Water Infrastructure That Works for Cities

Best Practices and Considerations for Preparing Long Term Control Plans to Control Combined Sewer Overflows

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DISCLAIMER

This white paper has been prepared for New Jersey Future and is being made available to provide guidance to the New Jersey CSS regulated community. It is not intended to be an endorsement of any USEPA, NJDEP or other policies or guidance, but is intended to provide best practices associated with addressing the requirements of the final NJPDES CSO permit. This white paper has not been endorsed by USEPA or NJDEP. All long term control plans will be reviewed by the Department to determine compliance with applicable statutes, regulations and permits.

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Executive Summary

New Jersey's older urban communities will have to plan for the investment of significant resources to control combined sewer overflows (CSOs) and to comply with requirements of the New Jersey Department of Environmental Protection (NJDEP) and the U.S. Environmental Protection Agency (EPA). No new mandate is welcome or painless for the municipalities that maintain sewers and other parts of the collection system or the regional utilities or authorities that maintain interceptors and treatment plants.

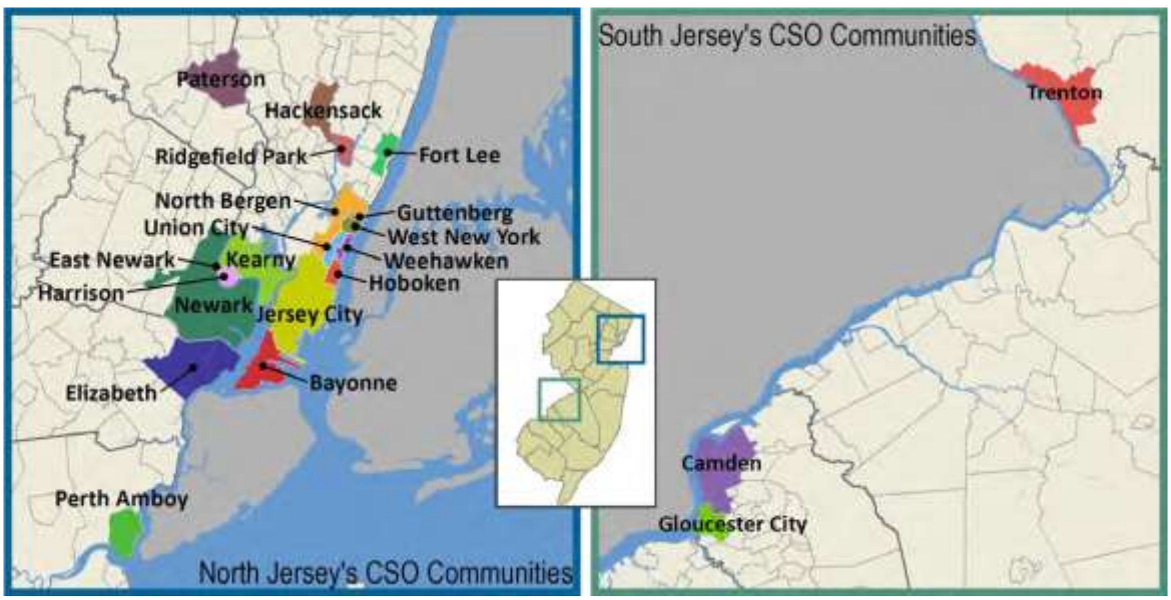
The next three to five years is a critical planning period for these capital improvements. A well run Long Term Control Plan (LTCP) process will minimize negative impacts and maximize the benefits of investing in community infrastructure. It is particularly important for communities to incorporate principles of benefit-cost decision frameworks, lifecycle cost analysis, prioritization, and transparent goal-setting into their LTCP develop in order to guide decisions and to facilitate a common understanding of challenges and opportunities. Similarly, principles of adaptive management, appropriate sequencing of work, comprehensive asset management to coordinate with existing or already planned capital work will help lower the overall costs of CSO controls over the decades-long. These techniques, which are described below, can help guide communities to invest in CSO controls that also have broad co-benefits, such as:

- CSO reductions and other water quality benefits;
- Recreational use of waters;
- Community economic development from waterfront development, with resulting tax and property value increases;
- Flooding control and insurance savings due to risk reduction;
- Cooling from planted areas and lower energy costs; and
- Neighborhood improvements from greening, with resulting tax and property value increases.

This white paper, along with the accompanying model request for proposals (RFP) for developing LTCPs, draws upon best practices from other communities across the country to provide New Jersey's leaders with the tools to develop smart alternatives that are allowable under EPA and NJDEP guidance and policies. It is not an exhaustive compendium of every LTCP completed to date, but rather a representative and diverse sample intended to spark creative thinking. Where best practices are contained in many plans, or conversely cannot be traced back to any published plan, then that is marked with a dash; unique practices are traced back to specific plans. This paper describes innovative "grey" infrastructure can provide cost-effective solutions to reduce the volume of CSOs, system optimization techniques can make the most of existing infrastructure, new "green" infrastructure techniques of engineered planted areas can create pocket parks, beautify playgrounds, and create more vibrant communities, and planning approaches that quantify all of the "co-benefits" that can be built into water quality programs. An LTCP that combines these elements in the way that fits each community will have more public support and will be more successful than more basic ways of meeting CSO control requirements.

Introduction

Mandatory investments to control Combined Sewer Overflows (CSOs) will ultimately involve large, unbudgeted costs for New Jersey municipalities. In this era of scarce public resources, municipalities and utilities must squeeze the most benefits possible out of their investments. This new reality puts a premium on coordinated solutions and multi-purpose infrastructure that will serve their primary function and also provide jobs, revitalize urban areas, improve health and safety, and advance sustainability, all in a measureable and cost-effective manner. Furthermore, these benefits must be readily apparent and clearly explained to garner support from ratepayers and taxpayers, many of whom are managing tight household budgets and all of whom are skeptical that public resources can be well-spent. The renewed focus on cities as attractive places to live and work, and the significant demographic trend of urban migrations, provide an opportunity to nest CSO controls within a larger strategy of urban revitalization. This white paper provides a roadmap for leaders to make the case for obtaining the greatest and broadest benefits from the CSO Long Term Control Plan (LTCP) process.



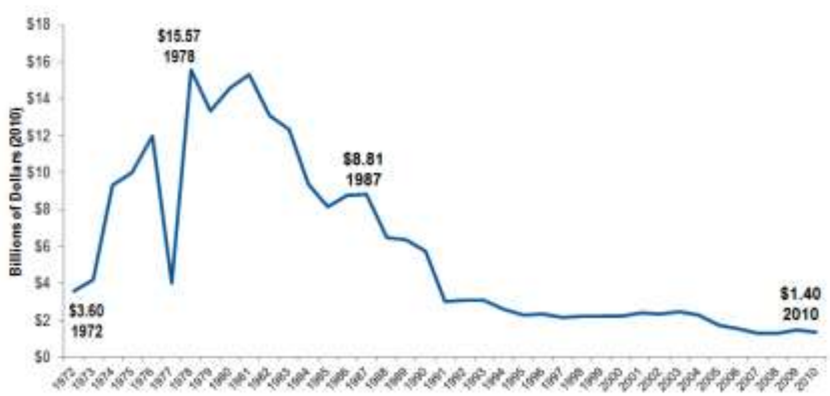
CSOs and Other Urban infrastructure Needs

Combined sewer systems (CSS) were introduced shortly after the invention of flush toilets in the mid-1800s and improved urban stormwater and wastewater management immediately over the ditch and cesspool systems then in use.[1] Most cities in the United States that were highly developed from this period to the mid-1900s installed CSS, including much of New England, the mid-Atlantic States, and the upper Midwest. Well over 40 million people in 32 states live in cities with CSS[2] and controls must be adopted or enhanced in over 772 cities.[3] While CSS are a proven technology, most are old and in need of repair and, more fundamentally, the design results in overflows during storms that will increase with predicted greater rainfall from climate change.

CSS are subject to extensive regulatory mandates. In 1989 Congress passed a statute extending the Clean Water Act to CSS, in 1994 the EPA promulgated a CSO Control Policy, and numerous consent decrees and permits since that time have imposed controls that have already required billions of dollars for planning, design, and construction of CSO controls. These costs have increased, not decreased, over time. In 2000, the EPA projected that municipalities and utilities would need $50.6 billion for CSO controls over 20 years.[4] Despite billions in investments already made, such as for storage tunnels, the EPA's 2008 needs projection grew to $63.6 billion for CSO-related repairs and upgrades.[5] New Jersey alone has over $9.3 billion in estimated CSO needs, which is the second highest need of any state, and an 83% increase over its needs just four years earlier.[6] Clearly, delaying action only increases costs.

However, the higher standards for CSO controls coincided with a sharp decrease in federal funding. In the late 1980s Congress discontinued the federal grants program that was used to fund implementation of the Clean Water Act during its first 20 years. Since then Congress has provided block grants to states that, in turn, provide loans to municipalities and utilities through State Revolving Funds. However favorable the terms, loans must be repaid and impose significant financial pressure not encountered in the grant era. Furthermore the loan programs cannot meet all needs, as Congress has cut the value of the grants.

Federal Spending on Clean Water Act Implementation



Source: NACWA Money Matters - Two Sides of the Same Coin: Increased Investment & Regulatory Prioritization (2011)

Municipalities and utilities must of course also invest in infrastructure other than CSO controls. A comprehensive study is difficult to find but comparisons of needs assessed in different years still show the daunting scale of the challenge. According to EPA's 2008 study, in addition to CSO needs of $63.6 billion, another $234.5 billion is needed for other clean water needs, including stormwater management programs, wastewater treatment plant upgrades, and new sewer pipes.[7] A 2013 study showed needs of $384 billion for drinking water infrastructure over the next 20 years, including the replacement and upgrade of thousands of miles of pipes and thousands of treatment plants, storage tanks and water distribution systems.[8] This represents a significant increase over the $334.8 billion needed for such infrastructure identified in a 2007 report.

