9 DEVELOPMENT AND COMPARISON OF ALTERNATIVES

9.1 ALTERNATIVE APPROACHES TO MEETING LTCPU GOALS

This section combines the watershed management and combined sewer overflow control options presented in Sections 6 through 8 into several alternatives. An alternative is a package of options that when implemented together will meet the goals of the Integrated Watershed Management Plan for a particular watershed. Within each watershed, a number of alternatives are evaluated in order to determine which provides the best balance between performance, cost, affordability, sustainability and social/environmental benefits, public support, and practical factors such as constructability. These evaluation factors are discussed in more detail in Section 5. Finally, the preliminary selected alternatives for each watershed are assembled into one system-wide alternative, refined, and optimized.

The engineering cost opinion and combined sewer overflow control effectiveness of each alternative is presented in the form of a cost-performance, or "knee-of-the-curve" plot. These plots allow a straightforward comparison of CSS performance and the present value of the cost of each alternative to the utility (Figure 9-1). However, these plots do not capture the full range of environmental, social, and economic costs and benefits of each alternative. Furthermore, comparing alternatives on a present value basis does not account for differences in time phasing and financing of each alternative. These factors are important in selecting an alternative and are examined following each cost-performance curve.

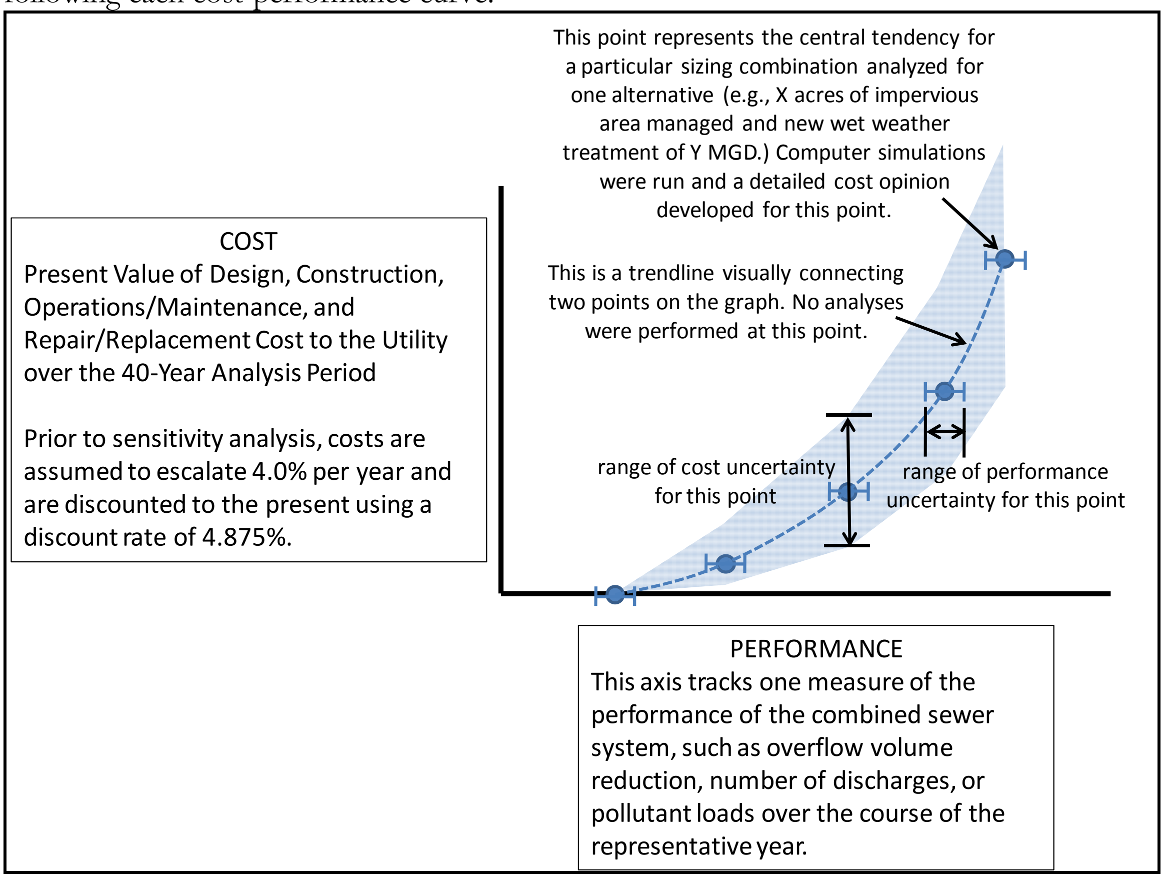

Figure 9-1 Interpretation of Cost-Performance Curves

Examination of the feasible alternatives for each of the watersheds resulted in the development of several alternative approaches to meeting program goals that can be applied in each of the watersheds. These alternatives are explained here in general terms that can be applied to all watersheds. More detailed descriptions, costs, and benefit information are then presented for each of the watersheds individually.

9.1.1 Complete Sewer Separation

Complete sewer separation is a stand-alone option (I.10) and alternative. An estimated present worth capital cost for this option for the combined area as a whole is $16 billion. This cost includes new sanitary sewer infrastructure; conversion of existing combined sewers to a municipal separate storm sewer system (MS4) where possible; disconnection, separation of combined sanitary and storm laterals on private property, and reconnection to the new system; and restoration of streets and sidewalks to their existing condition. However, this cost does not include pretreatment of stormwater or MS4 operation and maintenance activities. In order to comply with water quality standards, stormwater source controls may still be required similar to those being proposed in the combined-sewered areas.

This alternative is not cost-effective compared to other alternatives. Sewer separation may be considered on a smaller scale to solve localized problems, but large-scale sewer separation is not recommended.

9.1.2 Green Stormwater Infrastructure with Targeted Traditional Infrastructure

This alternative explores the range of combined sewer system performance, social and environmental benefits that can be achieved with green stormwater infrastructure in the absence of any new large-scale traditional infrastructure. The alternative seeks to reduce CSO frequency and volume through a range of land-based stormwater management techniques or source controls. As described in Section 6, these techniques are designed to reduce effective impervious area and reduce runoff reaching the sewer system by restoring a more natural hydrologic cycle.

The alternative includes the options discussed below. Options are listed in Tables 9-1 and 9-2 and described in more detail in Sections 6 through 8.

- The full range of options recommended in the individual Integrated Watershed Management Plans for each watershed.
- Measures to improve water quality in dry weather, including rehabilitation of interceptor sewers to reduce leakage in dry and wet weather.
- Restoration of the riparian corridors: stream channels, streambanks, floodplain connection, wetlands, recreational access and trails in the TTF and Cobbs Creek Watersheds
- Tidal wetland restoration along the Delaware and Schuylkill Rivers.
- Measures to manage stormwater runoff from directly connected impervious surfaces on a large scale on both public and private land. Examples are discussed in detail in Section 6 and include street trees, sidewalk planters, rain gardens, porous pavement, and many more technologies. As the program progresses, PWD will monitor emerging technologies that have the potential to improve performance or decrease cost. Additionally, there is potential for the creation of wetlands and opportunities to consolidate adjacent outfalls.
- Stormwater management measures following redevelopment are assumed to mitigate 20% of directly connected impervious surfaces over the course of the planning period. These

controls are assumed to have only an administrative cost to PWD, although their cost to the private sector is tracked and accounted for.

- Measures to increase water pollution control plant capacity by taking full advantage of the hydraulic capacity of the existing facilities, including appropriate bypass of secondary treatment in wet weather.
- Continuation of partnerships and stakeholder processes in all watersheds, and coordination with upstream municipalities to reduce pollutant loads from other sources and wet weather flows.

Table 9-1 Options Included in All Alternatives other than Full Sewer Separation

L.1	Sump Pump Disconnect	L.38	Catch Basin and Storm Inlet Maintenance
L.2	Illicit Connection Control	L.39	Require Industrial Pretreatment
L.3	Roof Leader Disconnect Program	L.40	On-Lot Disposal (Septic System) Management
L.4	Offload Ground Water Pumpage	L.41	Household Hazardous Waste Collection
L.5	Stream Diversion	L.43	Industrial Stormwater Pollution Prevention
L.6	Groundwater Infiltration Reduction	L.44	Litter and Illegal Dumping Enforcement
L.7	Reduction of Contractual Flow	L.45	Require Construction-Phase Stormwater/E&S Controls
L.18	Water Conservation	W.1	Dam Modification/Removal
L.19	Catch Basin Stenciling	W.2	Daylight Orphaned Storm Sewers
L.20	Community Cleanup and Volunteer Programs	W.3	Stream Cleanup and Maintenance
L.21	Recycling Programs	W.4	Channel Stabilization and Habitat Restoration
L.22	Pet Waste Education	W.5	Channel Realignment and Relocation
L.23	Lawn & Garden Maintenance	W.6	Plunge Pool Removal
L.24	Public Notification and Signage	W.7	Improvement of Fish Passage
L.25	Litter and Dumping Education	W.10	Constructed Wetlands along Stream Corridors
L.26	School-Based Education	W.12	Enhance Stream Corridor Recreational and Cultural Resources
L.27	Loading, Unloading, and Storage of Materials	W.13	Wetland Improvement
L.28	Spill Prevention and Response	W.14	Invasive Species Management
L.29	Street Sweeping Programs	W.15	Reforestation
L.30	Vehicle & Equipment Management	I.1	Nine Minimum Controls
L.31	Private Scrapyard Inspection and Enforcement	I.2	Inspection and Cleaning of Combined Sewers (Interceptors)
L.32	Employee Training	I.3	Combined Sewer Interceptor Rehabilitation
L.33	Record Keeping and Reporting	I.4	Regulator/Pump Station Inspection/Maintenance/Repairs
L.34	Flow Diversion and Exposure Minimization Structures	I.5	Outfall Maintenance Program
L.35	Responsible Landscaping Practices on Public Lands	I.8	Separation of Sanitary Sewage and Stormwater on Development Sites
L.36	Responsible Bridge and Roadway Maintenance	I.19	Real Time Control
L.37	Catch Basin Modifications for Solids Control		

Table 9-2 Additional Options Included in Green Stormwater Infrastructure with Targeted Traditional Infrastructure Alternative

L.9	Require Existing Resources Inventory, Sketch Plan, Initial Meeting
L.10	Require Integrated Site Design
L.11	Require Post-Construction Stormwater Management
L.12	Post-Construction Inspection and Enforcement
L.13	Demonstration Projects on Public Lands
L.14	Large-Scale Implementation on Public Lands
L.15	Street Trees and Street Greening
L.16	Revise Stormwater Rate Structure
L.17	Stormwater Management Incentives for Retrofit
I.36	Expansion of Wet Weather Treatment Capacity (Primary Treatment Bypass)

9.1.3 Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity

This alternative includes the same options as the previous alternative to address dry weather goals, restore living resources, and improve recreational opportunities. However, the alternative combines the large-scale green stormwater infrastructure approach with increased interceptor transmission capacity and increased wet weather wastewater treatment capacity. For a given combined sewer system percent capture level, a lower implementation level of green stormwater infrastructure is required compared to the Green Stormwater Infrastructure with Targeted Traditional Infrastructure alternative.

This alternative includes the options discussed below. Options are listed in Tables 9-1 and 9-3 and described in more detail in Sections 6 through 8.

- The full range of options recommended in the Cobbs and Tookany/Tacony-Frankford Integrated Watershed Management Plans.
- Measures to improve water quality in dry weather, including rehabilitation of interceptor sewers to reduce leakage in dry and wet weather.
- Restoration of the riparian corridor: stream channels, streambanks, floodplain connection, wetlands, recreational access and trails.
- Tidal wetland restoration along the Delaware and Schuylkill Rivers.
- Measures to manage stormwater runoff from directly connected impervious surfaces on a large scale on both public and private land. Examples are discussed in detail in Section 6 and include street trees, sidewalk planters, rain gardens, porous pavement, and many more technologies. As the program progresses, PWD will monitor emerging technologies that have the potential to improve performance or decrease cost. Additionally, there is potential for the creation of wetlands and opportunities to consolidate adjacent outfalls.
- Stormwater management measures following redevelopment are assumed to mitigate 20% of directly connected impervious surfaces over the course of the planning period. These controls are assumed to have no cost to PWD, although their cost to the private sector is tracked and accounted for.
- Proposed expansion of water pollution control plants to include a secondary treatment bypass where appropriate and, depending on the peak capacity needed, additional high rate treatment.

- New interceptors would provide additional transmission capacity along the same routes taken by existing interceptors. In the TTF and Cobbs Creek Watersheds, construction would be completed in conjunction with stream and stream corridor restoration.
- Continuation of partnerships and stakeholder processes in all watersheds, and coordination with upstream municipalities to reduce pollutant loads and wet weather flows entering the watershed.

Table 9-3 Additional Options Included in Green Stormwater Infrastructure with Increased Transmission and Treatment Alternative

L.9	Require Existing Resources Inventory, Sketch Plan, Initial Meeting
L.10	Require Integrated Site Design
L.11	Require Post-Construction Stormwater Management
L.12	Post-Construction Inspection and Enforcement
L.13	Demonstration Projects on Public Lands
L.14	Large-Scale Implementation on Public Lands
L.15	Street Trees and Street Greening
L.16	Revise Stormwater Rate Structure
L.17	Stormwater Management Incentives for Retrofit
I.20	Parallel Interceptors
I.36	Expansion of Wet Weather Treatment Capacity

9.1.4 Large-Scale Centralized Storage Alternative

This alternative seeks to reduce CSO volume, frequency, and duration using a traditional tunnel storage system. Combined sewage is stored temporarily and dewatered to the existing water pollution control plants. This alternative includes options to address dry weather goals, restoration of living resources, and improved recreational opportunities. However, if this alternative is selected it may be necessary to reassess the cost, affordability, and benefits of these programs in combination with a tunnel. This alternative does not include a significant amount of Green Stormwater Infrastructure for stormwater management.

The Large-Scale Centralized Storage alternative includes the options discussed below.

- The full range of options recommended in the TTF and Cobbs Creek Integrated Watershed Management Plans.
- Measures to improve water quality in dry weather, including rehabilitation of interceptor sewers to reduce leakage in dry and wet weather.
- Restoration of the riparian corridor in the TTF and Cobbs Creek Watersheds: stream channels, streambanks, floodplain connection, wetlands, recreational access and trails.
- Tidal wetland restoration along the Delaware and Schuylkill Rivers.
- Storage tunnels and associated infrastructure approximately parallel to existing interceptor sewers and perpendicular to existing trunk sewers. A minimum length for each tunnel is fixed by the location of trunk sewers it would intercept. Tunnel inner diameters studied include a range from the approximate minimum feasibly constructible (about 15 feet) to the maximum feasibly constructible (about 35 feet). Additionally, there is potential to consolidate adjacent outfalls.
- Continuation of partnerships and stakeholder processes in all watersheds, and coordination with upstream municipalities to reduce pollutant loads and wet weather flows entering the watershed.

9.1.5 Large-Scale Satellite Treatment Alternative

The Large-Scale Satellite Treatment alternative seeks to reduce CSO volume, frequency, and duration using satellite treatment facilities. Combined sewage is conveyed to a treatment facility using new consolidation sewers, treated, disinfected, and discharged to the creek. This alternative includes options to address dry weather goals, restoration of living resources, and improved recreational opportunities. However, if this alternative is selected it may be necessary to reassess the cost, affordability, and benefits of these programs in combination with large-scale satellite treatment. This alternative does not include green infrastructure for stormwater management.

Large-Scale Satellite Treatment alternative includes the options discussed below. Options are listed in Tables 9-1 and 9-4 and described in more detail in Sections 6 through 8.

- The full range of options recommended in the TTF Integrated Watershed Management Plan.
- Measures to improve water quality in dry weather, including rehabilitation of interceptor sewers to reduce leakage in dry and wet weather.
- Restoration of the riparian corridor in the TTF and Cobbs Creek Watersheds: stream channels, streambanks, floodplain connection, wetlands, recreational access and trails.
- Tidal wetland restoration along the Delaware and Schuylkill Rivers.
- Satellite treatment facilities and associated infrastructure. These facilities would be sited to take advantage of existing regulator structure geography and collection system capacity, subject to site constraints. Three technologies are considered: retention treatment basins, ballasted flocculation, and swirl/vortex systems.
- New conveyance conduits to transmit more flow to the treatment facilities.
- Continuation of partnerships and stakeholder processes in all watersheds, and coordination with upstream municipalities to reduce pollutant loads and wet weather flows entering the watershed.

Table 9-4 Additional Options Included in the Large-Scale Satellite Treatment Alternative

I.20	Parallel Interceptors
I.26	Disinfection
I.27	High Rate Treatment
I.36	Expansion of Wet Weather Treatment Capacity

9.2 Benefits and External Costs of Alternative Approaches

A key goal of PWD's *Green City, Clean Waters* program is to maximize the sustainability of the urban water resources system and to maximize benefits to the public of the money spent on reducing combined sewer overflows. A traditional engineering analysis of sewer system performance, capital costs, and operations and maintenance costs forms the core of the alternatives analysis and selection process, and will be presented later in this document. However, traditional analyses do not guarantee that benefits will be maximized because they leave out key variables that affect urban quality of life and long-term sustainability of the urban system.

PWD's *Green City, Clean Waters* program is designed to provide many benefits beyond the reduction of combined sewer overflows, so that every dollar spent provides a maximum return in benefits to the public and the environment. Traditional engineering economic analysis compares the construction cost of various alternatives to the effectiveness of those alternatives, such as percent capture of combined sewage. In this traditional framework, the alternative that meets the performance goal at least cost will be selected for construction. However, the traditional framework misses a number of costs and benefits that may not affect the utility directly, but affect the environment and the public at large. To fully understand these economic, environmental, and social benefits, PWD has undertaken a Triple Bottom Line analysis. The results of this analysis affect alternative selection by showing that some alternatives have significant benefits that are not accounted for in the traditional framework, while others have significant costs.

9.2.1 Green Stormwater Infrastructure Enhances Recreation and Restores Ecosystems

Green Stormwater Infrastructure Enhances Recreation

Throughout the Fairmount Park system, residents enjoy recreation along Philadelphia's stream corridors and waterfronts, but some areas do not live up to their full potential. Improved access, appearance, and opportunities in these areas will make them more desirable destinations for the public. Recreation also will be more desirable along newly greened neighborhood streets and public places (Figure 9-2).

