APPENDIX-B TECHNICAL SUPPORT DOCUMENT (TSD): Next-Generation Stormwater Management

Tisbury MA Impervious Cover Disconnection (ICD) Project: An Integrated Stormwater Management Approach for Promoting Urban Community Sustainability and Resilience

A technical direct assistance project funded by the U.S. EPA Southeast New England Program (SNEP)

Task 5 Technical Support Document (TSD):
Next-Generation Stormwater Management

Prepared for:

U.S. EPA Region 1

In Cooperation With:

Town of Tisbury, MA
Tisbury Waterways
Martha's Vineyard Commission
Massachusetts Department of Transportation

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I. Executive Summary

UNH Stormwater Center along with EPA Region 1, Paradigm Environmental and Great Lakes Environmental Center (collectively, the Project Team) have developed a new and innovative approach for next-generation stormwater (**SW**) management. The approach represents a paradigm shift away from historical approaches in several important ways:

- due to both cost and the lack of available space within geographically constrained urban environs, geospatially distributed small-scale SW control measures (**SCM**)[1]and SCM retrofits represent an emerging practicable approach to achieve watershed restoration objectives;

- geospatially distributed small-scale SCMs are readily, flexibly and cost-effectively implementable by municipal practitioners provided such municipalities accept and adopt small-scale SCM innovation (incl. maintenance);

- optimization algorithms and high-resolution geospatial data are leveraged to develop long-term management strategies to cost-effectively achieve water quality goals; and

- the benefits and limitations of small-scale SCM are communicated using metrics and measures the municipality and the public readily understand.

Over a decade or more, Project Team members have individually and/or collectively worked with select municipalities throughout the region (e.g., Berry Brook Dover, NH (UNH)) to promote these SW innovations (e.g., EPA's Opti-Tool model; Performance Curves[2]) by providing direct assistance for addressing water resource challenges that are increasingly exacerbated by climate change.

Most recently, the Project Team collaborated with the Martha's Vineyard Commission (MVC) and the Massachusetts Department of Transportation (MassDOT) in a direct technical assistance project for the Town of Tisbury, MA. The team addressed environmental challenges including SW-related flooding and water quality impacts to Martha Vineyard's Lagoon Pond resulting from uncontrolled SW nitrogen discharges. These problems represented an important, unique and challenging opportunity to address impervious cover (**IC**) disconnection (ICD) in an urbanized context – a further extension of the above-referenced work the Project Team has been conducting but with the added complexity of addressing IC disconnection-related flooding in an urban context having significant topological slope leading down to a business district located near the ocean that experiences chronic (if not acute) flooding regularly. The immediate goal of the project (**Tisbury ICD Project; the Project**) was to identify, assess and quantify

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[1] SCM includes green infrastructure (**GI**) SCM and is often referred to as "best management practice" (BMP). Except where it is technically appropriate to differentiate GI SCM from other SCM, SCM will be used to describe all SW control measures. In the context of this memo, SCM largely refers to structural SCM, although non-structural SCM is an important component of SW management and optimization.

[2] Performance Curves provide pollutant load reduction estimates for structural controls. A Performance Curve tells a SW practitioner how much of a given pollutant (e.g., nitrogen, bacteria) can be controlled simply based on the size of the SCM. Refer to **Appendix A**.

opportunities for the disconnection of IC within a geographically constrained urbanized New England municipality. Some related objectives the Project achieved include:

- **Concept Level Designs**
  The Project provides multiple SCM/GI concept-level designs identified as priorities by the Town and MVC;

- **Decision making; Education & Outreach**
  The Project provides a body of the technical documentation (incl. SCM quantified benefits and cost information) that can support the Town of Tisbury and MVC decision making, as well as public outreach and education;

- **Performance Curves for Bacteria**
  The Project developed technical information for use and application of Performance Curves for indicator bacteria to further quantify SCM benefits for protecting recreational uses in surface waters (Task 4D); and

- **Tech Transfer**
  The Project provides a refined model for SW optimization the Southeast New England Program (SNEP), its partners (e.g., the SNEP Technical Assistance Network (STAN)) and other municipalities across the Region and Nation to employ for developing cost-effective long-term SW management strategies.

