

# REGIONAL TRANSPORTATION RESILIENCE UPDATE: OVERVIEW OF RECENT PROJECTS

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## Extreme Heat and Economic Analysis Projects

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TPB Transportation Planner

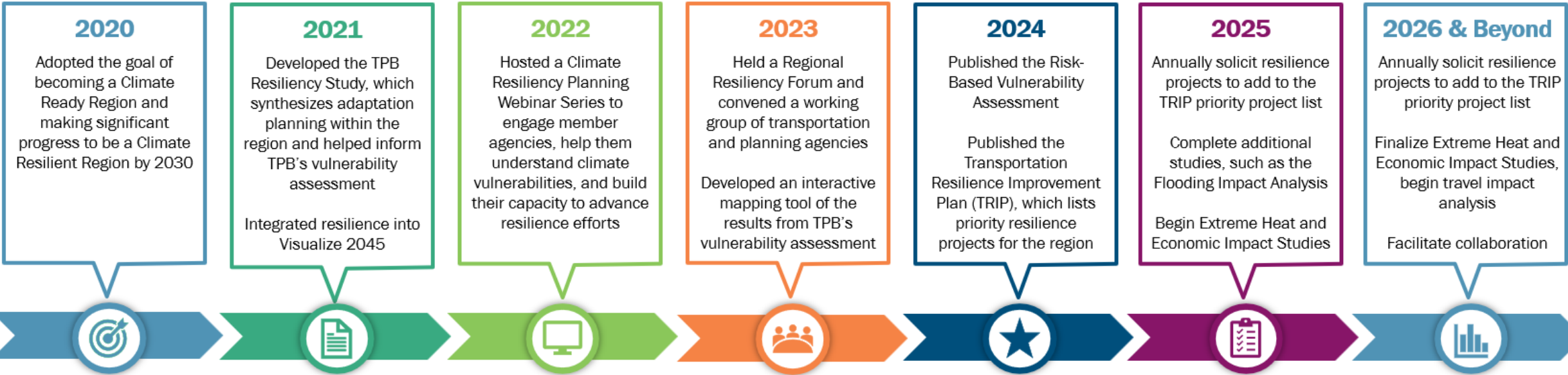
Community Advisory Committee  
June 11, 2026



National Capital Region  
**Transportation Planning Board**

# Regional Foundation for Transportation Resilience

## TPB's Road to Resilience



# Major Studies to Date

## NATIONAL CAPITAL REGION TRANSPORTATION SYSTEM CLIMATE VULNERABILITY ASSESSMENT

May 2024



## National Capital Region Transportation Resilience Improvement Plan

June 2024



## NATIONAL CAPITAL REGION TRANSPORTATION SYSTEM FLOOD ANALYSIS ADDENDUM



# Project Objectives

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## WHAT?

Understand potential impacts of extreme heat on transportation systems and users



## WHERE?

Identify where transit systems and users might be the most exposed to extreme heat



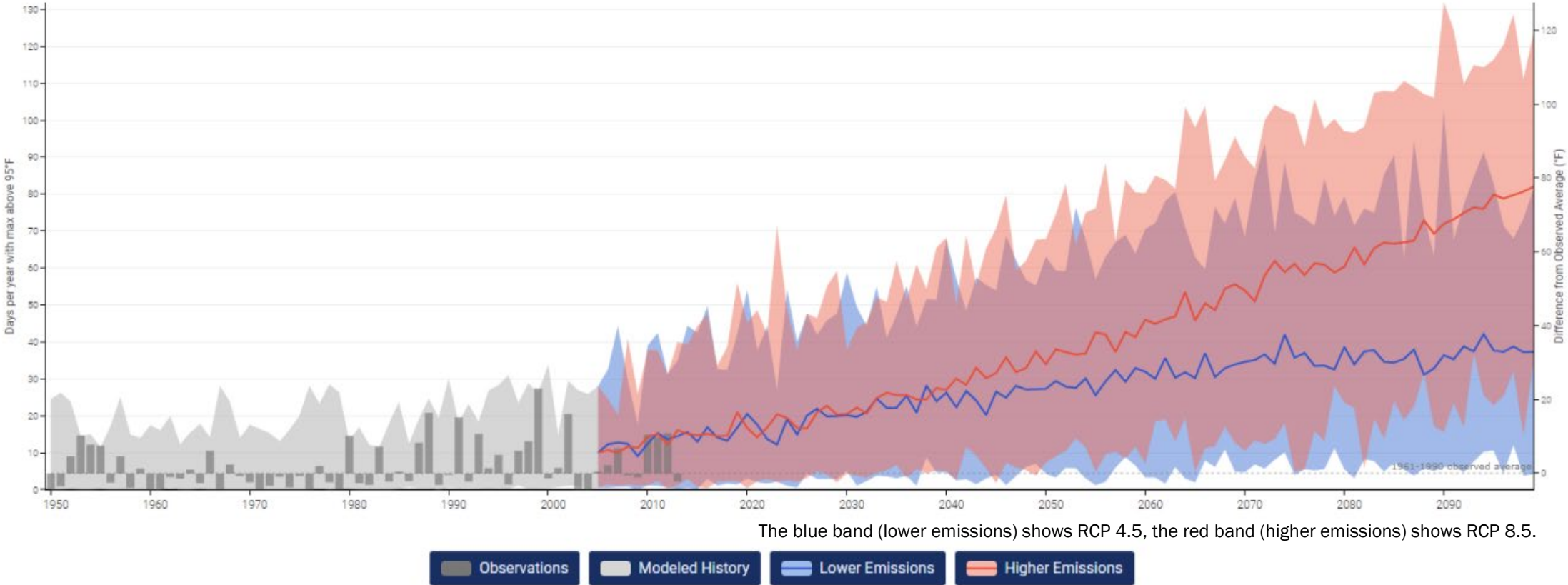
## HOW?

Provide resources that guide how the region might adapt to these impacts



# Extreme Heat in the National Capital Region

Days with extreme heat as identified by days with maximum temperatures above 95°F for Washington DC. Projections through 2100 given both low and high emissions are shown.



The blue band (lower emissions) shows RCP 4.5, the red band (higher emissions) shows RCP 8.5.

Source: NOAA Climate Explorer

# Overview of Products



**ITEM A** – Transit Infrastructure Resilience Analysis



**ITEM B** – Grant Application Support



**ITEM C** – Best Practice Design Guidance



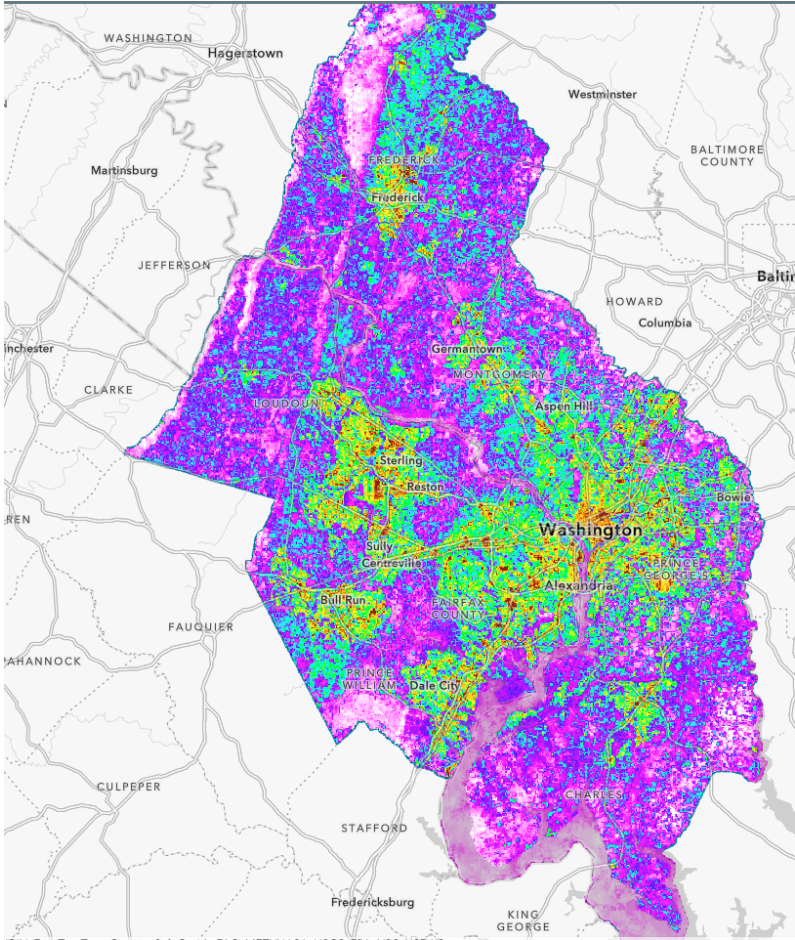
**ITEM D** – Policy, Planning, Guidance Use Cases