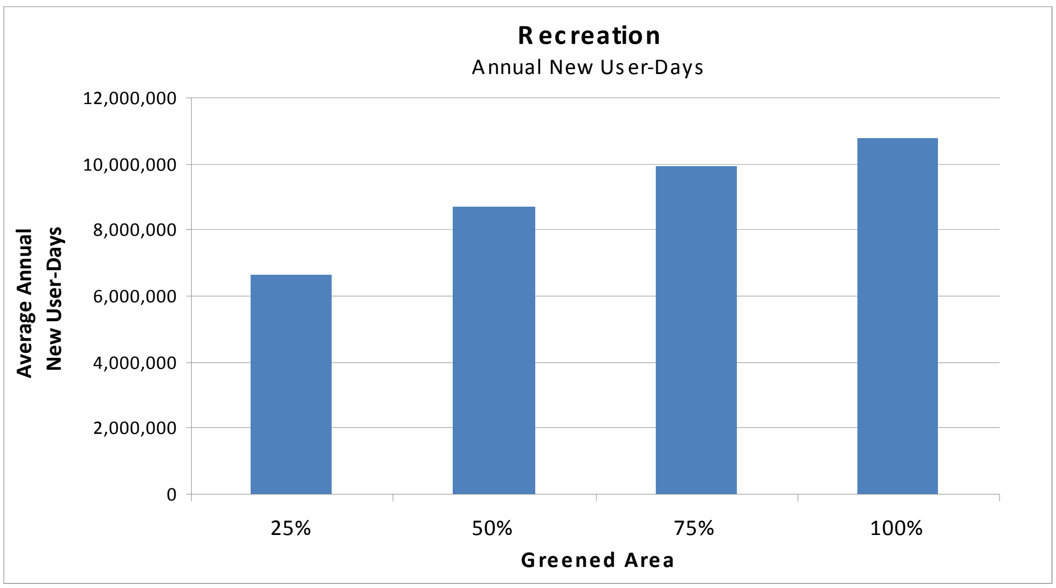

Figure 9-2 Recreational Benefits

Green Stormwater Infrastructure Restores Ecosystems

Green stormwater infrastructure improves ecosystems in two ways. First, by restoring a water cycle more similar to a natural watershed, green stormwater infrastructure allows rain to soak into the ground and return to streams slowly. This provides a natural water quality filter and limits erosion of stream channels caused by high flows, both of which benefit aquatic species. Second, PWD's green stormwater infrastructure approach includes physical restoration of stream channels and streamside lands, including wetlands, to restore habitat needed for healthy ecosystems (Figure 9-3).

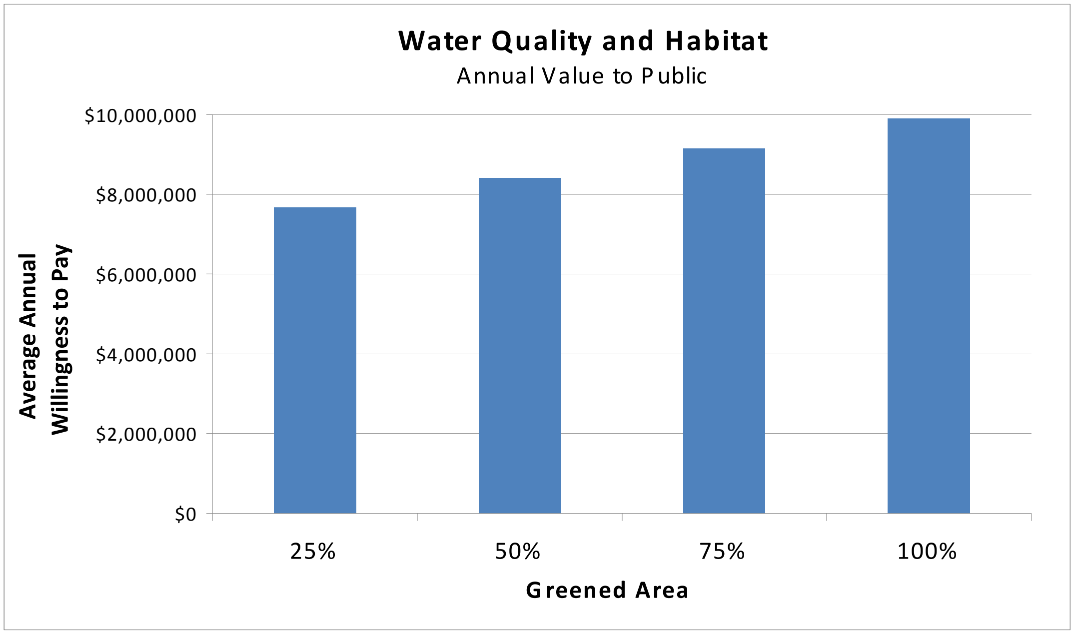

Figure 9-3 Water Quality and Habitat Benefits

9.2.2 Green Stormwater Infrastructure Improves Neighborhoods

Green Stormwater Infrastructure Improves Community Quality of Life

Trees and parks are an important part of the recipe that together can make an urban neighborhood into an inviting, exciting place to live, work and play. Residents clearly recognize and value this quality of life effect of urban vegetation, and yet it is difficult to assign it an economic value. One way to estimate a value is to study property values in areas that are close to parks and greenery (Figure 9-4).

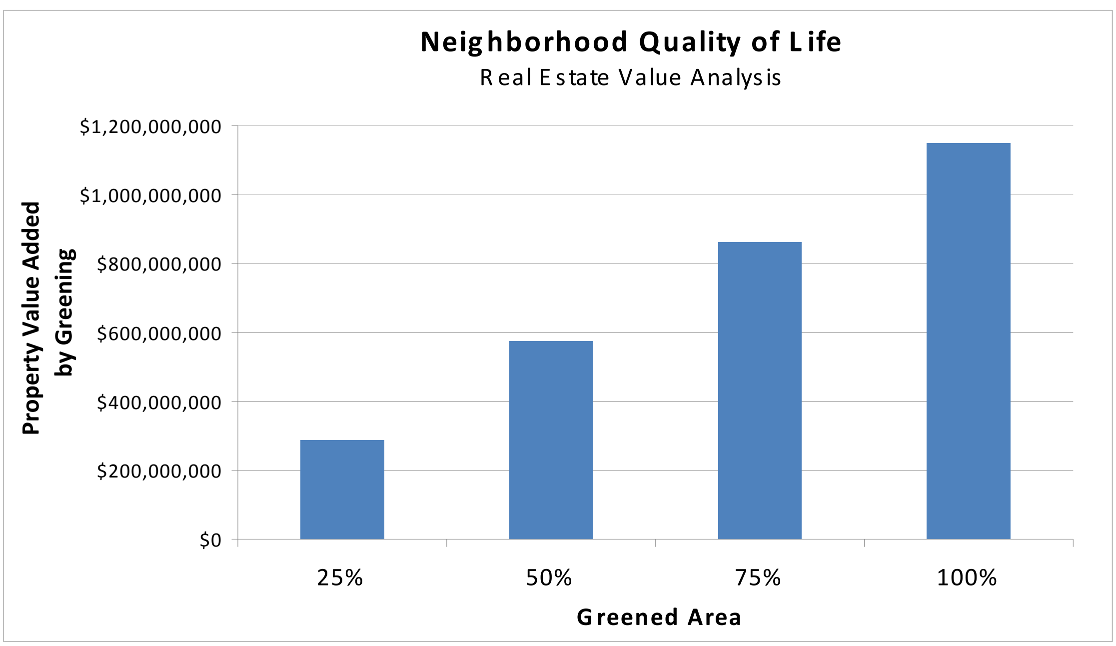

Figure 9-4 Quality of Life Benefits

Green Stormwater Infrastructure Jobs Reduce the Social Cost of Poverty

Governments at all levels incur significant costs in coping with poverty, and Philadelphia is no exception. Green stormwater infrastructure creates jobs which require no prior experience and are therefore suitable for individuals who might be otherwise unemployed and living in poverty. These new jobs create a benefit to society in reduced poverty-related costs, in addition to the wages paid to the individual workers (Figure 9-5). The stabilizing and transforming effects of green stormwater infrastructure in neighborhoods further reinforce and support the benefits of providing employment to a population that is outside the labor force. Green stormwater infrastructure is not by itself the solution to poverty, but it is a valuable tool in the toolbox of poverty reduction.

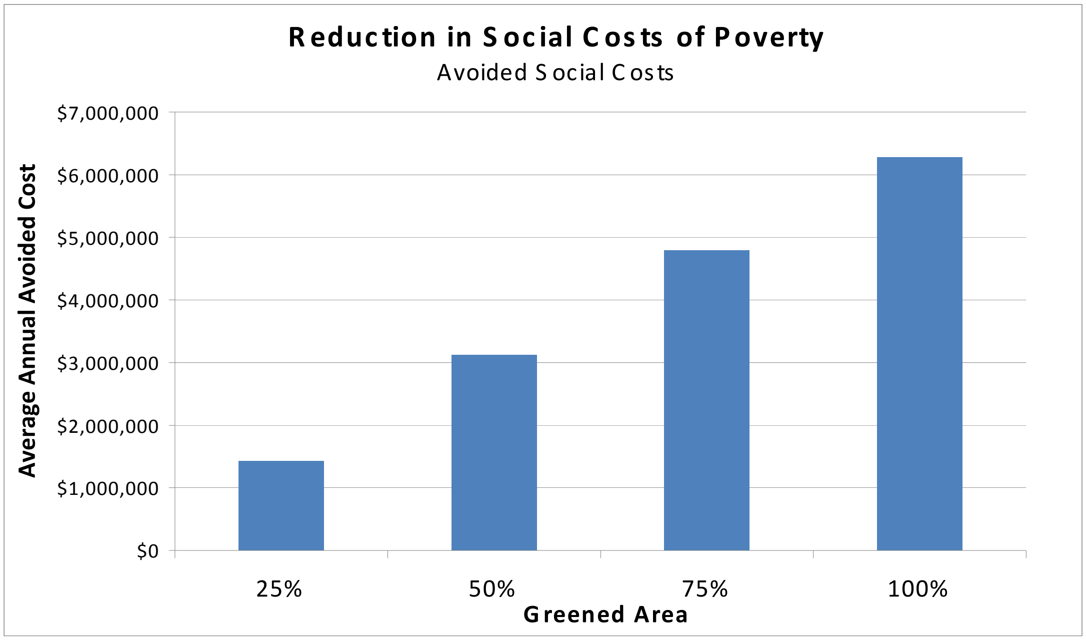

Figure 9-5 Benefits from Green Jobs

9.2.3 Green Stormwater Infrastructure Improves Public Health

Green Stormwater Infrastructure Reduces Effects of Excessive Heat

Heat waves are a fixture of summers in Philadelphia, including some severe enough that they have resulted in over 100 premature deaths (for example, the summer of 1993). These events may be more frequent and severe in the future due to climate change. Green stormwater infrastructure (for example, trees, green roofs, and bioretention sidewalks) reduces the severity of extreme heat events in three ways - by creating shade, by reducing the amount of heat absorbing pavement and rooftops, and by emitting water vapor – all of which cool hot air. This cooling effect will be sufficient to actually reduce heat stress-related fatalities in the city during extreme heat wave events (Figure 9-6).

Green Stormwater Infrastructure Improves Air Quality

Like many major cities in the United States, US EPA currently classifies the Philadelphia metropolitan area as exceeding federal air quality standards for both ozone (smog) and fine particles (soot). Known health impacts of these air pollutants include premature death, hospitalization for respiratory diseases, heart attacks, and lost work and school days (Figure 9-7). Green stormwater infrastructure will improve Philadelphia's air quality in two ways – by reducing emissions of pollutants (such as SO_2) and by removing ozone and particulates from the air. Reductions in energy and vehicle use will reduce emissions of pollutants. Once in the air, some ozone and particles are taken into the leaves of trees as they "breathe." Leaves also trap additional fine particulates, which then wash off in the rain or fall with the autumn leaf drop.

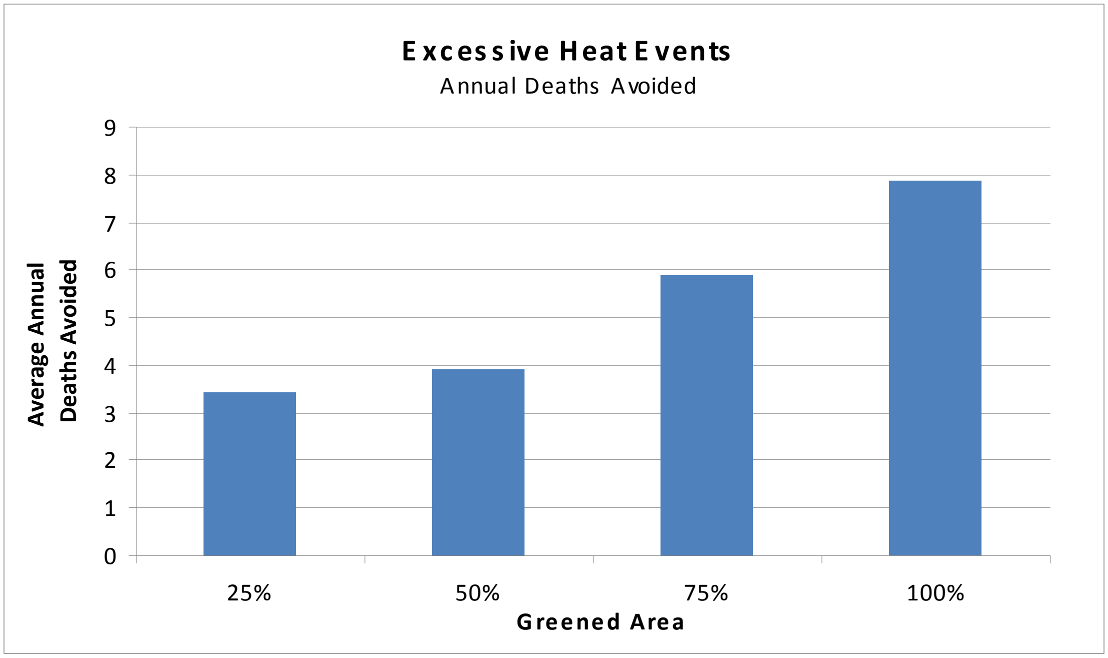

Figure 9-6 Reduction of Excessive Heat Related Deaths

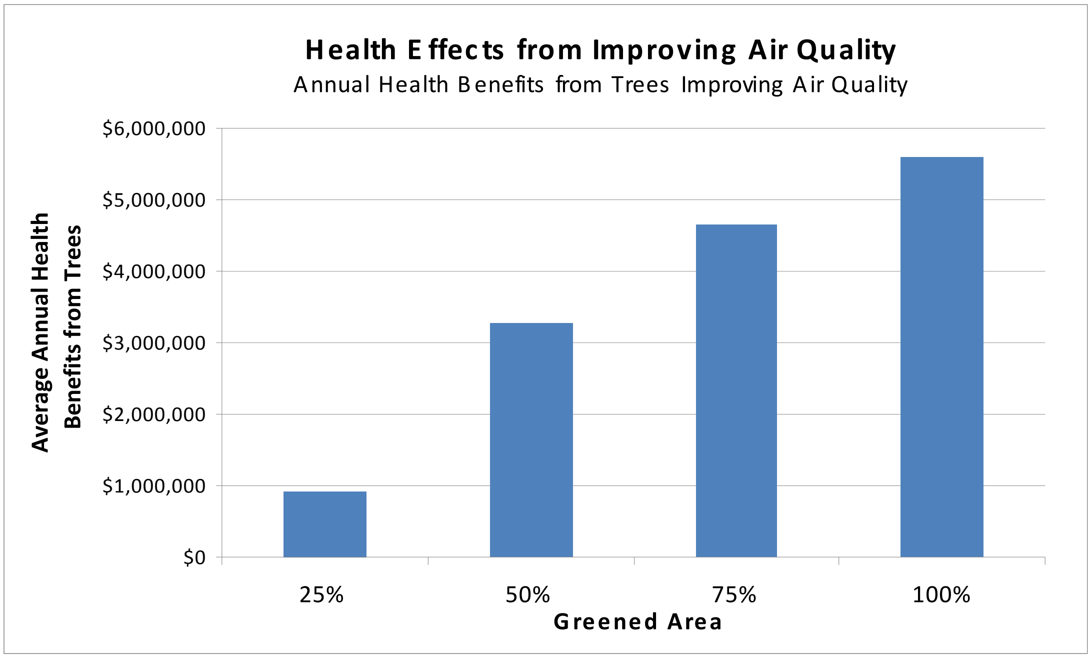

Figure 9-7 Health Benefits from Improved Air Quality

9.2.4 Green Stormwater Infrastructure Saves Energy and Offsets Climate Change

Green stormwater infrastructure reduces energy use, fuel use, and carbon emissions (Figure 9-8) in two ways. First, the cooling effects of trees and plants shade and insulate buildings from wide temperature swings, decreasing the energy needed for heating and cooling. Second, rain is managed where it falls in systems of soil and plants, reducing the energy needed for traditional systems to store, pipe, and treat it. Growing trees also act as carbon "sinks", absorbing carbon dioxide from the air and incorporating it into their branches and trunks.

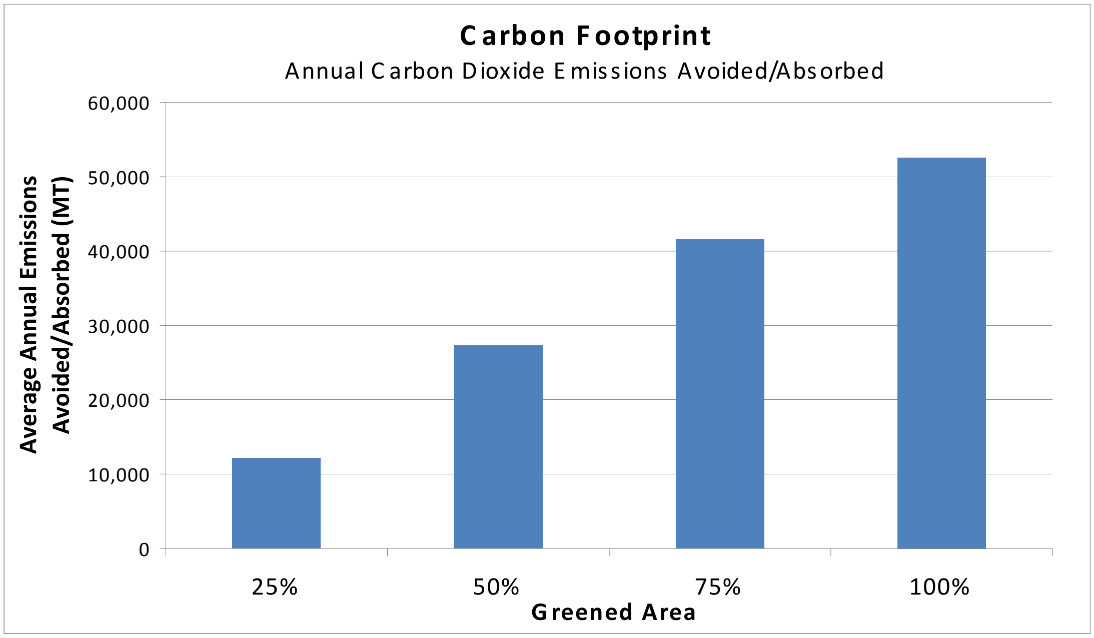

Figure 9-8 Reduction of Carbon Dioxide Emissions

9.2.5 Qualitative Factors of Green Stormwater Infrastructure

In addition to capital costs, operations and maintenance costs, external costs, and benefits, a number of factors must be considered which are qualitative in nature. Tables 9-5 through 9-9 summarize these factors for each of the alternatives.

