

# Source-Water Iodine Speciation Across Drinking Water Intakes and Implications for I-DBP Precursors

Olumide O. Ajulo, Kelly D. Good

Civil and Environmental Engineering, Vilanova University

Iodine in drinking water is receiving increasing attention because iodinated disinfection byproducts (I-DBPs) may exhibit greater toxicity than chlorinated and brominated DBPs. Among inorganic iodine species, iodide ( $I^-$ ) is generally considered the primary precursor for I-DBP formation during disinfection, while iodate ( $IO_3^-$ ) is a more oxidized and less reactive form of iodine. Despite growing interest in iodine occurrence in drinking water systems, limited information exists regarding iodine speciation across different source-water intake settings.

This study presents a reconnaissance snapshot of iodine speciation and bromide concentrations across six drinking water intake sources at two different utilities sampled during a single event in February and April 2026. The sampled sources included both groundwater and surface water sources. Samples were analyzed for iodide ( $I^-$ ), iodate ( $IO_3^-$ ), and bromide ( $Br^-$ ) to evaluate preliminary iodine speciation patterns and potential implications for I-DBP precursor occurrence. Measured concentrations were also compared with previously reported occurrence data from Sharma et al. (2023).

Iodide was below detection ( $<1 \mu\text{g/L}$ ) in all six sources during the sampling events. In contrast, iodate was detected in several sources and generally occurred at higher concentrations in groundwater sources ( $4.6\text{--}4.9 \mu\text{g/L}$ ) than in surface water sources ( $<1\text{--}2.1 \mu\text{g/L}$ ). Bromide concentrations ranged from  $<10$  to  $78 \mu\text{g/L}$ , with groundwater sources generally exhibiting higher concentrations than most surface water sources during sampling. Several measured bromide concentrations in surface water sources were lower than median values previously reported for comparable source water types, suggesting potential temporal variability associated with hydrologic conditions.

The predominance of iodate relative to iodide suggests predominantly oxidizing conditions during the sampling event. Because iodide is typically considered the most reactive inorganic precursor for I-DBP formation, its absence during sampling suggests limited immediate potential for I-DBP formation from inorganic iodine species at the time of collection. However, the dataset represents a single reconnaissance snapshot and is not intended to characterize long-term source water conditions. Future work will include repeated temporal sampling and direct quantification of total and organic iodine fractions to better evaluate iodine dynamics and I-DBP precursor variability in drinking water systems.

# **Predicting Sediment Deposition in Green Stormwater Infrastructure: A Hybrid Modeling Approach**

Behailu Bereded<sup>1</sup>, Virginia Smith<sup>2</sup>, Kristin Sample-Lord<sup>2</sup>, Amanda Hess<sup>3</sup>

<sup>1</sup>Graduate Research Assistant, Villanova University, Villanova Center for Resilient Water Systems, Department of Civil and Environmental Engineering

<sup>2</sup>Associate Professor, Villanova University, Villanova Center for Resilient Water Systems, Department of Civil and Environmental Engineering

<sup>3</sup>Research Assistant Professor, Villanova University, Villanova Center for Resilient Water Systems, Department of Civil and Environmental Engineering

## **Abstract**

While Green Stormwater Infrastructure (GSI) effectively manages stormwater runoff, its long-term performance and resilience are often compromised by the accumulation and deposition of fine sediments. These processes are governed by complex interactions among storm characteristics, media properties, and system design. This study integrates process-based modeling and machine learning to investigate the key drivers controlling erosion, transport, deposition, and sediment fate in GSI systems. First, a two-dimensional hydrodynamic and sediment transport model (SRH-2D) was applied to a well-instrumented bio-infiltration system to evaluate its ability to resolve sediment transport dynamics. Simulation results reproduced spatial patterns of sediment transport and deposition. The model's capability to capture key hydraulic and morphodynamic processes was demonstrated by comparing its results with those of an existing GSI. Building on this foundation, SRH-2D was then applied to a controlled, hypothetical bio-infiltration system to systematically explore sediment dynamics under varying storm conditions. These simulations generated high-resolution spatiotemporal datasets of flow depth, velocity, shear stress, and bed elevation change, enabling identification of persistent zones of fine sediment accumulation. These zones represent areas at risk of clogging. Using these results, a physics-informed machine learning framework was developed to predict fine sediment deposition using SRH-2D outputs as input features. A hybrid CNN-LSTM model was trained on time-resolved spatial grids generated from the hypothetical system simulations, capturing both temporal evolution and spatial heterogeneity of sediment processes. The model demonstrates strong predictive capability and serves as a computationally efficient complement to process-based simulations. This integrated framework provides a scalable approach for evaluating GSI design performance and informing sediment management and maintenance strategies.

Keywords: GSI, Sediment buildup, SRH2D, Machine Learning

## ***Pretreatment Comparison in Green Stormwater Infrastructure Design: A Technical Overview***

Joseph Bilardello<sup>1</sup>, Lauren Riviere<sup>1</sup>, Robert Traver<sup>1</sup>, Amanda Hess<sup>1</sup>

Villanova University, Department of Civil and Environmental Engineering<sup>1</sup>

With green stormwater infrastructure (GSI) becoming increasingly prominent within the stormwater management industry, it has become paramount to assess key design variables across GSI systems. The following serves as an overview of a preliminary investigation into two adjacent bio-infiltration systems with distinct inflow designs. The sites analyzed are part of the greater I-95 Revive Project in collaboration with the Pennsylvania Department of Transportation and the Federal Highway Administration. The two sites, codenamed I and J, are located in Fishtown, Philadelphia, and aim to manage 1 inch of runoff diverted from a directly connected impervious area of the I-95 Highway. Site J serves as a more traditionally designed bio-infiltration system, utilizing two separate inlet pipes that flow into distinct forebays. Runoff then overtops a quarter-inch invert, infiltrating into the surrounding soil. Site I, meanwhile, utilizes a single inlet and forebay that overtops into two infiltrating steps separated by metal, rectangular weirs.

