Case Study: CSO Mitigation and Green Infrastructure Implementation at the PWD Northeast Water Pollution Control Plant

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Highlights

- A new Preliminary Treatment Facility was designed to enable treatment of 300 mgd of additional wet weather flow, which will reduce combined sewer overflows as part of PWD's long term control plan.
- As part of the design and development of the new facility, green infrastructure was incorporated into the design to manage stormwater runoff, including a bioretention basin, pervious pavement and a green roof.

Introduction

The City of Philadelphia Water Department (PWD) owns and operates the Northeast Water Pollution Control Plant (WPCP) in Philadelphia, Pennsylvania. The Northeast WPCP is designed to treat an average daily flow of 210 million gallons per day (mgd) and peak wet weather flow of 420 mgd. PWD plans to upgrade the plant to enable it to treat 300 mgd of additional wet weather flow, which will reduce combined sewer overflows (CSO) as part of PWD's long term control plan. In order for the plant capacity to increase, an additional preliminary treatment facility was designed to treat the flow from the Frankford High Level (FHL) sewer system. The design team prime consultant was Whitman, Requardt & Associates, with Kleinfelder serving as the site/civil and stormwater engineer. The new WPCP infrastructure improvements consist of:

- Diversion Chamber
- Flow Metering of the FHL System.
- Preliminary Treatment Building 2 (PTB2), including Mechanical Bar Screens, Secondary Grit Washing and Classifying Equipment and Residuals Handling Equipment.
- Grit Facility (GRF), including Primary Grit Removal Tanks and Grit Pumps.
- Odor Control System (OCS)
- Double Barrel Flow Conduit
- Modification of the existing PST Set 2 influent header

To address the stormwater quality and water quantity requirements, a stormwater BMP treatment train was designed to incorporate 4,540 square feet of porous pavement and a green roof to reduce runoff volume and peak flows. Overflows from the green roof and flows from the porous pavement underdrain are connected to a bioretention basin. Surface runoff from the directly connected impervious areas were designed to be connected by inlets strategically located throughout the site and drained to the bioretention basin. The basin is equipped with an outlet structure that connects to an existing storm manhole at the southern end of the site.

The presentation will first provide an overview of the proposed Preliminary Treatment Facility, and then focus on the stormwater management design and proposed green infrastructure BMPs.

Methodology

Description of Site and Geotechnical Investigation

The project site is located on the eastern portion of the WPCP adjacent to the Wheatsheaf Lane entrance and extends onto neighboring private properties on Richmond Street. The private properties on Richmond Street were recently acquired and demolished, with the land being used for the proposed facilities. The existing land cover/land use on the project site area is a mixture of private residential row houses, wooded areas, open space/lawn areas and developed portions of the WPCP.

A geotechnical investigation was performed and generally indicated silty sands in the surficial soil layers (5 -10 feet deep) with coarser sands and gravels at greater depths. Based on these soil types, Hydrologic Soil Group "B" has been utilized for the stormwater design calculations.

Infiltration testing was performed in September 2012 at two locations to the southeast of the proposed bioretention basin. The double-ring infiltrometer tests showed stabilized infiltration rates ranging from 0.75 in/hr to 4 in/hr. In August 2019, additional infiltration testing was performed in targeted locations to determine suitability for infiltration best management practices (BMPs). Double-ring infiltrometer tests showed a stabilized infiltration rate of approximately 1.4 in/hr and 0.25 in/hr in the vicinity of the proposed bioretention basin and pervious pavement, respectively.

Stormwater Regulatory Compliance

Due to the site location, the on-site stormwater management measures was required to meet the following PWD's PCSM regulations, and applicable erosion and sediment control measures:

- Water Quality Standard: The Water Quality requirement stipulates infiltration of the first 1.5 inches of runoff from all DCIA within the limits of earth disturbance.
- Channel Protection Standard: The Channel Protection requirement stipulates the detention and release of runoff from the 1-year, 24-hour NRCS Type II design storm event for all DCIA within the limits of earth disturbance at a maximum rate of 0.24 cfs per acre of associated DCIA in no more than 72 hours. However, this standard was not applicable because the project was a redevelopment project that discharged to the Delaware River main channel.
- Flood Control Standard: The Flood Control requirement stipulates that a development project meet or reduce peak rates of runoff, as determined by its Flood Management District, from pre-development to post-development conditions during certain storm events.
- Public Health and Safety Release Rate Standard: The project site was not in a location with known flooding. There was no Public Health and Safety Release Rate requirement for the site.
- Erosion and Sediment Control: The project was required to provide erosion and sediment control measures to control stormwater runoff during and after construction. The project obtained an Individual NPDES Permit for Discharges of Stormwater Associated with Construction Activities.

