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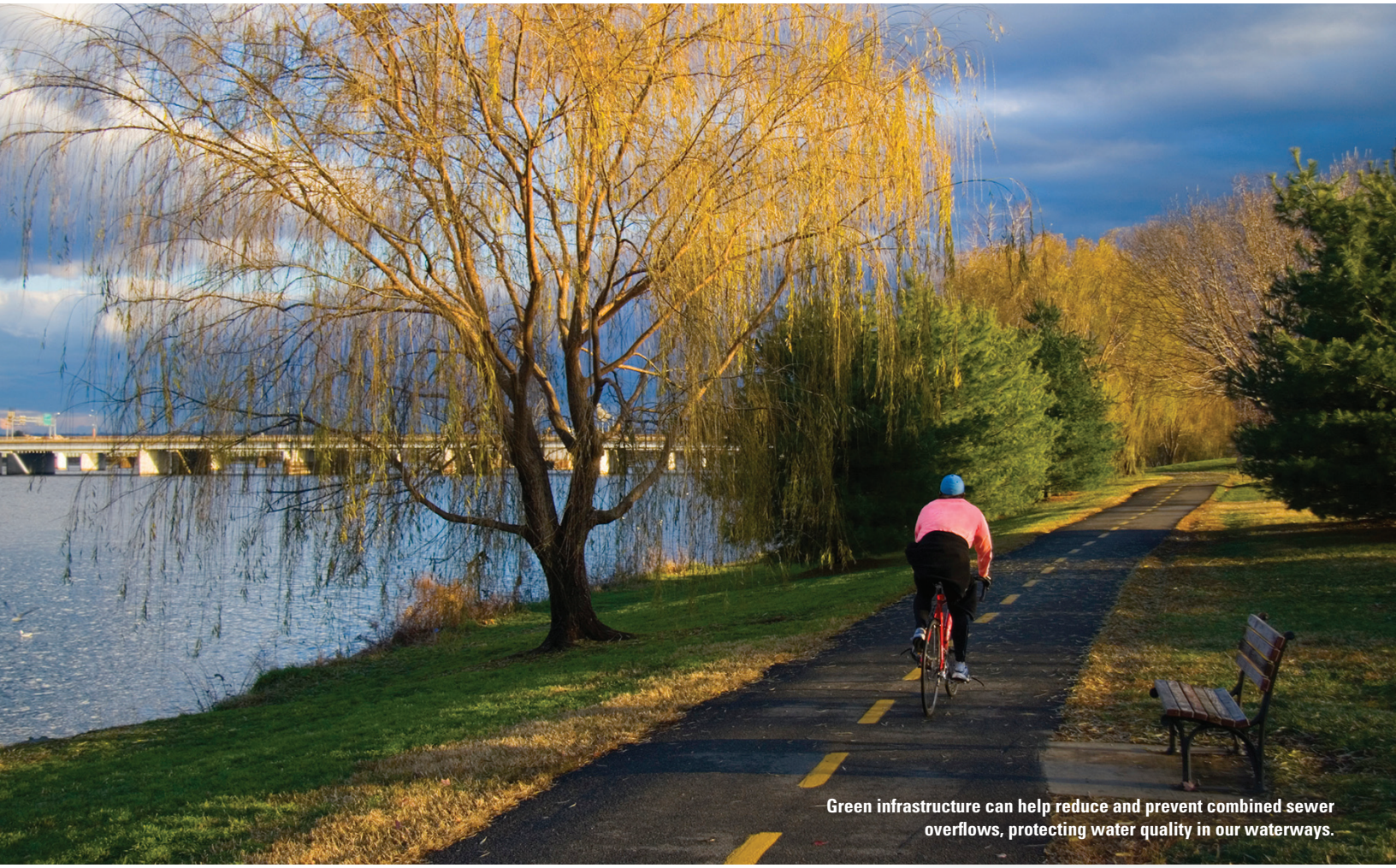

Green infrastructure can help reduce and prevent combined sewer overflows, protecting water quality in our waterways.

