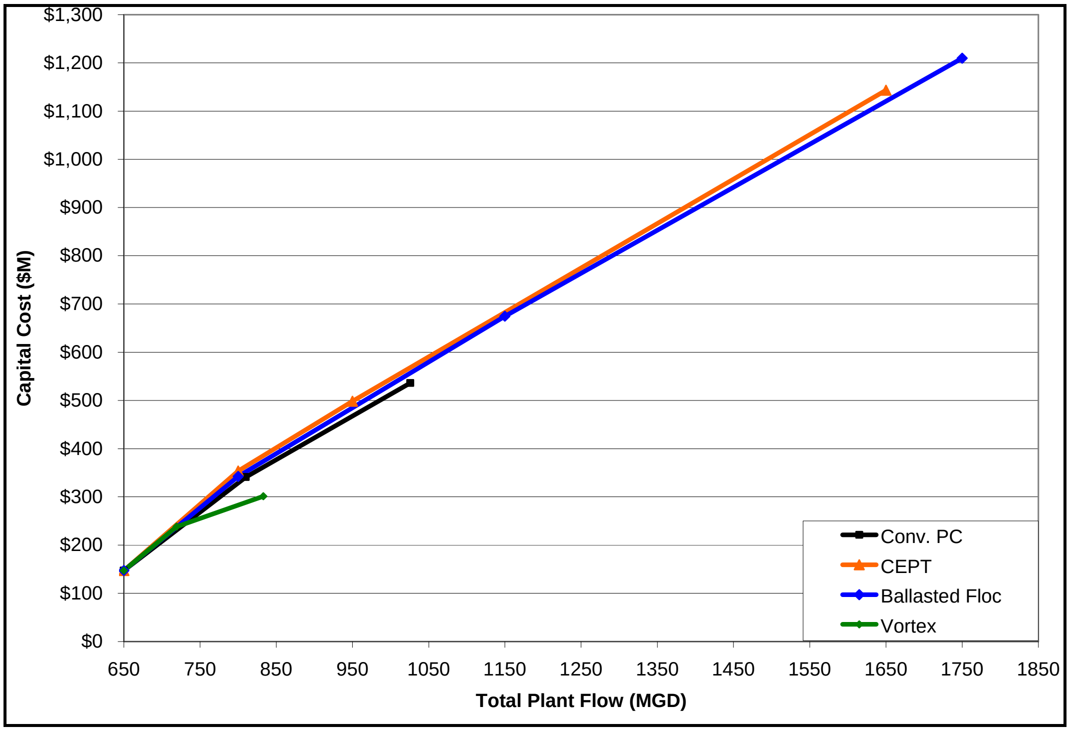

Figure 8-2 Comparison of Capital Costs for All Treatment Trains

Note: Capital cost presented includes cost of improvements recommended in the Stress Testing Report ($147 M). Total plant flow includes flow from both the conventional plant and the wet weather treatment facility.