In addition, several important observations may be summarized:

- **Significance of this Work Beyond Permit Requirements.** Increasingly, New England municipalities are recognizing the importance of their environmental resources and the economic services and benefits these resources provide. These same municipalities are cognizant of the impact of larger and more frequent storm events and the inability of older municipal SW infrastructure to effectively transmit SW runoff. Consequently, municipalities like Tisbury that are not required to conduct SW planning under a municipal separate storm sewer system (MS4) permit are nonetheless motivated to consider and embrace newer cost-effective innovations.

- **Optimization.** Optimization in the context of this project was the process for identifying optimal management solutions (mixture of optimal sizes of SCMs at the strategic locations on the landscape) through thousands of computer-simulated iterations using the Opti-Tool within a watershed to achieve desired flow and/or water quality objectives based on the cost-effectiveness.

- **Geospatially distributed small-scale SCM:**
  - in the aggregate, is more likely to result in watershed restoration than more expensive larger systems because runoff from more IC can be feasibly managed;
  - can be cost-effectively and flexibly implemented by municipal practitioners (viz., DPW);

  - can help to mitigate SW runoff that contributes to flooding. Although not all green infrastructure projects meet funding criteria of the Federal Emergency Management Agency (FEMA), broad-based implementation of small-scale SCM is potentially eligible for FEMA funding if the project meets certain requirements; and
  - the significance of geospatially distributed small-scale SCM implementation may go far beyond traditional SW management thinking: recent research which has had the benefit of time to assess the health and vitality of our watersheds indicates that efforts to restore the hydrological and ecological function of our watersheds is not likely to offset the past and future practices that continue to employ IC and other development practices that distort pre-development hydrology, pollutant export and hydrogeology. For instance, "billions of dollars continue to be invested in the physical restoration of urban channels . . . [However,] post-construction studies generally show . . . [these streams are in fact biologically] unrestored . . . *with some exceptions in cases where out-of-stream restoration practices, such as SW control measures have been implemented extensively*." (Hawley, 2015; emphasis added).

- **Effect of IC on Flooding.** SW-related flooding is highly correlated with impervious cover. Consequently, projects aimed at reducing IC, particularly in combination with SCM implementation, can be effective strategies and should be included in FEMA Hazard Mitigation Plans (HMP) and next-generation municipal bylaws / ordinance.

- **Constructing SCMs to Specification and Performing Maintenance.** Practitioners may conduct water quality monitoring of SCMs voluntarily or as otherwise required by Federal, State or local law (e.g., consent order, State permit). However, to the extent the following is not inconsistent with the above, by adopting Performance Curves into SW planning, municipal practitioners (and others) need <u>not</u> monitor for water quality parameters to determine SCM performance. Rather emphasis is to be placed on the construction of SCM to specification to ensure proper hydraulic function of the SCM; and thereafter, maintenance to ensure proper operation into the future.

  <u>Note</u>: Monitoring regimens necessary to validate SCM performance requires specialized expertise and intensive and costly effort. Collection of physical and chemical data, free of bias and false negative and false positive data, is complicated by numerous factors including flow velocities, flow paths, environmental conditions, etc. Consequently, if the SCM is constructed such that the hydraulic function of the SCM is as per specification, the pollutant load reduction estimate is given by the Performance Curves. The Performance Curves, therefore, provide a most economical solution to a highly complex and rigorous technical problem. If a given practitioner intends to conduct performance monitoring of a planned SCM, the monitoring design is best considered during design of the SCM to ensure flow gauging and sampling equipment will function to collect usable information not perplexed by random and systematic bias, and free of false negative and false positive data. Refer to Appendix A.

- **Today's Recommended Approach.** To reiterate, the approach set forth herein is recommended for SW implementation. The approach is predicated on the design, optimization and adoption of geospatially distributed small-scale SCM and incorporates the information provided by and within the Performance Curves (incl. indicator bacteria). The optimization process informs managers of the best SCM to implement when opportunities to implement arise through future municipal infrastructure work and public and private redevelopment projects.

This TSD has no regulatory import. Today's recommended approach is not intended to supersede or otherwise conflict with existing Federal, State or Municipal law.

