Extended Abstract

Smart Stormwater Management – An Intelligent Stormwater Infrastructure Solution

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Highlights

- New smart technologies in stormwater management stand to eliminate downstream flooding
- Implementation of smart systems is now feasible, effective, and climate-resilient
- Smart systems ingest data and react autonomously in real time at the BMP level

Introduction

In the pursuit of smarter, more connected technologies supporting environmental and stormwater practices, Bob Bathurst, PE, and a team of consulting engineers at Century Engineering, Inc. developed and produced the SmartSWM™ system. This system allows forecast data to intersect with the behavior of Smart Ponds, resulting in more efficient management practices.

Key Findings

The developed world has fundamentally changed the hydrologic cycle by permanently converting natural areas to roadways, parking lots, and buildings. These impervious surfaces generate significant volumes of stormwater runoff, which in turn cause downstream flooding and erosion. Stormwater runoff carries pollutants such as nitrogen, phosphorous, bacteria and sediment that reduce the water quality and biodiversity in receiving streams and water bodies. EPA approved methods for mitigating the effects of development include stormwater ponds and shallow wetlands. Surprisingly, all modern stormwater management (SWM) modeling software packages utilize a static “unit” hydrograph design approach. Essentially, the design of all modern SWM practices assumes that all precipitation events last exactly 24 hours with a temporal rainfall distribution like that of a bell curve. This uni-storm distribution/duration design approach has caused unexpected/undesirable SWM facility performance during most storm events. With climate change being the new reality, it is critical that we implement adaptive SWM systems if we are to have a sustainable future.

Fortunately, the state of wireless connectivity and microcomputer technology make it now practical to precisely control the timing, volume, and rate of discharge from SWM facilities; thereby greatly enhancing their performance. Smart SWM systems utilize artificial intelligence in the form of software to adapt SWM facility behavior to achieve desired performance goals. Smart SWM control software ingests actual precipitation forecast data (both rainfall quantity and temporal distribution) and adjusts system behavior in real time, including accounting for changes in forecast. Likewise, smart SWM facilities can maximize the opportunity for runoff reduction (via infiltration/evaporation) by retaining the runoff volume for the entire period of time between storm events. In so doing, smart SWM facilities also maximize pollutant reduction performance and opportunity for aquifer recharge and/or stormwater reuse. Smart SWM facilities release stored water in advance of the forecasted precipitation event in a volume equal to that necessary to fully capture the inflow from the forecasted storm event and at the lowest discharge rate possible. The timing of releases from smart SWM facilities are offset from that of other portions of the watershed; thereby reducing downstream erosion, flooding, and CSOs.

