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# Surveillance à Long terme pour Démontrer la Performance et la Résilience de l'Infrastructure Gerte des Eaux Pluviales

## *Long-Term Monitoring to Demonstrate Green Stormwater Infrastructure Performance and Resilience*

Bridget Wadzuk and Matthew McGauley

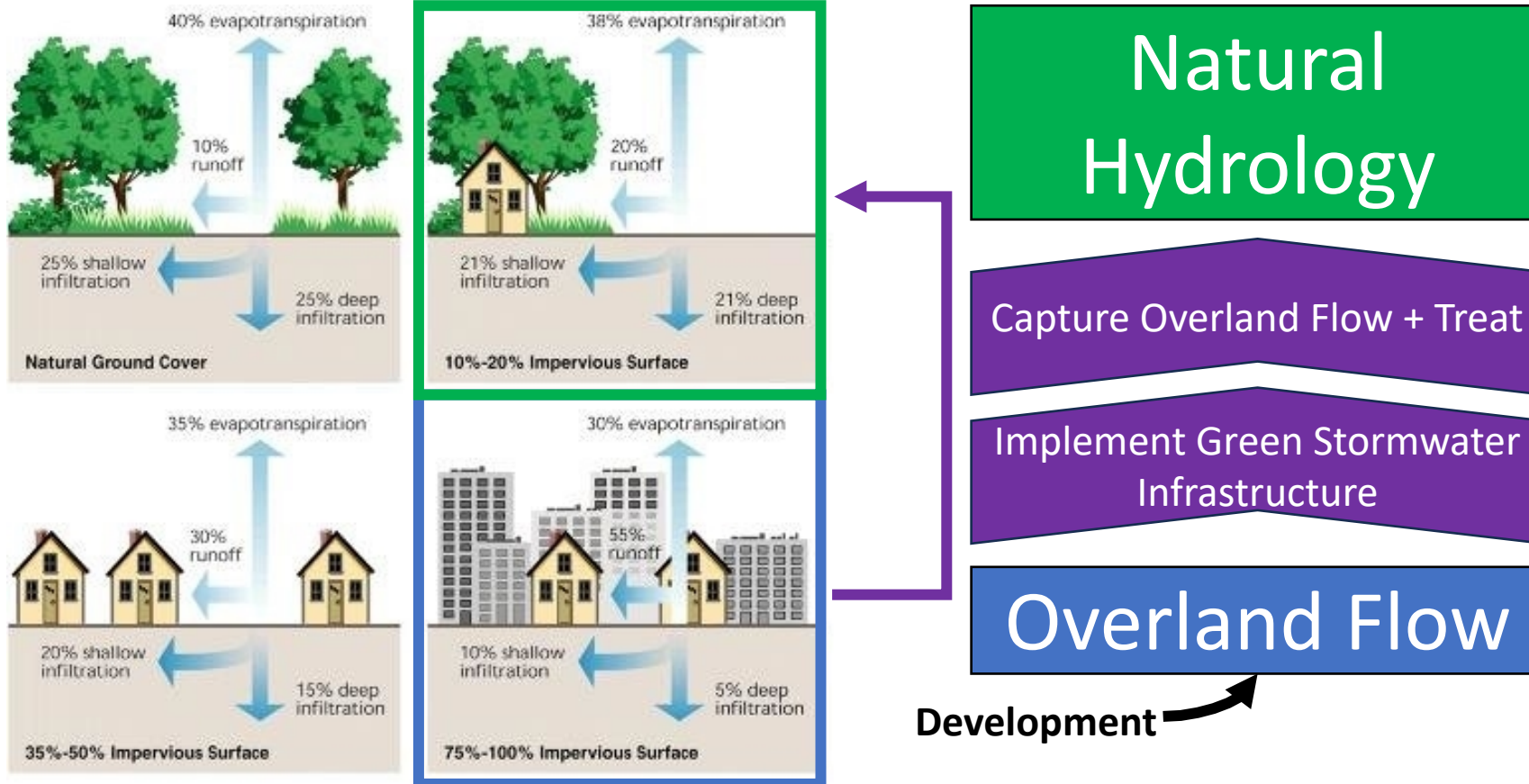
Villanova University, Center for Resilient Water Systems

