# NYC Columbia University Green Roofs


E. H. Blomstrom[1] and W. R. McGillis[2,3]

[1]School of International and Public Affairs (SIPA), Columbia University,
[2]Department of Earth and Environmental Engineering, Columbia University,
[3]Lamont Doherty Earth Observatory, Columbia University

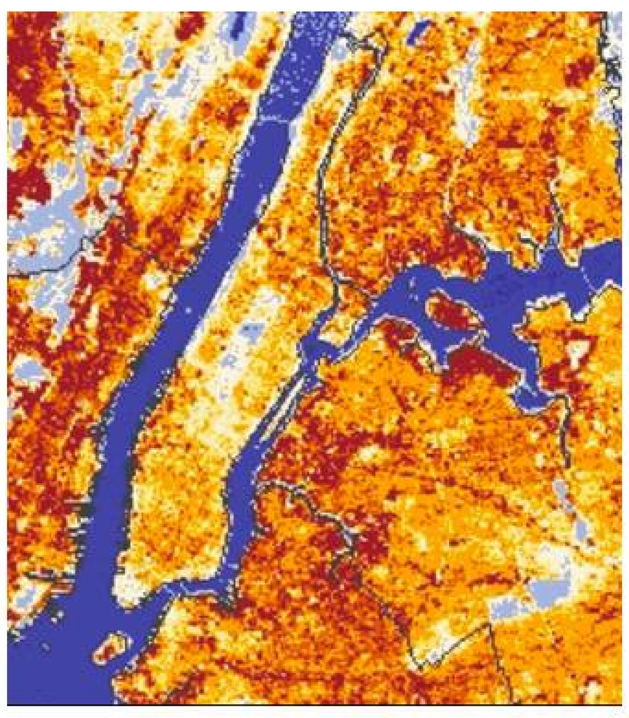

## Introduction

New York City's urbanized landscape is highly impermeable, which disrupts the earth's natural ability to absorb rainfall into soils for recharge to the groundwater and leads to excess runoff and flooding that is mitigated by storm sewers. However, the combined stormwater and wastewater sewer system of New York City has a limited capacity to convey stormwater runoff. Even a small precipitation event can overwhelm treatment plant capacity, leading to combined sewer overflows (CSOs), which discharge untreated waste and storm water into local waterways (Tillinger et al 2006).

New York City is expected to experience an increase in the frequency of extreme precipitation events as a result of climate change, which in turn will likely increase the occurrence of CSOs. While climate change forecasts at local levels remain uncertain, observed precipitation already shows an increase in heavy rainfall events and in the interannual variability of precipitation (NPCC 2009).

Increases in ambient temperature are also projected as a result of climate change. Since 1900, New York's annual mean temperature has increased 2.5 degrees Fahrenheit and seven of the ten warmest years have occurred since 1980 (NPCC 2009). Expected temperature increases and an increase in the frequency and duration of heat waves will likely exacerbate the Urban Heat Island effect.

Green roofs are an infrastructure adaptation that can both provide cooling effects and manage stormwater runoff into the city sewer system.



