

# Ecosystem Service Analysis of Green Infrastructure for Air and Water Resources Management in the District of Columbia

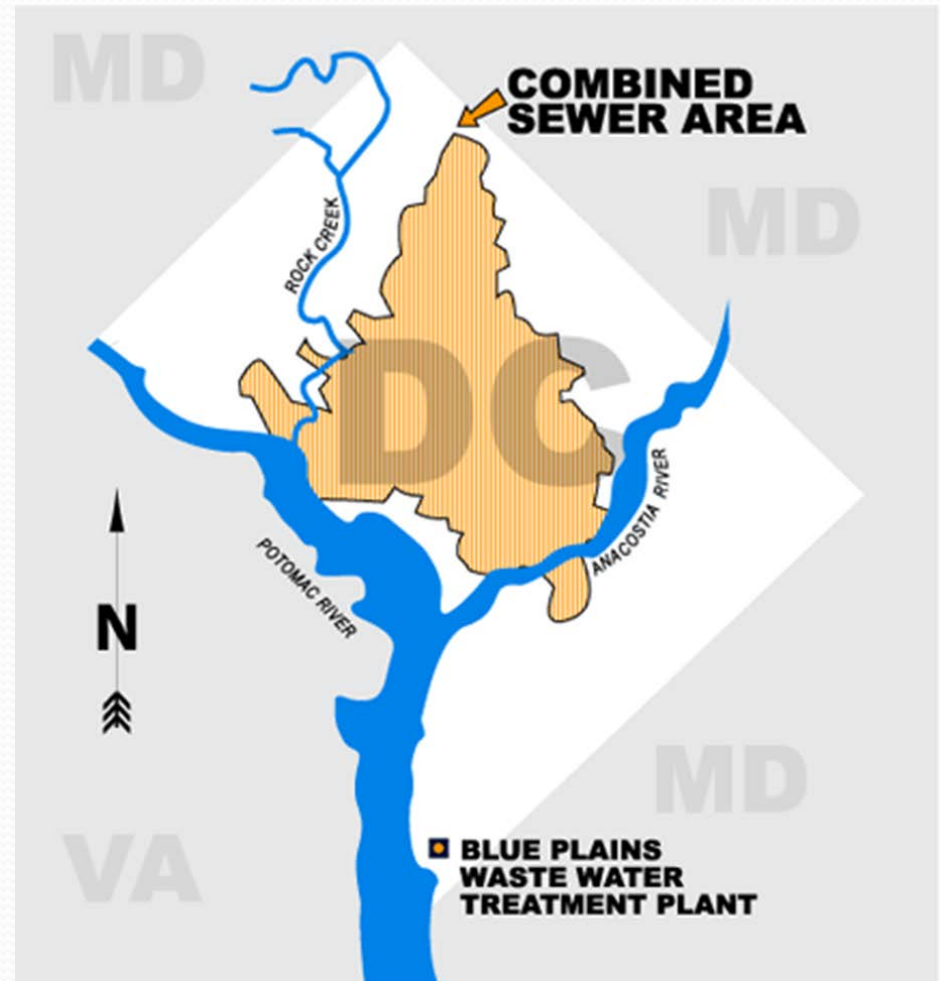
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*Director, WRI/ UDC*