The purpose of this technical support document (TSD) is to set forth this next-generation SW optimization approach as a model for the future. Because it is incumbent upon municipalities to implement these innovations, it is necessary to consider the social, economic and technological factors in municipal organizations that influence rates of adoption of innovative SW management approaches. Our thesis continues to be that such innovations are adopted from a 'diffusion' of practice led by certain early-adopting municipal practitioners who embrace the innovations that lead to the growing acceptance of the innovations and the mutual benefits the innovations provide for other municipalities, regulators, and outside consultants all working toward the same water quality goals. In short, disseminating case studies of successful SW planning, like this Tisbury ICD Project, helps bridge the technical performance gap that exists between innovative technology development and its implementation in a municipal context. The dissemination of success stories and lessons learned should be assisted by public education and outreach efforts and the collaborative sharing of experience between municipal practitioners

II. Process Summary

The innovative next-generation SW management optimization approach described herein necessitates discussion of the sociological and economic considerations underlying the process that is critical for engendering a meaningful and lasting transfer of technological innovation.

1. Engendering Meaningful and Lasting Transfer of Technology

Historical Perspective. In a conventional implementation approach, SW controls are often identified by suitable site characteristics. This approach tended to rely on the expertise of the SW consultant to develop a best solution, largely to achieve regulatory compliance. The solution usually assumed implementation (i.e., design and construction) of structural SCM(s) by the consultant and its subcontractors. Often, only SCM opportunities that would be consistent with conventional or standard sizing requirements would be evaluated, thus missing the more numerous opportunities to implement smaller but nevertheless effective SCM practices. Regardless, once constructed, the municipality was thereafter responsible for long-term operation and maintenance (O&M).

Although important, focusing largely upon achieving regulatory requirements may cause practitioners to miss opportunities to maximize other important benefits that optimization might provide the municipality (e.g., IC disconnection, flooding, habitat support, reduction of pollutant load to ecologically sensitive and economically important waters); and in situations when the municipality was not intimately involved in designing and implementing SCMs, the technology may have been divorced from its every day experience potentially frustrating municipal decision making. Also, in cases when municipal infrastructure owners were largely left out of the design process and the objective was not predicated on geospatial distributed small-scale SCM, the scale and costs of the technology may be greater than necessary and larger than could be sustained. Lastly, the municipality was often required by state and/or federal law to monitor the performance of the SCM at great cost and complexity. The discontinuity of this historical approach often resulted in the required O&M not being followed and the technology transfer stalled.

Next-generation SW Management Planning. Traditional approaches that focus solely on modeling solutions and engineering plans and information dissemination have not proven successful in the past. Purely technical information must address the problems faced by a community in terms the community can appreciate. Otherwise the community is not able to assimilate such information to enable sound, strategic decision making, realistic long-term O&M expectations and effective communication of anticipated needs with its constituencies (cost and personnel). In practice, traditional dissemination of scientifically robust information about the effectiveness of new strategies is unlikely to result in the desired adoption of these strategies by decision-makers (Clark, 2010). Studies suggest that cultural and social transmission processes are much more important to understanding the diffusion of innovations than is often assumed by most theorists (Damanpour and Schneider 2009) and thus ***more emphasis must be placed on linking scientific innovations to decision-making*** (Houle, 2015; Weisberg et al., 2007).

The next-generation SW planning process couples innovative watershed modeling optimization and the most effective SW control technologies to identify cost-effective pollutant load and runoff volume reduction strategies with a parallel process of ***engagement*** to ensure implementation sustainability, transfer of municipal ownership, and co-production of solutions as the basis upon which to build trust and support positive adoption decisions. Notably, this process was identified as a critical breakthrough in a recently completed 10-year study implementing a watershed management plan in the Berry Brook watershed in Dover, NH. The partnership between EPA, NHDES, UNHSC and the City led to implementation efforts that reduced the effective IC in the 185-acre urban watershed from 30% down to 10% EIC. The partnership engendered meaningful collaboration between academics, regulators and committed city staff and resulted in a reduction of SCM implementation costs, increased effectiveness, and led to more maintainable SW management systems. The focus of technical assistance engagement includes prioritization of cooperative identification of problems and co-development of solutions with project end users. Direct outreach with the participation of respected and trusted staff addresses three fundamental problems that are often associated with municipal adoption of innovative SW management approaches: compatibility, complexity and 'trialability'; in other words,

(i) does it fit our management culture? (compatibility),

(ii) can people understand it? (complexity), and

(iii) can local staff adapt the designs for greater utility? (trialability).

