DEPARTMENT OF PUBLIC WORKS
CITY OF WILMINGTON, DE

Combined Sewer Overflow Final Long Term Control Plan

Submitted to:

Delaware DNREC
Division of Water Resources
89 Kings Highway
Dover, DE 19903

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Contents

1. Executive Summary

The City of Wilmington's CSO control program is in its latter stages with the vast majority of wet weather control already in place. The City has made significant progress over the past couple of decades, particularly with help from a federal/State/City funding partnership. As a result, the City has achieved a very high level of CSO control. Accordingly, this Final Long Term Control Plan (LTCP) will provide the appropriate remaining, relatively minor increments of control – in the most sustainable and environmentally appropriate manner possible.

The City of Wilmington has been aggressively implementing its Enhanced Long Term Control Plan (ELTCP) since 2003 resulting in significant reductions in combined sewer overflows (CSOs). During the course of ELTCP implementation, the City has spent over $27 million on the design and construction of key CSO projects including the Canby Park Storage Facility, the Global Optimal Real Time Control (GO RTC) System, sewer diversions, elimination of dry weather overflows, nine minimum control compliance, sewer separation, street stormwater separation, and residential stormwater separation. Implementation of these key projects is estimated to achieve approximately 92% wet weather capture, on average system wide, well beyond the 85% capture requirement established in National CSO Policy.

The City has made considerable progress implementing the ELTCP despite unforeseen challenges, such as identification of a new CSO discharge upstream of the drinking water intake at Kentmere and Union, promulgation of the Christina Basin's Total Maximum Daily Load (TMDL), and the greatest economic recession since the Great Depression.

Despite these significant challenges, the City has gone beyond expectations of the ELTCP in many ways, such as incorporating elements of source control and green infrastructure activities. In 2007, the City created a stormwater utility featuring parcel billing based upon impervious area. This groundbreaking effort included financial incentives for private landowners to manage stormwater and should prove beneficial to the CSS over the long term. Other source control efforts include establishing a Source Water Protection Ordinance that requires stormwater management for new development in a part of the CSS upstream of the City's water intakes. Also, the City has directly supported a number of pilot green infrastructure projects including bio-swales, rain gardens, green roofs, and porous pavement.

Significantly, the implementation of the ELTCP has met its primary goal of meeting the 85% average annual wet weather capture provision pursuant to the presumptive approach in the National CSO Policy. More importantly, implementation of the ELTCP, with Real Time Control, achieves compliance with Christina Basin TMDL allocations for bacteria. With these significant milestones in hand, new opportunities in green infrastructure, and the clarification of regulatory requirements through the Christina Basin TMDL, a new plan for the City's "final" CSO efforts is possible and presented herein.

The City's Final LTCP features a period of evaluation and planning in order to (1) update system performance in response to key CSO control projects noted above, (2) prioritize outfall catchment basins and associated projects that will have the greatest impact on meeting future reductions and (3) develop plans for any further enhancement. The capability of traditional infrastructure projects to achieve reduction of CSOs beyond 92% capture is severely limited due to many economic, environmental, and social factors. Therefore, in the interest of long term sustainability, the City's Final LTCP proposes to develop a source control and green infrastructure program to reduce CSOs beyond the limits of traditional infrastructure.

2. Wilmington's Proven Track Record of Addressing CSOs

Over the past 30 years the City of Wilmington has been planning, expanding, and implementing a comprehensive Combined Sewer Overflow (CSO) management program. The City's program has evolved over the years, consistent with national CSO policy and CSO Task Force recommendations. The program has continually sought to achieve meaningful water quality improvements in the Christina River watershed. After several years of development with stakeholders and regulators, the City of Wilmington's CSO program evolved further in 2003, when an Enhanced Long Term Control Plan (ELTCP) was submitted to the Delaware Department of Natural Resources Environmental Control (DNREC). ELTCP implementation has accomplished the following significant efforts, directly benefitting the Christina Basin:

- Invested over $27 million in capital costs to reduce and eliminate CSOs via several key projects and related programs.
- Achieved an estimated annual average capture of 92%, which goes well beyond the 85% capture required in the National CSO Policy
- Worked with stakeholders and partners of the CSO Task Force to identify and implement projects to address CSOs, as described in its ELTCP
- Constructed and operated the Canby Park Storage Facility
- Began Construction on Global Optimal Real Time Control (GO RTC) System
- Eliminated a CSO above the drinking water intake at Rockford Eliminated dry weather overflows at CSO 4A/4B
- Actively participated in the Christina Basin TMDL development
- Conducted extensive public education, outreach, and awareness regarding CSOs
- Trapped and eliminated 2800 tons of debris, plus street sweeping waste, from entering the Christina Basin between 2003 and 2009.
- Implemented a stormwater utility based on impervious parcel land cover
- Supported green infrastructure pilot projects with partners such as the Delaware Horticulture Center to provide rain barrels. Implemented source controls such as rain-gardens, bio-swales, and porous pavement at private development projects with partners such as the Woodlawn Library, Shoprite and Acme to reduce runoff to the combined system.
- Separated the combined sewer system, where feasible, in places like the Wilmington Hospital and Rockford Road. The City continues to identify additional opportunities for separation.
- During this period, the City has also worked closely and effectively with its State and Federal delegation to advance a funding partnership, which has allowed the City to achieve much of its impressive progress to date.

The City has made tremendous progress in meeting or exceeding National CSO Policy requirements. Accomplishments to date have poised Wilmington to be one of the leading wet weather programs in the region. Beyond this success, the City is committed to making reasonable and effective long term progress to further reduce CSO discharges, improve urban stormwater management and water quality. In this Final LTCP, the City is proposing to achieve cost effective CSO reductions well into the future, exceeding requirements of the Christina Basin TMDL and protecting its water bodies for the citizens of Wilmington to enjoy.

3. Current CSO Status

Implementation of key ELTCP projects was designed to achieve the following during a typical year:

- Capture 85% of annual CSO volume, in an average year, via presumptive approach
- Eliminate dry weather overflows to the full extent practicable
- Eliminate CSOs upstream of the City's drinking water intake
- Meet load allocations for the Christina Basin TMDL

Based on these goals, Wilmington's ELTCP has been successful. Dry weather overflows and the Rockford Road CSO, upstream of the City's drinking water intake, have been abated. With completion of key CSO projects described later, most notably a Real Time Control System, the City anticipates achieving approximately 92% wet weather percent capture by volume. This capture meets the requirements of National CSO Policy. Also, completion of key ELTCP projects meets load allocations assigned by the Christina Basin High Flow TMDL to meet waste load allocations.

3.1. ELTCP Project Status

The ELTCP prioritized projects targeted at overflow volume reduction, related to CSOs 27, 28, 29, 4a, 4b, and Rockford Road. These key CSO projects represented a more than $26 million commitment by the City, as shown in Table 1 below.

TABLE 1 – SUMMARY OF COST EXPENDITURES FOR KEY CSO PROJECTS FROM 2003 ELTCP

Key Project Name	Outfalls Affected	Design Cost	Construction Cost	Year Completed
RTC Phase I	4a, 4b, 27, 28, 29, 30, 31	$5,939,000	$1,200,000	2009
RTC Phase II			$4,800,000	2011
Canby Park Storage	28, 29	~ $2,000,000	$6,000,000	2004
CSO 27 Diversion to Canby	27	$710,000	$1,420,000	2007
WWTP Headworks Upgrade	system wide	$610,000	$2,914,000	2011
CSO 4a/4b	4a, 4b	$64,000	$235,000	2004
Rockford Road Street Separation	Rockford outfall	$1,725,000	$615,280	2009
Rockford Road Home Separation	Rockford outfall		$611,000	2010
Clean & Reconstruct Stormwater inlets	All	$150,000	$998,000	2010
TOTAL		**$11,198,000**	**$18,793,280**	**$29,991,280**

Table 2 below provides a summary of the major activities that were completed or are underway from the ELTCP.

TABLE 2 – 2003 ELTCP KEY CSO PROJECTS UPDATE (AS OF SEPTEMBER 2010)

PROJECT	DESCRIPTION	STATUS
Key Projects from 2003		
Real-Time Control (RTC) System	City-wide collection system management to utilize available capacity and optimize flow. Includes flow measurement devices and software (Phase I) as well as infrastructure improvements (Phase II).	Phase I construction completed. Construction of Phase II expected to be completed in 2010 and operating in early 2011.
Canby Park CSO Storage Facility	Storage tank for CSOs 27, 28 and 29 to provide 93 percent capture in the high-priority Silverbrook Run CSO area.	Construction complete and in operation. Startup of facility in July 2004.
CSO 27 Diversion Sewer	Diversion of CSO 27 overflows to Canby Park Storage to reduce frequency and volume of overflows.	Construction complete November 2007.
CSOs 4a and 4b Improvements	Raised the dam at CSO 4A and reconfigured diversion structure at 26^{th} and Pine to reduce overflows from a high-volume CSO 4B to eliminate dry weather water treatment plant filter backwash overflows.	Raised dam at 4a and reconfigured diversion structure at 26^{th} & Pine completed February 2004. Dry weather overflows eliminated. Final wet weather improvements with bending weirs to be completed as part of RTC Phase II contract in 2011.
Rockford Road Sewer Separation	Partial sewer separation for the Rockford Road CSO area to mitigate a CSO located in a sensitive area near a City water supply intake. Removes all street runoff from combined system.	Construction completed. Plan for monitoring impacts under development.
Rockford Road Downspout Disconnect Program	Residential downspout disconnect program to mitigate the Rockford Road CSO area. In combination with sewer separation eliminates CSO in average year.	Currently under construction. 49 of 66 household parcels completed. Plan for monitoring impacts under development.
Waste Water Treatment Plant (WWTP) Headworks Upgrade	Headworks improvements at the WWTP to mitigate hydraulic bottlenecks and allow up to 400 MGD total flow. Consistent with 135 MGD maximum from City 11th Street Pump station.	Construction to be completed in mid 2011.

PROJECT	DESCRIPTION	STATUS
11th Street Pumping Station Upgrade	Replacement of pumps to increase peak wet weather pumping capacity from 135MGD to 200MGD.	Feasibility completed. Determined that hydraulic limitations upstream and downstream of pump station preclude need to increase capacity at this time. Meet 85% Capture and TMDL without project. May revisit after RTC implementation. Currently two pumps have been replaced to meet reliability and capacity needs.
Prices Run Diversion	Construct a new interceptor to divert wet weather flows from the Prices Run sewer system directly to the upgraded 11th Street Pumping Station, to increase wet weather conveyance capacity in the CSS, and further reduce overflows at CSOs 4a, 4b and other locations along the Brandywine Creek.	Feasibility completed. Same hydraulic limitation as 11th Street Pumping Station which preclude completion of this project at this time. Meet 85% Capture and TMDL without project. Will be reevaluated after RTC implementation.
Sewer GIS and Hydraulic Model	Assessment of existing model and updating collection system information	Continuous ongoing effort using various leading consulting firms.
New Projects Identified since 2003		
Kentmere and Union CSO	Recently discovered sensitive CSO upstream of a City water supply intake.	Completed regulator improvements to minimize overflows. Ongoing monitoring during wet weather. Phase I preliminary design completed to conduct partial separation of street drainage.
Brandywine, Christina, and Rattlesnake Run Siphons	Maximizes conveyance during wet weather and manages low flow to prevent sedimentation in the pipes	Automation to utilize both barrels during storm events. Part of RTC Phase II contract in 2011
Green Infrastructure	Various watershed projects in CSO areas to control stormwater at the source using green infrastructure.	Preliminary analysis performed to determine effectiveness in CSO 23 area. Other areas to be analyzed. A number of green infrastructure source controls have been completed with various partners. Next 5 year period will focus on continued implementation of green infrastructure source controls.
Hospital Storm Sewer Separation	Sewer separation for 10 acres of the Wilmington Hospital property that will reduce overflows to CSO 23.	Design complete. City will reimburse for work done by Hospital. Construction is underway.
South Wilmington Wetland Park	Creation of a stormwater treatment wetland park to provide sewer separation in	Feasibility study completed to remove a portion of drainage area from Interceptor DW drainage area.

PROJECT	DESCRIPTION	STATUS
	South Wilmington as part of Special Area Management Plan.	
Sewer Inspection and Cleaning	Ongoing	Ongoing
Rebuild and Clean storm inlets	Ongoing	Ongoing

Note: Current status of projects is available in CSO Annual Reports

3.2. Modeling to Determine CSS Status

This section describes the estimates of annual CSO volumes in relation to the City of Wilmington's sewer network. These estimates were used to calculate the network's capture rate and the bacteria loads from the City's combined sewers. They were compared to the requirements of the National CSO Policy and to TMDL allocations.

The model used to produce the estimates as well as the methodology and findings are explained in the following subsections and in full detail in Appendix B.

3.2.1. Csoft™ Combined Sewer System Model

ELTCP results were based on a XP-SWMM model of the City of Wilmington's sewer network. The XP-SWMM model was developed by RK&K and used to estimate baseline conditions, as well as predict CSO volume reductions, with implementation of key ELCTCP projects. However, performance of GO RTC for the ELCTP was evaluated using the Csoft™ software. At that time, the sewer network model used in Csoft™ had been directly imported from the XP-SWMM model.

Since the2003 ELTCP, the City of Wilmington's sewer network model was improved and modified to satisfy GO RTC needs. The following changes were made in Csoft™:

- To simplify the network, unnecessary small diameter pipes in the most upstream part of the network and fictitious manholes from the XPSWMM model were eliminated;
- RK&K XPSWMM sub-catchments were grouped when possible in order to simplify the network; The imperviousness of the sub-catchments was changed based on a new evaluation using information from land use maps, aerial photographs and a field visit;
- Areas of separated sewers were removed from the combined sewer model;
- A diurnal pattern was created for the dry weather flow (DWF);
- The model was calibrated in 2006 based on data from a 2001 measurement campaign carried out by ADS;
- The final design of the RTC control sites was accurately represented;
- Sewer separations and downspout disconnections in the Rockford Road CSO catchment were modeled;
- The newly discovered "Kentmere and Union" CSO site was modeled;

- A sewer separation near the Christiana Care Hospital (CSO 23), which will be completed shortly, was modeled.

In view of the above, the most up-to-date model of the Wilmington sewer system is indeed the Csoft™ model that represents the network with GO RTC planned for 2011.

Figure 1 shows the catchment areas in the current Csoft™ model based on their imperviousness, while Figure 2 indicates the drainage area that contribute flows upstream of each CSO site.

In the course of writing the final LTCP, simulations were run to compare the current Csoft™ model results to the previous XPSWMM results in baseline conditions as described in the ELTCP. Differences in CSO volumes were found, but they derive from model modifications, i.e.:

- CSO 4D, CSO 4E, CSO 4F, CSO 18, CSO 20, CSO 21A, CSO 21B, CSO 25, CSO 26, CSO 27, CSO 28, CSO 29 and Rockford Road:

  CSO volumes differences directly relate to the modifications with regard to total area and impervious area. Hence, they derive from model calibration.

- CSO 3 and CSO 31:

  Csoft™ predicts lower CSO volumes because it used a much lower contributing area than XPSWMM. This is a result of the modeling of separated sewer drainage areas. In the XPSWMM model, the entire geographic area was included, and the impervious areas of the separated sewer region were eliminated by lowering the imperviousness percentage. This means that in the XPSWMM model, large pervious areas still bring water in the combined sewers during big rainfall events. In reality, the rain falling on the separated sewer areas is drained to the receiving water body by the storm sewers, not the sanitary/combined sewers. Thus, the geographic areas of the separated sewer basins do not exist in the Csoft™ model. Therefore, the imperviousness of the remaining combined catchments is higher. In the end, both models have similar impervious areas, but the Csoft™ model has a smaller total area.