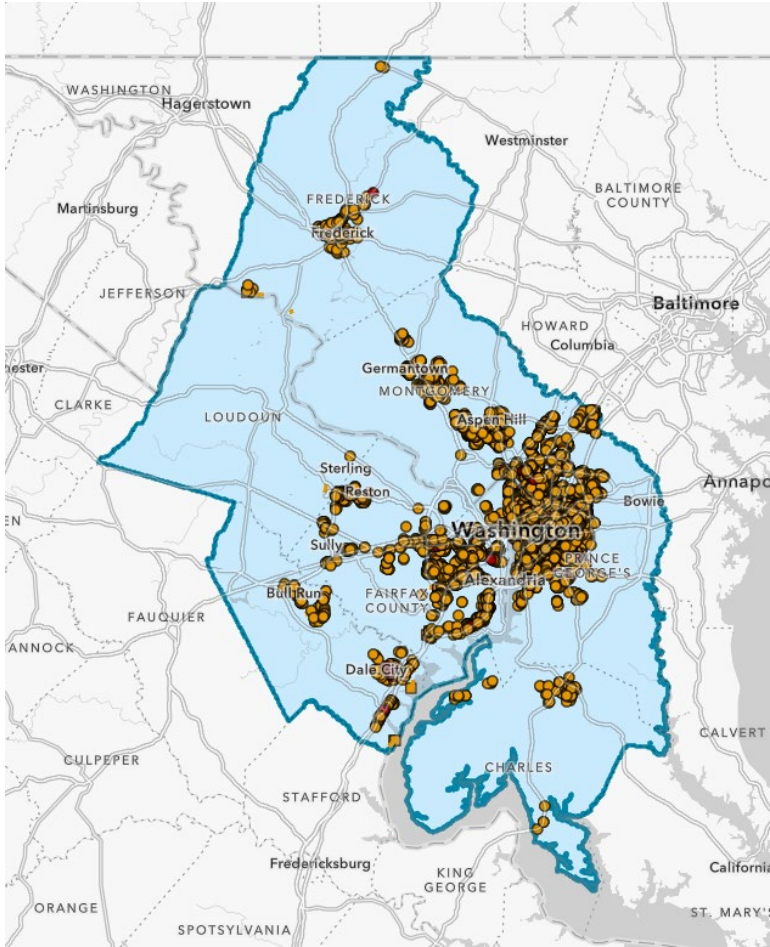
Photo Source: Pierre Gaunaud



# Extreme Heat in the National Capital Region



Median historical land surface temperature data for National Capital Region, Landsat 2018-2022 average



Bus stops, rail stops and rail lines scored as medium and high-risk to the impacts of extreme heat in TPB's Vulnerability Assessment, 2024



# Transit Infrastructure Resilience Analysis



Assess the past, projected, and downstream impacts of extreme heat on rail operations and ridership, to inform future resilience efforts.

- **A retrospective analysis** using historical high heat days and transit ridership data to understand how heat thresholds may impact ridership
- **A future analysis** using climate projections to anticipate high heat trends and the potential future impacts on ridership
- **A qualitative impacts analysis** of downstream consequences

**We gotta drop it when it's hot.**

**Extreme heat can expand the rails our trains run on.**

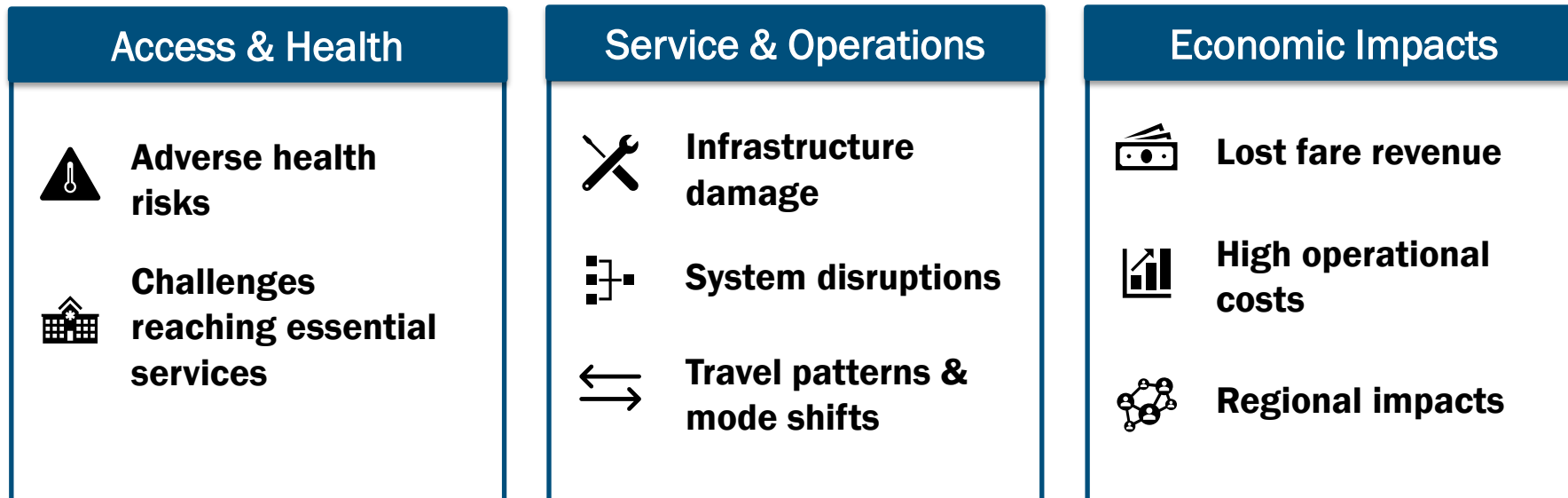
**For safety, trains will run at slower speeds during very hot weather.**



# Transit Infrastructure Resilience Analysis



Beyond just ridership loss, extreme heat impacts transit users and owners in other ways:



# ITEM A – Transit Infrastructure Resilience Analysis



Assess the past, projected, and downstream impacts of extreme heat on rail operations and ridership, to inform future resilience efforts.

1

Identify case studies

- **June 20-23, 2024:**
  - 3 days > 95F, heat emergency activated
  - Record-breaking temperatures, hottest since Aug 2016
  - Climatologically abnormal for time of year
- **July 13-17, 2024:**
  - Daily highs of 95 to 103F, high nighttime lows
  - Excessive heat warning
  - Record-breaking high temperatures
- **June 23-26, 2025:**
  - 4 days > 95F, heat index > 105F
  - Climatologically abnormal for time of year



# ITEM A – Transit Infrastructure Resilience Analysis



Assess the past, projected, and downstream impacts of extreme heat on rail operations and ridership, to inform future resilience efforts.

- 1 Identify case studies
- 2 Determine impact to ridership

- **June 20-23, 2024:**
  - Baseline daily ridership: 334k
  - High heat daily ridership: 308k
  - Percent change: **8%**
- **July 13-17, 2024:**
  - Baseline daily ridership: 336k
  - High heat daily ridership: 329k
  - Percent change: **2%**
- **June 23-26, 2025:**
  - Baseline daily ridership: 506k
  - High heat daily ridership: 504k
  - Percent change: **0.4%**



# ITEM A – Transit Infrastructure Resilience Analysis



Assess the past, projected, and downstream impacts of extreme heat on rail operations and ridership, to inform future resilience efforts.