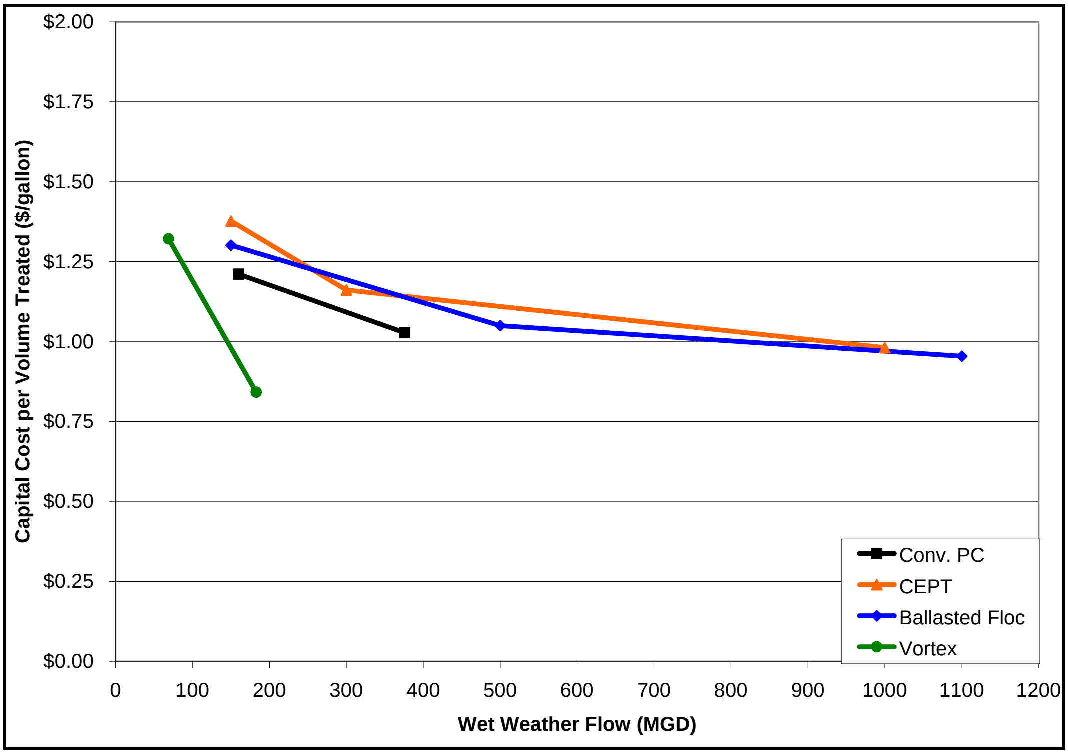

Figure 8-3 Comparison of Cost Effectiveness for All Treatment Trains

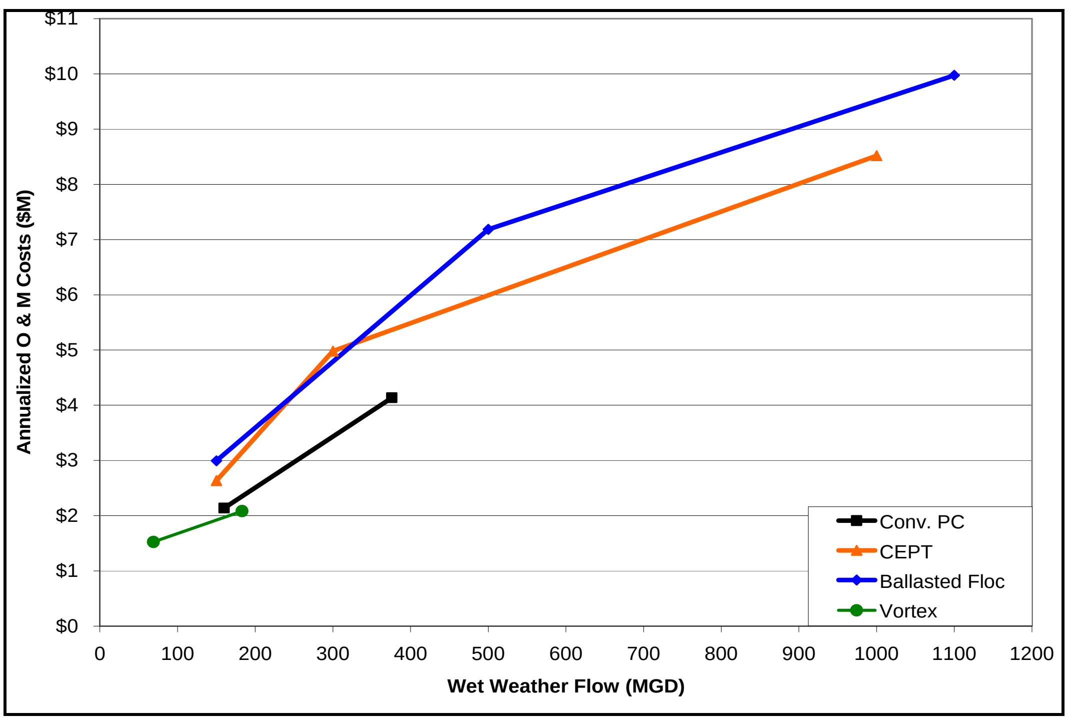

Figure 8-4 Comparison of Operations and Maintenance Costs for All Treatment Trains

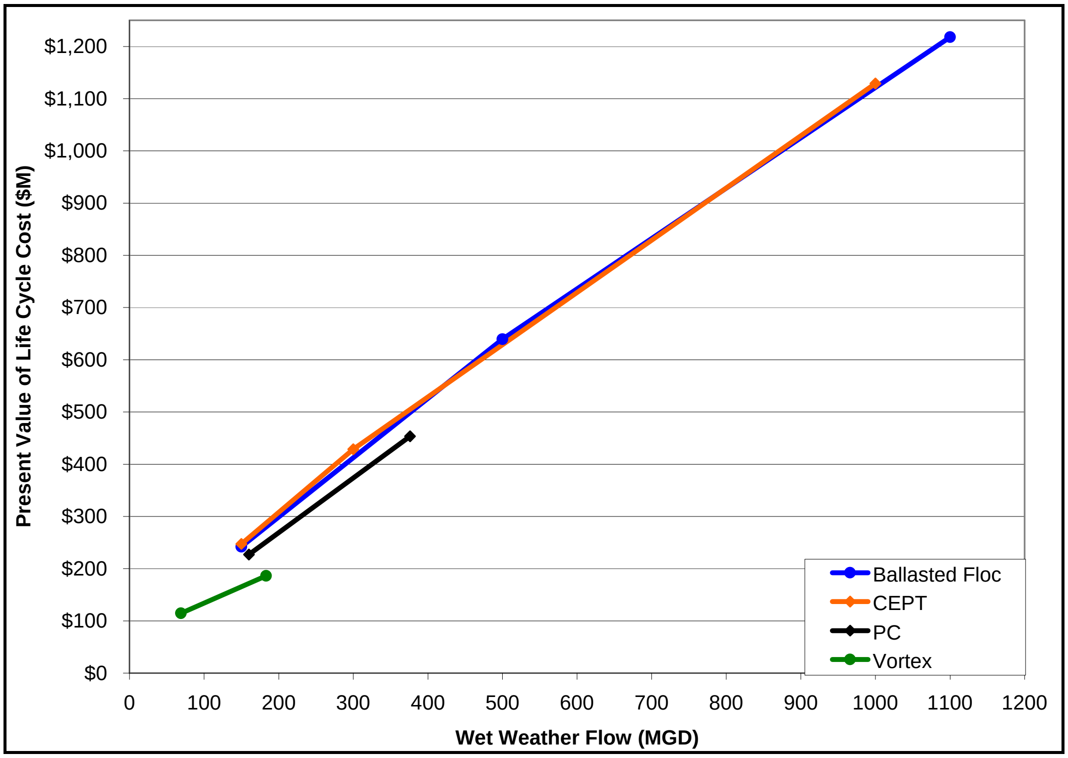

Figure 8-5 Comparison of Life-Cycle Costs for All Treatment Trains

Aside from capital, O&M, and lifecycle costs, there are numerous other criteria by which the treatment trains should be evaluated, including system reliability, community impacts, the ability to handle large variations in flow, land requirements, constructability, requirements for maintenance and operator attention, and sustainability. The main advantages and disadvantages for Treatment Trains #1 through#4, as evaluated are described in Table 8-8.

Table 8-8 Summary of Pros and Cons for Each Wet Weather Treatment Train

Treatment Train	Pros	Cons
Train #1:Vortex/Swirl Concentrators	• Simple operation • Low maintenance requirements no moving parts	• Maximum design flow may decrease if the assumed number of operating days per month is greater than 7. • Only cost competitive at high loading rates and low removal efficiencies.
Train #2: Conventional Clarifiers	• Simple operation • Same technology as existing plant –operators familiar with equipment	• Space limited • Maximum design flow may decrease if the assumed number of operating days is greater than 7.

Treatment Train	Pros	Cons
Train #3: CEPT	• Lower chlorine dose possible due to high TSS removal efficiencies • May be operated as Conventional Clarifiers if chemicals found to be unnecessary	• Operators unfamiliar with technology • Space limited • Maximum design flow may decrease if assumed number of operating days is greater than 9. • Uses two additional chemical systems for coagulation and flocculation
Train #4: Ballasted Flocculation	• Can treat up to 1500 mgd with available land on site • Highest removal efficiencies • Unlimited number of operating days per month • Lower chlorine dose possible due to high TSS removal efficiencies	• Operators unfamiliar with technology • Most labor intensive and complex system • Uses two additional chemical systems for coagulation and flocculation

The costs for wet weather treatment at the NEWPCP should be analyzed with the costs of other wet weather treatment alternatives, such as improvements in the collection system, to determine which treatment train alternatives and flow regimes should be evaluated further. Treatment trains that are selected for further evaluation should undergo more detailed design and costing methods, water quality sampling, and bench and pilot scale testing, so that removal efficiencies, land requirements, capital costs, and O&M costs can be further refined.

Southeast Wet Weather Treatment Alternatives

The wet weather treatment technologies for the SEWPCP evaluated are as follows

1. Vortex Swirl Concentrators (at low and high loading rates)
2. Conventional Clarifiers
3. Chemically Enhanced Primary Treatment (CEPT) with Conventional Clarifiers
4. CEPT with Plate Settlers (includes fine screening)
5. Ballasted Flocculation (includes fine screening)

Conceptual treatment trains were developed for each treatment technology at various wet weather flows ranging from 80 million gallons per day (mgd) to 1200 mgd and cost curves for capital, operations and maintenance (O&M), and lifecycle costs were generated for each treatment train alternative. In order to increase the flow capacity of the SEWPCP for wet weather conditions, the potential of maximizing flow through the existing plant was evaluated. According to stress testing results, the SEWPCP currently has a firm capacity of 240 mgd (Supplemental Documentation Volume 6: Stress Testing of the Southeast WPCP). With several process and hydraulic modifications, the SEWPCP's firm capacity can potentially reach 330 mgd. The necessary improvements to achieve this flow were identified in the Stress Testing Report and are based on results of stress tests on unit processes, long-term monitoring of the plant, hydraulic modeling, and input from SEWPCP plant staff. In sizing the wet weather treatment trains, it was assumed that the upgrades proposed in the Stress Testing Report will have been completed, increasing the plant's capacity to a minimum of 330 mgd. Thus, the baseline cost that is used in the wet weather treatment train cost estimates is $48.1 Million, which is reflected in the cost curves for each treatment train.