(near Philadelphia, Pennsylvania, USA)



CENTER FOR RESILIENT  
WATER SYSTEMS

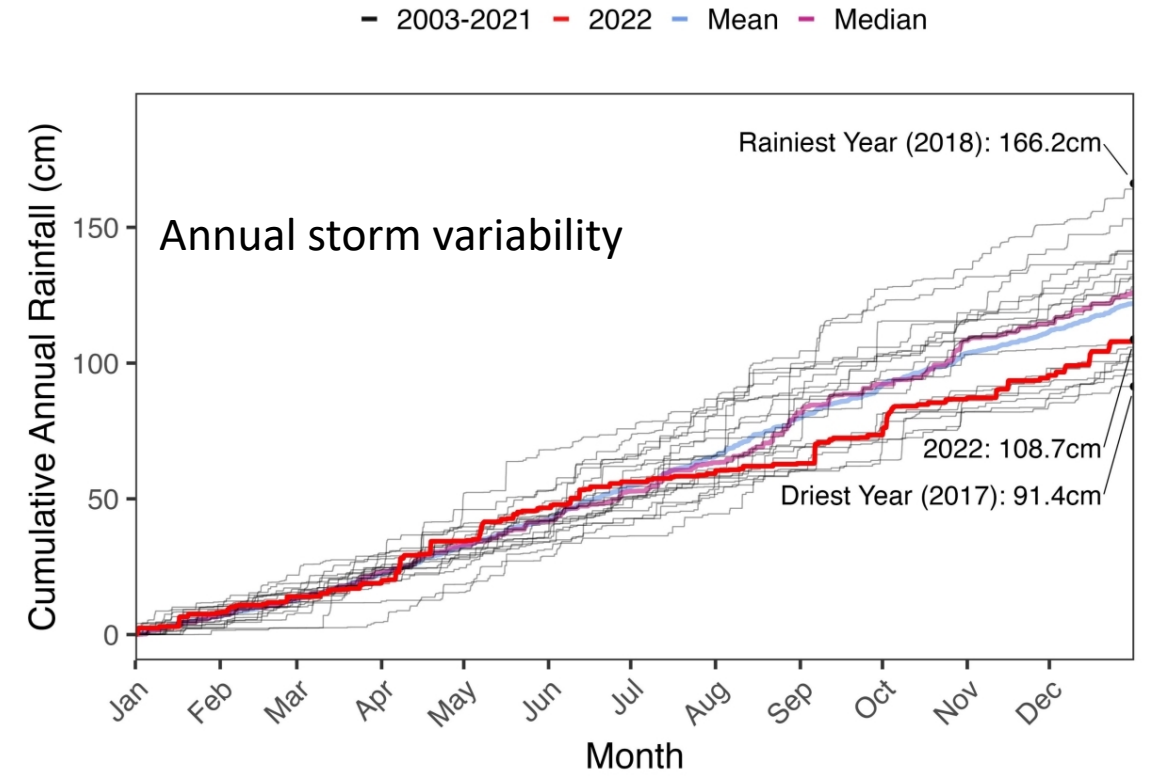
# The goal of urban stormwater management is to replicate a more natural hydrology



To what degree is this achieved?

And does it continue long-term?