Table 9-5 Qualitative Factors for Green Stormwater Infrastructure with Targeted Traditional Infrastructure

Qualitative Factor	Rating	Discussion
Public Support	Medium	Public is supportive of concept, sometimes hesitant of neighborhood disruption.
Construction Feasibility	High	Construction uses routine equipment and methods.
Operation Feasibility	Medium	The technology is simple but routine maintenance is needed on a large scale.
Reliability and Past Performance of Technology	High	The likelihood of failure is moderate but consequences are low.
Complexity and Difficulty of Solution	High	The alternative requires difficult coordination of many phases, technologies, sites, or contracts.
Coordination and Consistency with other PWD and City Programs	High	This alternative directly supports and benefits from many other urban greening initiatives.

Table 9-6 Qualitative Factors for Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity

Qualitative Factor	Rating	Discussion
Public Support	Medium	Public is supportive of concept, sometimes hesitant of neighborhood disruption.
Construction Feasibility	High	Construction uses routine equipment and methods.
Operation Feasibility	Medium	The technology is simple but routine maintenance is needed on a large scale.
Reliability and Past Performance of Technology	High	The likelihood of failure is moderate but consequences are low.
Complexity and Difficulty of Solution	High	The alternative requires difficult coordination of many phases, technologies, sites, or contracts.
Coordination and Consistency with other PWD and City Programs	High	This alternative directly supports and benefits from many other urban greening initiatives, including stream corridor restoration.

Table 9-7 Qualitative Factors for Large-Scale Centralized Storage Alternative

Qualitative Factor	Rating	Discussion
Public Support	Low	The public has a limited understanding of how they benefit from this alternative.
Construction Feasibility	Low	Construction is high-risk and requires a specialty contractor.
Operation Feasibility	Low	The technology is unfamiliar. New staff, skills, and training are required.
Reliability and Past Performance of Technology	High	The likelihood of failure and consequences of failure are both low.
Complexity and Difficulty of Solution	Medium	The alternative requires only one contract but extremely long duration, multi-phase construction.
Coordination and Consistency with other PWD and City Programs	Medium	This alternative may reinforce flood abatement programs but not urban greening initiatives.

Table 9-8 Qualitative Factors for Large-Scale Satellite Treatment Alternative

Qualitative Factor	Rating	Discussion
Public Support	Low	The public has a limited understanding of how they benefit from this alternative.
Construction Feasibility	Medium	Construction is moderately difficult or risky.
Operation Feasibility	Medium	The technology is familiar but requires skilled staff working at multiple locations and transport of chemicals.
Reliability and Past Performance of Technology	Low	The likelihood of failure is low/moderate but consequences are high for aquatic life.
Complexity and Difficulty of Solution	Medium	The alternative requires construction and operation at several sites.
Coordination and Consistency with other PWD and City Programs	Low	This alternative does not support greening initiatives, occupies park or waterfront land, and may jeopardize habitat and aquatic life.

9.3 Tookany-Tacony/Frankford Creek Watershed

This section presents costs and benefits of each alternative in the TTF Watershed. For each alternative two graphs are presented (Figure 9-9 to 9-16), the first is a summary of cost to PWD and the second is a summary of the total private and public cost compared with the net benefits.

9.3.1 Green Stormwater Infrastructure with Targeted Traditional Infrastructure

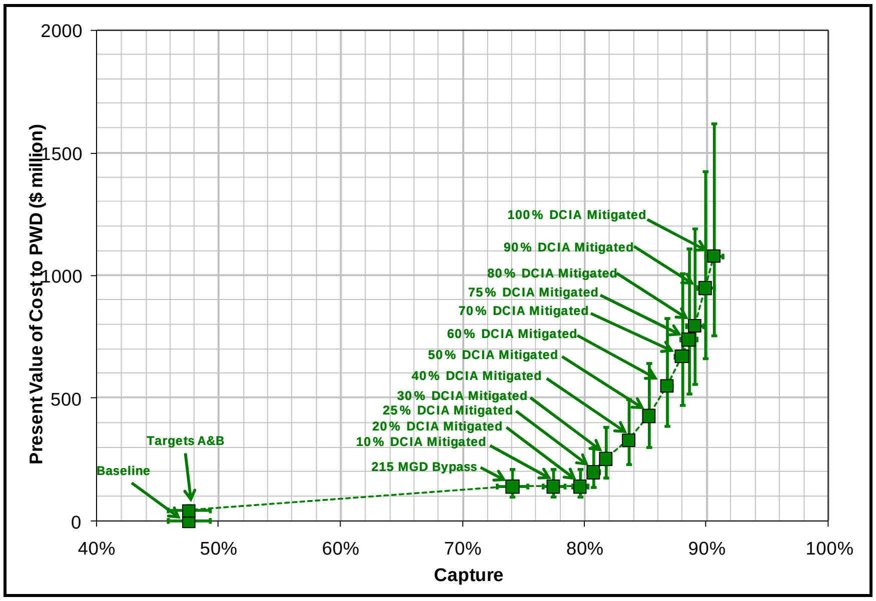

Figure 9-9 TTF Green Stormwater Infrastructure with Targeted Traditional Infrastructure Cost-Performance Curve

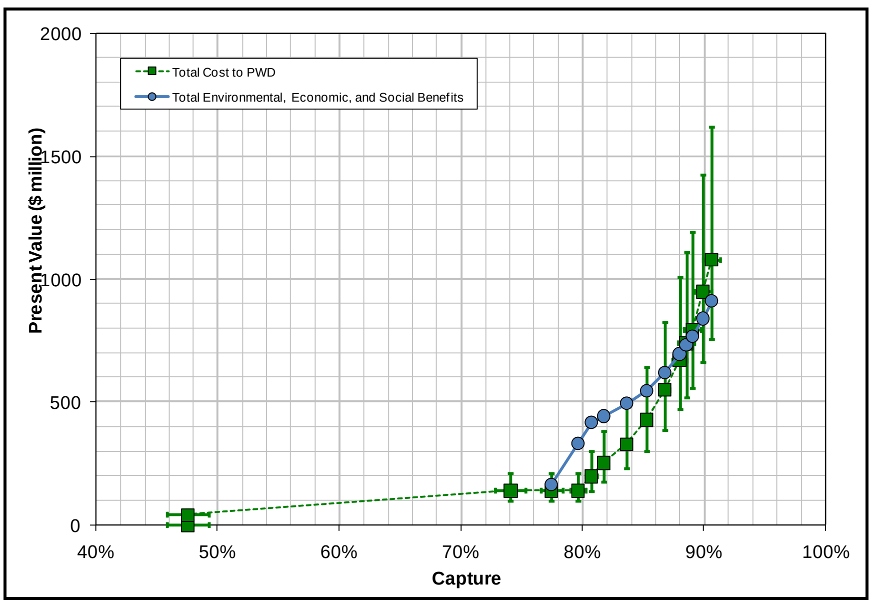

Figure 9-10 TTF Green Stormwater Infrastructure with Targeted Traditional Infrastructure Cost-Benefit Comparison

9.3.2 Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity

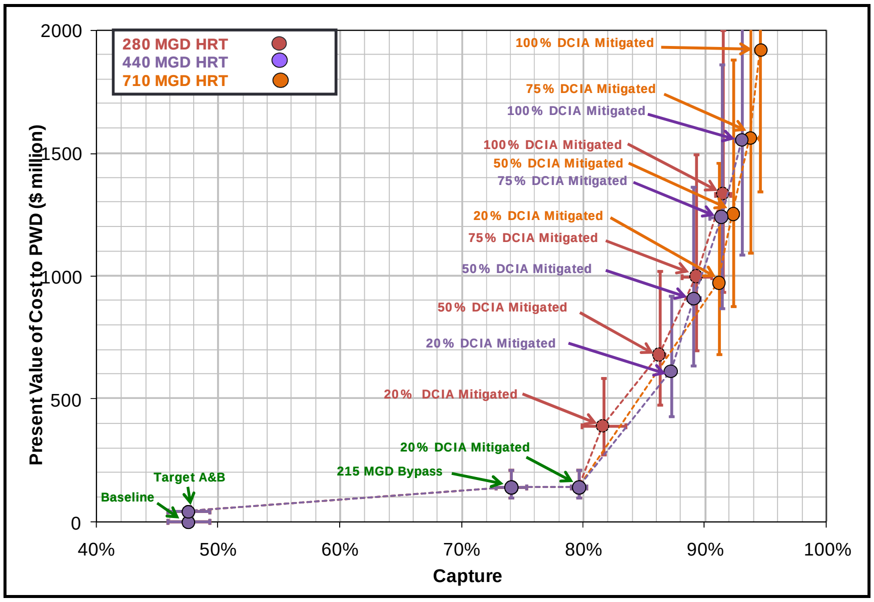

Figure 9-11 TTF Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Cost-Performance Curve

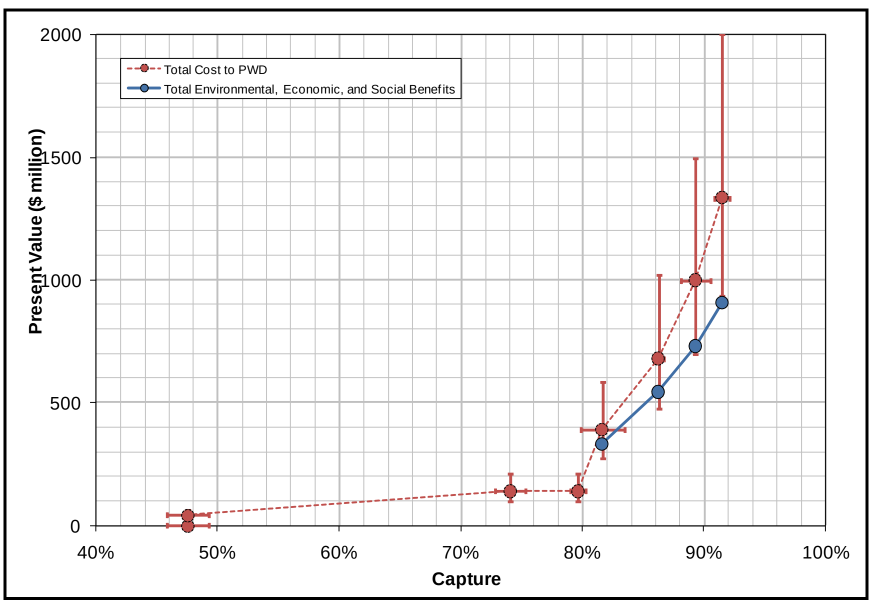

Figure 9-12 TTF Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Cost-Benefit Comparison

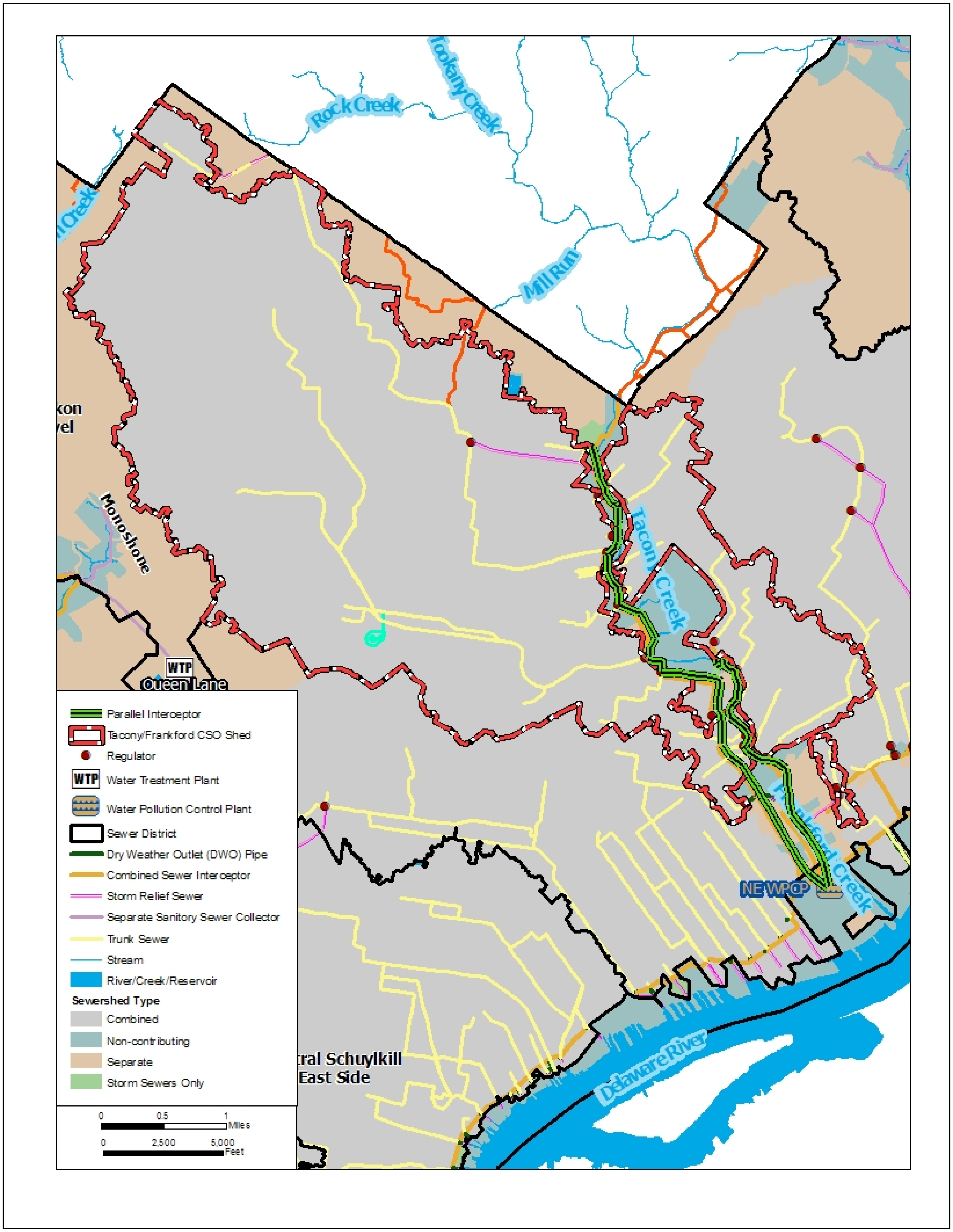

Figure 9-13 Location of TTF Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Alternative

9.3.3 Large-Scale Centralized Storage Alternative

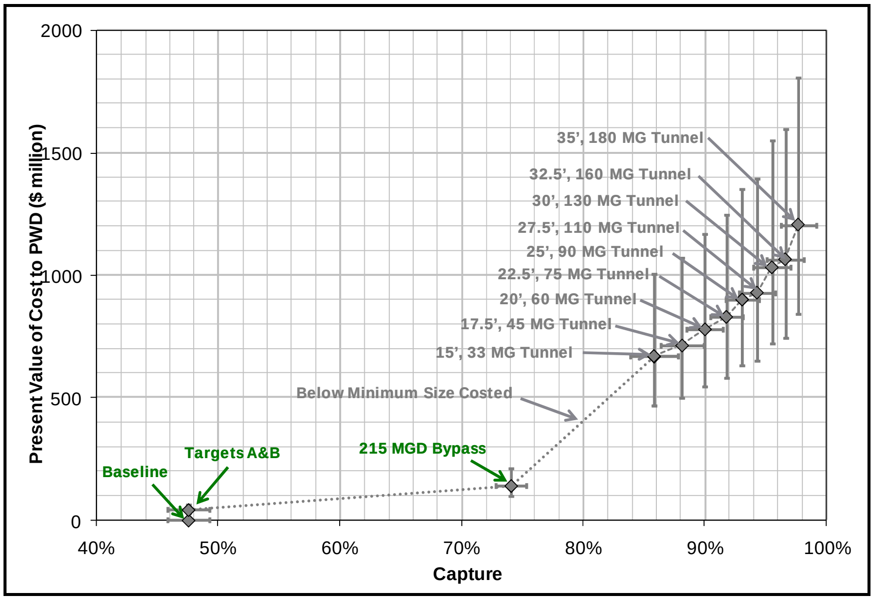

Figure 9-14 TTF Large-Scale Centralized Storage Alternative Cost-Performance Curve

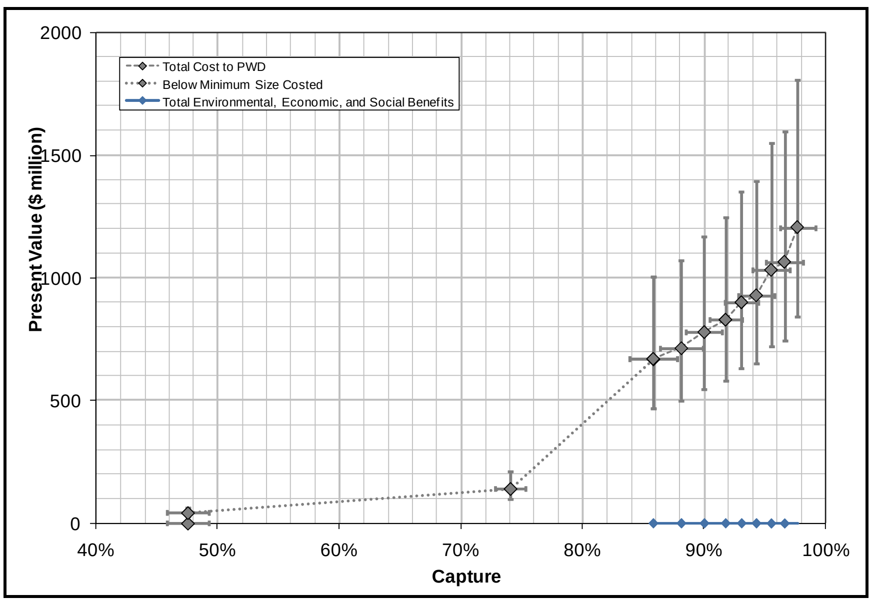

Figure 9-15 TTF Large-Scale Centralized Storage Alternative Cost-Benefit Comparison