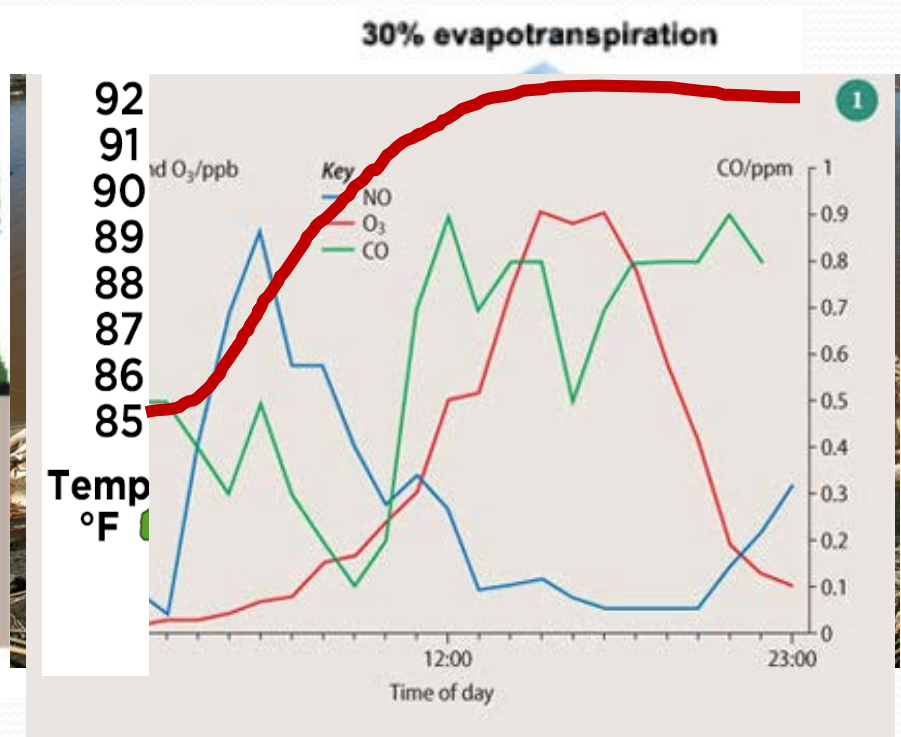
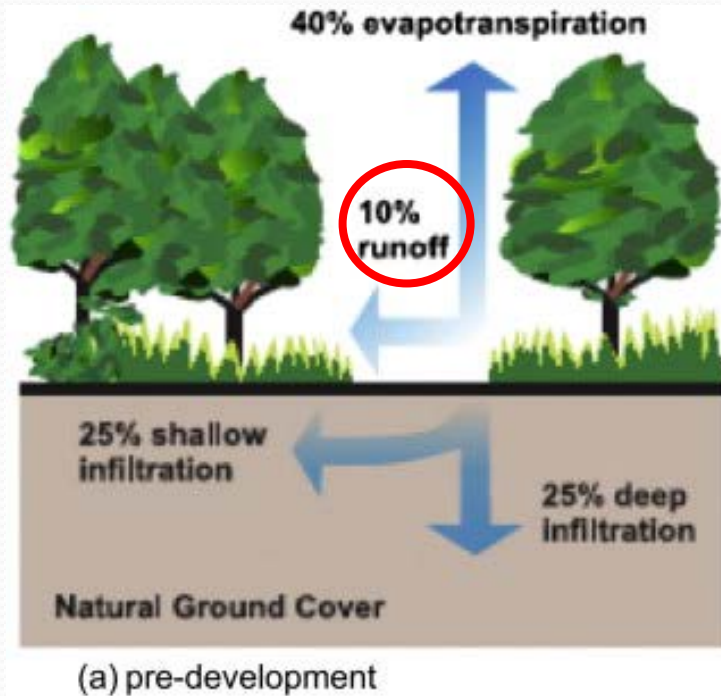
*2014 Mid-Atlantic Regional Water Conference, WV  
September 24, 2014*

# Problem: Combine Sewer Overflows in DC

- In DC, 1/3 of the sewer system is Combine Sewer System built in late 19<sup>th</sup> century
- Now, almost for every rainfall event there is a Combine Sewer Overflow (CSO)
- 600 MG CSO per year
- All water ways are impaired