Visual observation, soil property testing, and continuous data collection all serve as key indicators of each site's overall health and effectiveness. In particular, continuous, autonomous data collection provides information surrounding inflow functionality during storm events, while documented visual observations and soil tests highlight outflow performance. Testing and documentation also pinpoint future areas of investigation. Annual infiltrometer tests present variability in hydraulic conductivity at different Site I step locations, while visual observations and recorded depths demonstrate Site J's affinity for ponding. These trends highlight the significance of consistent site testing and data collection in monitoring the effectiveness of innovative bio-infiltration designs across extended timeframes.

# How Often Do You Need to Clean Your Sediment Pond with Climate Change?

Shirley E. Clark, P.E., Ph. D.

Department of Civil, Construction and Environmental Engineering, The Pennsylvania State University Harrisburg, Middletown, PA 17057; E-mail: sec16@psu.edu

## What I will be presenting:

In the Revised Universal Soil Loss Equation (RUSLE), the rainfall erosivity  $R$  describes the storm's ability to dislodge and transport soil. Climate change in the mid-Atlantic United States is expected to increase the energy associated with storm events, in addition to increasing the total volume of rainfall. To evaluate climate change impacts on  $R$ , the rainfall records for four Pennsylvania cities were used to calculate the annual  $R$  from 1973 through 2024 using the USEPA approximation for calculating  $R$ . The number of storm events and annual  $R$  values were separated into two periods: 1973 – 1999 and 2000 – 2024. The results showed that, for only Philadelphia, the number of storm events increased for all storms and for storm events greater than 12.5 mm, the number of events increased for all cities but Erie. For annual  $R$ , all cities but Erie showed an increase from 2000 – 2024 compared to 1973 – 1999. This highlights that the total number of storms may not be changing, but the storm energy is increasing. Using the increased  $R$  value, the need for increased sediment pond maintenance is highlighted for Philadelphia. Doubling the required maintenance of a sediment pond is a cost that will need to be included in construction cost estimates.

## What the audience will learn:

In the mid-Atlantic, we seem to be seeing more intense storms. This analysis shows that our observations are correct for most of Pennsylvania. The increase in intensity is resulting in an increase in rainfall energy. This has tremendous implications for construction site erosion control. This analysis, which was run for Philadelphia, the city with the most extreme increases, shows that sediment pond maintenance may double in its frequency. These more intense storms also may increase the amount of soil lost below a vegetated mat, which may result in a lack of root establishment. The energy also could severely damage a straw mat, requiring a more expensive, but more durable, liner. All of these potential impacts are costs to the contractor. Improving our ability to model the impacts of increasing rainfall energy will allow contractors and site owners to have more realistic understanding of the erosion control budget.



## Dynamics of Pollutants in a Bioinfiltration SCM

Holly M. Dearworth <sup>1\*</sup>; Amanda Hess, PhD PE<sup>2</sup>; Robert Traver, PhD PE<sup>3</sup>; Bridget Wadzuk, PhD<sup>3</sup>

<sup>1</sup>Graduate, Villanova University, Water Resources and Environmental Engineering Department, Villanova, PA 19085

<sup>2</sup>Research Assistant Professor, Villanova University, Dept. of Civil and Environmental Engineering, Villanova, PA 19085

<sup>3</sup>Professor, Villanova University, Dept. of Civil and Environmental Engineering, Villanova, PA 19085

\*Corresponding author email: [hdearwor@villanova.edu](mailto:hdearwor@villanova.edu)

### What I will be presenting:

This presentation examines long-term pollutant dynamics within a bioinfiltration SCM constructed in 2001 on Villanova University's campus and monitored continuously since 2003. Using this uniquely extensive dataset, the study evaluates mass loads of total phosphorus (TP) and total suspended solids (TSS) by integrating onsite rainfall measurements, inflow and outflow monitoring, ponding observations, and discrete water-quality sampling of first flush, ponded water, and system overflow. The analysis focuses on quantifying both inflow and outflow pollutant loads and, critically, the magnitude and behavior of first flush mass loads compared to the entire system. Statistical analysis and visualization are performed in R to interpret trends from 2018 to 2024. Initial findings highlight how pollutant transport varies across storm events and seasons, offering new insight into long-term SCM performance. Ultimately, this work advances the understanding of pollutant fate in bioinfiltration systems and supports improved design and management of bioinfiltration SCMs for nutrient and sediment reduction.

### What the audience will learn:

The audience will gain a deeper understanding of how stormwater control measures (SCMs) function to mimic natural hydrologic processes and improve water quality through infiltration, evapotranspiration, and pollutant retention. This presentation will clarify how pollutant mass loads (defined as concentration multiplied by volume) move through the bioinfiltration system and why quantifying these loads is essential for evaluating SCM performance. Attendees will see long-term trends in TP and TSS behavior from 2018 to 2024, including how pollutant concentrations evolve during storm events and how the first flush phenomenon influences mass load distribution. By examining real-time storm event data, the audience will learn how SCMs reduce pollutant loads, how performance changes over time, and how these insights can inform more effective design, maintenance and monitoring of bioinfiltration SCMs and other similar SCMs. Furthermore, the audience will be showed the challenge of connecting continuous water quantity data to water quality discrete sampling data.