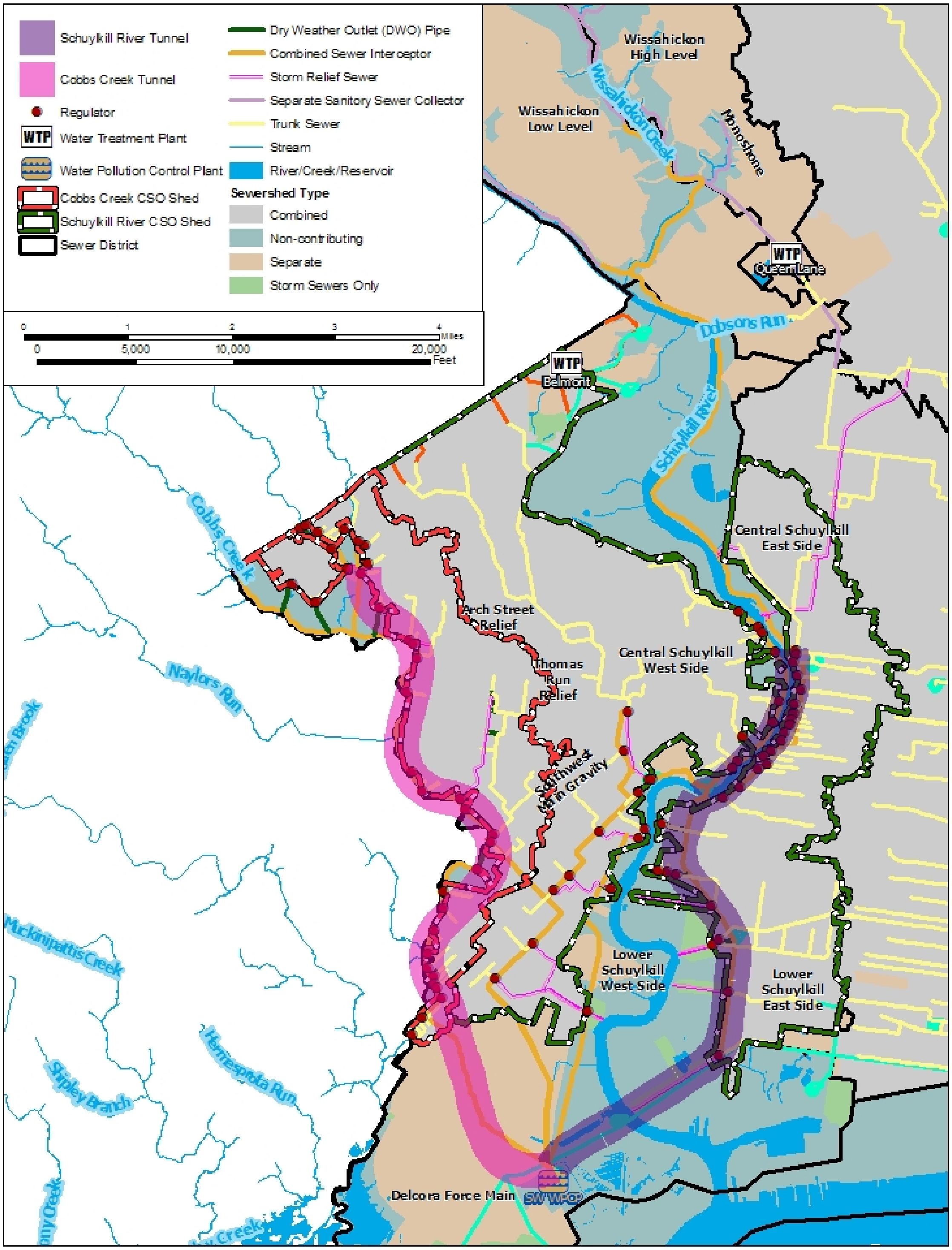

Figure 9-16 Location of TTF Large-Scale Centralized Storage Alternative

9.3.4 Large-Scale Satellite Treatment Alternative

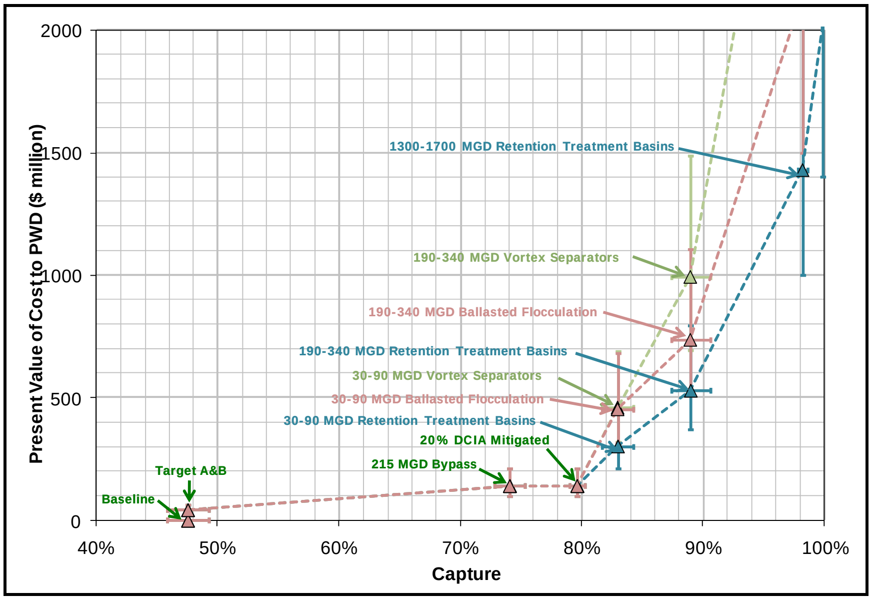

Figure 9-17 TTF Large-Scale Satellite Treatment Alternative Cost-Performance Curve

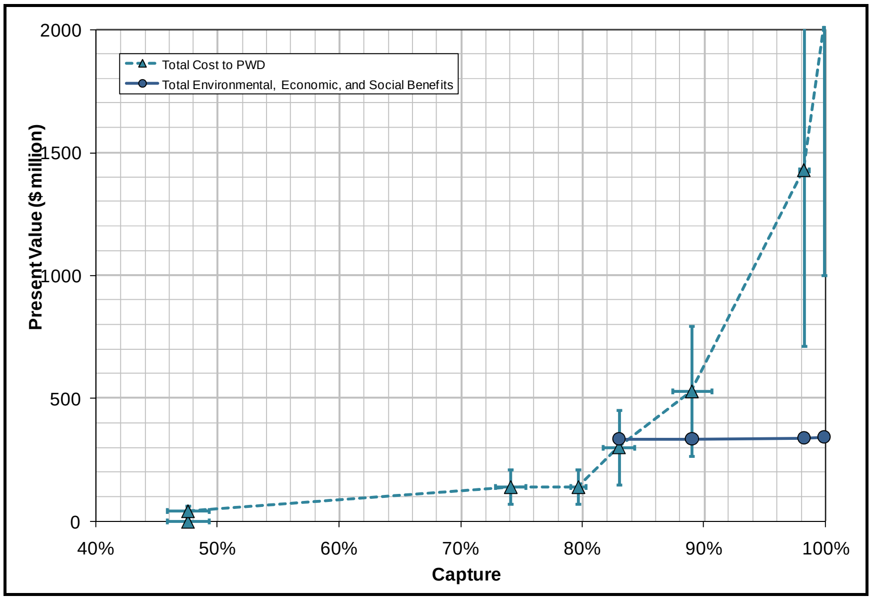

Figure 9-18 TTF Large-Scale Satellite Treatment Alternative Cost-Benefit Comparison

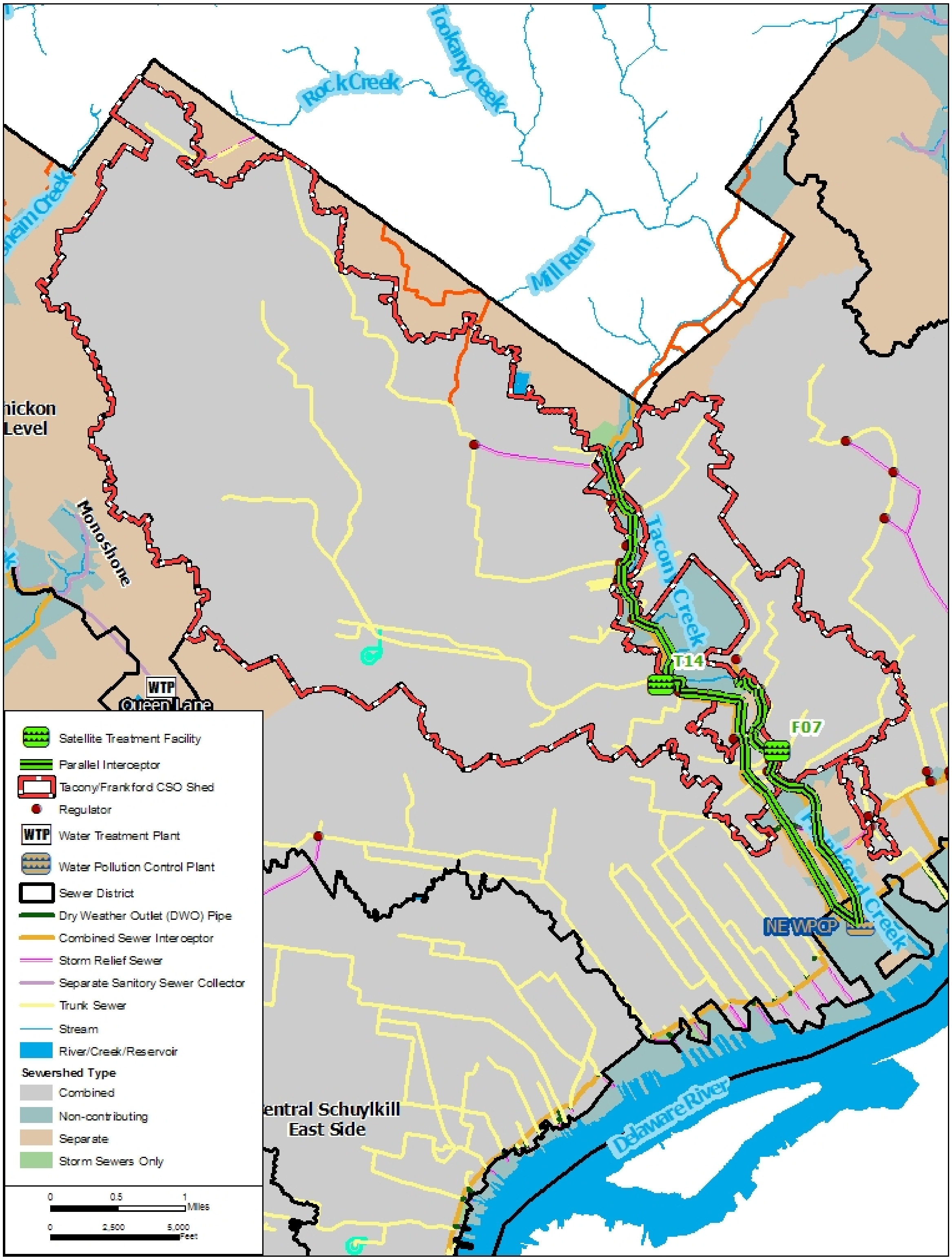

Figure 9-19 Location of TTF Large-Scale Satellite Treatment Alternative

9.4 COBBS CREEK WATERSHED

This section presents costs and benefits of each alternative in the Cobbs Watershed. For each alternative, a map (if applicable) and two graphs are presented (9-17 to 9-17). The first graph is a summary of cost to PWD and the second graph is a summary of the total private and public cost compared with the net benefits.

9.4.1 Green Stormwater Infrastructure with Targeted Traditional Infrastructure

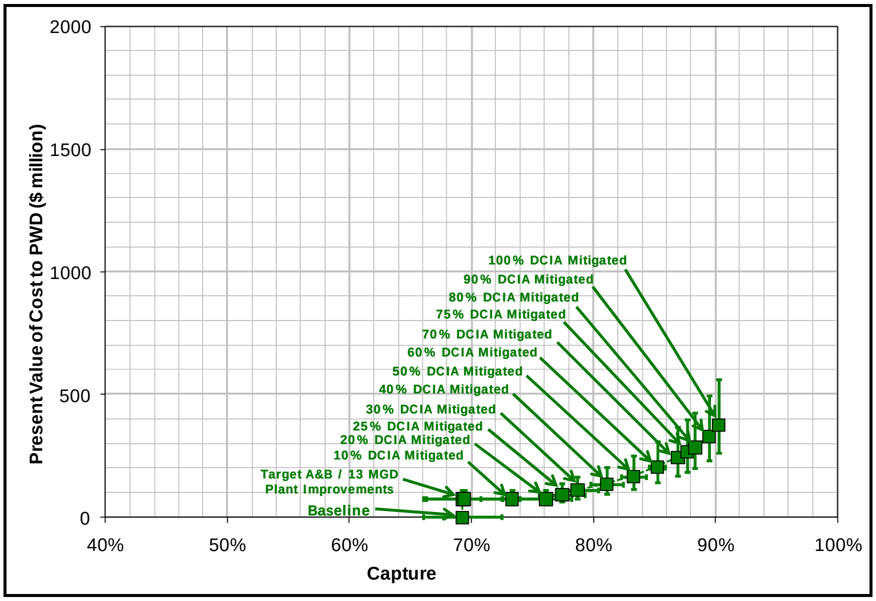

Figure 9-20 Cobbs Green Stormwater Infrastructure with Targeted Traditional Infrastructure Cost- Performance Curve

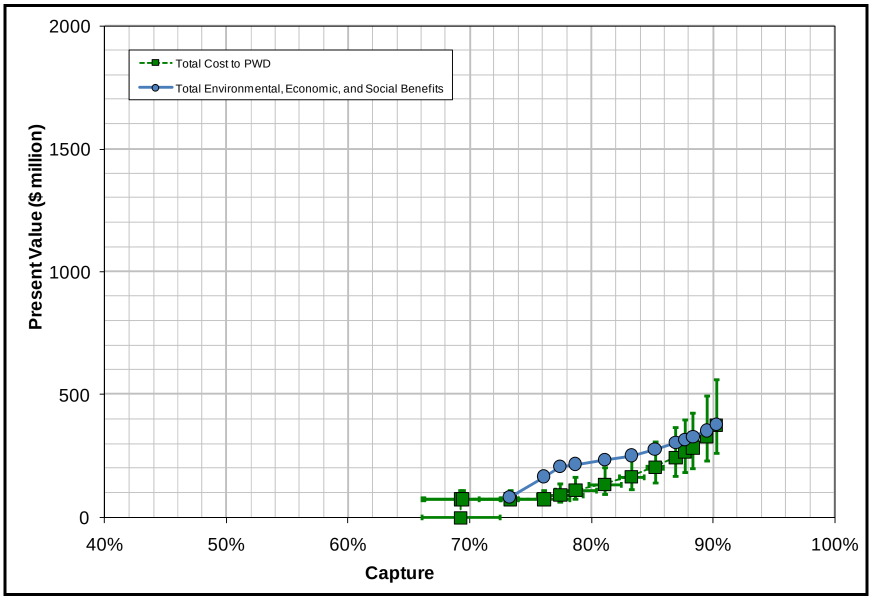

Figure 9-21 Cobbs Green Stormwater Infrastructure with Targeted Traditional Infrastructure Cost- Benefit Comparison

9.4.2 Cobbs Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity

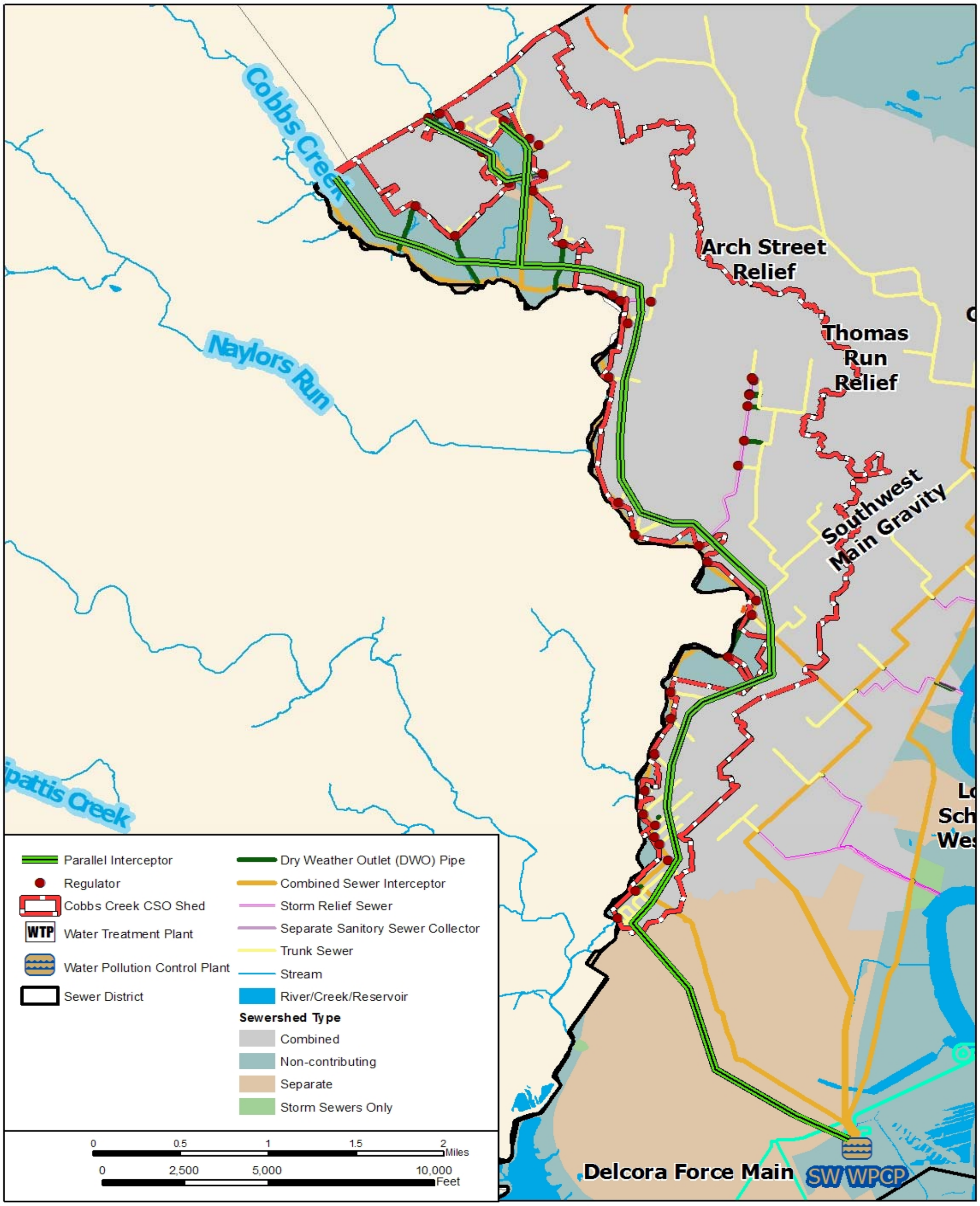

Figure 9-22 Location of Cobbs Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Alternative