- CSO 4A and 4B:

  CSO 4A and CSO 4B are interconnected and should be analyzed together. The total area contributing to CSO 4A and CSO 4B is smaller in Csoft™ than in XPSWMM, but the impervious area is greater in Csoft™. The total difference in CSO volume is below 10%.

- CSO 9A, CSO 9C, CSO 10 and CSO 17 (Interceptor DW&D):

  The total area in the Csoft™ model is 72% smaller than the total area in the XPSWMM model (from 597.5 acres *versus* 169.7 acres). Large areas of the interceptor DW&D's sewershed consist of separated sewers or of undeveloped land. Hence, these areas do not contribute flows to the combined sewers. This leads to notably decreased CSO volumes.

- CSO 19:

  The Christina Siphon (Interceptor DW&D) brings much less water, which reduces the levels in the downstream section of Interceptor C, thus reducing CSO volumes at CSO 19.

- CSO 24:

  The upstream catchment area was calibrated using the data from flowmeter 7J. Thus, we have confidence in the newly simulated CSO volumes.

- CSO 5, CSO 6, CSO 7, CSO 11, CSO 12, CSO 13, CSO 14, CSO 15, CSO 16 and CSO 30 (C09 Basin, Interceptor C):

  Generally speaking, the total area and the impervious area are greater, yet there are less CSO volumes in the Csoft™ model than in the XPSWMM model. The hydraulics of Interceptor C is linked to that of the Christina and Brandywine Siphons (CSO 17 and CSO 19). Globally, the difference between the CSO volumes predicted by both models is just over 5%. This is within the expected range of precision.

- CSO 21C, CSO 22B, CSO 22C and CSO 23:

  Area alone cannot explain all the differences. Parameters such as catchment slope, drainage width and invert modifications, most likely explain them.

In the assessments presented herein, a constant average tide of -0.081 ft NAVD88 was used in all the simulations. The model simulations to evaluate CSO performances presented in this final LTCP were run with the Csoft™ RTC software, which can reproduce global, optimal, real time control (GO RTC) operation status.

FIGURE 1: CSOFT™ SUBCATCHMENTS BASED ON IMPERVIOUSNESS

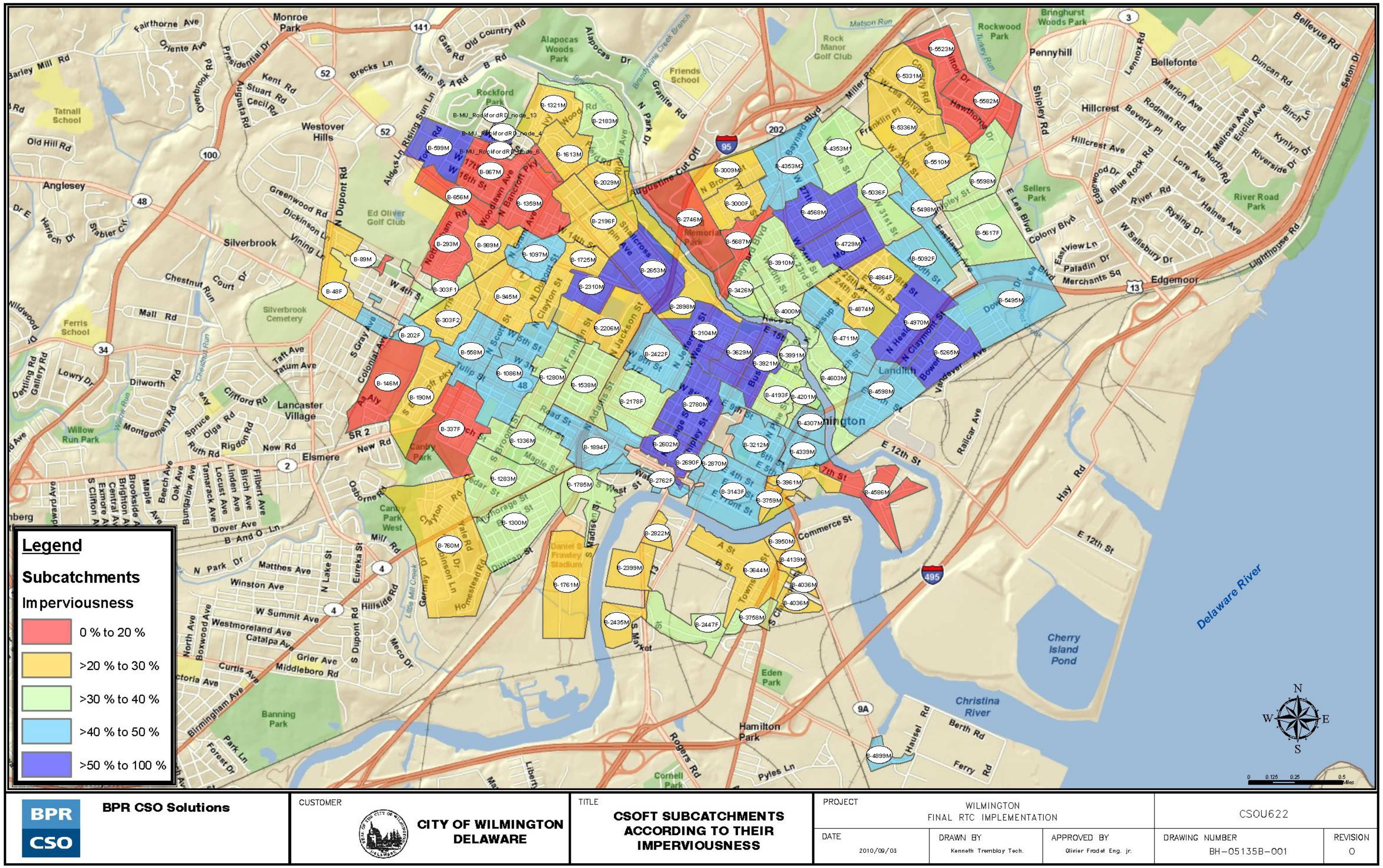
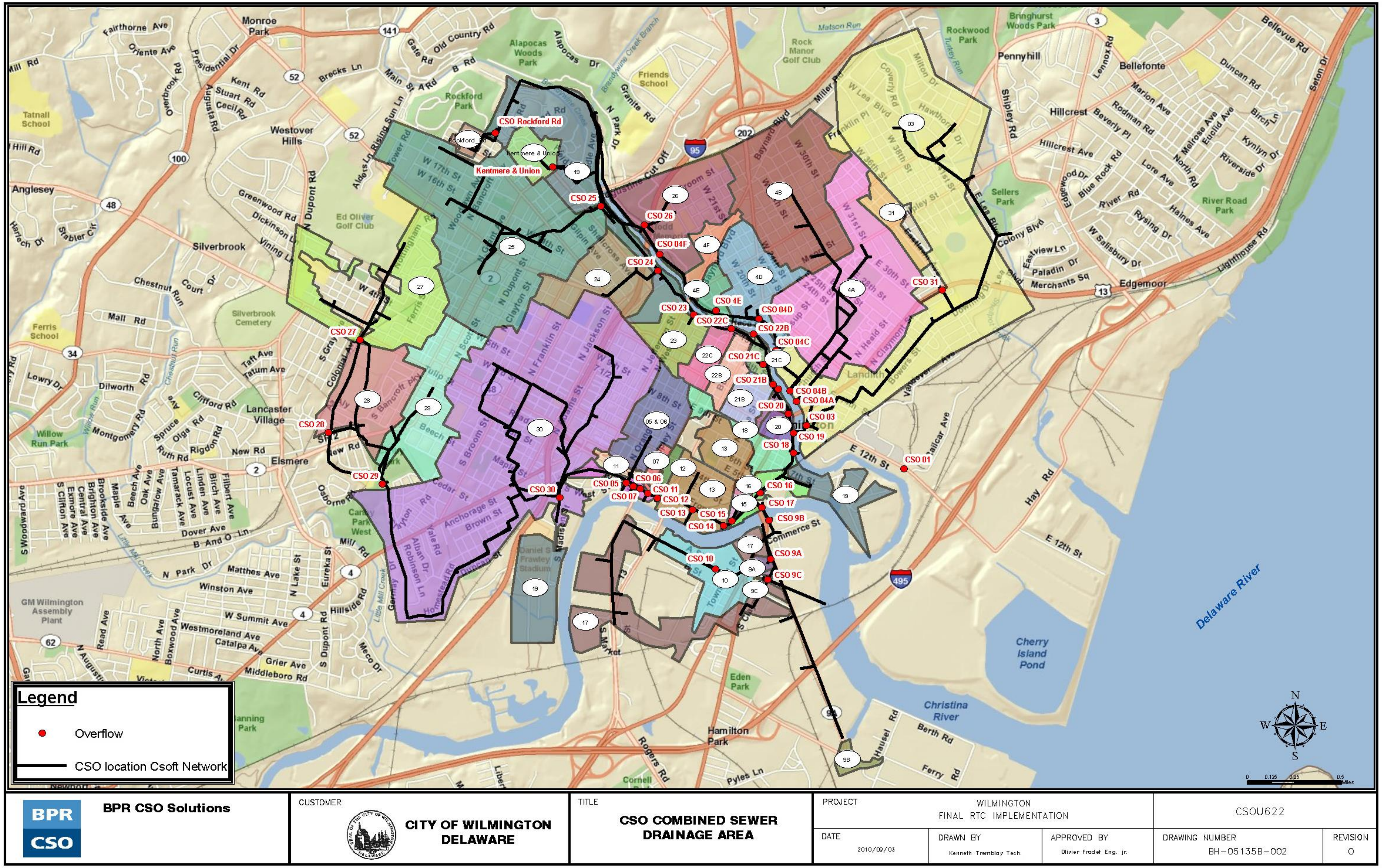


FIGURE 2: CSO COMBINED SEWER DRAINAGE AREA



3.2.2. Annual CSO Volume Estimation Methodology

Csoft™ software is designed to optimally manage flows in sewer systems in real time. The high frequency and amount of data capture make it unsuitable for long term continuous simulations. This is different than other commercial software such as XP-SWMM, because it requires a lot of time to simulate a full annual chronology. The simulation and analysis of CSO volumes using the Csoft™ model was performed with twelve selected rainfall events representative of various durations, total rainfall depths, and average and maximum intensities. Table 3 below lists the events selected.

TABLE 3: EVENTS SIMULATED WITH CSOFT™ FOR AVERAGE ANNUAL CSO VOLUME ESTIMATES

Beginning of Event	Total Depth (in)	Maximum Intensity (1 hour)	Duration (hours)
09-21-1983, 12:00 p.m.	2.79	0.85	14
10-14-1995, 06:00 a.m.	2.44	0.94	21
05-17-1985, 09:00 a.m.	2.41	0.76	22
05-16-1983, 06:00 a.m.	2.06	0.45	16
06-19-1996, 04:00 a.m.	2.01	0.86	22
09-16-1996, 02:00 p.m.	1.75	0.46	14
07-25-1985, 05:00 p.m.	1.63	0.46	42
06-30-1996, 12:00 a.m.	1.42	0.37	12
10-02-1985, 01:00 p.m.	0.99	0.31	24
09-22-1995, 12:00 a.m.	0.99	0.28	24
10-31-1994, 11:00 p.m.	0.27	0.10	19
11-28-1983, 05:00 a.m.	0.25	0.10	16

The methodology described herein was developed by BPR CSO and previously used successfully to estimate the annual overflow volumes of sewer networks in Cleveland, Ohio and Louisville, KY, as well as in Ottawa and Hamilton, in Canada.

The methodology used to evaluate the average annual CSO volume consists in finding a mathematical relationship (regression) from the twelve simulated events linking the total CSO volume of each event to its rainfall depth. Then, the regression is applied to each event in a given year to find the associated CSO volume based on the rainfall depths. The annual CSO volume estimate is obtained by summing the CSO volume of each event. Average annual CSO volume can be carried over a few years, as it was the case for the two chronologies.

A regression was modeled for the total network CSO volume versus rainfall depth for the twelve events. This regression allows calculation of total network annual CSO volume and capture rate. Using the same rainfall events, regressions of individual CSO volume versus rainfall depth were determined for each CSO location. These regressions are used to compute the annual CSO volume of individual overflow locations. Annual CSO volume of individual overflow locations can be summed and compared to the total network annual CSO volume and corresponding capture rate in order to verify results. Figure 3 graphically shows the regression for the entire network, while Figures 4 through 6, show three examples of regressions for single CSO locations.

From the error sum of squares between the regression curve and the simulated events, a statistical 95% confidence interval was calculated. The confidence intervals represent the outer boundaries of the estimation error caused by the regression technique on average annual overflow volume. If an entire year had been simulated, there is a 95% probability that the results would have been within the confidence interval. The confidence intervals are also shown on Figure 3 through Figure 6.

Two additional rainfall events were simulated with Csoft™ after the results were extrapolated. The objective consisted in confirming that the regression was indeed valid for events with rainfall depths greater than those of the largest simulated event. These simulation results are shown in Figure 3 through Figure 6, which graphically show the regressions for the entire network and the largest overflow points (CSO 24, 30, and 4A). The overflow volumes for the rainfall events with greater depths fell within the 95% confidence interval limits for most the sites. Consequently, redoing the regressions with these larger rainfall events was determined to be unnecessary.

FIGURE 3: TOTAL SIMULATED NETWORK OVERFLOW VOLUMES, REGRESSION ESTIMATES AND 95% CONFIDENCE LIMITS BASED ON RAINFALL DEPTH