Combined Sewer Overflows

This factsheet is the second in a series of six on integrating green infrastructure concepts into permitting, enforcement, and water quality standards actions.

Integrating Green Infrastructure Concepts into Permitting, Enforcement, and Water Quality Standards Actions

*This factsheet is the second in a series of six factsheets in the U.S. EPA Green Infrastructure Permitting and Enforcement Series (*http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm#permittingseries*). This series describes how EPA and state permitting and enforcement professionals can incorporate green infrastructure practices and approaches into National Pollutant Discharge Elimination System (NPDES) wet weather programs, including stormwater permits, Total Maximum Daily Loads (TMDLs), combined sewer overflow (CSO) long-term control plans (LTCPs), and enforcement actions. This series builds upon EPA's continued investment in green infrastructure and low impact development. Existing EPA authority, guidance, and agreements enable EPA Regions and state agencies to work with permittees to include green infrastructure measures as part of control programs.*

For additional resources on green infrastructure, go to the EPA Green Infrastructure Web page: http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm**.**

Key green infrastructure guidance issued to date can be found at: http://water.epa.gov/infrastructure/greeninfrastructure/gi_policy.cfm.

Combined Sewer Overflows (CSOs)

Introduction

Green infrastructure can reduce the volume of water going into combined systems during precipitation events, which may reduce numbers and volumes of overflows. Green infrastructure can also slow the delivery of wet weather flows to sewer systems, helping to mitigate peak flows while providing filtration through soil for some portion of the release into the sewer system, thereby reducing pollutant loads. The implementation of green infrastructure practices may allow communities to downsize certain grey infrastructure components of their CSO control plans. This may provide some CSO communities with significant cost savings.

EPA GUIDANCE: CONSIDER SOURCE CONTROLS

Existing EPA guidance states that, as part of the "Identification Control Alternatives" for inclusion in CSO LTCPs, CSO communities must consider source controls, which are defined specifically to include green infrastructure approaches (Combined Sewer Overflows Guidance for Long-Term Control Plan, EPA 832-B-95-002, at pp. 3-31 – 3-33).

Under the Clean Water Act and EPA's 1994 CSO Control Policy, most CSO communities are required to develop and implement a Long-Term Control Plan (LTCP) to restore and protect water quality. National Pollutant Discharge Elimination System (NPDES) permits and administrative or judicial orders establish requirements for developing and implementing LTCPs. There is also existing guidance on development and implementation of LTCPs (see sidebar below).

Existing Guidance on Development and Implementation of LTCPs

PERMITTING: http://cfpub.epa.gov/npdes/home.cfm?program_id=5

ENFORCEMENT: http://www.epa.gov/compliance/resources/policies/civil/cwa/csosso-guidelines-enf.pdf

CSO POLICY: http://cfpub.epa.gov/npdes/cso/cpolicy.cfm

Evaluating the Potential of Green Infrastructure for CSO Control

In many cases planning for the use of green and grey infrastructure will be most effective if both elements are integrated throughout the planning and engineering design processes. Therefore, it is recommended that communities carry out integrated green/grey planning to identify opportunities to use green infrastructure in cost-effective combinations with grey infrastructure. This can help lower upfront and/or operational costs. If, for example, a community does engineering analyses to plan grey infrastructure, sized to achieve high levels of control, and then adds green infrastructure as a layer near the end of the planning process, the community may conclude that green infrastructure does not appreciably increase the level of control. However, if planning specifically encompasses green and grey infrastructure together throughout the process, it is likely the planning will reveal many opportunities to use green infrastructure to keep water out of the system in some or all sewersheds. By capitalizing on opportunities to place green infrastructure in sewersheds, communities may be able to reduce the size of grey infrastructure controls.

This is not meant to imply that grey infrastructure controls are not needed; in most communities green infrastructure alone will not resolve CSO problems for large storms.

Depending on land uses, land owners, and other variables, some sewersheds are well-suited for green solutions whereas others may provide less opportunity. Therefore, stormwater reduction analyses typically should be considered sewershed by sewershed. Estimating the maximum or optimal amount of green infrastructure that can be implemented in a sewershed requires an analysis of land use and technical/environmental factors such as soil types and topography, as well as institutional considerations, such as the need to develop incentives to facilitate implementation of green infrastructure features on private property.