Using a different methodology – the amount needed just to keep infrastructure in a state of good repair, i.e., in workable and functioning condition – the American Society of Civil Engineers reported overall infrastructure needs of $3.6 *trillion* in 2013, including $126 billion for water/wastewater infrastructure.

ASCE 2013 Report Card for America's Infrastructure: Costs to Maintain Current "State of Good Repair"

Category	Total Needs ($ billions)
Surface Transportation	1,723
Electricity	736
Schools	391
Public Parks and Recreation	238
Airports	134
Water/Wastewater Infrastructure	126
Rail	100
Hazardous and Solid Waste	56
Levees	80
Inland Waterways and Marine Ports	30
Dams	21
Total	3,635
Yearly Investment Needed	454

These costs do not reflect increasing costs of repair from extreme weather and natural disasters, nor the needs to make our cities and infrastructure resilient against sea level rise or other effects of climate change. Just over the last few years, such costs have increased dramatically, as measured solely by Federal disaster expenditures.

Congressional Funding for Disasters (FY11-FY13)

Fiscal year appropriations or supplementals	Estimated disaster relief spending ($ billions)
FY 2011	21.38
FY 2012	32.41
FY 2012 Supp.	8.17
FY 2013	14.32*
FY 2013 Supp.	60.21*
Total	136.49

*Before sequestration cuts

While these financial challenges are daunting, maintaining existing infrastructure represents a good investment that is necessary to accommodate and facilitate the ongoing migration of the U.S. population to cities and to facilitate an improved tax base. For example, from July 2013 to July 2014, over $394 billion was invested by private parties to develop or redevelop U.S. real estate.[9] This amount of private investment in just one year is nearly equal to the annual public investment needed for all infrastructure according to ASCE or the 20-year need for clean water investments identified in the EPA survey. Increasingly, these investments are being used to build vibrant urban cores of transit-oriented, walkable, mixed-use, and round-the-clock communities.

Multi-functional Stormwater Park Anchoring Urban Revitalization in Historic Fourth Ward, Atlanta, GA

The mutually reinforcing connections between infrastructure investments, environmental protection, and the long-term sustainability of cities has led to the adoption of municipal sustainability plans and programs over the past decade. One professional organization counts over 120 urban sustainability directors in the United States.[10] These programs facilitate agency cross-collaboration on solutions that solve multiple problems, including climate change, public health, energy efficient, air pollution, transportation, and of course water pollution. Local, comprehensive approach to sustainability include Newark's Sustainability Action Plan,[11] Sustainable Hoboken,[12] TrentonGreen[13] and Bridgeport's BGreen 2020[14] programs.

Long Term Control Plans for CSOs

New Jersey municipalities have extensive experience in planning. Euclidian zoning and zoning plans have existed for nearly a century and set the basic framework for land use and real estate development in cities. Sustainability plans, as discussed above, have existed for less than a decade but have a similarly sweeping scope that affects built infrastructure of all varieties. Cities also employ specific plans to deal with issues from capital investments to be made in the near and medium future, traffic management, demographics, specific capital projects, and solid waste policies. At its best, municipal planning involves developing a shared vision, prioritizing or allocating resources and rights for the best possible societal outcome, and balancing economic development, environmental impacts, and equity through full stakeholder engagement.

New Jersey municipalities do not, however, have experience with mandatory planning to control CSOs, a technical process of developing Long Term Control Plans (LTCPs) under close supervision by EPA and NJDEP. LTCPs deal with a very narrow issue, the long term control of CSOs. However, municipalities can and should apply their long-standing planning traditions used to protect public welfare in a manner that is inclusive, transparent, data-driven, and coordinated with existing, related land use and policy frameworks, including more traditional planning authorities, land use and building code review authorities, and transportation and park operations. Coordinating LTCP with these more typical, traditional responsibilities. In fact, the EPA's CSO Control Policy encourages "municipalities, permitting authorities, water quality authorities, and the public engage in a comprehensive and coordinated planning effort to achieve cost-effective CSO controls"[15] and also communities "to consider innovative and alternative approaches and technologies…"[16]

The contents and timing of LTCPs are governed by individual NPDES discharge permits under the federal Clean Water Act or administrative or judicial consent orders tailored to each discharger and influenced greatly by each regulator. All LTCPs must be consistent with the EPA's CSO Control Policy that was adopted in 1994.[17] That guidance document is the result of negotiations among municipal organizations, environmental groups, and State agencies and reflects their input by adopting balanced goals and a stepwise approach. For example, the CSO Policy explicitly states that controls should be cost-effective and meet local environmental objectives, which is explicitly expressed by four principles that LTCPs should:

1. Provide clear levels of control that would be presumed to meet appropriate health and environmental objectives;

2. Provide sufficient flexibility to municipalities, especially financially disadvantaged communities, to consider the site-specific nature of CSOs and to determine the most cost-effective means of reducing pollutants and meeting CWA objectives and requirements;

3. Allow a phased approach to implementation of CSO controls considering a community's financial capability; and

4. Review and revise, as appropriate, water quality standards and their implementation procedures when developing CSO control plans to reflect the site-specific wet weather impacts of CSOs.[18]

The CSO Policy anticipates that communities will fulfill these principles in a two step process. First, CSO communities are to implement operational CSO controls, which are "not expected to require significant engineering studies or major construction." Rather, EPA's Guidance for Nine Minimum Controls[19] describes minimum technology-based controls tjat are designed to first fix problems in and optimize operations of collection and treatment systems before building anything new:

1. Proper operation and regular maintenance programs for the sewer system and the CSOs;

2. Maximum use of the collection system for storage;

3. Review and modification of pretreatment requirements to assure CSO impacts are minimized;

4. Maximization of flow to the publicly owned treatment works for treatment;

5. Prohibition of CSOs during dry weather;

6. Control of solid and floatable materials in CSOs;

7. Pollution prevention;

8. Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts; and

9. Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.[20]

Second, CSS communities must develop LTCPs that will ultimately provide for full compliance with the Clean Water Act, including attainment of water quality standards. The CSO Control Policy and EPA's Guidance for Long-Term Control Plan[21] identify the following essential elements of a long-term control plan:

1. Characterization, monitoring, and modeling of the combined sewer system;

2. Public participation;

3. Consideration of sensitive areas;

4. Evaluation of alternatives to meet CWA requirements using either the "presumption approach" or the "demonstration approach";

5. Cost/performance considerations;

6. Operational plan;

7. Maximizing treatment at the existing POTW treatment plant;

8. Implementation schedule; and

9. Post-construction compliance monitoring program.

The bottom line is that New Jersey's CSS communities will have to make it a top priority to meet Clean Water Act requirements and will make significant investments in water quality controls. Nationwide, several communities have completed their LTCPs and have built control structures, while many others are in various stages of completion, including characterizing their combined sewer systems, monitoring the impacts of CSOs on waterways, discussing water quality and CSO controls, evaluating alternatives, and negotiating compliance schedules with permitting authorities. NJ communities therefore can benefit from lessons learned from other communities' planning processes and institute best practices in conjunction with baseline investments.

Planning Frameworks

Under the draft permits issued by NJDEP that are expected to be finalized in January 2015, New Jersey's CSS communities have three to five years to develop LTCPs. While a lot of work is required during this period to assess systems, develop conceptual designs, estimate costs, and analyze alternatives, this schedule allows time to structure the planning process to accomplish additional goals. Three critical steps that can ensure a successful multi-year planning process include adopting (1) a benefit-cost decision framework, (2) appropriate water quality goals, and (3) a decision hierarchy allowing for adaptive management and prioritization. If these steps are taken – and additional best practices are followed – then in three to five years communities will have created a broad-based public infrastructure investment scheme that will provide broad benefits and stronger communities, rather than a single purpose program with costs that will be resented by taxpayers.

Benefit-Cost Decision Framework. To guide its decisions and to facilitate a common understanding of challenges and opportunities, a municipality should adopt and clearly explain the decision-support framework it will use for prioritizing options. The framework should reflect the basic benefit-cost, "knee of the curve" process for evaluating controls in the CSO Policy, which steers communities to investing up to the point of diminishing returns. The framework should present overall benefits and costs for stakeholders, including residents, businesses, and property owners.

The advantages to this approach are:

- Flexible design goals to reflect multiple perspectives.
- Objectivity and Consistency. An objective reflection of the design goals using quantitative measures of performance where possible against prioritization criteria agreed upon by major stakeholders will provide the best foundation for a common understanding of project goals and the tradeoffs in control and design concepts. Where quantitative valuation of impacts is not possible, the decision-support frameworks will use alternative measures.
- Transparency through clearly stating assumptions behind and methods of calculating each decision criterion.

The decision-support framework should include life cycle costs (capital, operations, maintenance) of CSO controls as well as the broad economic impacts of co-benefits, which might include:

- CSO reductions and other water quality benefits;

- Recreational use of waters;

- Community economic development from waterfront development, with resulting tax and property value increases;

- Flooding control and insurance savings due to risk reduction;

- Cooling from planted areas and lower energy costs; and

- Neighborhood improvements from greening, with resulting tax and property value increases.