To expand the flow capacity of SEWPCP beyond 330 mgd for the treatment of wet weather flows, a separate wet weather treatment train will be required. Wet weather flows in excess of 330 mgd will be diverted to one of the new treatment trains, listed above, eventually blending with effluent from the existing plant. Conceptual designs and cost estimates were performed for each treatment train at various design flows.

The maximum allowable flow through each wet weather treatment train is a function of its removal efficiency, the achievable effluent concentration after blending, and the plant's continued ability to meet NPDES permit limits for weekly and monthly TSS and BOD concentrations. With the exception of the vortex/swirl train at high loading rates, the flows through the candidate wet weather treatment trains were not limited by permit requirements, assuming that the wet weather treatment facility operates for no more than seven days per month. Other design flow points were selected based on the existing collection system capacity, the existing outfall conduit capacity, and limits of available land on site and are indicated in the Table 8-9.

Table 8-9 Design Flows Evaluated for each Wet Weather Treatment Train

Treatment Train	Design Flows Evaluated (mgd)
#1 - Vortex/Swirl Concentrators	
High Loading Rate:	80, 200, 380
Low Loading Rate:	80, 200, 900
#2 - Conventional Clarifiers	80, 200, 540, 900
#3 - CEPT w/ Conventional Clarifiers	80, 200, 470, 900
#4 - CEPT w/ Plate Settlers	80, 200, 900
#5 - Ballasted Flocculation	80, 200, 900, 1200

While each flow scenario for each treatment train evaluated is sized to produce blended effluent concentrations compliant with permit limits, the resulting water quality differs widely between different scenarios. In general, ballasted flocculation achieves the lowest TSS and BOD concentrations after treatment and can operate an unlimited number of times during the month and continue to meet permit limits.

The TSS and BOD concentrations of the blended effluent for each treatment train and flow scenario is shown in Tables 8-10 and 8-11.

Table 8-10 TSS concentrations for each treatment train and flow value.

Treatment Train	Wet Weather Treatment Train Effluent Conc. (mg/L)	Blended Effluent TSS Concentration (mg/L)						
		Wet Weather Treatment Train Flow (mgd)						
		80	***200***	***380***	***470***	***540***	***900***	***1200***
#1) Vortex/Swirl Concentrators								
High Loading Rate:	154	59	81	99				
Low Loading Rate:	77	44	51				66	

Treatment Train	Wet Weather Treatment Train Effluent Conc. (mg/L)	Blended Effluent TSS Concentration (mg/L) Wet Weather Treatment Train Flow (mgd)						
		80	200	380	470	540	900	1200
#2) Conventional Clarifiers	99	48	60			75	82	
#3) CEPT w/ Conventional Clarifiers	44	38	39		41		42	
#4) CEPT w/ Plate Settlers	42	37	38				40	
#5) Ballasted Flocculation	21	33	30				25	24

Notes: Based on the 95th percentile wet weather TSS concentration of 36 mg/L and a maximum of 330 MGD through the existing plant. Allowable daily blended effluent TSS concentration on wet weather days is 99 mg/L, based on permit limits.

Table 8-11 BOD concentrations for each treatment train and flow value.

Treatment Train	Wet Weather Treatment Train Effluent Conc. (mg/L)	Blended Effluent BOD Concentration (mg/L) Wet Weather Treatment Train Flow (mgd)						
		80	200	380	470	540	900	1200
#1) Vortex/Swirl Concentrators								
High Loading Rate:	100	38	52	64				
Low Loading Rate:	63	31	38				52	
#2) Conventional Clarifiers	74	38	52			71	79	
#3) CEPT w/ Conventional Clarifiers	47	28	32		37		41	
#4) CEPT w/ Plate Settlers	46	28	32				40	
#5) Ballasted Flocculation	36	26	28				33	33

Notes: Based on the 95th percentile wet weather BOD concentration of 23 mg/L and a maximum of 330 MGD through the existing plant. Allowable daily blended effluent BOD concentration on wet weather days is 106 mg/L, based on permit limits.

The capital cost estimates for the five treatment trains are shown in Figure 8-6. Train #4, CEPT with Plates, is the most expensive, followed by Train #1, vortex/swirl at low loading rates. Trains #2, 3, and 5 appear to have similar costs throughout the entire flow range, with Train 5 being slightly less costly. Translated into a cost per volume treated, all trains appear to become more cost effective as flow capacity increases (Figure 8-7). The comparison of O&M costs for each treatment train is shown in Figure 8-8. As expected, the O&M costs are lowest for vortex swirls at high loading and conventional clarifiers, which do not require chemical settling aids. Vortex swirls at low loading rates have the highest O&M costs for repair and maintenance of the large number of vortex units and gravity thickeners required. Taking construction, non-construction, and O&M costs into consideration, Figure 8-9 shows the present value of the total cost of each wet weather treatment train. Train #4, CEPT with Plates, remains most costly since it requires the highest capital and

O&M costs. Train #1, vortex/swirl concentrators, appears to be least costly from the life-cycle cost perspective, especially at lower flows. This is due to its low chemical usage and minimal operations and maintenance needs.

