7.0 Recommendations

As required by the Consent Decree (CD), each Sewershed Study and Plan is required to identify specific improvements or other corrective actions needed to address deficiencies identified during the sewershed evaluation to aid in reducing rainfall dependent inflow and infiltration (RDI/I) contributing to sanitary sewer overflows (SSOs) or combined sewer overflows (CSOs); address deficiencies identified during the hydraulic analyses and address other deficiencies that contribute to SSOs or CSOs in the Low Level Sewershed. This section outlines how the data analysis, evaluation and the decision-making criteria were utilized to identify and prioritize improvements within the Low Level Sewershed.

7.1 Decision Making Criteria

As part of the sewershed studies, the City developed a condition and criticality protocol that provides a framework for a continuous rehabilitation strategy of all collection system components based on both criticality (consequence of failure) and condition (probability of failure). Assets whose failure can have large impacts on the community and the environment and whose condition is the poorest will receive a higher criticality rating and will receive attention sooner. Assets that receive a lower criticality rating will receive some level of continued monitoring but no immediate action or rehabilitation at this time.

The prioritization process consists of five steps illustrated below.

Step 1 - Identify the condition and criticality factors that will be used to assess the sewer system. These factors have been identified and include proximity to human population, to bodies of water, to forests, and to wildlife habitat that could potentially be affected by a sewer system failure.

Step 2 - Collect data that will be used to evaluate each factor including CCTV inspection data, manhole inspection data, pumping station inspection data, GIS data, results of hydraulic modeling, and sewer complaint data.

Step 3 - Assign different levels to each factor so that pipes, manholes, and pumping stations can be differentiated in terms of their condition or criticality.

Step 4 - Assign a condition and criticality rating for each pipe, manhole and pumping station. The ratings are assigned by using the level assigned to each factor and the relative importance of each factor.

Step 5 - Use the ratings to prioritize the system and determine short-term and long-term rehabilitation projects.

For each category, factors will be used to measure the criticality and condition of every asset. Table 7.1.1 below lists the condition and criticality categories and factors that were considered.

Table 7.1.1 – Condition and Criticality Factors

Criticality Category	Criticality Factor
Quantity of Flow Conveyed	Pipe Diameter Pumping Station Capacity
Transportation/Urban Impact	Proximity to Historic Areas Proximity to Community Areas (Parks, Schools, Etc.) Traffic Conditions Proximity to Railroad Easements
Environmental Impact	Proximity to Forested Areas Proximity to Waterways / Streams Proximity to Wetlands
Public Health Impact	Population Density Proximity to Floodplains SCADA / Warning Systems
Ease of Emergency Repair	Accessibility Ability to Re-route Flow Proximity to City Conduits Building Encroachment System Redundancy Emergency Power Ability to Bypass Flow Pipe Depth
Condition Category	**Condition Factor**
Structural Condition	Structural Pipe Rating Manhole Inspection Rating
Maintenance Frequency	O&M Pipe Rating Number of SSOs or CSOs Known Maintenance Issues Documented RDI/I Rates
Capacity	Need for Additional Capacity

Each condition and criticality factor is assigned a rating from 1 to 5. The purpose of assigning ratings to each condition and criticality factor is to differentiate sewer pipes, manholes, and pumping stations in terms of the consequences and probability of their failure.

The rating assigned increases as the consequence of failure or probability of failure increases. For example, a break in a 24-inch diameter interceptor sewer can result in more wastewater being released than a break in an 8-inch diameter collector sewer. Therefore, the larger diameter pipe has a higher criticality rating based on the amount of flow being conveyed. The 24-inch diameter interceptor sewer would be assigned a higher rating (5) for the 'Quantity of Flow Conveyed' criticality factor and the 8-inch diameter collector sewer would be assigned a lower rating (1) for the same factor.

After the individual factor ratings are assigned, an overall criticality rating and an overall condition rating is calculated for each system component. The criticality rating is calculated using the highest individual level assigned to any of the criticality factors within each Criticality

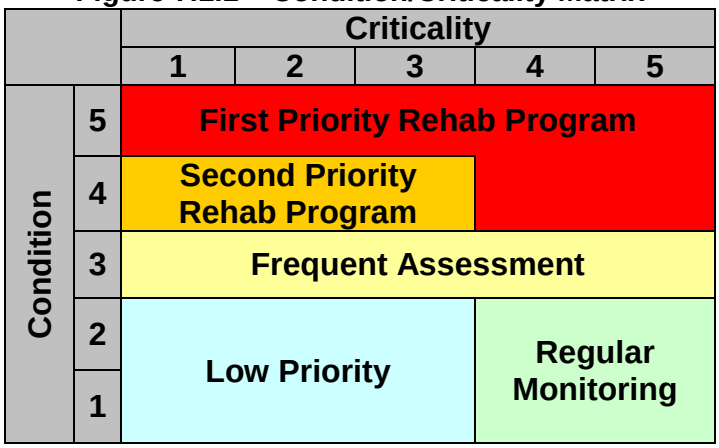
Category multiplied by a relative importance value. The condition rating is equal to the highest individual NASSCO PACP or MACP rating assigned to any of the condition factors. The relative importance value for the criticality rating is the weighting, expressed as a percentage, applied to each criticality factor to calculate an overall rating. The relative importance values are the same for each collection system component and are presented in Table 7.1.2.