- 1 Identify case studies
- 2 Determine impact to ridership
- 3 Determine fare revenue lost

- **June 20-23, 2024:**
  - Daily fare revenue lost: **\$82k**
- **July 13-17, 2024:**
  - Daily fare revenue lost: **\$22k**
- **June 23-26, 2025:**
  - Daily fare revenue lost: **\$6k**



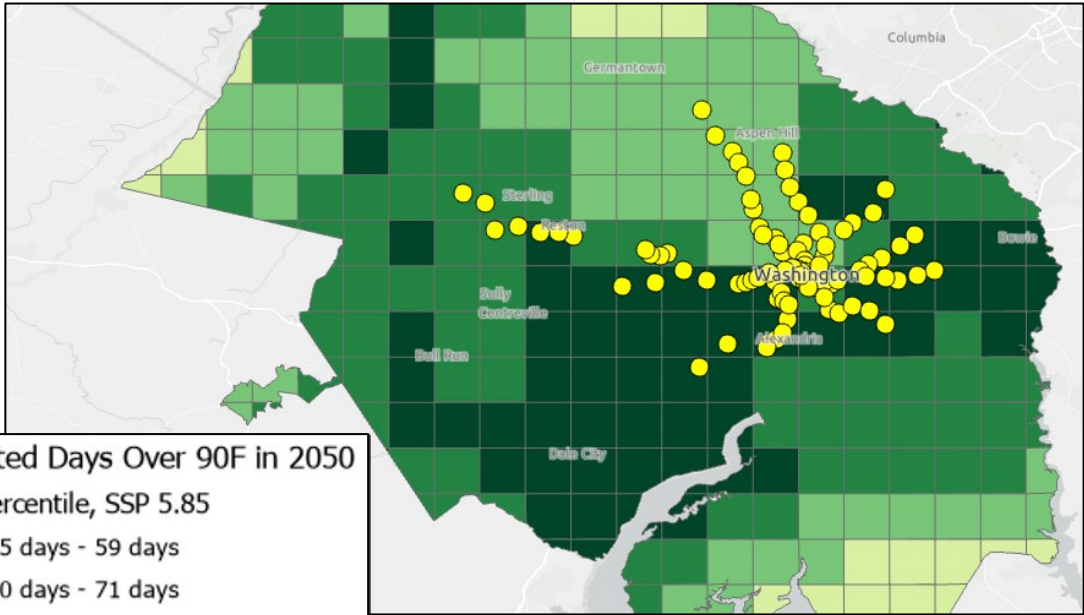
# ITEM A – Transit Infrastructure Resilience Analysis



Assess the past, projected, and downstream impacts of extreme heat on rail operations and ridership, to inform future resilience efforts.

- 1 Identify case studies
- 2 Determine impact to ridership
- 3 Determine fare revenue lost
- 4 Project future loss

- 2030 65 high heat days/year → \$2.8M annual fare revenue lost
- 2050 87 high heat days/year → \$4.6M annual fare revenue lost



# Question

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**Have you ever been traveling on bus or rail during an extreme heat delay? What was that like? What do you wish had been different?**

# ITEM B – Grant Application Support

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Grant matrix to help agencies identify and develop strong applications for funding opportunities.

**Deliverable:** Matrix of funding programs applicable for extreme heat projects, including:

- Critical deadlines, evaluation criteria, applicant requirements, project requirements
- Win themes for each funding source to support a strong application



# ITEM B – Grant Application Support

## 1. General Program Information

## 2. Applicable Natural Hazards

## 3. Eligibility

- Applicable State
- Agency Type
- Asset Type
- Cost Share
- Eligible Activities

## 4. Applicant Resources

- Evaluation Criteria
- Past Awards
- Win Themes

General Program Information						
Funding Type	Funding Agency	Program Overview	Max Award Amount	Submission Deadlines	Funding Cycle Frequency	Contact Information
Federal	Federal Emergency Management	HMGP provides post-disaster funding for mitigation projects that	The HMGP program does not have a maximum award amount.	Dependent upon disaster declarations and varies by state.	Dependent on disaster declarations by FEMA. Typically annually.	Vermecia Alsop, DC Hazard Mitigation Officer: vermecia.alsop@dc.gov
Federal	Federal Railroad Administration	The FSP Grant Program supports planning and capital projects that	Not specified.	The 2024-2025 opportunity for projects outside of the Northeast Corridor is due on	2023 was first and last program year.	Sergio Coronado: Sergio.Coronado@dot.gov Remi Work:

Applicable Natural Hazards				
Extreme Heat	Temporary Flooding	Permanent Flooding	Extreme Winter	Extreme Wind
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Applicant Resources		
Evaluation Criteria	Past Awards	Win Theme
an evaluation criteria are for the State/Territory Grantee unit for alignment with state	Not publicly available	Applications should address climate hazard vulnerability regional hazard mitigation
n review and selection of projects of an eligibility review, review, steering committee	For FY 2022 - 2023, 25 projects in the northeast corridor were awarded over \$16.4 billion, and 10 projects outside of	Applications should include railroad data and quality accessibility improvement
re evaluated on seven	All past award recipients are posted on	Applications should ad

Eligibility												
Agency Type				Asset Type								
MPO	Transit Authority	City or County	Agency Department	Roads	Bridges	Culverts	Rail	Bus	Transit Station	Green Infrastructure	Asset Details	Cost
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Eligible states, territories,	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	There are no specified restrictions	Yes
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Eligible agencies include states	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Funding may only be used for	Yes
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	CSCI grants require a team of three	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	There are no specified restrictions	No

# ITEM C – Best Practice Design Guidance

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Best practices and design guidelines for cooling solutions, with region-specific examples.

**Deliverable:** A best practices and draft design guidelines framework that includes:

- Examination of **3 typologies** with **4 cooling interventions** for each
- Three-dimensional simple block diagrams of each typology
- **Region-specific design and implementation considerations** and backing references for each cooling element

**Goals:**

- Identify **strategies to reduce heat exposure and impact** on people navigating the public realm
- Focus on **first-last mile connections to transit and active transportation**



# ITEM C – Best Practice Design Guidance

## Regional Typologies:

### Streetscapes



### Bus Station Areas



### Trailhead Plazas



# ITEM C – Best Practice Design Guidance

## Heat Mitigation Elements:

Trees



Paving



Groundcover and Bioretention Areas



Shade Structures



Water Features



## Heat Management Elements:

Seating



Drinking Fountains and Refreshments





# ITEM C – Best Practice Design Guidance

## Elements in Context

Table 1 presents key guidance and considerations for the heat mitigation and management elements that are most important to consider in streetscapes: trees, paving, groundcover and bioretention areas, and seating. Click the corresponding icons to jump to the full section for each element.

Table 1: Streetscape Elements in Context

	<p><b>Trees</b> Regularly spaced trees are the most effective cooling strategy for streetscapes. Spacing tree specimens to minimize canopy overlap will maximize shading potential.</p> <p><b>Key Guidance</b></p> <ul style="list-style-type: none"> <li>• <b>Spacing:</b> Plant trees 20 to 30 feet apart from each other, <u>on center</u>, minimizing overlap and gaps between canopies, to maximize their cooling potential.</li> <li>• <b>Dense Canopies:</b> Select species with high leaf-area index scores to maximize shading and evaporative cooling potential.</li> <li>• <b>Resilient Species:</b> Select trees expected to thrive in current and future climate conditions and plant a variety of species within a district to promote species diversity.</li> </ul>
	<p><b>Paving</b> Paving can be a secondary cooling strategy, best implemented with other elements including trees and groundcover. Intentional paving design can also directly support the success of trees.</p> <p><b>Key Guidance</b></p> <ul style="list-style-type: none"> <li>• <b>Application:</b> Paving must be functional, durable, and accessible to work in a streetscape setting. Portland cement and light-colored pavers are suitable for pedestrian <u>through-zones</u>. Permeable pavers have gaps between units to enable infiltration and are best left for set-out areas and locations with lower travel.</li> </ul>



## Heat Mitigation Elements

The impacts of extreme heat on people can be reduced through heat mitigation elements. These are passive design choices that reduce the air and surface temperatures of a place. Each heat mitigation element is introduced and given context before specific design and implementation guidance is provided to help achieve the desired cooling effect and ensure long-term success.

### Trees

Trees are highly effective at mitigating urban heat because they provide two forms of cooling. They reflect solar radiation and absorb less heat than harder surfaces, decreasing both LST and air temperature. They also release water from their leaves during the day, cooling the air through evapotranspiration. Planting trees in urban and suburban environments also has many co-benefits such as helping manage stormwater, providing habitat space, and dampening sound.



### Cooling and Design Considerations

#### TREE SPECIES

Trees with denser canopies tend to cool more effectively than other species because there is more surface area of leaves to shade and cool. This metric is measured through Leaf Area Index (LAI), calculated as the ratio of total leaf area of a tree divided by ground surface area defined by the tree's extents <sup>9</sup>.