## What We Know about SCM Performance under Climate Change Conditions

Katherine J. Eimer,<sup>1</sup> Shirley E. Clark, P.E., Ph. D.,<sup>2</sup> Lauren McPhillips, Ph. D.,<sup>3</sup>

<sup>1</sup> Department of Civil, Construction, and Environmental Engineering, The Pennsylvania State University – Harrisburg, Middletown, PA 17057; E-mail: kje5348@psu.edu

<sup>2</sup> Department of Civil, Construction and Environmental Engineering, The Pennsylvania State University – Harrisburg, Middletown, PA 17057; E-mail: sec16@psu.edu

<sup>3</sup> Department of Civil & Environmental Engineering and Department of Agricultural & Biological Engineering, The Pennsylvania State University, University Park, PA 16802; E-mail: lxm500@psu.edu

### What I will be presenting:

As climate change impacts accelerate, the characteristics (frequency, depth, intensity) of rainfall events are expected to become more intense and volatile. This study seeks to use historical data to examine stormwater control measures' (SCM) ability to remove common pollutants during high intensity/depth storm events. This study examines bioretention, grassed swales, detention ponds, and retention ponds due to their prevalence within stormwater systems, varying susceptibility to scour, variety of treatment mechanisms, and depth of data available. Pollutant and rainfall depth data were extracted from the International Stormwater Best Management Practice (BMP) Database. Percent removal as a function of rainfall depth was then calculated. The findings suggest that performance degrades in these devices as the storm depth increases. The greatest change in performance are for those devices such as grassed swales where scour becomes concerning. The other devices are designed to slow the water and reduce the energy. Grassed swales are primarily conveyance devices.

### What the audience will learn:

The percent removals that have historically been used by many jurisdictions and models to predict pollutant removal are not valid when the rainfall depths are higher than the design flows. The most resilient systems are those with standing water to prevent scour and that are large enough to reduce the velocity of the water. Even bioretention, with its bypass piping, is not immune to degraded performance at higher rainfall depths, either due to reduced contact time in the media or due to media wash-through that creates small pipes in the media that then accelerate the movement of water in future storms through the system.

Title: "ASSESSMENT OF HISTORICAL MICROPLASTICS REMOVAL IN TWO BIORETENTION SYSTEMS OF DIFFERENT AGES"

Authors: Erica R. Forgione, Ph.D.<sup>1,\*</sup>, Kelly D. Good, Ph.D.<sup>1</sup>

<sup>1</sup> Department of Civil and Environmental Engineering, Villanova University, Villanova, PA, USA

\*Corresponding author email: [erica.forgione@villanova.edu](mailto:erica.forgione@villanova.edu)

Urban stormwater is a major source of microplastics (MPs), including tire and road wear particles (TRWPs), which are of concern due to their potential to cause negative human and environmental health effects. While bioretention systems have been shown to be effective at removal of particulate matter overall, little research has evaluated their removal of MP particles specifically. If bioretention systems are successfully removing MP particles as stormwater flows through them, MPs should accumulate in bioretention basins over time. This hypothesis was explored in a study of two infiltrating bioretention systems with similar land use: 1) one at Villanova University (24 years old) and one at Abington Friends School (5 years old). In 2025, soil cores from the top layer of bioretention media were collected in triplicate at the inlet side of each basin as well as a background soil core from outside of each basin. Three depths (0 to 3-cm, 6 to 9-cm, and 12 to 15-cm) were processed via a 6-step extraction procedure and analyzed for MPs >50- $\mu\text{m}$  and  $\geq 1.4 \text{ g/cm}^3$  density. Visual microscopy and Raman spectroscopy were used to quantify and identify particles.

Results for each site will be compared including evaluation of results compared to site age and land use, including for potential TRWPs, which cannot be confirmed via Raman. Additionally, quality control methods used to determine which data are above detection will be demonstrated. The data indicate that most of the large particles (>212- $\mu\text{m}$ ) were retained in the 0 to 3-cm depth of the bioretention basins and TRWPs are suspected to be a major fraction of stormwater MPs based on visual observations. The methods used to isolate MPs likely had an effect on which MPs were observed based on density and size. The presence of an artificial turf field next to the Villanova site will also be discussed as an additional source of potential TRWP observations.

# Detecting potential clogging in floodplain area by modeling fine-sediment deposition

Bel Juarez<sup>1</sup>, Kimia Ahmadiyehyazdi<sup>1</sup>, Dr. Virginia Smith<sup>1</sup>

Department of Civil and Environmental Engineering, Villanova University, Villanova, PA, USA<sup>1</sup>

## Abstract:

Fine-sediment deposition can reduce streambed permeability and contribute to clogging, affecting hyporheic exchange and aquatic habitat. This study combines field grain-size observations with two-dimensional HEC-RAS sediment modeling to examine the spatial distribution of fine-sediment deposition in Pennypack Creek, Pennsylvania. Bed-material samples collected at four study sites were analyzed to characterize field grain-size distributions and provide sediment inputs and comparison data for the model. Event-scale simulations were completed using 5-ft and 12-ft computational meshes to evaluate mesh-resolution sensitivity and the computational requirements of each configuration. Model outputs included bed change, active-layer grain-size metrics, water depth, and velocity. Preliminary results showed spatially variable hydraulic and depositional patterns associated with channel geometry and changing discharge. Water depth and velocity increased within the primary flow path near peak discharge and declined during the falling limb, when lower-energy conditions favored sediment deposition. Following the storm event, the 5-ft model indicated that fine sediments accumulated primarily in floodplain areas. Field samples collected from these locations also contained fine sediments, providing preliminary agreement between the modeled patterns and field observations. This spatial correspondence suggests that fine-sediment accumulation may contribute to reduced permeability and potential clogging in these floodplain regions. Comparisons with the 12-ft model will assess whether the coarser mesh reproduces these principal depositional patterns. This work provides a foundation for simulating additional storm events and developing physics-guided models to predict fine-sediment accumulation and potential clogging.

