

Cost-Benefit Analysis of Green Infrastructure at WMATA Stations

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Introduction and Problem Background

- WMATA operates across D.C., Maryland, and Virginia, which have distinct regulations for managing stormwater
- Cost-benefit analysis informs WMATA's decisions of where to prioritize Green Infrastructure
- The question is often which compliance pathway is most cost-effective: Green Infrastructure, Gray Infrastructure, or purchasing third-party credits – but Green Infrastructure includes additional co-benefits that other compliance options do not
- In most jurisdictions, Green Infrastructure must be implemented to some extent before opting for other compliance pathways; some jurisdictions require implementation of Green Infrastructure to the Maximum Extent Practicable
- All WMATA stations were ranked according to Fathom-Informed 2030 flood risk score, and five stations were selected based on a qualitative assessment of flood risk, reported drainage problems, site suitability for Green Infrastructure, and equity considerations

What is Green Infrastructure?

Green infrastructure (GI) refers to stormwater management practices that mimic natural hydrologic processes

Instead of moving runoff quickly into pipes and discharging it downstream, GI captures, slows, filters, and infiltrates runoff at or near where it falls.

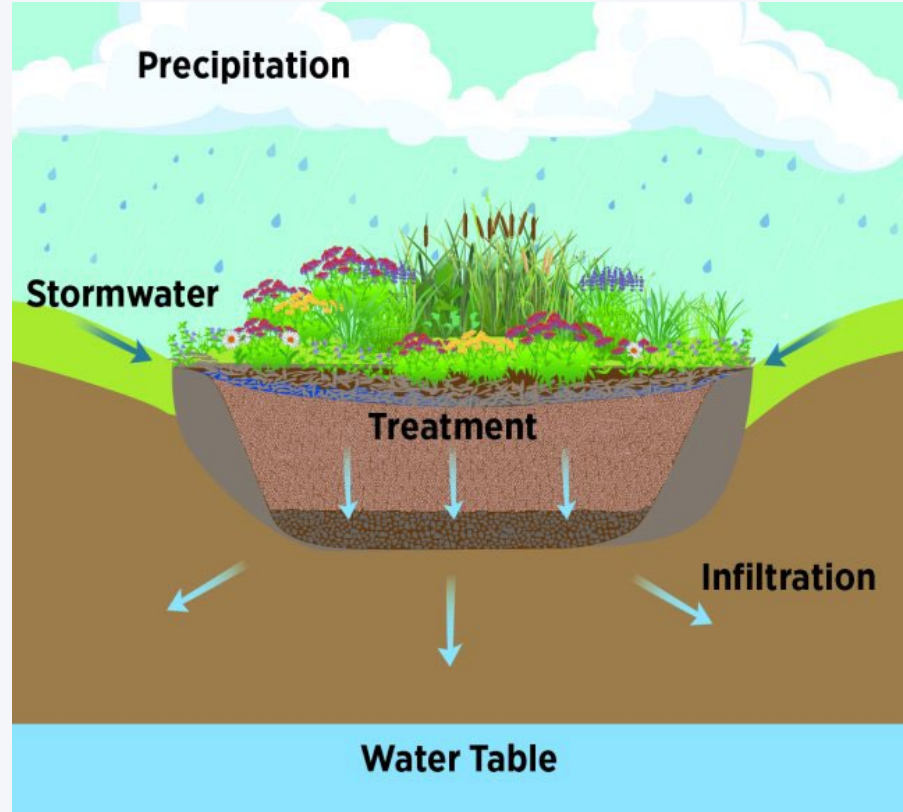


Bioswale located at Montgomery County Health Department in Silver Spring, MD. ([Public Domain](#))

What is Green Infrastructure?

How GI works

- Engineered soil media absorb and filter runoff
- Vegetation slows water flow and supports evapotranspiration
- Infiltration returns water to the ground rather than the storm sewer
- Surface storage holds runoff during peak flows and releases it gradually



Green Infrastructure Facilities Considered for WMATA

Bioswales

Bioswales are at-grade practices that capture, slow, filter, and infiltrate runoff through engineered soil media and vegetation before it enters the conventional drainage system.