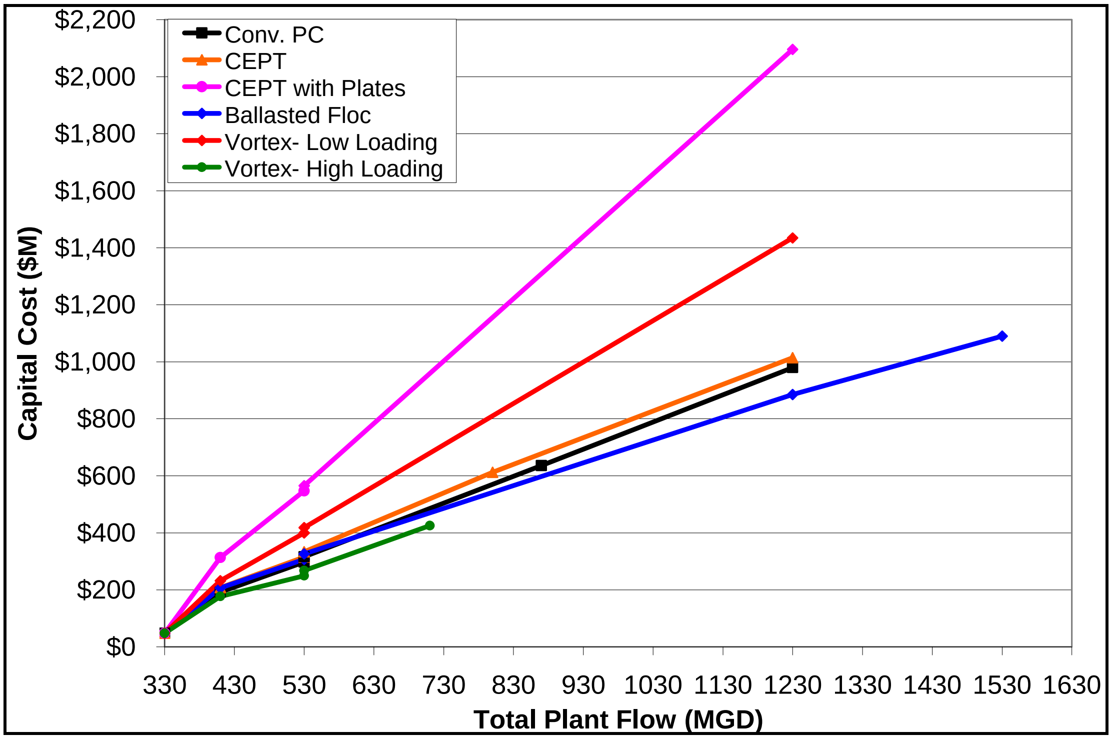

Figure 8-6 Comparison of Capital Costs for All Treatment Trains

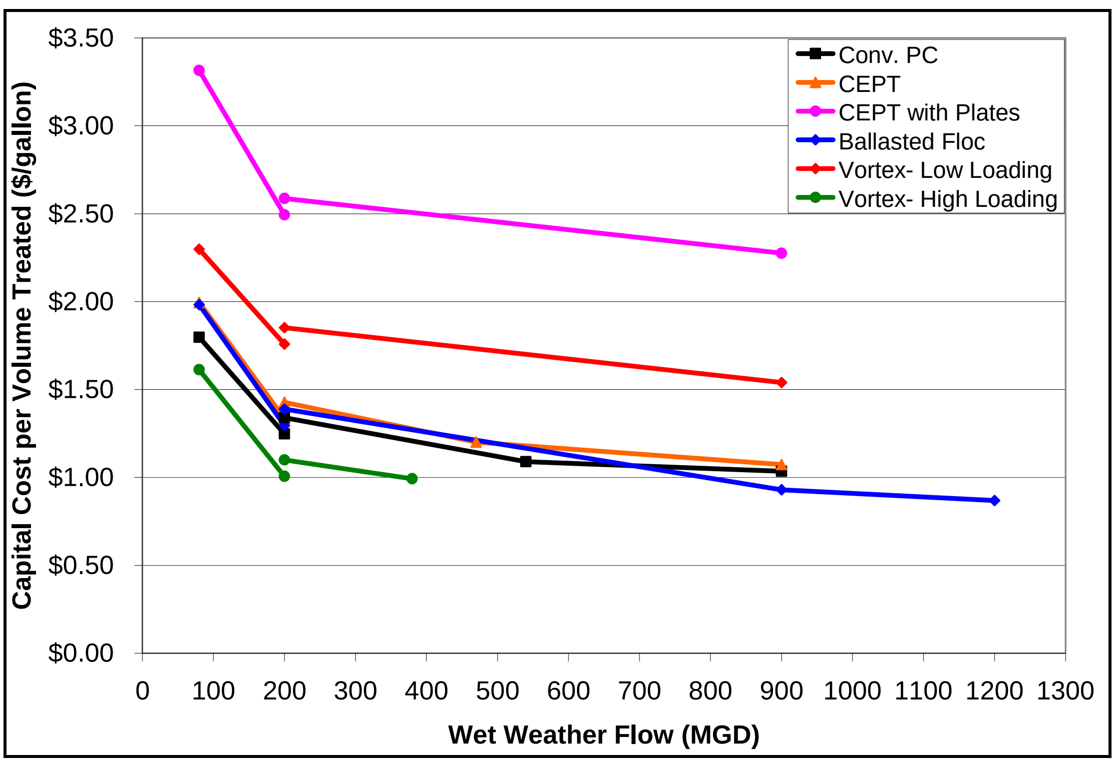

Figure 8-7 Comparison of Cost Effectiveness for All Treatment Trains

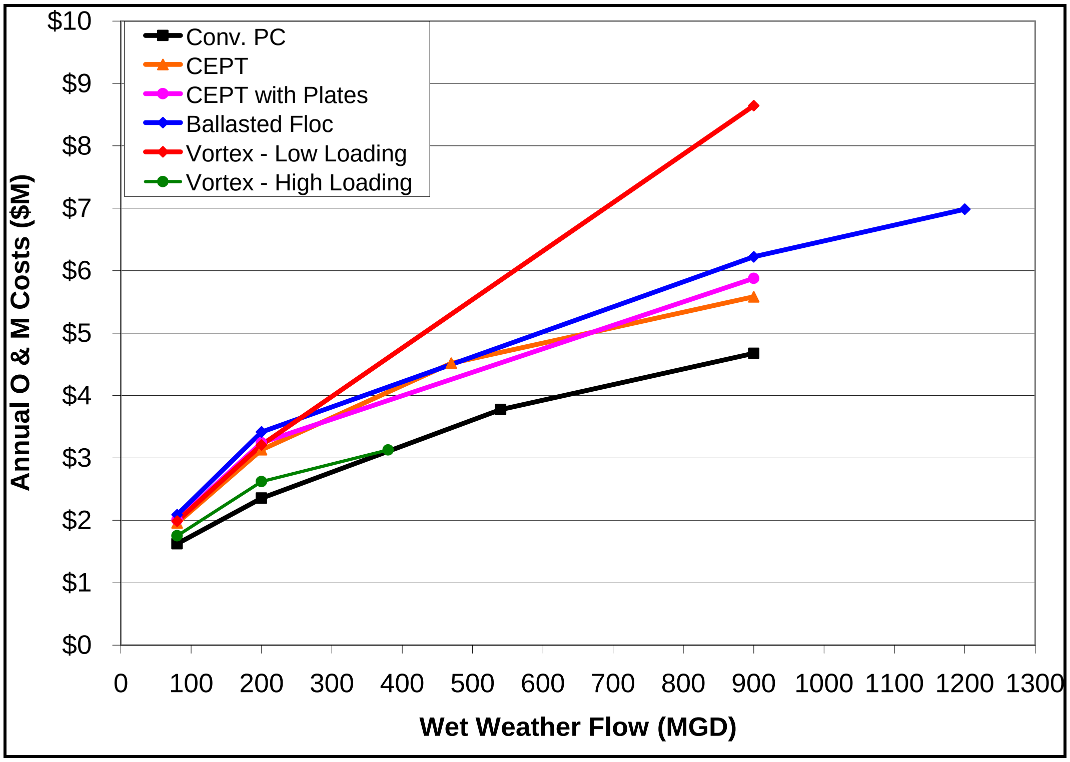

Figure 8-8 Comparison of Operations and Maintenance Costs for All Treatment Trains