# An Initial Application of a Hydrologic Performance Index to a Long-Term Bioinfiltration Rain Garden

T. B. Juárez<sup>1\*</sup>, A. J. Amur<sup>2</sup> & B. M. Wadzuk<sup>2,3</sup>

*<sup>1</sup>Department of Mathematics and Statistics, Villanova University, Lancaster Ave, Villanova, Pennsylvania, 19085, United States of America*

*<sup>2</sup>Department of Civil and Environmental Engineering, Villanova University, Lancaster Ave, Villanova, Pennsylvania, 19085, United States of America*

*<sup>3</sup>Sustainable Engineering, Villanova University, Lancaster Ave, Villanova, Pennsylvania, 19085, United States of America*

*\*Corresponding author email: [tjuare01@villanova.edu](mailto:tjuare01@villanova.edu)*

## What I will be presenting:

Villanova University's Bioinfiltration Rain Garden (BTI) is one of the longest continuously monitored rain gardens in the United States, with hydrological data collected since 2003. Designed to treat runoff from a 0.51 ha watershed and manage storms up to 2.5 cm, the BTI has been widely studied for peak flow rate and runoff volume control. However, its hydrological performance has not previously been systematically classified.

The Southern California Coastal Water Research Project (SCCWRP) recently published a method to assess the effectiveness of best management practices (BMPs) through a Shiny application. Using precipitation depth, inflow, outflow, bypass, and BMP design parameters, the tool calculates a Performance Index Score (PIS) and classifies each storm as a 'success', 'failure', 'excess', 'relative to bypass fraction', or 'check data'.

This study evaluates how the SCCWRP hydrological performance index assesses the BTI. Preliminary analyses of 688 storm events from 2004-2021 produced a PIS score of 1.87 out of 10 and classified 77.76% of events as successes, 3.92% as excesses, and 18.31% as failures. Results were further analyzed by year, season, storm size, and antecedent moisture conditions to understand BMP performance. Results were compared to previously investigated storm events' peak intensity rates and effective rainfall duration metrics.

## What the audience will learn:

The audience will gain insight into how hydrologic performance indices can be applied and provide insight into a long-studied site. Specifically, the research aims to use the BTI as a case study and demonstrate how the recently developed PIS framework can classify the storm events and quantify overall BMP effectiveness. Moreover, this work highlights the importance of evaluating BMP performance by utilizing standardized assessment tools. While consistent evaluation is valuable for individual sites, it is arguably more important to establish common performance standards that can be applied across multiple rain gardens and stormwater BMP systems.

In addition, the audience will learn how to interpret results from the SCCWRP Shiny application, investigate what it means for a storm to be classified as success, failure, etc. for the BTI, and how this approach can be applied to their own sites. Key lessons learned include how assumptions regarding drainage area and changing watershed conditions can significantly affect PIS calculations, storm classifications, and overall performance evaluations.

# The Role of Visual Microscopy in Microplastic Characterization: Complementing Raman Spectroscopy for Environmental Sample Analysis

*Priscilla Jung \*<sup>1</sup>, Julia Otto<sup>1</sup>, Catherine Ferry, P.E.<sup>2</sup>*

<sup>1</sup>College of Liberal Arts & Sciences, Villanova University, 800 E. Lancaster Ave., Villanova, PA, 19085, USA

<sup>2</sup>Department of Civil & Environmental Engineering, Villanova University, 800 E. Lancaster Ave., Villanova, PA, 19085, USA

*Corresponding author email: [pjung01@villanova.edu](mailto:pjung01@villanova.edu)*

## What I will be presenting:

Accurate identification and characterization of microplastics in environmental samples remains a significant analytical challenge. Visual microscopy is commonly used as an initial screening tool to identify, count, measure, and classify particles based on their physical characteristics, including size, shape, and color. However, visual identification alone can overestimate microplastic abundance because non-polymeric materials may exhibit similar appearances. This presentation examines the role of visual microscopy within a study that subsequently used Raman spectroscopy to determine polymer composition of suspected microplastic particles.

Environmental samples were first analyzed using microscopy to quantify particle abundance and record physical characteristics. Selected particles were then subjected to Raman analysis for polymer verification. Results demonstrated that a substantial proportion of visually identified particles were ultimately determined to be non-polymeric materials, highlighting the limitations of relying solely on visual observations. At the same time, Raman spectroscopy provided definitive polymer identification but did not include automated particle dimension measurement, or color classification. Consequently, important physical descriptors of confirmed particles and identification of important patterns in sample contamination could only be obtained through the microscopy stage. The findings demonstrate that integrating visual and spectroscopic techniques provides a more complete understanding of microplastic occurrence than either method alone.

## What the audience will learn:

The audience will gain insight into the strengths and limitations of both visual microscopy and Raman spectroscopy for microplastic analysis. The presentation will demonstrate how visual microscopy remains an essential component of microplastic investigations, despite the increasing availability of advanced spectroscopic techniques.