Table 7.1.2 – Criticality Factor Relative Importance Values

Criticality Factors	Relative Importance Value
Quantity of Flow Conveyed	30%
Transportation/Urban Impact	15%
Environmental Impact	20%
Public Health Impact	15%
Ease of Emergency Repair	20%
Total:	**100%**

The final assessment culminates in a rating of 1 through 5 for criticality and utilizing NASSCO's MACP or PACP, a 1 through 5 rating for condition, which determines priorities for repairs or continuous condition assessment or monitoring. This approach allows the City to focus their available resources and funding on the most immediate system repair needs. Figure 7.1.1 is a matrix showing the recommended course of action for each sewer system component based on the combination of condition and criticality. The vertical 1 through 5 rating scale is for condition and the horizontal 1 through 5 scale is a rating for an asset's criticality within the collection system.

Figure 7.1.1 – Condition/Criticality Matrix



Each of the recommended courses of action is briefly described in more detail below. The specific improvement projects and/or other corrective actions will vary based on the type of collection system component (gravity sewer, force main, manhole, or pumping station).

First Priority Rehabilitation Program
Assets that receive a condition rating of 5 regardless of criticality, and assets that receive a condition rating of 4 and criticality rating of 4 and 5 are placed at the highest priority for rehabilitation, repair or replacement. These assets lack hydraulic capacity, contribute to system inflow and infiltration (I/I) and/or are likely to fail in the near future. They present the potential for SSOs or could create a major disruption in service and potentially impact the environment and/or public health if not addressed.

Second Priority Rehabilitation Program
Assets that receive a condition rating of 4 and criticality rating of 1, 2, or 3 will be given second priority in the rehabilitation program. These assets contribute to system I/I, and are likely to continue to deteriorate and to require attention in the foreseeable future.

Frequent Assessment
Assets that are in fair physical condition (PACP/MACP condition rating of 3), should have their condition assessed frequently, every 2 to 3 years regardless of the criticality rating. The purpose of frequent assessment is to check if the condition has deteriorated to a point that the asset would need to be moved to a higher priority.

Regular Monitoring
The assets in the regular monitoring category are typically in serviceable condition (PACP/MACP condition rating of 1 or 2), but received a high criticality rating of 4 or 5. These assets should be checked every 3 to 5 years.

Low Priority
The low priority category includes assets that are believed to be in good condition (PACP/MACP condition rating of 1 to 2), and received a lower criticality rating of 1 through 3. The assets in this category will receive some level of inspection (once every 5 to 10 years) to verify that their conditions are not continuing to deteriorate.

7.2 Proposed Improvements

It should be noted that the interrelationship between the City's sewersheds, known as boundary conditions, must be understood and carefully considered before significant hydraulic repairs are completed. The Jones Falls, Herring Run, High Level, Low Level, and Dundalk sewersheds flow into the Outfall sewershed. These six sewersheds are connected and hydraulically interdependent, creating "boundary" conditions that must be defined and considered for hydraulic modeling. Ultimately, the collection system within the six interdependent sewersheds should be modeled as one. The City has begun development of a model to accomplish the system-wide modeling, which will be refined and improved as the individual sewershed studies complete calibration of their respective sewershed models. This Plan provides certain recommended improvements that would be implemented by the City in accordance with a proposed schedule. However, the Plan should not be considered final and may require amendment as necessary once the system-wide hydraulic model is completed and system-wide simulations are performed. System-wide simulations could alter the recommendations identified by an individual Sewershed Study and Plan.

Once the sewer system improvement projects and/or other corrective actions required to address deficiencies were identified and ranked based on the criticality and condition ratings; assets that received a condition rating of 5, regardless of criticality, were included in a “First Priority” corrective action plan. Assets that had a condition rating of 4 and a criticality rating of 4 or 5 were also included in a “First Priority” corrective action plan. Assets that received a condition rating of 4, but were not considered to be as critical (3 or less) were included in the “Second Priority” corrective action plan.

Asset prioritization was developed with consideration that all proposed improvement projects required to eliminate SSOs must be completed before January 01, 2016 as stipulated by the CD. These assets included First and Second Priority manholes and sanitary sewers, identified SSO structures, and recommended hydraulic improvements to the collection system. These proposed improvement projects are as follows:

7.2.1 Sanitary Sewer Overflow Structure Identification and Elimination

As a requirement of the City’s CD, the Sewershed Study and Plan is required to identify undocumented SSO structures. No undocumented SSO structures were discovered during the Low Level Sewershed investigation.

7.2.2 Structural Deficiencies Identified

Proposed Manhole Improvements:
Table 7.2.2.1 shows a listing of all manholes inspected within the Low Level Sewershed based on the results of the Condition and Criticality rankings. The manholes that received a final assessment of “First Priority” or “Second Priority” are recommended for repairs as part of the rehabilitation program.

Table 7.2.2.1 – Manhole Condition and Criticality Assessment

Final Condition and Criticality Assessment	No.	%
Low Priority	702	11%
Regular Monitoring	0	0%
Frequent Assessment	4,865	75%
Second Priority Rehabilitation	389	6%
First Priority Rehabilitation	138	2%
“Could Not Locate” (CNL) Manholes	408	6%
TOTAL MANHOLES	**6,502**	**100%**

CNL Manholes were not assigned a Condition and Criticality Assessment Score as no valid condition data was available. Manholes that were identified as abandoned or non-sewer assets are not included in the totals.