Development of CSO LTCPs involves analysis of the financial capability of the community and analysis of alternatives for reducing CSO frequencies, volumes, and pollutant loads. Historically, grey infrastructure approaches and operational enhancements have been the key components of LTCPs. Recently, there has been greater interest in using green infrastructure approaches, often in combination with grey infrastructure and operational enhancements, to meet CSO control needs. This approach may have the advantage of distributing the cost of control more broadly, rather than relying solely on utility ratepayers. For example, if a green streetscapes project is implemented it may be possible to cost-share between the stormwater or CSO authority and a transportation organization. In other cases a school or park district may cost-share with the local stormwater/CSO authority. Additionally, several recent CSO consent decrees have required the retrofitting of sizeable areas with green infrastructure as part of holistic approaches to CSO reduction.

(See Supplement 1).

Case Study of the Impacts of Trees and Green Roofs on Stormwater Runoff

Various organizations and communities have recently conducted studies to estimate the potential for reducing flows into combined sewer systems through systematic use of green infrastructure practices. In 2007, Casey Trees and LimnoTech, with funding from EPA, conducted a modeling study of the impacts of trees and green roofs on stormwater runoff in the Washington, DC area (http://caseytrees.org/programs/policyadvocacy/). The Casey Trees modeling estimated, upon completion of implementation of green infrastructure projects:

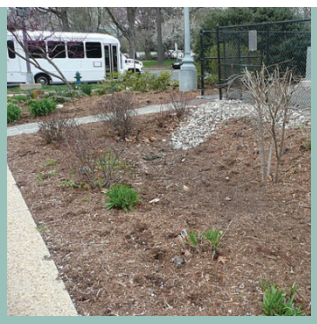

Figure 1: A bioretention cell absorbs runoff.

- For an average year, the intensive greening scenario would prevent over 1.2 billion gallons of stormwater from entering the sewer systems, resulting in a reduction of over 1 billion gallons in discharges to local rivers.
- For an average year, the moderate greening scenario would prevent over 311 million gallons of stormwater from entering the sewer systems, resulting in a reduction of 282 million gallons in discharges to local waterways.
- With the intensive greening scenario, installing 55 million square feet of green roofs in the Combined Sewer System (CSS) area would reduce CSO discharges by 435 million gallons, or 19%, each year.

The initial round of modeling focused only on green roofs and enhancing the urban tree canopy. Further work was then done to model the effects of other green infrastructure components in the Washington D.C. service area. Other communities and regional sewer authorities that have incorporated green infrastructure controls in their CSO planning include New York, Cincinnati, Louisville, , Omaha, San Francisco, Kansas City, and Cleveland.

Developing Quantitative Implementation Targets

Once a community has evaluated the potential of green infrastructure practices for CSO control, and determined green infrastructure practices can be a cost-effective component of an LTCP, it is important to identify the locations for green infrastructure implementation and to quantify the projected level of green infrastructure implementation. A community can identify what green infrastructure of what size/capacity can be put where in a sewershed, and can then determine what level of reduction that will achieve in terms of wet weather flows entering the sewer system. The new flow information can then be used in the sizing of grey infrastructure. See Supplement 3 for a summary of tools and calculators that are available to help quantify the impacts of green infrastructure.

Once a community has completed a desktop analysis identifying priority sewersheds for green infrastructure implementation, a more detailed analysis must be completed to establish a quantitative green infrastructure implementation target. A discussion of alternative analysis methodologies is beyond the scope of this document. In general, however, the methodology should first develop a set of green infrastructure scenarios, and then assess the outcomes associated with each scenario. The scenario that best meets the community's needs may be adopted as an implementation target. Ideally, the methodology should allow the community to compare the cost-effectiveness of each alternative in meeting CSO control targets, and the range of environmental benefits provided by each alternative. The checklist on Page 5 provides a general methodology for establishing a quantitative green infrastructure implementation target. Note that this is only one of many approaches that a community might take.