Attendees will learn that particle counts generated through microscopy should be interpreted as potential microplastics until polymer composition is confirmed analytically. They will also learn that microscopy provides valuable information on particle size distributions, morphology, and color characteristics that may not be captured during Raman analysis. The study highlights the importance of combining physical and chemical characterization methods to improve data quality, reduce false-positive identifications, and provide a more comprehensive assessment of microplastic contamination in environmental samples. These lessons can support the development of more robust monitoring programs and improve confidence in microplastic datasets used for environmental management and research.

# Evaluating the Hydrologic Implications of Gridded and Point-Based Precipitation Representation in Urban Watersheds

*Nayeon Kwak<sup>1\*</sup>, Virginia Smith, Ph.D.<sup>1</sup>, & Kelly Good, Ph.D., P.E.<sup>1</sup>*

*<sup>1</sup>Department of Civil and Environmental Engineering, Villanova University, 800 Lancaster Ave, Villanova, PA 19085, USA*

*Corresponding author email: [nkwak1@villanova.edu](mailto:nkwak1@villanova.edu)*

## What I will be presenting:

Hydrologic analyses and stormwater design applications have historically relied on point precipitation gages to represent watershed rainfall conditions. While these measurements provide accurate local observations, they may not fully capture the spatial and temporal variability of rainfall across urban watersheds. Advances in radar-derived precipitation products, including NCEP Stage IV, now allow precipitation to be represented continuously across watersheds at fine spatial and temporal scales.

This work evaluates differences between watershed-integrated NCEP Stage IV precipitation and representative point gage precipitation across urban watersheds in Austin, TX, Atlanta, GA, and Philadelphia, PA from Water Years 2018–2025. Comparisons are conducted at annual and event scales using metrics describing storm magnitude, timing, duration, and intensity distribution. Statistical analyses including Mann–Whitney, Anderson–Darling, and Cliff’s delta tests are used to evaluate differences between datasets.

Results indicate that while annual precipitation totals between datasets are relatively similar, event-scale data show significant differences. For the same watershed, Stage IV precipitation generally produces longer-duration events with delayed peak timing and lower average intensities compared to point gage measurements. Hydrograph–hyetograph analyses further illustrate how these differences can influence interpretation of watershed response.

## What the audience will learn:

Audience members will learn how precipitation representation varies at the watershed-scale and how differences in rainfall timing and structure can influence interpretation of runoff generation and hydrologic response. The presentation will demonstrate that datasets with similar cumulative precipitation totals may still produce substantially different representations of storm behavior at event scales.

Attendees will also gain insight into how spatially distributed precipitation datasets such as Stage IV can better represent watershed-scale rainfall variability. They will be introduced to a potential method of exploring gridded precipitation data in hydrology, and why this may become increasingly important for hydrologic modeling, urban stormwater analysis, and infrastructure planning and design.

More broadly, this presentation highlights the need to reconsider long-standing assumptions and approaches regarding precipitation representation in hydrology. As gridded precipitation datasets become more accessible this is an increasingly important issue. The work emphasizes that precipitation

representation is not simply a data input choice, but a methodological decision that can shape interpretation of watershed behavior and hydrologic processes.

# Optimizing SCM Design using On-Site Data Collection and Computer Modelling

Conor D. Murphy<sup>1</sup>; Amanda Hess, PhD PE<sup>2</sup>; Robert Traver, PhD PE<sup>3</sup>; Gerald Zaremba, PhD<sup>4</sup>

<sup>1</sup>Graduate, Villanova University, Dept. of Civil and Environmental Engineering, Villanova, PA 19085

<sup>2</sup>Research Assistant Professor, Villanova University, Dept. of Civil and Environmental Engineering, Villanova, PA 19085

<sup>3</sup>Professor, Villanova University, Dept. of Civil and Environmental Engineering, Villanova, PA 19085

<sup>4</sup>Director of Research Operations, Villanova University, Dept. of Civil and Environmental Engineering, Villanova, PA 19085

\*Corresponding author email: [cmurph87@villanova.edu](mailto:cmurph87@villanova.edu); Faculty advisors emails: [amanda.hess@villanova.edu](mailto:amanda.hess@villanova.edu), [robert.traver@villanova.edu](mailto:robert.traver@villanova.edu), [gerald.zaremba@villanova.edu](mailto:gerald.zaremba@villanova.edu)

## What I will be presenting:

Sprawling urban expansion has greatly reduced the amount of pervious surface in developed environments, leading to a need for Stormwater Control Measures (SCMs) to manage excess runoff via nature-inspired unit processes. Five parallel rock-lined basins that collect and infiltrate stormwater runoff from the elevated highway deck above have been monitored since 2022 in Philadelphia, Pennsylvania. With the aid of PennDOT funding, continuous ponding, climate data (from a nearby SCM site), and inflow have been collected to evaluate site performance. A Stormwater Management Model (SWMM) has been developed and calibrated using the observed data and a LiDAR scan conducted in 2025. While each rock basin can capture inflows from all observed storms without overtopping, certain basins infiltrate far slower than others. Average drawdown rates per basin are estimated at 0.1, 0.3, 0.6, 1.2, and 2.5 inches per hour for storm events occurring between 6/25-5/26. Differences in rates are attributed to surface clogging processes as drawdown trends do not correlate to underlying preconstruction infiltration rates. In an effort to optimize onsite performance and inform future SCM design, SWMM simulations will test theoretical hydraulic connections between underperforming and overperforming basins to maintain overall function and meet drawdown goals. Preliminary results show consistent halving of ponding times for the most intense storms. Future work includes establishing a comprehensive understanding of sediment movement through various SCM components (such as forebays and connected systems) to better predict clogging impacts. Recommendations will be made on how to incorporate resiliency measures in SCM design, such as capped conduit connections between basins and use of sacrificial areas, to enable adequate function of combined SCMs should clogging occur.