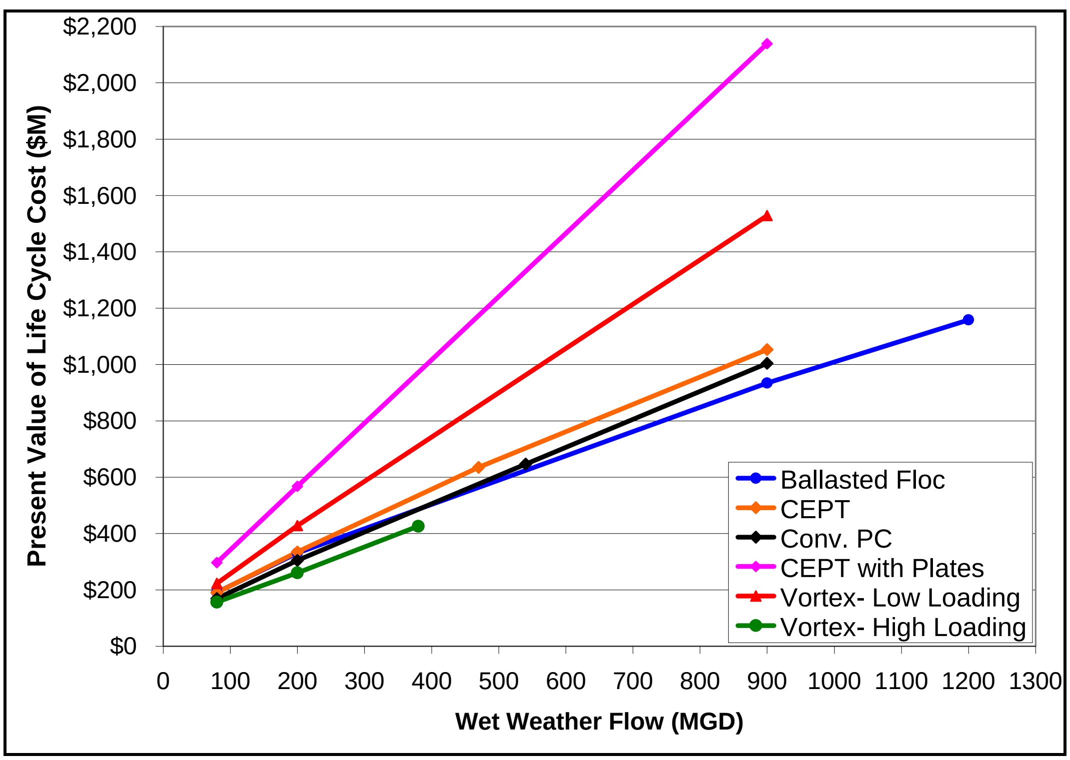

Figure 8-9 Comparison of Life-Cycle Costs for All Treatment Trains

Aside from capital, O&M, and lifecycle costs, there are numerous other criteria by which the treatment trains should be evaluated, including:

- Reliability of the system
- Community and environmental impacts or perception
- Ability to handle large variations in flow
- Land requirements
- Constructability
- Requirements for maintenance and operator attention
- Sustainability

The main advantages and disadvantages for Treatment Trains #1 through #5, as evaluated are described in Table 8-12.

The costs for wet weather treatment at the SEWPCP should be analyzed with the costs of other wet weather treatment alternatives, such as improvements in the collection system, to determine which treatment train alternatives and flow regimes should be evaluated further. Treatment trains that are selected for further evaluation should undergo more detailed design and costing methods, water quality sampling, and bench and pilot scale testing, so that removal efficiencies, land requirements, capital costs, and O&M costs can be further refined.

Southwest Wet Weather Treatment Alternatives.

The wet weather treatment technologies for the SWWPCP evaluated are as follows:

1. Vortex Swirl Concentrators
2. Conventional Clarifiers
3. Chemically Enhanced Primary Treatment (CEPT) with Conventional Clarifiers
4. Ballasted Flocculation (includes fine screening)

Conceptual treatment trains were developed for each treatment technology at various wet weather flows ranging from 220 million gallons per day (mgd) to 1740 mgd and cost curves for capital, operations and maintenance (O&M), and lifecycle costs were generated for each treatment train alternative.

Currently, the SWWPCP has a flow capacity of 400 mgd. With several process and hydraulic modifications, as identified in the Stress Testing Report, the capacity of the existing plant can potentially reach 540 mgd (Supplemental Documentation Volume 8: Stress Testing of the Southwest WPCP). In sizing the wet weather treatment trains, it was assumed that these upgrades, costing $64.60 Million, will have been completed, increasing the plant's capacity to a minimum of 540 mgd. Any wet weather flow in excess of 540 mgd would be diverted to the new wet weather facility.

Table 8-12 Summary of Pros and Cons for Each Wet Weather Treatment Train

Treatment Train	Pros	Cons
Train #1:Vortex/Swirl Concentrators	• Simple operation • Low maintenance requirements no moving parts	• Only cost competitive at high loading rates and low removal efficiencies • Maximum design flow may decrease if the assumed number of operating days is greater than 7.
Train #2: Conventional Clarifiers	• Simple operation • Same technology as existing plant –operators familiar with equipment	• Space limited • May exceed instantaneous blended effluent BOD concentration at high flows • Maximum design flow may decrease if the assumed number of operating days is greater than 7.
Train #3: CEPT	• Lower chlorine dose possible due to high TSS removal efficiencies	• Operators unfamiliar with technology • Space limited • Uses chemicals • Can treat less flow on existing site than conventional clarifiers
Train #4: CEPT with Plates	• Can treat 900 mgd with available land on site • Lower chlorine dose possible due to high TSS removal efficiencies • Unlimited number of operating days per month	• High capital and O&M costs • Operators unfamiliar with technology • Labor intensive to clean plates • Uses chemicals
Train #5: Ballasted Flocculation	• Can treat up to 1200 mgd with available land on site • Highest removal efficiencies • Unlimited number of operating days per month • Lower chlorine dose possible due to high TSS removal efficiencies	• Operators unfamiliar with technology • Second most labor intensive • Uses chemicals

The new wet weather facility is sited on two tracts of land currently utilized by the Biosolids Recycling Center (BRC), the Upper and Lower BRC areas. Due to the likely infeasibility in routing a new outfall conduit from the BRC area through the Philadelphia International Airport to the Delaware River, a new outfall conduit to the Schuylkill River is proposed to be constructed for the new wet weather treatment facility. Unlike the Southeast and Northeast WPCPs, effluent from the wet weather facility will not co-mingle with the effluent from the conventional plant. This means that the regulating agencies may view the new facility as a separate wet weather treatment facility requiring a new discharge permit. If blending of the two plant effluents is required or desired, the outfall for the existing plant could be relocated to the Schuylkill by constructing a new outfall conduit. The cost of this conduit, and thus co-mingling, is estimated at $155 million. Despite the difference in outfall locations, this assumes that the SWWPCP and its new wet weather facility will operate as one system.