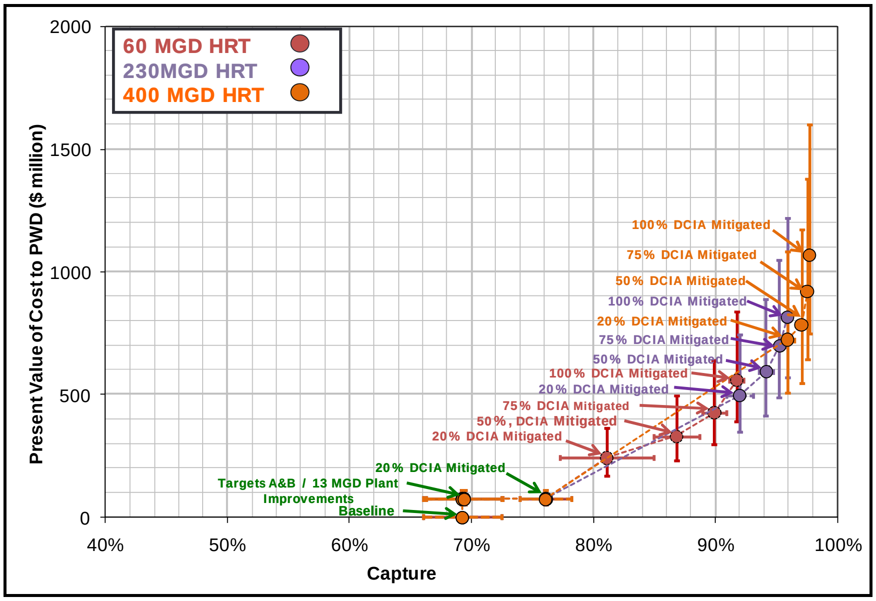

Figure 9-23 Cobbs Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Cost-Performance Curve

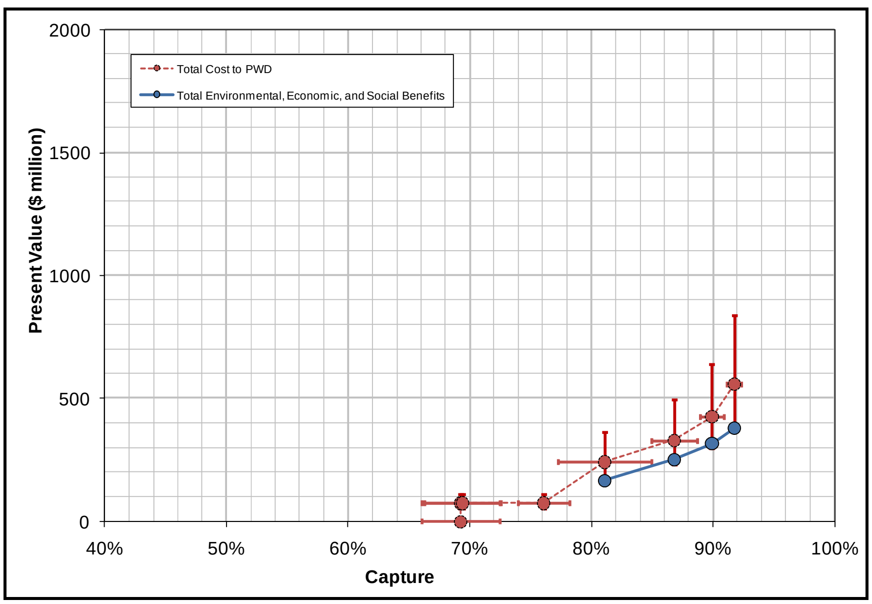

Figure 9-24 Cobbs Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Cost-Benefit Comparison

9.4.3 Cobbs/Schuylkill Large-Scale Centralized Storage Alternative

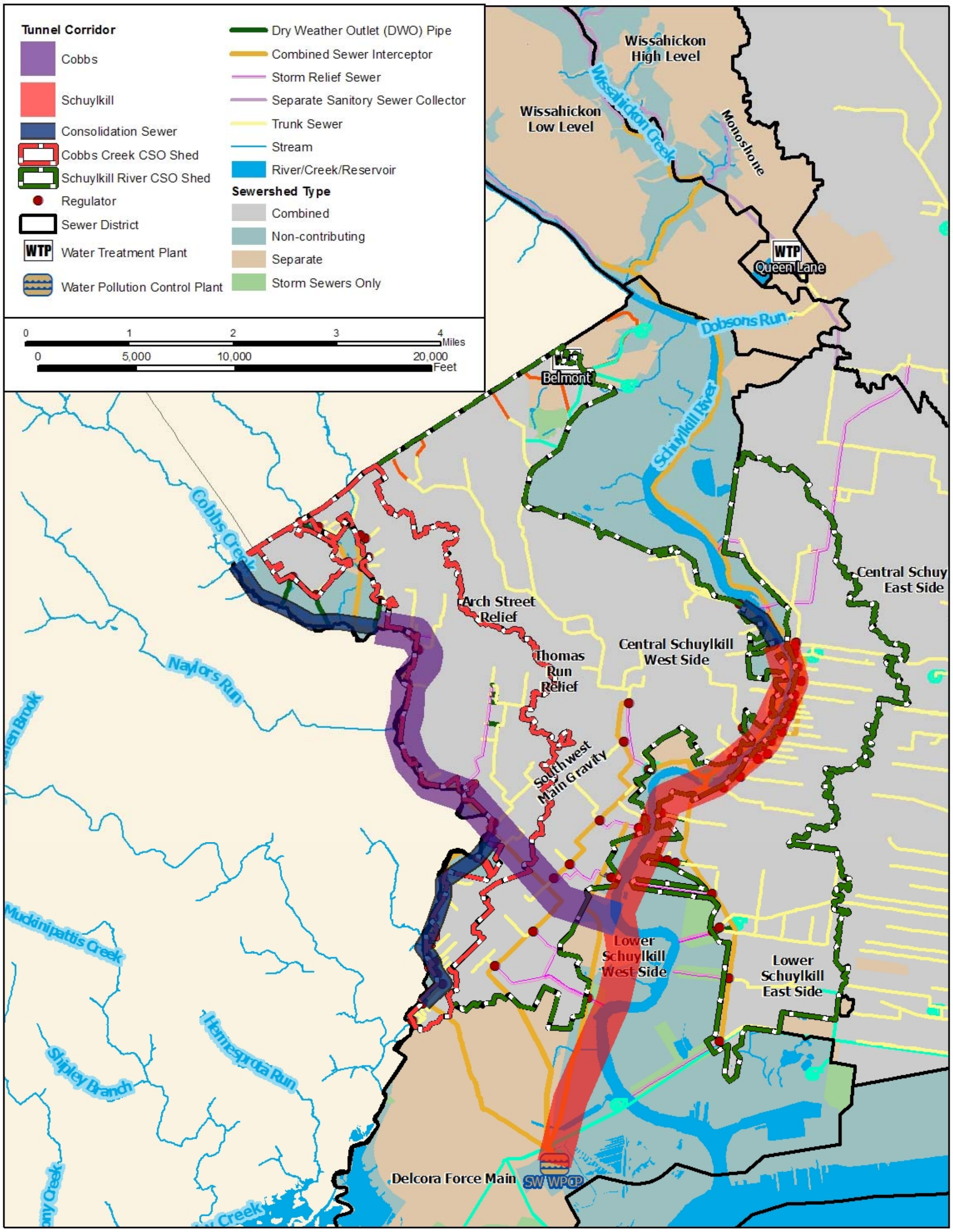

Figure 9-25 Location of Cobbs/Schuylkill Large-Scale Centralized Storage Alternative

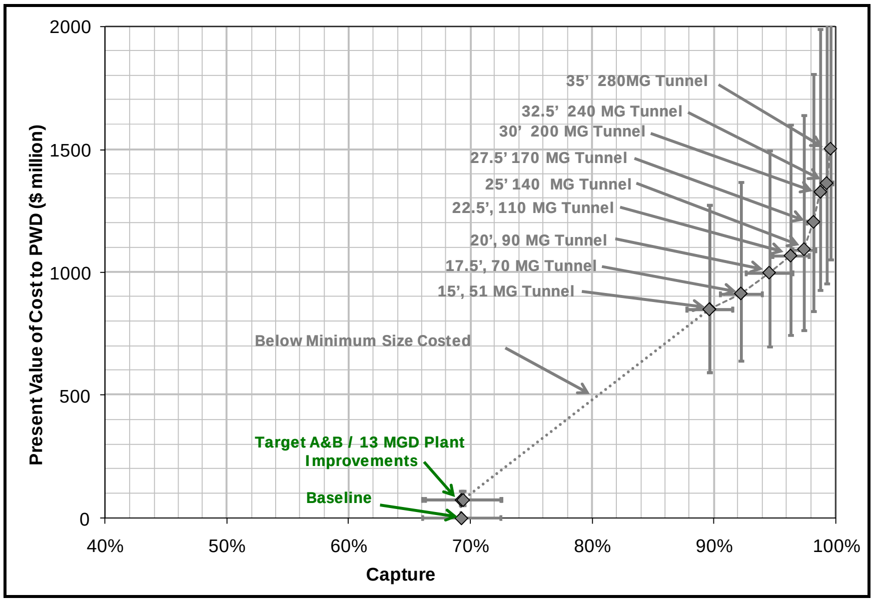

Figure 9-26 Cobbs Large-Scale Centralized Storage Alternative Cost-Performance Curve

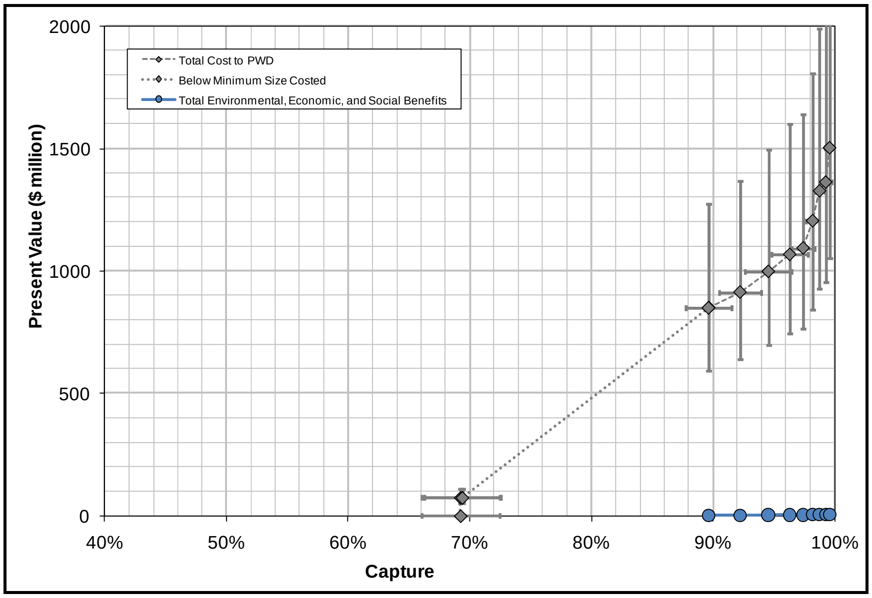

Figure 9-27 Cobbs Large-Scale Centralized Storage Alternative Cost-Benefit Comparison

9.4.4 Large-Scale Satellite Treatment Alternative

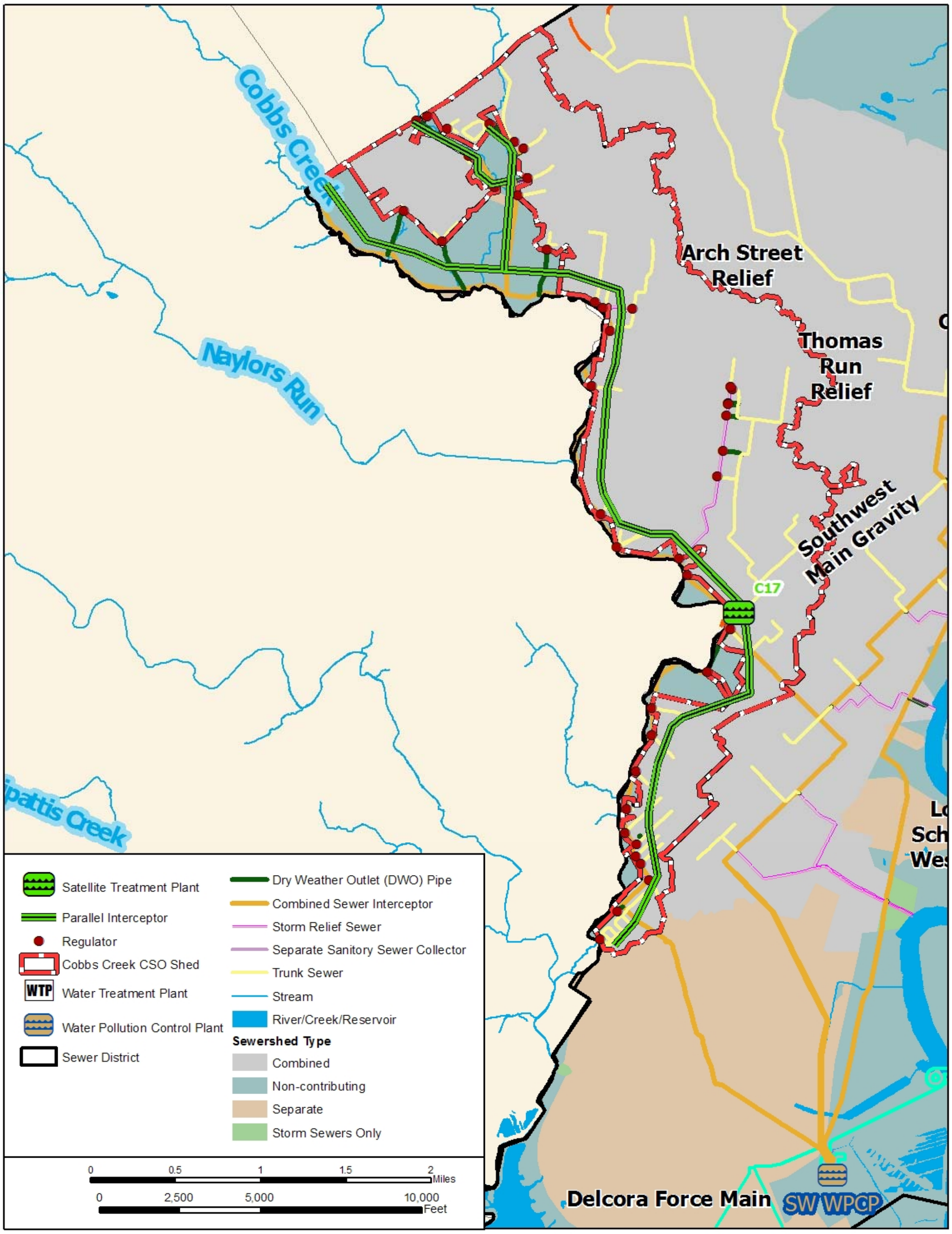

Figure 9-28 Location of Large-Scale Satellite Treatment Alternative

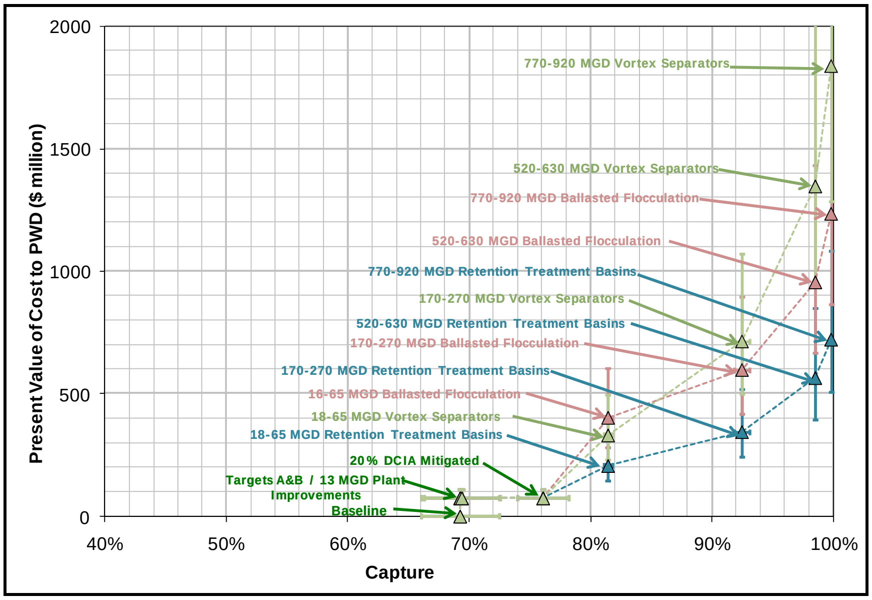

Figure 9-29 Cobbs Large-Scale Satellite Treatment Alternative Cost-Performance Curve

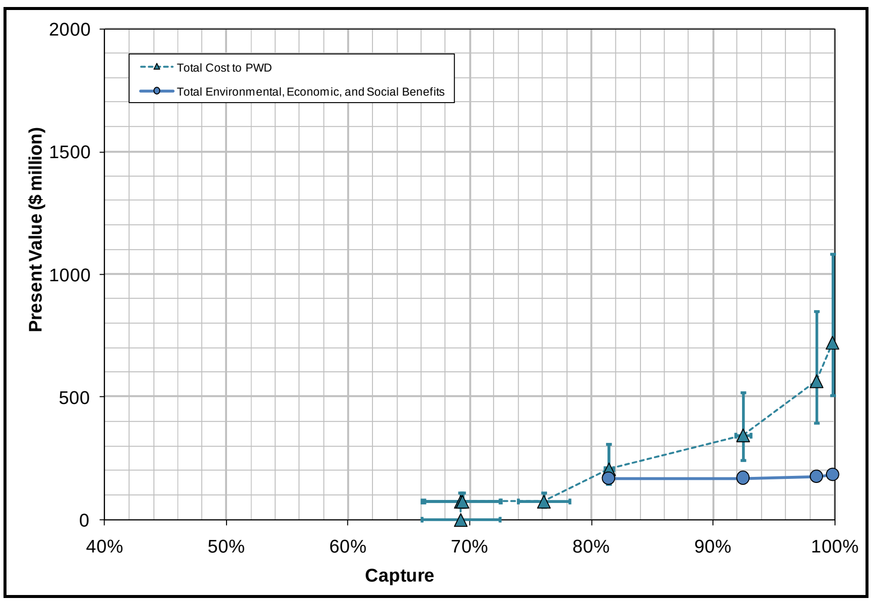

Figure 9-30 Cobbs Large-Scale Satellite Treatment Alternative Cost-Benefit Comparison

9.5 DELAWARE RIVER DIRECT WATERSHED

This section presents costs and benefits of each alternative in the Delaware River Watershed. For each alternative, a map (if applicable) and two graphs are presented (9-28 to 9-38). The first graph is a summary of cost to PWD and the second graph is a summary of the total private and public cost compared with the net benefits.