## What the audience will learn:

Calibrating the SWMM model to accurately represent the observed system is a vital part of this study and an aspect from which many lessons can be learned to make future studies more efficient. Mathematical validation of accuracy between observed and simulated data over a common time series ensures confidence in any subsequent results, and allows for further analysis of possible retrofits or alternative designs. Audience members will walk away from this study with a strong understanding of SWMM and its capabilities in the field of stormwater management analysis and optimization. Specific to this study, the effectiveness of existing and proposed SMP setups will be quantified; particularly, connective conduits and a focus on the use of sacrificial area to maximize unit processes while extending the lifespan of future SMPs will be explored.

# Exploring a quantification methodology to examine GSI performance variability under different environmental conditions

Kaleigh P. Myers<sup>1</sup>, Bridget M. Wadzuk<sup>1</sup>, Amanda J. Hess<sup>1</sup>

<sup>1</sup>Villanova Center for Resilient Water Systems, Villanova University, 800 Lancaster Avenue, Villanova, PA, USA 19085 E-mail: [kmyers8@villanova.edu](mailto:kmyers8@villanova.edu); [bridget.wadzuk@villanova.edu](mailto:bridget.wadzuk@villanova.edu); [amanda.hess@villanova.edu](mailto:amanda.hess@villanova.edu)

## What I will be presenting:

Green stormwater infrastructure (GSI) incorporates various natural elements into designs with the aim to re-establish elements of the natural hydrologic cycle (e.g., infiltration, water retention, evapotranspiration), and therefore can exhibit some inherent variability in performance, influenced by a variety of factors, including design-related elements (i.e., specifications and construction) as well as environmental conditions (i.e., antecedent dry time, temperature/season, and vegetation). Common criticisms of GSI involve skepticism regarding their long-term performance consistency, which typically stems from a lack of understanding of their intended design and functioning. Therefore, it is necessary to quantify this variability to effectively communicate the intended functioning of GSI to increase widespread implementation. This presentation aims to describe a methodology to quantify GSI variability for selected parameters (ponding, overflow, and cumulative outflow volume) across differing antecedent dry times for the same rainfall event. Three, identical as possible, lab-scale rain gardens (38 cm soil, 15 cm ponding zone, 15 cm diameter) were created and filled with loamy sand (84% sand, 15% silt, 1% clay by USDA soil classification), compacted to 1.3 g/cm<sup>3</sup>. Preliminary results indicate slight variations among measured parameters (ponding depth, outflow, overflow responses) across the differing conditions.

## What the audience will learn:

The primary insights from this research aim to communicate the key factors influencing GSI performance variability. The preliminary findings indicate that for each set of replicate trials for a unique antecedent dry time, the column construction (i.e., comparing all three soil columns for the replicate simulations) was found to have a greater impact than experimental variability (i.e., comparing one column's results for the replicate simulations). This highlights crucial aspects of GSI, emphasizing the influence of design and construction on performance, and how these factors can contribute to overall variability. The applications of this demonstrate the necessity of properly designing and constructing systems, as minor discrepancies occurring in either of the processes can significantly influence variability. Furthermore, the dry time between simulations was found to contribute to the variability, slightly decreasing peak ponding and the occurrence of overflow events, which emphasizes the importance of rainfall event timing when evaluating or assessing GSI performance. Overall, the audience will learn about key factors impacting

variability and the extent to which they influence GSI performance, which can reframe how we contextualize and evaluate GSI performance.

# A Method to Estimate the Long-term Nutrient Load of a Constructed Stormwater Wetland

L.V. Navarro<sup>1</sup>, B. Wadzuk<sup>2\*</sup>

<sup>1</sup> Master's Student, Sustainable Engineering Department, Villanova, PA 19085

<sup>2</sup> Professor, Edward A. Daylor Chair in Civil Engineering, Director of Sustainable Engineering, Director Villanova Center for Resilient Water Systems, Civil and Environmental Engineering Department, Villanova University, Villanova, PA 19085

\*Corresponding author email: [lnavar02@villanova.edu](mailto:lnavar02@villanova.edu)

## What I will be presenting:

Constructed stormwater wetlands (CSWs) are engineered systems designed to provide both water quantity control and water quality improvement by attenuating flows and retaining nutrients from urban runoff, a major contributor to downstream nutrient enrichment and eutrophication in receiving waters. Despite their widespread implementation, long-term evaluations of CSW performance remain limited, particularly with respect to sustained nutrient retention. At Villanova University, a CSW was retrofitted from a detention basin in 1999, and subsequently redesigned in 2010. The system drains an approximately 17-hectare watershed with 47% impervious cover, receives inflow from two primary pipes, and discharges through a single outflow. Since 2011, the CSW has been monitored during both baseflow and stormflow conditions for a range of hydrologic and water quality parameters. In this study, about 12 years of monitoring and sampling data are used to calculate event-based and annual nutrient mass loading at inlet and outlet locations to evaluate long-term wetland performance and contextualize water quality benefits. Performance is assessed using nutrient mass loading and retention efficiency, with a focus on nitrogen and phosphorus, which are key limiting nutrients for eutrophication.