Rain Gardens and Bioretention Cells function similarly to Bioswales, but use a greater depth of engineered soil to retain a greater volume of water.

Street Planters

Street Planters are a more constrained urban form of bioretention, typically located in the public right-of-way.

Street planters use vertical concrete walls, engineered media, underdrains, and curb cuts to manage runoff in dense settings where open at-grade practices aren't feasible.

Benefits of Green Infrastructure

Primary Benefits:

- Stormwater Management
- Regulatory Compliance

Secondary Co-Benefits:

- Reduced Runoff and Ponding
- Reduced “Heat Island” Effect
- Improved Station Appearance and Rider Experience

Stormwater Management and Regulatory Compliance

- Green Infrastructure provides on-site removal of sediment, nutrients, metals, and hydrocarbons
- Regulations in Maryland, D.C., and Virginia require treatment of a certain amount of stormwater using on-site “Best Management Practices”
- When on-site management is not possible, compliance must be achieved by purchasing credits

Secondary Co-Benefits and Equity

Many WMATA stations are located in “Equity Emphasis Areas” which have significant populations of low-income and/or minority populations, identified in the Transportation Resilience Study

These areas tend to lack shade or cooling areas, exacerbating the urban “heat island” effect. Green Infrastructure creates a visible investment in these historically underserved communities while providing some shade and local cooling via transpiration.

Compliance Value Varies by Jurisdiction

District of Columbia

- 1.2-inch Stormwater Retention Volume requirement effectively requires on-site retention, with limited off-site flexibility through the Stormwater Retention Credit (SRC) market.
- Credits traded at ~\$1.41/credit in Q4 2024
- GI value = avoided cost of purchasing SRCs
- Most of WMATA's most vulnerable stations are not well-suited to GI

Maryland

- ESD-to-MEP framework prioritizes distributed GI as the starting point
- Green Infrastructure must be used to the maximum extent practicable before opting for other compliance pathways
- Nutrient credit pathways exist and are generally preferred at larger scale where on-site infrastructure is not practical

Virginia

- Virginia has fewer specific requirements for Green Infrastructure as a Best Management Practice
- However, WMATA stations in Virginia tend to have more specific local jurisdictional requirements (e.g. City of Alexandria, Arlington County, and City of Fairfax operate on separate MS4s)

Key point: The economic case for green infrastructure relies on its cost relative to other compliance pathways.

Estimated Capital Costs of Green Infrastructure

A 2021 study by the University of Maryland Center for Environmental Science estimated capital costs for a bioswale range from **\$179,647 to \$256,885** per impervious acre treated (adjusted for inflation)

However, these costs are from pre-pandemic projects and may not reflect current prices

Estimated Maintenance Costs of Green Infrastructure

Annual maintenance for green infrastructure features is typically estimated at **5 to 6 percent** of the capital cost, but the 2021 UMCES study raises this to **11.5 percent**, about **\$20,660 to \$29,542** per impervious acre

In practice, maintenance for Bioswales in Landover last year totaled **\$8,599.61** across three visits

Costs of Green Infrastructure vs. Other Compliance Pathways

- Stormwater must be managed with a combination of Green Infrastructure, Gray Infrastructure, and/or purchasing third-party credits
- Gray Infrastructure is more cost-effective at larger scales, but construction is costly and difficult
- Green Infrastructure is much more cost-effective for smaller drainage areas, where Gray Infrastructure is not feasible