The District of Columbia Department of Transportation (DDOT) has studied the impacts of long-term shifts in climate on the District's urban forests and developed guidance to manage the impacts. Part of this effort included vetting suitable tree species for future planting based on factors such as climate and pest vulnerability. Many of the trees recommended for increased and sustained rates of planting in the District in the future have high LAIs, meaning there is ample opportunity to select for both resilience and cooling. For example, many species of oak trees (of the *Quercus* genus) score highly on the District's resilience criteria and have dense canopies, and are already some of the most common street trees found the District <sup>9</sup>. Note that the species listed below do not comprise a definitive, comprehensive list of tree species suitable for planting in the region, and collaboration with arborists and landscape architects will help to determine the ideal species to plant in different locations.



Figure 8: Fruitless Sweetgum Tree  
Source: Hannele Lahti

#### HIGH LEAF DENSITY SPECIES

DC Tree Planting List: Recommended to Increase Planting Frequency

- Liquidambar rotundiloba (Fruitless sweetgum)
- Platanus occidentalis (American sycamore)

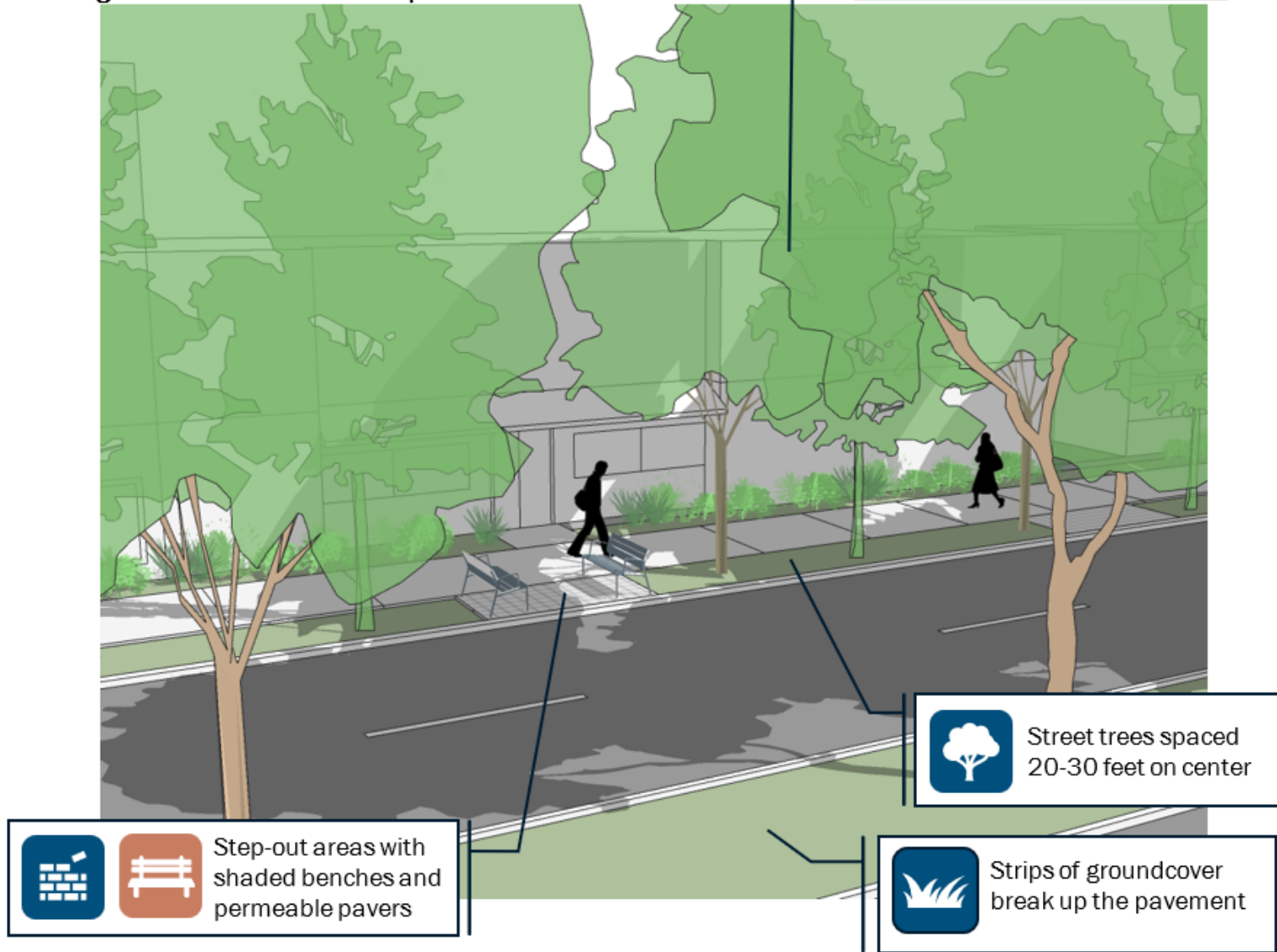


# ITEM C

## Streetscapes:

- Trees
- Paving
- Groundcover
- Seating




Figure 5: Model Cool Streetscape



# ITEM C

## Streetscapes: Recommendations for Different Regional Contexts

Table 2: Streetscape Recommendations for Different Regional Contexts

	Suburban Arterial Road	Mixed-Use Arterial Road	Constrained Urban Street
<b>Regional Example</b>	 <p>Richmond Highway, Fairfax County, VA</p>	 <p>Wisconsin Avenue, Bethesda, MD</p>	 <p>Campbell Avenue, Arlington, VA</p>
<b>Trees</b>	<ul style="list-style-type: none"> <li>Continuous landscape strips with shade trees planted on sides of streets and in medians</li> </ul>	<ul style="list-style-type: none"> <li>Street trees spaced at projected full canopy distance, in continuous strips, individual tree planting beds, and bioretention areas as context allows</li> </ul>	<ul style="list-style-type: none"> <li>Continuous landscape strips with shade trees on sides of streets with selective trees in medians where street cross-sections allow</li> </ul>
<b>Pavement</b>	<ul style="list-style-type: none"> <li>Continuous light-colored concrete sidewalks</li> </ul>	<ul style="list-style-type: none"> <li>Light-colored two-toned pavers</li> <li>Permeable paver step-out areas for street furniture and bus stops between tree planting beds</li> </ul>	<ul style="list-style-type: none"> <li>Continuous light-colored concrete sidewalks</li> <li>Permeable paver step-out areas for street furniture and bus stops between tree planting beds</li> </ul>
<b>Groundcover</b>	<ul style="list-style-type: none"> <li>Can be dictated by other project needs and goals</li> </ul>	<ul style="list-style-type: none"> <li>Native grasses and low shrubs in tree planting beds and <u>along</u> building footprints</li> </ul>	<ul style="list-style-type: none"> <li>Native grasses and low shrubs in tree planting beds and <u>along</u> building footprints</li> </ul>
<b>Seating</b>	<ul style="list-style-type: none"> <li>Located regularly along streets, co-located with other heat mitigation and management elements</li> </ul>	<ul style="list-style-type: none"> <li>Located regularly along streets, co-located with other heat mitigation and management elements</li> </ul>	<ul style="list-style-type: none"> <li>Located regularly along streets, co-located with other heat mitigation and management elements</li> </ul>