3. The Significance of Trialability. Researchers that focus specifically on the adoption of innovations in municipal organizations contend that implementation experience is required by public organizations to make informed adoption decisions (Boyne, 2005; Damanpour and Schneider, 2009; Walker, 2008). In other words, understanding the context within which public organizations operate and the characteristics of the organization itself are critical to encouraging behavior change, ***but for municipalities to adopt innovative solutions there must be implementation***.

Many of the conventional modeling approaches that have been undertaken in New England have not led to broad and meaningful watershed-wide implementation even though watershed-wide implementation is imperative for achieving water resource goals. Only with implementation at the municipal level comes experience and understanding of different SW management technologies and their cost implications that are crucial to technology transfer (i.e., adaptation). More importantly, without implementation, organic innovation adaptations are not advanced as a critical requirement for reinforcing positive adoption and program sustainability.

4. Next-generation SW Planning Summary. This next-generation approach is additive (often in parallel) to conventional larger-scale implementation efforts. There are ample SW management needs such that both approaches are complimentary. However, there are limitations and sustainability issues with exclusively advocating a conventional approach. The next-generation process critical to engender meaningful and lasting transfer of innovative technology to municipal practitioners and decision-makers can be summarily contrasted from what was the traditional or historical approach, as follows:

> **Conventional:** Consultants research, design, and construct SCMs on large available parcels available for development within the municipality. The well-intended process is designed principally to achieve regulatory compliance. This may lead to the construction of the largest SCMs possible on the available land. The design process can fail to engage municipal staff adequately in design and maintenance concerns and leaves the municipality or homeowners association with an additional O&M burden.
>
> Result: Limited in scope and context, larger more complex SCMs, failed O&M, lack of cost optimization to reach regulatory goals, little or no behavior change at the municipal level to continue implementing SCMs, and no meaningful watershed restoration.
>
> **New:** Consultants work with municipal practitioners to understand the motivations for municipal interest in SW optimization that considers current municipal operations and design and maintenance concerns. It is imperative that knowledge of the extent of impacts due to inadequate SW management, as well as quantified benefits of potential cost-effective SW management strategies, are transferred to local partners during this process. Motivations could include public perception of ecosystem degradation on the local economy, outdated infrastructure, flooding, other costs and benefits and regulatory compliance. Consultants work to help municipalities identify priority actions for SCM implementation that includes optimizing cost considerations and designing around O&M concerns. This process includes a thorough desktop-based review of high-resolution geospatial data to identify opportunity areas for SCM implementation. Importantly, the review gives a municipality a better sense of the opportunities and limitations of distributed small-scale SCM within their urbanized areas. Emphasis is placed on ensuring the municipality understands how SCMs operate and can implement simple concept SCM designs for enhanced SW control.
>
> Result: Flexible and cost-effective implementation of geospatially distributed small-scale SCMs. Municipal decision-makers understand how SCMs operate and are constructed. Implementation led by DPW results in broad appreciation for SCM technology and increases the likelihood for meaningful and lasting transfer of technology, and watershed restoration.

2. Next-Generation Innovative SW Planning Process: Step by Step

The step by step outline provided here is predicated on the discussion above and captures key SW optimization modeling and design steps employed for the Tisbury ICD Project.

A. Pre-Optimization Considerations

i. Understand What is Important to the Municipality

Ultimately the municipal officials must effectively communicate the importance of SW optimization and SCM implementation to the public. Municipal officials must also convey cost and performance expectations and anticipated needs with its constituencies. Understanding the drivers and concerns of the municipality and the public surrounding SW is critical, whether it be flooding, crumbling infrastructure, sustainability, cost concerns, healthy resources, development, etc.

ii. Increase Local Knowledge of IC-related SW Impacts to Water Resources

The practitioner must understand how, why and to what extent IC produces excess SW runoff impacting water resources. Then, the quantified benefits of effective SCM implementation are best demonstrated in metrics and measures the municipality can appreciate.

iii. Assess the Resources Available to the Municipality

It is important to understand the resources available to the municipality to undertake enhanced SW management, including exploration of low-interest loans, grants, and the existence of a SW enterprise fund. Additionally, it is important to assess the capacity of the municipal engineering department and DPW. Sustainable financing is an important component to an effective municipal SW asset management program. If a municipality has limited implementation experience, they may lack critical economic information of what an effective SW program requires.