Proposed Sanitary Sewer Improvements:
Table 7.2.2.2 shows the length of the sanitary sewers located within the Low Level Sewershed and their respective Condition and Criticality rankings. The PACP quick ratings for each pipe were converted to a single pipe rating by summing the segment grade scores for the two highest defect grades per the methodology used in the BaSES manual.

Each sewer receiving an initial First or Second Priority ranking was then examined in detail to determine the proper rehabilitation technique for each pipe segment. This review identified numerous sewers that were identified as First or Second Priority sewers that had been placed in those categories due to types of defects that could not be directly addressed using point repairs or cured-in-place-pipe lining, such as settled deposits, minor obstructions and other defects that would be addressed through a system cleaning. A total of 76 lengths were identified in this evaluation and were re-rated as Frequent Assessment lengths and should be inspected according to the requirements of that category. Similarly, sewers that were initially rated Low Priority, Regular Monitoring or Frequent Assessment were screened to determine if any of these sewers had specific defects that could escalate to a pipe failure condition. A total of 39 lengths were identified with these serious defects and were re-rated as First Priority lengths.

Table 7.2.2.2 - Sanitary Sewer Condition and Criticality Assessment

Final Assessment	LF	%
Low Priority	580,386	54%
Regular Monitoring	53,874	5%
Frequent Assessment	305,927	29%
Second Priority Rehabilitation	20,802	2%
First Priority Rehabilitation	112,501	10%
Total LF	**1,073,490**	**100%**

Note that the total lengths included here do not include pipes which will not be inspected due to easement considerations, were abandoned, were identified as non-sewer assets or other approved reasons.

7.2.3 Proposed Low Level Collection System Hydraulic Improvements

The 2-year, 24-hour storm event is used as the baseline for establishing the minimum hydraulic improvements that are required to eliminate SSOs in the Low Level Sewershed. Details on improvements required to address SSOs for other return period storm events can be found in Section 5.0 and in Attachment 5.4.1 – Low Level Sewershed Alternatives Analysis and Recommendations Report. For the 2-year storm, 3.5 million gallons of SSOs are predicted for the Low Level Sewershed in the Gwynn's Falls Area, the Locust Point Area, the East Low Level Area and the North Central Area of the sewershed. The recommended improvements for the identified overflows are described in the following sections and can be seen on Map 7.2.3.

General Improvements
System Cleaning: To restore lost capacity to the collection system, the system will be cleaned of all sediment and debris. It is estimated that system cleaning will reduce the 2-year design storm SSO volumes by about 600,000 gallons. The cleaning is anticipated to remove approximately 4,700 tons of sediment and debris from the collection system. In general, the areas with more

significant sediment levels are along the lower portions of the East and West Interceptors and in collection pipeline adjacent to the interceptors.

Reduce the Operating Water Level in the Eastern Avenue Pumping Station (EAPS) by 2 Feet: Currently, and including the on-going upgrades to the control strategy and instrumentation at the pumping station, the EAPS operates at a very high water level. This high water level results in high backwater effects on the collection system and can be a cause of sedimentation in the pipes and surcharging of sections of the system. Dropping the water level at EAPS would provide a larger volume of system storage to manage peak flows and would reduce the required length of West Interceptor upsizing. It is assumed that the change in operating water level would be primarily a control system programming effort. However, the impact of the water level change would need to be evaluated for impacts to pump hydraulics (e.g., NPSHA, etc).

Construct 10-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction in the vicinity of the Eastern Interceptor between Ellwood Street and Lindwood Street, approximately 810 feet of 10-inch parallel sewer will be installed. Seven manholes will be installed as part of this improvement.

Locate and Inspect CNL Manholes: The 408 manholes identified as “Could Not Locate” (CNL) will be located and inspected for inclusion in the City’s asset tracking database.

Gwynn’s Falls Area

Seal Manholes in the Gwynn’s Falls Floodplain: The floodplain adjacent to Gwynn’s Falls and in other low-lying areas often experiences both SSOs and flooding from inflow and infiltration due to high river levels during storm events. It is proposed that 77 manholes be sealed to prevent overflow of sewage from the collection system as well as to prevent direct inflow and infiltration of river water into the collection system during large storm events.

Upsize the West Interceptor: Approximately 2,800 feet of 33-inch and 36-inch pipe would be upsized to 54-inches and approximately 3,400 feet of 36-inch pipe would be upsized to 60-inches to provide additional capacity in the Western Interceptor. This improvement includes replacing 28 manholes along the interceptor.

CIPP Line All Sewer Pipes in 21 Subcatchments: 21 subcatchments in the Gwynn’s Falls area would be subjected to a system-wide CIPP lining and manhole rehabilitation program to reduce the overall wet weather flow from the subcatchments.

Upsize 8-Inch Pipe to 18-Inch Pipe: To eliminate a hydraulic restriction along Benson Avenue near DeSoto Road, approximately 130 feet of 8-inch pipe is proposed to be upsized to 18-inch pipe to match the surrounding pipes. Three manholes would be replaced as part of this improvement.

Upsize 10-Inch Pipe to 15-Inch Pipe: To eliminate a hydraulic restriction along the railroad near the intersection of Laurey and Severn Street, approximately 20 feet of 10-inch pipe is proposed to be upsized to 15-inch pipe.