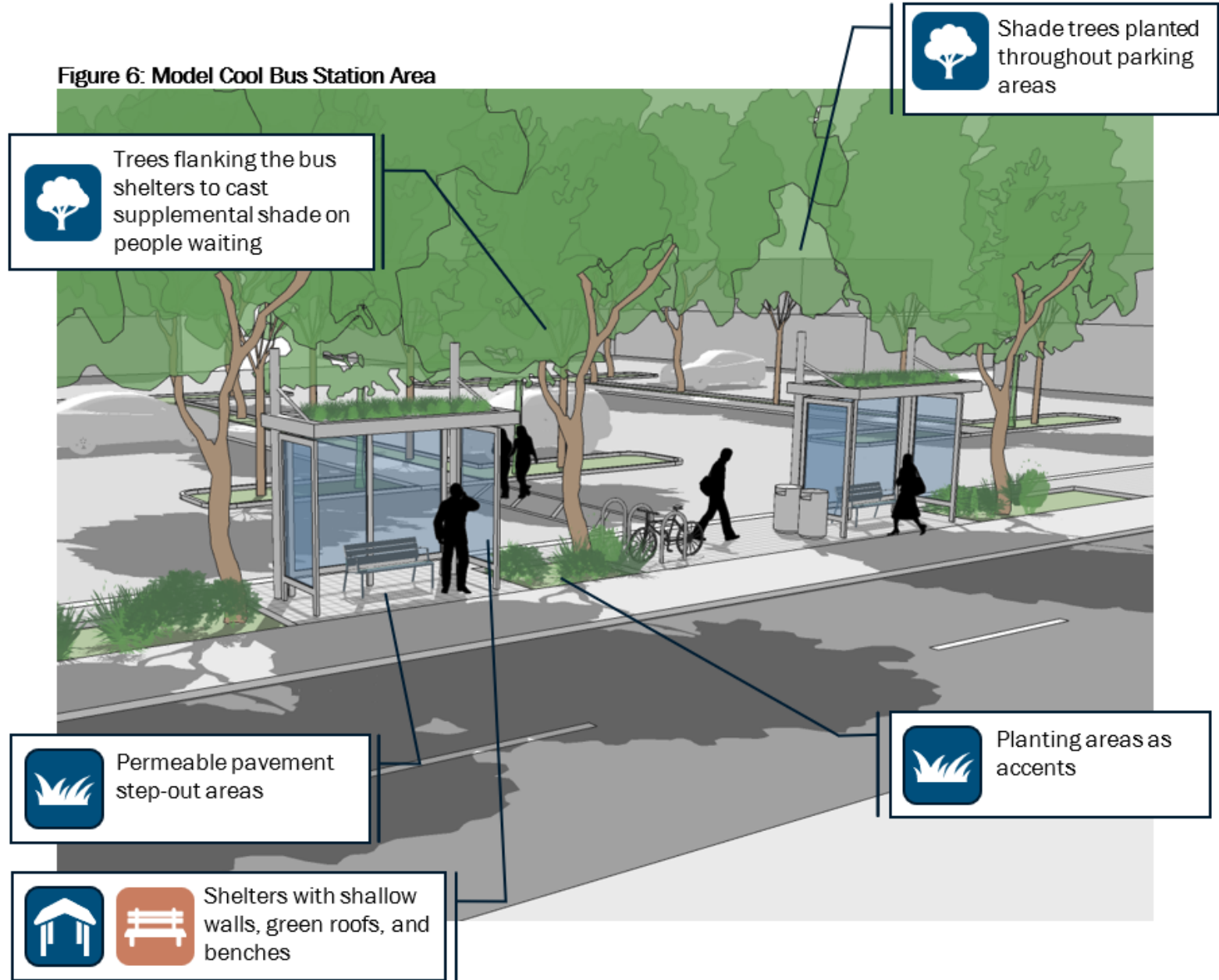


# ITEM C

## Bus Station Areas:

- Trees
- Groundcover
- Shade Structures
- Seating

Figure 6: Model Cool Bus Station Area




# ITEM C


Figure 7: Model Cool Trailhead Plaza

## Trailhead Plaza:


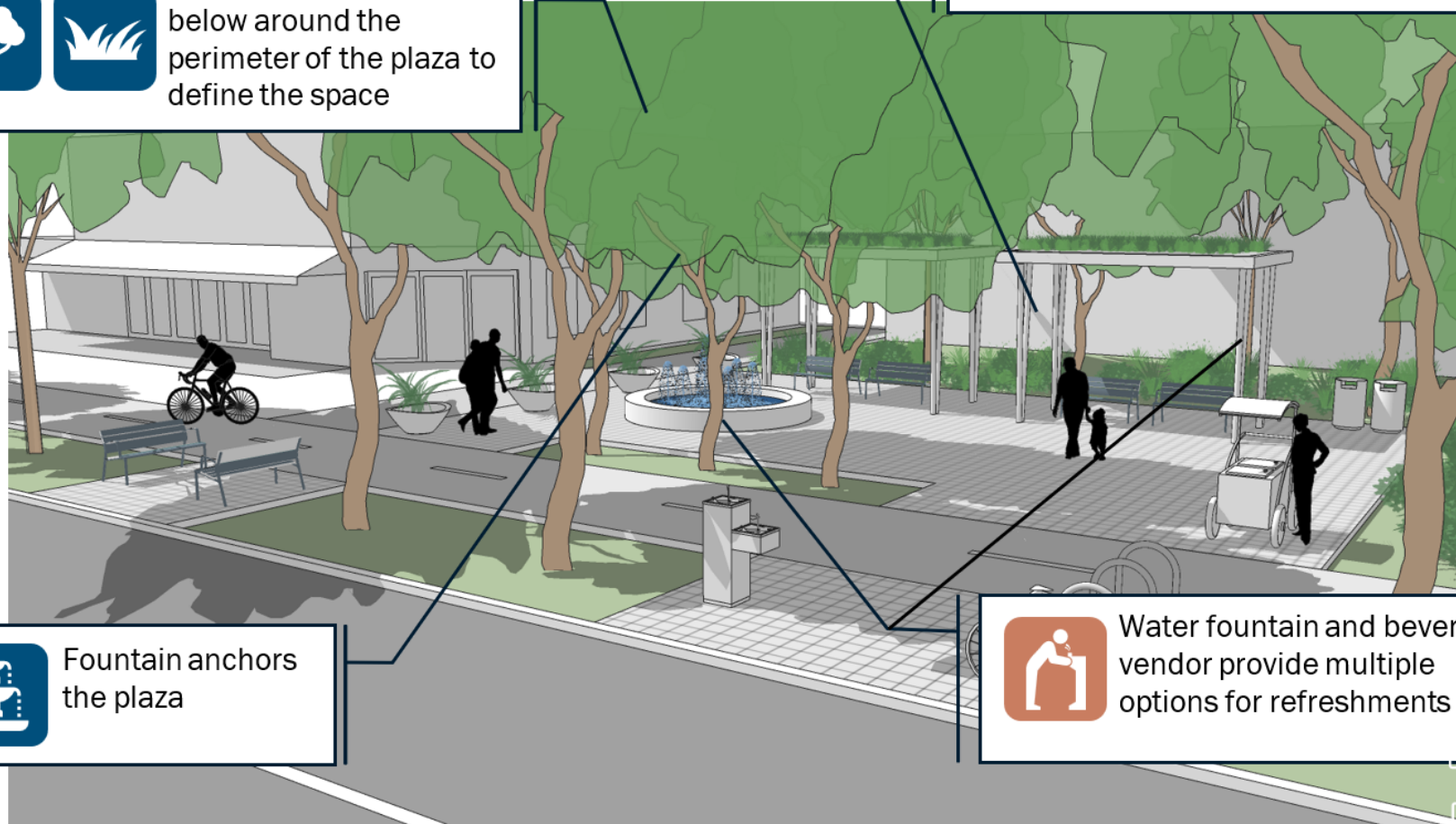
- Trees
- Shade Structures
- Water Features
- Drinking Fountains and Refreshments




Trees with groundcover below around the perimeter of the plaza to define the space



Shade structures with green roofs, placed with supplemental shade from trees and buildings



Fountain anchors the plaza



Water fountain and beverage vendor provide multiple options for refreshments

# Question

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**Do any of these regional typologies exist in your community? Can you think of any good examples of heat mitigation measures for transit or active pedestrian users in your community, or any areas that could use a project to make it easier to travel through during extreme heat events?**

# ITEM D – Policy, Planning, and Design Considerations

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Policy, planning, and design guidance considerations to promote the use of cooling strategies.