Green Infrastructure BMP Selection and Design

The porous pavement, bioretention basin, and green roof are proposed to meet the water quality standard and reduce peak flows in accordance with the applicable stormwater management standards. A rendering of the proposed Preliminary Treatment Facility site with the locations of the green infrastructure is shown in Figure 1.

- **Porous Pavement** is located to the west of the PTB-2 and covers approximately 4,540 square feet. The porous pavement captures rain that falls directly upon the surface of the system. The captured rainfall infiltrates and enters the underlying storage bed. The porous pavement system has been designed to store and infiltrate the first 1.5 inches of runoff in the stone storage bed below the invert of the underdrain. The proposed underdrain is an 8" perforated HDPE pipe designed to drain excess flows to the bioretention basin.
- **A Bioretention Basin** is located towards the southwestern part of the site. This basin receives the flows from the porous pavement system, the roof drain system, and the collection inlets on the site. The basin has been designed with a two-foot media layer and a stone underdrain layer. An 8" perforated HDPE underdrain system which connects to an outlet structure has been designed within the stone layer. The underdrain is capped within the outlet structure in order to retain stormwater within the basin, with the option to drain the bioretention basin media layer if needed for maintenance purposes. After leaving the outlet structure, flows are conveyed to an existing downstream storm manhole. The basin also includes a 15' wide emergency spillway, and a piped bypass system so that the entire bioretention basin system can be taken offline if needed during the establishment period or for future maintenance needs.
- **A Green Roof** is located on the roof of the PTB-2. The green roof comprises sedum carpet with 5" of growing medium beneath, followed by 6" of polystyrene insultation. There is a gypsum roof sheathing and polyethylene root barrier to keep the roof sealed. The roof is equipped with seven drains to tie into the stormwater pipe system and ultimately to the bioretention basin. For the purposes of the water quantity calculations, we have conservatively treated this area as an impervious surface.

Figure 1. Preliminary Treatment Facilities Rendering

Key Findings

This project offered a challenging opportunity to incorporate green infrastructure into the design of a facility that will allow PWD to treat an additional 300 mgd of wet weather flows and significantly reduce CSOs in the community.

Recommendations

This $100M project is currently under construction and funded through PENNVEST. Long term success of the stormwater BMP treatment train system will be ensured with continued inspections and maintenance of the system which will be managed by PWD's Green Stormwater Operations Unit.

References

N/A

Building Resiliency in NJ and Beyond: Lessons Learned from the Rebuild by Design Meadowlands Program

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Highlights

- Regulatory requirements, best management practices, and sustainable technologies are constantly evolving.
- Large-scale resiliency projects require innovative solutions that may not reside in your local design manual.
- Communication between designers, agencies, and reviewers is key at all project stages.

Introduction

The need to build climate resilient infrastructure grows each year as the intensity and frequency of extreme weather events increases. Government and regulatory agencies understand how crucial investments in stormwater management are to ensuring a future with healthy communities and functional local economies. However, it can be difficult to plan large-scale improvements in challenging geographies when state regulations and even nomenclature differ from region to region. At the same time, engineers, scientists, and other technical professionals are always innovating and developing new solutions in stormwater management. Designers need to be able to pull industry knowledge from multiple sources to offer the most efficient solutions for their projects and clients. The Rebuild by Design Meadowlands (RBDM) project provided a unique opportunity for design teams, state agencies, and reviewers to collaborate in order to reduce flood risk, cultivate local ecologies, and energize communities impacted by Hurricane Sandy.