Locust Point Area

CIPP Line All Sewer Pipes in 5 Subcatchments: Five subcatchments in the Locust Point area would be subjected to a system-wide CIPP lining and manhole rehabilitation program to reduce the overall wet weather flow from the subcatchments.

The total estimated cost for the improvements required to convey the 2-year event for the Low Level Sewershed is $29.3 million (2008 dollars).

7.3 Proposed Improvement Implementation Schedule

An implementation schedule for completion of the proposed SSO elimination and sewer system improvements has been developed as part of this project based on project cost, anticipated project duration, available manpower, and materials. In all cases, projects have been scheduled to minimize public impact and coordinated with other similar projects being conducted throughout the City. The implementation schedule was developed with consideration that all proposed improvements must be completed before January 1, 2016 as stipulated by the CD. The following schedules have been developed providing time to successfully complete the required work.

Manhole Rehabilitation:
The schedule provided in Table 7.3.1 represents a reasonable duration required for the City to select an engineering consultant to prepare the required design documents, advertise the project, select a contractor to complete the required repairs and have the effectiveness of the repairs evaluated.

Table 7.3.1 – Manhole Rehabilitation Implementation Schedule

Paragraph 9 Project	Project	Description	CD Milestone Dates		
			Advertise Project	Construction Complete	Evaluation Phase Completion
1	Sanitary Sewer Manhole First Priority Rehabilitation	Completion of First Priority Manhole Rehabilitation/ Replacement Projects Throughout the Low Level Sewershed	1/1/2012	1/1/2015	1/1/2016
1A	Sanitary Sewer Manhole Second Priority Rehabilitation	Completion of Second Priority Manhole Rehabilitation/ Replacement Projects Throughout the Low Level Sewershed	1/1/2013	1/1/2015	1/1/2016

Sanitary Sewer Rehabilitation:
The schedule provided in Table 7.3.2 represents a reasonable duration required for the City to select an engineering consultant to complete the required design documents, advertise the project, select a contractor to complete the work and have the effectiveness evaluated.

Table 7.3.2 – Sanitary Sewer Rehabilitation Implementation Schedule

Paragraph 9 Project	Project	Description	CD Milestone Dates		
			Advertise Project(s)	Construction Complete	Evaluation Phase Completion
2	First Priority Rehabilitation	CIPP, Point Repairs, and Combination CIPP/Point Repairs for First Priority	1/1/2012	1/1/2015	1/1/2016
2A	Second Priority Rehabilitation	CIPP, Point Repairs, and Combination CIPP/Point Repairs for Second Priority	1/1/2013	1/1/2015	1/1/2016

Hydraulic Improvements:
The schedule provided in Table 7.3.3 represents a reasonable duration for the City to select an engineering consultant to complete the required design documents, advertise the project, select a contractor, implement the required improvements and evaluate the effectiveness of the repairs. The improvements included in this list are those recommended to eliminate all SSOs as a result of the 2-year storm event.

Table 7.3.3 – Hydraulic Improvement Schedule

Paragraph 9 Project	Project	Description	CD Milestone Dates		
			Advertise Project	Construction Complete	Evaluation Phase Completion
3	Low Level Sewershed Cleaning	Cleaning Sediment and Debris from Low Level Sewershed Collection System	1/1/2012	1/1/2013	1/1/2014
4	EAPS Water Level Modifications	Revise SCADA System and Instruments to Operate EAPS 2-Feet Lower	7/1/2011	7/1/2012	7/1/2013
5	Seal Manholes Along Gwynn's Falls	Seal 77 Manholes Along Gwynn's Falls	7/1/2012	7/1/2013	7/1/2014
6	Various Pipe Upsizing and Installation	Upsizing of 8-Inch and 10-Inch Pipes (2 Locations for 150 LF) and installation of 10-inch relief sewer	1/1/2013	1/1/2014	1/1/2015
7	West Interceptor Capacity Increase	33-Inch and 36-Inch Replacement (6,200 LF)	1/1/2013	1/1/2015	12/31/2015
8	Gwynn's Falls I/I Reduction & Rehabilitation	CIPP Lining 21 Subcatchments	1/1/2013	1/1/2015	12/31/2015
9	Locust Point I/I Reduction & Rehabilitation	CIPP Lining 5 Subcatchments	1/1/2013	1/1/2015	1/1/2016
10	Locate and Inspect CNL Manholes	Locate and Inspect 408 Manholes In Low Level Sewershed	9/1/2014	7/1/2015	1/1/2016

7.4 Estimated Costs of Proposed Improvement Projects

To characterize expected costs for the collection system improvements necessary in the Low Level Sewershed, the City completed a review of information compiled from prior City projects for various types of repairs, rehabilitation and replacement of manholes and sanitary sewers. In addition costs were collected from RS Means literature and a national study of unit costs for a wide variety of repair/replacement options in locations throughout the United States. Once

compiled, the information was reviewed, compared and normalized for use in preparing reasonable estimates for the City's sewershed improvements.