The implementation target identified may call for many decentralized green infrastructure practices. In a permit or enforcement action, it will be important to include appropriate provisions to ensure the decentralized practices (many of which will not be on land owned/controlled by the sewer authority) are properly installed, preserved over time, and maintained.

Many communities have identified municipally-owned properties and road right-of-ways, and other parcels that may be well-suited for green infrastructure practices, (e.g., corporate campuses, school campuses, and vacant parcels where there is no near-term demand for redevelopment). These communities have quantified the flow volumes that could be managed at these sites, and then incorporated the results into planning of the complementary grey infrastructure controls.

Also, important factors in some sub-watersheds may be the preservation or enhancement of natural green infrastructure, including features like riparian buffers, forest preserves, floodplains, wetlands, and parks. In estimating flows coming out of a sewershed, the capacity of such areas to absorb stormwater flows needs to be considered. It may be appropriate to incorporate the need to preserve, and in some cases enhance such areas in a LTCP.

Figure 2: Stormwater park at Saylor Grove in Philadelphia

In some urban areas, a city or sewer authority may determine that it will focus on relatively larger green infrastructure practices, perhaps at the block scale, and will set up ownership and operation of the sites and practices under the direct control of the city or sewer authority. An example of this would be where a city constructs "stormwater parks" to store and infiltrate wet weather flows (see Figure 2). With an approach like this, the capacity of the practice can be readily determined, much like a detention pond, and green infrastructure plans and commitments can reflect the number, locations, and sizing of the larger-scale green practices. Stormwater parks can be planned at strategic locations in the sewer network, and where they fit well into the fabric of the community area. Using larger scale green infrastructure practices, where the city or sewer authority retains control over the practices, may be advantageous for a community in terms of assuring the practices are properly built, preserved, and maintained.

Adaptive management approaches can be used during LTCP implementation to ensure green infrastructure measures are being implemented and are working to the degree expected (see further discussion below). Closely monitoring green infrastructure implementation and performance is important to ensure the projected levels of storage and control are being achieved. Mid-course adjustments can be made if necessary. The monitoring of implementation and performance coupled with the use of adaptive management approaches — making adjustments to future efforts based on lessons learned — can help alleviate possible uncertainty or perceived risks about implementing green solutions as part of a CSO control program.

A General Methodology for Establishing a Quantitative Green Infrastructure Implementation Target

- [ ] Select a sample set of sewersheds that are generally representative of the service area as a whole, in terms of land uses, land ownership, soils, and topography.
- [ ] Characterize existing land use/land cover in the subwatersheds; this can often be done using aerial photographs and/or a community's geographic information system (GIS) coverages.
- [ ] Create templates for the various land uses in the sewersheds (e.g., typical single family residential lot, typical commercial/office site). Estimate the pervious and impervious areas for the templates.
- [ ] Identify green infrastructure opportunities for the different land use categories (templates) in the sewersheds, taking into account space needs, soil types, and slopes.
- [ ] Estimate the total green infrastructure that could be implemented in the sewershed by extrapolating from the templates to the sewershed as a whole. This estimate should take into account current and future zoning and institutional considerations, such as acceptance by property owners of green infrastructure features on private property. The level of buy-in to the green infrastructure program on the part of local property owners is an important variable, and needs to be explicitly considered in CSO planning. The estimate should also consider public properties and parks that may be good candidates for green infrastructure practices.
- [ ] Examine the cost-effectiveness of green infrastructure approaches. Will the green solutions reduce upfront or operational costs? Experiment with various combinations of green and grey infrastructure to determine what combination results in the lowest costs.
- [ ] Estimate the green infrastructure opportunities for the CSO service area as a whole by extrapolating from the sample set of sewersheds studied.
- [ ] Estimate the stormwater volumes that can be kept out of the system by the green infrastructure, taking into account the level of estimated implementation and the size of the practices. Also consider if there should be a margin of safety to reflect actual green implementation that may vary from projections, especially for sites not under the direct control of the sewer authority.