Goal-Setting. A critical question communities must answer is the water quality endpoint to be achieved, which will dictate the amount of CSOs to be reduced and the nature of those reductions in time and place. The CSO Policy provides options for either a presumptive approach (e.g., less than four overflows per year) or a demonstration approach (e.g., that projected CSO reductions will achieve water quality standards). Both approaches will require the use of computer models of flows through the sewer system to assess the degree to which alternative controls will reduce CSOs. Under the presumptive approach, once alternatives are shown by models to limit overflows to four per year, the costs of controls can be estimated. Ultimately, however, post-construction monitoring will have to demonstrate that the system is meeting water quality requirements. Under the demonstration approach, additional ambient water quality modeling is required to assess whether control alternatives will achieve water quality goal. This is generally an iterative process until the appropriate level of control is approved by regulators. Generally, the benefit of the presumptive approach is that it requires less analysis at the outset, but the downside is that reduction to four overflows per year requires the construction of more controls, which are expensive. The benefit of a demonstration approach is that it may entail less costly controls, but the downside is that it will require more extensive modeling for both system hydraulics and water quality impacts at the outset, which will take up more resources at the beginning of the planning process and may involve a lot of time to gain acceptance by state authorities.

Adaptive Management Approach and Decision Hierarchy. When assessing CSO control strategies at the concept development stage, municipalities will need to account for a number of factors. The most important is the relative cost of controls and effort required to put them in place.

The chart below shows the relative characteristics of different strategies and techniques to minimize effort and cost and maximize volume reduction and benefits. The most effective LTCPs combine techniques with and achieve an optimal balance between green and gray infrastructure.

Benefits and Costs of CSO Control Strategies

CSO Control Strategy	Techniques	Level of Effort	Life-Cycle Cost	CSO volume	Co-benefits
Minimize inputs to the combined sewer	Water conservation programs	✓	✓	✓	✓✓✓
	Green infrastructure	✓✓	✓✓	✓✓✓	✓✓✓✓
	Development/redevelopment stormwater standards	✓	✓	✓✓✓	✓
	Infiltration/inflow removal	✓✓✓	✓✓✓	✓✓✓	✓
	Tide gate repair	✓	✓✓	✓	✓
	Sewer separation	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Maximize conveyance capacity of existing system	Catch basin cleaning	✓✓	✓✓	✓	✓✓
	FOG programs	✓✓	✓✓	✓	✓✓
	Smart infrastructure and O&M	✓	✓✓	✓	✓✓
	Interceptor cleaning	✓✓	✓✓	✓✓	-
Maximize storage capacity of the existing system	Weir adjustments	✓✓✓	✓✓✓	✓✓✓	-
	In-line storage	✓✓✓✓	✓✓✓✓	✓✓✓	-
	Off-line storage (tanks/tunnels)	✓✓✓✓✓	✓✓✓✓✓	✓✓✓✓✓	-
Maximize treatment	Outfall disinfection	✓✓✓	✓✓✓	*	-
	Treatment Plant upgrade	✓✓✓✓✓	✓✓✓✓	✓✓✓	✓✓

*reduces pathogens but does not reduce CSO volume

The EPA's CSO Control Policy and LTCP Guidance anticipate that these techniques may all be plotted along a performance-cost curve to arrive at the optimum control strategy at the "knee of the curve". However, there are additional factors that can significantly the types and timing of control strategies selected and the overall cost of a CSO control program.

One key factor is the sequence of implementing control strategies. As shown in the figure above, certain techniques are relatively easy and inexpensive to implement.

Water conservation programs, for example, could be launched in the first year of an LTCP planning process. Such a program would, over time, reduce base flows in the sewer system and create storage space for variable wet weather flows, thereby reducing CSOs. Although the overall reduction of CSO volume will be small, it may be favorable on a dollar per gallon basis if conservation is one of the first techniques adopted. Furthermore, the aggregate CSO reductions from inexpensive controls such as conservation, sewer cleaning, and even green infrastructure may reduce the size and cost of major storage facilities while creating additional co-benefits such as lower drinking water treatment costs. If, on the other extreme, such a program were the last adopted after the construction of a multi-billion dollar storage tunnel that would meet CSO control standards, then it would not be worth implementing for CSO controls no matter how inexpensive. Costs and performance do not need to be known with precision to adopt a "no regrets" plan of implementing inexpensive and easy CSO controls earlier in the control sequence. An EPA report speaks to the importance of modelling green infrastructure opportunities first and then gray infrastructure opportunities. [22]

Best Practices for Modeling and Data for Performance:
Spotlight on Steubenville, Ohio

Data collection and calibration unique to each system is critical for the development of a credible LTCP for regulator approval and the impact on the sequencing of improvements on affordability. This became an issue in Steubenville, Ohio, which owns and operates 16 CSO outfalls along the Ohio River in the Appalachia region. Steubenville's CSO system consists of many outfalls, nodes and interconnections despite the size of the population it serves. Control costs need to be carefully assessed because its rate base is a population of just under 19,000 people with a median household income (MHI) of $35,188. A lack of funding has affected CSO control planning, forcing costly repetition.

The initial modeling of the CSO system did not have sufficient flow monitoring data from the appropriate locations for calibration and the Ohio Environmental Protection Agency (OEPA) disallowed use of the model results and called into question the LTCP outcomes. The City and a new consultant team have recently initiated flow monitoring and modeling revisions, to ensure the acceptance of a new LTCP. This will occur in phased fashion, following the City's current effort to develop a No Feasibility Alternatives (NFA) analysis, which will look at both the collection system and wastewater treatment plant to determine the flows that can be practically conveyed to and treated by the plant, incorporating related necessary improvements. In order to make this cost-effective, the team is simplifying the modeling according to industry standards.

In the current LTCP and modeling effort, Steubenville's operators are greatly involved in all project tasks to support data collection for modeling and to identify the steps involved for collection system and plant improvements. Operator involvement along with more accurate modeling results will support the financial study to be completed for the NFA. T, which anticipates reducing the cost of the program by linking smaller projects to improve the collection system and controlling peak flows, which each smaller project funded by public agencies, low interest loans, or grants as appropriate. This strategy is potentially more affordable large capital improvements at the plant, given that the City's MHI will not support large rate increases.

A second key factor is ***coordination*** with existing or already planned capital work. Coordinated planning is a best practice because it is much less expensive to add on additional elements for CSO control at an incremental cost, whenever possible, to other planned projects. For example, if a city knows that a road will be reconstructed in a few years, and can incorporate green infrastructure into the design, then the CSO program will not have to bear the full costs of procurement, design, mobilization, construction, and construction management. On a larger scale, the wholesale redevelopment of a neighborhood creates many opportunities to apportion the costs of catch basins, sewers, interceptors, green infrastructure, parking lot detention fields, and other CSO controls. This principle of incremental costs also applies within a water infrastructure capital plan; a trunk sewer replacement project can include CSO controls such as partial sewer separation or in-line storage at an incremental cost to a stand-alone project.

Sequencing and coordination best occur with the context of an ***asset management program***, a best practice for general utility management and LTCPs. Asset management programs seek to maintain a desired level of service through a consistent state of good repair, under which assets are inventoried and assigned a life-cycle, with planned rehabilitation, repair or replacement as appropriate no earlier than necessary. As explained above, coordinating CSO investments with other projects in an asset management program can provide the benefits of incremental costs, e.g., combining planned street construction and sewer projects to share the costs of excavation, mobilization, and fill. Moreover, municipalities and utilities must prioritize investments and balance CSOs with other needs, including other Clean Water Act obligations (e.g., nutrients, discharge limits), street flooding, and making facilities resilient against extreme weather and sea level rise. That is why the EPA has set forth an Integrated Planning Framework that allows communities to balance CSO controls for municipal separately sewered stormwater systems (MS4), and other Clean Water Act obligations. In addition, NJDEP will be promulgating asset management rules in the near future and provides financial incentives to subsidize asset planning.[23]

Best Practices in Planning Approach
(Benefit-Cost, Asset Planning, Adaptive Management,
Evaluation of Current System and Future Controls)

Practice	Benefit to the Community	Plan
Modeling	Using a model to predict the effects of different CSO control scenarios; creating a computer model that can easily be changed to reflect work done to the system; using the model to modify the sequence of construction, implementation plan or other aspects of the redesign.	Lynchburg
Dynamic Monitoring and System Evaluation	Installing monitoring devices such as flow meters to check and/or contribute data to the model on an ongoing basis; real time monitoring and control allows for improved observation of how collection systems respond to varying storm events and that information was used to update existing hydraulic models.	South Bend (IN)
Updating System Characterization Data for the Model	Scrub sewer network data, check connectivity check, fill data using data flags to form an audit trail and identify data sources, assumptions and interpolations, and highlight future data needs; critical surveys used to confirm accuracy and/or fill in data gaps especially around interceptors, operating/diversion chambers, outfall locations, and other critical infrastructure.	--