iv. Identify Maintenance Concerns

Work closely with DPW officials to understand maintenance concerns that would impede SCM adoption. Focus on how the DPW currently maintains the SW system and how they hope to conduct maintenance moving forward. This will refine the type of SCMs available for implementation in the municipality to promote long term sustainable adoption of SCMs

v. Assess Availability of Data Requirements

Ideally this will begin with the review of GIS data layers including land use, impervious cover, assessor’s data, slope / LIDAR data, and asset management system data. **Usually, these do <u>not</u> include GW elevations or detailed soil data which are best determined during site-specific implementation.** It is important to understand the status of SW infrastructure including the condition of catch basins, trunk lines and outfalls. The process should leverage existing data including catchment delineations that may have occurred as an MS4 permit requirement.

B. Optimization Process: Step by Step Summary

i. Watershed Characterization

a. Precipitation and Climate

Summarize local meteorological conditions using hourly precipitation timeseries and daily air temperature data. This data is used as input to the EPA SW Management Model (SWMM) (U.S. EPA., 2016) to generate hydrologic response units timeseries for SW runoff and pollutants of interest (e.g., TN and pathogen loading). The SWMM output is then used as input into the Opti-Tool (U.S. EPA. 2016). Refer to Task 4 Technical Memorandums (TM) available at EPA Tisbury ICD Project and as discussed in Section 2.1 of the **Subtask 4J Final Report**.

b. Develop HRUs

Hydrologic Response Units (**HRUs**) are the core hydrologic modeling land unit that drives runoff and pollutant loading in the EPA developed Opti-Tool (U.S. EPA. 2016) watershed model. Each HRU represents areas of similar physical characteristics attributable to core processes identified through GIS overlays of the spatial datasets described below. Refer to Section 2.2 of the Subtask 4J Final Report available at EPA Tisbury ICD Project. It is important to note that HRUs can be developed at variable spatial scales. The EPA Tisbury ICD Project HRUs were developed at a 1m x 1m scale. Other models have successfully used parcel-based scales. These decisions require transparency and a broad understanding of the model assumptions.

Use available GIS datasets including land use, slope, soils, and impervious cover which can all influence runoff and pollutant loading. For the Tisbury ICD Project, GIS data was primarily obtained from the Massachusetts Bureau of Geographic Information Systems (MassGIS) website. The following datasets were identified as primary inputs for the watershed characterization:

- Land Use
- Hydrologic Soil Group
- Elevation and Slope
- Impervious Cover
- Building Structures

The figure above is a visual representation of the overlaying of land use, soil, slope, imperviousness, and structure layers to create a single HRU layer for Tisbury, MA.

c. Develop HRU Timeseries

Establishing the baseline condition runoff and pollutant loading. When performing simulation for BMP planning, the baseline condition becomes the basis for evaluating all management scenarios. Employing the climate data discussed above in Section 2(i)(a) (Section 2.1 of the Subtask 4J Final Report), the SWMM-HRU model is used by the Opti-Tool to simulate watershed hydrology and water quality processes to generate hourly surface runoff volumes and concentrations for target pollutants (e.g., total nitrogen (TN), total phosphorous (TP), total zinc (Zn), and total suspended solids (TSS)). Refer to Sections 2.3 and 2.4 of the Subtask 4J Final Report available at EPA Tisbury ICD Project.

ii. SCM Opportunities and Designs

The next-generation SW planning process couples innovative and cost-effective pollutant load and runoff volume reduction modeling with a parallel process of community engagement. The community engagement includes investigating sites of local concern and developing conceptual designs that could address the local site conditions but are also flexible enough to be applied in other areas and include local input. Consistent with the above discussion, this process of engagement ensures implementation sustainability, transfer of municipal ownership, and co-production of solutions as the basis upon which to build trust and support positive adoption decisions.