# Problem: Unsustainable Urban Development

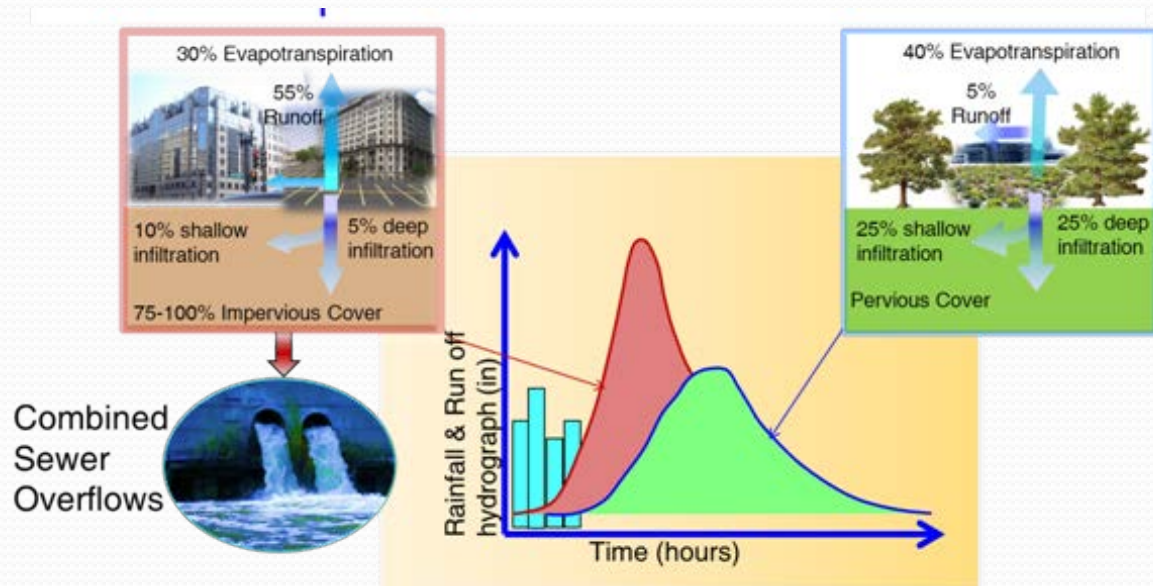


# Sustainable DC Plan

- Sustainable DC plan, by 2032:
  - All DC water ways to be 100% swimmable and fishable
  - Zero unhealthy air quality days



# Green Infrastructure and Runoff



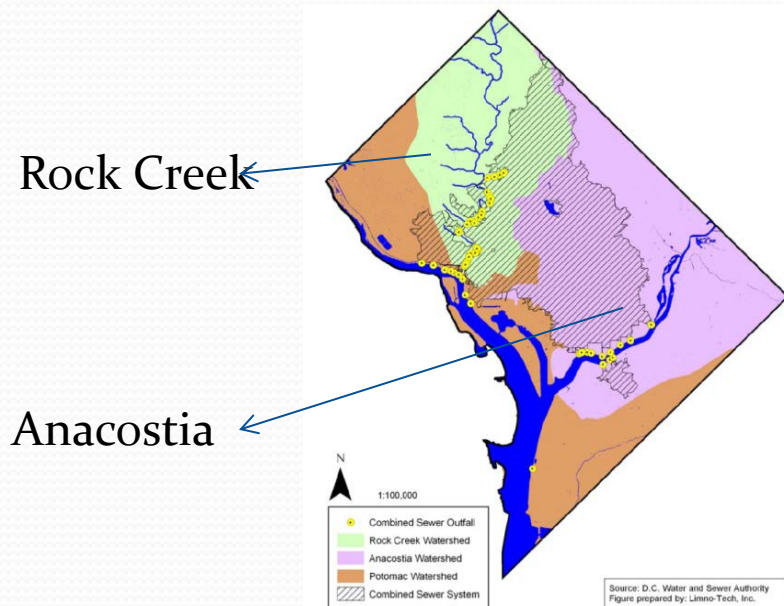
# What do we need to assess/predict the effectiveness of green infrastructure(GI)?

- We need a tool that can:
  - Quantify environmental benefits or ecosystem service of green infrastructures
  - Assess the effectiveness GI
  - Integrate both air and water pollution assessment



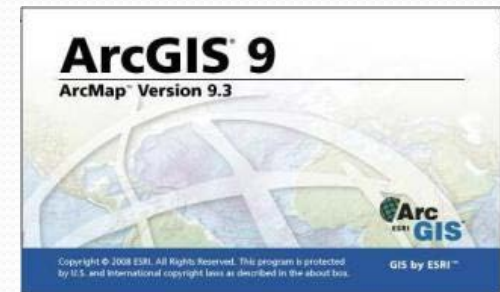
# Objective

- To apply GIS based modeling to quantify the effect of green infrastructure (green roof) on air and water quality improvement in the District of Columbia.