Practice	Benefit to the Community	Plan
Model Adjustments	Refined data collection and model calibration following industry standards[24] to develop a credible LTCP for regulator approval, more cost-effective CSO controls, and more effective communications to regulators and ratepayers about sequencing and affordability. Models should also be updated on a regular basis to incorporate the latest data gathered from ongoing CSO and SSO inspections, targeted flow monitoring, sewer inspections, GPS surveys, discovered infrastructure, and record drawings of completed capital projects and private developments.	Steubenville, SD1 of Northern Kentucky
Flexible, Adaptive Implementation Schedule	Allows for a "refinement period" to fill data gaps identified during planning, update analytical assumptions, identify training needs or adjust costs and schedule without requiring a permit modification or penalties associated with milestone dates.	Omaha
Co-benefit Quantification	The NYC Green Infrastructure Plan was a preliminary plan that preceded and underlies Long Term Control Plans that are under development for 11 watersheds in NYC. The Green Infrastructure Plan estimated that at the end of a 20-year implementation cycle, CSO controls under a green infrastructure strategy would provide $139 to $400 million in additional benefits to residents. Adapting existing studies, the plan calculated that each additional, fully planted acre of green space would provide total annual benefits of $8,522 in reduced energy demand, $166 in reduced CO_2 emissions, $1,044 in improved air quality, and $4,725 in increased property value. This analysis allows for more complete understanding of all life-cycle benefits and a deeper understanding of control strategy trade-offs.	NYC Green Infrastructure Plan
Adaptive Management	Allows for five-year assessments of green infrastructure progress, with monitoring of impacts on a neighborhood basis; goals can be adjusted accordingly. Such structures allow communities to adopt emerging technologies and avoid overly conservative, and costly, CSO control programs.	NYC Consent Order
Prioritization	Modeling runs were used to prioritize 59 different project areas ranked by aesthetics, public health considerations, environmental characteristics, and water quality criteria in a matrix approved by the state regulator.	Lynchburg (VA)
Cost Assessment per Watershed	Estimating costs of grey and green infrastructure and optimization strategies per watershed allows installations to be focused in the areas where the performance to cost ratio is the most favorable.	NYC Green Infrastructure Plan
Asset Management	Provides lowest life cycle cost of asset ownership while meeting service level targets; in the LTCP context, CSO controls can be matched with related asset rehabilitation or replacement projects to lower the cost of the overall program.	--
Integrated Planning	Integrated planning, including under the EPA's new Integrated Planning Framework, is intended to prioritize community assets for the most pressing water quality obligations under the Clean Water Act. For communities facing MS4 or effluent limit costs in addition to CSO costs, balancing these obligations can result in a longer CSO compliance period.	--

Public Participation

Stakeholder engagement is required during LTCP formation because of the public interest involved in the cost and impact of CSO controls. Under the EPA's CSO Policy, the public has a significant role to play in identifying recreational uses of water, recreational access points, and Sensitive Areas deserving of greater CSO controls, all of which drive the cost of control alternatives. The public may prefer certain dual-purpose alternatives that create additional community benefits, such as green infrastructure, urban revitalization, or green jobs programs, even if these choices increase up front costs or community impacts from construction.

CSO communities should look beyond compliance to a robust public participation program during LTCP formation and throughout the decades-long implementation period so that there is sustained support for the program. In addition, robust public participation can lower the costs of certain programs by providing homeowners and community leaders with the opportunity to install and maintain infrastructure such as rain barrels and rain gardens or to implement supporting programs, such as litter and floatables control. Interested stakeholders should include developers, transit agencies, utilities, and other entities that have landholdings and facilities that will be affected by any rules requiring on-site stormwater controls.

It is also critical for the permitted utility or water quality entity to engage local elected and appointed officials and staff during the entire LTCP and CSO control process. Local elected officials have direct or indirect control over utility budgets, create and enforce local master plans, zoning ordinances, and building codes, control capital budgets for roads and parks, and oversee development and redevelopment planning review and approvals. Their understanding and support for the recommended CSO solutions is key for successful implementation. Furthermore, such officials ensure that local conditions are clearly represented even if members of the public cannot dedicate sufficient time to provide input.

In these respects an LTCP-related public participation program should be just one facet of an overall proactive, multi-layered communications approach. Best practices for stakeholder engagement include informative billing inserts and websites, rapid response to customer complaints, use of social media, email and text notifications of water quality issues, water use and other issues of interest, and general awareness initiatives like the Water Environment Federation's "Water's Worth It" campaign or DC Water's "Water is Life" branding efforts. These general efforts, and LTCP-specific outreach, remind users of the value of water and wastewater infrastructure and the utilities and municipalities who build and maintain that infrastructure.

Best Practices for Stakeholder Engagement: Spotlight on Omaha, Nebraska

The City of Omaha, Nebraska owns and operates 1,950 miles of sewers across 275 square miles to serve approximately 600,000 residents. The combined sewer system is approximately 43 square miles, with 32 CSO outfalls discharging about 3.5 billion gallons per year of combined sewage overflows during 86 wet weather events. The median household was determined to be $49,344 in 2013. Omaha developed its LTCP by dividing its combined sewer system into 10 drainage basins, each of which had an external advisory panel to evaluate alternatives, identify priorities for investment and communicate the financial impacts on ratepayers for implementation. The Basin Advisory Panels included 83 neighborhood associations, utilities, local business, developers, and environmental groups. Approximately 130 community members not affiliated with the advisory panels participated in a meeting dedicated to a discussion of critical considerations for selecting a preferred CSO control alternative. In addition, a citywide Community Basin Panel was appointed by the Mayor of Omaha to represent the concerns of the overall community.

The City and its consultant project team developed recommendations by starting with a standardized list of control alternatives and a hybrid or "triangle" approach combining sewer separation, storage, and treatment. After screening alternatives, the options were presented to the advisory panels with criteria that included community enhancements, flood reduction, and water quality. The advisory panels and community members ranked the criteria important to each basin. This ranking was used to develop the cost-benefit analysis presented to the community at a subsequent meeting. In this way, the alternatives evaluation extended beyond the typical knee-of-the-curve analysis to include the issues of greatest concern to the community. The success of this process performance uncertainty associated with storm variation in "typical" year and resulted in the development of a financial plan and implementation schedule that was supported by the City, Nebraska Department of Environmental Quality and USEPA Region 7.

Omaha's funding strategy successfully prioritized improvements that provide community benefits as well a compliance schedule that recognized that certain CSO controls would become more expensive if deferred. An affordability analysis completed by the University of Cincinnati in 2013 determined that available cash flow early on in the implementation phase should fund projects representing community priorities such as eliminating sewer back ups and flooding. In addition, the analysis identified WWTP upgrades and investments in Nine Minimum Controls that would be cost-effective to implement early in the process. The City is anticipating upfront bond rate increases of 2-3% before hitting the affordability ceiling of 9% average annual rate increase during the LTCP implementation phase (2016-2027). The project continues to update the affordability analysis and review costs for feasible CSO control alternatives to make sure cost assumptions during planning phases remain correct as design progresses, funding is maxed out, and cash flow is diminished. For example, a tunnel system was determined to result in lower life cycle cost savings than end-of-pipe treatment technologies because of higher operational and maintenance costs for chemicals and staffing, but the project team continues to review decentralized alternatives such as end-of-pipe treatment and green infrastructure in the event a tunnel cannot be fully funded.

Best Practices in Public Engagement for LTCPs

Practice	Benefit to the Community	Plan
Basin Advisory Panels	Public support for CSO control strategies, adoption of strategies that meet other community needs, buy-in to rate increases, acceptance by the regulators.	Omaha
Public Education Program	Consensus around recreational usage, waterfront vision, and related water quality endpoints; Support for rate increases when necessary.	--
Survey	Broad-based survey to gauge public support for various CSO control alternatives.	Philadelphia
Anti-litter Campaign	Inexpensive floatables programmatic control that can supplement controls such as screening/netting facilities (required in NJ) or hooded catch basins and/or reduce the cost of operations and maintenance by reducing the amount of floatables collected at outfalls.	--
Downspout Disconnection	With homeowner support a major source of infiltration and inflow and can be eliminated for as little as $50 per house.	Portland
Adopt-a-Bioswale	By educating the public about green infrastructure, the city can ease the way for its public bioswale construction program and can get the public to assume some responsibilities for maintenance.	NYC
School Education Programs	Educates the next generation of environmental and school leaders; children and teachers in turn educate parents; school systems may directly help with stormwater management (see green infrastructure matrix below).	--
Reporting and /or Automated Public Notification of CSOs	Measured or forecasted rainfall, in combination with collection system hydraulic models, can be used to estimate the frequency and total volume of the overflow locations and notify the public on a daily, weekly, monthly, or quarterly basis. To improve accuracy, models can be updated quarterly to incorporate the latest data gathered from ongoing CSO and SSO inspections, targeted flow monitoring, sewer inspections, GPS surveys, discovered infrastructure, and record drawings of completed capital projects and private developments. A further refinement is to push out information on predicted overflows via email or the internet in advance of storms. The public's awareness of CSOs and their impact creates support for control programs and investments.	Orange County (CA), SD 1 of Northern Kentucky, NYC

Water Conservation Programs

Declining water use can reduce base flows in the system and create storage capacity in conveyance systems and treatment capacity in plants. In addition to these CSO benefits, conservation programs can reduce the upstream costs of treating and pumping drinking water and the downstream costs of pumping and treating wastewater. Reduced usage can reduce utility income unless adjustments are made to the rate or rate structure or both. The following are some of the best practices for water conservation.

Best Practices in Conservation

Characteristic	Benefit to the Community	Plan
Reduced flow and conservation	By accounting for water use trends and additional conservation programs in modeling for sewer and plant capacity in the 2045 model year, NYC was able to quantify a reduction in CSOs of 1.7 BGY by 2030 at a nominal cost.	NYC Green Infrastructure Plan
Advanced meter infrastructure	Meters that upload data automatically to utility servers allow for more accurate usage charges, greater knowledge by users (if there is notification program or access to user accounts, even sooner than the billing cycle), and fewer estimated bills. These changes reinforce price signals for water and typically result in stronger revenues.	--
Meter replacement programs	Replacement of old, under-reporting meters can reinforce price signals and user motivation for conservation.	--
Monthly billing	Billing on a monthly schedule like other utilities, rather than on a yearly or quarterly schedule, will more closely align usage and costs.	--
Conservation rate structure or ordinance	Rate structures that escalate charges after minimum amounts for necessary uses will incentivize users to reduce optional uses of water such as car washing and irrigating lawns, or ordinances may serve the same purpose.[25]	--
Toilet and fixture replacement programs	Rebates or other incentives can accelerate the turnover of old fixtures to EPA WaterSmart certified water saving fixtures	--

Green Infrastructure

One relatively new method of reducing stormwater contribution to the combined sewer system and therefore CSO volume is to use “green infrastructure” – planted areas and other small-scale installations that are designed to absorb stormwater runoff and either retain it through plant uptake or infiltration to the ground or detain it until peak storm flows end. This technique address a root cause of CSOs, which is the conversion of watersheds from large areas of pervious surfaces such as fields and forests to predominantly impervious surfaces rooftops, roads, parking lots, and other man-made structures. These land use changes mean that even a small storm creates a lot of runoff; every acre of impervious surfaces generates 25,000 gallons for each inch of rain. Green infrastructure seeks to reverse this trend by retrofitting urban areas with planters, rain gardens, planted roofs, and pervious surfaces. While each green infrastructure installation cannot absorb much rainfall on its own, the gradual adoption of such practices over time will create decentralized networks of runoff controls can collectively reduce storm surges in sewers and, therefore, CSOs, to some extent.