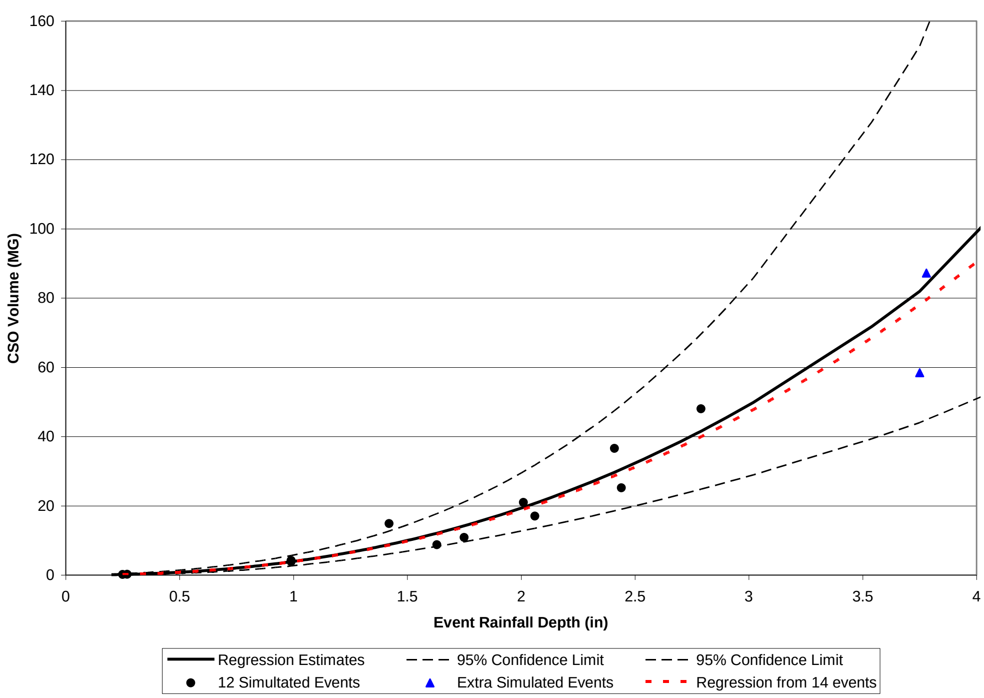


FIGURE 4: CSO 24 SIMULATED OVERFLOW VOLUMES, REGRESSION ESTIMATES AND 95% CONFIDENCE LIMITS BASED ON RAINFALL DEPTHS

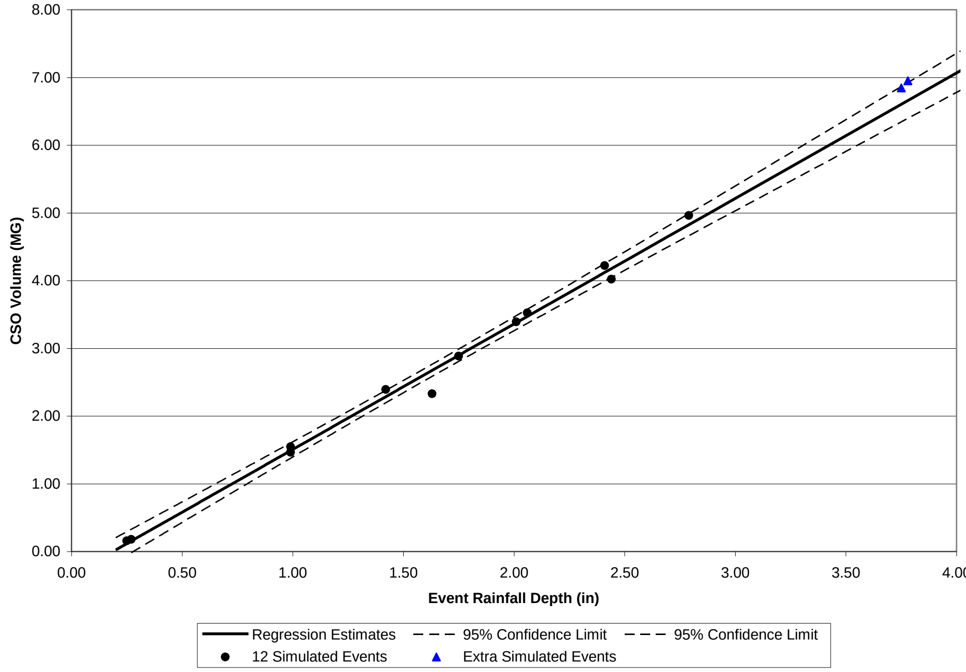


FIGURE 5: CSO 30 SIMULATED OVERFLOW VOLUMES, REGRESSION ESTIMATES AND 95% CONFIDENCE LIMITS BASED ON RAINFALL DEPTHS

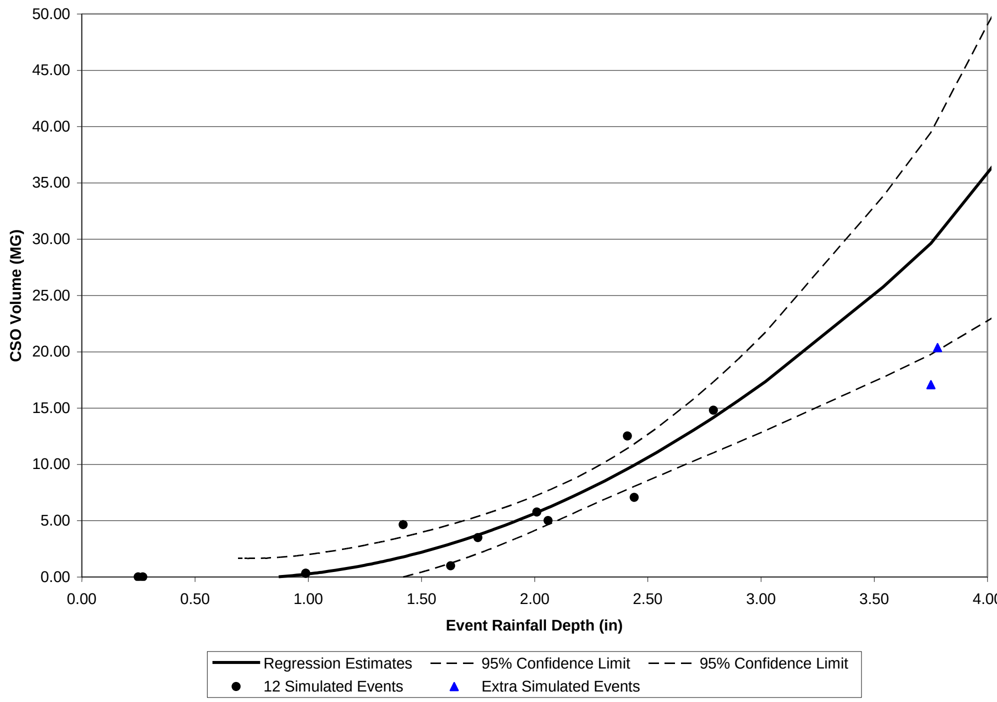
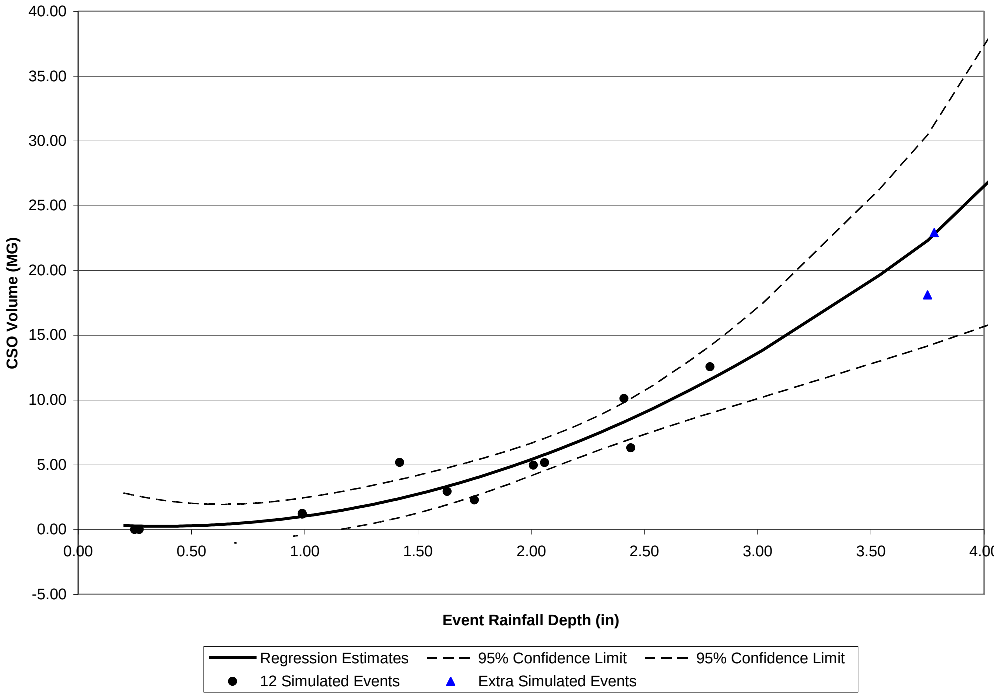


FIGURE 6: CSO 4A SIMULATED OVERFLOW VOLUMES, REGRESSION ESTIMATES AND 95% CONFIDENCE LIMITS BASED ON RAINFALL DEPTHS



The detailed modeling approach and results are discussed in more depth later in this section and in Appendix B. Note that 1983 to 1985 was the average rainfall period selected for the ELTCP submittal. October 1994 to October 1998, was the representative period selected for the High Flow Christina Basin TMDL. Since the TMDL chronology is based on meeting Water Quality standards, it is the basis of measurement of future progress.

3.3. CSS Modeling Performance Results

Table 4 shows modeling results of the annual capture rate predicted by Csoft™ for the network operated under GO RTC. These results show that on average, a capture rate of 92% is achieved by the network. This exceeds the 85% requirement established by the National CSO Policy. Table 5 shows the predicted annual loads per stream segment as modeled in the TMDL and compares them to the waste load allocations (WLA) defined in the TMDL report. Figure 7 below shows the stream segments as delineated for the Christina Basis TMDL. Wilmington CSOs discharge into segments B34, C9 and C5. Results relate to the October 1994 to October 1998 chronology, which is applicable for TMDL goals. Table 5 shows that bacteria TMDL objectives are met. Table 6 details the annual CSO volume estimated for each of the CSO locations.

TABLE 4: WILMINGTON ACHIEVES >85% AVERAGE ANNUAL CAPTURE BY VOLUME AND MEETS NATIONAL CSO POLICY (AS ESTIMATED AFTER RTC AND ELTCP PROJECTS FULLY OPERATIONAL)

CSO System Performance	Predicted Annual Overflows and % Capture	
Time period:	1983-85 (avg)	1994-98 (avg)
Wet Weather Volume MG/yr	3056	2656
Total Overflow Volume (sum of individual CSOs)) MG/yr	277	200
Capture Rate (sum)	**90.9%**	**92.5%**
Total Overflow Volume (System wide regression) MG/yr	265	211
Capture Rate (System wide)	**91.3%**	**92.0%**

TABLE 5: WILMINGTON ACHIEVES BACTERIA WASTE LOAD ALLOCATIONS OF THE CHRISTINA BASIN HIGH FLOW TMDL (AS ESTIMATED AFTER RTC AND ELTCP PROJECTS FULLY OPERATIONAL)

	CSO ID #	WLA (cfu/yr)	Predicted Annual Load (cfu/yr)	Additional CSO Volume Reduction Needed (MG)
Little Mill Creek (C05)	27, 28, 29	3.69E+13	5.105E+12	0
Christina River (C09)	5, 6, 7, 9A, 9C, 10, 11, 12, 13, 14, 15, 16, 17, 30	9.75E+13	9.247E+13	0
Brandywine Creek (B34)	3, 4A-F, 18, 19, 20, 21A-C, 22B, 22C, 23, 24, 25, RR, K&U	2.55E+14	2.473E+14	0

FIGURE 7: STREAM SEGMENTS OF THE CHRISTINA BASIN TMDL

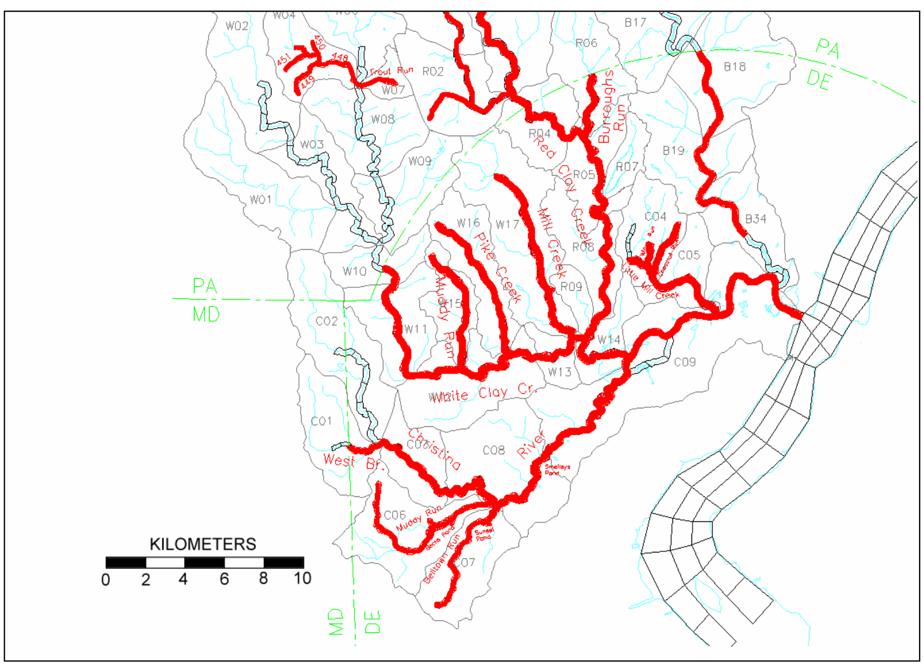


TABLE 6: ESTIMATED COMBINED SEWER OVERFLOWS AT INDIVIDUAL OUTFALLS AFTER COMPLETION OF THE ELTCP AND REAL TIME CONTROL CENTER OPERATION

EFDC Grid Cell	Hydrologic Basins	Interceptor	CSO ID	Predicted Average Annual Overflows		
				Oct 1994 - Oct 1998 Chronology		
				Average MG	Interval Upper Limit MG	Interval Lower Limit MG
54,17	B34	A	4A	**52.9**	66.0	39.9
			4B	**0.0**		
			4C	**0.0**		
			4D	**13.5**	14.8	12.2
54,18			4E	**0.3**	0.4	0.2
			4F	**0.7**	0.9	0.6
54,20			25	**4.4**	5.5	3.2
			26	**0.3**	0.4	0.2
54,17		B	20	**0.2**	0.3	0.1
			21A	**0.0**	0.0	0.0
			21B	**0.3**	0.5	0.1
			21C	**0.0**	0.0	0.0
54,18			22B	**0.6**	0.8	0.4
			22C	**0.5**	0.6	0.3
			23	**6.7**	7.5	5.9
			24	**47.1**	48.2	45.9
54,21			Rockford Road			
54,20			Kentmere & Union	**0.5**	0.6	0.4
54,16		C	18	**1.2**	1.4	0.9
54,17			19			
54,17		E	3	**2.7**	3.5	1.9
52,13	C09	C	5	**11.5**	13.1	9.9
			6			
			7	**0.3**	0.3	0.2
			11	**0.8**	1.0	0.7
			12	**0.1**	0.1	0.1
			13	**0.9**	1.3	0.4
53,13			14			
			15			
			16	**0.2**	0.3	0.1
52,13			30	**39.1**	48.2	29.9
53,13		DW & D	9A	**0.1**	0.1	0.1
			9B			

EFDC Grid Cell	Hydrologic Basins	Interceptor	CSO ID	Predicted Average Annual Overflows		
				Oct 1994 - Oct 1998 Chronology		
				Average MG	Interval Upper Limit MG	Interval Lower Limit MG
55,13			9C	**0.0**	0.0	0.01
53,13			10	**0.3**	0.4	0.1
			17			
44,55	**C05**	**Silverbrook Run**	27	**1.5**	2.0	1.0
			28	**0.0**	0.1	0.0
45,55			29	**1.4**	2.3	0.5
57,15	**Shellpot Creek**	**E**	31	**0.4**	0.6	0.3
Total Overflow Volume (sum):				**188**	**205**	**172**
Wet Weather Volume				**2565**	2565	2565
Capture Rate (sum)				**93%**	92%	93%
Average Total Overflow Volume (system regression)				**185**	204	167
Capture Rate (system regression)				**93%**	92%	93%

The Final LTCP clearly indicates compliance with Bacteria TMDL WLAs in the stream segments C05-Little Mill Creek, C09-Christina River, and B34-Brandywine Creek. These WLAs were calculated through our calibrated model, which is well vetted by DNREC. The predicted loads are presented by EFDC cell in Table 7 for a better understanding of segment performance. However, it is important to note that the TMDL requires compliance for total loads per stream segment, not for individual cells. The following language is found in the main TMDL Report, Section 4.1.6.2 on page 4-7:

"The TMDL CSO load reductions shown in Appendix D, Table D-3, are one scenario of load reductions which, together with other sources' reductions, result in achieving in-stream water quality criteria throughout the length of the impaired waterbody. It should be noted that other scenarios are possible."