## What the audience will learn:

Long-term monitoring of green stormwater infrastructure is a very complex process, with factors limiting the extent to which continuous primary data exists to calculate nutrient load. The Villanova CSW is equipped with various on-site recording devices that monitor water quantity parameters, including velocity, depth and flow. Water quality data is also collected at the CSW but requires laboratory analysis, limiting the number of samples recorded annually. These water quantity and quality values allow the nutrient load for these events to be calculated, as well as the retention of nutrients, in order to evaluate the performance of the wetland. However, sampled events represent only around 30% of the total number of events that occur annually. Currently, average concentration values are used to calculate annual loads, as it is not feasible to sample every storm event. However, this practice may not consider other factors, such as seasonality. This highlights the need for a method of estimating annual nutrient loads that include unsampled events, to truly understand the performance of CSWs in different conditions. This presentation will give the audience a better understanding of current practices for calculating nutrient loads for sampled events, as well as modelling an estimation of total nutrient loads for unsampled events, providing more reliable data on the performance of CSWs in terms of nutrient retention.

# Evolution of Soil Media in a Stepped-Bioinfiltration System for Highway Stormwater Management

L. Riviere<sup>1\*</sup>, K. Sample-Lord<sup>1</sup>, V. Smith<sup>1</sup>, A. Hess<sup>1</sup>

<sup>1</sup>*Department of Civil Engineering, Villanova University, 800 E. Lancaster Avenue, Villanova, PA 19085*

*\*Corresponding author email: [lrivie01@villanova.edu](mailto:lrivie01@villanova.edu)*

Bioinfiltration systems are increasingly utilized for stormwater management of urban runoff. However, the longevity and maintenance needs of these systems are still uncertain. This is due to the large volume of incoming sediment that leads to internal erosion and general changes in the soil media characteristics over time. Assessing the evolution of soil media and infiltration behavior over time can improve prediction of lifecycle performance and inform maintenance requirements. Therefore, a study was done on a stepped bioinfiltration system treating highway runoff along I-95 in Philadelphia, Pennsylvania. At this site, runoff is routed from a highway deck to a concrete forebay, which then overflows into a stepped bioinfiltration system where there are two steps and a basin separated by weirs. Over the course of several years, soil sample collection and infiltration testing have been performed spatially across the system. Soil samples were then analyzed for particle size distribution, organic content, and plasticity. The field and laboratory data were combined to assess changes in soil media characteristics over time due to incoming sediment. Preliminary results indicate that for smaller storm events, infiltration and coarse sediment accumulation occur primarily within the steps and not the basin. However, for larger storm events, finer sediment is resuspended and is redistributed throughout the system. This assessment will provide the groundwork for a HYDRUS-2D model to simulate flow under variable conditions. Results of the model will quantify the hydraulic and sediment dynamics of highway runoff in a stepped bioinfiltration system. This work will demonstrate how a stepped bioinfiltration system can spatially isolate incoming sediment to smaller areas, enhancing the longevity of these systems and enabling targeted maintenance. The work provides useful insight for planning maintenance, predicting lifecycle performance, and designing stepped bioinfiltration systems.

# Can GIS-Based Tools Capture Urban Nuisance Flooding? Testing the ArcGIS Pro Flood Simulation Tool in Germantown, Philadelphia

P. Roy<sup>1,\*</sup>, P. Kremer<sup>1</sup> & V. Smith<sup>2</sup>

<sup>1</sup>Department of Geography and the Environment, Villanova University, Villanova, PA-19085, USA

<sup>2</sup>Department of Civil and Environmental Engineering, Villanova University, Villanova, PA-19085, USA

\*Corresponding author email: [proy02@villanova.edu](mailto:proy02@villanova.edu)

## What I will be presenting:

Urban Nuisance Floods (UNFs) are shallow, localized inundation events that disrupt everyday urban functions, pedestrian movement, street access, and routine neighborhood activity without causing major structural damage, and are notoriously difficult to model. Their microspatial scale, sensitivity to short-duration rainfall bursts, and dependence on inlet capacity and fine-scale surface routing have driven the field toward increasingly complex hydrodynamic and hybrid modeling approaches. These platforms are data and computation-intensive, often inaccessible to planners and practitioners working in standard GIS environments. An open question is whether GIS-based tools can credibly capture UNF exposure at neighborhood scales.

This presentation tests the ArcGIS Pro Flood Simulation tool, a GPU-accelerated 2D overland flow simulator for mapping nuisance flood exposure in Germantown, Philadelphia. The tool is configured with a high-resolution LiDAR-derived elevation surface, building footprints raised as flow barriers, and a short-duration rainfall scenario based on Philadelphia Water Department guidance. We apply a contextualized depth threshold to isolate shallow inundation from the simulated flood surface and examine how flood depth and extent evolve during the storm. The results allow us to assess whether the tool resolves UNF patterns at a meaningful spatial and temporal resolution, and where its design choices shape what it can capture.

## What the audience will learn:

This presentation demonstrates how GIS-based flood simulation can be adapted to represent the micro-scale processes that control nuisance-level flooding, which are often not captured in traditional modeling approaches. The audience will learn how to incorporate high-resolution topography, land-cover classifications, and surface-specific hydrologic parameters to simulate shallow inundation with greater spatial detail to better represent realistic small-scale urban flooding. A central takeaway is the application of a contextualized flood detection threshold to define nuisance flooding in a way that reflects neighborhood-scale impacts, rather than relying on metrics designed for extreme events. The presentation also shows how design rainfall scenarios can serve as a practical alternative to event replication, allowing identification of locations that are consistently sensitive to routine storm conditions. In addition, the audience will gain insight into how different land cover types interact in a realistic flood situation, particularly the adverse impacts of impervious expansion. Overall, the work provides a structured approach for identifying and interpreting UNF exposure, with direct relevance for urban flood modeling, planning, and risk assessment at the neighborhood scale.