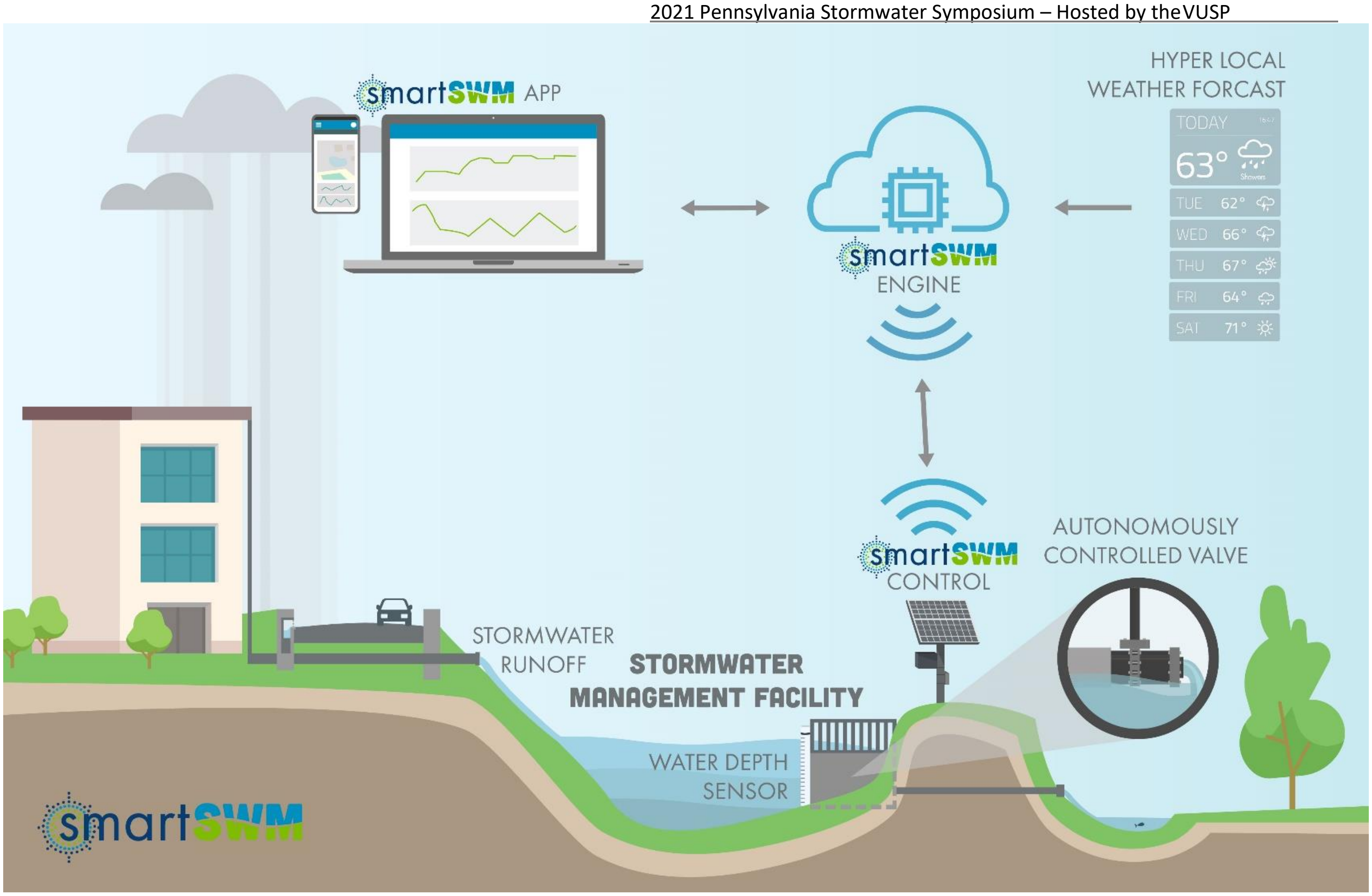

Figure 1. Diagram of basic functions/flow of the SmartSWM system.

Recommendations

Bringing technological advances to stormwater management practices can increase efficiency, while eliminating downstream flooding and lead to cleaner, healthier watersheds. With the implementation of these new smart systems, facilities, communities, ecosystems, and watersheds all stand to benefit.

Using Smart Stormwater Controls to Meet Stormwater Requirements and Preserve the Aesthetic Character of Two Historic Ponds in Harrisburg, PA

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Highlights

- Implementation of CMAC to optimize stormwater performance in existing historic community ponds.
- Pond retrofit to achieve multiple benefits – ecological function, aesthetics, recreation, CSO flow reduction.
- Historic spillway interpretation uses CMAC to integrate modern flow controls for CSO reduction.

Introduction

The purpose of this project was to develop a pond retrofit plan for two historical man-made ponds to improve water quality, optimize the ponds for stormwater management, provide safe conveyance for extreme events, and improve the aesthetics and ecological benefits of the ponds, while respecting the historical characteristics of the surrounding community of Bellevue Park. The design includes the integration of a continuous monitoring and adaptive control (CMAC) system to maximize storage volume capacity and control outflows from the ponds to provide optimal wet weather flow reductions to the combined sewer system operated by CRW. The system meets and exceeds regulatory retention requirements while maintaining existing water surface elevations in the ponds and free surficial discharge over the pond spillway as desired to maintain the historic character of the ponds, while providing CRW flexibility to modify flow discharges from the ponds as needed to adapt to future changes in the watershed.

Background & Project Description

Background

Bellevue Park is a landscaped neighborhood in Harrisburg, PA designed in 1909 by Warren H. Manning. The neighborhood design includes open space "reservations," with two connected ponds known as the "Upper" Willow Pond and "Lower" Spruce Pond. The ponds were experiencing damage and impacts to aquatic habitat from stormwater and its associated sediment and pollutant loading and as a result were heavily silted with eroding banks, and in need of dredging and repair. In 2016, Bellevue Park Association (BPA) began working with Capital Region Water (CRW) to address the ponds as part of CRW's City Beautiful H2O Program and Green Stormwater Infrastructure (GSI) Plan. .