**Deliverable:** Five use cases for extreme heat policy, planning, and guidance updates, including examples from other jurisdictions:

- Integrating extreme heat preparedness language into **goals and vision statements**
- Developing language for **land use and zoning policies** that encourage preserving or expanding the tree canopy
- Updating **design standards and manuals** to help mainstream the use of cooling strategies
- Updating **worker safety policies and protocols** to include extreme heat safety measures.
- Developing **contracting and procurement language** to encourage use of cooling strategies in project design and implementation



# How a Planner Might Use this Toolkit of Resources



**ITEM A** – Transit Infrastructure Resilience Analysis



**ITEM B** – Grant Application Support



**ITEM C** – Best Practice Design Guidance



**ITEM D** – Policy, Planning, And Guidance Use Cases

*Use the results to determine that it is worth constructing shade structures at unsheltered transit stops, given the increasing heat-related burden on riders at those stops.*



# How a Planner Might Use this Toolkit of Resources



**ITEM A** – Transit Infrastructure Resilience Analysis



**ITEM B** – Grant Application Support



*Use the database to determine what funding opportunities might be available to support the type of project you have in mind.*



**ITEM C** – Best Practice Design Guidance



**ITEM D** – Policy, Planning, And Guidance Use Cases



# How a Planner Might Use this Toolkit of Resources



**ITEM A** – Transit Infrastructure Resilience Analysis



**ITEM B** – Grant Application Support



**ITEM C** – Best Practice Design Guidance

*Refer to the design guidelines to scope out and design your project.*



**ITEM D** – Policy, Planning, And Guidance Use Cases



# How a Planner Might Use this Toolkit of Resources



**ITEM A** – Transit Infrastructure Resilience Analysis



**ITEM B** – Grant Application Support



**ITEM C** – Best Practice Design Guidance



**ITEM D** – Policy, Planning, And Guidance Use Cases



*Refer to this guidance for use cases and sample language to support your efforts to mainstream your heat resilience projects and priorities.*



# How Might YOU Use this Toolkit of Resources?



**ITEM A** – Transit Infrastructure Resilience Analysis



**ITEM B** – Grant Application Support



**ITEM C** – Best Practice Design Guidance



**ITEM D** – Policy, Planning, And Guidance Use Cases

*How could you all use this toolkit in your communities?*

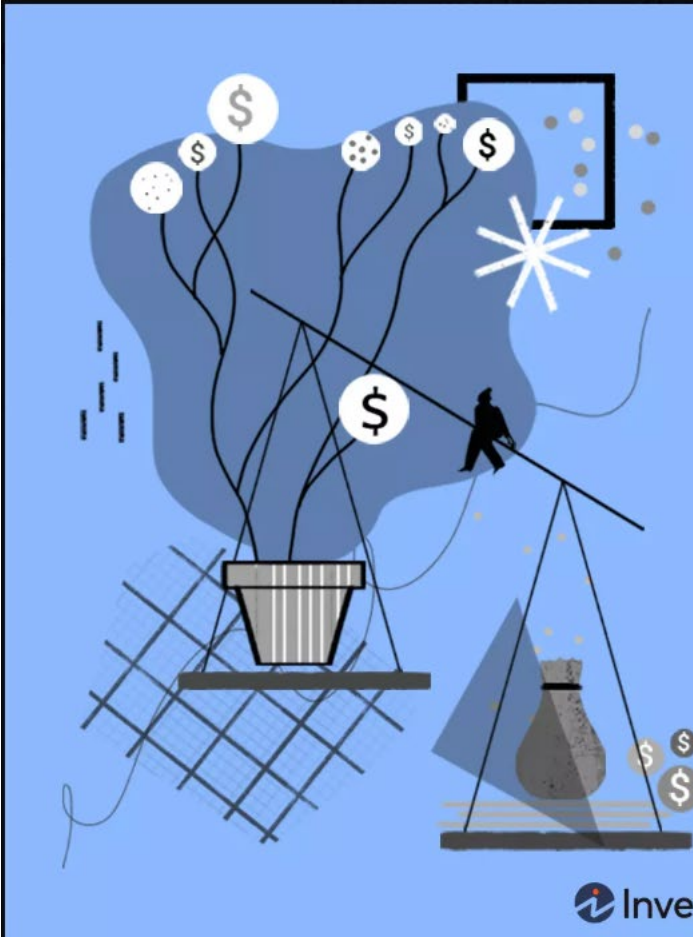


# Economic Impact Analysis Project

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# What is a Benefit-Cost Analysis (BCA)?



The illustration depicts a person walking a tightrope, symbolizing the delicate balance between costs and benefits. On the left side of the scale, a large pot is filled with dollar signs, representing costs. On the right side, a smaller bag is filled with dollar signs, representing benefits. The person is positioned in the center, maintaining equilibrium. The background features a grid pattern and various symbols like dollar signs and a starburst, suggesting a complex financial analysis.

## Cost-Benefit Analysis

*[kós(t)-'be-nə-,fit ə-'nɑ-lə-səs]*

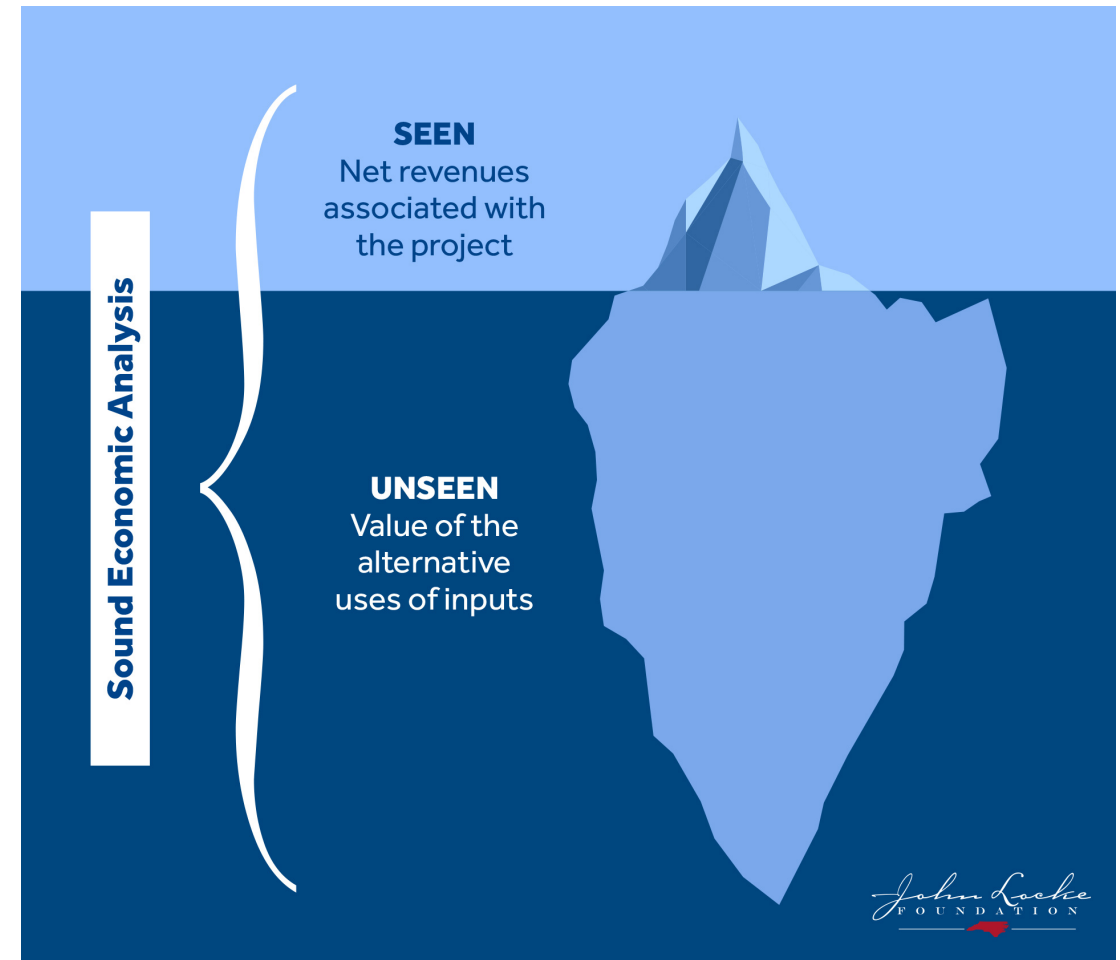
A systematic process of evaluating the desirability of a decision by weighing its potential benefits and costs.

Investopedia



# Why are BCAs important?

- Improves investment decisions and helps with project prioritization
- Strengthens funding competitiveness
- Makes “avoided losses” visible
- Supports transparent and accountable planning – both short-term and long-term
- Often required for funding applications



# Question

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**Does anyone here have experience with benefit cost analyses in their work or daily life?**

# Why are resilience investments important?

- Increasing frequency and severity of flooding, heat, storms, and other hazards
- Growing exposure of transportation assets and system users
- Competing funding priorities within TIPs, LRTPs, CIPs: prioritization assistance
- Bond ratings
- High risk/vulnerability does not always mean high reward



**Amount spent on preparedness reduces the economic impact on the local community.** Every \$1 spent on preparing for disasters is worth \$7 in saved economic costs for the community, including job losses, reduced incomes, and other economic impacts.



**Disaster preparedness is a good idea in large cities and small communities alike.** Investments in resilience and preparedness have large potential benefits in smaller communities whether it's a large \$1 billion disaster or a smaller one.