# Using 20 years of data from a monitored rain garden, what is the hydrologic balance?



# Developing the hydrologic balance

$$P + Q_{Runoff} - Inf - ETO - Q_{out} = \Delta S$$

$P$  Measured \* Surface Area(Depth)

$Q_{Runoff}$  Curve Number(Precipitation)

$Inf$  **Unknown**

$ETO$  Hargreaves Equation(Temperature)

$Q_{out}$  Measured

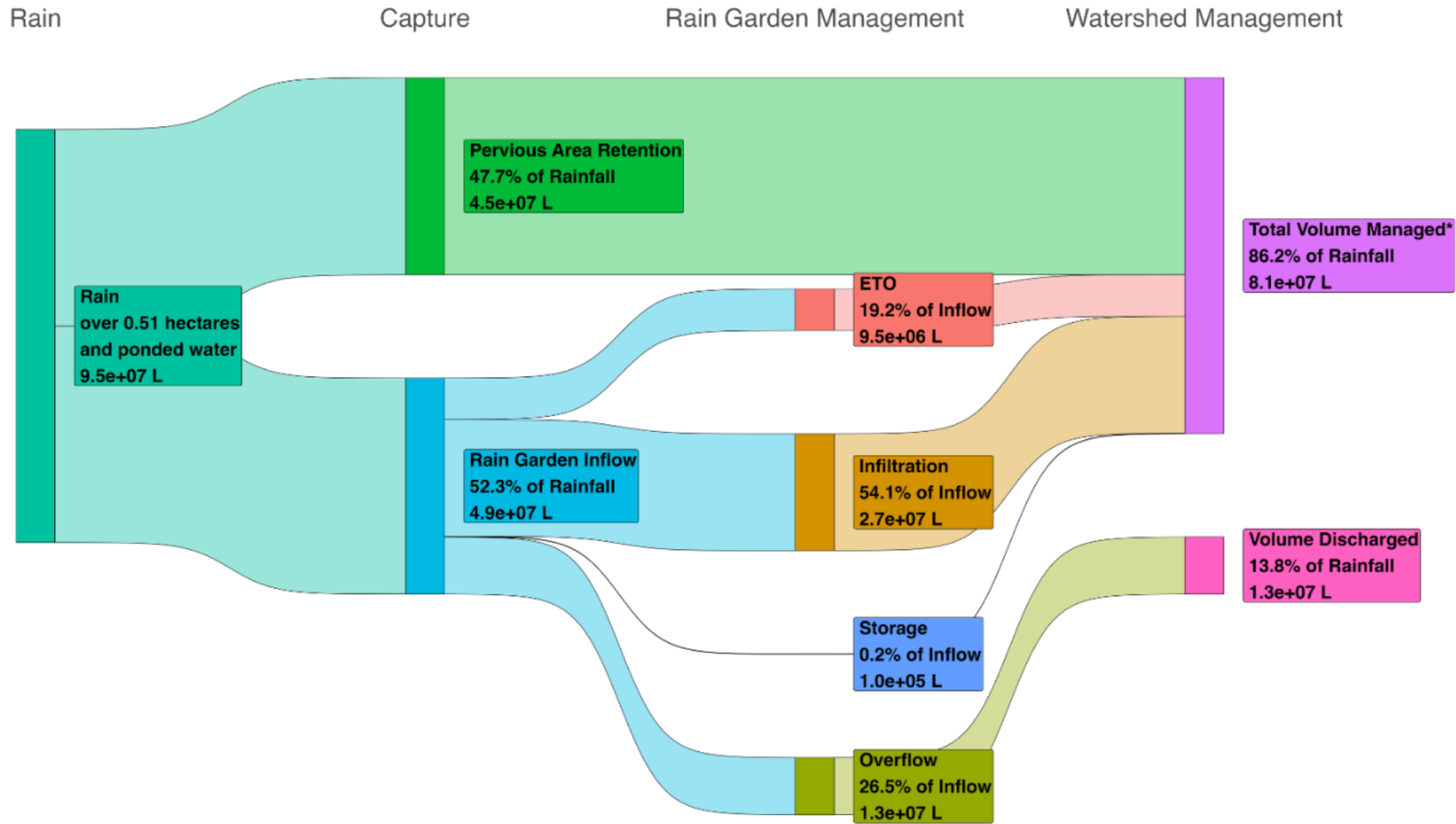
$\Delta S$  Volume(Depth)<sub>t</sub> - Volume(Depth)<sub>t-5mins</sub>