9.5.1 Green Stormwater Infrastructure with Targeted Traditional Infrastructure

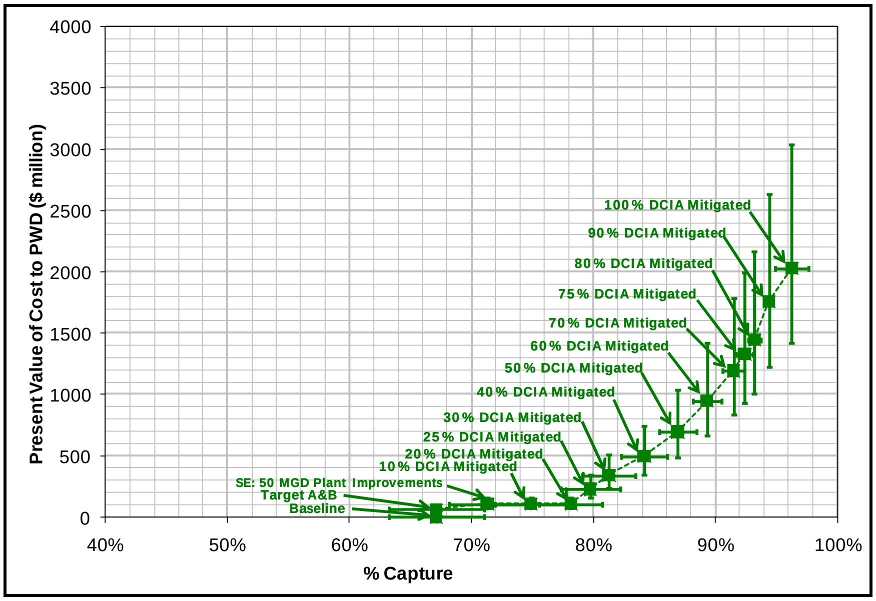

Figure 9-31 Delaware Direct Green Stormwater Infrastructure with Targeted Traditional Infrastructure Cost-Performance Curve

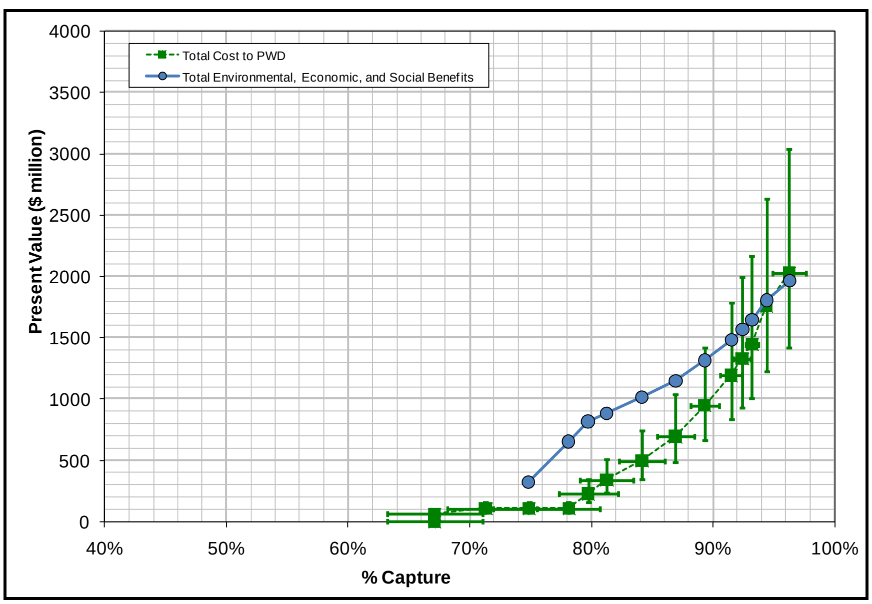

Figure 9-32 Delaware Direct Green Stormwater Infrastructure with Targeted Traditional Infrastructure Cost-Benefit Comparison

9.5.2 Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity

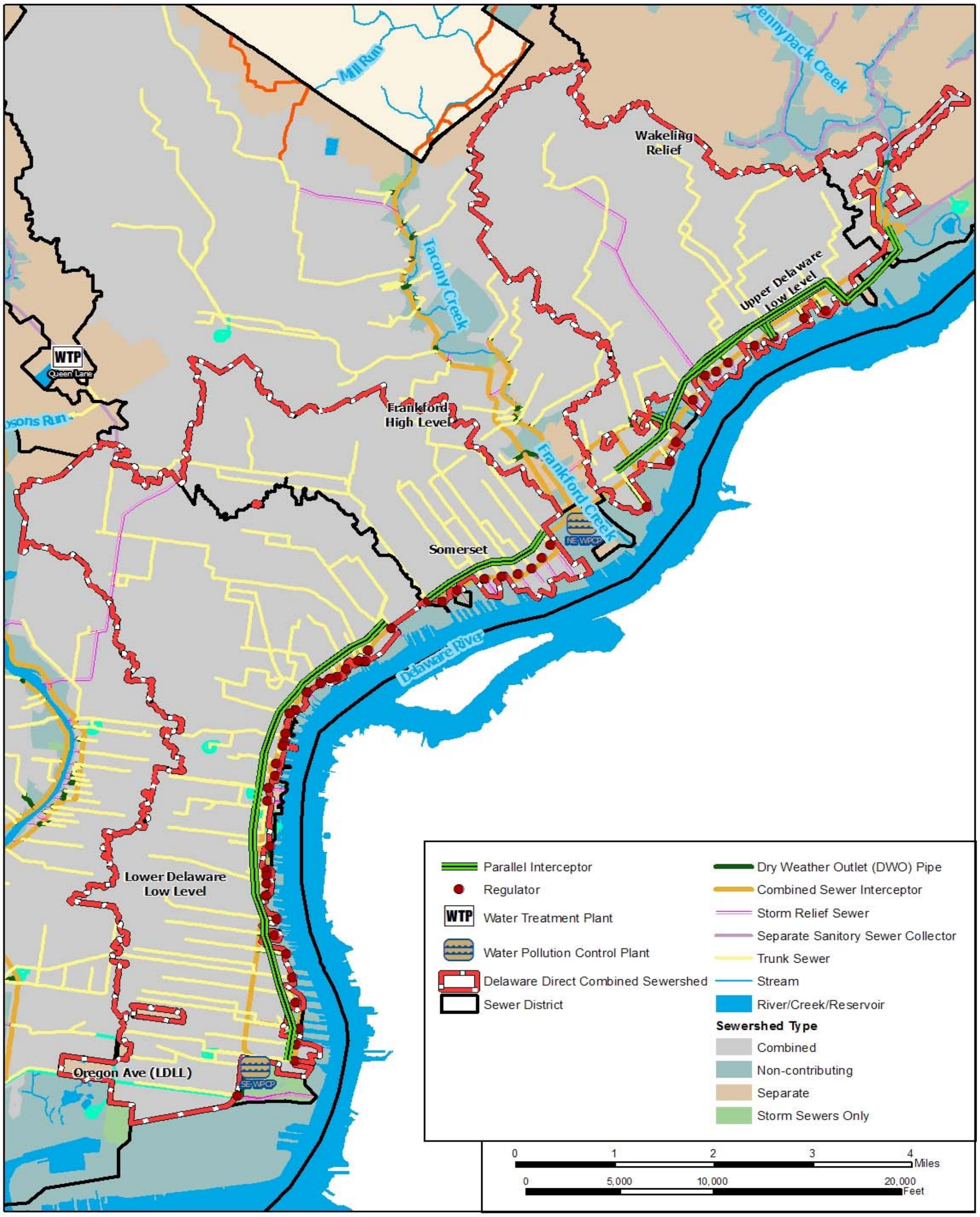

Figure 9-33 Location of Delaware Direct Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Alternative

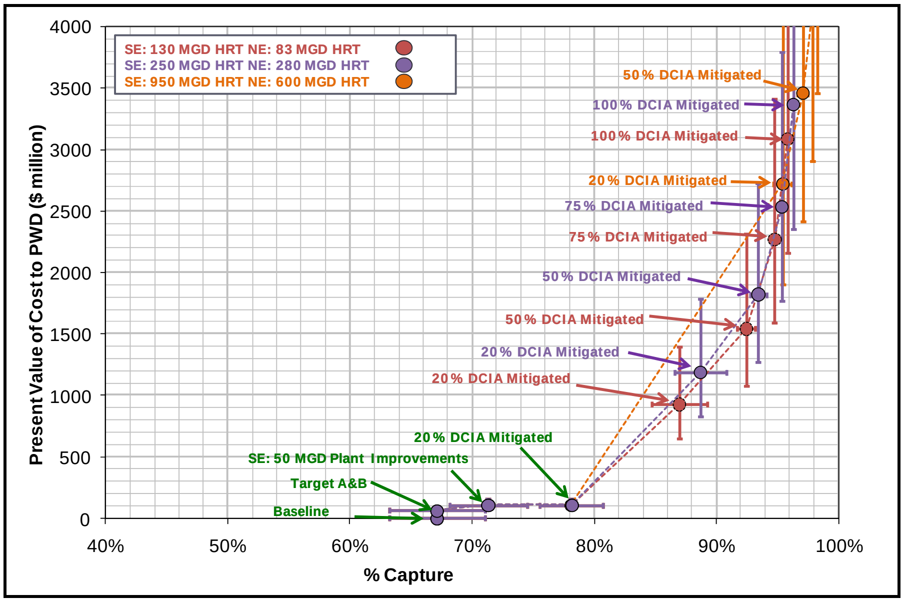

Figure 9-34 Delaware Direct Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Cost-Performance Curve

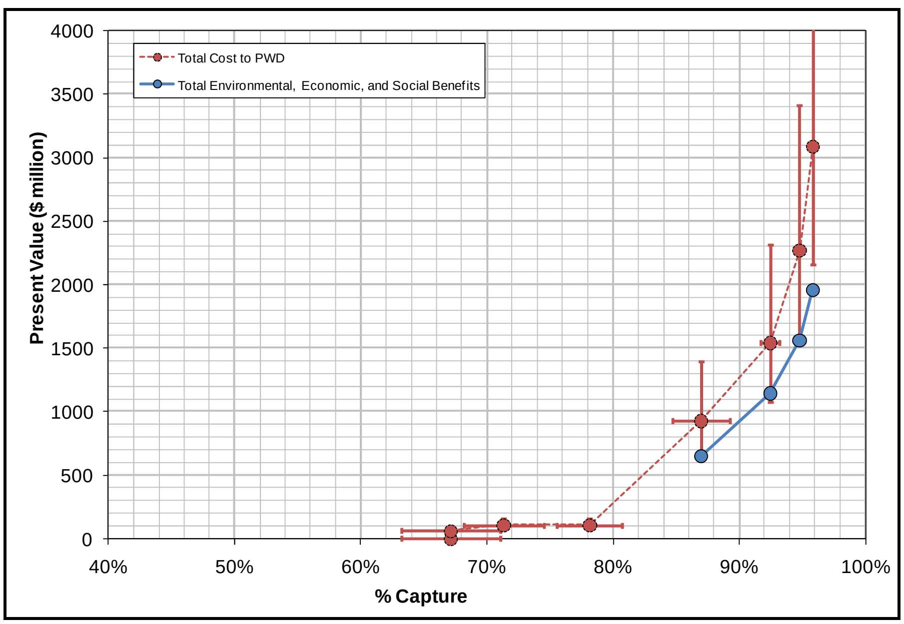

Figure 9-35 Delaware Direct Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Cost-Benefit Comparison

9.5.3 Large-Scale Centralized Storage Alternative

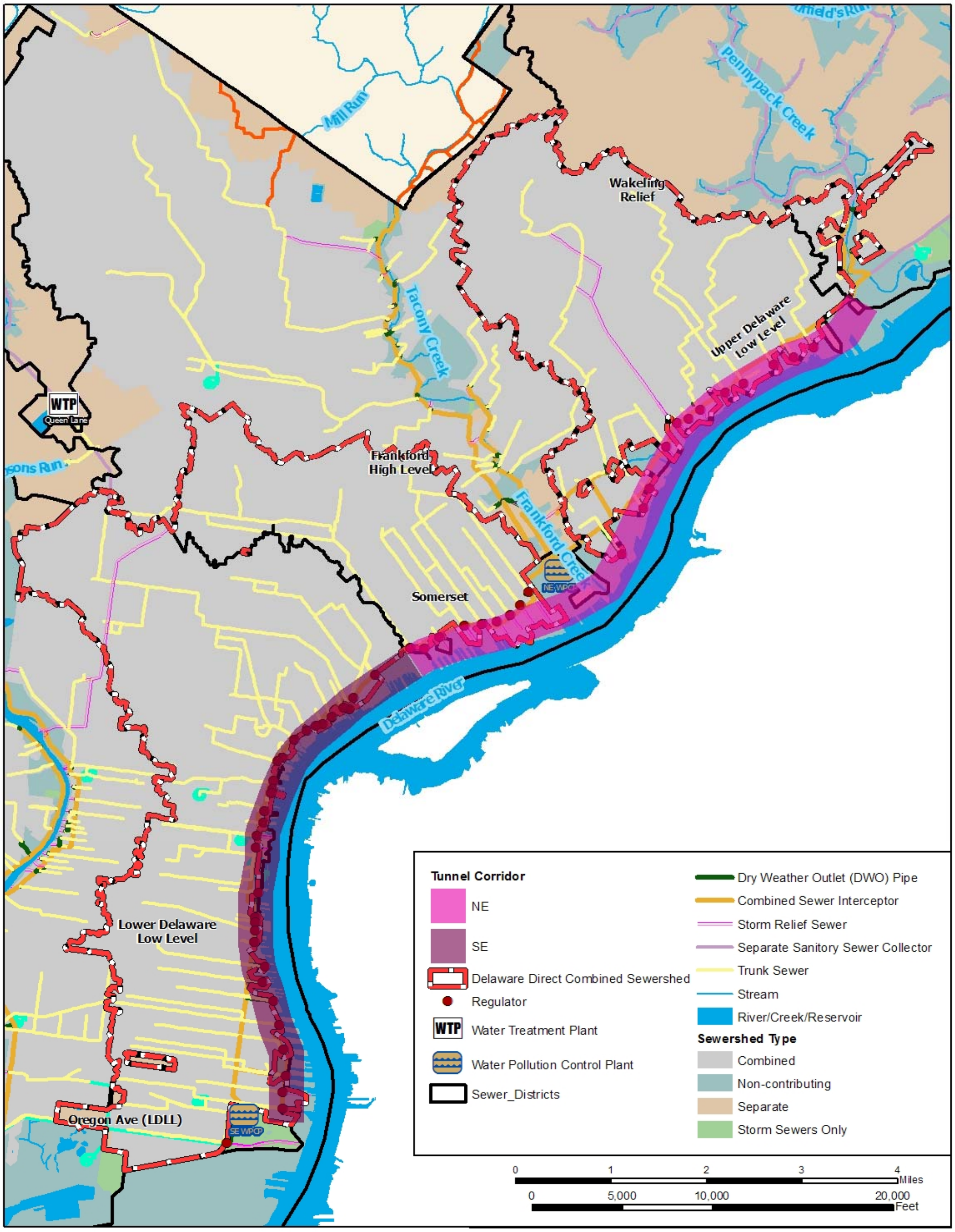

Figure 9-36 Location of Delaware Direct Large-Scale Centralized Storage Alternative

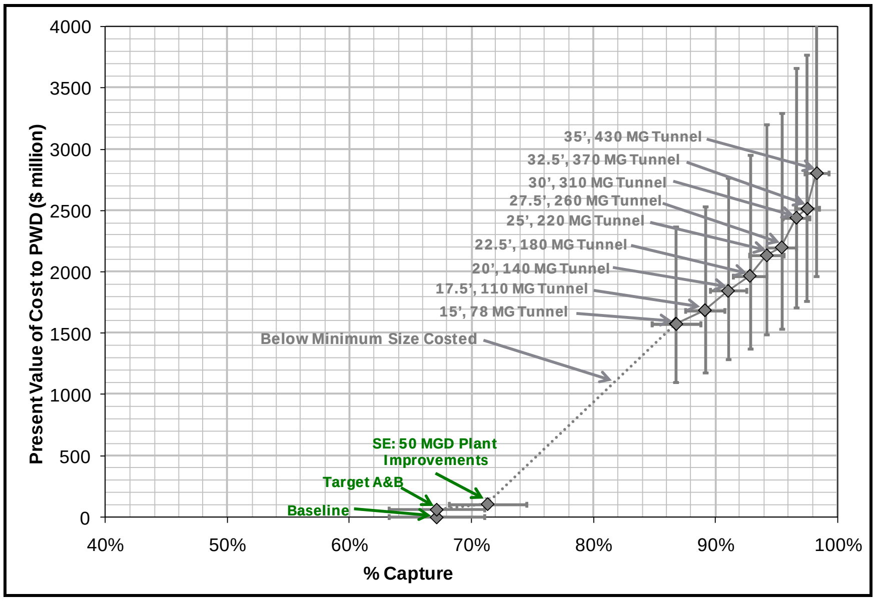

Figure 9-37 Delaware Direct Large-Scale Centralized Storage Alternative Cost-Performance Curve