Background

Rebuild by Design Meadowlands (RBDM) Program History

The devastation from Hurricane Sandy was intense and costly to people and businesses across the New York Metro Area. In the RBDM Project Area, 3,500 residents had to be evacuated and the cumulative costs to the community including loss of income, loss of property taxes, and property damage were estimated to be over $40 million, over half of which were from property damages alone (NJDEP 2018). The Hurricane Sandy Rebuilding Task Force created the Rebuild by Design competition in the summer of 2013 to develop ideas to improve the physical, ecological, and economic resilience of these hard-hit regions. RBDM was one of the six (6) selected projects and crosses through five New Jersey municipalities: the Boroughs of Teterboro, Little Ferry, Moonachie, and Carlstadt, and the Township of South Hackensack.

Green Infrastructure Challenges

The RBDM Project Area presented the design team with unique challenges to standard New Jersey Department of Environmental Protection (NJDEP) green infrastructure design. The area is urban, low-lying, and built on top of a high groundwater table. With barely 3-foot depth to groundwater in many locations, typical best management practice (BMP) profiles in the state design manual (NJDEP 2004) would not be feasible in the area. NJDEP officials were made aware of the standard BMP limitations and were open to accepting alternative designs that were in line with the project goals while still taking budget and local maintenance concerns into account. The collaborative design process took place as NJDEP was also preparing to update their own stormwater rules and BMP manual in 2020-2021.

Key Findings

In researching cost-effective, technically feasible solutions for the RBDM project area, the team first observed differences in BMP terminology. Not even “green infrastructure” was defined the same way across agencies. Naming convention would differ widely even if the function of the system would be the same in each area. For example, a

"Stormwater Bumpout" in Philadelphia (PWD 2021) could be considered a "Bioswale" in New Jersey (NJDEP 2004), which could be "Stormwater Greenstreets" in New York City (NYC DEP 2020). Matching BMP types was critical to communication between the designers in Philadelphia, the agency in New Jersey, and the reviewers in Massachusetts and elsewhere.

Once equivalent BMP types were identified by name, the variations in standard designs were assessed. Different methodologies were used to inform design of elements such as pretreatment options or geotextile liner configurations. Urban design standards from neighboring cities were reviewed because the RBDM project area is highly developed. New Orleans green infrastructure was also reviewed as it is an urban area with many surrounding wetlands and high groundwater tables. Many of the additional sources referenced other state manuals, and even back to NJDEP. Massachusetts' and West Virginia state manuals both cite New Jersey's stormwater management protocols as comparable (MassDEP 2008, WVDEP 2012). After researching alternatives, the team proposed designs to NJDEP with that included the use of some specialized products, above-ground planters, and shallow-profile BMPs based on experience and research outside of NJ. Open communication with NJDEP was critical during each step of the design process to ensure adherence to the changing NJ stormwater rules and a commitment that the area's challenges would not disqualify the community from all green infrastructure.

Recommendations

- Research BMPs in other regions to overcome design challenges on your project.
- Take note of when new versions of standards and protocols are released and if there are outdated references.
- Talk to your agency reps about alternative design options because our communities may not be able to afford the "Do Nothing" approach as the climate continues to change.

References

Massachusetts Department of Environmental Protection (MassDEP), Stormwater Handbook (2008).

New Jersey Admin. Code, Stormwater Management § 7:8-1.1 — 7:8-6.3 (2004, Rev. 2020)

New Jersey Department of Environmental Protection (NJDEP), Final Environmental Impact Statement for the Rebuild by Design Meadowlands Flood Protection Project (2018). https://www.nj.gov/dep/floodresilience/rbd-meadowlands-feis.htm (accessed 12 August 2021)

NJDEP, New Jersey Stormwater Best Management Practices Manual (2004, Rev. 2021).

NJDEP, Rebuild by Design Meadowlands Project; Strengthening New Jersey for Today's Climate Threats (15 April 2021). https://www.youtube.com/watch?v=Q3X5U4CTIxo (accessed 11 August 2021).

New York City Department of Environmental Protection (NYC DEP), Standard Design and Guidelines for Green Infrastructure Practices (2020). https://www1.nyc.gov/site/dep/water/green-infrastructure.page (accessed 12 August 2021).