Table 7 shows the individual EFDC grid cell loads comprising the stream segment bacteria loads. The DNREC approved City model is representative of combined sewer system behavior after construction of Real Time Control. It is not the same scenario that was modeled by EPA's Engineer and shown in Appendix D, Table D3 of the TMDL. Three cells in the City model run exceed the cell loads given in the TMDL's Appendix D, however seven cell loads are lower in the City model compared to the TMDL's Appendix D. The City's position with regard to TMDL compliance is that the stream segment loads are met in the TMDL. Additionally, compliance at the grid cell level is not required by any other pollution source. For example, urban storm water does not appear to be divided up the EFDC grid cell in the TMDL. On a final note, EFDC grid cells are a model construct not necessarily tied to natural stream hydrology. This reinforces TMDL compliance at the hydrologic basin, stream segment level.

TABLE 7: PREDICTED AVERAGE ANNUAL BACTERIA LOAD FROM CSO FOR THE OCTOBER 1994 TO OCTOBER 1998 CHRONOLOGIES FOR TRC 2011 CONDITIONS AND CALIBRATED IMPERVIOUSNESS

					Oct 1994-Oct 1998 Chronology
Hydrologic Basins	EFDC Grid Cell	CSO ID	From the TMDL Appendix D Table D-3 cfu/yr	TMDL WLA cfu/yr	Predicted Average Annual Loa
C05	44, 55	27, 28	2.652E+13		2.678E+12
	45, 55	29	1.037E+13		2.427E+12
	Segment Subtotal		**3.689E+13**	**3.690E+13**	**5.105E+12**
C09	52, 13	5, 6, 7, 11, 12, 13, 30	5.960E+13		9.148E+13
	53, 13	9A, 9B, 10, 14, 15, 16, 17	3.744E+13		9.416E+11
	55, 13	9C	4.384E+11		4.081E+10
	Segment Subtotal		**9.749E+13**	**9.750E+13**	**9.247E+13**
B34	54, 16	18	0		2.013E+12
	54, 17	3, 4A, 4B, 4C, 4D, 19, 20, 21A, 21B, 21C	6.301E+13		1.287E+14
	54, 18	4E, 4F, 22B, 22C, 23, 24	1.157E+14		9.719E+13
	54, 20	25, 26, Kentmere & Union	7.586E+13		1.088E+13
	54, 21	Rockford Road	0		0
	Segment Subtotal		**2.545E+14**	**2.550E+14**	**2.388E+14**
Shellpot Creek	57, 15	31	2.991E+13	N/A	7.118E+11
Totals			**8.073E+14**		**6.734E+14**

(green)	Indicates City model load less than TMDL Appendix D Table D3
(yellow)	Indicates City model load greater than TMDL Appendix D Table D3

Through modeling and presumptive approaches it suggests that the City will have complied with the Bacteria TMDL upon completion of several key projects. However, the City also understands that it will be necessary to demonstrate its discharges and the stream segments achieve the TMDL load allocations through some form of monitoring. The City began a voluntary monitoring program in March 2006 for ambient water quality. The monitoring program was not initiated in response to a specific regulatory mandate from the State, but to support both City and regional watershed efforts of the Christina River Clean Water Partnership. The data is used to better understand water quality trends throughout the Brandywine Creek and Christina watershed. Note that the mission of the Christina Basin Clean Water Partnership is to restore the waters of the Brandywine, Red Clay, and White Clay Creeks, and Christina River in Delaware and Pennsylvania to fishable, swimmable, and potable status by 2015. The City has been an active partner since its inception.

In order to capture conditions representative of naturally occurring seasonal and climate variation, sampling was scheduled for the third Wednesday of each month. From March 2006 through January 2011, a little over 50 samples were collected at 7 locations throughout the Brandywine, Christina, and Little Mill Creek watersheds. About 25% of these samples were collected during wet weather, as defined by greater than 0.2" of precipitation in the precedent 48 hour period. The sampling data of most interest to the CSOs and Christina River High Flow TMDL is the enterococci bacteria data. This data is summarized below in Table 8.

When assessing the data, several significant points should be considered. First, these data do not correspond to the typical CSO year or the climatic period used in the TMDL. These are multi-year data from an overall wetter period than used in the CSO LTCP and TMDL. Thus, they are not directly comparable and likely represent a worst case situation than contemplated for the LTCP/TMDL. Second, throughout this sampling period Real Time Control, a key project, had not yet been constructed. Also, the data geometric means are from a rolling number of months rather than a certain number of samples taken during each individual month.

Subject to the limitations noted in Table 7 above, Table 8 below, indicates the geometric mean for the 50+ samples shows water quality is meeting Delaware's water quality standard of 100 cfu/100mL for primary recreations contact at most locations, with the exception of Little Mill Creek. Little Mill Creek bacteria levels are high whether wet or dry and would indicate a significant source of bacteria not related to the CSOs. However, our model continues to predict that the CSO loading to Little Mill Creek from the TMDL are being met. The City will continue to evaluate Little Mill Creek for other potential sources of the bacteria, which our ambient monitoring has identified. A DNREC led, more robust data gathering initiative may be warranted for Little Mill Creek to definitively determine whether bacteria criteria is being met.

TABLE 8: CITY OF WILMINGTON ENTEROCOCCI DATA FROM MONTHLY SAMPLES 2006 TO 2011

	Brandywine Creek at Smith Bridge	Brandywine Creek at Exp. Station	Brandywine Creek at Footbridge	Brandywine Creek at BFP intake	Brandywine Creek at Northeast	Christina River - 7th St. Peninsula	Christina River at 3rd St. Bridge	Little Mill Creek at MD Ave Bridge
	State line/Upstream of CSOs	Upstream of CSOs	RR CSO can impact	adjacent to Footbridge; weekly samples	CSOs 3, 4A-F, 18, 19 ,20, 21A-C, 22B, 22C, 23, 24, 25,	CSOs 5, 6, 7, 11, 12, 13, 30, 9a, 10, 14, 15, 16, 17, 9c	CSOs 5, 6, 7, 11, 12, 13, 30, 9a, 10, 14, 15, 16, 17, 9c	CSOs 27, 28, 29
geomean, all data	36.0	33.4	54.7	19.7	46.8	61.6	74.9	161.2
NUMBER OF SAMPLES								
# samples	51	34	53	134	51	53	52	53
dry	38	23	39	NA	37	39	38	39
wet	13	11	14	NA	14	14	14	14

wet weather was defined as 0.2 inches within past 48 hours

3.3.1. TMDL Compliance for Christina and Brandywine Rivers

In addition to the Bacteria TMDL, there was also a TMDL for nutrients including total nitrogen and total phosphorus. At that time the original FLTCP was designed in 2006 primarily to achieve the load reductions necessary to meet the Bacteria TMDL requirements. The City assumed at the time from 2007 to 2010 when the analysis was completed that compliance with Bacteria load reductions would also achieve the necessary nitrogen and phosphorus load reductions as well. Based on this assumption, the FLTCP did not have estimates conducted for the nitrogen and phosphorus loads to achieve the TMDL requirements.

The methodologies from the bacteria TMDL previously described in this section were used to develop the estimates with the following clarifications and adjustments. The Event Mean Concentrations (EMCs) from the published EPA TMDL for nitrogen and phosphorus were used to multiply by the flow (plus unit conversions) to obtain the load estimates of nutrients before the FLTCP and after the FLTCP implementation. The load estimates for after the FLTCP implementation were compared to the EPA published nitrogen and phosphorus Waste Load Allocations (WLAs) for compliance with the TMDL. The difference between the WLA and the FLTCP nutrient load estimates were then used to estimate potential additional load reductions that would be necessary to achieve the TMDL requirements

Table 9: Event Mean Concentrations Used for City of Wilmington CSOs by EPA in the TMDL

	EMC April 2005 TMDL (mg/L)			EMC for Revised TMDL (mg/L)		
CSO	TN	TP	TOC	TN	TP	TOC
4b	2.966	0.31	6.92	2.619	0.334	11.94
25	2.947	0.618	21.7	2.928	0.655	20.58
3	4.451	0.69	12.63	7.591	1.041	15.84
All other	4.451	0.69	12.63	2.753	0.339	15.68

TABLE 10: PUBLISHED EPA TMDL WASTE LOAD ALLOCATIONS AND REDUCTIONS BY RECEIVING WATER SEGMENT

Location (subbasin)	EFDC cell [I,J]	CSO ID numbers	Baseline (kg/yr)	TMDL (kg/yr)	Reduction
TOTAL NITROGEN					
Little Mill Creek (C05)	[44,55]	27,28	683.6	162.1	76.3%
Little Mill Creek (C05)	[45,55]	29	267.5	63.5	76.3%
Christina River (C09)	[52,13]	5, 6,7,11,12,13,30	1055.2	363.2	65.6%
Christina River (C09)	[53,13]	9a, 10, 14, 15, 16, 17	1057.4	229.6	78.3%
Christina River (C09)	[55,13]	9c	52.2	2.6	95.1%
Brandywine Creek (B34)	[54,16]	18	0.4	0	100.0%
Brandywine Creek (B34)	[54,17]	3, 4a, 4b, 4c, 4d, 19, 20, 21a, 21b, 21c	2210.1	398.2	82.0%
Brandywine Creek (B34)	[54,18]	4e, 4f, 22b, 22c, 23, 24	262.1	261	0.4%
Brandywine Creek (B34)	[54,20]	25, 26	1643.6	839.9	48.9%
Brandywine Creek (B34)	[54,21]	RR	60.6	0	100.0%
Shellpot Creek CSO 31*	[57,15]	31	258.8	182.1	29.6%
		Total Average Annual Nitrogen Load	7292.7	2319.9	68.2%
TOTAL PHOSPORUS					
Little Mill Creek (C05)	[44,55]	27,28	115.7	27.4	76.3%
Little Mill Creek (C05)	[45,55]	29	45.3	10.6	76.6%
Christina River (C09)	[52,13]	5, 6,7,11,12,13,30	178.5	61.7	65.4%
Christina River (C09)	[53,13]	9a, 10, 14, 15, 16, 17	178.9	38.7	78.4%
Christina River (C09)	[55,13]	9c	8.8	0.4	95.8%
Brandywine Creek (B34)	[54,16]	18	0	0	0.0%
Brandywine Creek (B34)	[54,17]	3, 4a, 4b, 4c, 4d, 19, 20, 21a, 21b, 21c	328.9	60.2	81.7%
Brandywine Creek (B34)	[54,18]	4e, 4f, 22b, 22c, 23, 24	44.9	44.5	0.8%
Brandywine Creek (B34)	[54,20]	25, 26	333.6	161.7	51.5%
Brandywine Creek (B34)	[54,21]	RR	10.2	0	100.0%
Shellpot Creek CSO 31*	[57,15]	31	43.8	30.7	30.0%
		Total Average Annual Phosphorus Load	1244.7	405.2	67.4%

*CSO31 not included in total CSO load since it discharges outside of Christina River Basin

TABLE 11: PUBLISHED EPA TMDL WASTE LOAD ALLOCATIONS BY RECEIVING WATER SEGMENT

			Baseline			TMDL		
CSO ID	EFDC grid [I,J] index	HSPF Subbasin	Overflow volume (MG)	TN Load (kg/yr)	TP Load (kg/yr)	Overflow volume (MG)	TN Load (kg/yr)	TP Load (kg/yr)
3	[54,17]	B34	11.56	348.6	45.6	5.67	170.8	22.3
4a	[54,17]	B34	30.64	324.1	54.8	5.72	60.6	10.2
4b	[54,17]	B34	70.37	711.8	89.1	0	0	0
4c	[54,17]	B34	0	0	0	0	0	0
4d	[54,17]	B34	11.46	121.9	20.4	11.46	121.9	20.4
4e	[54,18]	B34	0.11	1.1	0.4	0.01	0	0
4f	[54,18]	B34	0	0	0	0	0	0
5	[52,13]	C09	14.61	154.8	26.3	2.2	23.4	4
6	[52,13]	C09	1.68	17.9	2.9	0.2	2.2	0.4
7	[52,13]	C09	0.31	3.3	0.7	0.01	0	0
9a	[53,13]	C09	15.32	162.1	27.4	4.78	50.7	8.4
9c	[55,13]	C09	4.94	52.2	8.8	0.25	2.6	0.4
10	[53,13]	C09	9.17	97.1	16.4	1.02	10.6	1.8
11	[52,13]	C09	4.15	44.5	7.7	0.62	6.6	1.1
12	[52,13]	C09	0.08	0.7	0	0	0	0
13	[52,13]	C09	11.23	119	20.1	1.16	12.4	2.2
14	[53,13]	C09	0.22	2.2	0.4	0	0	0
15	[53,13]	C09	0.49	5.1	0.7	0	0	0
16	[53,13]	C09	0.35	3.7	0.7	0.07	0.7	0
17	[53,13]	C09	73.75	787.3	133.2	15.69	167.5	28.5
18	[54,16]	B34	0.03	0.4	0	0	0	0
19	[54,17]	B34	56.01	593.9	100.4	0	0	0
20	[54,17]	B34	0.09	1.1	0	0	0	0
21a	[54,17]	B34	4	43.1	7.3	0.78	8.4	1.5
21b	[54,17]	B34	5.78	64.2	11	3.19	35.4	5.8
21c	[54,17]	B34	0.13	1.5	0.4	0.09	1.1	0
22b	[54,18]	B34	4.95	53.3	9.1	4.95	53.3	9.1
22c	[54,18]	B34	1.53	16.4	2.9	1.53	16.4	2.9
23	[54,18]	B34	17.73	191.3	32.5	17.73	191.3	32.5
24	[54,20]	B34	52.95	563.9	95.3	42.36	451.1	76.3
25	[54,20]	B34	95.17	1,065.10	235.8	34.08	381.4	84.3
26	[54,20]	B34	1.38	14.6	2.6	0.69	7.3	1.1
27	[44,55]	C05	54.16	573.4	97.1	12.83	135.8	23
28	[44,55]	C05	10.32	110.2	18.6	2.44	26.3	4.4
29	[45,55]	C05	25.21	267.5	45.3	5.97	63.5	10.6
30	[52,13]	C09	67.56	715	120.8	30.12	318.6	54
31*	[57,15]	-	24.45	258.8	43.8	17.22	182.1	30.7
Rockford Road	[54,21]	B34	5.73	60.6	10.2	0	0	0
		Totals	**663.19**	**7292.7**	**1244.7**	**205.63**	**2319.9**	**405.2**

*CSO 31 discharges to Shellpot Creek outside the Christina River Basin and is not included in totals

Table 12 and Table 13 provide the comparison of the estimated load produced by Wilmington's CSOs for Total Nitrogen and Phosphorus as compared to the TMDL WLA's by EPA. The estimates suggest that Total Phosphorus (Table 13) will be reduced sufficiently following the FLTCP and RTC in order to meet the EPA TMDL requirements without further actions in all receiving waters (Little Mill Creek, Brandywine Creek, and Christina River. However, estimates suggest that the Total Nitrogen (Table 12) will not be reduced following the FLTCP and RTC in order to meet the EPA TMDL requirements without additional actions for the Brandywine Creek and the Christina River. Estimates suggest that for the Brandywine Creek and Christina River another 23.4 and 15.6 million gallons per year of CSO discharges may need to be reduced beyond the original FLTCP on average. This is an additional 14% and 21% reduction in CSO loadings beyond the original FLTCP to the Brandywine Creek and Christina River respectively. To put these reductions in perspective, after the implementation of the RTC, there are an estimated 128 and 53.2 MG/yr of CSO overflows remaining into the Brandywine Creek and Christina River respectively. Therefore, identifying where and how the City would achieve an additional 23.4 and 15.6 MG/yr of CSO reduction from those amounts will be conducted once the original FLTCP work has been completed and post construction monitoring provides better data and modeling for accurate identification of efforts.

In the original FLTCP that was proposed in 2010, there are a number of activities proposed to conduct source controls of runoff to the system and for structural activities such as sewer separation projects that were not quantified for overflow benefit as they were to carry the City beyond the CSO National Policy (85% capture) and the TMDL requirements (about 92% capture) towards a long term goal of CSO elimination.