The prices utilized in estimating these costs represent average unit costs that were derived from the sources identified. There was, however, some significant variability noted when comparing the unit costs developed by contractors bidding on the same project, and there was considerable variability when comparing these documented unit costs with other similar types of repair techniques employed on different projects. Such unit cost variability reflects both the site specific nature of each project as well as the normal variability typically associated with varying markets, project time constraints and other construction related considerations. While it is understood that site specific attributes will have an impact on final costs for a given rehabilitation/repair/replacement effort, it is the City's intent to ensure that all of the sewersheds use the same baseline cost assumptions for consistency and planning purposes. These fully-loaded costs are an attempt to capture all the relevant costs associated with a construction project such as mobilization, bypass pumping, site/paving restoration, and repair of other utilities, which can add significantly to the cost, but are typically required to complete the overall project.

7.4.1 Estimated Improvement Budget

The following section outlines the proposed costs utilizing fully-loaded cost data required to implement the First and Second Priority collection system improvements.

Estimated Manhole Rehabilitation Budget:
Table 7.4.1.1 summarizes the estimated 2008 costs required to rehabilitate all First and Second Priority sanitary sewer manholes identified in the Low Level collection system.

Table 7.4.1.1 – Estimated Manhole Rehabilitation Improvement Budget

First Priority Manholes				
Item	**Method**	**Unit Cost**	**Quantity (ea.)**	**Cost**
Manhole	Rehabilitation/Replacement	$3,719	138	$513,222
			Design, Const. Mgmt./Insp. Etc. (42%):	$215,553
			Total - First Priority MH's	$728,775
Second Priority Manholes				
Manhole	Rehabilitation/Replacement	$3,719	389	$1,446,691
			Estimated Design, Const. Mgmt./Insp. Etc. (42%):	$607,610
			Total - Second Priority MH's	$2,054,301
			Total Estimated First and Second Priority Manholes:	**$2,783,076**

Estimated Sanitary Sewer Rehabilitation Budget:
Table 7.4.1.2 summarizes the estimated 2008 costs required to rehabilitate all First and Second Priority sanitary sewers identified in the Low Level collection system.

Table 7.4.1.2 – Estimated Sewer Rehabilitation and Replacement Improvement Budget

First Priority Sewers					
Sewer Size	**Unit Cost (s)**		**Quantity (LF)**		**Cost**
CIPP Lining					
8" Sewer Lining:	$45		5,412		$243,554
8+" - 12" Sewer Lining:	$64		2,740		$175,331
12+" - 18" Sewer Lining:	$87		1,299		$112,985
18+" - 24" Sewer Lining:	$124		1,862		$230,947
24+" - 30" Sewer Lining:	$169		354		$59,891
30+" - 36" Sewer Lining:	$186		2,400		$446,416
54+" Sewer Lining"	$550		267		$146,691
Total CIPP Lining:			14,334		$1,415,816
Estimated Design, Const. Mgmt./Insp. Etc. (42%):					$594,643
Total First Priority CIPP Lining:					$2,010,459
Point Repairs (assume 10' repair)					
8" Point Repairs:	$378		660		$249,480
8+" - 12" Point Repairs:	$378		1,440		$544,320
12+" - 18" Point Repairs:	$378		280		$105,840
18+" - 24" Point Repairs:	$672		140		$94,080
24+" - 30" Point Repairs:	$841		860		$723,260
30+" -36" Point Repairs:	$988		410		$405,080
42+" - 48" Point Repairs:	$1,134		160		$181,440
48+" – 54" Point Repairs:	$1,197		70		$83,790
54+" Point Repairs:	$1,260		30		$37,800
Total Point Repairs:			4,050		$2,425,090
Estimated Design, Const. Mgmt./Insp. Etc. (42%):					$1,018,538
Total First Priority Spot Repairs:					$3,443,628
Point Repair & CIPP Lining					
	Point Repair	CIPP	Point Repair	CIPP	
8" Point Repairs/CIPP:	$378	$45	110	1,087	$90,513
8+" - 12" Point Repairs/CIPP:	$378	$64	190	2,117	$207,320
12+" - 18" Point Repairs/CIPP:	$378	$87	20	224	$27,010
Total Point/CIPP Repairs:			320	3,428	$324,843
Estimated Design, Const. Mgmt./Insp. Etc. (42%):					$136,434
Total First Priority Point/CIPP Repairs:					$461,277
Total Estimated First Priority Sewers:					**$5,915,364**

Table 7.4.1.2 – Estimated Sewer Rehabilitation and Replacement Improvement Budget (continued)

Second Priority Sewers					
Sewer Size	**Unit Cost (s)**		**Quantity (LF)**		**Cost**
CIPP Lining					
8" Sewer Lining:	$45		4,425		$199,134
8+" - 12" Sewer Lining:	$64		1,562		$99,994
12+" - 18" Sewer Lining:	$87		167		$14,494
Total CIPP Lining:			6,154		$313,621
Estimated Design, Const. Mgmt./Insp. Etc. (42%):					$131,721
Total Second Priority CIPP Lining:					$445,343
Point Repairs (assume 10' repair)					
8" Point Repair:	$378		650		$245,700
8+" - 12" Point Repairs:	$378		300		$113,400
12+" - 18" Point Repairs:	$378		90		$34,020
18+" - 24" Point Repairs:	$672		80		$53,760
24+" - 30" Point Repairs:	$841		30		$25,230
Total Point Repairs:			1150		$472,110
Estimated Design, Const. Mgmt./Insp. Etc. (42%):					$198,286
Total Second Priority Spot Repairs:					$670,396
Point Repair & CIPP Lining					
	Point Repair	CIPP	Point Repair	CIPP	
8" Point Repair/CIPP:	$378	$45	200	2,953	$208,490
8+" - 12" Point Repairs/CIPP:	$378	$64	40	621	$54,847
18+" - 24" Point Repairs/CIPP:	$672	$124	20	235	$42,599
Total Point/CIPP Repairs:			260	3,809	$305,936
Estimated Design, Const. Mgmt./Insp. Etc. (42%):					$128,493
Total Second Priority Point/CIPP Repairs:					$434,429
Total Estimated Second Priority Sewers:					**$1,550,167**
Total Estimated First and Second Priority Sewers:					**$7,465,532**