Green infrastructure affects land use in a very visible way, much more than other stormwater controls. This is generally a positive development and can earn public support from community members that might care more about visual streetscape improvements than stormwater controls. That is one of the main drivers of quantifying and explaining the many co-benefits of green infrastructure. At the same time, any land use change can be controversial in an urban area where there are many competing demands for space. Best practices,

Best Practices for Green Infrastructure Planning: Spotlight on Onondaga County, New York

Onondaga County’s Save the Rain Program is a comprehensive stormwater management plan that seeks to reduce CSOs and improve the water quality of Onondaga Lake and its tributaries through a combination of smart gray investments with innovative green infrastructure solutions. The program started with a 1989 Consent Judgment, which required a series of engineering and scientific studies, and a 1998 amended judgment that required the construction of conventional grey infrastructure improvements. These CSO controls included upgrading the County’s main sewage treatment plant, several CSO storage and remote treatment facilities, and a monitoring program to evaluate the effects of the improvement projects on the water quality of the lake and tributary streams. Several years later, community resistance to siting facilities caused the County to reevaluate the desirability of building satellite sewage treatment plants in working class neighborhoods and in Armory Square, a tourist destination. The County launched a study of the feasibility using green infrastructure in combination with smart gray infrastructure to control CSOs.

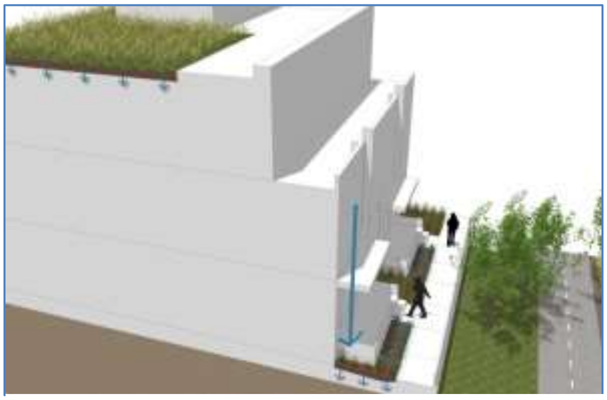
Working with a variety of stakeholders, the County developed a more cost-effective and sustainable solution combining green and gray infrastructure. It obtained an amended consent order that contained an aggressive schedule to build green streets, green parks, and myriad environmental and property improvements throughout the community. To date, the County has advanced more than 175 distinct green infrastructure projects, on public and private property, including:

- rain gardens,
- green roofs,
- bioswales,
- permeable pavement,
- rain barrels, and
- cisterns.

See Save the Rain, www.ongov.net www.ongov.net/environment/lake.html.

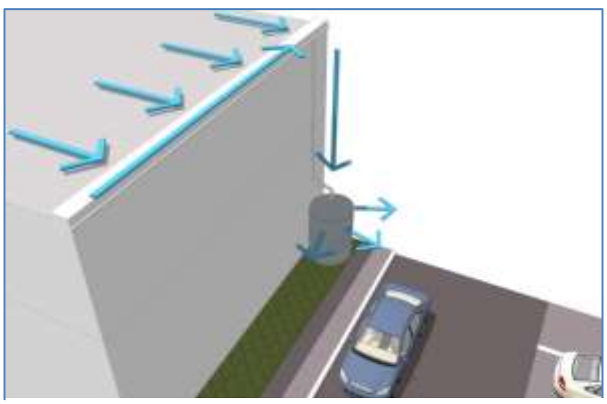
then, emphasize comprehensive land use planning that incorporate green infrastructure into planned infrastructure projects and redevelopment areas where co-benefits will have the greatest impact.

Major Types of Green Infrastructure for Urban Areas

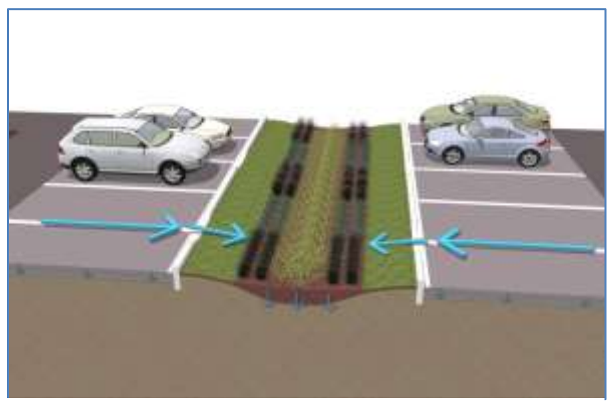


Green Roof

Planter



Cistern



Bioswale

Some of these best practices are discussed below and are derived from city green infrastructure plans, including those from Camden[26] and Hoboken[27] in New Jersey.

Best Practices in Green Infrastructure[28]

Characteristic	Benefit to the Community	Plan
Land Use Analysis	Completed with Geographic Information Systems (GIS) to identify percent of total area for each land use and the appropriate Green Infrastructure (GI) technology; as a next step, modeling may be needed to determine GI application rates or targets for each land use.	Philadelphia, King County, NYC, Chicago
Opportunities Analysis	Relies on local knowledge combined with GIS rather than modeling to identify known stormwater-related problem areas, large sites and community needs or priorities for reinvestment; GI application rates determined based on available opportunities.	Columbus
Community-Driven Site Selection	Both high priority sites and "low-hanging fruit" identified for the siting and sizing of GI for upfront community benefits as well as potential cost efficiencies i.e., larger GI projects or partnerships; In NEORSD, for example, committed to controlling an additional 44 MG of wet weather CSO volume through green infrastructure (GI) and spend at least $42 million dollars to build GI projects focused on areas where overflows remained after grey infrastructure, compatible land uses, and where projects can most improve socioeconomic conditions.	San Francisco, Pittsburgh, Northeast Ohio Regional Sewer District
Pilot and Demonstration Projects	Provides a "real-life test" of requirements and costs needed to execute a larger program and the anticipated performance of various technologies under different site specific conditions; at the same time, provides visible projects and related information within community and for potential partners; for example, DC Water's Clean Waters Green District plan proposes a large-scale, multimillion dollar GI demonstration project in the Potomac and Rock Creek watersheds to evaluate the practicality and efficacy of GI techniques for CSO control in these watersheds.	Washington (DC), NYC, St. Louis, Omaha
Education and Branding	Provides user-friendly information within the affected community to elevate stormwater management as a significant environmental issue, describe the co-benefits associated with GI and proactively inform rate payers of the costs involved and what the city is doing to minimize these costs.	Philadelphia, Onondaga County (NY), Camden
Basin Stewards, Watershed Planning Charettes	Basin stewards work with the community and other public agencies to improve and protect watersheds and local habitats through a variety of conservation and restoration projects, and to identify and evaluate opportunities for stormwater retrofit projects in drainage basins through a combination of community design charettes and engineering/economic analysis.	King County (WA)

Characteristic	Benefit to the Community	Plan
Grant Programs and Stormwater Fees	Incentivizes GI installations on private properties which comprise significant portions of urban CSO areas but can be difficult opportunities for public agencies to retrofit. Grant awards provide base funds for GI implementation but often these funds are matched or supplemented by private dollars to meet regulatory requirements or enhance designs onsite for users which can lead to greater stormwater retention volumes. Under stormwater fee programs, credits for GI serve the same purpose.	Philadelphia, Onondaga County (NY), NYC
Innovative financing for green infrastructure	Providing incentives to building and land owners allows for private financing of stormwater infrastructure. Examples including credits against stormwater or other charges for the adoption of site-level stormwater controls (Washington, DC and Philadelphia) and a public-private partnership for $100 million of green infrastructure projects (Prince George's County).	Washington (DC), Philadelphia, Prince George's County (MD)
Development and Redevelopment Standards	New site connection standards require a minimum retention or detention of stormwater on-site, keeping it out of the sewer system. Developers pay for construction and are also required to maintain the stormwater controls, but because such costs are included in overall new construction the increment is very small, as low as 1% of construction costs.	Philadelphia, NYC
Constructed Wetlands	Constructed wetlands to treat CSOs can be more cost-effective than other options. Constructed wetlands can remove pollutants and mitigate peak storm flows, while creating wildlife habitat and community green space.	Onondaga County (NY), Washington (IN)

Coordinating Investments Across Agencies

CSO controls, particularly green infrastructure, may be less expensive when incorporated into other relevant infrastructure projects. Conversely, the cost of those other projects can be partially defrayed by stormwater controls. And private groups may contribute funds. For example, in Syracuse, New York, the Coach Jim Boehiem Foundation has funded new basketball courts in underserved areas that are built with porous asphalt to absorb rainfall. Another example is NYC's Million Tree program to support the planting of one million new trees in larger tree pits, with the goals of providing shade, cleaning the air, sequestering carbon, cooling the pavement, reducing energy bills, soaking in rainwater, creating green corridors, beautifying neighborhoods, improving property values, and fostering neighborhood pride and cohesion. These multiple benefits exceed $5 in benefits for every $1 spent on tree planting and care. Similar programs with multiple benefits include the replacement of asphalt playgrounds with turf fields and plants, bike lanes made of porous asphalt, and green roofs that replace black asphalt roofs.