It is anticipated that the City will use source controls as the primary means for achieving the remaining additional CSO reduction to meet the nitrogen TMDL WLA. Original very rough work using the CSO model suggested impact of reducing 5% of impervious area on CSO overflows. In that analysis it suggested that in some CSO subsewersheds an impervious area reduction (or inferred as a source control) would be effective in reducing CSOs (around 1 acre of impervious reduced created roughly around 1 MG/yr of CSO reduction). For example, in the Brandywine Creek CSO area, it is estimated that roughly 12 acres of impervious area managed/removed in the CSO 4A subshed would potentially achieve upwards of 24 MG/yr of CSO discharges. For example, in the Christina CSO area, it is estimated that roughly 11.5 acres of impervious area managed/removed in the CSO 5 subshed would potentially achieve upwards of 11 MG/yr of CSO discharges. However, this would still be about 4 MG/yr short of the amount needed to achieve the TMDL reduction which is well within the model error ranges at this time. Similar efforts would need to be tracked and evaluated for CSO 30 once the key FLTCP projects have been completed and post construction monitoring is conducted in order to update the model and overflow estimates.

TABLE 12: PREDICTED AVERAGE ANNUAL LOAD BY STREAM SEGMENTS FOR THE TWO CHRONOLOGIES AND YEARS 2004-2006 FOR RTC 2011 CONDITIONS AND CALIBRATED IMPERVIOUSNESS – TOTAL NITROGEN

Location	CSO ID Numbers	WLA	1983-1985 Chronology			Oct. 1994 - Oct. 1998 Chronology		
			Predicted Average Annual Load	Additional Reduction Needed	Additional CSO Volume Reduction Needed *	Predicted Annual Load	Additional Reduction Needed	Additional CSO Volume Reduction Needed *
		kg/yr	kg/yr		MG	kg/yr		MG
Little Mill Creek (C05)	27, 28, 29	225.6	68.1	-231%	-15.1	47.2	-378%	-17.1
Christina River (C09)	5, 6, 7, 9A, 9C, 10, 11, 12, 13, 14, 15, 16, 17, 30	595.3	1051.8	**43%**	**43.8**	757.5	**21%**	**15.6**
Brandywine Creek (B34)	3, 4A, 4B, 4C, 4D, 4E, 4F, 18, 19, 20, 21A, 21B, 21C, 22B, 22C, 23, 24, 25, 26, RR, K&U	1499.1	2288.2	**34%**	**75.7**	1742.4	**14%**	**23.4**

* Additional CSO Volume is computed from the Total Nitrogen event mean concentration of 2.73 mg/L from the EPA TMDL

* The confidence interval on the total overflow volume from sum is based on the hypothesis that the annual CSO volume estimation errors of individual locations are independent variables (covariance=0).

TABLE 13: PREDICTED AVERAGE ANNUAL LOAD BY STREAM SEGMENTS FOR THE TWO CHRONOLOGIES AND YEARS 2004-2006 FOR RTC 2011 CONDITIONS AND CALIBRATED IMPERVIOUSNESS – TOTAL PHOSPHORUS

Location	CSO ID Numbers	WLA	1983-1985 Chronology			Oct. 1994 - Oct. 1998 Chronology		
			Predicted Average Annual Load	Additional Reduction Needed	Additional CSO Volume Reduction Needed *	Predicted Annual Load	Additional Reduction Needed	Additional CSO Volume Reduction Needed *
		kg/yr	kg/yr		MG	kg/yr		MG
Little Mill Creek (C05)	27, 28, 29	38.00	8.38	-353%	-23.1	4.37	-769%	-26.2
Christina River (C09)	5, 6, 7, 9A, 9C, 10, 11, 12, 13, 14, 15, 16, 17, 30	100.80	129.51	**22%**	**22.4**	79.16	-27%	-16.9
Brandywine Creek (B34)	3, 4A, 4B, 4C, 4D, 4E, 4F, 18, 19, 20, 21A, 21B, 21C, 22B, 22C, 23, 24, 25, 26, RR, K&U	266.40	298.43	**11%**	**25.0**	209.32	-27%	-44.5

* Additional CSO Volume is computed from a Total Phosphorus event mean concentration of 0.339 mg/L from the EPA TMDL

* The confidence interval on the total overflow volume from sum is based on the hypothesis that the annual CSO volume estimation errors of individual locations are independent variables (covariance=0).

Given these findings, the City proposes to achieve the additional Total Nitrogen reductions necessary to meet the TMDL via source reduction primarily in the appropriate sewersheds in order to achieve an additional 23.4 and 15.6 MG/yr of CSO reduction. This effort is above and beyond the original FLTCP from 2010 and will be revisited for additional targeting and efforts once the key FLTCP projects are completed, post construction monitoring is conducted, the CSS/CSO model is updated to provide more accurate estimates. With that information in hand the City expects to provide a more detailed plan to achieve the remaining CSOs for nitrogen reduction. In the meantime, during the course of the FLTCP, the City will track public and private source reduction projects in these sewersheds in order to allow their impact to be estimated for additional CSO reductions beyond that estimated in the 2010 FLTCP. In addition, the City will place focus upon green infrastructure and source control concepts via activities G3 and G5 (see section 4.2.4) to provide preliminary concepts for additional CSO reductions to meet the Nitrogen TMDL.

4. Wilmington's Future Approach to Addressing CSOs

Controlling CSOs requires implementing source controls, improving conveyance/transmission, improving treatment, and increasing system storage. The ELTCP focused on conveyance, treatment, and storage opportunities to make substantial progress. However, it identified that moving beyond 92% capture using traditional infrastructure requires massive storage and treatment changes that would have a negative impact on the very fabric of the City of Wilmington. Therefore, the Final LTCP will (1) complete the implementation of ELTCP projects which remain underway, (2) document the effects of the past projects on the system performance, and (3) embark on implementing key elements using an integrated and adaptive management watershed approach to land, water, and infrastructure to maintain and enhance compliance with the TMDL WLAs for the Christina Basin

A watershed approach will feature adaptive management implementation. As defined by EPA, adaptive management is the process by which new information about the health of the watershed is incorporated into the watershed management plan. Adaptive management is a challenging blend of scientific research, monitoring, and practical management that allows for experimentation and provides the opportunity to "learn by doing." It is a necessary and useful tool because of the uncertainty about how ecosystems function and how management approaches affect ecosystems. Adaptive management requires explicit consideration of hypotheses about ecosystem structure and function, defined management goals and actions, and anticipated ecosystem response (Jensen et al. 1996). http://www.epa.gov/owow/watershed/wacademy/wam/step5.html). The results of this process are essential to show that management solutions have been implemented and are effective at achieving watershed objectives. The objectives of the Adaptive Management step are as follows:

- To create a system to monitor changes in the watershed.
- To evaluate trends using monitoring data.
- To modify the watershed management plan as necessary.

Following the principles of adaptive management, the proposed approach will include a significant effort dedicated to evaluation of impacts of previous CSO related projects and programs. At this moment the

Real Time Control Center is capturing new data that is critical not only to the real time application of Csoft hydraulic software, but also integral to developing data for extended period (multi-year) simulations to measure CSS performance. On-going performance measurement and evaluation requires an updated XP-SWMM model of the CSS in order to perform extended period simulations. RTC implementation and other completed key projects and activities achieve a high level of capture. Consequently, future efforts to achieve even greater CSO reductions will require capture of significantly larger storms or very site specific projects at a few remaining overflow locations. As stated previously, traditional infrastructure options to achieve further CSO reductions are anticipated to be exhausted due to their location and size or identified as too disruptive to the fabric of the City to achieve the remaining few percent capture of the overflows. Therefore, an approach favoring green infrastructure and source controls will be developed to achieve sustainable long term reductions in these small remaining overflow locations and potentially city wide. This approach is consistent with current US EPA green initiatives. If a source control approach is implemented city wide it not only offers the ability to reduce flows into the system and to further reduce overflows, but it may also provide synergy with current projects to achieve reductions beyond what was anticipated.

Since the original 2003 ELTCP, new approaches in green infrastructure and source controls have emerged as viable elements of a Long Term Control Plan. Many cities are turning to green infrastructure to achieve long term compliance with the CSO National Policy. Cities such as Washington D.C., Philadelphia, Chicago, Cincinnati, Portland, Seattle, New York City, and Kansas City have proposed elements or a comprehensive approach to reducing CSOs using green infrastructure. These programs state that green infrastructure is the most sustainable approach to addressing CSOs the greatest social, economic, and environmental benefits compared to a traditional approach. Some programs have shown that a green infrastructure approach starts achieving compliance immediately as compared to traditional infrastructure that requires an entire permit cycle until a project is built and operated to achieve the same effect http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan). Given the factors described above, the City will embark on developing its own green infrastructure program during the Final LTCP.

4.1. Future CSO Objectives

The 2003 CSO ELTCP identified the following objectives:

- Achieve 85 percent capture and treatment of annual average wet weather flows;
- Comply with Total Maximum Daily Loads under development for the Christina basin
- Pursue pollution sources upstream of the City's CSO areas
- Meet ELTCP objectives by 2010.

As documented in this report and plan, the City has substantially achieved these objectives. A number of key projects are still anticipated to be completed by the end of 2010 to achieve over 92 percent capture and treatment of annual average wet weather flow system wide.

Regarding the adaptive management approach to watershed management, any process of environmental management utilizes a continuous cycle of planning, implementation, and evaluation. The Final LTCP will evaluate prior planning and implementation in order to update the performance of the CSO program and to identify and design effective projects and activities as necessary to achieve even further improvements.

The objectives of the Final LTCP are the following:

1. Maintain compliance with CSO TMDL WLAs for the Christina Basin.
2. Evaluate the performance and effects of the key CSO projects for the Christina Basin. Reevaluate and reprioritize the CSO outfalls based on the measured and anticipated impacts of the implementation and operation of the key CSO projects on CSO discharges.
3. Implement cost effective projects and activities to achieve reasonable further progress
4. Develop and establish a source control and green infrastructure program to obtain cost-effective and sustainable additional long term CSO reductions and benefits.
5. Continue to pursue and identify pollution sources upstream of the City's CSO areas.
6. Continuation of compliance and performance of the Nine Minimum Controls

4.2. Future CSO Priorities and Projects

As further detailed in this section, the City has completed a preliminary attempt to explore new CSO priorities using the existing CSoft real time CSO model. Modeling methodology was previously presented in Section 3 and is also described in Appendix B. Results in section 3 demonstrate the system meets National CSO policy and Christina Basin TMDL allocations, but potential overflows still exist at individual outfalls. These results confirm that the City has met its legal obligations. However, as described in this section, the City will continue to evaluate additional improvements over time.

Key benchmarks to measure the success of the CSO Program were achieving 85% average annual wet weather capture by volume and meeting waste load allocations determined by the TMDL for the Christina Basin. With these benchmarks accomplished, the City proposes in this FLTCP to use the water quality based chronology of the High Flow TMDL of October 1994 to October 1998 to measure further progress.

Exploratory analysis conducted by the City identified that the combined system model is somewhat sensitive to impervious land cover inputs, i.e. a 5% change in the impervious land cover impacted annual overflow volumes by over 100 MG. This knowledge provides a greater understanding of how the combined sewer system could respond to source control approaches that include green infrastructure and how important verification of input data is to model variability and uncertainty.

Priority activities in the next several years for the City will focus on evaluating performance of key CSO projects. Knowing existing performance once RTC is complete will enable meaningful identification of future efforts to continuously improve the system. With this information, outfalls can be prioritized such that alternative projects for individual CSO and system wide areas can be planned to provide the most improvement. For example, a simplified approach for prioritization of CSO outfalls for future improvements could include the use of overflow volume by outfall, overflow volume by stream segment, and/or the potential effectiveness of impervious area reduction via source controls such as green infrastructure.

A possible approach for assessing potential feasibility for green infrastructure is shown in Table 14. Csoft™ overflow data was used to predict which sewersheds would provide more meaningful source control implementation. The Table shows for each individual outfall how much volume of overflow can be mitigated by reducing impervious cover in the CSOs drainage As shown, a 5% reduction in impervious area does not always yield a linear relationship in terms of reduction in CSO volume and is not always related to the area of the sewershed. Diminishing returns on source control management is to be expected. As the impervious area nears lower limits, each acre of reduction, tends to have less of an impact. This analysis shows a wide range of results for green infrastructure feasibility in the system. For instance, some sewersheds appear to have greater impacts per unit effort than other sewersheds. Figure 8 provides a preliminary ranking based on the impact of reducing impervious area. It shows that sewersheds for outfalls 4A, 4D, 4F, 5, 11, 23, and 24 appear to have the most potential for green infrastructure to feasibly reduce overflows. These outfalls also have the greatest remaining annual overflow volumes based on the 1994 to 1998 simulation period, as shown in the light blue shading in Table 14. The outfalls with green infrastructure potential represent an estimated 70% of the remaining average annual overflow volume. This suggests strong potential for green infrastructure to achieve reasonable further progress.

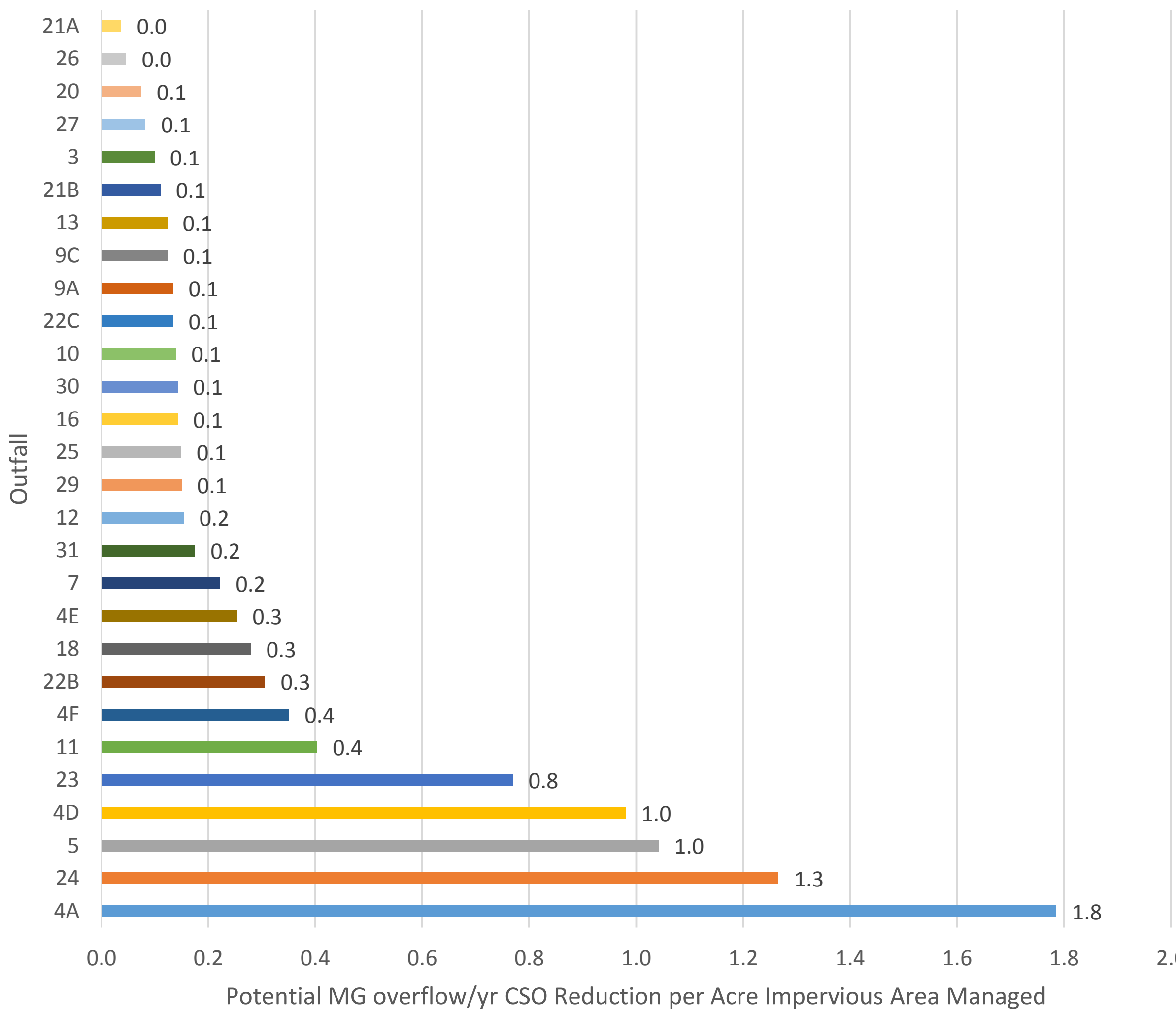
TABLE 14: EXAMPLE OF POTENTIAL GREEN INFRASTRUCTURE FEASIBILITY TO REDUCE CSOS

Hydrologic Basins	Interceptor	CSO ID	Drainage Area (acres)	5% of drainage area	5% reduction in Impervious MG/acre	Predicted Overflow Volume MG/yr
		4A	316.7	15.8	**1.8**	**52.9**
		4B	248.7	12.4		
		4C		0		
		4D	99.1	5	**1.0**	**13.5**
		4E	25.1	1.3	0.3	0.3
		4F	31.5	1.6	**0.4**	0.7
		25	454.3	22.7	0.1	4.4
	A	**26**	147.1	7.4	0.0	0.3
		20	18.3	0.9	0.1	0.2
		21A	9.6	0.5	0.0	0.0
		21B	34.5	1.7	0.1	0.3
		21C	13.5	0.7		0.0
		22B	31.3	1.6	0.3	0.6
		22C	36.2	1.8	0.1	0.5
		23	51.6	2.6	**0.8**	**6.7**
B34	**B**	**24**	96.5	4.8	**1.3**	**47.1**