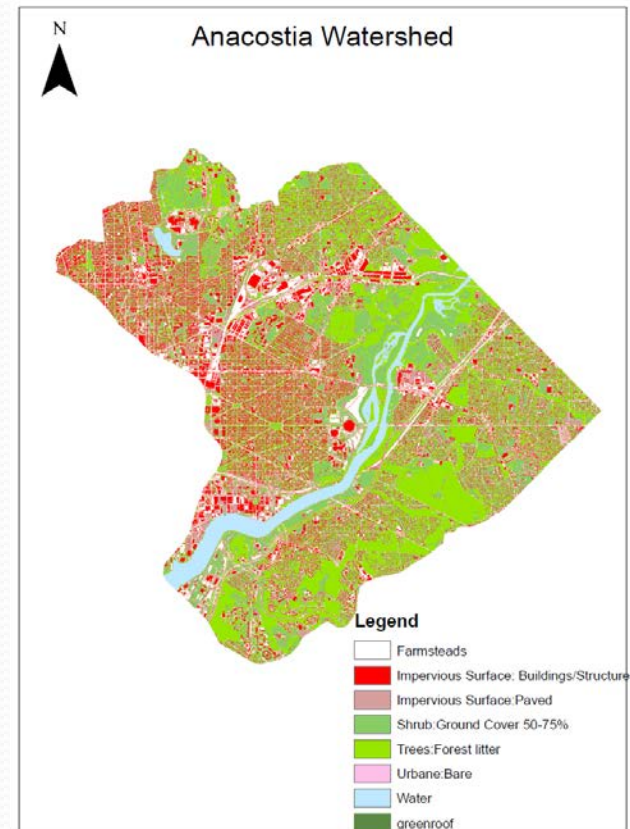
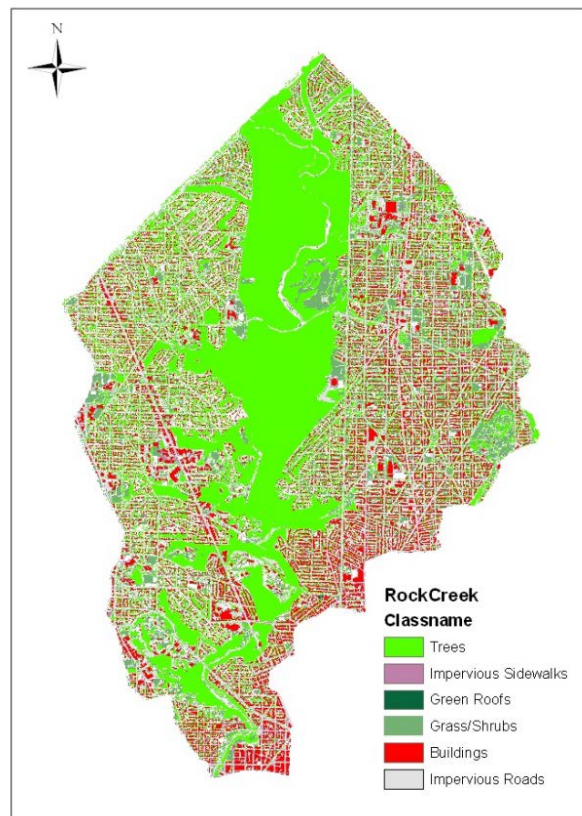
# Methodology: Model components

- Orthophotography of 2010 with 16 cm resolution
- Modeling Tools:
  - ArcGIS with spatial analysis
  - City green for ArcGIS with three sub-models:
    - Storm water runoff model (U.S. NRC)
    - Water quality model (U.S. NRC)
    - Air pollution model (USDA)



# Methodology: Study Areas

## Rock Creek and Anacostia Watershed in DC



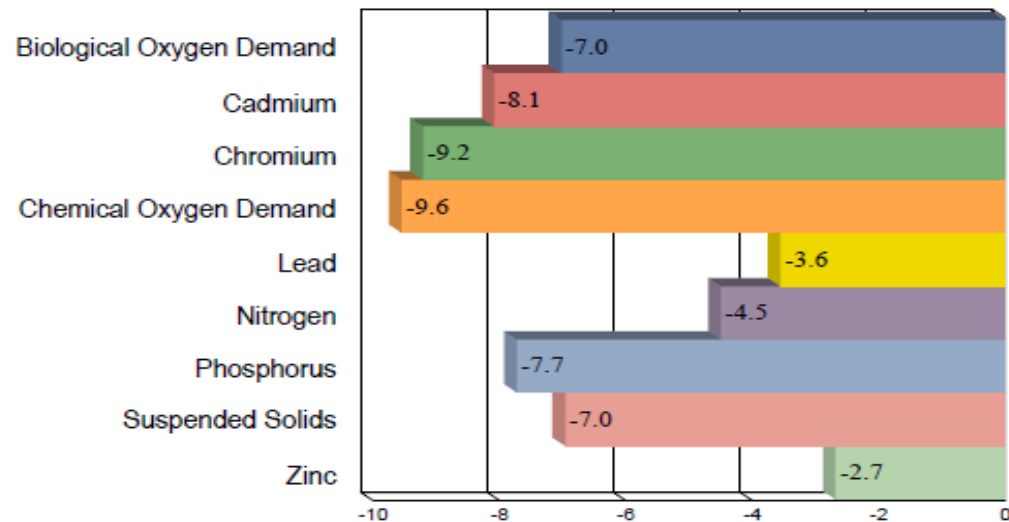
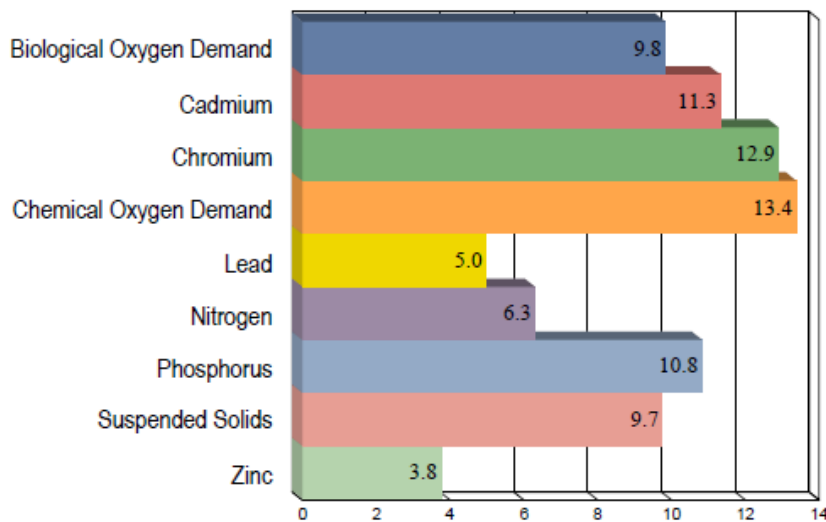
# Methodology: Model Inputs