Retrofit Design

The proposed pond retrofits to the Bellevue Park Ponds include grading and sediment removal to increase the storage capacity within both ponds, modification of the existing pond outlet structures and spillways, and landscape improvements to support ecological functions, stabilize the pond banks, and provide aesthetic improvements. The design maintains the existing water surface elevation in the ponds to maintain free flow through the ponds and to allow water flow over the existing lower pond spillway as it has historically operated.

The design includes the integration of a continuous monitoring and adaptive control (CMAC) system to maximize storage volume capacity and control outflows from the ponds to provide optimal wet weather flow reductions to the combined sewer system operated by CRW. Flow through the pond orifices will be controlled by automated butterfly valves to open and close based on weather forecast information. The goal of using weather forecast enabled infrastructure at the site is to manage stormwater runoff to minimize the rate of wet weather discharges to the stream and ultimately the combined sewer infrastructure, while maintaining the existing normal water surface elevation in each pond. The physical setup of continuous monitoring and adaptive control (CMAC) stormwater systems includes three primary components: a water level sensor to provide data on the facility's current state, an actuated valve to control its hydraulics (typically outflow), and an Internet connection most often provided in remote locations by cellular data.

The CMAC system adds "smart" controls to the discharge through each proposed low-flow orifice; the CMAC system will drain (or partially drain) the ponds in anticipation of precipitation events, recovering volume for stormwater runoff storage needed during the rainfall event. The CMAC system integrates real-time water level monitoring in each pond, and forecasted meteorological data from a nearby weather station, to predict the storage capacity needed for rainfall event capture. The CMAC system uses this information to decide when and for how long the pond low-flow orifices will open and discharge to the stream (during dry weather) and when water will be kept in the ponds to maintain the pond's normal water surface elevation. The CMAC system will also maintain flow through the ponds at the maximum allowable slow-release rate during wet weather, when needed.

The ponds were designed with the goal of providing storage capacity to manage between 0.8 inches and 1.4 inches of runoff generated during the 1-year, 24-hour design storm, minimizing wet weather flow rates out of the Lower Pond during the typical year to at or below CRW's maximum release rate, and providing increased flow capacity for extreme storm events. The maximum release rate calculated for the total drainage area to the ponds was 0.823 cfs and is based on CRW's maximum release rate of 0.05 cfs per impervious acre. PC SWMM was utilized to model the pond's inflow and outflow for both existing and proposed conditions. CRW's typical year H&H model was used as a basis for the existing conditions model.

The model results indicate that the proposed retrofit will reduce the hours of wet weather flow that exceeds the maximum release rate by over 80% over existing conditions. The total wet weather volume of flow released over the typical year is reduced by 32% and the volume of flow that is released above the maximum release rate is reduced by 80%. The proposed design results in 87% of the total runoff in the watershed being captured or managed at or below the release rate, and this results in a capture depth of 1 inch from the impervious drainage area to the ponds, as reflected in Figure 1.

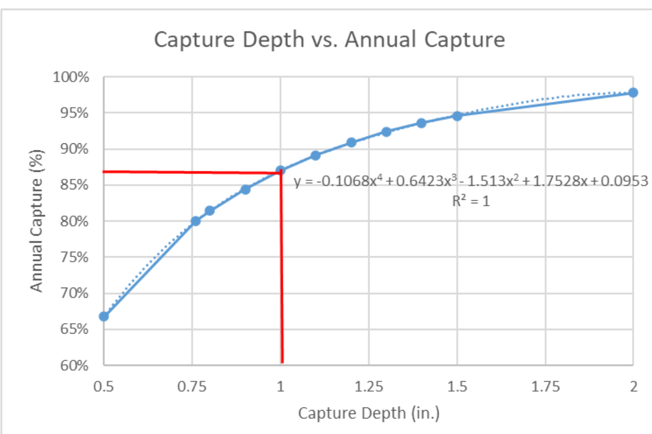

Figure 1. The pond retrofit design results in capture/management of 1-inch of runoff from 16.6 acres of impervious area draining to the ponds (16.6 greened acres) contributing to management of 87% of the annual runoff from the watershed.

Key Findings

The weather forecast enabled design for the Bellevue Ponds provides flexibility in the design that will allow CRW to control water storage in the ponds based on real time NOAA forecasted precipitation. The system meets and exceeds regulatory retention requirements while maintaining existing water surface elevations in the ponds and free surficial discharge over the pond spillway as desired to maintain the historic character of the ponds, while providing CRW flexibility to modify flow discharges from the ponds as needed to adapt to future changes in the watershed.