Philadelphia Water Department (PWD), Green Stormwater Infrastructure Planning and Design Manual, Version 3.0 (2021).

West Virginia Department of Environmental Protection (WVDEP), Stormwater Management and Design Guidance Manual (2012).

The 2021 GSI Designer Survey – the data, the results and take home message

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Highlights

- The 2021 GSI Designer Survey collected important feedback from GSI professionals
- A lack of collaboration became the common thread among the results of each question
- The findings of the study need to deeply impact our GSI project processes to ensure better outcomes

Introduction

In 2021, Mr Woodman conducted a thirty 30 question survey for designers of Green Stormwater Infrastructure (GSI) – both civil engineers and landscape architects to complete answering questions about their typical design process, engagement and involvement in installation, and the connection between (or lack thereof) between the designer and post installation ongoing maintenance. Are specifications for plant establishment included in the bid package?, are pre-bid meetings mandatory?, Is the designer involved in construction oversight?, Is maintenance budgeted for?, Are post project forensics completed prior to starting the next project?, and a general question: What is the biggest challenge in the furtherance of green infrastructure?. Well – the results are in. Designers from states across the country have completed the survey and some interesting feedback has been compiled. This presentation with provide a summary of the results for all 30 questions and draw suggested conclusions on specific common threads and the need for a more collaborative approach to GSI projects from concept through to completion.

Background

Data Collection:

After building a list of thirty (30) questions, Mr Woodman used Google Forms to construct the survey for ease of use. To attract participants, a strategy including personal invitations and social media posts was deployed to appeal to professionals and colleagues actively working in GSI design projects. The survey was left open for approximately three months. Once the data collection period closed, the data was compiled and analyzed.

Key Findings

- 86% of participants were Civil Engineers with the remainder a mix of landscape architects and "other" professionals in the industry.
- Over 50% of those surveyed had over 15 years of experience.
- 80% of those surveyed are working on projects where both water quality *and* quantity are needed to be addressed.
- With regard to water quality – two thirds of participants are mostly focused on TSS *and* nutrients.
- 67% of designers who completed the survey consider themselves to be "passionate" about defending downstream natural resources.
- The results were mixed when asked "do you believe your designs connect with the triple bottom line co benefits of green infrastructure".
- 85% of those surveyed consider innovative practices once traditional practices have been exhausted.
- Only 31% of the time did the participants feel that that civil engineers and landscape architects *always* collaborate.
- Only in 31% of those who completed the survey feel that plant selection is *always* a priority.
- When asked if pretreatment is included in your GSI designs? 23% said "always", 52% said "most of the time" and 24% stated "rarely".
- Three questions were asked regarding permeable pavers. The results highlighted that for those who use permeable surfaces, it is mostly permeable pavers and for those who do not, it is mostly based on maintenance concerns.
- When the participants were asked if they meet/huddle for post project forensics to review the previous project before moving onto the next one, only 9.5% of those surveyed stated "always".
- The final set of questions were tied to maintenance:

- When asked “are the systems you designed maintenance to the level you are hoping for?” only 1% stated “always”, 49% said “most of the time” and 47% stated “rarely”.
- 56% of those surveyed believed they inform their clients on maintenance obligations
- Only 15.5% of designers who completed the survey believe that maintenance is “always” budgeted for.

Recommendations

Based on the results of the survey there are several items that we need to be thinking about in future GSI projects and considering about how, in our own spheres of influence, we can do our part in making sure these items are addressed. Some key take aways include:

- We need to be thinking about ways to better collaborate from design all the way through to post installation maintenance.
- We need pause and take what we are learning in the field and modify / adapt / revise our approaches for more sustainable outcomes. Pretreatment is a big one!
- We need to consider using new approaches and solutions to achieve goals.
- We need to consider ways to leverage the triple bottom line co-benefits of GSI
- We need to communicate maintenance obligations more clearly and make sure that maintenance to happening.
- We need to make sure we are budgeting for maintenance.
- We need to work together to overcome the biggest challenges facing GSI – Cost and maintenance