Surface Area/Volume → ArcGIS  
3D Spatial Analyst Tools

Rearrange, Solve for Unknown



# Runoff from a 50% impervious and 50% mowed lawn watershed routed through a rain garden acts better than 100% cultivated land



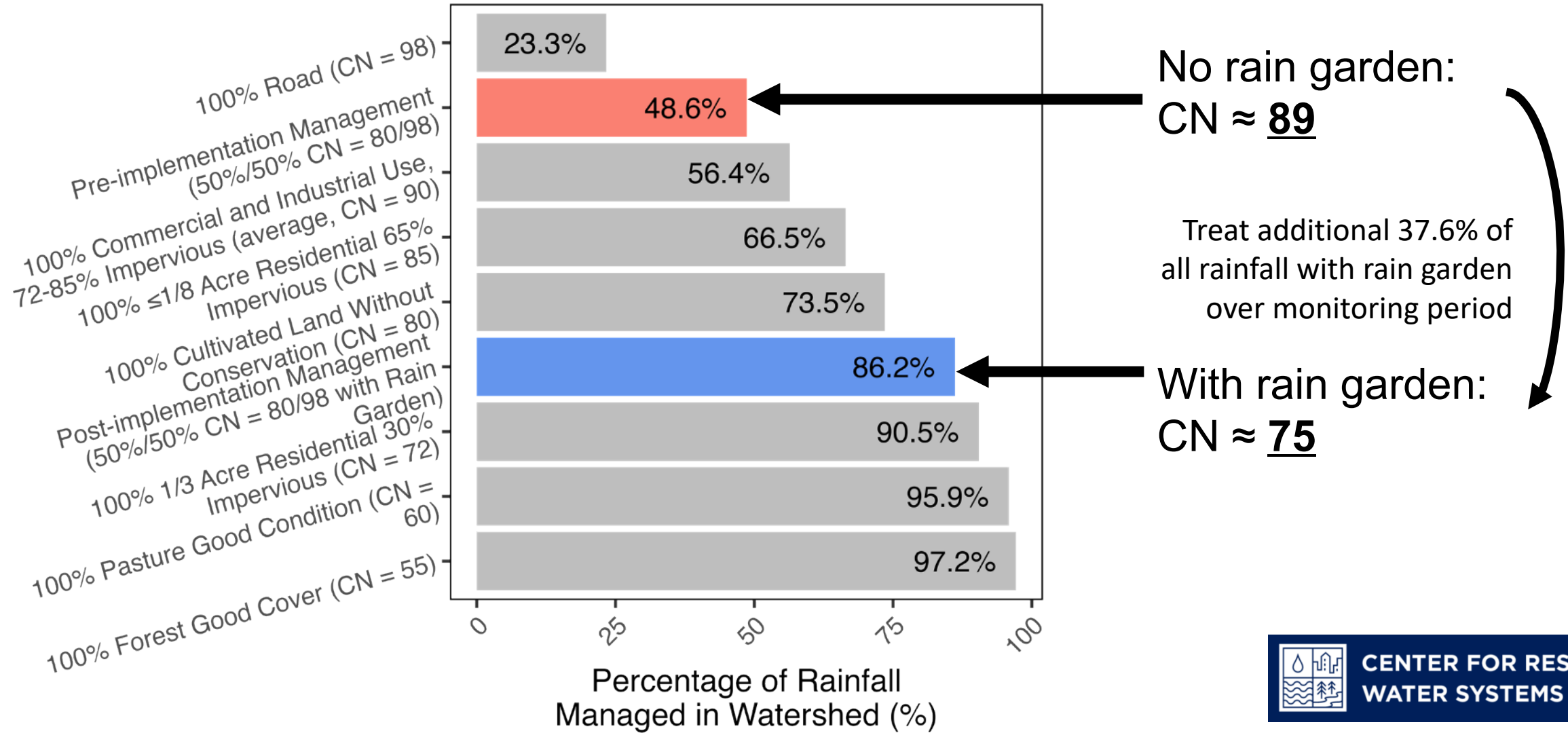
20 Years of Data  
(1846 storm events)