Hydrologic Basins	Interceptor	CSO ID	Drainage Area (acres)	5% of drainage area	5% reduction in Impervious MG/acre	Predicted Overflow Volume MG/yr
		Rockford Road				
		Kentmere & Union				0.5
		18	39.1	2	0.3	1.2
	C	19		0		
	E	3	181.9	9.1	0.1	2.7
		5	72.7	3.6	1.0	11.5
		6	11.2	0.6		
		7	10.4	0.5	0.2	0.3
		11	17.6	0.9	0.4	0.8
		12	9.3	0.5	0.2	0.1
		13	76.7	3.8	0.1	0.9
		14		0		
		15	8.6	0.4		
		16	28.5	1.4	0.1	0.2
	C	30	1230.8		0.1	39.1
		9A	5.6	0.3	0.1	0.1
		9B		0		
		9C	4	0.2	0.1	0.0
		10	39.8	2	0.1	0.3
C09	DW&D	17				
		27	188.6	9.4	0.1	1.5
		28	127.7	6.4	0.0	0.0
C05	Silverbrook Run	29	134.8	6.7	0.1	1.4
Shellpot Creek	E	31	36	1.8	0.2	0.4

*Annual overflow volume is average overflow volume from Oct 1994-Oct 1998 TMDL simulation period

FIGURE 8: ESTIMATED POTENTIAL FEASIBILITY OF GREEN INFRASTRUCTURE BASED ON 5% IMPERVIOUS AREA REDUCTION FROM CURRENT STATE



While further evaluation and prioritization is occurring, the City will be exploring and establishing the elements of a sustainable long term approach to CSO reduction via green infrastructure and source controls. This includes enhancements to the current parcel based billing stormwater utility structure for improved source control credits, investigating a stormwater management ordinance to reduce runoff from new and redevelopment, and examining a variety of pilot programs, such as rain gardens, planters, bioswales, and tree pits, along city streets or in public areas. Based on green infrastructure project performance, future City water and sewer replacement projects may be examined for long term incorporation of green infrastructure elements. In addition to City sponsored green pilot projects, the City will look nationally at similar pilot programs by other proactive cities and evaluate their application in Wilmington.

The City will also continue its compliance with the Nine Minimum Controls. The improved monitoring and modeling information during the next permit phase may identify opportunities to enhance the City's performance of the Nine Minimum Controls.

The following section provides detailed information about the specific projects, deliverables, and schedules for implementation during the Final LTCP. Table 15 provides a summary of implementation projects and anticipated completion dates.

The City acknowledges that the current FLTCP includes the evaluation of the implementation of the ELTCP projects to meet CSO national policy and achieve TMDL requirements. It also acknowledges that in order to make reasonable progress, the City is conducting many studies to examine new approaches to continue CSO reductions.

As a feasibility study completed by the City, the annual CSO report to DNREC will provide a summary of the findings of that work and the City's schedule for an action plan to be completed or re-evaluation. As a plan is completed by the City, the annual CSO report to DNREC will provide a summary of the findings of that work and the City's schedule for implementation of the plan. In the case there may be many plans and studies competing for limited resources, the City will prioritize resources towards efforts that will achieve the greatest triple bottom line benefit (environmental, economic, and social) to the City.

TABLE 15: PROPOSED IMPLEMENTATION PROJECTS FOR THE FINAL LTCP

Project ID #	Description/Title	Targeted Completion Date (Calendar Year End)
G1	Feasibility Study of Leveraging Stormwater Utility Credits To Incentivize Source Controls	2015
G2	Feasibility Study of Stormwater Ordinance	2016
G3	Plan for green infrastructure initiatives in public street projects	2017
G4	Plan for green infrastructure initiatives in public building projects	2017
G5	Plan for green infrastructure initiatives in private properties	2017
G6	Study of code changes to support green infrastructure	2017
P1	Upgrade of CSS Model	2018
P2	Flow monitoring plan to support CSO model	2015
P3	Modeling Plan to Verify CSO percent capture and Achievement of Christina TMDL loads	2015
P4	Develop Final LTCP benchmark/baseline for CSO discharges & reprioritization of outfalls, as appropriate.	2017
S1	Complete sewer separation of Wilmington Hospital	2017
S2	Identify new development projects or desired areas for potential sewer separation and develop a special area management plan	2018
N1	WWTP Headworks upgrade construction completion	2015
N2	Plan for Kentmere & Union elimination for average year	2015
N3	WWTP headworks upgrade full operation	2015
N4	Kentmere & Union elimination for average year	2018
K1	Real Time Control System Construction completion	2015
K2	Real Time Control System full operation	2015
K3	Elimination of Rockford Road for average year	2016
K4	11th St. Pumping Station re-evaluation study	2015
K5	Prices Run Diversion re-evaluation study	2015

4.2.1. Completion of Prior Key CSO Projects

In this section the scope of each of the projects will be described in detail and the specific deliverables to DNREC for each item.

Project/Initiative: K1 – Real Time Control System Construction

Deliverable & Year: in 2015, the City will complete the construction and implementation of the Real Time Control system.

Scope: The Real Time Control system (RTC) was identified in the 2003 ELTCP as an opportunity to improve performance of the existing combined sewer system by dynamically reacting to changes. Model analysis and results suggests that completion of the RTC system achieves an estimated system wide 92% capture.

Real Time Control in a sewer system utilizes real time monitoring data of rainfall, water levels and/or flows. Changes in their values trigger movements of sluice gates, or pump speed to regulate the flow in the Collection System. RTC is based on a Global Optimal and Predictive strategy. A "Global" strategy means that all regulators are controlled according to the conditions of the CS as a whole. The "Predictive" strategy uses the rainfall data to predict incoming flows in the CSS. The "Optimal" strategy consists in defining an objective function that minimizes overflow and maximizes inflows to the WWTP.

RTC system provides improved flow management in the CSS through an integrated system of flow monitoring, flow control devices and control software. The primary objective is to optimize, on a real time basis, in-system storage and routing of flow. Wilmington's RTC system originally comprised a four-site system to regulate and optimize flows in CSO areas 4A, 25 and 30 and at the Canby Park existing storage tank. The following system components were designed and are in the process of being constructed:

- Regulator control devices, consisting of sluice gates and bending weirs into the interceptors to optimize use of available interceptor capacity.
- Flow monitoring system at key locations in the interceptor and at the controlled regulators.
- RTC control software, consisting of a control module based on a customized linear optimization program, integrated with the XP-SWMM hydraulic model.
- Telemetry systems including programmable logic controller (PLC) and radio units
- A central control station located at the WWTP.

RTC Design and construction was divided into two distinct phases. Phase I focused on developing the Supervisory Control and Data Acquisition (SCADA) backbone for the RTC system. Construction of Phase I was completed in 2009, and included the construction and interconnection of five rain gauges at distributed locations in the City and one flow monitor in interceptor A. Phase I construction also included development and installation of a composite SCADA system at the City's wastewater treatment plant.

RTC Phase II construction is focused on mechanical and civil engineering elements of the integrated system. This includes specific mechanical controls at CSOs 25, 4A, 30 and at Canby Park storage tank as well as controls at the Brandywine, Rattlesnake Run, and Christina siphons. While the mechanical weir or gate controls at the CSO outfalls are for overflow minimization during storms, the controls at the siphons are directed to optimize flushing flows to prevent sedimentation during dry weather flow. This will in turn maximize capacity of the siphons during wet weather. Phase II elements include installation and operation of sluices, gates, weirs, and their respective controls. This Phase began in 2010 and will be completed by late 2011.

Project/Initiative: K2 – Real Time Control System Full Operation

Deliverable & Year: By the end of 2015 the second phase of Real Time Control system will be complete and the system will be fully operational, as described above.

Scope: As described above.

Project/Initiative: K3 – Elimination of Rockford Road for average year

Deliverable & Year: By the end of 2016, the City will have eliminated CSO discharges from the Rockford Road CSO outfall in the average year condition.

Scope: Currently, construction for the Rockford Road CSO Sewer Separation Project is complete. New stormwater pipes and catch basins have been installed within Red Oak Road, Riverview Avenue, and Delaware Avenue. Existing catch basins within the CSO drainage area have been rerouted to connect to the new stormwater system. The Downspout Disconnect Project has successfully completed construction for 39 of the 67 residential properties. Of the total 123,495 square feet of roof area, 54,582 square feet, or 44%, have been disconnected from the CSO drainage basin. The solutions for 5 additional homes have been developed and are awaiting construction, while 4 more properties are in the design phase. Construction is expected to be complete by the end of 2010.

The hydraulic model for the project was updated to reflect the anticipated success of the projects by year 3 of the permit. Overall, 57% of the roof leaders are expected to be removed from the system. The disconnected roof area and the street runoff that was separated from the combined system were incorporated into the model. In addition, the weir at the first interconnection at the intersection of Red Oak Road and Riverview Avenue was raised. Raising the weir permits 1.25 MGD to pass through the pipe in Red Oak Road. While surcharging in manholes occurs due to raising the weir, water levels are not anticipated to cause basement backups. With the weir raised and surcharging allowed, occurrence of overflows will be eliminated to greater than the 2-year storm and nearly the 5-year storm. If in-system problems result, the City will reevaluate the weir level.

Project/Initiative: K4 –11th St. Pumping Station re-evaluation study

Deliverable & Year: A re-evaluation of options and capabilities to manage the larger storm events for the 11th St. Pumping Station will be conducted including examining new alternatives and an implementation plan will be developed, if appropriate.

Scope: A preliminary evaluation of the 11th Street Pumping Station was performed to identify the feasibility of upgrading the capacity of the existing station. Based on this 2003 evaluation, replacing pump impellers, drives and ancillary equipment, existing pumps could be upgraded to provide a peak capacity of 200 mgd, with four pumps in operation and one pump as a backup. Based on this, in 2003 the proposed capacity upgrade appeared to be a cost-effective CSO control measure. In order to ensure existing pump station capacity, the City replaced two pumps as part of ongoing preventive maintenance. Current pump station capacity of 135 MGD is considered sufficient for a large range of events based on hydraulic modeling. In the ELTCP, the increase in pumping capacity from 135 MGD to 200 MGD only gains another 1.5% capture because it only allows for interception of high peak flows from infrequent events. This made the project of limited value given project costs. Instead, the City decided to evaluate more cost-effective options.

Furthermore, after 2003, a more detailed hydraulic examination of the 11th St. Pumping Station was completed. This analysis revealed that the increase in pumping capacity would result in cavitation due to hydraulic limitations upstream and downstream of the pump station in the system. A new pump station would need to built around the existing operating station station and a new transmission pipeline constructed in order to address these hydraulic limitations. These additional elements made this project much more complex, cost-ineffective, and required significant reevaluation. Therefore, during the next permit period, the City proposes to evaluate the impact of other key CSO control projects, such as Real Time Control, and examine other alternatives to achieve the same or better results. Also, in partnership with DNRECT, the City proposes to explore other more sustainable options to reduce flow to the pump station from New Castle County contributions outside the City.

Project/Initiative: K5 – Prices Run Diversion re-evaluation study

Deliverable & Year: A re-evaluation of options to manage the larger storm events for Prices Run will be conducted including examining new alternatives and an implementation plan, if appropriate.

Scope: This project proposed the construction of a new interceptor to convey excess wet weather flows from the Prices Run Interceptor system directly to the 11th Street Pumping Station. This project was developed to reduce overflows from CSO 4A and integrate with the RTC system in order to free up capacity in Interceptor A. The proposed diversion interceptor, comprising approximately 2,300 linear feet of 36-inch diameter pipe, was planned to connect to the existing Prices Run relief sewer downstream of the regulator and upstream of CSO 4A outfall. This project was originally proposed in the 2003 ELTCP for completion in 2010.

This project has been temporarily put on hold because further analysis during RTC development indicated it would not be cost effective. Additional overflow volume reduction would be minimal for a substantial capital cost. As stated previously, without this project, and with RTC, 92% system wide capture is met.

4.2.2. New CSO Projects

During the course of the implementation of the 2003 ELTCP, several new projects were identified for implementation. These projects either addressed a priority area or potential system limitations. In this section the scope of each of the projects will be described along with the specific deliverables to DNREC for each item.

Project/Initiative: N1 – WWTP Headworks Upgrade Construction

Deliverable & Year: In 2015, the City will complete construction of upgrades linking the Real Time Control System to the WWTP headworks. This project eliminates hydraulic bottlenecks at the primary and secondary bypasses at the WWTP.

Scope: The goal of the headworks upgrade is to add automatic controls on gates and screens in order to maximize the amount of peak wet weather flow processed at the treatment plant. This includes more capability to bypass to primary lagoons with the installation of bending weirs at the grit tanks and slide gates at the secondary bypass chamber. The upgrade improvements will allow the WWTP to achieve full 400 mgd peak flow capacity during wet weather. Currently during peak flow situations, the City needs to cut back below 135 MGD at 11th Street Pump Station due to uncontrollable flows coming from the County force mains. Final LTCP percent capture is based on pumping the full 135 MGD at 11th Street. The WWTP headworks improvement project has been designed and bids for construction have been received. The construction cost is $2.7M, with another $0.2M in construction engineering support services.

Project/Initiative: N2 – Plan for Kentmere & Union CSO elimination for average year.

Deliverable & Year: The City will assess overflow volumes and frequencies at the Kentmere & Union CSO and identify specific projects, programs, and schedule to eliminate the Kentmere & Union CSO in the average year.