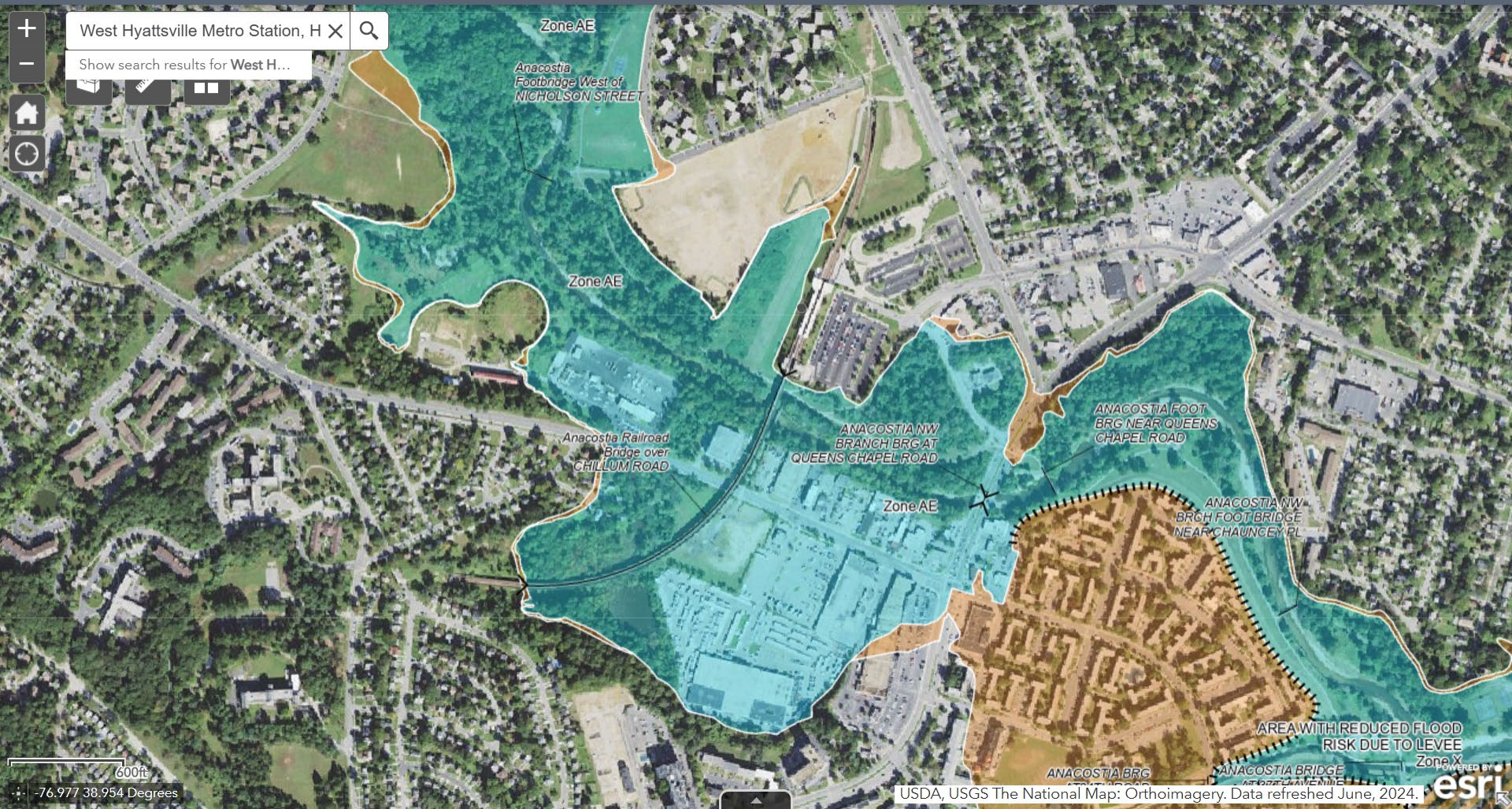
Site Screening Methods and Scope

Five Stations Analyzed

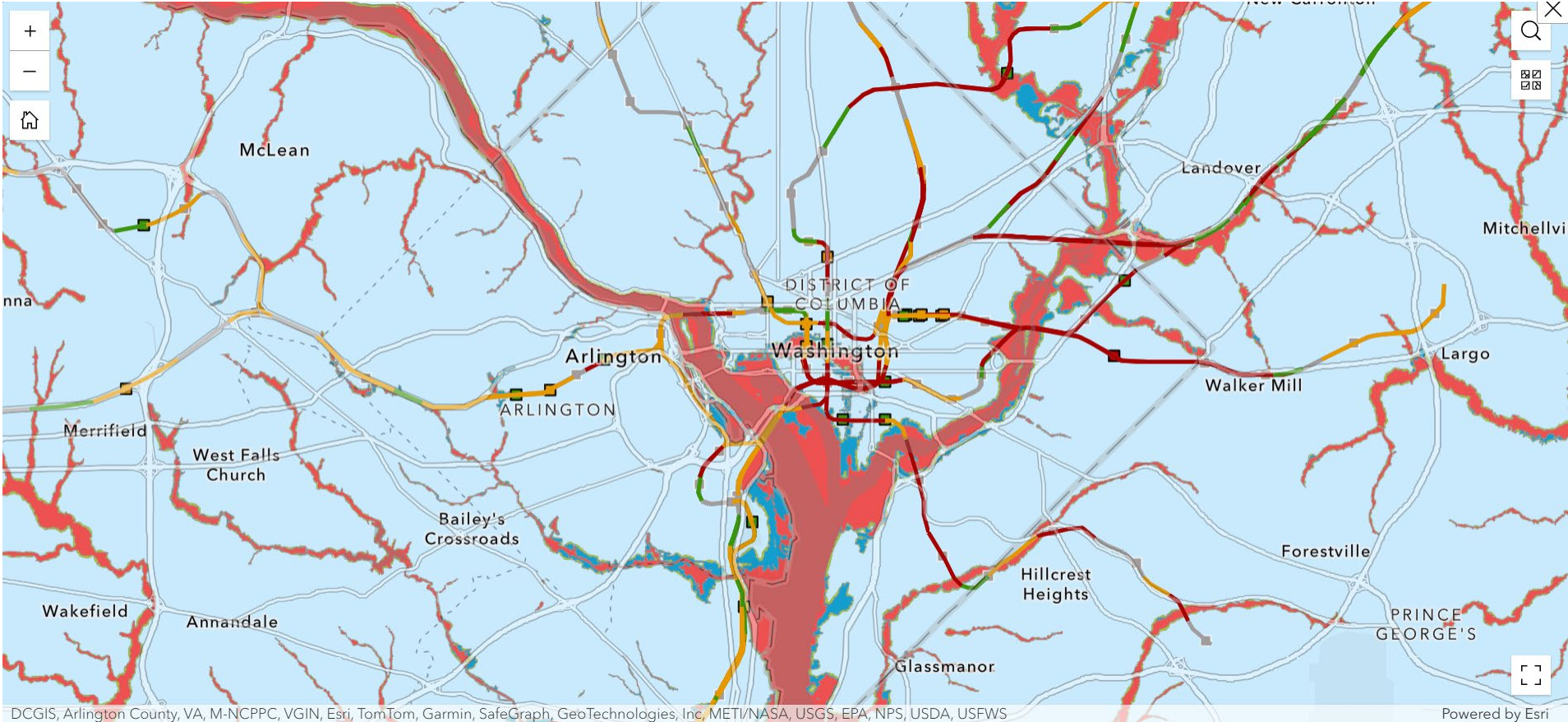
- Benning Road (D.C.)
- Archives–Navy Memorial (D.C.)
- Deanwood (D.C.)
- West Hyattsville (Maryland)
- King St–Old Town (Virginia)

Analytical Approach

- Flood risk screened via TPB Climate Change Vulnerability Assessment and FEMA National Flood Hazard Layer
- Hydrologic modeling conducted via EPA National Stormwater Calculator at 25%, 50%, and 100% GI coverage
- Cost data obtained from published estimates and compared with actual cost data from WMATA
- Stations partially selected for jurisdictional and site-condition variation, not solely based on flood risk