86% of all rainfall is managed

14% of all rainfall is discharged

\*Total volume managed by watershed and rain garden

# Curve Number is used as a proxy for development



# How few years of data could have produced the same result?

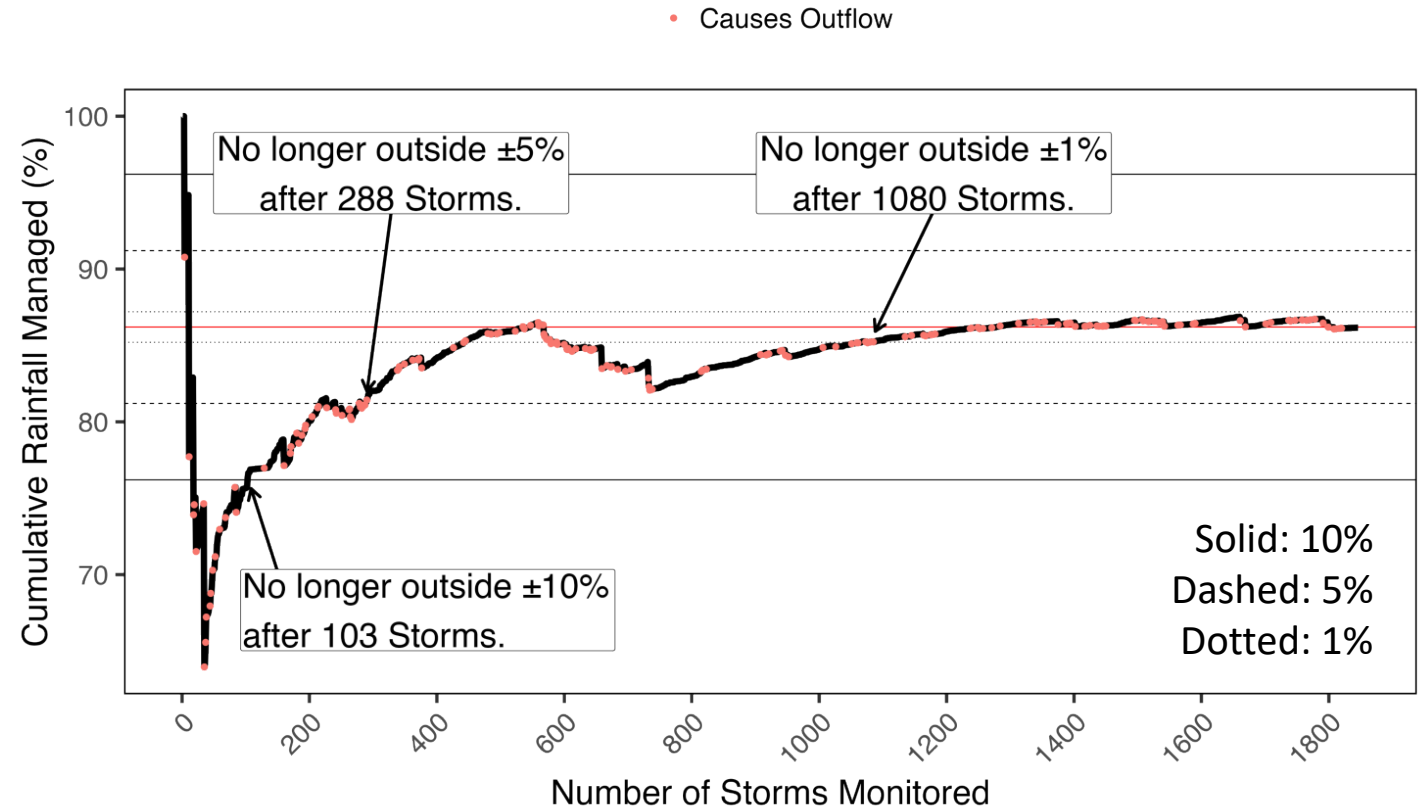
Through a cumulative analysis:

## 5% level of uncertainty

- 288 monitored storm events
- 3 years of continuous monitoring in a Cfa climate

## 1% level of uncertainty

- 1080 monitored storm events
- 11 years of continuous monitoring in a Cfa climate



# How few years of data could have produced the same result?

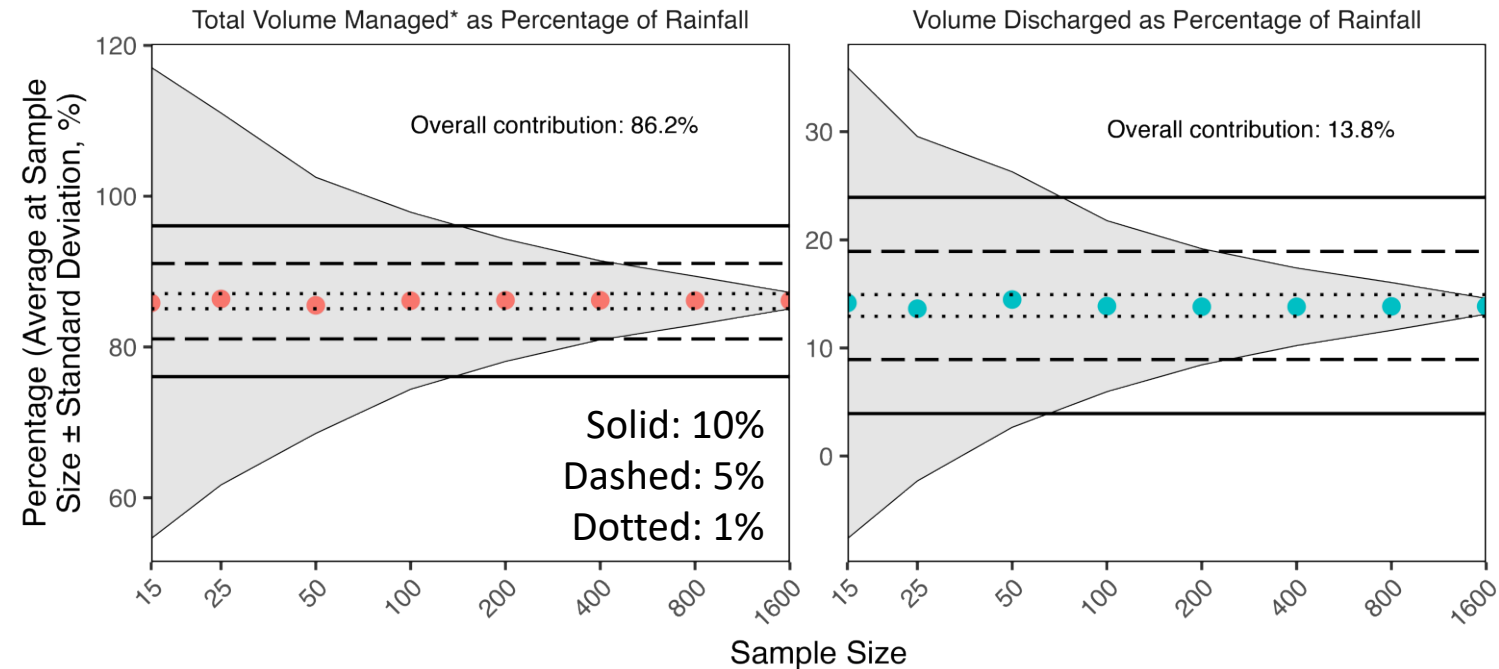
Through a random sampling analysis:

## 5% level of uncertainty

- 200-400 storm events
- 2-3 years of continuous monitoring in a Cfa climate

## 1% level of uncertainty

- Not achieved in terms of total volume managed
- Order matters



\*Total volume managed by drainage basin and rain garden

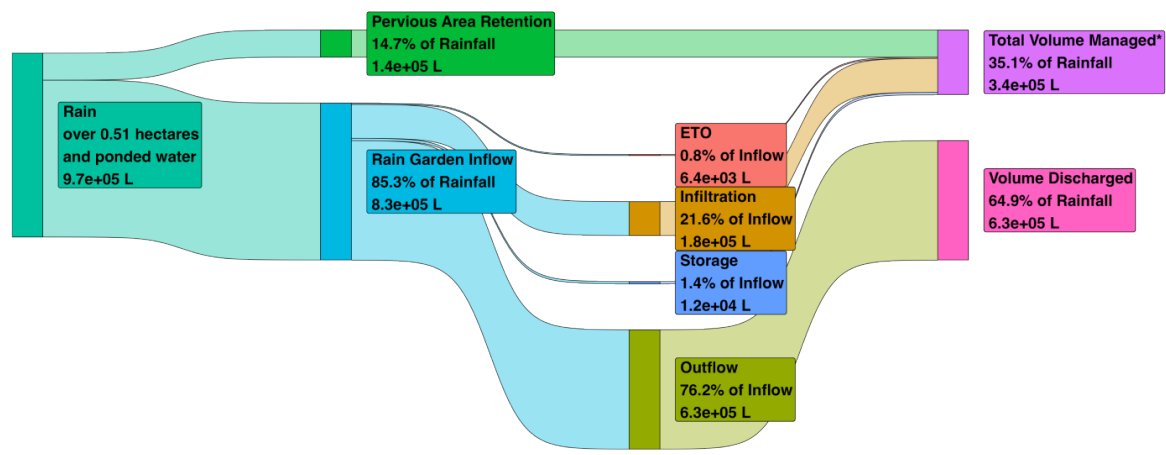


# Extreme events (hurricanes) have reduced management, but still have some management

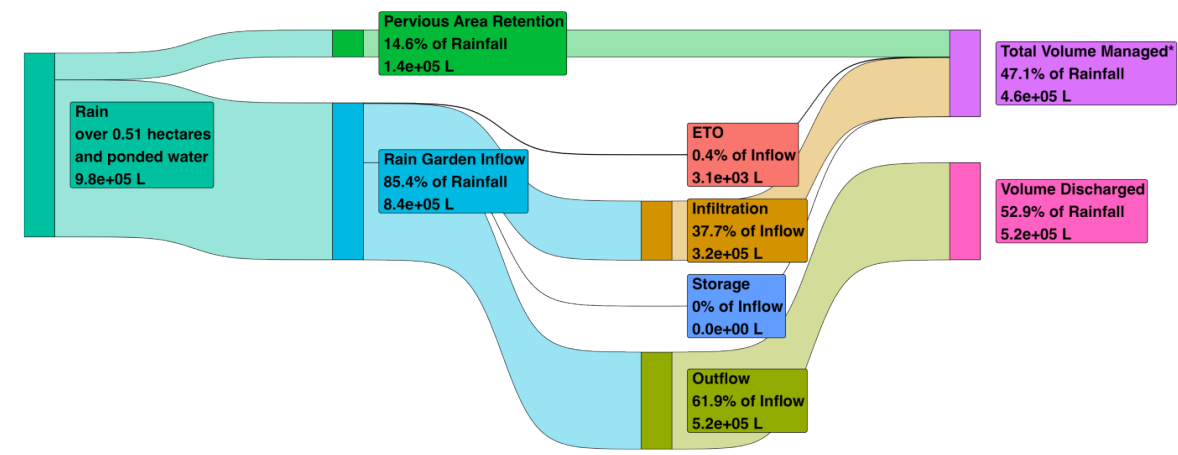
35% of rainfall is managed  
65% of rainfall is discharged

47% of rainfall is managed  
53% of rainfall is discharged

Tropical Storm Jeanne (2004, 180.34mm)



Hurricane Isaias (2020, 182.37mm)