Scope: During the implementation of the ELTCP a new combined sewer overflow was located at Kentmere & Union above the City's drinking water intake. The City will develop a plan that estimates frequency of the overflows at the Kentmere & Union CSO and identifies specific projects, programs, and schedule to eliminate the Kentmere & Union CSO in the average year. This plan may include partial separation of stormwater from streets, the implementation of the Source Water Ordinance controls, and other elements including rainbarrel programs.

Project/Initiative: N3 – WWTP Headworks Upgrade Full Operation

Deliverable & Year: The City will conduct full operation of the upgrades linking the Real Time Control System to the WWTP headworks for bypass of wet weather flows in excess of 168 mgd.

Scope: The goal of the headworks upgrade is to add automatic controls on gates and screens in order to improve the ability to bypass during wet weathers without interference from flows to the headworks by New Castle County. This includes more capability to bypass upstream of the bars and grit tanks with the installation of bending weirs at the grit tanks and slide gates at the bypass chamber. The upgrade improvements will allow the WWTP to achieve the full 400 mgd peak flow capacity during wet weather by maximizing the capability of the bypass. The latest WWTP headworks improvement project has been designed and bids for construction have been received. As mentioned previously, this enables the City to pump its full capacity at 11th Street of 135 MGD, since the County flows during wet weather are the predominant flow source.

Project/Initiative: N4 –Kentmere & Union CSO elimination for average year under construction

Deliverable & Year: The City will implement projects from the Kentmere & Union Plan to eliminate the Kentmere & Union CSO in the average year.

Scope: During the course of the ELTCP a new combined sewer overflow was located at Kentmere & Union above the City's drinking water intakes. The City will implement projects from the Kentmere & Union Plan to eliminate the Kentmere & Union CSO in the average year. This may include partial sewer separation of street runoff, rainbarrel programs, or other elements to properly eliminate the overflows.

4.2.3. Sewer Separation Feasibility

Sewer separation is traditionally the most expensive option to address CSO discharges in existing areas of a City. However, when large scale urban renewal projects occur, the cost may be incremental because an entire area is being developed like a new development. Therefore, large scale and long term redevelopment projects associated with urban renewal represent a significant potential opportunity for synergy with sewer separation projects. However, such separation will be weighed against the reality that it will cause an urban discharge during every rain event (since new separate storm sewer outfalls would most likely be constructed, directly or indirectly discharging to the area water bodies) as compared to the current situation where overflows are far less frequent. Additionally, expansion of the City's storm sewer system by way of CSS separation initiatives will eventually impact the City's MS4 stormwater management program.

Project/Initiative: S1 – Wilmington Area Hospital Sewer Separation

Deliverable & Year: The Wilmington Hospital Sewer Separation Project will remove an estimated 10 acres of drainage from the CSO system. The construction will be completed and estimates of the reduction of related CSOs as will be provided in a report in 2017. Below, Figure 9 presents the separated storm sewer and diversion manhole in relation to the Hospital and Brandywine Creek.

FIGURE 9: WILMINGTON HOSPITAL SEWER SEPARATION PROJECT

Scope: The Wilmington Hospital is located in the drainage area to CSO 23 at Washington Street and 14th Street and discharges into segment #34 of the Brandywine Creek. The project separates 10 acres of the Wilmington Hospital property, as well as the Hercules Building, and Orange Street from the Combined Sewer System into a separate stormwater sewer. The separate stormsewer helps mitigate overflows at CSO 23. For example, for a 1” rainfall event, 272,000 gallons will be removed from the combined sewer system. Additionally, a vortex device is being installed in a diversion manhole, that conveys a controlled flow of 0.1 cubic feet per sec (the first flush) to the WWTP. The design for this project is completed and construction is underway. The City will reimburse the Hospital for the sewer separation costs, estimated at $500,000.

Project/Initiative: S2 – Special Area Management Plan (SAMP) to identify and analyze areas for potential stormwater separation from the CSO system in conjunction with large development/redevelopment activities.

Deliverable & Year: Parcels with waterfront access over one acre will be compared with current City Plans and future planned development to identify opportunities for separation from the CSO system during construction. A plan identifying and prioritizing potential parcel clusters for separation during development with conceptual separation designs and related cost and technical analyses will be completed by the end of the permit cycle.

Scope: There are an estimated 47 parcels along the Christina riverfront in Wilmington. Approximately 30 of those parcels are over one acre comprising 205 of the 216 acres or roughly 95% of the riverfront area. Disconnection of 205 acres of riverfront area from the combined system to a managed and treated (anticipated to be a wetlands system) discharge into the river directly is roughly the equivalent of a 5% reduction in impervious area to the CSS.

Sewer separation is often the most expensive of all the options to control CSO discharges. However, opportunities may arise during the development / redevelopment process where separation of large parcels and properties along waterfront areas or areas that can be directed downstream of the CSO regulator in order to reduce flow into the CSS. In these cases, the incremental cost of separation with the development project may be more attractive than the traditional approach or the management of the runoff due to local ordinances in CSO areas may drive a developer to separate in order to avoid costly treatment systems. This activity will be coordinated with project G2 that examines a stormwater ordinance.

This project proposes to develop a plan that identifies and prioritizes potential clusters of parcels that are over one acre with waterfront access or than can be directed to discharge downstream of the CSS regulator for stormwater separation during the future development process. The plan will also compare the potential cluster parcels with current City Plans and future planned development to identify opportunities for separation from the CSO system during construction. A workshop with other City agencies will be conducted to initialize identification of these future development areas for focused study. The plan will also examine conceptual separation designs and related cost and technical analyses for priority areas that are linked to major development planned to begin construction during the next 3-5 years.

A good example of how these efforts can be planned to gain CSO benefits is the recent South Market Street Shoprite Project. A partial sewer separation was conducted from first phase of new development on South Market Street. The storm water was directed under South Walnut St into a plunge pool and a grass lined ditch going north towards the Christina River. The closest affected CSO is CSO #10, but this work also affects other CSO points between South Market Street and the 11th St Pumping Station. The City is working on estimating the benefits of this project.

4.2.4. Source Controls and Green Infrastructure Projects

The 2003 ELTCP showed that traditional infrastructure improvements necessary to achieve beyond 92% capture system wide required costs well beyond the affordability of an economically stressed urban area. Additionally, the physical location and construction of these improvements would severely and irreparably damage the remaining green space of the City, while causing significant disturbance to the City. These findings provided a clear delineation of the limits of traditional infrastructure for long term CSO control and elimination. These findings suggested that beyond 92% capture, the City will need to identify alternative approaches to make long term steady progress at addressing CSOs.

In cities nationwide, green infrastructure and source controls are being identified as the key approach to "closing the gap" remaining after traditional infrastructure projects has been completed for CSOs. One of the reasons green infrastructure and source controls are so attractive is their "triple bottom line" benefits related to social, environmental, and economic metrics as compared to traditional infrastructure. For example, the carbon footprint of green infrastructure projects is often much smaller and can improve urban air quality or reduce urban heat island effects while creating "green jobs" that result in street level improvements that make areas potentially more attractive for economic development or improve real estate values. Locally, a recent study of Wilmington's parks by the Trust for Public Lands also suggested there are additional significant public health benefits of the green infrastructure via the park system due to increased recreation to reduce obesity which is a significant cause of illnesses that creates excessive burden on the current health care system nationwide (http://www.tpl.org/tier3_cd.cfm?content_item_id=23159&folder_id=3208).

Recently, the City began to establish the initial keystone elements to a source control program by establishing a stormwater utility with parcel based billing and credits for management as well as a Source Water Protection Ordinance that requires stormwater management from development projects in a portion of the City. In addition to the administrative and regulatory elements of the source control program, the City has supported a number of green infrastructure projects throughout the City. Some examples include, grants through Delaware Nature Society for rain barrels, backyard habitats, green roof on Riverfront, a tree ordinance, porous pavement at Woodlawn Library, and McMillan Square.

During the Final LTCP, the City will move beyond these initial steps and establish a green infrastructure and source control program. Plans will need to first be developed to create a roadmap to establishing such prioritization and programs for public buildings, public rights of ways and streets, and private properties. This overarching program will include approaches and mechanisms to enhance the current regulatory and billing approaches as well as develop plans and approaches for implementation of green infrastructure projects in conjunction with City streetscape projects and projects at public facilities or parks. Some of the first activities will focus on enhancements to the language for stormwater credits in order to provide specific technical details that will improve storm water management on private properties discharging to the CSO system. Also, the City will pursue an initiative to build upon the Source Water Protection Ordinance and explore a stormwater management ordinance to facilitate source control requirements for development and redevelopment activities.

Beyond ordinances and stormwater financial incentives to address impervious cover runoff from private lands, green infrastructure and source control programs will be explored for the following:

- Public Streets
- Public Properties and Buildings
- Private Properties

In this section the scope of each of the implementation projects will be described in detail and the specific deliverables to DNREC for each item.

Project/Initiative: G1 - Feasibility Study of Leveraging Stormwater Utility Credits to Incentivize Source Controls

Deliverable & Year: A study with recommendations for the City to implement to increase source controls through its current impervious cover parcel based stormwater billing approach. Target completion date will be end of 2015.

Scope: The City of Wilmington established a stormwater utility in 2007. The stormwater utility uses a parcel based impervious cover approach to determining the stormwater bill for properties. This billing approach also currently includes a very general stormwater credit program to properties that manage their stormwater. However, the technical criteria for the billing credits could be examined to determine if they could be adjusted to be more complementary to accelerating private implementation of source controls to further enhance the Final LTCP. Technical elements such as a required management volume or rate will be examined as well as potential geographic and green infrastructure incentives. The study will also estimate the extent of area needed by credits to achieve the reductions required in the TMDL.

Project/Initiative: G2 - Feasibility Study of Stormwater Ordinance

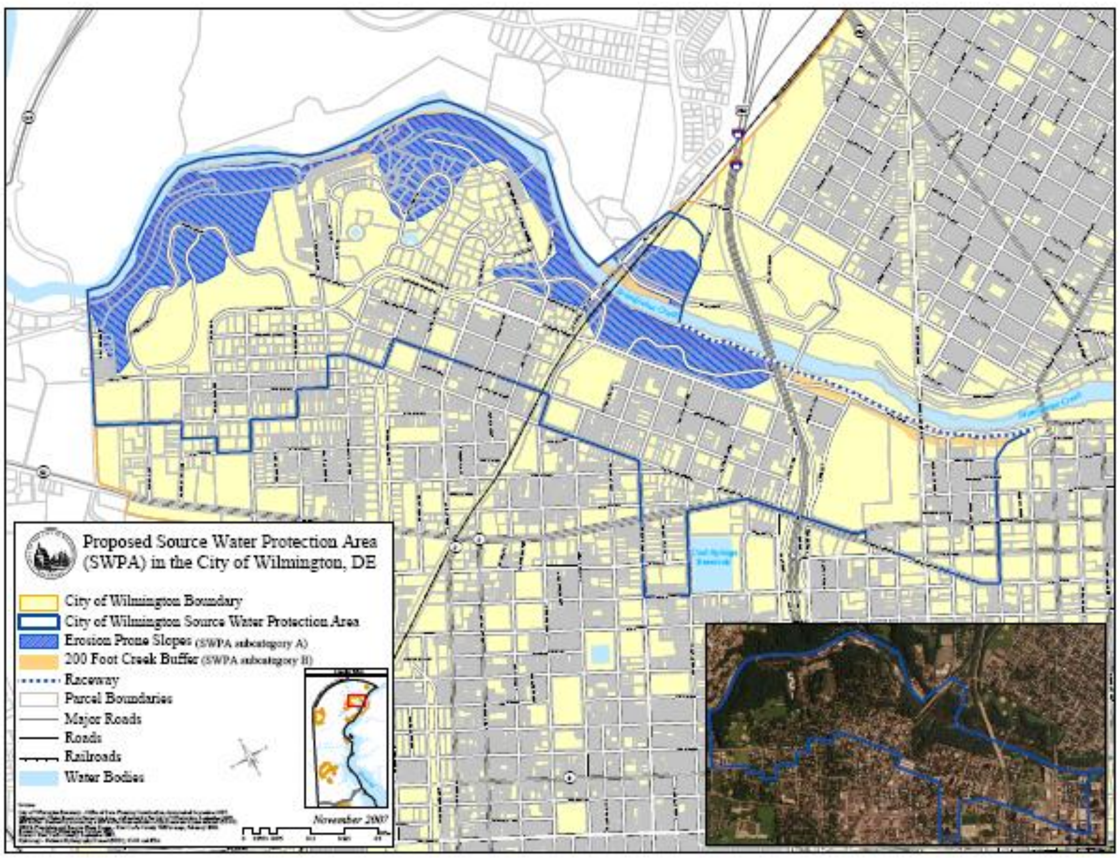
Deliverable & Year: A study with recommendations for the City to implement some form of stormwater ordinance in order to gain additional source controls through requiring specific stormwater management controls with development and redevelopment projects. Target completion date will be by end of 2016.

Scope: Nationwide many communities depend on stormwater ordinances to require stormwater management on private lands during the development and redevelopment process. In Delaware the Water Resources Protection Area (WRPA) is a good example of how ordinances can be utilized to protect water resources from degradation. In Philadelphia, over half of the Green Waters Clean City CSO Long Term Control Plan implementation success depends on stormwater management from private development.

The City of Wilmington is already starting these types of activities. In 2009, the City adopted a Source Water Protection Area Ordinance in order to protect its water supply intakes that required stormwater management as well as established additional criteria protective of the water quality and quantity of the

Brandywine Creek Watershed. The ordinance area covers roughly 10% of the City. As shown in Figure 10 below, the ordinance affects parts of the drainage areas for Interceptor A, Interceptor B, Rattlesnake Run, and the Jackson St. Drainage Area of the CSO system. Within these areas there is potential for benefit of stormwater management due to development for CSO outfalls 24, 25, and 26 as well as the discharges at Rockford Road and Kentmere and Union. The stormwater management requirements for development are directly linked in the ordinance to DNREC's requirements. During the next permit cycle, the City will compile and analyze the benefits of the Source Water Protection Ordinance on the CSS and relevant outfalls.

FIGURE 10: SOURCE WATER PROTECTION AREA ALONG BRANDYWINE CREEK IN WILMINGTON



The proposed feasibility study would expand on that effort and include examination of requirements for stormwater management on private lands due to development and redevelopment using various criteria that have been successfully employed by others and with modifications specific to the needs of Wilmington. The study will also examine the range and degree of potential impacts of such an ordinance and its requirements on business and residential sectors, the process and resources necessary by the City to administer any potential stormwater ordinance program to ensure it is implemented and enforced. The technical criteria for the stormwater management due to development could be examined to determine if they could be adjusted to be more complementary to accelerating private implementation of source controls for priorities in the Final LTCP. Technical elements such as a required disturbance thresholds, stormwater management volume or rate will be examined as well as potential geographic and green infrastructure requirements. For example, the study may suggest that instead of a citywide stormwater ordinance that it focus within particular sewersheds that contribute to the Brandywine, that particular steep sloped areas require more management, fee in lieu, trading/banking, or varying levels of earth disturbance thresholds/triggers depending on location, or that certain additional water quality treatment requirements are necessary in addition to water quality management requirements depending on the location. Other options may also include having incentives that require developers with waterfront parcels or that can connect downstream of the CSS regulators to separate the stormwater produced by the development from the CSS during the development process. The study will also estimate the extent of area needed by the ordinance in order to achieve the reductions required in the TMDL and based on past development rates an estimate of the time it would take development to achieve those levels.

Project/Initiative: G3 - Plan for green infrastructure initiatives in public streets and rights of ways

Deliverable & Year: A study with recommendations for the City to implement in order to gain additional source controls to achieve the nitrogen TMDL through implementing a variety of initiatives to manage stormwater from public streets. Target completion date will be by end of 2017.