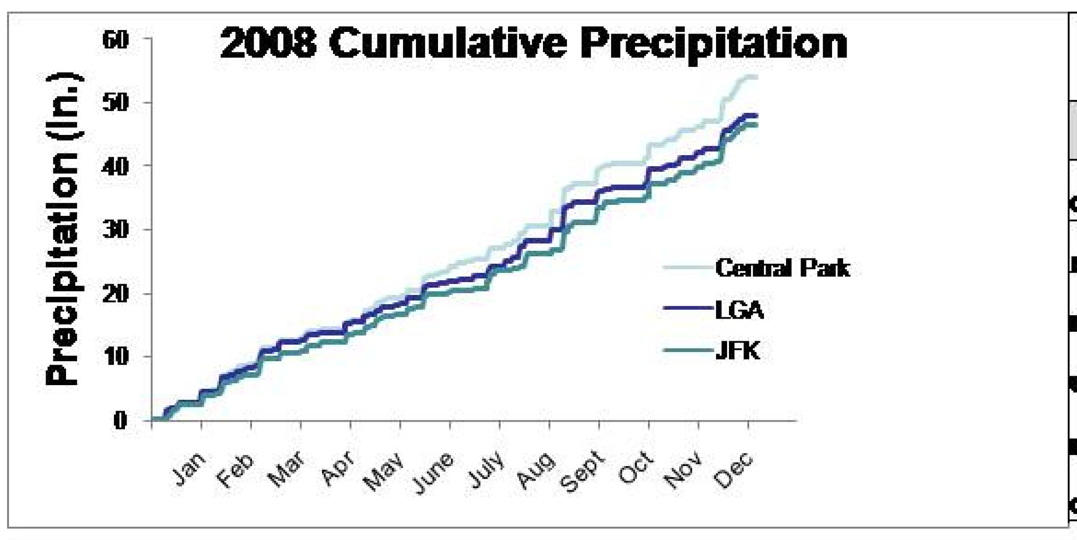
### Urban Heat Island Mitigation

Surface temperature distribution in New York City (Rosenzweig 2006). Green surface areas have a noticeably lower temperature and mitigation of the urban heat island (as much as 5 degrees).

## Urban Precipitation Island

Understanding precipitation patterns is key to adapting to climate change, particularly to quantifying and understanding the climate change adaptation potential of engineering options such as green roofs.

Studies have shown that air pollution has an effect on precipitation, causing both an increase and a decrease in rainfall. Some research has shown that pollution above a certain threshold causes an enhanced albedo as aerosols in the atmosphere reflect sunlight and prevent moist air from rising to form rain. Other studies have shown that mild levels of pollution enhance precipitation by increasing the number of cloud condensation nuclei (CCN). Because the urban heat island in New York City causes moist air to rise, the combination with pollution increases precipitation in the City. In 2008, our data synthesis shows 16% more precipitation in NYC than the surrounding suburban areas.

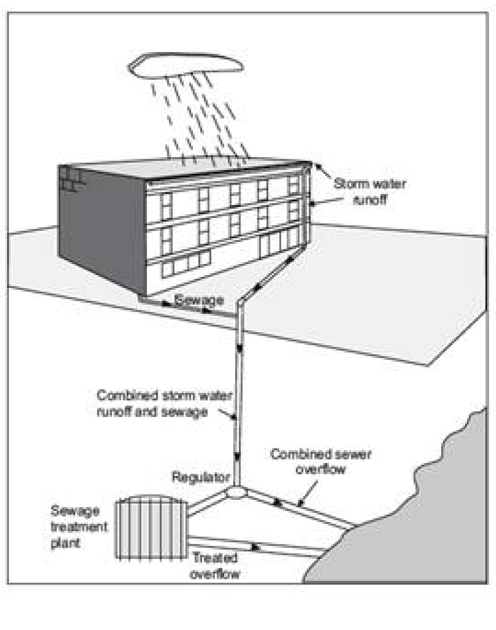


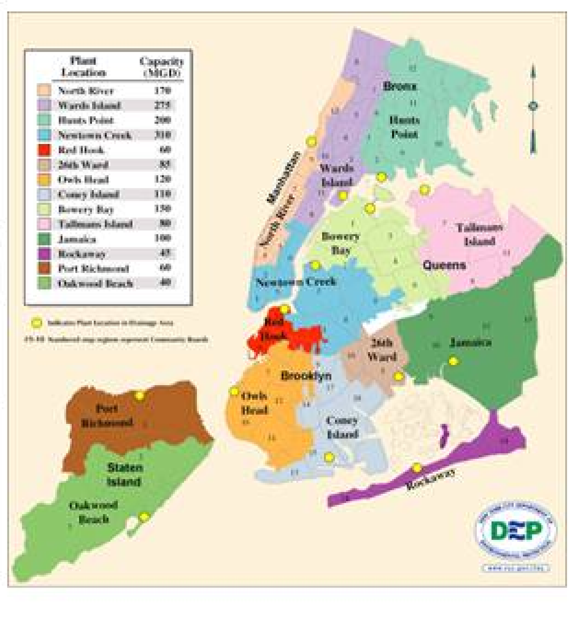

**2008 Rainfall Comparison with Central Park**

| | Total | % difference |
|---|---|---|
| Central Park | 54.07 | |
| JFK | 46.34 | 17% |
| LGA | 47.79 | 13% |
| Upton | 44.17 | 22% |
| Bridgeport | 47.75 | 13% |
| Glendale Queens | 47.27 | 14% |