TPB Climate Change Vulnerability Assessment

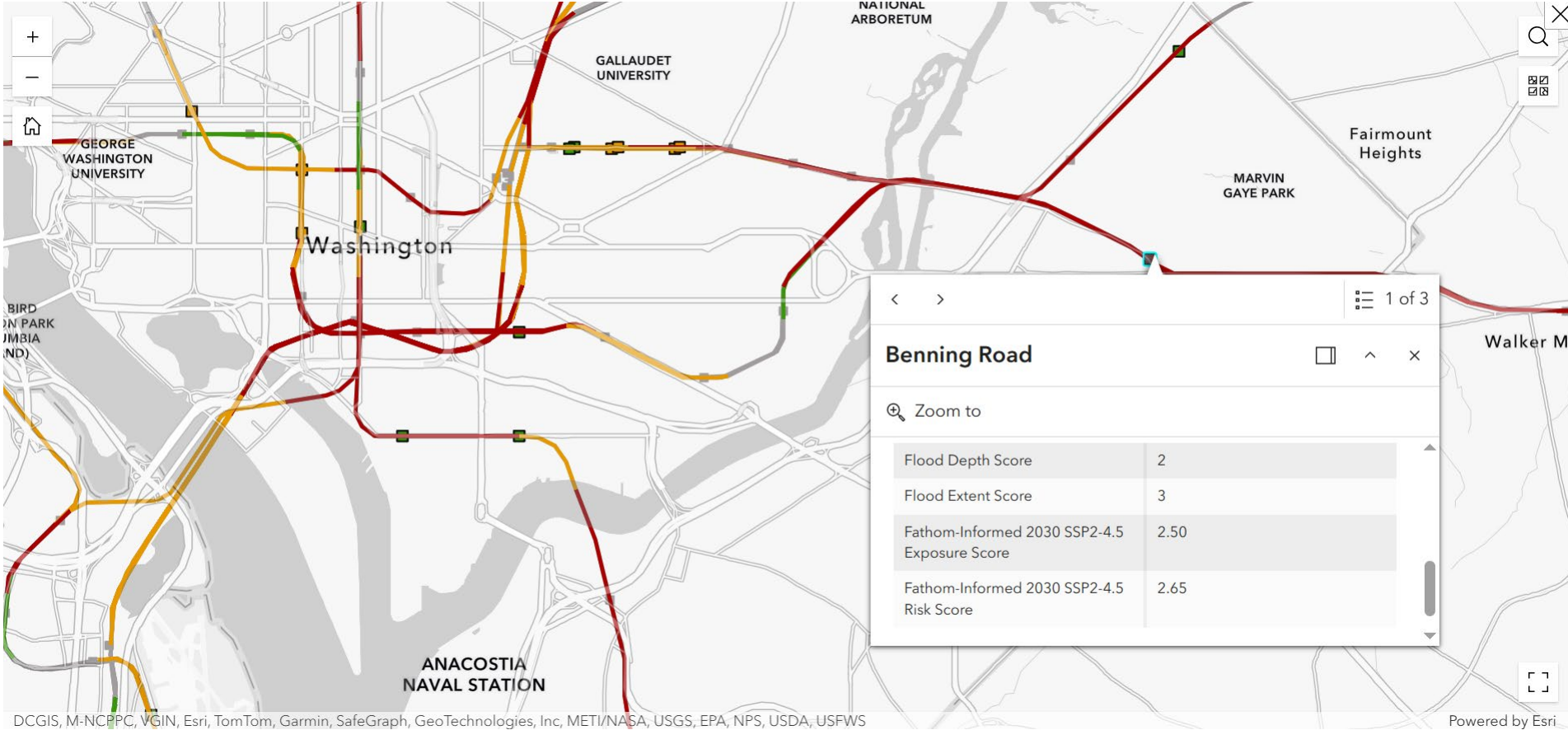


TPB Climate Change Vulnerability Assessment

The TPB Climate Change Vulnerability Assessment (2023) scores transportation assets across the region for vulnerability to four climate hazards:

- Extreme heat
- FEMA-informed inland flooding (current conditions)
- Fathom-informed inland flooding (forward-looking, climate-adjusted)
- Sea level rise

TPB Climate Change Vulnerability Assessment (Station Detail)



EPA National Stormwater Calculator

EPA National Stormwater Calculator is a planning tool that pulls from national datasets for soil, topography, rainfall, and evaporation to model how various GI scenarios impact:

- Average annual runoff
- Days per year with runoff
- Percent of wet days retained
- Maximum rainfall retained before runoff begins



Location

Directions

Bring your site into view on the map and then mark its exact location by clicking the mouse pointer over it or entering your address or zip code below.