Estimated Hydraulic Improvement Budget:
Table 7.4.1.3 contains the estimated 2008 costs required to complete the hydraulic improvements for the 2-year storm event in the Low Level Sewershed.

Table 7.4.1.3 – Estimated Hydraulic Improvement Budget

Improvement	Unit Cost	Hydraulic Improvements	
		Qty.	Total Cost
CIPP Lining (LF)			
MH Rehab (ea)	$3,719	374	$1,390,906
<8-inches	$45	27,789	$1,250,501
9-12 inches	$64	4,902	$313,734
13-18 inches	$87	5,276	$458,999
19-24 inches	$124	8,271	$1,025,576
25-30 inches	$169	6,756	$1,141,766
31-36 inches	$186	1,503	$279,535
49-54 inches	$495	55	$27,172
Pipe Replacement (LF)			
New MH (ea)	$3,719	27	$100,413
9-12 inches	$495	810	$400,950
13-18 inches	$585	150	$87,750
49-54 inches	$1,800	2,793	$5,027,400
>54 inches	$1,890	3,393	$6,412,770
Clean System	$500/T	4,656	$2,327,778
Seal Manholes (ea)	$1,240	77	$95,454
EAPS Water Level Drop	$25,000	1	$25,000
Locate/Inspect CNL Manholes (ea)	$700	408	$285,600
	SUBTOTAL		**$20,651,303**
Estimated Eng. Design, Const. Mgmt./Insp., Admin., Post Eng. Services & Cont. (42%)			$8,673,547
Total Estimated Hydraulic Improvement Costs:			**$29,324,850**

The combined total costs associated with completing the First and Second Priority manhole and sewer system repairs, and the hydraulic improvements to the conveyance system in the Low Level Sewershed are estimated to be approximately $39,573,000.

7.5 Sewershed Re-Inspection Program

Per the requirements of the CD, the City's Low Level Sewershed collection system needs to be re-inspected by January 1, 2016. The following sections outline the requirements of the re-inspection program and provide a general schedule to complete this work.

7.5.1 Re-Inspection Prioritization Scheme

The City's condition and criticality protocol provides a framework for a continuous rehabilitation strategy of all collection system components based on both criticality (consequence of failure) and condition (probability of failure). Assets whose failure can have large impacts on the community and the environment and whose condition is the poorest will receive a higher criticality and condition rating and will receive attention in a more timely manner. Assets that receive a lower criticality and condition rating will receive some level of continued monitoring as recommended herein but no immediate action or rehabilitation. Refer to Section 7.1 Decision Making Criteria for details. The following sections detail the requirements of future inspection programs.

7.5.2 CCTV and Manhole Inspections

The implementation schedule provided includes provisions for the re-inspection of each of the Low Level Sewershed collection system components by January 1, 2016. The proposed re-inspection schedule includes provisions for, but is not necessarily limited to, a prioritization scheme for further inspection of collection system components based on the following criteria:

1) Prior identification of system defects, prior NASSCO PACP or MACP rating codes, grease blockages, root intrusion or system complaint data.
2) Prior criticality and condition ratings.
3) Expected life cycle of system components.
4) Estimated rate of existing or potential inflow and/or infiltration.
5) Scheduled rehabilitation or other corrective action of a system component; and the predetermined re-inspection frequency of a collection system component.

Current sewershed studies are scheduled to be completed between January 2009 and July 2010. Following these studies, the City intends to implement a continuous CCTV and manhole inspection program aimed at re-inspecting all gravity sewers 8-inches and larger, and all force mains, pumping stations, manholes and other sewer structures by January 1, 2016. The planned re-inspection activities will be prioritized based on the condition and criticality factors determined during this project.

The implementation schedule for re-inspection of these sewershed system components is outlined in Table 7.5.2.1:

Table 7.5.2.1 - Sewershed Re-Inspection Implementation Schedule

Task	Duration (Yrs.)	Start Date	End Date	2011	2012	2013	2014	2015	2016
Manhole Inspections	3 1/2	7/1/2012	12/31/2015						January 1, 2016
Analysis and Report	1 1/2	7/1/2014	12/31/2015						
Pumping Station Insp.	1/2	1/1/2014	6/30/2014						
Analysis and Report	1/2	7/1/2014	12/31/2014						
Force Main Inspections	1	7/1/2014	6/30/2015						
Analysis and Report	1/2	7/1/2015	12/31/2015						
Sewer Inspections	3 1/2	7/1/2012	12/31/2015						
Analysis and Report	1 1/2	7/1/2014	12/31/2015						

Based on the condition of the assets observed during this study, manholes and sewers that received higher condition and criticality rating scores were recommended for inclusion on the First and Second Priority corrective action plan. Once rehabilitated, these manholes and sewers should be placed on a “Low Priority” inspection program with regular inspections occurring once every 5 to 10 years. The manholes and sewers that received condition ratings of 3 were classified as requiring “Frequent Assessment” under the condition and criticality rating system and should be inspected on regular 2-3 year inspection intervals to ensure the continuity of the collection system. Manholes and sewer segments that are currently in serviceable condition but received higher criticality ratings were identified as requiring “Regular Monitoring” and should be inspected every 3-5 years. Based on the results of those inspections, any manholes and/or sewers that have continued to deteriorate to a point that requires repair should be repaired on an as-needed basis to address specific problems or deficiencies that have occurred.