Conceptual designs and cost estimates were developed for the design flows for each wet weather treatment train under evaluation (Table 8-13 shows the various design flows evaluated for each of the treatment trains). These flows were selected based on the ability to meet permit requirements (assuming co-mingling with existing plant), the capacity of the existing collection system, the land area available at the Upper and Lower BRC sites, and the maximum expected flow from the upgraded collection system.

Table 8-13 Design Flows Evaluated for each Wet Weather Treatment Train

Treatment Train	Design Flows Evaluated (mgd)
#1) Vortex/Swirl Concentrators	220, 702
#2) Conventional Clarifiers	220, 600, 1200
#3) CEPT w/ Conventional Clarifiers	220, 550, 1000
#4) Ballasted Flocculation	220, 980, 1740

Due to the varying removal efficiencies of each candidate treatment train, the resulting water quality differs widely between different trains. The TSS and cBOD concentrations of the effluent for each wet weather treatment train and flow scenario is presented in Tables 8-14 and 8-15. In general, ballasted flocculation provides the best treatment, achieving TSS and cBOD concentrations even lower than the existing plant.

Table 8-14 TSS Concentrations for each Treatment Train and Flow Value.

Treatment Train	Wet Weather Treatment Train Effluent Conc. (mg/L)	Blended Effluent TSS Concentration (mg/L) *Wet Weather Treatment Train Flow (mgd)*							
		220	***550***	***600***	***702***	***980***	***1000***	***1200***	***1740***
#1) Vortex/Swirl Concentrators	158	61			99				
#2) Conventional Clarifiers	102	45		64				77	
#3) CEPT w/ Conventional Clarifiers	45	29	34				37		
#4) Ballasted Flocculation	21	22				21			21

Notes: Based on the 95th percentile wet weather TSS concentration of 22 mg/L and a maximum of 540 MGD through the existing plant. Allowable daily blended effluent TSS concentration on wet weather days is 112 mg/L, to meet monthly TSS permit limits.

Table 8-15 BOD Concentrations for each Treatment Train and Flow Value.

Treatment Train	Wet Weather Treatment Train Effluent Conc. (mg/L)	Blended Effluent cBOD Concentration (mg/L) Wet Weather Treatment Train Flow (mgd)							
		220	*550*	*600*	*702*	*980*	*1000*	*1200*	*1740*
#1) Vortex/Swirl Concentrators	75	27			46				
#2) Conventional Clarifiers	64	24		37				47	
#3) CEPT w/ Conventional Clarifiers	54	21	31				38		
#4) Ballasted Flocculation	49	20				34			39

Notes: Based on the 95th percentile wet weather cBOD concentration of 8 mg/L and a maximum of 540 MGD through the existing plant.

Figure 8-10 shows the capital costs for all the treatment trains and figure 8-11 shows the cost effectiveness of all the treatment trains. Of the four treatment trains, treatment train #3, CEPT, is the most expensive in terms of the capital cost estimates, followed by Trains #2 and #4, Conventional Clarification and Ballasted Flocculation, which appear similar in cost. The cost of Train #1, Vortex/Swirl, is significantly less expensive than the other three trains. Translated into a cost per volume treated, all trains appear to become more cost effective as flow capacity increases.

The reason that CEPT is more expensive than Ballasted Flocculation for the SWWPCP wet weather facility is likely due to the limited length and increased number of its clarifiers. The comparison of O&M costs for each treatment train is shown in figure 8-3. As expected, the O&M costs for vortex swirls and conventional clarifiers, which do not require chemical settling aids, are the lowest. Ballasted Flocculation has the highest O&M costs due to its chemical usage and the complexity of its system. Taking construction, non-construction, and O&M costs into consideration, Figure 8-4 shows the present value of the total cost of each wet weather treatment train. Again, CEPT and Ballasted Flocculation remain most costly due to their high capital and O&M costs (Figure 8-12). Train #1, vortex/swirl concentrators, is significantly less expensive compared with other technologies from the life-cycle cost perspective (Figure 8-13). This is due to its low chemical usage and minimal operations and maintenance needs.