**The U.S. averages about 10 \$1 billion disasters each year.** From 1980 to the present, the U.S. has suffered 383 weather and climate disasters that caused more than \$1 billion in damage. Those disasters caused more than \$2.7 trillion of damage in total.<sup>3</sup>



**Investment in disaster preparedness pays off.** Every \$1 invested in resilience and preparedness saves \$13 in economic savings, damage, and cleanup costs after the event.



**Investments in resilience and preparedness have economic benefits even if a disaster never occurs.** As investments in disaster preparedness climb, communities see more jobs, the workforce grows, more people move to the area, and production and incomes increase.



# Regional Transportation Resilience Economic Analysis

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- Analysis to demonstrate the cost of inaction and provide support for the benefits of proactive resilience investment
- Five case studies quantifying the costs and benefits of resilience and adaptation
- Transportation assets (one each of: rail stops, bus stops, road segments, rail segments, bridges)
- Natural hazards (flooding and extreme heat)
- Develop a framework for risk-based economic impact analysis, and guidance for the evaluation of further assets and projects



# Case Studies



Bus Stop: Army Navy Drive & S. Joyce St stop in Arlington



Rail Stop: Greenbelt MARC Station



Bridge: Liverpool Point Road



Railway: Silver line between Loudon Gateway and Washington Dulles



Roadway: Anacostia Freeway



National Capital Region  
Transportation Planning Board



# Case Study: Bus Stop Army Navy Drive & S. Joyce St stop in Arlington

## Impacts of Extreme Heat on Bus Commuters

### Inputs:

- Ridership
- Heat-related emergencies
- Cost of heat-related health emergencies
- Heat days

### Solutions:

- No Action
- Low-Cost – bus shelter solution
- High-Cost – bus shelter plus vegetation solution



National Capital Region  
Transportation Planning Board

Transportation Resilience
Transit: Bus Stop

**Case Study**

**Overview:** The National Capital Region Transportation Planning Board (TPB) is conducting five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

**Study Site:** The focus of this case study is the Army Navy Drive & South Joyce Street westbound/southbound bus stop in Arlington, VA. This Metrobus and Arlington Transit bus stop serves roughly 70 riders per day and lacks existing shelter or vegetation.

**Context:** Studies, such as those by the Center for American Progress,<sup>1</sup> show that exposure to extreme heat results in increased emergency department (ED) visits and hospitalizations, and that the number of days with extreme heat is expected to increase. Research published by Arizona's Sun Tran bus service<sup>2</sup> and Lanza et al. (2025)<sup>3</sup> shows that shelters and surrounding vegetation can lower ambient and ground temperatures and help mitigate health impacts at bus stops. This case study examines a low-cost solution of erecting a bus shelter and a high-cost solution of supplementing the shelter with additional trees and foliage to lower temperatures around the stop. In addition, the new bus shelter would provide space for advertising, thereby producing advertising revenue.

**Results:** BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)<sup>4</sup> benefit-cost ratios of 3.0 and 2.7, respectively. These results imply that for every \$1 invested in solutions, there is a return of nearly \$3 in health and advertising revenue benefits. Net benefits are estimated at around \$100,000 over 20 years.

**Key Takeaways**

- Shelters and foliage solutions at bus stops can significantly lower ambient temperatures, resulting in decreased health costs.
- Over 20 years, no investment could result in nearly \$7,000 in health impacts at a single location.
- Results suggest a 3:1 ROI for proactive investment.
- Similar action could be taken at a regional level to address health concerns in the National Capital Region.



Bus stop with shelter (killane/Shutterstock)



Aerial view, Army Navy Drive/South Joyce Street (Google Maps)

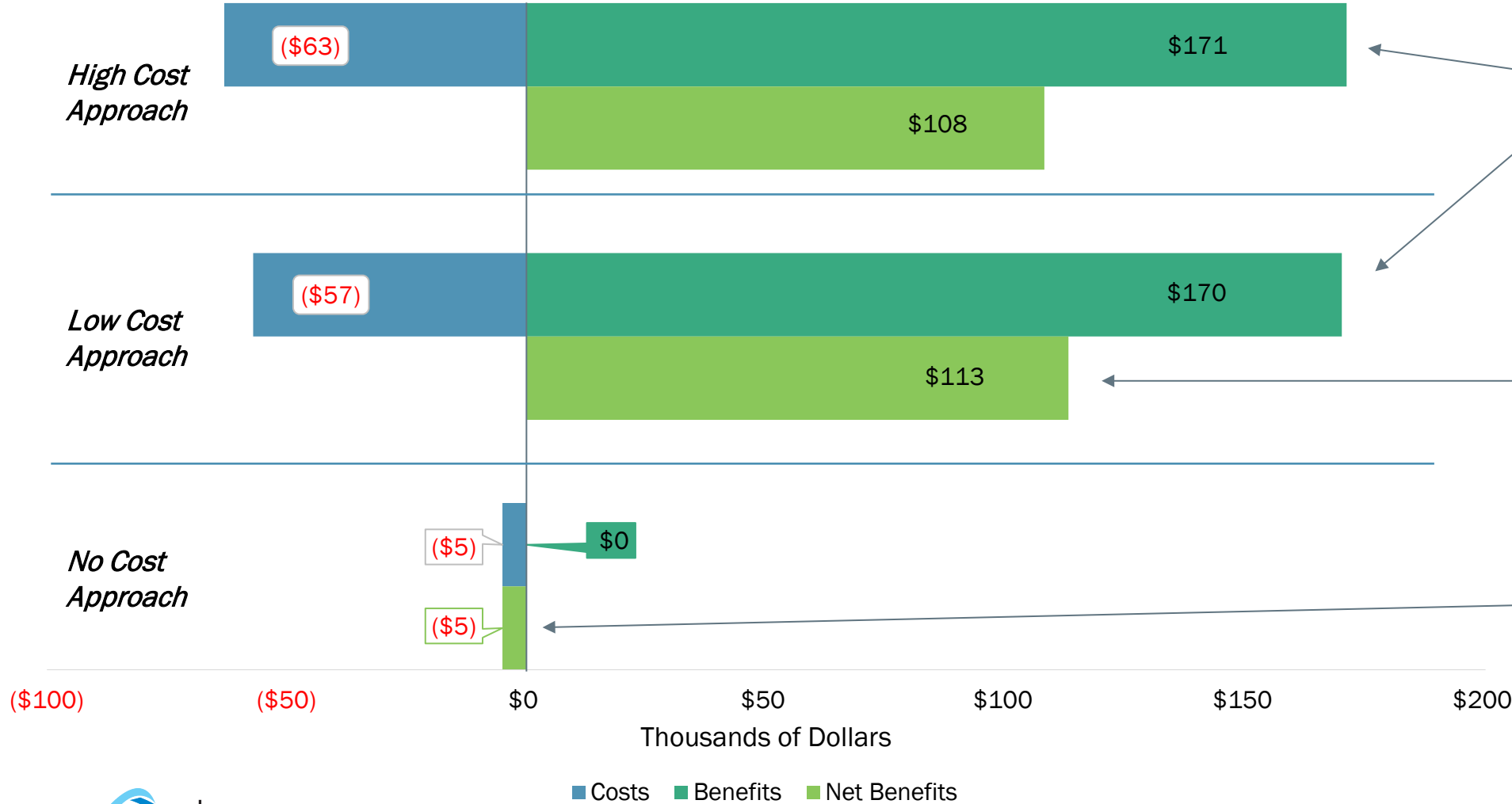


National Capital Region  
Transportation Planning Board





## Cost Comparison, Bus Stop Investment Approaches (Discounted 3.1%)



The **Low Cost approach** yields similar benefits to the High Cost approach at a lower cost.

The **Low Cost approach** also has the highest net benefits.

Lack of investment could cost \$5,000 over 20 years.