## Green Roof Adaptation Potential

Green roofs have implications for infrastructure adaptation in New York City, notably through stormwater and sewer management. Given historical precipitation and the available roof surface area in NYC, green roofs could potentially mitigate 40% of CSOs.



### Combined Sewer Overflow

In an average year, 27 billion gallons of CSOs discharge into New York City's water bodies.

## Work of the Columbia Green Roof Consortium

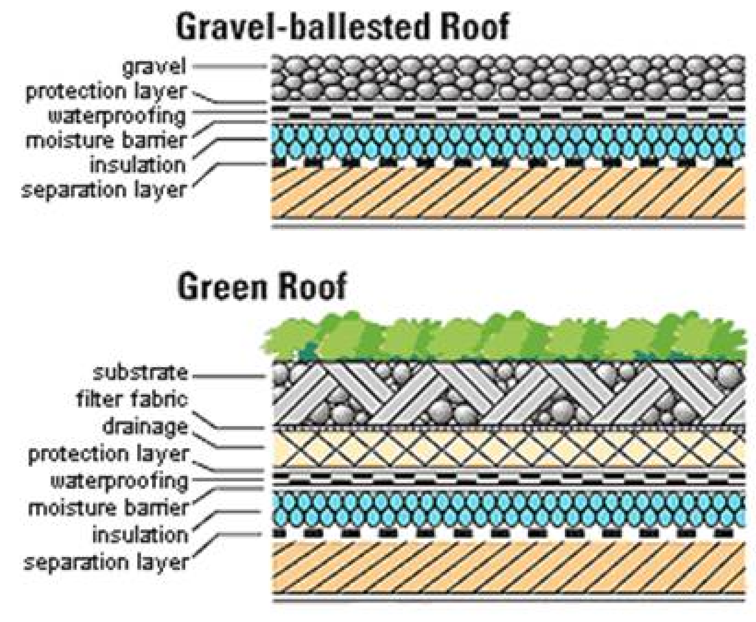
Green Roof Locations (Test Boxes on Pupin)

**Benefits of Green Roofs**

- Education
- Heat Island Mitigation
- Storm Water Management
- Building Energy
- Pollutant Mitigation
- Carbon Sequestration
- Extend Roof Life Cycle
- Living habitat for birds, etc
- Reduce Noise Transfer
- Aesthetics

