

The Manhattanville Project: Managing Stormwater Impacts

Linda Sohl, Ph.D.¹; Maria Grech²; Somdat Bhola³, and Kristal Quispe⁴

¹Team Principal Investigator (GISS), ²High School Teacher (NYCRI), ³Undergraduate (CIPAIR), ⁴High School Student (NYCRI)

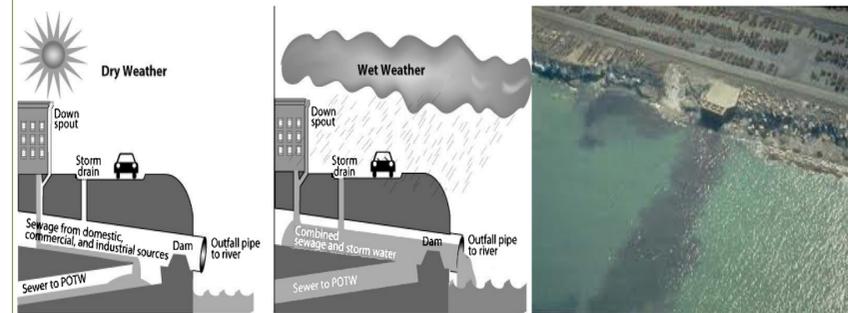
Abstract

Combined sewer systems are designed to carry commercial and residential waste as well as storm water runoff to wastewater treatment plants (WWTPs) before returning water to the environment. During heavy rainfall, the combined runoff may exceed the capacity of the WWTPs, leading to the release of untreated waste into water bodies. This event is called a Combined Sewage Overflow (CSO). CSOs are projected to become worse and more frequent over time, as human populations increase and climate continues to change. Street-level green infrastructure (GI) such as bioswales, enhanced tree pits, street side infiltration swales and permeable pavements are engineered solutions that can help mitigate CSOs by controlling stormwater runoff, a benefit that is not provided by simple street tree planting.

Street-level GI should have a positive impact in New York City both now and in the future, but the long-term efficiency of GI has not yet been explored. For this project, we have used Columbia University's planned Manhattanville campus expansion as a case study to achieve two objectives: 1) analysis and quantification of the benefits that the introduction of street-level GI would have on CSOs in an otherwise impermeable urban environment, and 2) assessment of the robustness of this street-level GI under different climate scenarios of future climate change.

CSOs and Stormwater Runoff

NYC has a combined sewer system. In dry weather wastewater is transported to a treatment plant, where it is treated before being discharged to a body of water. Combined Sewer Overflows (CSOs) occur during periods of heavy rainfall when stormwater volume exceeds capacity. To prevent sewage backup, the system discharges excess wastewater directly into the nearest water body. CSOs occur about 27 times a year at the North River Wastewater Treatment Plant, which is adjacent to our project area.



To ease the burden on the neighborhood's North River Wastewater Treatment Plant, Columbia's campus expansion plan involves the installation of a new separate storm sewer, and the upgrade and relocation of an outdated combined sewer and water main system along West 125th Street. Columbia's campus expansion plan also includes green infrastructure, but public details provided are limited in scope. Here we explore how additional green infrastructure at street level can aid in stormwater control and reduce the potential for CSOs on the Manhattanville campus.



Our plan for implementing GI on the Manhattanville campus.



Sponsors:
National Aeronautics and Space Administration (NASA)
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Contributors:
Linda Sohl, Ph. D (PI)
Maria Grech (High School Teacher)
Somdat Bhola (Undergraduate)
Kristal Quispe (High School Student)

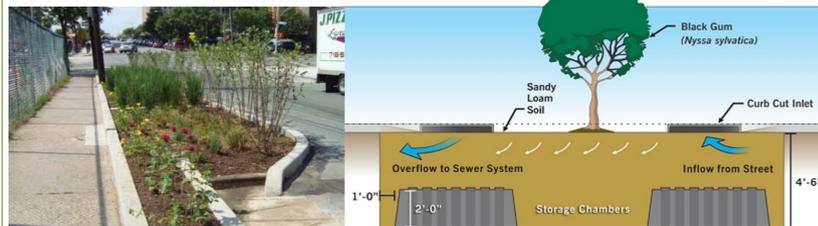


Street-Level Green Infrastructure

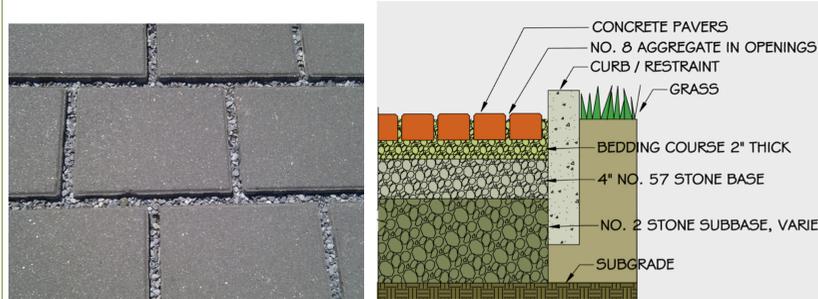
Bioswales are green infrastructure that contain vegetation and are effective in capturing silt and other pollutants that normally would just drain off into the sewage system. Bioswales usually have high stalk density, are insensitive to submergence and droughts, and are able to grow through sediment coverage.