a. Identify SCM Opportunities and Strategies

The identification of SCM opportunities and strategies will depend on identifying municipal priorities. These priorities will be evaluated against, among other things, regulatory compliance objectives, cost and scope. With respect to scope, opportunities should initially emphasize locally defined needsas these will facilitate a discussion of municipal capacity and capability, and to help reinforce and empower municipal partners to take the first steps towards implementation. With respect to regulatory compliance objectives, it will be helpful to determine how, for instance, the location of impaired or TMDL waters will influence SCM siting based in part on permit requirements (if any). Identification of priority areas should be influenced by the presence of impaired waters, critical habitat, and importance of beaches and shellfishing areas, frequently flooded area, etc. SCM concept designs will employ Opti-Tool analysis to inform optimal sizing of various SCM types, particularly in the case of SCM retrofits where sizing can often determine feasibility. Performance Curves can help identify optimal SCM sizing optimization that helps avoid cost inefficiencies due to marginal cost returns. It is always important to emphasize and empower municipal refinement and adaptation of SCM concept designs so that the municipality can understand and appreciate how SCM designs can be modified for different situations and readily incorporated into planned capital improvement projects. Lastly, it will be important to focus on maintenance concerns. Refer to Sections 3.1 through 3.3 of the Subtask 4J Final Report available at EPA Tisbury ICD Project.

b. Develop SCM Concept Designs

The SCM Opportunities and Strategies identified above are used to develop small-scale SCM designs and provide an alternative implementation strategy for municipalities interested in adopting more effective SW management. The designs are vetted with the Town officials including public works staff to ensure they can be locally sourced, adapted and implemented by Town staff and Town-owned equipment. The co-development of small-scale designs provide the Town with examples of what the modeled solutions might look like. As discussed above, only with implementation comes the hands-on experience necessary to understand and adopt SCM solutions and develop defensible effective communications of anticipated needs in terms of dollars and personnel with its constituencies. Without implementation, local municipal knowledge and understanding of the SW management technologies and their inherent flexibility are not fully transferred. Refer to Sections 3.4 of the Subtask 4J Final Report available at EPA Tisbury ICD Project.

iii. Quantify SCM Benefits

To increase the capacity of a municipality to implement SCM and adopt next-generation approaches into municipal decision making, benefits must be clearly communicated to Town officials as well as the public using metrics and measures the Town and the public readily understand, such as runoff volume captured in *gallons*, pollutants treated in *pounds*, area of sub-watersheds / sub-catchments addressed in *acres*, discharge volume reduced in *event days* and estimated cost of municipal-led implementation in *dollars*. Hydrographs and Performance Curves can be used as visual aids to help demonstrate the benefits of SCM optimization and implementation. Municipalities and tribes can estimate load reductions from SCM implementation to compare against total maximum daily loads (TMDL). Refer to Section 4.2 of the Subtask 4J Final Report for quantification of Indicator Bacteria, Section 4.4 for quantification of target catchments identified as primary contributors of IC-related flooding in Tisbury due to poor transmission of SW flow discharge via Outfalls Nos. 2 and 7, and Section 4.5 for quantification of municipal-wide SCM strategies.

For purposes of reiteration, a useful summary of the steps leading to benefit quantification for the Tisbury ICD Project is provided in Section 4.4.3 of the Subtask 4J Final Report:

1. Establish baseline condition: Unit-area HRU timeseries for the period of interest (Jan 1998 – Dec 2018) were used as the boundary condition to the SCM simulation model. The Opti-Tool provides a utility tool that runs the SWMM models, calibrated to Region 1 specific land use average annual loading export rates, and generates the HRU hourly time series in the format needed for the Opti-Tool. The HRU hourly timeseries were developed using the hourly rainfall and daily min/max temperature data from a local rain gage located at the Martha Vineyard's airport.
2. Set Management objective: The management objective was to identify the most cost-effective SW controls (types and sizes) for achieving a wide range of TN loading, SW volume, and storm flow rate reductions at the two outfall locations.
3. Set Optimization target: Cost effectiveness-curves for average annual TN load and average annual SW volume reduction were developed.
4. Incorporate Land use information: The area distribution for the major land use groups within the pilot watershed was estimated. Each land use group in the model was assigned the corresponding unit-area HRU timeseries.
5. Incorporate SCM information: Two SCM types, infiltration trench and infiltration basin, were selected for six major land use categories based on the Management Category analysis. SCM specifications were set using the default parameters and SCM cost function available in the Opti-Tool (Table 4-12). Impervious drainage areas were assigned to be treated by each SCM type in the model.
6. Run optimization scenario: The simulation period (Jan 1998 – Dec 2018), the SW metrics of concern (flow volume and TN loading), the objective function (minimize cost) were defined and input files were created for the optimization runs. The optimization was performed using the continuous simulation SCM model to reflect actual long-term precipitation conditions that included a wide range of actual storm sizes to find the optimal SCM storage capacities that provided the most cost-effective solution at the watershed scale. Each optimization runs generated a CE-Curve showing the optimal solutions frontier for a wide range of SW volume and TN load reduction targets.