Use this polygon drawing tool to draw your project area on the map.

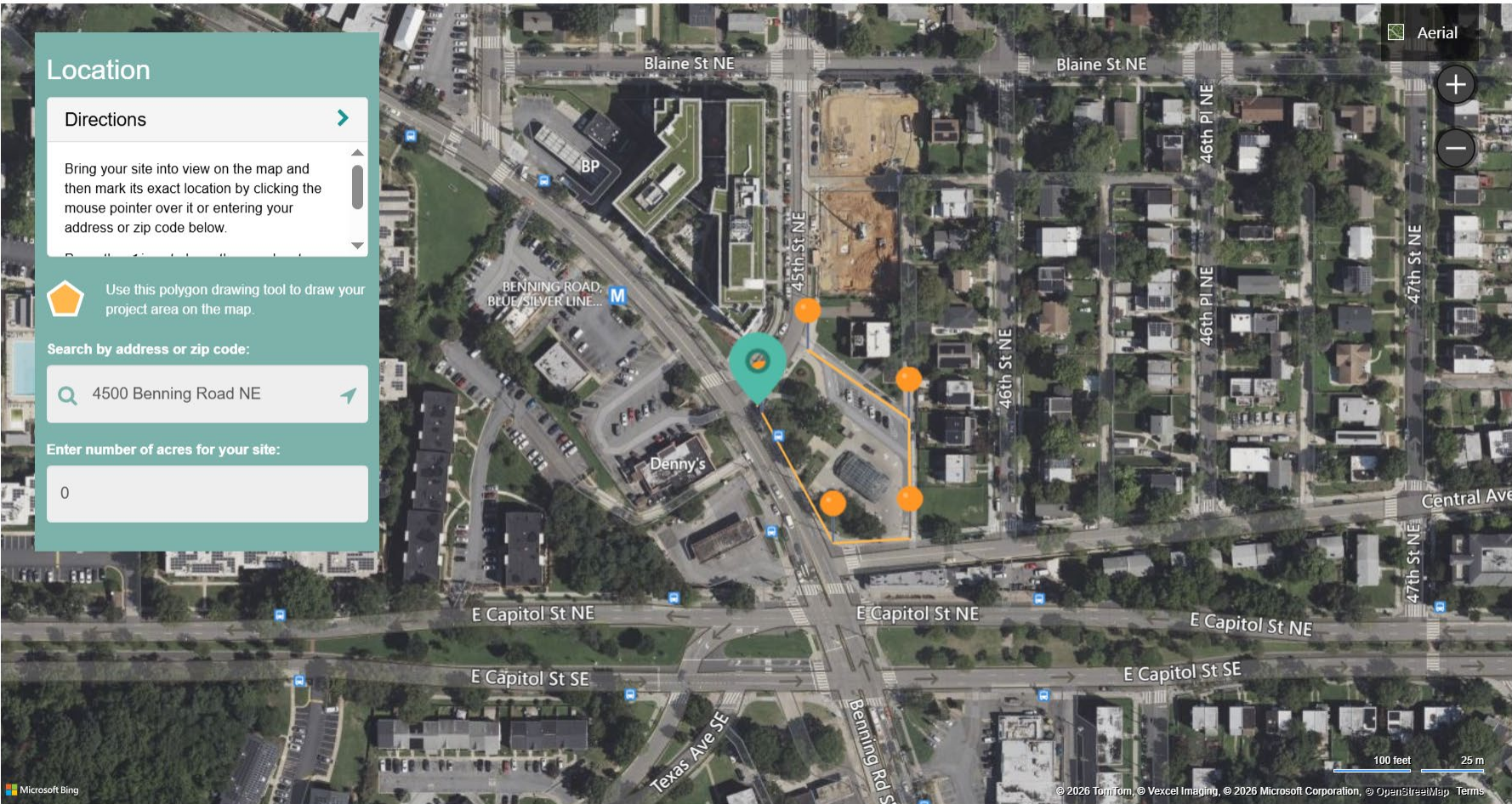
Search by address or zip code:



4500 Benning Road NE

Enter number of acres for your site:

0



Aerial



100 feet 25 m



LID Controls

Directions

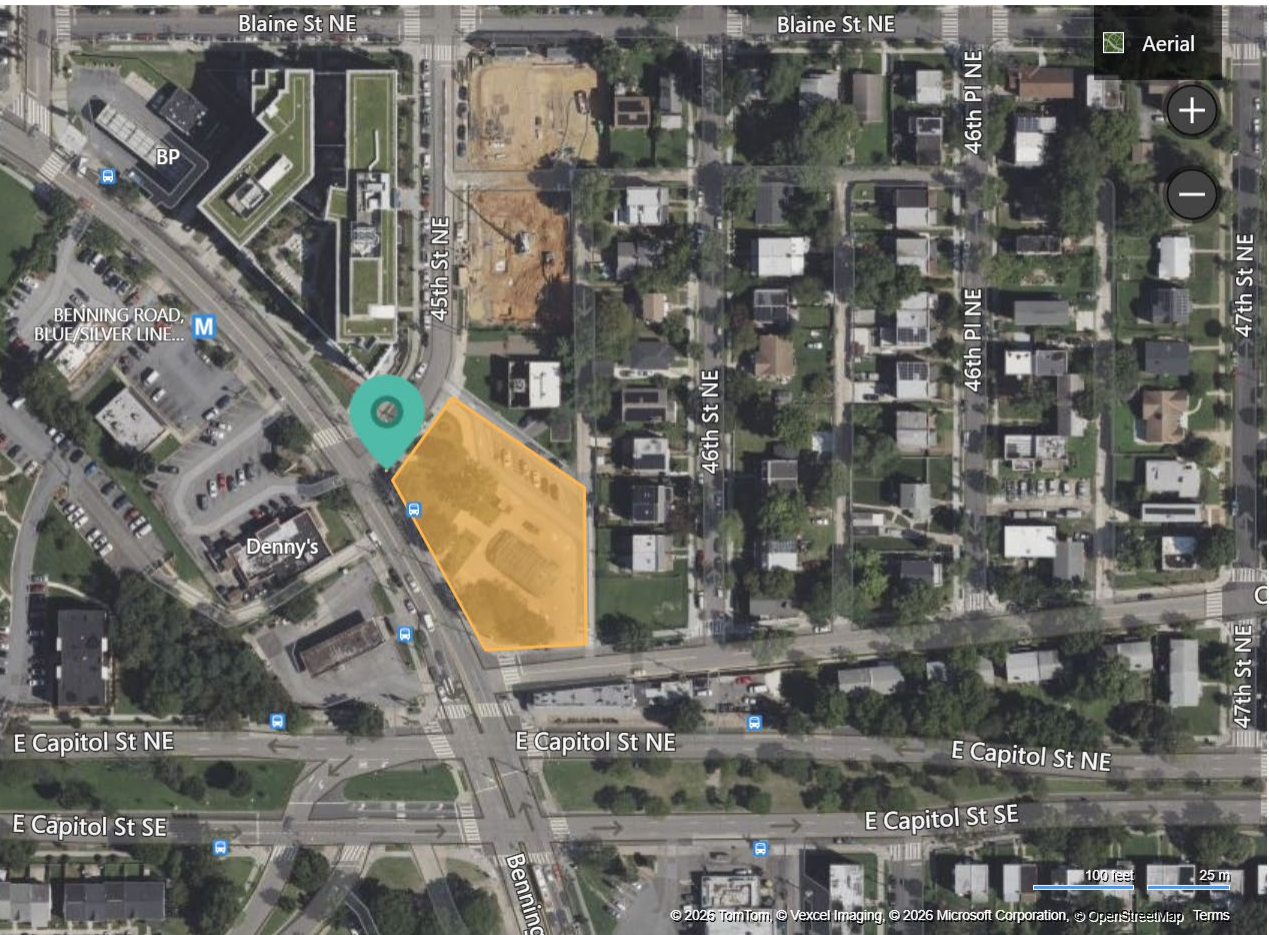
Enter the percentage of your site's impervious area you would like to be treated by the listed LID Controls.