Incorporating Green Infrastructure Approaches into Long-Term Control Plans

Green infrastructure components should be explicitly identified and accompanied by compliance schedules in LTCPs along with grey infrastructure components. A list of the items that should be included in a LTCP if a community chooses to utilize green infrastructure measures is provided in the checklist on Page 6.

The timing for green infrastructure implementation should be expressly considered in CSO planning. Some green infrastructure benefits will probably be realized sooner than those for grey solutions, while others may take longer. It is important to achieve a reasonable balance while keeping in mind the overall environmental objectives. Discussion of these items and how they will be addressed in the LTCP should be done jointly between the community carrying out implementation and the permitting/enforcement authority.

As a companion to LTCP implementation, CSO communities planning for significant green infrastructure implementation should:

- Develop strategies or standard operating procedures (SOPs) for green infrastructure implementation;
- Consider approaches for dealing with legal and institutional issues including updating codes and ordinances;
- Consider changes to fee structures to incentivize green infrastructure;
- Consider how they will work to systematically install green infrastructure on different types of sites, e.g., municipally-owned public sites, schools, park district sites, corporate sites, and residential properties. The issues that will be encountered in putting rain gardens in parks or schools will be very different from the issues to be dealt with in getting green roofs on public and private buildings.

SOPs can help communities plan for and implement effective approaches to place green infrastructure at different types of sites within their service area.

Preservation of green infrastructure sites and practices

In addition to including provisions for operation and maintenance of green infrastructure practices, permits, and enforcement actions also need to consider mechanisms to assure green infrastructure is preserved (i.e., that a site or green infrastructure practice is not changed or removed at some point in the future). For example, language in a general permit issued by Ohio EPA specifies that protection (preservation) of infiltration areas shall be by binding conservation easements that identify a third party management agency, such as a homeowner or condominium association, political jurisdiction, or third party land trust. See: http://www.epa.state.oh.us/dsw/permits/GP_ConstructionSiteStormWater_Darby.aspx.

Including Green Infrastructure in LTCPs

Green infrastructure components should be explicitly identified and accompanied by compliance schedules in LTCPs along with grey infrastructure components.

The following should be included in an LTCP with green infrastructure:

- ☐ The planned (and quantified) level of green infrastructure implementation (what will be installed where, e.g., number of infiltration practices to be installed and associated sizes/capacity);
- ☐ Key implementation steps (actions);
- ☐ Sequencing (ensure green and grey elements fit together; also in many cases it may work well to start in upstream areas and work toward downstream areas);
- ☐ Schedule;
- ☐ Methods and milestones for tracking and reporting on green infrastructure implementation (are the green infrastructure practices going in as planned and scheduled);
- ☐ Requirements to assure appropriate operation and management (O&M) of the green infrastructure;
- ☐ Methods for monitoring the performance and effects of green infrastructure implementation (e.g., are individual practices working as planned, are collections of practices in a sewershed keeping flows out of the sewer system as projected);
- ☐ Provisions for adaptive management/corrective actions if green infrastructure performance (at the site scale and/or the sewershed scale) does not meet expectations

Green for Grey Substitutions

In some cases much of the foundational planning and engineering work on CSO controls may have focused on grey infrastructure practices, but well into CSO planning work the idea of incorporating green infrastructure into the LTCP may have been raised. In these types of situations it may be appropriate in a permit or enforcement action to include provisions that would govern a possible substitution of green infrastructure control measures for grey infrastructure control measures. The Consent Decrees dealing with CSOs in the Kansas City, Missouri and Cleveland, Ohio areas are examples of agreements that include provisions for green for grey substitutions. Supplement 2 provides example language which addresses some of the issues that may be associated with green for grey substitutions.