Blue-Green Stormwater Infrastructure: Overview and Emerging Trends

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Highlights

- Learn what blue-green stormwater infrastructure (BGSI) is and why it is being increasingly used to improve resiliency.
- See examples of BGSI from around the region and the world.
- Examine how BGSI can be incorporated in your projects and factors impacting the cost of doing so.

Introduction

This presentation will focus on the important, emerging water resources strategy of "blue-green" stormwater infrastructure (BGSI) that combines the water quality and community enriching benefits of "green" infrastructure coupled with the flood reduction and climate resiliency benefits of "blue" infrastructure. Whereas green stormwater infrastructure (e.g., bioretention and permeable pavement) typically uses vegetation, soils, and/or rainwater harvesting to treat and reduce smaller, more frequent stormwater flows, blue stormwater infrastructure (wet ponds and detention) temporarily stores larger volumes of stormwater without significant reliance on vegetation. As a combined strategy, BGSI encompasses both types of infrastructure and often includes such innovative, "floodable" systems such as "floodable parks", "wet plazas", and "retention boulevards" that can collectively provide a range of both stormwater-related benefits and other community benefits.

Background

The stormwater benefits of BGSI can include water quality improvements, groundwater recharge, and detention and flood mitigation benefits. The community benefits of BGSI can entail urban heat island mitigation, air quality improvement, climate resiliency, habitat creation and improvement, and numerous other social benefits (job creation, improved urban aesthetics, increased property values, improved pedestrian safety, and enhanced recreational spaces). With intense rainfall and urban flooding projected to increase significantly, BGSI offers a new mitigation tool (Figure 1).

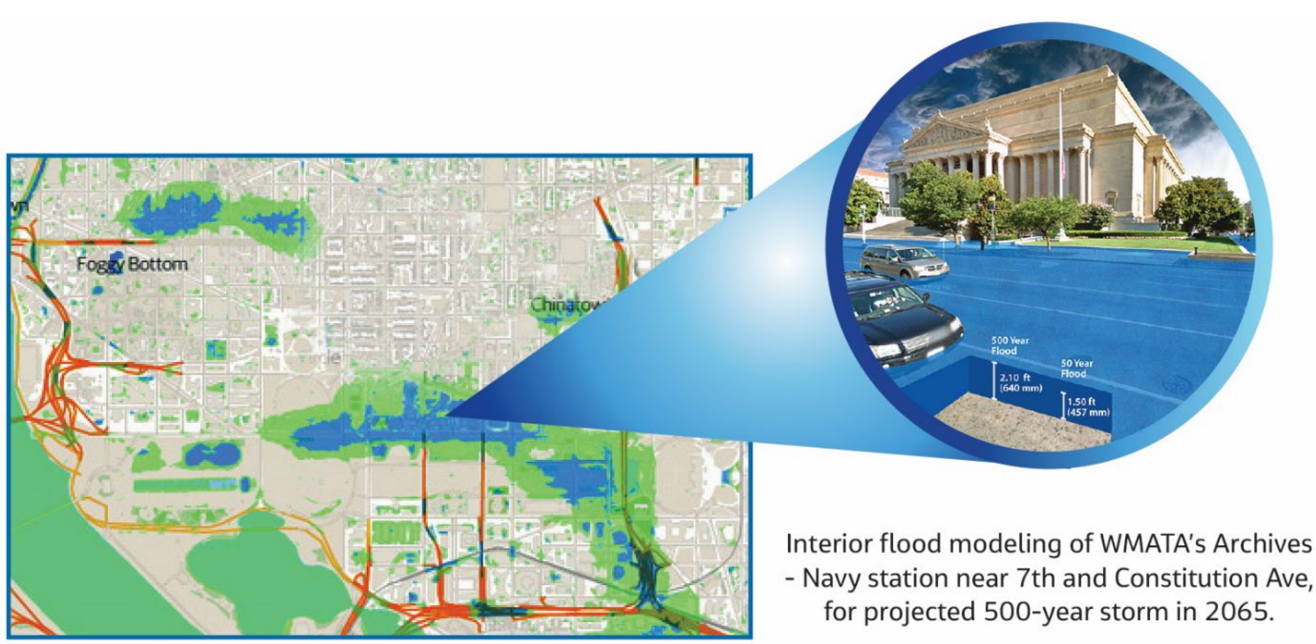

Figure 1. With urban flooding projected to increase significantly (shown here for Washington DC), new mitigation techniques such as BGSI are needed.