Best Practices in Inter-Agency Coordination

Practice	Benefit to the Community	Plan
Asphalt to turf fields	Asphalt can be converted to pervious turf build on a base layer of gravel for the storage of stormwater or to facilitate infiltration. Such fields can withstand year round use and, especially if lighted at night, can greatly expand recreational opportunities in underserved areas.	--
Schoolyards to Playgrounds	Similarly, impervious schoolyards can be refreshed to include upgraded play equipment, mini turf-fields, and planted areas to receive runoff from slanted uplands.	--
Porous basketball courts	New basketball courts built with porous asphalt add new recreational areas on unused land while infiltrating runoff.	Syracuse
Green roofs on schools	Partnerships of teachers, parents, and utilities join together to create living classrooms of planters and green roofs that also absorb stormwater.	--
Traffic calming measures with planted areas	"Bump outs" and other curb extensions designed to calm traffic and increase pedestrian safety can incorporate curb cuts and planted areas to manage stormwater and create green corridors of shade trees.	Seattle
Porous pavers and pavement	Parking lots, driveways, and other paved areas can be built with a substrate of gravel for storage and a surface of porous pavers, porous concrete or porous asphalt; tests at the University of New Hampshire stormwater center show that such areas ice over less frequently in the winter and clear rain much quicker, creating safer surfaces.	Chicago, Syracuse (NY)

Practice	Benefit to the Community	Plan
Stormwater re-use systems	Roof leaders can be routed to basement storage tanks where the water can be used for a variety of purposes, including truck wash water and supply water for an ice rink.	Syracuse, NYC
Development and redevelopment projects	Master plans, site plan review authorities, subdivision controls, and building codes can incorporate or incentives green infrastructure and landscaping, which will both add value to development projects and helps meet regulatory obligations for on-site control of runoff.	Washington (DC), Philadelphia
Parks	Poorly maintained parks – including overused areas of compacted soil – can be re-landscaped to improve infiltration and also accept runoff from neighboring streets and sidewalks, providing a free source of water for irrigation.	Camden
Street Repair and Reconstruction	Complete street reconstruction that involves excavation and resetting of the roadbed provides an opportunity to install additional planted areas, gravel substrate and porous pavement, bioswales, and planted strips.	--
Public facilities	Design standards for public facilities (hospitals, sanitation garages, firehouses, police stations, etc.) can encourage innovative, on-site stormwater controls and even reuse systems, thus leading the way for more widespread adoption.	--

Grey Infrastructure System Optimization and Reducing Wet Weather Surges

Removal of extraneous flows from the combined sewer system should be considered during the evaluation of alternatives. Extraneous inflows can enter the combined sewers in the following ways:

- Infiltration through joints and cracks in combined sewers;
- Streams and creeks connected to the combined sewers, generally in upstream portions of certain collection systems;
- Rainfall derived inflow and infiltration where roof leaders, sump pumps and other connections add wet weather flow to storm sewers in separately sewered areas;
- Interconnections between separately sewered area storm sewers and combined sewers; or
- Inflow to manholes in stream corridors.

With the exception of infiltration through joints and cracks, the other sources of inflow can add large amounts of water into combined sewer systems or to interceptors flowing toward wastewater treatment plants servicing combinations of separately sewered and combined sewered communities during storm events. These inflows take away capacity from those systems to convey and safely treat combined sewage. Elimination of these items can be a cost effective way to reduce CSO overflows and inflow and infiltration (I/I or I&I) controls should be evaluated during the LTCP process. Two of the largest sources of extraneous flows are streams and interconnections between separate, storm, and combined sewers.

Streams. In many older communities combined sewers were often constructed in then-existing streambeds, necessary incorporating the entire streamflow from the water shed directly into the upstream sections of combined sewer systems. In addition, combined sewers and portions of interceptors built in stream and river floodplains can experience water flowing into these sewers through manhole covers in periods of high stream flows that inundate those manholes. "Stream daylighting" is one technique to uncover buried streams and restore their natural course to receiving waters and away from the sewer system.

Interconnections. Very few combined sewer municipalities are serviced purely by combined sewers. More often, the conveyance system includes large areas serviced by separate storm sewers. In older communities, poor recordkeeping or oversight, or simply different historical standards, can result in the connection of storm sewers to combined sewers and separate sanitary trunk sewers to combined interceptors. And in older separated systems, sanitary sewers are often found to have roof leaders, yard/driveway drains and sump pumps connected to them. It is not uncommon for these factors to result in flows peaking in wet weather in these sanitary sewers at five to ten times the base dry weather sanitary sewage flow levels. Accordingly, LTCPs should consider the impact and cost of programs to reduce or eliminate rainfall induced I/I in separate sewered areas connected to CSS. Some of the more advanced system optimization practices include real-time controls, additional cleaning, advanced blockage notification systems, performance benchmarking and crew accountability, manhole sliplining, and service line insurance programs to facilitate repairs of privately owned and maintained service connections.

Best Practices in System Optimization and Reducing Wet Weather Surges

Practice	Benefit to the Community	Plan
I/I Control Plans	Methodical, cost effective plan to reduce extraneous flows, starting with the greatest flows at the least cost	Cincinnati, Johnson Co. (KS)
Stream Daylighting	Reduces large volumes of extraneous flows while providing natural stream corridors that can be recreational corridors with bike and jogging paths.[29]	Camden, Cincinnati, Yonkers
Watertight manhole covers	Reduces extraneous flows through manholes that are situated in floodplains or other flood prone areas.	--

Practice	Benefit to the Community	Plan
Manhole sliplining	Reduces extraneous flows through manhole column walls; access and site mobilization can be easier and less expensive than other I/I projects	--
Additional Cleaning	Removal of sediment and other obstructions can create additional storage in the sewer and increase conveyance to large interceptors.	--
FOG control program	Removes obstructions that, in addition to causing CSOs, can cause sewer backups into basements and streets.	--
Advanced Blockage Notification Systems	New technology such as in-pipe camera systems and sonar devices on the underside of manhole covers to detect sewer levels can provide crews with the information to proactively remove blockages.	--
Catch Basin Inspection, Repair, and Hood program	A regular inspection program will identify catch basins that are blocked or otherwise a source of significant floatables discharged to rivers. Hoods can keep out floatables. These programs will also alleviate street flooding.	--
Performance Benchmarking, Metrics, and Accountability	These management techniques will optimize operational repairs and proactive programs, leading to cleaner sewers, faster repairs, and fewer overflows.	NYC State of the Sewers Report
Real time controls	Where feasible, real time controls can shunt high level flows from watersheds that received a lot of rain to sewers draining dryer watersheds.	--
Service Line Protection Programs	Service Line Protection programs, including on-bill payment for sewer line repairs, facilitate the rapid repair of broken sewer service lines that can collectively create significant I/I. In addition, SLP programs buffer consumers from the high costs of unexpected repairs.	Pittsburgh, NYC
Downspout Disconnection	With homeowner support a major source of I/I can be eliminated for as little as $50 per house.	Portland
Optimization strategy	Assessing the benefits of optimization strategies – sewer separation, interceptor cleaning, tide gate repairs, and I/I controls – leads to immediate implementation of strategies predicted to reduce CSOs by 586 million gallons per year. This will sequence more cost-effective controls before additional grey infrastructure controls.	NYC Green Infrastructure Plan

Gray Infrastructure Approaches to CSO Storage and Treatment

Treatment plants are designed with the capacity to handle dry weather and some wet weather flows, and plant expansion to a degree will help reduce the discharges of untreated CSOs. It would be cost-prohibitive, however, to size plants to treat all of the highly variable wet weather flow, which can be more than 10 times dry weather flow. Therefore, a typical strategy is to also store flows temporary until storms pass, when the combined sewage can be pumped to the plant for treatment. Common storage methods include in-line storage, above ground or below ground storage tanks, and deep storage tunnels that can be several miles long and over 20 feet in diameter. Such storage facilities can be expensive to build and operate. Some of the best practices below can help reduce the costs and impacts of such facilities. Another option is to treat discharges by providing for disinfection at the outfalls, which does not reduce CSO volume but can help meet water quality standards for pathogens.

Best Practices in Storage and Treatment

Practice	Benefit to the Community	Plan
Adjusting Weir Heights, including Bending Weirs	Cost-effective method of creating in-line storage using existing structures and raising heights to provide for new hydraulic grade lines, where system modeling shows it will reduce CSOs without causing basement backups.	--
In-Line Storage	Expansion of trunk sewers and interceptors to allow for additional storage during wet weather, as verified by HGL analysis and system modeling. Generally, these controls will be within existing infrastructure corridors and will not disrupt land uses or cause other community concerns. May be expensive given the need for excavation and rerouting of flows during construction. However, operational expenses can be low if installations can use gravity flow to the plant.	Lynchburg (VA)
Storage Tanks and Community Benefits	Any infrastructure can serve multiple purposes, although the operational needs and odors from a CSO storage facility can be challenging. One example is the Paerdegat Basin CSO facility, which is covered by a green roof, and the crew quarters also include community meeting space.	NYC
Storage Tunnel	Coordinating timing with transportation and other tunnel infrastructure can ensure that several major construction projects are not occurring at the same time, which will drive up bids and project costs.	--
Treatment Plant Expansion	Plant expansion will solve multiple problems and can allow for overall modernization and energy efficiency to be embedded into the treatment process, lowering per unit operating costs.	--

Practice	Benefit to the Community	Plan
Outfall Disinfection	Outfall disinfection can be an expedient, if temporary, solution to water quality challenges.	Oswego (NY)

Flooding and Resiliency

The proliferation of impervious surfaces that has increased runoff to combined sewers has also led to frequent flooding. CSO controls that help address flooding and resiliency are a best practice of employing dual-purpose infrastructure whenever possible. Indeed, for many members of the public, voluntary spending to reduce flooding would be a higher priority than mandatory spending to reduce CSOs. Projects that achieve both will provide greater benefits for the community, will have a more immediate and apparent impact, and therefore will have greater support.