iv. Additional: Local Regulations

The next-generation process for enabling cost-effective and flexible small-scale distributed SCM implementation will increase the resiliency of municipal SW management systems, may be used to achieve pollutant reductions in TMDLs approved for their waterbodies, and increase the likelihood of watershed restoration. Next-generation municipal SW post-construction bylaws / ordinances are a critically important tool to effectuate progress toward watershed restoration goals and address local concerns such as flooding. Care should be taken to review local regulations to ensure impediments to implementation of SCM, including green infrastructure and low impact development (LID) techniques, are removed from all Town ordinances and bylaws. In addition, municipalities should choose SW post-construction management standards that are effective for their municipality and meet the regulatory federal and state minimums, where applicable.

One of the most important aspects of the model regulation is the adoption of the actual trigger threshold which would require a new development or redevelopment to comply with the regulatory standards. Often this decision is made by comparing the state or federal program trigger thresholds based on area of disturbance (43,560 sf of disturbance) to the proposed town standard. Many current approaches advocate adoption of a lower threshold trigger (e.g., 5,000 – 20,000 sf). This aspect of the regulation has a substantial effect on the future water quality and pollutant load reduction potential and should be carefully considered. Adoption of more stringent requirements, which are relatively easy and inexpensive to implement, can be highly effective in meeting TMDLs and restoring waters by reducing future pollutant loads not only from future developments but from existing untreated commercial land uses as well (redevelopment). Local regulatory updates can leverage the economic investment of developers in redevelopment projects to improve water quality conditions in the watershed and meet future state and federal permit requirements. For municipal areas characterized as medium and high-density residential, as well as commercial and industrial areas, it is suggested the thresholds triggering requirements be set low to prevent the accretion of IC and to effectuate disconnection of existing IC. Lastly, as risk mitigation strategies are likely to increase due to concern over larger and more frequent storm events linked to climate change, municipalities should ensure their FEMA Hazard Mitigation Plans (HMP) are current and include planned and implemented small-scale SCM: although not all green infrastructure projects meet FEMA funding criteria, small-scale SCM is potentially eligible for FEMA funding if the project meets certain requirements.

III. Conclusions

The purpose of this technical support document (TSD) has been to set forth a next-generation SW planning process and approach as a model for the future. The process represents a paradigm shift away from historical approaches in several important ways:

- due to both cost and the lack of available space within geographically constrained urban environs, distributed small-scale SCM and SCM retrofits represent an emerging practicable approach to achieve watershed restoration objectives;

- geospatially distributed small-scale SCMs are readily, flexibly and cost-effectively implementable by municipal practitioners provided such municipalities accept and adopt small-scale SCM innovation;

- optimization algorithms and high-resolution geospatial data are leveraged to develop long-term management strategies to cost-effectively achieve water quality goals; and

- the benefits and limitations of small-scale SCM are communicated using metrics and measures the municipality and the public readily understand.

The available literature and the collective municipal experience indicate conclusively enough that municipal implementation experience is critical to adapt 'textbook' research-based designs with what is practical for a public works department working in an urban setting. The methods have been successful in Dover NH, Arlington, MA, Franklin, MA - and now, Martha's Vineyard.

The next–generation approach is a highly collaborative one where consultants work with municipal practitioners to understand the motivations for municipal interest in SW optimization and that consider current municipal operations and design and maintenance. The process emphasizes geospatially distributed small-scale SCM implementation through adaptation at the municipal level. Emphasis is placed on ensuring the municipality understands how SCMs operate and ensuring the municipality can implement simplified concept SCM designs. By adopting Performance Curves into SW planning, municipal practitioners (and others) can estimate resulting pollutant load reductions and need not monitor for water quality parameters to determine SCM performance provided other applicable regulations do not require monitoring. Rather emphasis is to be placed on the construction of SCM to specification and thereafter, maintenance to ensure proper operation into the future. The result is:

- flexible and cost-effective implementation of geospatially distributed small-scale SCMs,
- municipal decision-makers understand how SCMs operate and are constructed, and
- implementation led by DPWs result in broad appreciation for SCM technology which increases the likelihood for meaningful and lasting transfer of technology, and watershed restoration.