423 W. 118th Street: Green roof and monitoring equipment

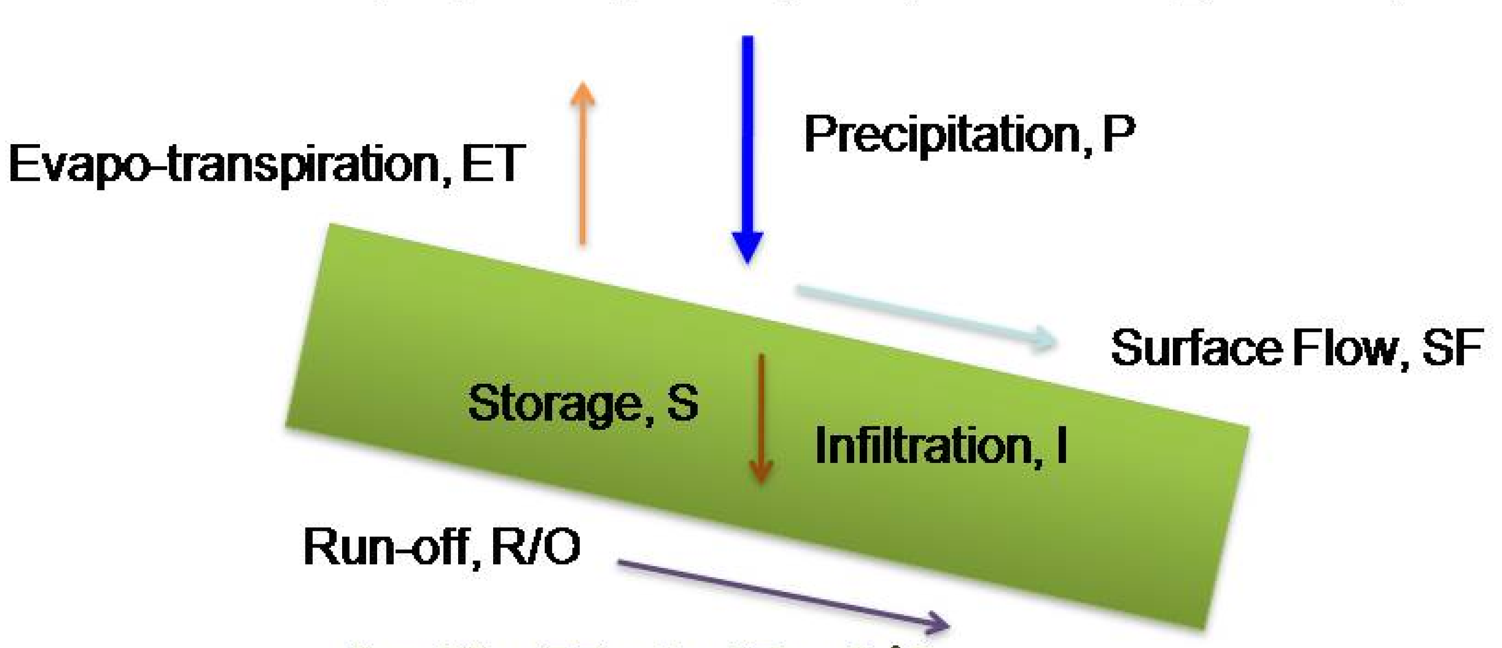
### Comparison of Green Roof Elements




### Green Roof Water Budget

**Perform Research and Assessment of P, ET, S, I, and SF to:**

- **Optimize R/O (RUNOFF) for water management and harvesting**
- **Understand ET (Evapotranspiration) to improve building efficiency**




$$P = SF + ET + I + ST + R/O$$

## Acknowledgements


Internship of the Earth Institute Climate Change Adaptation Initiative is made possible by a grant from HSBC in the Community (USA) Inc. The Columbia Green Roof Consortium including: Patricia Culligan, George Deodatis, Stuart Gaffin, Jack McGourty, Nilda Mesa, Marty Odlin, and Richard Plunz.


## References


"Does Dirty Air Always Bring Rain?" RedOrbit News. September 9, 2008. Accessed 2/21/2009. http://redorbit.com/news/display/?id=1548869

Intergovernmental Panel on Climate Change (2007a). /Climate Change 2007 - The Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the IPCC/. Cambridge: Cambridge University Press. ISBN 978 0521 88009-1 </index.php?title=Special:Booksources&isbn=9780521880091>

PlaNYC Sustainable Stormwater Management Plan 2008. The City of New York. 2008.

Rosenzweig, C., S. Gaffin, and L. Parshall (Eds.), 2006. Green Roofs in the New York

Metropolitan Region: Research Report. Columbia University Center for Climate Systems Research and NASA Goddard Institute for Space Studies. New York. 59 pages.

Rosenzweig, Cynthia and William Solecki. New York City Panel on Climate Change (NPCC). Climate Risk Information. Release version February 17, 2009.

Tillinger, D., G. Ostroff, D. Beattie, R. Berghage, P Mankiewicz, F. Montalto. 2004. "Hydrologic functions of green roofs in New York City." In Green Roofs in the New York Metropolitan Region: Research Report. Rosenzweig, C., S. Gaffin, and L. Parshall (Eds.) 2006. Columbia University Center for Climate Systems Research and NASA Goddard Institute for Space Studies. New York.