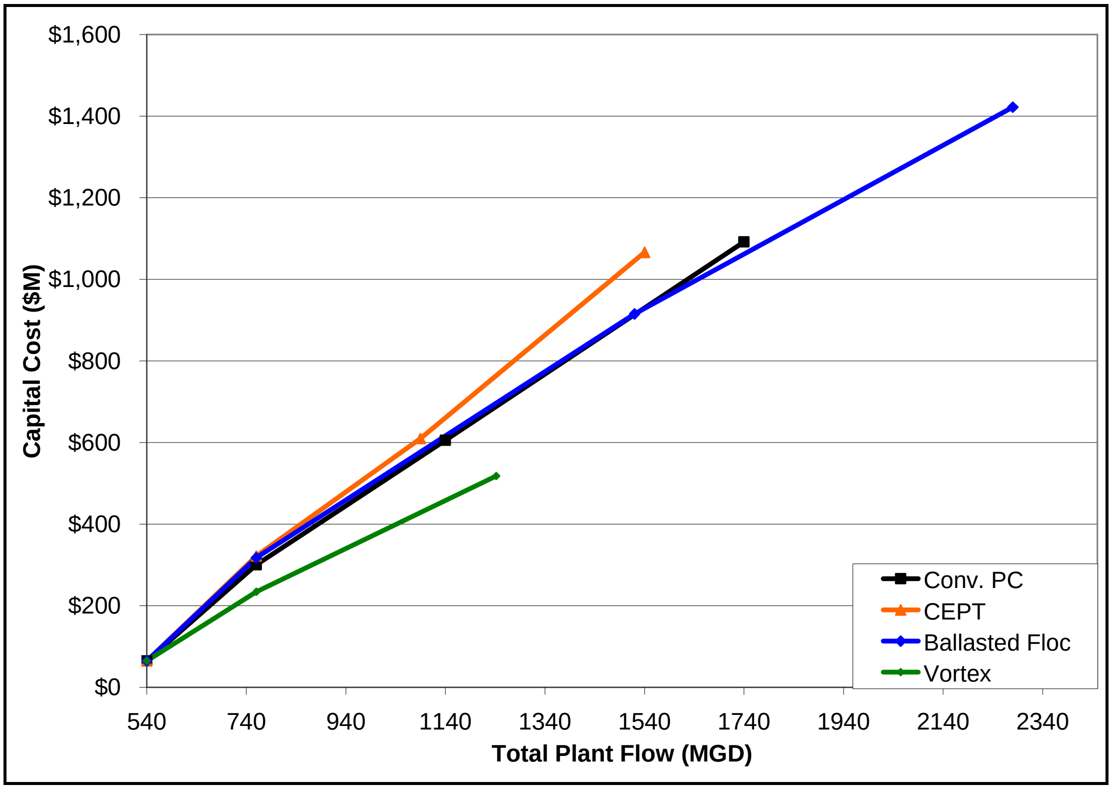

Figure 8-10 Comparison of Capital Costs for All Treatment Trains

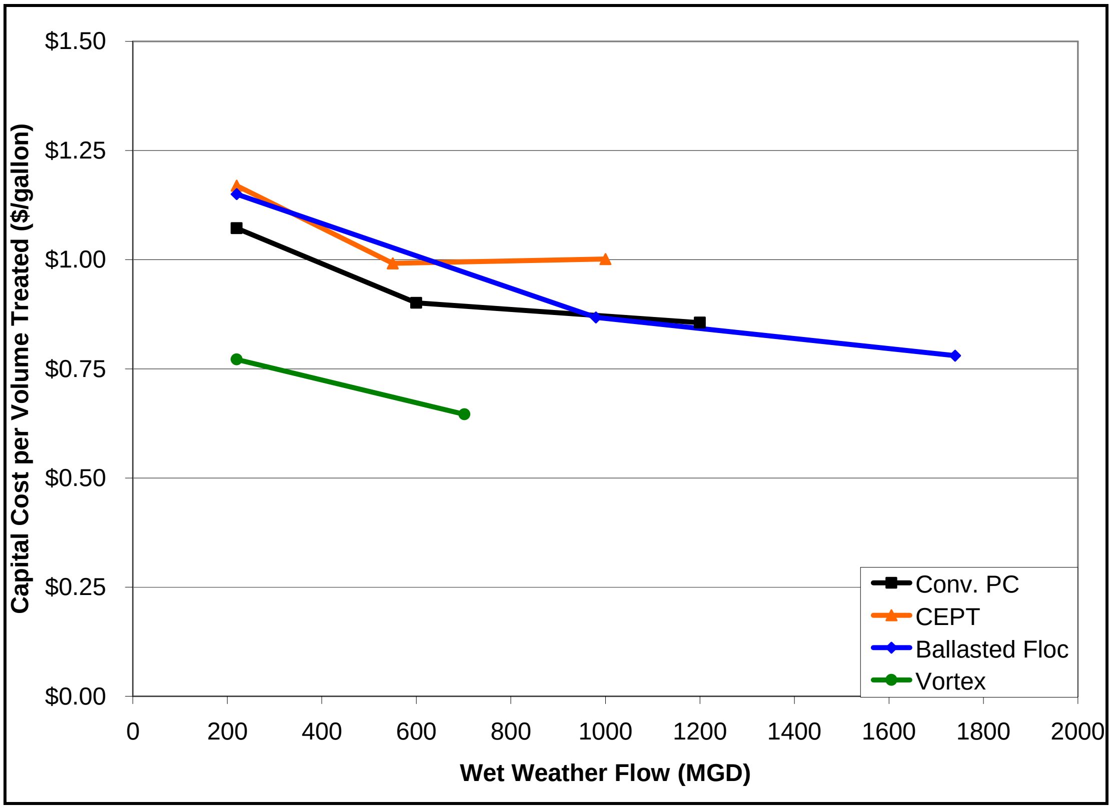

Figure 8-11 Comparison of Cost Effectiveness for All Treatment Trains

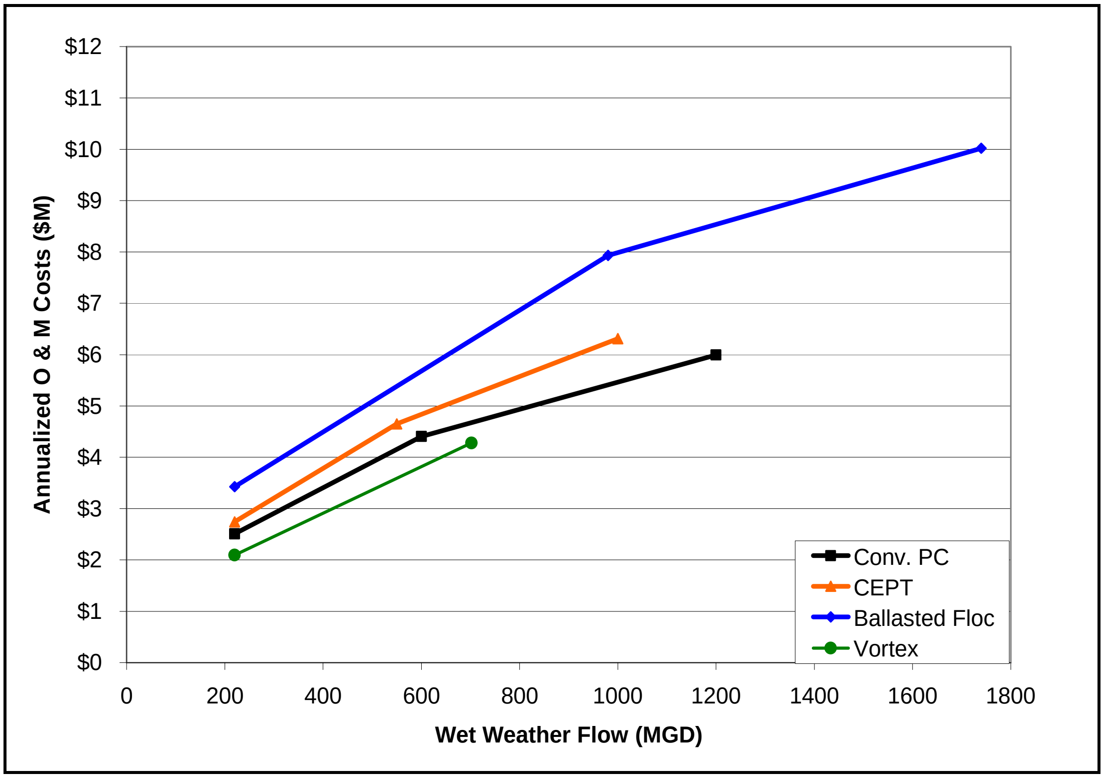

Figure 8-12 Comparison of Operations and Maintenance Costs for All Treatment Trains