Monitoring and Evaluating Green Infrastructure Performance

Permits and enforcement actions that include green infrastructure measures should include provisions for evaluating the performance and effects of installed green infrastructure control measures. These provisions would be an essential component of post-construction monitoring required for CSO control practices. It may also be appropriate to include requirements for corrective action implementation if green infrastructure practices do not perform as projected. Following is example language to address post-construction monitoring for green infrastructure practices: [http://www.ohioenvironmentallawblog.com/uploads/file/NEORSD%20Green%20infrastructure%20CO.pdf]

"The Sewer District shall submit a plan for performing green infrastructure post-construction monitoring ("GIPCM") at two scales: (a) site or practice scale; and (b) sewershed scale. The monitoring shall be planned to evaluate the performance and effectiveness of the green infrastructure control measures, as further defined below. Once approved by EPA and the State, the District shall implement the GIPCM program in accordance with the approved GIPCM plan. The District shall submit green infrastructure post-construction monitoring reports providing the results of the GIPCM programs to EPA and the State.

a. The site or practice scale GIPCM program shall evaluate the effectiveness of the green infrastructure control measures on a site-specific scale. The GIPCM plan shall set forth the ways the various types of green infrastructure control measures to be implemented (e.g., constructed wetland, etc.) will function to control wet weather flows (e.g., through storage, infiltration, and/or evapotranspiration), and the monitoring/assessment methods that will be used to evaluate the performance and effectiveness of the various types of practices. The GIPCM plan shall set forth the District's methods and procedures for evaluating the performance of green infrastructure control measures on a site-specific scale, such as monitoring practices during and after rain events to gauge storage and/or infiltration performance. The GIPCM plan shall establish procedures for conducting performance evaluations on the fully constructed and operating green infrastructure control measures. Under the site-specific program, performance evaluations shall assess the effectiveness of the practices in terms of the functions the green infrastructure control measure was intended to fulfill (e.g., storage, infiltration). Each site-specific green infrastructure control measure (or a representative sample if similar practices are installed at similar sites) shall be monitored for a minimum of 12-months immediately following implementation.

b. The sewershed-specific GIPCM program shall set forth the steps the District shall take to evaluate the performance and effectiveness of green infrastructure measures on a sewershed scale. Examples of such methods and procedures include collecting rainfall and wet weather flow data sufficient in scope and detail to allow: (i) characterization of the performance of the green infrastructure measures in a sewershed, and (ii) hydrologic adjustment of the sewershed portion of the collection system model to determine the impacts of the green infrastructure measures on system performance within the subject sewershed. The District shall adjust the hydrologic model parameters directly related to the green infrastructure control measures as necessary to accommodate changes in model parameterization caused by shifts in runoff hydrology from the green infrastructure measures. The District shall then use both the appropriate CSO model without the green infrastructure measures, and the model that includes the green infrastructure measures, to simulate the sewershed's typical year performance both with and without the green infrastructure measures in order to demonstrate the CSO volume reduction.

c. If the green infrastructure post-construction monitoring report submitted by the District fails to demonstrate that the green infrastructure control measures have met the performance criteria specified for such control measures, then within 180 days of submission of the report, the District shall submit to EPA and the State a corrective action proposal. The corrective action proposal shall define the green or grey infrastructure enhancements/expansions to be carried out to address performance shortcomings and ensure the performance criteria are met. The proposal shall include a schedule for completion of all corrective action measures and an updated post-construction monitoring plan to evaluate whether the corrective actions have resulted in the performance criteria being met. The performance criteria for the green infrastructure sites/practices must be achieved within [XX] years of entry of the Consent Decree."

Green street projects raise the possibility of cost sharing between the stormwater or CSO authority and the transportation department.

Green Infrastructure Permitting and Enforcement Series

This series on integrating green infrastructure concepts into permitting, enforcement, and water quality standards actions contains six factsheets plus four supplemental materials that can be found at ***http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm#permittingseries****.*

Factsheets

1. Potential Challenges and Accountability Considerations
2. Combined Sewer Overflows
3. Sanitary Sewer Overflows
4. Stormwater
5. Total Maximum Daily Loads
6. Water Quality Standards

Supplemental Materials

1. Consent Decrees that Include Green Infrastructure Provisions
2. Consent Decree Language Addressing Green for Grey Substitutions
3. Green Infrastructure Models and Calculators
4. Green Infrastructure in Total Maximum Daily Loads (TMDLs)

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