Flooding controls will become even more important over the 20 years or more of LTCP implementation and the 20 to 30 year lifespan of CSO controls. A recent Rutgers University study predicts an increase in annual precipitation in New Jersey of over 4 inches (about 9%) per century and an increase in heavy precipitation events, which occur twice as often in recent years compared to the past century.[30] Accordingly, stream flooding will become more frequent, and the public will demand adequate responses.

Municipalities and utilities with discharge points to or service areas along tidal rivers or coastal waters will also have to respond to sea level rise and increasing coastal flooding. The New Jersey coast has already experienced a sea level rise of 1.5 inches per decade and projections include a range of 7 to 16 inches by 2030, 13 to 28 inches by 2050, and 30 to 71 inches by 2100.[31] During this period coastal flooding will become more frequent and saltwater intrusion into the sewer system and changes to the hydraulic grade lines during high tide will worsen CSOs unless action is taken.

The best practices described below can help integrate these efforts.

Best Practices in Flooding and Resiliency

Practice	Benefit to the Community	Plan
Include Climate Change Variables Into Water Planning	Acknowledge current and future trends and impacts of climate change – especially increases in precipitation, extreme rain events, and sea level rise – provides time to develop and execute adaptation strategies.[32]	New York City's "A Stronger, More Resilient New York", Pennsylvania, Maryland, Massachusetts water plans

Practice	Benefit to the Community	Plan
Design Elevations	Criteria for new designs to follow 100 yr + 30" or 500 yr flood elevations will ensure continuity of operations during extreme weather events in the future.	NYC Wastewater Resiliency Plan
Stream Daylighting	Resurrecting natural streams that once passed through urban centers, or creating new natural streams and wetlands, can reduce pollution, reduce erosion of pipe outfalls, slow storm water surges, and create more green spaces for the community to enjoy. Though they are complicated projects, introducing a system that absorbs groundwater as well as runoff can lower the ground water table and allow rain gardens to be more effective.[33]	Seoul (South Korea), Yonkers
Green Infrastructure	Most green infrastructure methods attempt to reduce the storm surge by reducing the amount of paved surface area in urban locations. These methods include green buildings that modify a building's roof to contain vegetation and/or materials that are designed to introduce storm water into a system slowly. They also include programs that support rain gardens, bio-swales and the redesign of parking lots so that they are more pervious to storm water. In addition to reducing the storm surges in a taxed storm water collection system (separated and or combined) replacing pavement with more natural vegetation has been shown to increase the happiness of a community's citizens.[34]	--
Sewer Separation	This is a commonly used method for handling storm water. It can be designed to handle whatever storm events that are expected and can completely eliminate flooding in local streets. However, this method can also greatly increase the stresses on outfall water bodies (streams and rivers that do not naturally experience the storm surges that would be introduced to them) and could require large retention basins. Furthermore, these separate storm sewers are generally not treated, and have been shown to still introduce contaminants into the natural waterbodies.[35]	--
Sediment Control	The accumulation of sediments, in addition to introducing more contaminants into the system, could greatly reduce the capacity of existing sewers. The effect of this is comparable to an undersized sewer, where roadways, public spaces, and even resident's basements become flooded. Though regular street sweeping can reduce the amount of sediments introduced during storm events, CSOs are subjected to sediment accumulations from sanitary flows, and the relatively small flow passing through large CSO pipes during dry weather is not fast enough to self-clean the system. Regularly cleaning lines can reduce the amount of flooding during major events, however the process becomes laborious and expensive as the amount of sediments left in lines accumulates.[36]	--

Regional Issues and Solutions

The three basic components of a combined sewer system – networks of building connections and trunk sewers, large interceptor sewers, and treatment plants – are typically owned and operated by different entities parties in New Jersey. Ownership and often operation of collection systems at the "headwaters" of the sewer system resides with local municipalities, while downstream components may be owned by regional or even state-chartered authorities. In New Jersey, overflow discharge points may be contained within both the collection system and the interceptors. Discharge permits may be held by both groups.

Regional Sewer Service Areas in New Jersey

Regional Wastewater Plant	Number of Member Municipalities with CSOs	Number of Other Member Municipalities
Passaic Valley Sewerage Commissioners	8	41
North Hudson Sewer Authority	4	0
Bergen County Utility Authority	3	44
Camden County Municipal Utility Authority	2	38
Joint Meeting of Essex and Union Counties	1	14
North Bergen Municipal Utility Authority	2	1
Middlesex County Utility Authority	1	34
Trenton Sewer Authority	1	0

CSO controls require the participation of both treatment and collection owners and operators. With regard to complying with the Nine Minimum Controls, for example, collection systems must be properly operated, regularly maintained, optimized for storage, optimized to maximize flow to treatment plants, and assist with control of litter and other "floatables." LTCPs also require the participation of all entities, as shown in the following chart.

Regional Involvement in LTCPs

LTCP Element	Part of CSS Involved		
	Collection and CSO	Interceptor and CSOs	Treatment Plant
Characterization, monitoring, modeling	✓	✓	✓
Public participation	✓	✓	✓
Consideration of sensitive areas		✓	✓
Evaluation of alternatives	✓	✓	✓
Cost/performance considerations	✓	✓	✓
Operational plan	✓	✓	✓
Maximizing treatment			✓
Implementation schedule	✓	✓	✓
Compliance monitoring	✓	✓	✓

Even where the permit is held by a regional owner of the treatment plan and interceptor, LTCP development will require implementation by the municipalities that own collection systems. For example, municipalities would be required to partner on green infrastructure built on their streets and sidewalks and in other public places, and undertake other methods to control inflow and infiltration. The characterization, monitoring, and modeling of the hydraulic grade line and flows within the unified system should be coordinated across the same platform and with the same parameters. And it is in everyone's interest to have the alternatives analysis consider a full range of controls so that the least cost/highest performance controls can be implemented first regardless of where they may be located. For example, it may be much less expensive to undertake partial sewer separation in one municipality than in another that shares the same interceptor or flows to the same treatment facility.

These solutions can build on a tradition of shared services among New Jersey's 566 municipalities for the fire, police, sanitation, school, and other public services they provide. Accordingly, we highlight some of the best practices around the country in following shared, regional approaches to developing LTCPs.

Best Practices in Regional Approaches

Practice	Benefit to the Community	Plan
Regional LTCP	Economies of scale, systems integration, and increased consistency in meeting water quality standards to the region; an added incentive in New Jersey is a five year period to complete an LTCP rather than 3 years from the date of the permit.	--
Shared System Characterization Report	More efficiently completed by a single consultant working in multiple municipalities.	--
Regionally Separated Regulation	In cases where regions share overflows, if calculations show that one region is responsible for the overflow and the other region is not, the overflow event will not count as one of the latter region's four overflows for the year[37]	--
Regional Consolidation	The consolidation of regions in order to accommodate one another is a practice that should be superseded by geological, geographical, and engineering considerations. Since it is in the public's best interest to reduce CSO and storm water pollutants in the most cost effective way; the combination of regions shall be evaluated regardless of ownership.[38]	--
Public Notification System	Automated public notification systems that use a combination of weather forecasts and model predictions of CSOs can be shared on a regional basis.	NYC

Best Practices: Regional Cost-Sharing
Spotlight on Allegheny County Sanitary Authority, Pennsylvania

Allegheny County Sanitary Authority (ALCOSAN) provides regional wastewater conveyance and treatment for the City of Pittsburgh and 83 other municipalities to approximately 836,600 people. ALCOSAN owns, operates, and maintains the 250 million gallon per day (MGD) Woods Run wastewater treatment plant, over 92 miles of interceptor and sewers and 300 regulator structures along the interceptor system. Its customer municipalities own, operate, and maintain over 4,000 miles of wastewater collection sewers and over 140 regulator structures.

In January 2013, ALCOSAN submitted a Wet Weather Plan (WWP) identifying wastewater infrastructure improvements to be implemented and operated by 2026 and to meet the requirements of their Consent Decree with the EPA, Pennsylvania Department of Environmental Protection (PADEP), and the Allegheny County Health Department (ACHD). The sewer conditions and needs of multiple planning basins within ALCOSAN's service area were assessed but the WWP is not considered a "regional" plan in that all of the customer municipalities have to respond to their own consent orders with either PADEP or ACHD to address overflows and implement their own long-term and costly improvement programs. In addition, ALCOSAN's WWP recommended a predominantly "gray infrastructure" approach for CSO control in that it depends heavily on upgrading the treatment facilities and infrastructure under its control.