Enhanced Tree Pits (ETPs) and Streetside Infiltration Swales (SSISs) are built on sidewalks upstream from catch basins to divert the stormwater. Water pools in the system and infiltrates through the top layer of soil and vegetation. In instances where the system cannot contain all of the stormwater, excess water flows through an outlet and into the gutter.



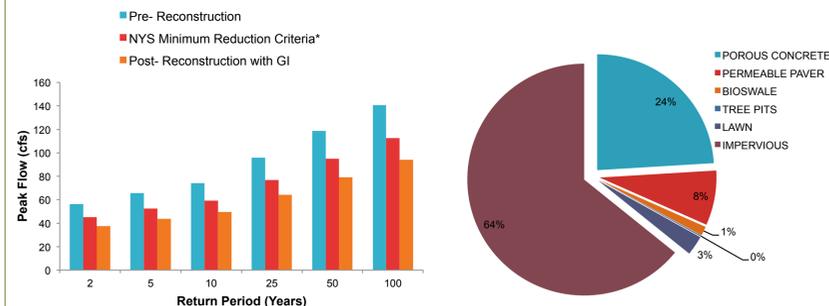
Permeable pavements reduce the amount of water flowing into a storm drain and eventually a sewer by allowing water to seep through the material and infiltrate into the ground, thereby restoring the hydrologic cycle.



Peak Flow Analysis

Quantifying peak flow and storm severity was done using the rational method. This method estimates the peak flow generated by an area, given rainfall conditions and surface runoff characteristics.

$$Q = kCIA$$



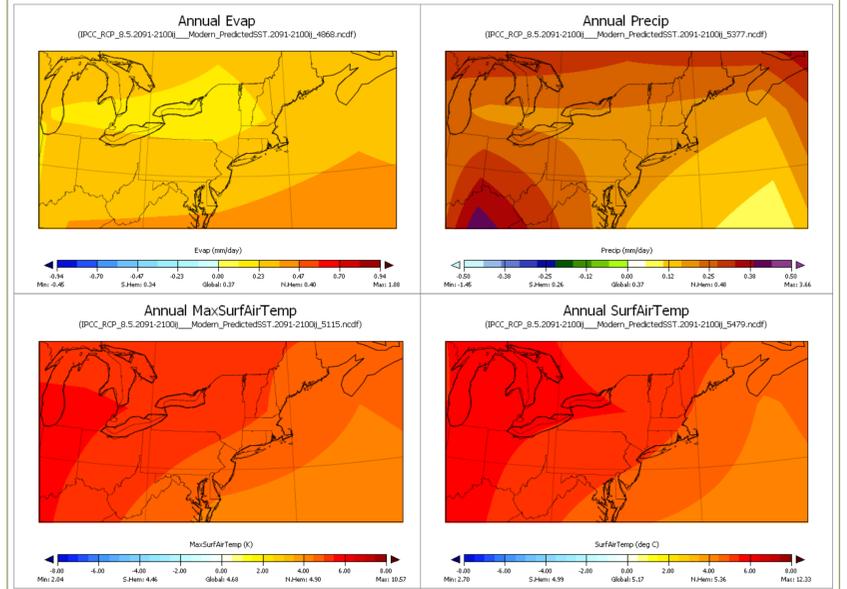
(L) Peak flows as a result of varying rainfall return period (2-100 yrs). Peak flow reduction of 33% is achieved from GI, exceeding NYS minimum requirement of 20%.
(R) Surface area distribution under a proposed green infrastructure plan with 36% permeable surfaces.

Climate Analysis Results

ANOMALIES FOR ANNUAL AVERAGES (2051-2060)	Surface Air Temperature (C)	Max Surface Air Temperature (K)	Precipitation (mm/day)	Evaporation (mm/day)
Climate Scenario				
RCP 3PD	1.71	1.06	0.13	0.13
RCP 4.5	2.28	2.24	0.43	0.21
RCP 6.0	2.36	1.98	0.32	0.17
RCP 8.5	2.96	2.48	0.58	0.28

ANOMALIES FOR ANNUAL AVERAGES (2091-2100)	Surface Air Temperature (C)	Max Surface Air Temperature (K)	Precipitation (mm/day)	Evaporation (mm/day)
Climate Scenario				
RCP 3PD	1.47	1.84	0.11	0.11
RCP 4.5	2.75	2.93	-0.1	0.08
RCP 6.0	3.73	3.23	0.17	0.14
RCP8.5	5.67	5.38	0.21	0.22

We ran four simulations of possible future climate scenarios defined by the Intergovernmental Panel on Climate Change (IPCC) for its newest climate assessment (AR5), using EdGCM software. The scenarios reflect increasing amounts of CO2 in the atmosphere by the end of this century, and thus each simulation (from RCP 3PD to 8.5) represents increasingly warm climate scenarios.



Conclusion

Preliminary analysis suggests that our suggested implementation of street-level green infrastructure has the potential to reduce stormwater runoff on the Manhattanville campus by 33% under current climate conditions. Our plan can be considered an upper estimate for the reduction of runoff, given the number of structures we chose to implement and the total available area for GI on the campus.

Next steps will include a more in-depth analysis of future climate impacts on the GI plan we have devised, including an assessment of how the GI might be expected to perform at mid-century and at the end of the century, and what the lifecycle of these structures might be in terms of continued efficiency for stormwater runoff control.

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