As part of the ongoing manhole inspection program, it is recommended that a field crew be assigned to investigate manholes that could not be located during this study and to inspect them if possible. These manhole inspections are included in the hydraulic upgrade costs and are identified in the hydraulic improvements schedule. To date, 408 manholes were designated as “CNL” (could not locate) and are shown on Table 7.2.2.1 and listed in Appendix 4.2.1.

7.6 Future Data Collection and Evaluation Services

As required by the CD, under Paragraph 9-C-xii, the City will be required to implement several continuous data collection programs in order to assess the effectiveness of the rehabilitation

programs and other O&M enhancement efforts within the sewershed. These programs will be comprehensive, system-wide initiatives that will include a long-term flow monitoring plan, a sewer cleaning program, CCTV and manhole inspection programs and root control and grease control programs. These are discussed in more detail in the following sections.

7.6.1 Long-Term Flow Monitoring Plan

In 2006 the City of Baltimore implemented a comprehensive flow monitoring program for the purpose of evaluating the severity of infiltration and inflow and for calibration of the hydraulic model. This comprehensive program consisted of a network of about 350 flow meters, 20 rain gauges, 33 groundwater monitoring stations and extended for a period of one year from May 2006 through May 2007. In May 2007, the network was reduced to about 100 flow meters that were placed at key points and junctions in the collection system for the purpose of long term assessment and continuous calibration of the hydraulic model. All 20 rain gauges remained in operation. The City plans to continue monitoring the flows in order to assess the effectiveness of the on-going and future rehabilitation and O&M enhancement programs.

7.6.2 Sewer Cleaning Program

The effectiveness of a sewer conveyance system is largely dependent on its ability to convey the flows generated within the sewer basin without surcharging the system to a point where overflows occur. As part of the sewer inspection program completed for this study, all sewers that were inspected were also cleaned. The intent of the cleaning was to clean the sewer so the inspections could identify defects that otherwise would not be visible during the inspection and to remove debris from the sewer to restore the sewer to at least 95% of its original carrying capacity. When significant restrictions such as roots or other debris was encountered, heavy cleaning was utilized to restore the capacity of the sewers and allow for internal inspection. Heavy cleaning involved root cutting, grease removal and/or additional passes of the hydro-cleaning equipment to remove heavy accumulations of sediment and debris. All debris was removed from the sewers and disposed of at an approved disposal site. When significant blockages were encountered that could not be addressed by cleaning operations, they were reported to the City and the City promptly coordinated with the wastewater maintenance division or their on-call contractor to resolve the deficiency.

Based on the cleaning work completed during this project and observations from the inspection work completed, it is recommended that sewers which contain heavy accumulations of grease, debris and/or roots, large interceptor sewers, sewer siphons, and sewers with velocities less than 3 feet per second (fps) should be cleaned on regular 5 year intervals. These cleaning operations should be closely coordinated with the sewer re-inspection program, which needs to be completed by January 1, 2016 and prioritized based on condition and criticality rating factors that were determined during the inspections described in Section 7.1. Under normal operating conditions, the remaining sewers should not require additional cleaning between the 5 to 10 year Low Priority sewer inspection cycles.

7.6.3 CCTV and Manhole Inspection Programs

The City also intends to implement continuous citywide CCTV and manhole inspection programs following the completion of the CD sewershed studies, which are scheduled to be completed between January 2009 and July 2010. These programs will be aimed at re-inspecting all gravity sewers 8-inches and larger in diameter, force mains, pumping stations, manholes and other sewer structures by January 1, 2016. The planned re-inspection activities will be prioritized based on each segment's condition and criticality ratings that were derived during the sewershed inspections described in Section 7.1 of this report.

Based on the results of the inspections completed during this sewershed study, the re-inspection schedule identified by the CD and the rehabilitation work which has been detailed as part of this plan, it is recommended that all PACP condition grade 1 and 2 sewers in the Low Level Sewershed be re-inspected in a 5 to 10 year range. All PACP condition grade 3 sewers should be re-inspected in 2 to 3 years to reassess their condition and assign appropriate repairs as needed.