- Storm water management modeling parameters:
  - 2-yr, 24-hr rainfall 3.2 inches
  - Curve Number of existing condition = 88
  - Curve number of replacement land cover = 91
  - Dominating soil Type: B
  - Construction cost per cu. ft. \$2.00

# Result: Rock Creek

| Storm water quantity                                               | Exiting condition | 2% green roof cover |
|--------------------------------------------------------------------|-------------------|---------------------|
| Runoff volume (Cubic feet)                                         | 8,055,158         | 271,898             |
| Total Stormwater Value                                             | \$16,110,317      | \$5,437,971         |
| Annual Stormwater Value based on 20-year financing at 6% interest) | \$1,404,571       | \$930,464           |

## Water Quality:

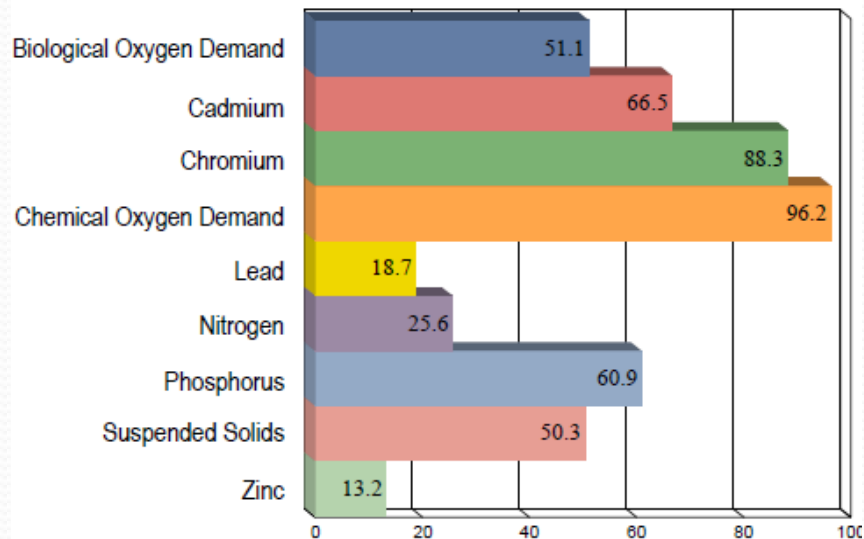


# Result: Rock Creek

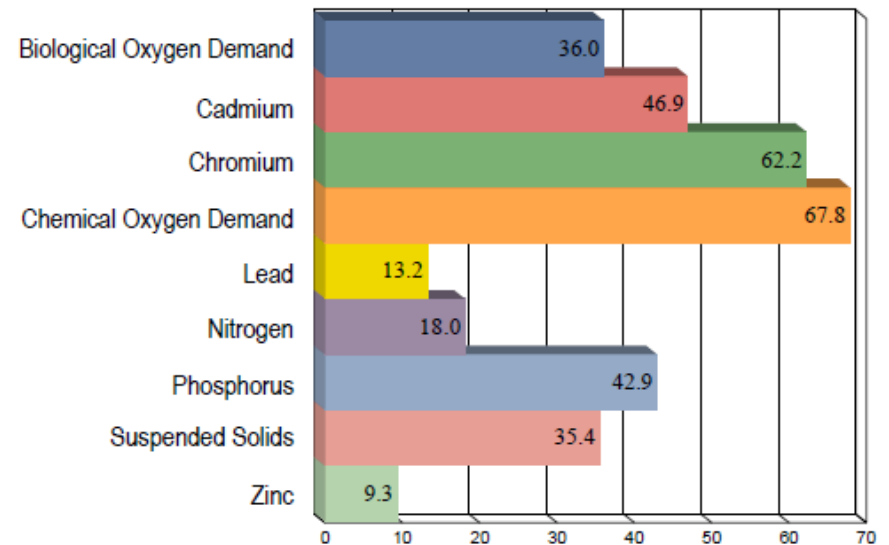
| Air quality Variables | Air pollution removal (lbs/yr) |               |             | Dollar Value/yr |            |             |
|-----------------------|--------------------------------|---------------|-------------|-----------------|------------|-------------|
|                       | Existing                       | 2% Green Roof | Differences | Existing        | Green roof | Differences |
| Carbon Monoxide       | 12,950                         | 12,921        | 29          | \$6,355         | \$6,341    | 14          |
| Ozone                 | 148,922                        | 148,588       | 334         | \$526,149       | 524,969    | 1,180       |
| Nitrogen Dioxide      | 42,087                         | 41,992        | 95          | \$148,694       | 148,361    | 333         |
| Particulate Matter    | 123,023                        | 122,747       | 276         | \$290,191       | 289,541    | 650         |
| Sulfur Dioxide        | 9,712                          | 9,691         | 21          | \$8,382         | 8,363      | 19          |
| Total                 | 336,693                        | 335,938       | 755         | \$979,772       | 977,575    | 2,197       |

| Storm water quantity                                               | Exiting condition | 2% green roof cover |
|--------------------------------------------------------------------|-------------------|---------------------|
| Runoff volume (Cubic feet)                                         | 35,000,000        | 25,000,000          |
| Total Stormwater Value                                             | \$70,000,000      | \$47,000,000        |