# An Observational Analysis of Human Activity, Physical Conditions, and Social Context Around Green Stormwater Infrastructure Sites in Kensington, Philadelphia

M. Sanders<sup>1\*</sup>, P. Kremer<sup>1</sup>, G. Coonfield<sup>2</sup>, V. Smith<sup>3</sup> & M. Gandy<sup>1</sup>

<sup>1</sup>Department of Geography and the Environment, Villanova University, 800 E. Lancaster Ave., Villanova, PA, 19085, United States

<sup>2</sup>Department of Communication, Villanova University, 800 E. Lancaster Ave., Villanova, PA, 19085, United States

<sup>3</sup>Department of Civil and Environmental Engineering, Villanova University, 800 E. Lancaster Ave., Villanova, PA, 19085, United States

\*Corresponding author email: [msande05@villanova.edu](mailto:msande05@villanova.edu)

## What I will be presenting:

As cities implement Green Stormwater Infrastructure (GSI) programs to meet combined sewer overflow (CSO) regulations, attention has turned to governance and management strategies that optimize sustained GSI performance. Integrated, multi-stakeholder governance is increasingly recognized as effective for sustaining neighborhood GSI benefits. Understanding perceptions, practices, and uses of neighborhood GSI sites is critical to these strategies. While several studies have assessed knowledge and attitudes using self-reporting and survey-based methods, few have documented existing patterns of human activity and social engagement with neighborhood GSI. Through participant observation at 34 GSI sites in Kensington, Philadelphia between spring and fall of 2026 – along with archival research on study sites, analysis of satellite imagery, and interviews with GSI-related stakeholders – this research documents patterns of community-GSI interactions and physical conditions of the sites, contextualizing these observations with site-specific attributes and temporal variation. This presentation will summarize existing challenges with urban GSI, methods developed to document interactions and maintenance patterns at GSI sites, and initial findings based on collected data. These observations will inform the broader NSF Smart and Connected Communities project of which this work is part, contributing community-grounded data to the development of AI tools for GSI management that integrate technical performance with neighborhood context.

## What the audience will learn:

The audience will first learn about the range of existing challenges to sustained GSI performance and the roles that various neighborhood dynamics play in contributing to – and addressing – these challenges. Relatedly, they will gain an understanding of why perceptions, uses, and maintenance practices towards neighborhood GSI installations are critical to developing more resilient stormwater management systems. With this background, the audience will learn how mixed methods (e.g. archival research, structured interviews, imagery analysis, repeated site observations, and conversations with GSI stakeholders) were developed to: 1) develop a narrative history of Kensington's GSI and the land that they occupy, 2) assess maintenance risks that emerge from GSIs' placement in an urban environment, and 3) form a holistic understanding of the roles GSI play in neighborhoods beyond stormwater functions. Research for this project will be ongoing through the summer, and more specific findings will follow. However, preliminary findings suggest that physical conditions of GSIs vary widely across the neighborhood, significant maintenance of sites is undertaken by informal stewards, and integration of GSI with recreational or multi-purpose land uses increases likelihood of consistent engagement and maintenance.

# Transport and Bioavailability of Heavy Metals Across Grain Sizes From Highway Sediments Deposited in Receiving GSI installations

C. Wildonger<sup>1\*</sup>, S.T. Goldsmith<sup>1</sup>, K. Good<sup>2</sup>, P. Kremer<sup>1</sup>, V. Smith<sup>2</sup>,

<sup>1</sup> Department of Geography and the Environment, Villanova University, 800 Lancaster Avenue, Villanova, Pennsylvania 19085

<sup>2</sup> Department of Civil and Environmental Engineering, Villanova University, 800 Lancaster Avenue, Villanova, Pennsylvania 19085

\*Corresponding Author Email: [Cwildong@villanova.edu](mailto:Cwildong@villanova.edu)

## What I Will Be Presenting:

Urban highways generate sediments laden with heavy metals from vehicle wear and atmospheric deposition, which stormwater runoff then transports into green stormwater infrastructure (GSI) installations designed to capture and treat that runoff. How these metals distribute across particle sizes, accumulate in different parts of GSI, and shift between total and bioavailable forms over time remains poorly characterized, with direct implications for system performance, maintenance practice, and exposure risk in surrounding communities. This research aims to quantify total and bioavailable concentrations of six heavy metals (Cd, Cr, Cu, Ni, Pb, Zn) across grain sizes and spatially within two contrasting GSI installations receiving runoff from Interstate 95 in Fishtown, Philadelphia, and to relate those concentrations to storm characteristics and antecedent dry period (ADP) length. Sediments are collected after individual storm events and after ADPs, then partitioned into three fractions (<63  $\mu\text{m}$ ; 64–250  $\mu\text{m}$ ; 251–2000  $\mu\text{m}$ ) and analyzed by X-Ray Fluorescence (XRF) for total metals and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) following acetic acid extraction for bioavailable fractions. Hypothesized expectations are that bioavailable fractions decrease with increasing ADP length while total loadings increase with storm duration.

## What The Audience Will Learn:

Attendees will gain a clearer picture of how heavy metals partition across grain sizes in highway-derived sediments and how they move through GSI systems under varying storm conditions. The presentation will address whether GSI installations reliably retain these metals or release them downstream, with implications for long-term system performance. Since GSI systems are designed to retain sediments known to contain heavy metals, it is important to understand heavy metal concentrations within GSI systems for long-term protection of maintenance workers, researchers, and members of the community where these systems may function for decades. Part of the long-term monitoring at these sites included recent research that looked at quantifying overall sediment inflow to inform accurate sediment cleaning schedules. The presented research will look to connect these cleaning schedule recommendations with potential heavy metal loadings to better understand the risk to maintenance workers.