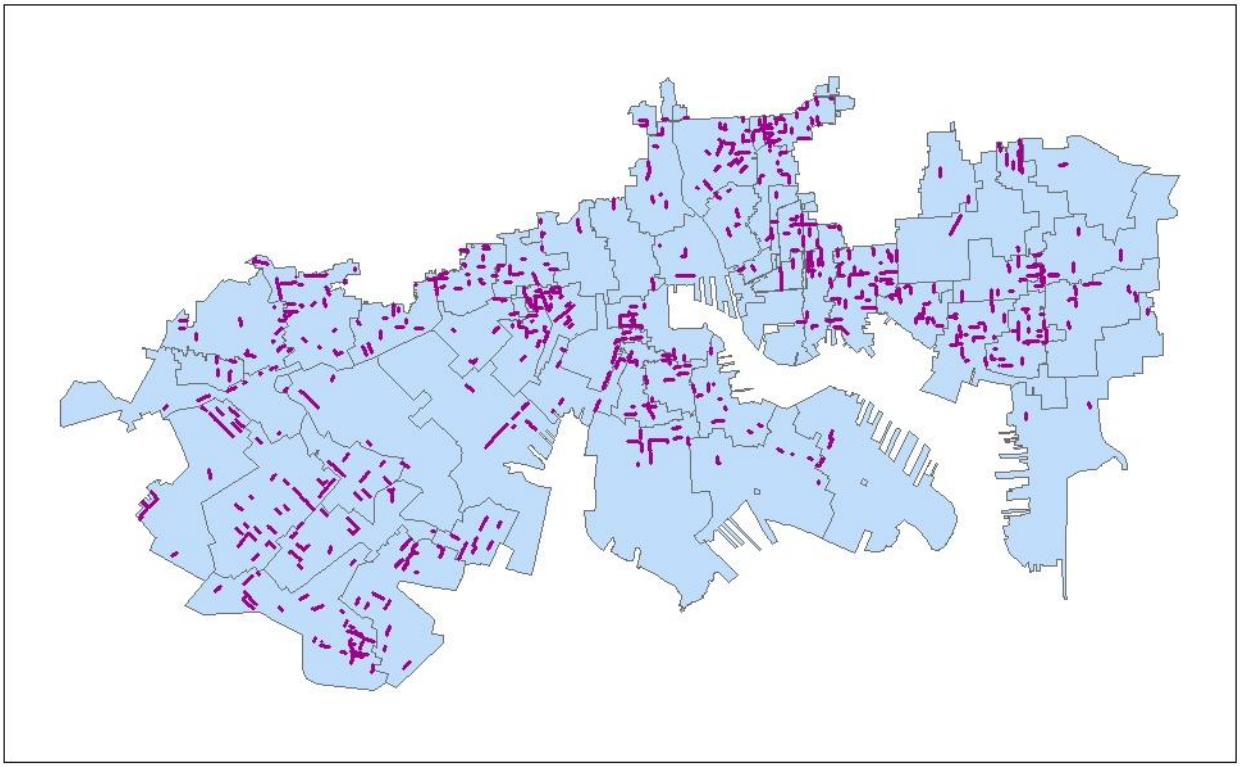
7.6.4 Root Control Program

In 2004, the City began monitoring the impacts of root infestation in their collection system by tracking and geocoding customer calls related to root problems in the sewer. In 2006, the City identified an area in the Herring Run Sewershed having severe root intrusion problems (approximately 1,500 acres, 230,000 linear feet of pipe). The City proceeded to implement a root control chemical application pilot project in this area in 2007, which included the treatment of approximately 150 house laterals and service connections. The pilot project yielded promising results. The City is therefore expanding the Root Control Program (RCP) into other areas of the collection system with documented root intrusion problems. A recent evaluation of customer calls in 2007 identified two additional areas with severe root infestation: one area in the Western Run section of the Jones Falls Sewershed, and the other in the Maidens Choice section of the Gwynn's Falls Sewershed.

To evaluate the effectiveness of the on-going root control program, other sources of information, such as CCTV and manhole inspections, will be used to validate and direct the root control efforts. The goal of the on-going RCP is to treat all areas of the collection system experiencing root infestation once every three to five years. The effectiveness of the RCP will be assessed by continued monitoring of the areas and continuous evaluation of customer complaint calls within these areas on a six month review basis.

Figure 7.6.4 shows the CCTV data indicating the pipe segments in the Low Level Sewershed that were observed to have medium, ball or tap roots intrusion. These various sewers represent over 140,000 linear feet of pipe ranging in diameter from 8-inches (the smallest pipe diameter examined using CCTV) to 74-inches. The areas with the most concentrated root intrusion reports, specifically the area surrounding Patterson Park, the north-central portion of the sewershed and the area to the northeast of Carroll Park, should be considered for inclusion in the on-going City RCP.

Figure 7.6.4 – Low Level Sewershed Root Analysis



7.6.5 Fats, Oils, and Grease Control Program

Similar to root infestation in the sewer system, the City also began assessing the impacts of Fats, Oils and Grease (FOG) in the collection system in 2004. The City geocoded and mapped all customer complaint calls related to FOG and identified five sections of the collection system where severe problems exist. Not surprisingly, these sections serve areas with numerous restaurants and/or food establishments, namely Little Italy and the Johns Hopkins Hospital area - where many restaurants serve the hospital community, and the upper reaches of the High Level Sewershed, which have numerous restaurants and a major mall with a food court. The City proceeded to outfit two of its newest sewer vac-trucks with de-greasing equipment and began treating the targeted areas in 2006. These areas are currently on a regular cleaning schedule and are addressed twice a year for grease. Baltimore will continue to evaluate customer complaint calls and utilize CCTV and manhole inspection data in order to assess and guide future activities of the FOG Program.