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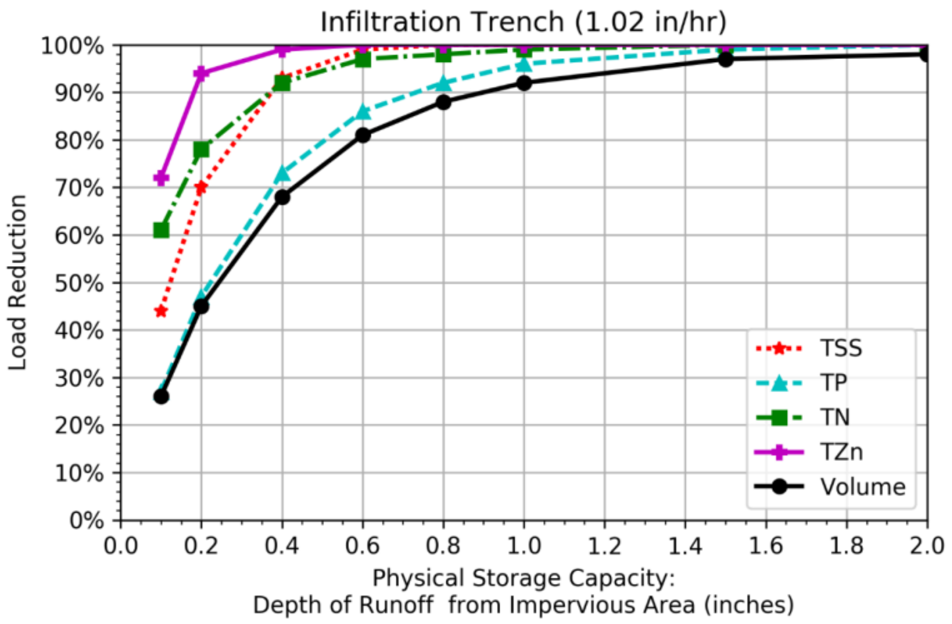
Appendix A: Performance Curves

In general, Performance Curves provide pollutant load reduction estimates for structural SCMs. A Performance Curve tells a SW practitioner how much of a given pollutant (e.g., nitrogen) may be controlled on an average annual basis simply based on the size of the SCM. This is important because the practitioner need not spend time and resources monitoring SCMs to assess pollutant removal (i.e., treatment) efficiency. Rather, practitioners need only (a) construct SCMs to specification and (b) operate and maintain the SCMs to function as designed.



This Performance Curve is for an Infiltration Trench SCM. At a design storage volume (DSV) sizing of 0.4 in. of runoff depth, a practitioner can expect to control better than 90% of the nitrogen load from the contributing impervious cover (IC) areas. The DSV represents the maximum design storage volume capacity of a SCM to hold water (i.e., equals volume of potential ponding and aggregate pore space of the SCM). Moreover, Performance Curves emphasize the opportunities that relatively small design capacity SCMs offer to make progress towards achieving water resource goals. This information is particularly valuable for installing SCMs in already-built environments (i.e., retrofitting) to manage IC runoff. In other words, the Performance Curves tell the practitioner to not limit investigations to consider only conventional SCM design capacities (e.g., water quality volume of 1 inch) for retrofitting but to expand the analysis to consider all opportunities where smaller design capacity SCMs can be installed. This flexible, distributed GI approach for retrofitting the built environment can potentially save communities significant amounts of money on implementation while making the SW system more resilient. For instance, the curve above informs the practitioner not to build an SCM for more than about 0.6 in. of runoff depth because very little additional load reduction results from a larger SCM, thereby saving design and construction costs.

For more information, refer to:

- SW BMP Pollutant Removal Tools and Information
  https://www.epa.gov/npdes-permits/SW-tools-new-england#swbmp
- Performance Curves for Indicator Bacteria
  https://www.epa.gov/sites/production/files/2020-01/documents/tisbury-subtask-4d-ps.pdf and
  https://www.epa.gov/sites/production/files/2020-01/documents/tisbury-subtask-4d-tm.pdf