Key Findings

In this presentation, BGSI designers will provide an overview of BGSI practices and strategies, planning and design considerations, how public spaces might be transformed into dual purpose ("floodable") stormwater management opportunities, cost implications, and the role of both dynamic (continuous) design and automated ("real time") controls. Co-benefits of BGSI will be discussed and examples provided (Figure 2).

Figure 2. BGSI can provide many co-benefits as shown conceptually (left) and with the completed photo (right) of the project in Washington, DC

Recommendations

The presentation will highlight considerations for planning, designing, and modeling BGSI for resiliency, including potential impacts to location, size and depth, inlet/outlet configurations, plant selection, and maintenance. The benefits of neighborhood-scale BGSI, dynamic sizing and continuous monitoring and adaptive control (CMAC) will also be discussed (Figure 3).

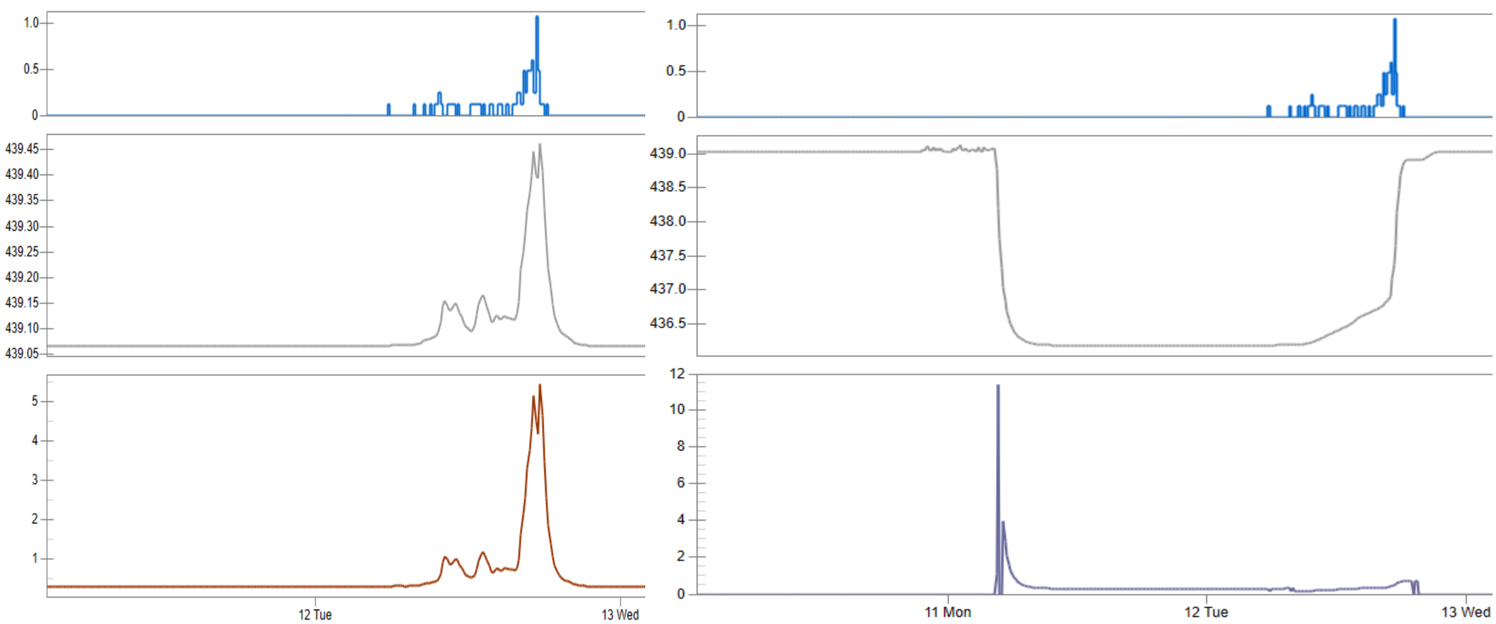

Figure 3. This simulation of a BGSI project in Harrisburg, PA shows that the CMAC (right) can essentially eliminate the wet weather discharge during and after this storm event compared to conventional passive control (left). Rainfall (in.) is shown on the upper plots, stage (ft.) in the middle, and discharge (CFS) in the lower plots.

References

Will be provided for the paper/presentation.