Scope: Nationwide many communities are implementing programs to manage stormwater from public streets using green infrastructure. The City will develop a plan that outlines the requirements, resources, and policies appropriate to facilitate the use of green infrastructure to manage street runoff. The City will examine how to develop and adopt a standard process to include green infrastructure with streetscaping or water and sewer replacement project conducted in the City which will include potential elements such as street trees, tree pits, rain gardens, or bioswales to provide additional management of stormwater. This study will include potential costs and impacts. For example it may examine the benefits of additional street trees because every tree (of a certain type) planted within 10 feet of impervious area once mature will accomplish the management of the first 1 inch of stormwater for 100 square feet of impervious area nearby.

Once the plan identifies the various ways and creates the internal City standards and processes to manage stormwater runoff from streets, a pilot program for focused green infrastructure projects within public streets will need to be developed for specific CSOs before it is adopted citywide and so that standards can be evaluated. Once the CSO outfalls have been reprioritized, the City will identify one or several CSO outfalls where green infrastructure "opportunity areas" have been identified such that stormwater from streets can be diverted away from the CSO system and effectively managed in bioswales, planters, tree pits, rain gardens, or other methods. Typically these initial opportunity areas would generally occur first in areas where there is potentially green space available for management such as near park or recreational areas. However, other opportunity areas would be sites of significant street reconstruction or streetscaping associated with a significant redevelopment or infrastructure renewal project that allows for an opportunity to provide the value added benefit of a green infrastructure element. The plan will also identify green infrastructure approaches and pilot areas sidewalks, streets, alleys, and other areas to be developed and piloted during the Final LTCP. The plan will also prioritize areas for initial projects based on opportunity and targeted initiatives due to outfall priority based on revised CSO modeling results.

Project/Initiative: G4 - Plan for green infrastructure Initiatives in public building projects

Deliverable & Year: A study with recommendations for how the City processes and standards would need to change in order to can gain additional source controls through implementing a variety of initiatives to manage stormwater from public buildings and properties. Will be completed by the end of 2017.

Scope: Nationwide many communities are implementing programs to manage stormwater from public properties using green infrastructure. The City will develop a plan that outlines the requirements, resources, processes, and policies required to use green infrastructure to manage runoff from public properties during capital improvements or maintenance projects. The City will examine how to develop and adopt a standard process to include green infrastructure when feasible with every parking lot or roof replacement conducted by the City which will include potential elements such as porous pavement, green roofs, rain gardens, or bioswales to provide additional management of stormwater. This study will include potential costs and impacts.

Public buildings and parking lots are significant opportunities to implement green infrastructure elements. For example, roof replacements can incorporate portions of green roofs or parking lots can be replaced with porous pavement. Additional green elements such as bioswales, rain gardens, and tree pits can also be considered. A mixture of public street and public property activities can also be accomplished. For example, a small portion of a public park could have stormwater park elements such as swales and raingardens incorporated to take nearby street and sidewalk runoff surrounding it. The location and impervious area of these facilities in relation to priority CSOs for reductions to meet the TMDL will assist in developing a pilot area for the study and future implementation. A plan that identifies green infrastructure approaches and pilot areas for different public properties such as office buildings, parking lots, maintenance facilities, parks, recreation centers, schools, cemeteries, or other types will be developed, piloted, and initiated during the Final LTCP. The plan will also prioritize areas for initial projects based on opportunity and targeted initiatives due to outfall priority based on revised CSO modeling results. A review of the building code will be made with initiative G6 since local building requirements to accommodate green roofs will most likely require a change to building code and standards.

Project/Initiative: G5 - Plan for green infrastructure initiatives on private properties

Deliverable & Year: A plan with recommendations for the City to implement in order to gain additional source controls to achieve the nitrogen TMDL through implementing a variety of initiatives to manage stormwater on private property. This effort will be completed by the end of 2017.

Scope: The City will develop a plan that outlines the requirements, resources, and policies required to use green infrastructure to increase the management of runoff from private properties. First, the City will need to conduct an analysis of impervious areas in the watershed on private lands which identifies the categories of private lands that have the largest impervious areas. The impervious area analysis will develop the ability for prioritization and development of specific programs aimed at critical impervious areas on private or public lands. For example, it is anticipated based on studies in other large cities that roughly half the impervious area is in public areas and the other half is on private lands. The proposed ordinance and stormwater billing approaches may not be completely effective is there are specific land uses that are not impacted in certain commercial or residential classes. Therefore, depending on the landowner type, programs aimed at providing incentives, tools, or services may need to be developed.

These may include enhancements to the current rain barrel initiatives in the City for residents or specific programs aimed at supporting stormwater retrofits for schools or other types of properties. Another element may be necessary to provide synergy with vacant lands. The information from the impervious area analysis will be incorporated into the development of the green infrastructure pilot program described earlier. A plan that identifies green infrastructure approaches and pilot areas for various private property types will be developed, piloted, and initiated during the Final LTCP. The plan will also prioritize areas for initial projects based on opportunity and targeted initiatives due to outfall priority based on revised CSO modeling results.

Project/Initiative: G6 - Study of code changes to support green infrastructure

Deliverable & Year: A study with recommendations for the City to implement in order to identify ways City codes can be adjusted to facilitate green infrastructure. Target completion date will be end of 2017.

Scope: Zoning codes, building codes, plumbing codes and other codes may have elements that can conflict with or hinder the implementation of green infrastructure. For example some plumbing codes may prevent the ability to use materials or techniques in green infrastructure or building codes may have an element that makes green roofs too expensive or not allow disconnection or exterior downspouts. Zoning codes may prevent green space for green infrastructure in certain zoning categories or not allow for exceptions in the placement of green infrastructure. A comprehensive review of the zoning, building, plumbing, and other relevant City codes will be conducted to identify potential conflicts and opportunities to facilitate green infrastructure for source controls in the City.

4.2.5. Post Construction Monitoring Plan

Post construction monitoring is a critical aspect of any CSO program. Post construction monitoring efforts of the Final LTCP are designed to provide data to properly benchmark and assess the implementation of projects to reduce CSO discharges. As shown, modeling will be the primary tool used to assess the elements of the Final LTCP, but discrete monitoring activities will be required to examine performance of the key CSO projects. In this section the scope of each of the projects will be described in detail and the specific deliverables to DNREC for each item.

Project/Initiative: P1 – Upgrade of CSS Model

Deliverable & Year: A CSS Model that includes up to date impervious cover and runoff information, key CSO projects, green infrastructure modeling capabilities, etc.

Scope: The CSS model needs to be upgraded to address new information and revised characteristics of the City's land use, rainfall data, hydraulic elements, operational techniques, source control programs. It also will require validation and calibration of the model with monitoring data that will be collected during this period as part of project P2. The CSS Model upgrade will include development of refined rainfall data and impervious cover information to address runoff generation. The hydraulic elements of the model will be revised to reflect the appropriate storage, conveyance, and flows in the system due to the ELTCP projects. The model will be revised to include the capability to estimate impacts of the proposed sewer separation and green infrastructure projects in the Final LTCP.

Project/Initiative: P2 – Flow monitoring plan to support CSO model

Deliverable & Year: A flow monitoring plan of the CSO discharges related to key CSO projects and CSOs that require additional attention will be submitted at the end of 2015.

Scope: The Flow Monitoring Plan will identify aspects of the Final LTCP that will require flow monitoring data in order to properly calibrate and validate the CSS Model. This includes specific monitoring activities to measure the performance of the key CSO projects such as the Real Time Control System and Rockford Road projects. The monitoring plan will also include focused monitoring of areas in the CSS system that require further calibration to reduce the variability and uncertainty of the CSS model.

Project/Initiative: P3 – Modeling Plan to estimate CSO percent capture and Christina TMDL loads

Deliverable & Year: A plan of modeling activities and outputs to estimate the CSO percent capture and compliance with the Christina TMDL loads will be developed. The plan will be executed by the end of 2015.

Scope: The Modeling Plan will provide a list of activities to model the current and future performance of the CSS as it relates to the National CSO Policy and Christina TMDL. The plan will include approaches to modeling Final LTCP elements such as green infrastructure, new priority projects, and sewer separation.

Project/Initiative: P4– Develop Final LTCP benchmark/baseline for CSO discharges & reprioritization of outfalls

Deliverable & Year: A report providing the benchmark of the current CSO discharges and CSS performance due to completion of the ELTCP including prioritization of CSO outfalls based on their compliance with required TMDL loads, discharge volume, and discharge frequency will be provided by the end of 2017.

Scope: The prior ELTCP projects were developed based on addressing certain priority outfalls. However, in order to prioritize future projects and initiatives in the Final LTCP, the current CSS performance and CSO discharges require a new post ELTCP completion benchmark established. The outputs from the benchmarking effort may result in the reprioritization of CSO outfalls based on a number of factors such as TMDL load compliance, CSO discharge volume, and CSO discharge frequency.

4.2.6. Continued Compliance with NMC

As described earlier, the City will continue to implement its approved Nine Minimum Control Program. Periodic reports and updates will be provided to DNREC during the permit period. This includes requirements for sewer inspection and cleaning.

5. Glossary of Acronyms

CSO – Combined Sewer Overflow

CSS – Combined Sewer System

TMDL – Total Maximum Daily Load

WLA – Waste Load Allocation

EPA – Environmental Protection Agency

DNREC - Delaware Department of Natural Resources and Environmental Control

ELTCP – Enhanced Long Term Control Plan

FLTCP – Final Long Term Control Plan

WWTP – Wastewater Treatment Plant

RTCC – Real Time Control Center

SWMM – EPA Stormwater Management Model

MG – Million Gallons

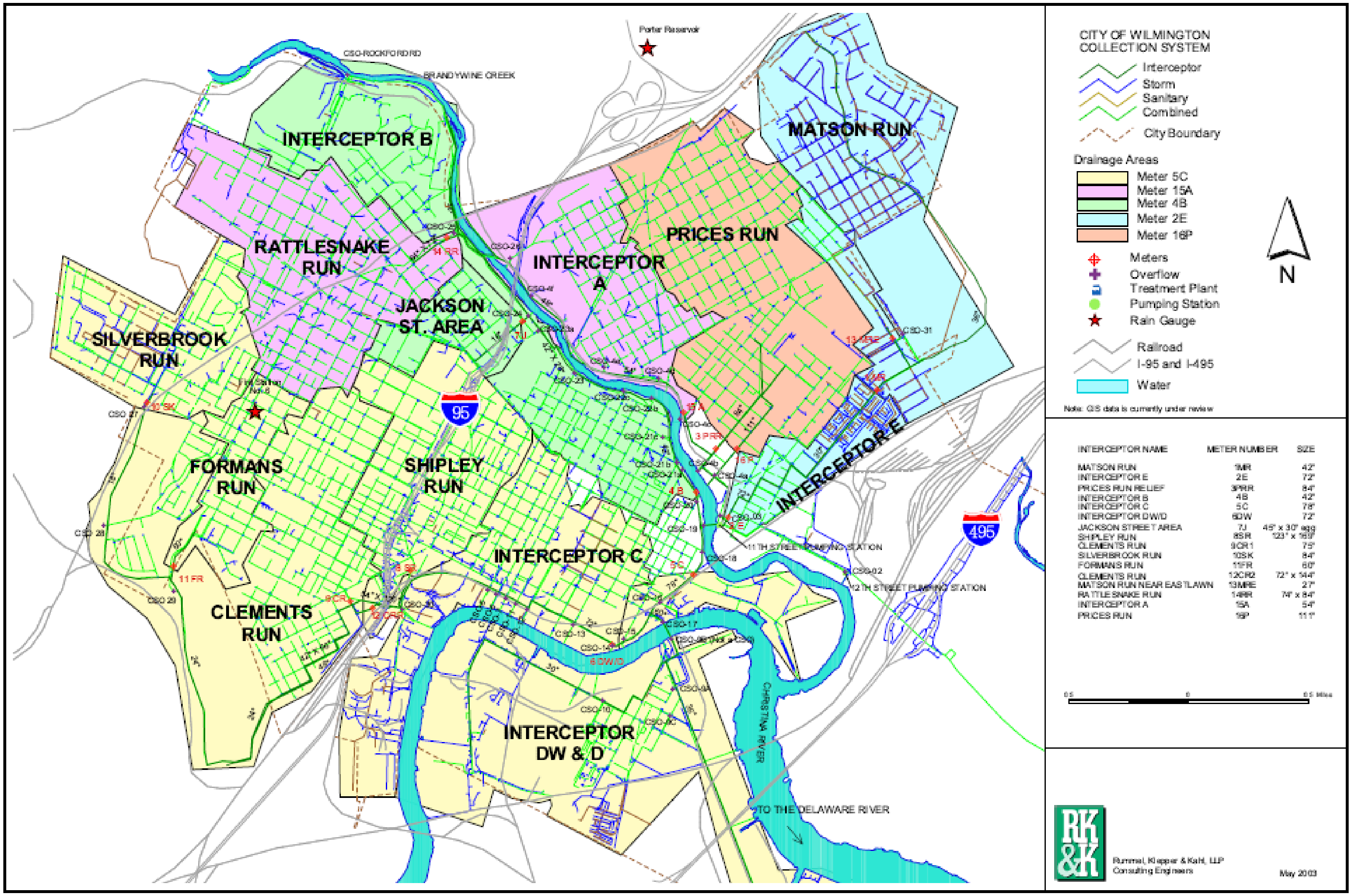
MGD – Million Gallons per Day

XP SWMM - Stormwater Management Model produced by XP Software

SCADA – Supervisory Control and Data Acquisition

6. Appendices

APPENDIX A: COMBINED SEWER SYSTEM INFORMATION


INTERCEPTOR B
RATTLESNAKE RUN
JACKSON ST. AREA
INTERCEPTOR A
PRICES RUN
MATSON RUN
SILVERBROOK RUN
FORMANS RUN
SHIPLEY RUN
INTERCEPTOR C
INTERCEPTOR E
CLEMENTS RUN
INTERCEPTOR DW & D
BRANDYWINE CREEK
CHRISTINA RIVER
TO THE DELAWARE RIVER
11TH STREET PUMPING STATION
12TH STREET PUMPING STATION
Porter Reservoir
95
495
CITY OF WILMINGTON COLLECTION SYSTEM
Interceptor
Storm
Sanitary
Combined
City Boundary
Drainage Areas
Meter 5C
Meter 15A
Meter 4B
Meter 2E
Meter 16P
Meters
Overflow
Treatment Plant
Pumping Station
Rain Gauge
Railroad
I-95 and I-495
Water
N
Note: GIS data is currently under review
INTERCEPTOR NAME | METER NUMBER | SIZE
MATSON RUN | 1MR | 42"
INTERCEPTOR E | 2E | 72"
PRICES RUN RELIEF | 3PRR | 84"
INTERCEPTOR B | 4B | 42"
INTERCEPTOR C | 5C | 78"
INTERCEPTOR DW/D | 6DW | 72"
JACKSON STREET AREA | 7J | 45" x 30" egg
SHIPLEY RUN | 8SR | 123" x 169"
CLEMENTS RUN | 9CR1 | 75"
SILVERBROOK RUN | 10SK | 84"
FORMANS RUN | 11FR | 60"
CLEMENTS RUN | 12CR2 | 72" x 144"
MATSON RUN NEAR EASTLAWN | 13MRE | 27"
RATTLESNAKE RUN | 14RR | 74" x 84"
INTERCEPTOR A | 15A | 54"
PRICES RUN | 16P | 111"
RK&K
Rummel, Klepper & Kahl, LLP
Consulting Engineers
May 2003