| Annual Stormwater Value based on 20-year financing at 6% interest) | \$6,000,000       | \$4,000,000         |

Percent change in contaminant loadings



Percent change in contaminant loadings



# Result: Anacostia

| Air quality Variables | Air pollution removal (lbs/yr) |               |             | Dollar Value/yr |            |             |
|-----------------------|--------------------------------|---------------|-------------|-----------------|------------|-------------|
|                       | Existing                       | 2% Green Roof | Differences | Existing        | Green roof | Differences |
| Carbon Monoxide       | 27,405                         | 27,362        | 43          | \$13,450        | \$13,429   | \$21        |
| Ozone                 | 137,026                        | 136,705       | 321         | \$454,118       | \$483,362  | \$756       |
| Nitrogen Dioxide      | 105,705                        | 105,540       | 165         | \$373,463       | 372,850    | \$613       |
| Particulate Matter    | 184,006                        | 183,718       | 288         | \$434,041       | \$433,364  | \$677       |
| Sulfur Dioxide        | 19,575                         | 19,545        | 30          | \$16,894        | 16,868     | \$26        |
| Total                 | 473,717                        | 472,977       | 740         | \$1,321,966     | 1,319,902  | \$2,064     |

# Summary

| Parameters  | Rock Creek |            |             | Anacostia   |             |             |
|-------------|------------|------------|-------------|-------------|-------------|-------------|
|             | Existing   | Green Roof | Differences | Existing    | Green roof  | Differences |
| Runoff      | \$1.4 mil  | \$0.9 mil  | \$0.5 mil   | \$70 mil    | \$47 mil    | \$29 mil    |
| Air Quality | \$979,772  | \$977,575  | \$2,197     | \$1.329 mil | \$1.319 mil | \$ 0.1 mil  |

# Conclusion

- The result shows that 2% increase of green roof area can decrease water and but not much effect on air pollution as expected.
- Over all study of this project shows the usefulness of the proposed tool to
  - Quantify the stormwater, water quality and air quality ecosystem service.
  - Calculate the effects of future land cover change before those changes are made.
  - Quantify the costs of parts of the green area if lost to the residence.

# Acknowledgement

- This project was funded by USGS through the DC Water Resources Research Institute.
- Ivelina Lambova, Toni Davidson, Recheal Perry and Matthew Fialla assisted in digitizing green roof and tree canopy area.



# Q&A

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