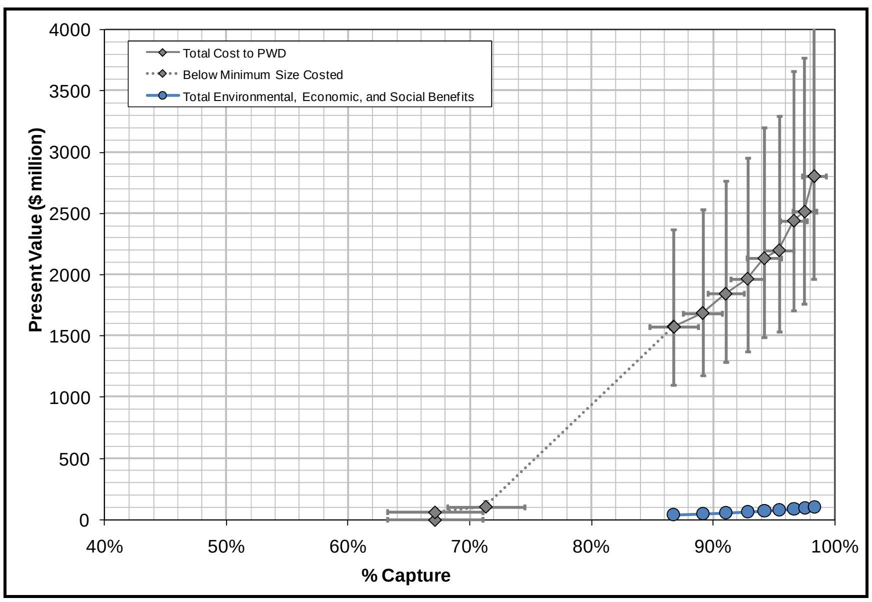

Figure 9-38 Delaware Direct Large-Scale Centralized Storage Alternative Cost-Benefit Comparison

9.5.4 Large-Scale Satellite Treatment Alternative

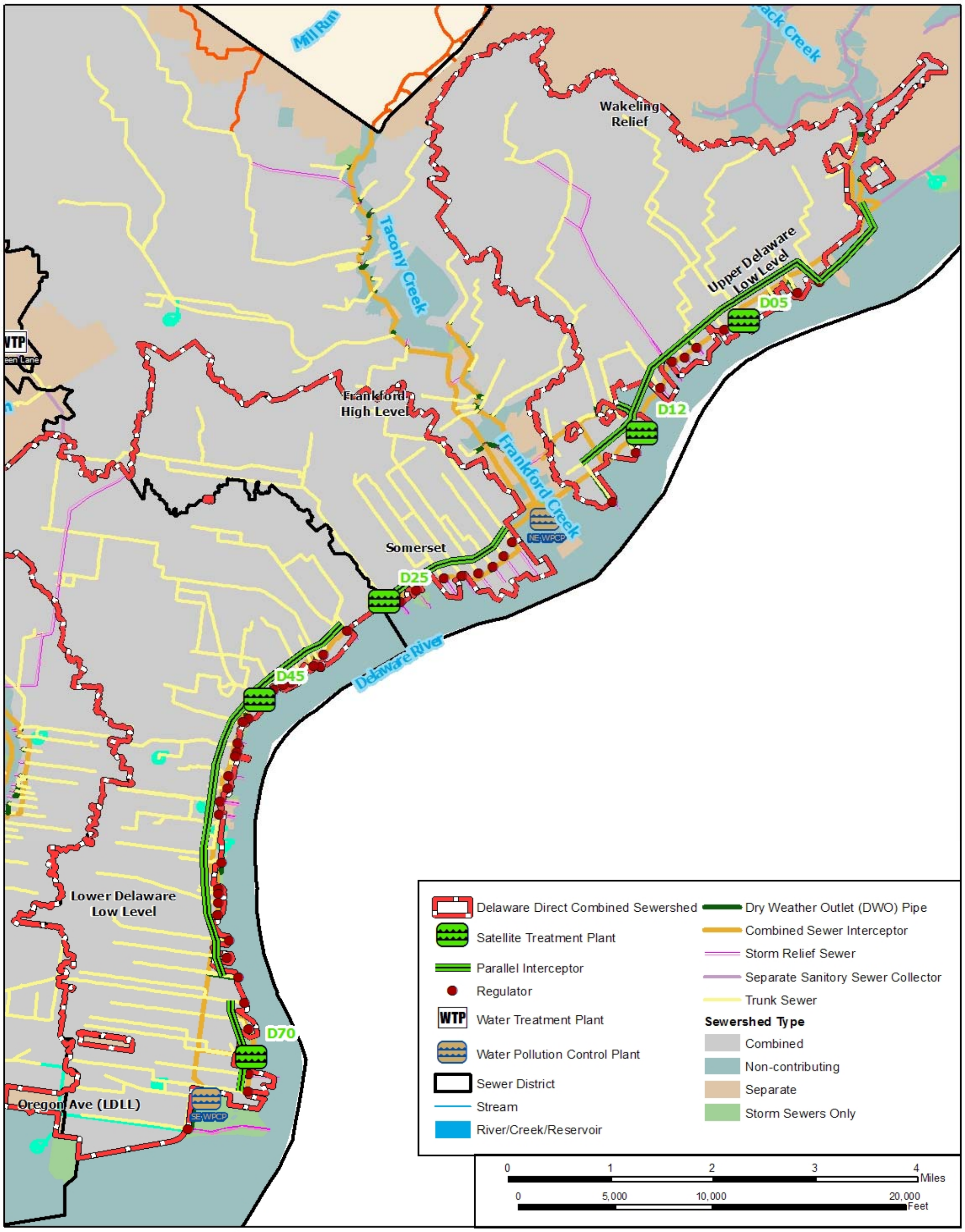

Figure 9-39 Location of Delaware Direct Large-Scale Satellite Treatment Alternative

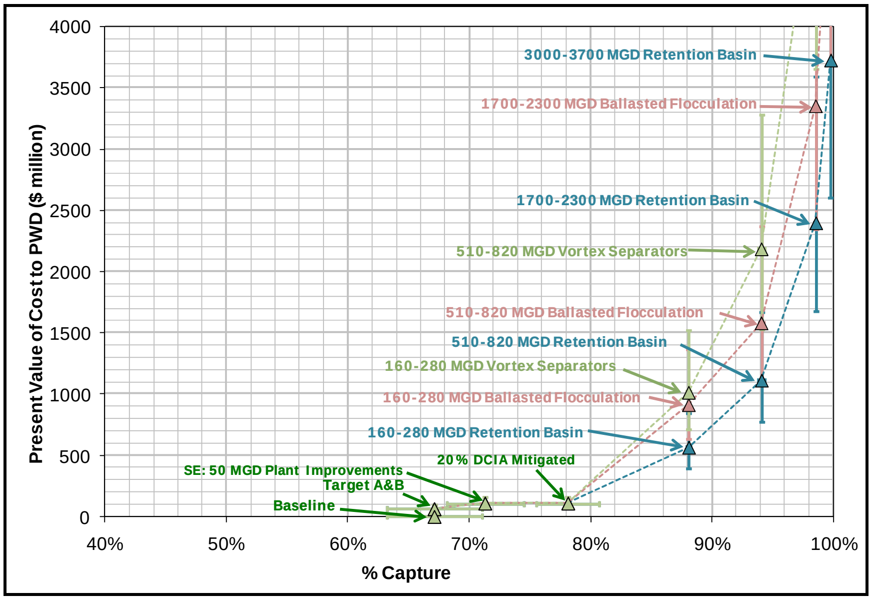

Figure 9-40 Delaware Direct Large-Scale Satellite Treatment Alternative Cost-Performance Curve

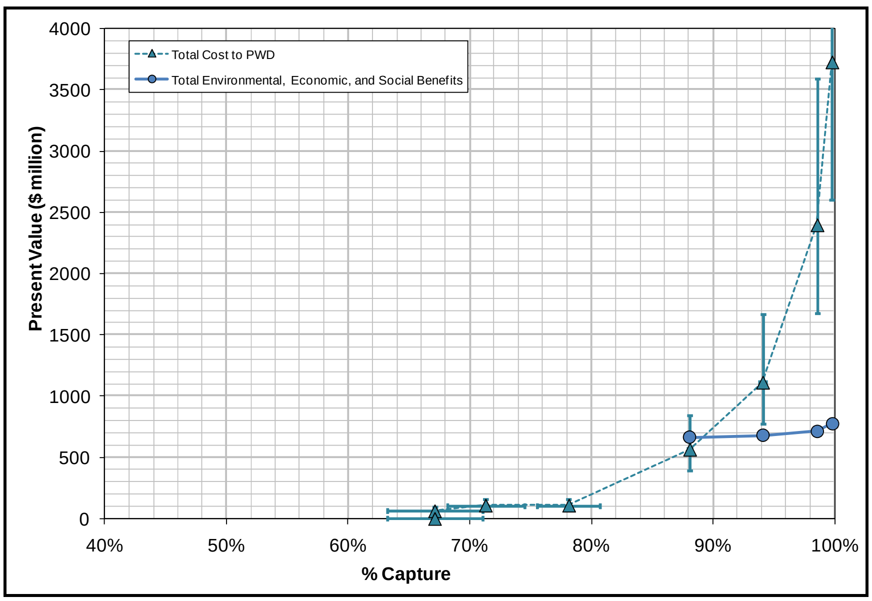

Figure 9-41 Delaware Direct Large-Scale Satellite Treatment Alternative Cost-Benefit Comparison

9.6 SCHUYLKILL RIVER DIRECT WATERSHED

This section presents costs and benefits of each alternative in the Schuylkill River Watershed. For each alternative, a map (if applicable) and two graphs are presented (9-39 to 9-49). The first graph is a summary of cost to PWD and the second graph is a summary of the total private and public cost compared with the net benefits.

9.6.1 Green Stormwater Infrastructure with Targeted Traditional Infrastructure

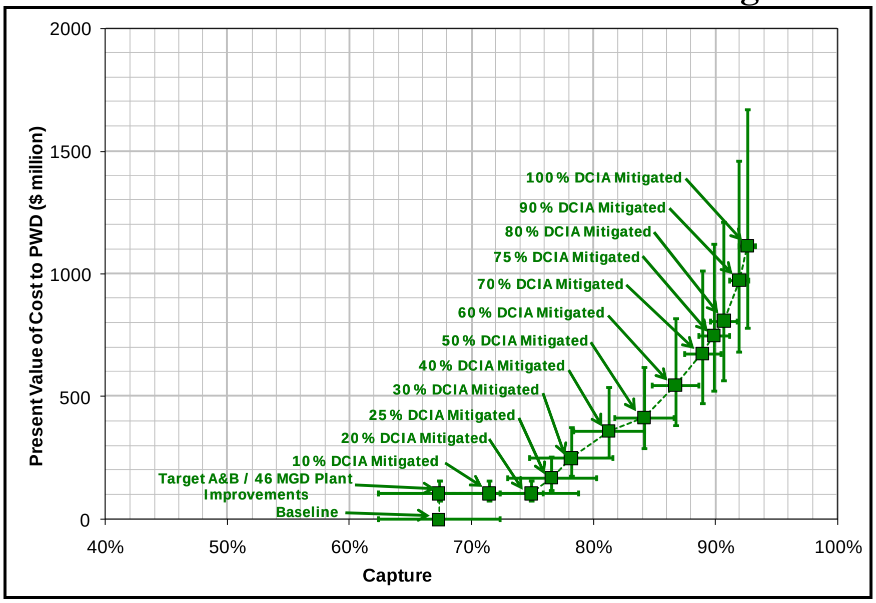

Figure 9-42 Schuylkill Direct Green Stormwater Infrastructure with Targeted Traditional Infrastructure Cost-Performance Curve

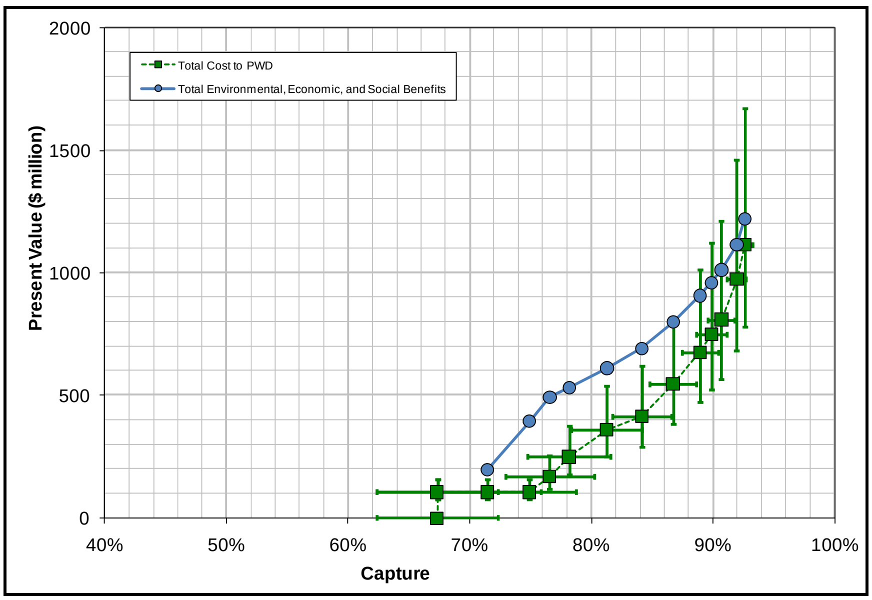

Figure 9-43 Schuylkill Direct Green Stormwater Infrastructure with Targeted Traditional Infrastructure Cost-Benefit Comparison

9.6.2 Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity

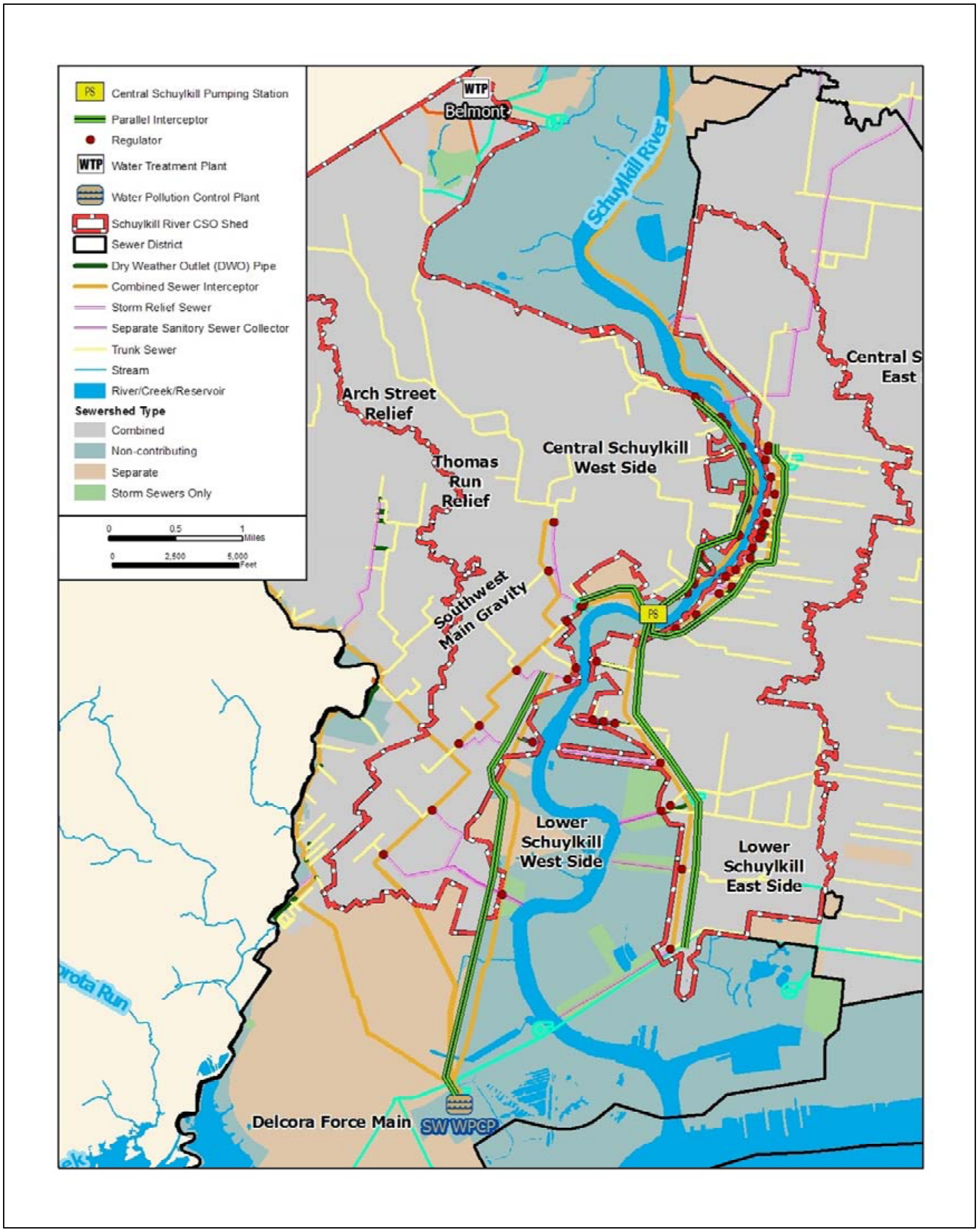

Figure 9-44 Location of Schuylkill Direct Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Alternative