In a parallel process, a Sewer Regionalization Review Panel was formed in coordination with ALCOSAN and the Allegheny Conference on Community Development to develop and evaluate regionalization. Between 2011 and 2013 the Review Panel and various subcommittees evaluated opportunities to bring economies of scale, systems integration, and increased consistency in meeting water quality standards to the region. Similarly, the Review Panel was asked to consider source controls or green infrastructure applications that could be implemented as part of a regionalized approach to wastewater management since flow is conveyed through multiple municipalities. A March 2013 Regionalization Evaluation Study found that improved alignment, stronger collaboration and greater integration among the various responsible parties would result in better services and better water quality for local residents, businesses and communities. Several of the recommendations are advancing toward implementation including expanded participation of customer municipalities on ALCOSAN's board and the transfer of approximately 125 miles of inter-municipal lines 12" or larger to ALCOSAN for upgrades and control. These strategies are expected to facilitate implementation of decentralized improvement projects by leveraging ALCOSAN's bonding capacity and ability to group and competitively bid projects, which would otherwise require the municipalities to fund $500 million worth of municipal capital improvements identified in the WWP. While the findings from the Regionalization Study are actively being discussed and assessed for implementation, ALCOSAN and customer communities have not yet committed to this approach.

Procurement and Development

There are considerations for effective procurement and development of an LTCP, with the understanding that the ultimate responsibility lies with the elected and appointed officials who oversee permit holders and the municipalities that own combined sewer systems, and these parties must stay involved. One goal of the LTCP planning process should be to make sure that permit holders and municipalities are well-equipped to take on implementation from a technical, economic, management, and political perspective.

LTCPs may be prepared by outside consultants, by a permittee's in-house staff, or some combination of the two. The least used method is using in-house staff exclusively to prepare an LTCP. Although possible, even the largest utilities and municipalities lack sufficient staff with all of the varied skill sets required to complete the LTCPs (e.g., modeling, system performance, CSO control design, cost estimating, affordability analysis). In addition, development of a LTCP would divert in-house staff from their ongoing operational or other responsibilities, and the skills required to develop LTCPs (and design and build controls) are not the same as those required to operate the system over the long term. For that reason, agencies or municipalities responsible for the combined sewer system tend to rely on outside consultants to develop LTCPs.

Typically, LTCP work is shared. For larger and more complex systems where the CSO permittee has a dedicated, trained and technically sophisticated staff of engineers and planners, there tends to be a partnering relationship employed in the LTCP development. With larger municipalities such as New York or Philadelphia, in-house staff take on technical roles and conduct activities that fulfill various LTCP responsibilities. For example, in New York City, staff members have taken on the responsibility of performing the analyses to define where and how much green infrastructure will be constructed and writing the section of the LTCPs that deals with green infrastructure. The Philadelphia Water Department has an in-house sewer system modeling staff that performs sewer system characterization work, with some assistance from consultants. More typically, permittees take on large if not full responsibility for public participation programs, performing the program development and formulation work as well as being the face in front of the public, and call on consultants to provide supporting graphic materials or production type work. (Both NYC and Philadelphia follow this approach.) Other typical areas of permittee staff participation include framing the overall approach and directing consultants to follow either the presumption or the demonstration method; determining the types of CSO controls; assessing the total costs for CSO controls for the selected plan; and selecting locations for CSO controls. In those matters, consultants perform technical activities to screen and shortlist alternatives, conduct siting evaluations and develop facility planning level CSO control concept designs and costing analyses. Armed with this information, the permittee's decision makers will finalize decisions used by the consultants in the LTCP reports.

Smaller communities with a limited number of outfalls or staff trained technical staff may find it advantageous to provide a larger role for consultants up to preparing and submitting a fully developed LTCP.

In order to effectively oversee outside consultants, municipalities and permit holders can hire an engineer with direct LTCP experience to manage consultants more effectively and require training and capacity building to transfer the knowledge and skills required to operate the system.

Best Practices in CSO Procurement and Development

Practice	Benefit to the Community	Plan
Program Management Services	Treating CSO controls as a unified program can be more effective; hiring program management staff to oversee a CSO program will free up staff to maintain operations; changing existing culture to become more proactive; instituting maintenance schedules that are actually followed	Pittsburgh Water and Sewer Authority
Prepare Facility Plans or other Documents Before RFP	Complete, preliminary documentation, such as facility plans with a detailed analysis of existing systems and models, will allow respondents to submit more advanced proposals for LTCP development that should be more cost-effective and take less time.	Bridgeport, NYC
Capacity Building / Integrated Team	An integrated team with consultants and city staff will develop capacity of municipalities to develop and implement LTCPs.	Lynchburg (VA)
Integrated Project Team	A project team with a ratio of approximately 12 to 15 consultant roles to one City staff role allowed the City to focus on existing operations and permit compliance and to avoid hiring until it developed appropriate job descriptions and protocols for the longer implementation phase. The consultant staff consisted of engineers and modelers with knowledge of the City's systems as well as national experts used on a selective basis, for example, as part of a fast track review during "CSO week" to exploring feasible alternatives during an expedited screening process.	Omaha
Value Engineering	Value Engineering Workshops with consultants and city staff conducted as part of a preliminary study to identify cost-saving alternatives to current CSO control projects.	South Bend (IN)
Incidental Design Services Included in LTCP RFP	Keeps program moving forward and allows for faster transition from LTCP development to implementation by getting a head start on design while standard design bids are procured.	Pittsburgh
Two-step Procurement	Issuing an RFQ, followed by an RFP, allows municipalities and utilities to assess overall team strength first and then winnow down the field to qualified firms who will present detailed technical approaches for review.	Bridgeport

Conclusion

New Jersey's combined sewer communities can adopt best practices from communities in other states who have started or completed the LTCP process. Those best practices should be considered when structuring RFPs for developing LTCPs. There is no limit to creative approaches under the EPA's and NJDEP's guidance documents and communities should embrace a robust and comprehensive planning process to develop and implement a multi-layered urban revitalization program.

Endnotes

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[1] John Tibbets, Envtl. Health Perspectives 113:465-467 (2005).

[2] Ibid.

[3] EPA, Report to Congress: Impacts and Control of CSOs and SSOs (2004).

[4] Ibid.

[5] US EPA, Report to Congress: Clean Watersheds Needs Survey (2008), at 2-16.

[6] Ibid.

[7] Ibid. at v.

[8] EPA, Report to Congress: Drinking Water Infrastructure Needs Survey and Assessment (2013).

[9] Real Capital Analytics, citied in Emerging Trends in Real Estate 2015 (PWC and Urban Institute), located at http://www.pwc.com/en_US/us/asset-management/real-estate/assets/pwc-emerging-trends-in-real-estate-2015.pdf.

[10] Urban Sustainability Directors Network, http://usdn.org/public/About-us.html.

[11] See http://sustainablenewarknj.com/category/sustainability-action-plan/.

[12] See http://www.hobokennj.org/sustainablehoboken/.

[13] See http://www.trentonnj.org/Cit-e-Access/webpage.cfm?TID=55&TPID=10188.

[14] See http://www.bridgeportct.gov/bgreen.

[15] EPA, CSO Control Policy, 59 Fed. Reg. 18688, 18690 (Apr. 19, 1994).

[16] Ibid. at 18690.

[17] EPA, CSO Control Policy, 59 Fed. Reg. 18688 (Apr. 19, 1994).

[18] Ibid. at 18689.

[19] EPA, Guidance for Nine Minimum Controls (1995).

[20] Ibid. at 18691.

[21] EPA, Guidance for Long Term Control Plan (1995).

[22] EPA, http://water.epa.gov/infrastructure/greeninfrastructure/upload/Greening_CSO_Plans.PDF.

[23] For example, NJDEP's SRF funding provide bonus points for municipalities and utilities that have an asset management plan and for projects that are identified in an asset management plan. See generally NJDEP, Asset Management Guidance and Best Practices.

[24] At the WEF 2014 Collections System Conference in Baltimore, Maryland, several technical discussions were dedicated to identifying the appropriate threshold for collection system modeling. While the consensus from these discussions identified 24" pipe size or greater would adequately and cost-effectively support planning, it is recognized that design would lower this threshold to include all pipes and modeling results may need to be modified as a result.

[25] For a description of Camden's water conservation ordinance see http://www.camdensmart.com/uploads/6/2/8/5/6285355/conservation_ordinance.pdf.

[26] Camden's plan is found at http://www.camdensmart.com/projects.html.

[27] Hoboken's Green Infrastructure Strategic Plan is found at http://togethernorthjersey.com/?grid-portfolio=hoboken-green-infrastructure-strategic-plan.

[28] The information in this table is a synthesis of information obtained from interviews, existing program summaries and technical assistance documents describing lessons learned about GI Planning as well as a review of LTCPs which include GI as part of the menu of alternatives evaluated or preferred plan.

[29] For a daylighting example in Camden, see http://www.courierpostonline.com/story/news/local/south-jersey/2014/07/23/flood-relief-project-launched-camden-park/13071597/.

[30] Rutgers Climate Institute, State of the Climate: New Jersey 2013, http://climatechange.rutgers.edu/ docman-list/special-reports/133-state-of-the-climate-new-jersey-2013/fle.

[31] Ibid.

[32] NJ Climate Adaptation Alliance, A Summary of Climate Change Impacts and Preparedness Opportunities for the Water Resources Sector in New Jersey (March 2014),found at http://njadapt.rutgers.edu/docman-lister/resource-pdfs/98-njcaa-water/file.

[33] Clark Kingsbury, "Breathing Life Into Urban Streams." Water Canada 14.3 (2014): 24-25 (Dec.15, 2014).

[34] NJ Future, Ripple Effects: The State of Water Infrastructure in New Jersey Cities and Why it Matters (2014).

[35] EPA Guidance for Long-Term Control Plan (p. 3-34)

[36] EPA Guidance for Long-Term Control Plan (pg. 3-31 through 3-34); Personal experience working with a sewer cleaning company.

[37] EPA Guidance for Long-Term Control Plan (pg. 3-9)

[38] EPA Guidance for Long-Term Control Plan (pg. 3-26 & 4-13)