Rain      Capture      Rain Garden Management      Basin-Wide Management

Rain      Capture      Rain Garden Management      Basin-Wide Management

# Key takeaways

- At least **3 years** of continuous monitoring data is needed for an accurate green stormwater infrastructure water balance
- Using green stormwater infrastructure can replicate a more natural landscape
  - **>50% infiltration**
  - **>30% ET**
  - **CN ~ 75**
- Maintaining sedimentation build-up and infiltration function are key to long-term performance

[This work is forthcoming in a journal article:](#)

*McGauley, M.W., Amur, A., Shakya, M., Wadzuk, B.M. (2023) A Complete Water Balance of a Rain Garden. Likely in Water Resources Research.*



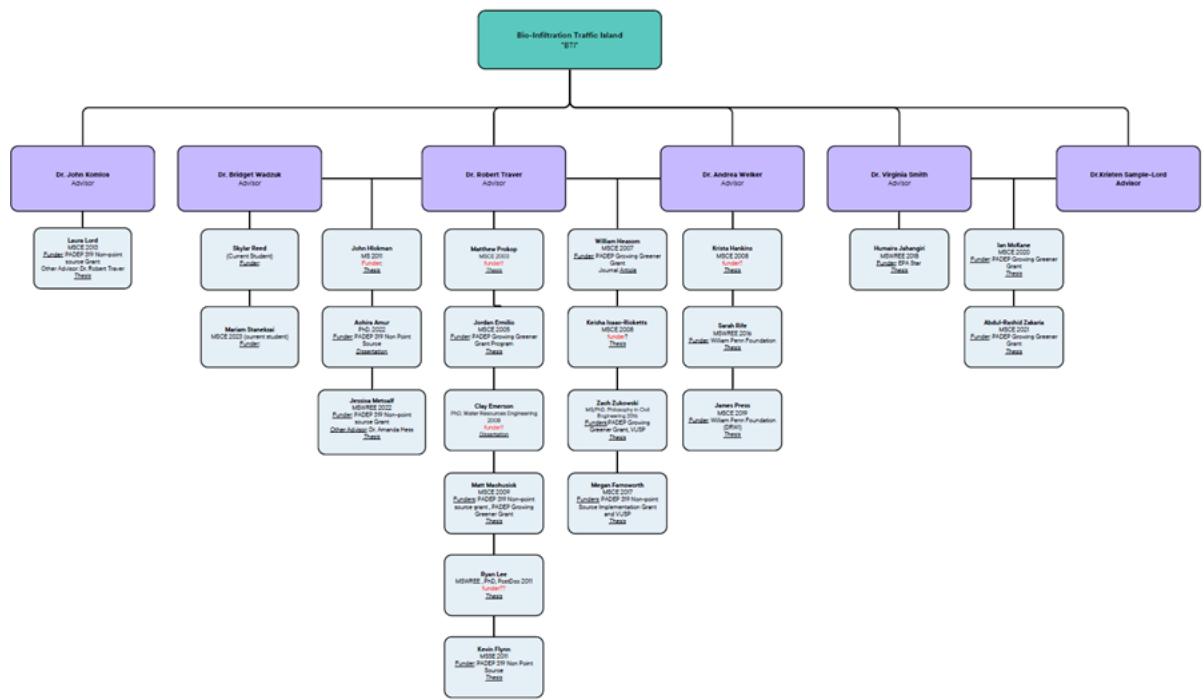
# Future work

- Apply balance concept to nutrient mass loads
- Can we take this data to help understand the biodiversity support of the site?
- Apply the hydrologic balance to other green stormwater infrastructure sites

**See a paper about our database with [more than 130 million observations](#) (scan the QR code to the right):**

Smith, V. B., M. W. McGauley, M. Newman, A. Garzio-Hadzick, A. Kurzweil, B. M. Wadzuk, and R. Traver. 2023. "A Relational Data Model for Advancing Stormwater Infrastructure Management." *Journal of Sustainable Water in the Built Environment*, 9 (1): 04022023. American Society of Civil Engineers. <https://doi.org/10.1061/JSWBAY.SWENG-478>.





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# Thank you!



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