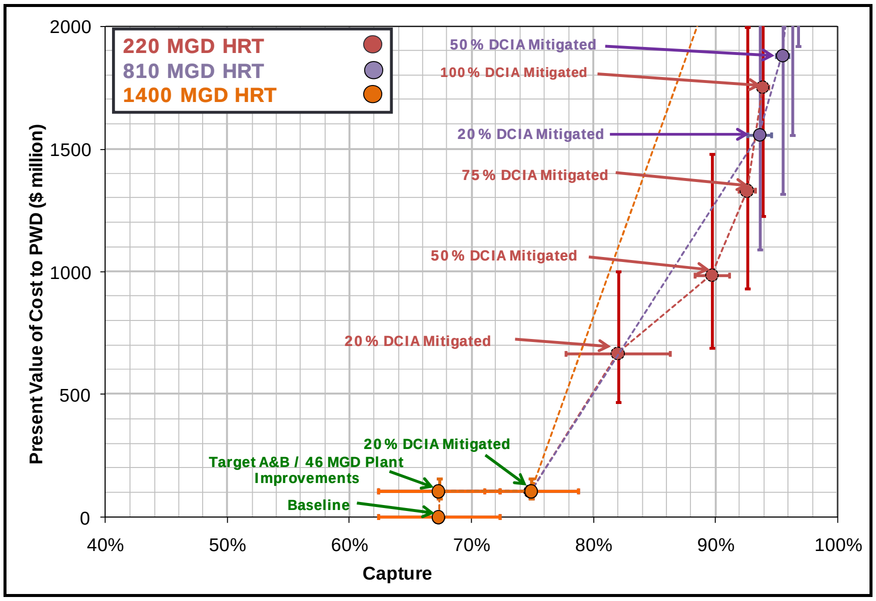

Figure 9-45 Schuylkill Direct Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Cost-Performance Curve

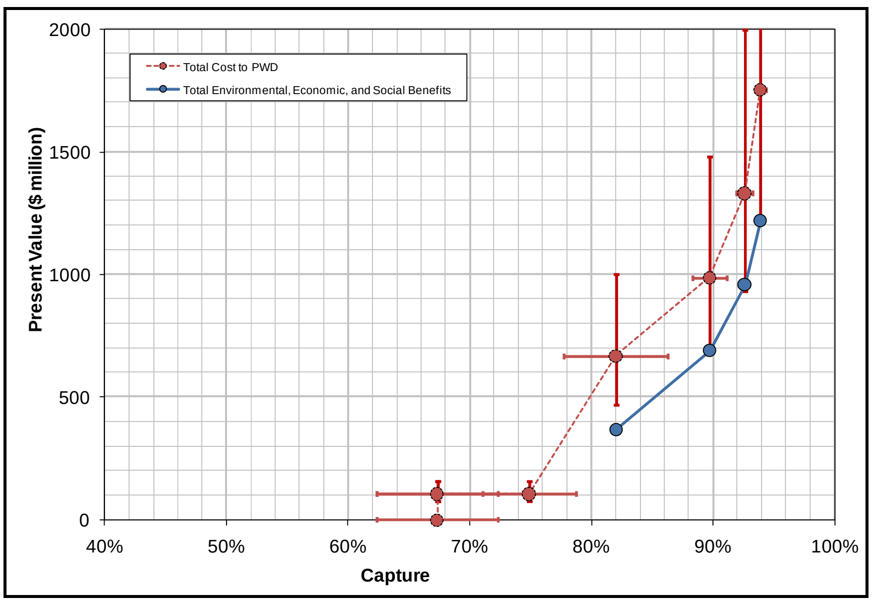

Figure 9-46 Schuylkill Direct Green Stormwater Infrastructure with Increased Transmission and Treatment Capacity Cost-Benefit Comparison

9.6.3 Large-Scale Centralized Storage Alternative

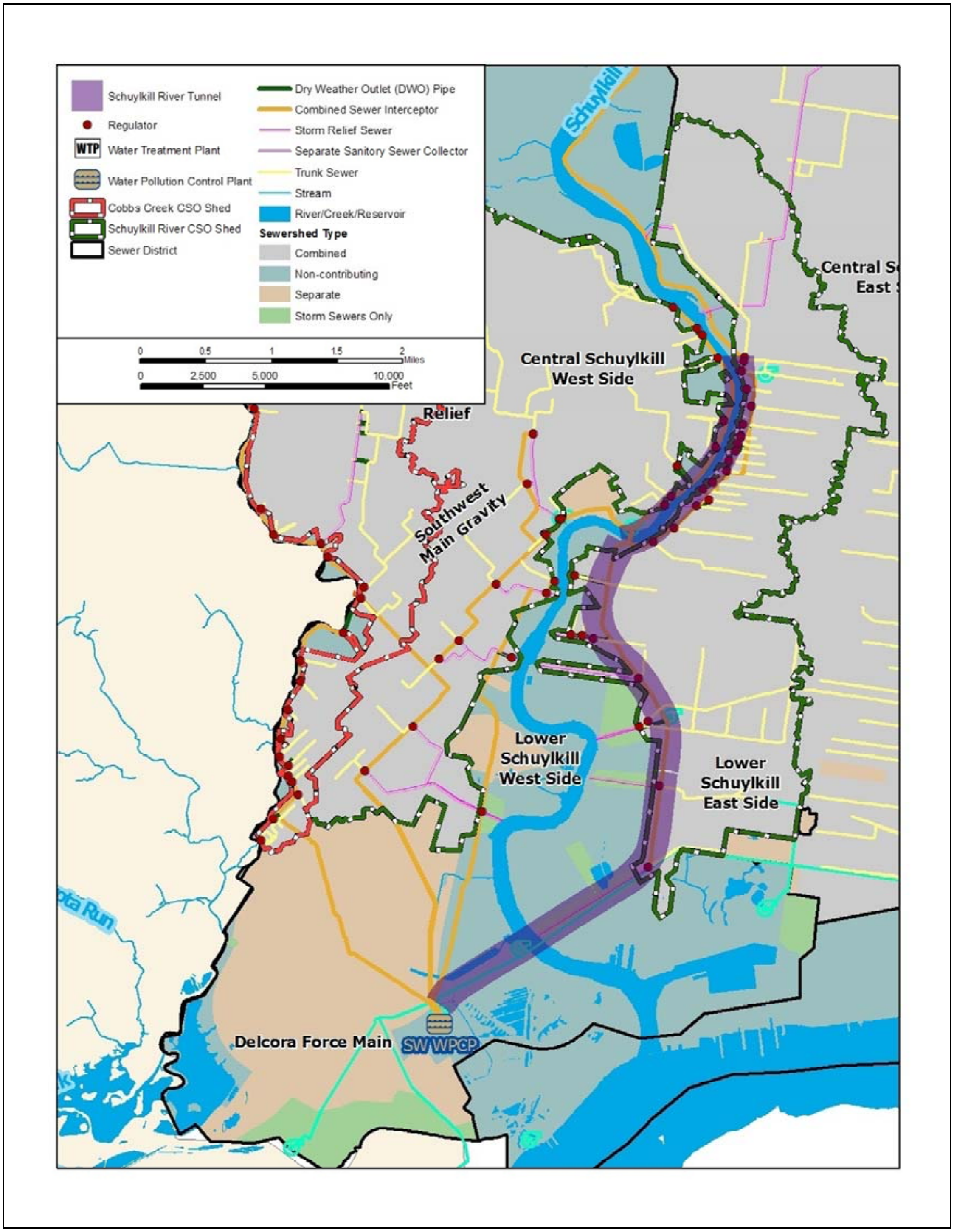

Figure 9-47 Location of Schuylkill Direct Large-Scale Centralized Storage Alternative

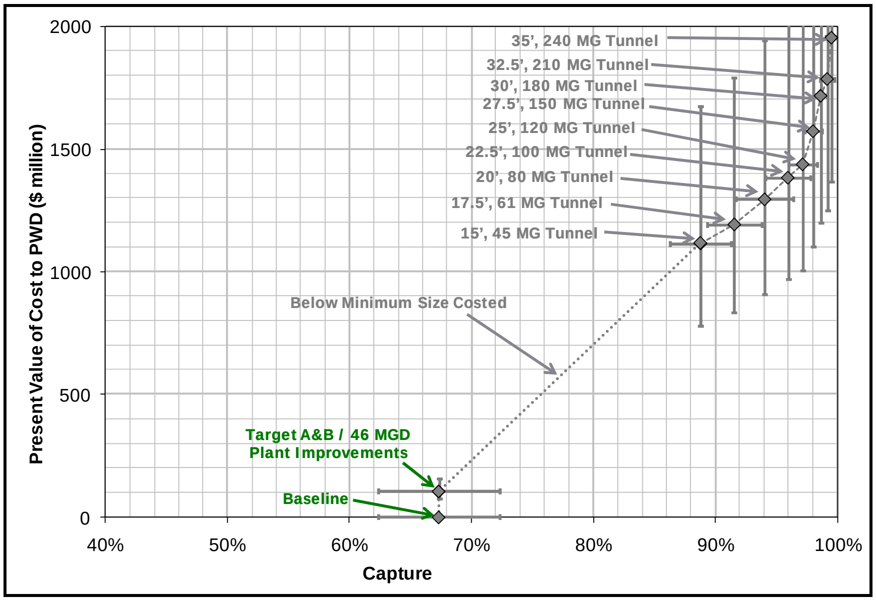

Figure 9-48 Schuylkill Direct Large-Scale Centralized Storage Alternative Cost-Performance Curve

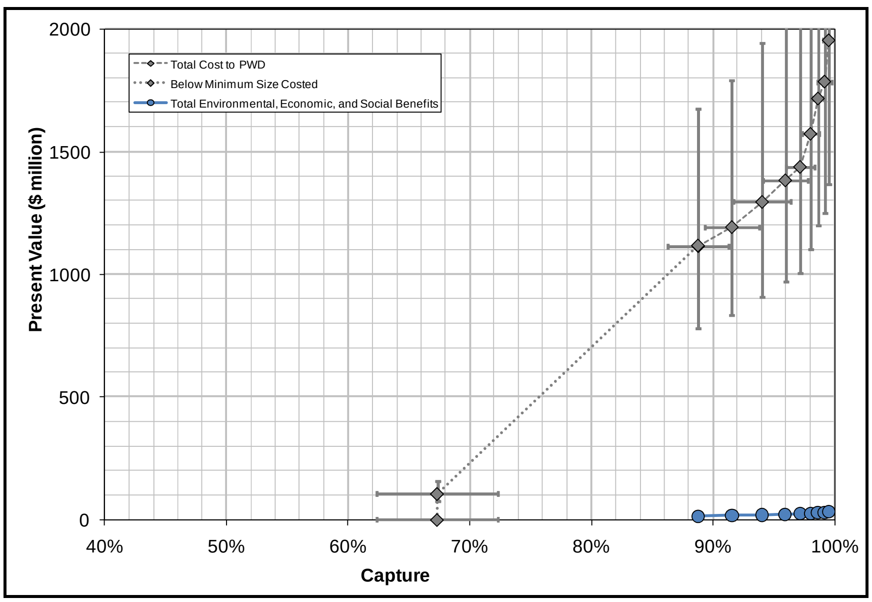

Figure 9-49 Schuylkill Direct Large-Scale Centralized Storage Alternative Cost-Benefit Comparison

9.6.4 Large-Scale Satellite Treatment Alternative

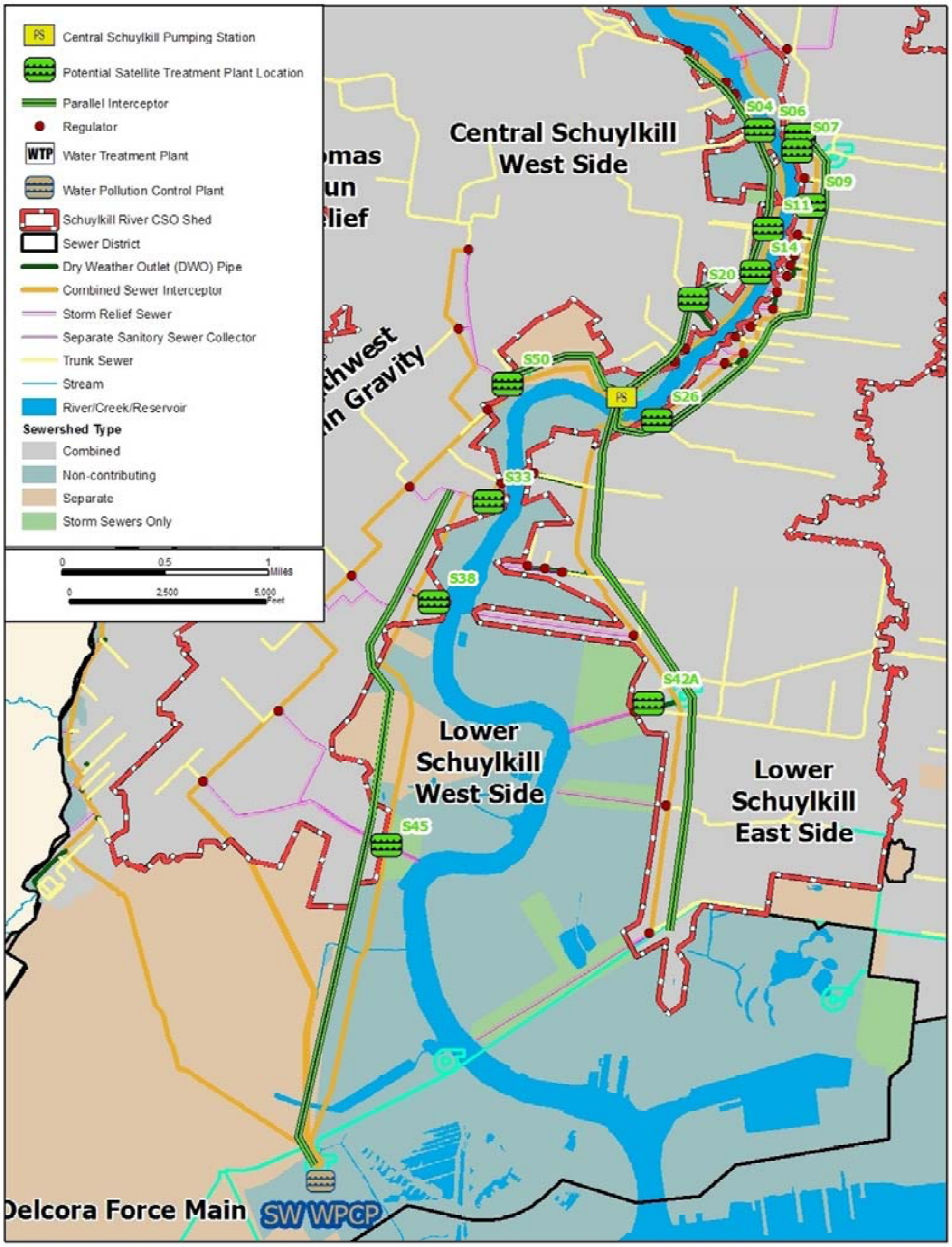

Figure 9-50 Location of Schuylkill Direct Large-Scale Satellite Treatment Alternative

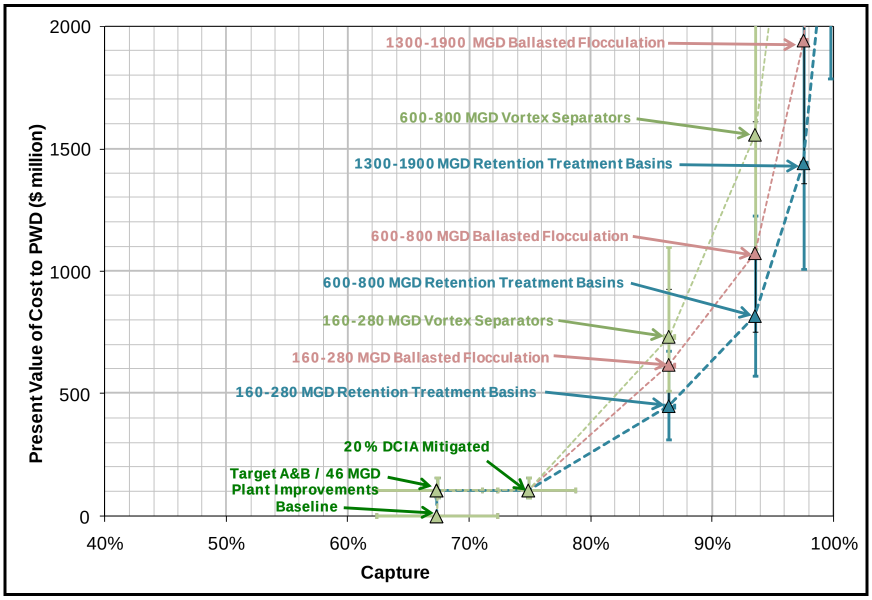

Figure 9-51 Schuylkill Direct Large-Scale Satellite Treatment Alternative Cost-Performance Curve

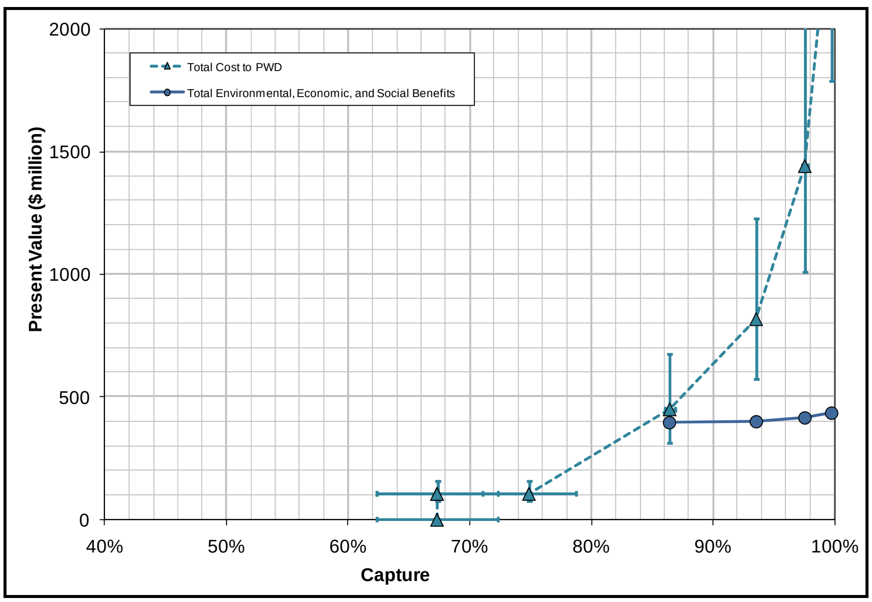

Figure 9-52 Schuylkill Direct Large-Scale Satellite Treatment Alternative Cost-Benefit Comparison