Click a practice to learn more about it or to change its design parameters. For example:

Disconnection:	<input type="range"/>	0	%
Rain Harvesting:	<input type="range"/>	0	%
Rain Gardens:	<input type="range"/>	50	%
Green Roofs:	<input type="range"/>	0	%
Street Planters:	<input type="range"/>	0	%
Infiltration Basins:	<input type="range"/>	0	%
Permeable Pavement:	<input type="range"/>	0	%

Design Storm for Sizing: 1.2 in.

Help



Rain Gardens



Rain Gardens are shallow depressions filled with an engineered soil mix that supports vegetative growth. They are usually used on individual home lots to capture roof runoff.

Typical soil depths range from 6 to 18 inches

The Capture Ratio is the ratio of the rain garden's area to the impervious area that drains onto it.

[Learn More \(Minnesota Stormwater Design Manual\)](#)

Ponding Height: 6 in.

Soil Media Thickness: 12 in.

Soil Media Conductivity: 10 in./hr

% Capture Ratio: 8 %

☐ Pre-Treatment



LID Controls

Directions

Enter the percentage of your site's impervious area you would like to be treated by the listed LID Controls.

Click a practice to learn more about it

Disconnection: 0

Rain Harvesting: 0

Rain Gardens: 50

Green Roofs: 0

Street Planters: 0

Infiltration Basins: 0

Permeable Pavement: 0

Design Storm for Sizing: 1.2
[Help](#)



GI Improves Performance at All Five Modeled Stations

~80%

Annual runoff reduction

Benning Rd, Deanwood, West Hyattsville
at max GI coverage

~88%

Wet-day retention

Rising from ~17–20% baseline
to ~88% at maximum coverage

3×

**Rainfall retained
before runoff begins**

Rising from 0.5–0.8" baseline
to 1.6–1.8" at max coverage

- Archives and King Street show steady but more modest gains, reflecting constrained site conditions and smaller intervention scales
- Gains come from improved performance during frequent small storms; green infrastructure is limited in capturing larger storm volumes

Recommendations

Prioritize GI in locations where three conditions apply:

1. The local jurisdiction requires use of GI for stormwater management
2. The station is physically suited to GI construction and maintenance
3. Modeling with EPA Stormwater Calculator shows that GI will be effective at the chosen site

Station	Guidance	Key Rationale
Benning Road	Highest Priority	Equity Emphasis Area, strongest flood exposure, largest modeled gains, area not too constrained
Deanwood	Higher priority	Equity Emphasis Area, located on a stream, and surrounded by high flood risk areas
West Hyattsville	Moderate Priority	Equity Emphasis Area, large site suitable for GI, and located in Maryland which requires ESD-to-MEP
Archives	Coordinate with area partners to consider GI	Limited area suitable for GI, urban environment
King St–Old Town	Consider studying and expanding existing GI interventions at this site (street planters)	Currently has street planters in place, but flooding issues reported due to large impervious surface area; additional GI shows modest gains

Limitations and Further Research

Current Limitations

- Cost data are planning-level estimates from studies performed pre-pandemic
- Hydrologic results are modeled, not observed; site areas and land cover were approximated due to modeling limitations
- TPB Climate Vulnerability Assessment identifies flood risk based on future predictions, whereas EPA Stormwater Calculator uses only historic rainfall data
- Jurisdictional requirements vary and may change in the future, resulting in different GI needs

Further Research Needed

- WMATA-specific capital and O&M cost records to replace planning benchmarks
- SRC translation: map modeled retention to project-level D.C. off-site obligations
- Maryland and Virginia credit-pathway costs confirmation applicable to WMATA projects
- Site-level engineering screening and involvement of jurisdictional partners at recommended sites, especially Archives



*Bioswale located at Fort Detrick in Frederick, MD.
(Public Domain)*

Thank you!

Any Questions?