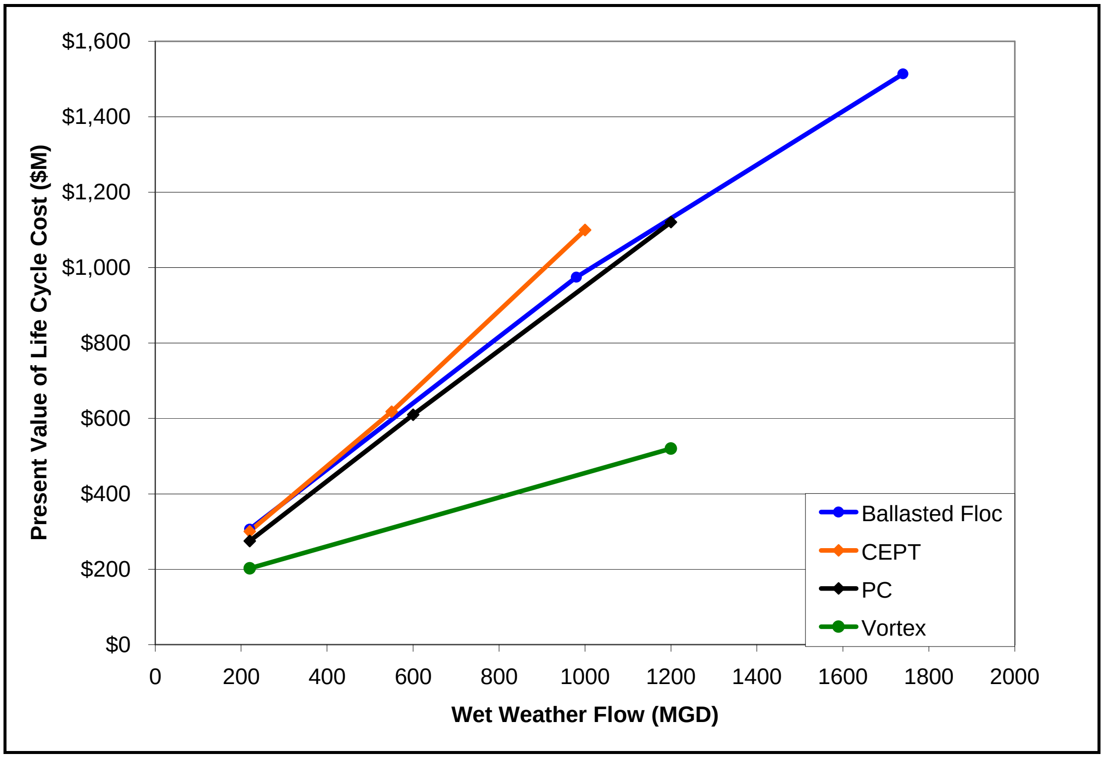

Figure 8-13 Comparison of Life-Cycle Costs for All Treatment Trains

Aside from capital, O&M, and lifecycle costs, there are numerous other criteria by which the treatment trains should be evaluated, including system reliability, community impacts, the ability to handle large variations in flow, land requirements, constructability, requirements for maintenance and operator attention, and sustainability. The main advantages and disadvantages for Treatment Trains #1 through #4, are evaluated and described in Table 8-16 below.

The costs for wet weather treatment at the SWWPCP should be analyzed with the costs of other wet weather treatment alternatives, such as improvements in the collection system, to determine which treatment train alternatives and flow regimes should be evaluated further. Treatment trains that are selected for further evaluation should undergo more detailed design and costing methods, water quality sampling, and bench and pilot scale testing, so that removal efficiencies, land requirements, capital costs, and O&M costs can be further refined.

8.2 SCREENING CRITERIA

The following criteria are proposed for initial screening of options:

1. Options that are required by NPDES permit or other regulation are recommended for inclusion in all management alternatives.
2. Options recommended for implementation in one of PWD's Integrated Watershed Management Plans are recommended for inclusion in all management alternatives.
3. Other options must meet at least one stated goal of the LTCPU to be considered for inclusion in management alternatives. Options also must be technically feasible to implement and maintain.

Table 8-16 Summary of Pros and Cons for Each Wet Weather Treatment Train

Treatment Train	Pros	Cons
Train #1:Vortex/Swirl Concentrators	• Simple operation • Low maintenance requirements no moving parts	• Maximum design flow may decrease if the assumed number of operating days per month is greater than 7. • Unless operated at lower loading rates, removal efficiency may not be high enough to operate alone without blending effluent with main plant effluent.
Train #2: Conventional Clarifiers	• Simple operation • Same technology as existing plant –operators familiar with equipment	• Space limited • Maximum design flow may decrease if the assumed number of operating days is greater than 9 per month.

Treatment Train	Pros	Cons
Train #3: CEPT	• Lower chlorine dose possible due to high TSS removal efficiencies • May be operated as Conventional Clarifiers if chemicals found to be unnecessary	• Operators unfamiliar with technology • Space limited • Can treat less flow on land available than conventional clarifiers • Uses two additional chemical systems for coagulation and flocculation
Train #4: Ballasted Flocculation	• Can treat up to 1740 mgd with available land on site • Highest removal efficiencies • Unlimited number of operating days per month • Lower chlorine dose possible due to high TSS removal efficiencies	• Operators unfamiliar with technology • Most labor intensive and complex system • Uses two additional chemical systems for coagulation and flocculation

8.3 SCREENING RESULTS

Based on the information presented above, each of the potential options were placed in one of the three categories for inclusion, consideration, or exclusion. Table 8-17 contains the ratings assigned to each infrastructure-based option.

Table 8-17 Ratings Assigned to Infrastructure-Based Options

Number	Category	Option	Include in All Alternatives	Consider Including in Alternatives	Do Not Include in Alternatives
I.1	Nine Minimum Controls	Nine Minimum Controls	X		
I.2	Operation and Maintenance	Inspection and Cleaning of Combined Sewers	X		
I.3	Operation and Maintenance	Combined Sewer Rehabilitation	X		
I.4	Operation and Maintenance	Regulator/Pump Station Inspection/Maintenance/Repairs	X		
I.5	Operation and Maintenance	Outfall Maintenance Program	X		
I.6	Operation and Maintenance	House Lateral Repairs		X	
I.7	Sewer Separation	Permitted Discharge to Receiving Water for Waterfront Properties		X	
I.8	Sewer Separation	Separation of Sanitary Sewage and Stormwater on Development Sites	X		
I.9	Sewer Separation	Separate Street Runoff from Combined System		X	
I.10	Sewer Separation	Complete Separation into Sanitary and Storm Sewer Systems		X	
I.11	Sewer Separation	Permitted Discharge to Receiving Water for Waterfront Interstate Highways		X	
I.12	Outfall Consolidation/Elimination	Outfall and Regulator Consolidation		X	
I.13	Storage	Instream Storage Technologies		X	
I.14	Storage	In-Line Storage in Interceptor or Trunk Sewer		X	
I.15	Storage	Earthen Basins		X	
I.16	Storage	OffLine Covered Storage Basins		X	
I.17	Storage	OffLine Open Storage Basins		X	
I.18	Storage/Transmission	Deep Tunnels		X	
I.19	Storage/Transmission	Real Time Control	X		
I.20	Transmission	Parallel Interceptors		X	
I.21	Transmission	Remove Flow Bottlenecks		X	
I.22	Transmission	Diversion of Trunk Flow Directly to WPCP		X	
I.23	Treatment at Discharge Point	Vortex Separators		X	
I.24	Treatment at Discharge Point	Swirl Concentrators		X	
I.25	Treatment at Discharge Point	Disinfection		X	
I.26	Treatment at Discharge Point	High Rate Treatment		X	
I.27	Treatment at Discharge Point	Screens		X	
I.28	Treatment at Discharge Point	Netting		X	
I.29	Treatment at Discharge Point	Booms		X	
I.30	Treatment at Discharge Point	Baffles		X	
I.31	Treatment in Receiving Water	Debris Skimming Vessels	X		
I.32	Treatment at Existing WPCP	Expand Primary Treatment Capacity		X	
I.33	Treatment at Existing WPCP	Expand Secondary Treatment and Disinfection Capacity		X	
I.34	Treatment at Existing WPCP	Flow Equalization		X	
I.35	Treatment at Existing WPCP	Expansion of Wet Weather Treatment Capacity		X	