# Case Study: Rail Stop Greenbelt MARC Station in Maryland

## Impacts of Heat and Flooding on MARC Commuters

### Inputs:

- Ridership
- Heat days
- Heat-related emergencies
- Risk of heat-related track failure
- Nuisance flooding

### Solutions:

- No Action
- Low-Cost – Temporary signage, pumps for nuisance flooding
- High-Cost – Shelter for heat, track hardening eliminates track flooding entirely



National Capital Region  
Transportation Planning Board

**Case Study**

**Overview:** The National Capital Region Transportation Planning Board (TPB) is conducting five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

**Study Site:** The focus of this case study is Greenbelt station in Greenbelt, MD. This station is served by both Maryland Area Rail Commuter (MARC) and Washington Metropolitan Area Transit Authority (WMATA) and serves roughly 2,100 passengers per day during the summer (2,060 WMATA<sup>1</sup> and 30 MARC<sup>2</sup>). The site also contains a WMATA railyard which has capacity for 284 railcars<sup>3</sup> and is a potential location for the future FBI headquarters.<sup>4</sup>

**Context:** The MARC station at Greenbelt is exposed to the elements, and studies show that exposure to extreme heat results in increased healthcare costs, and that heat impact days are expected to increase across the region.<sup>5</sup> Research suggests that shelters can help mitigate health impacts.<sup>6</sup> Historically, the station and railyard are also at risk of flooding.<sup>7</sup> This case study examines a low-cost solution to address heat and minor flooding impacts, and a high-cost solution for mitigating future flood impacts.

**Results:** BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)<sup>8</sup> benefit-cost ratios of 1.07 and 0.85, respectively. These results imply that for every \$1 invested, the low-cost solution will return about \$1.07 in health and flooding response benefits. The high-cost solution would result in about \$0.85 in benefits per dollar invested. Net benefits are estimated at around \$100,000 over 20 years.

**Methods:** This analysis uses data on regional heat event days to identify summer health impacts at the Greenbelt station. Assuming health care costs of about \$750 for ED visits, hospitalization costs of about \$15,000,<sup>9</sup> and roughly 30 commuters per day,<sup>10</sup> the no action heat-related health impacts are

**Key Takeaways**

- Heat and flood impacts pose a risk to commuters that can be abated by proactive investments.
- Over 20 years, no investment could result in nearly \$3,000 in heat-related health impacts and \$830,000 in flood related impacts at Greenbelt station.
- Results suggest a 1.07:1 ROI for proactive investment in the low-cost solution.
- Similar action could be taken at a regional level to address health and infrastructure concerns in the National Capital Region.

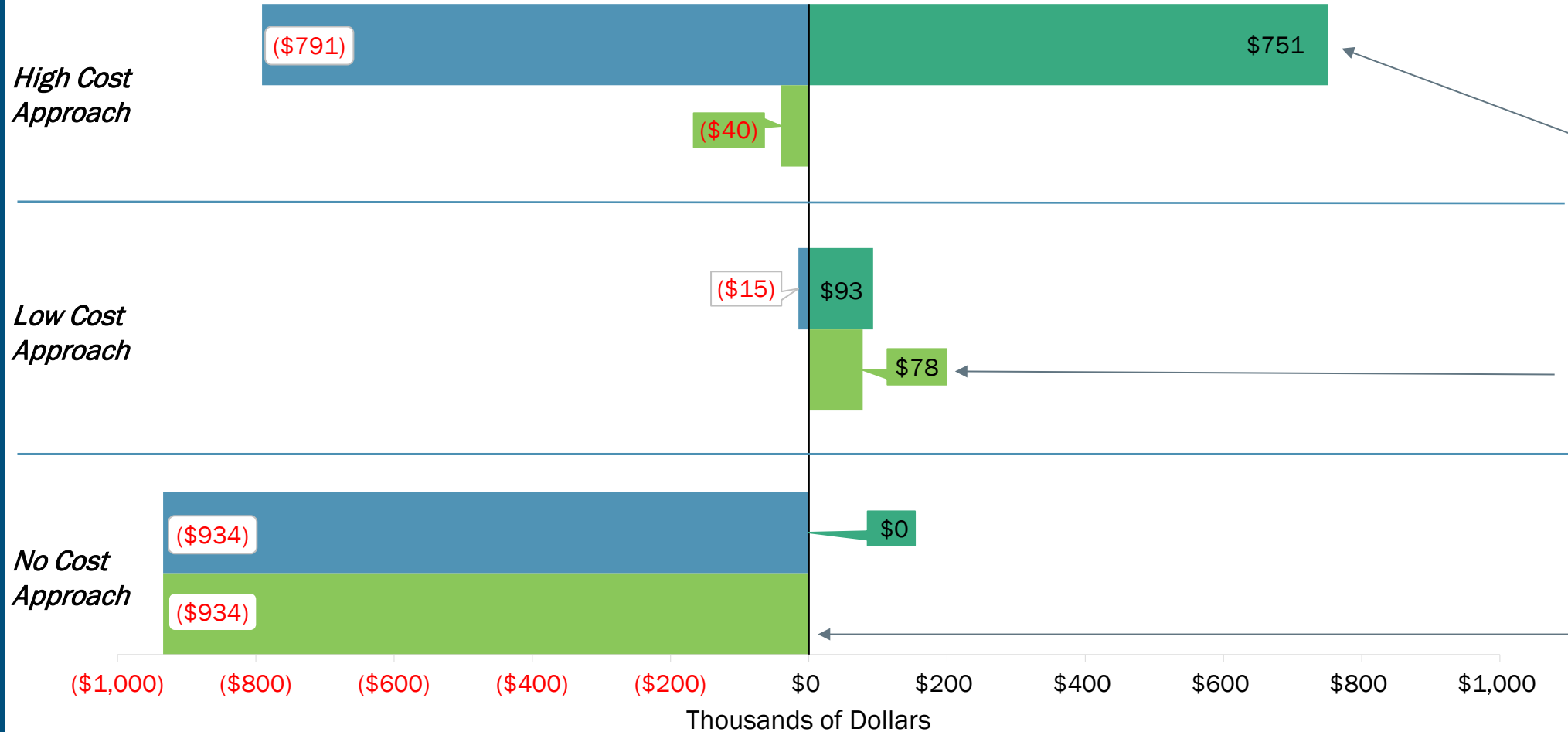
**Aerial View, Greenbelt Station**

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## Cost Comparison, Rail Stop Investment Approaches (Discounted 3.1%)



The **High Cost approach** yields the highest benefits, but costs more than it would save.

The **Low Cost approach** offers the highest net benefits.

Noninvestment could cost over \$900,000 over 20 years.





# Case Study: Bridge Liverpool Point Road in Charles County, MD

## Impacts of Flooding on Road Users

### Inputs:

- Average Annual Daily Traffic
- Frequency and length of flooding-related bridge closures

### Solutions:

- No Action
- Low-Cost – Embankment hardening
- High-Cost – Full bridge replacement

**Case Study**

**Overview:** The National Capital Region Transportation Planning Board (TPB) is conducting five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

**Study Site:** The focus of this case study is the Liverpool Point Bridge in Charles County, MD. This bridge conveys two lanes of vehicle traffic across Beaverdam Creek and is estimated to experience average daily traffic of approximately 400 vehicles.<sup>1</sup>

**Context:** The Liverpool Point Road bridge at Beaverdam Creek is at grade with the roadway. According to flooding projections, the bridge is expected to be overtaken by flood waters in both 1-in-100-year and 1-in-500-year flooding events. Vehicles with a destination on Liverpool Point Road, or that would normally use Liverpool Point Road to travel between the major routes it connects (Riverside Road/State Route 224 and Port Tobacco Road/State Route 6), will need to take a detour to avoid the flooded Liverpool Point Road bridge. This analysis assumes that drivers will instead use Sandy Point Road, driving an additional four miles and four minutes.

**Results:** BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)<sup>2</sup> benefit-cost ratios of 0.12 and 0.03, respectively. These results imply that for every \$1 invested, the low-cost solution will return about \$0.12 in flooding prevention benefits. The high-cost solution would result in about \$0.03 in flooding benefits per dollar invested.

**Methods:** For no action flooding impacts, the analysis assumes that nuisance flooding—during which the bridge is impassable to vehicles, but is not damaged—occurs 1 time per year. Nuisance flooding is expected to make the bridge impassable for one-half of a day (12 hours). For each of these events, Charles County staff are assumed to spend 1 hour setting up road side signage to warn drivers of the flooded bridge and point them to detours. The analysis assumes that the county is already in possession of these signs and reuses them. Signage setup thus only occurs a labor cost, which is estimated to be a loaded hourly wage of \$41.44<sup>3</sup> once per year. In addition, drivers forced to take an

**Key Takeaways**

- Flood impacts pose a risk to road users that can be abated by proactive investments.
- Based on this analysis, investment in the Liverpool Point Road bridge for flood prevention does not prove to be cost-effective due to high capital costs and low daily traffic.
- Similar action could be taken at a regional level for other bridges with likely lower capital costs and/or greater average daily traffic to address infrastructure concerns in the National Capital Region.

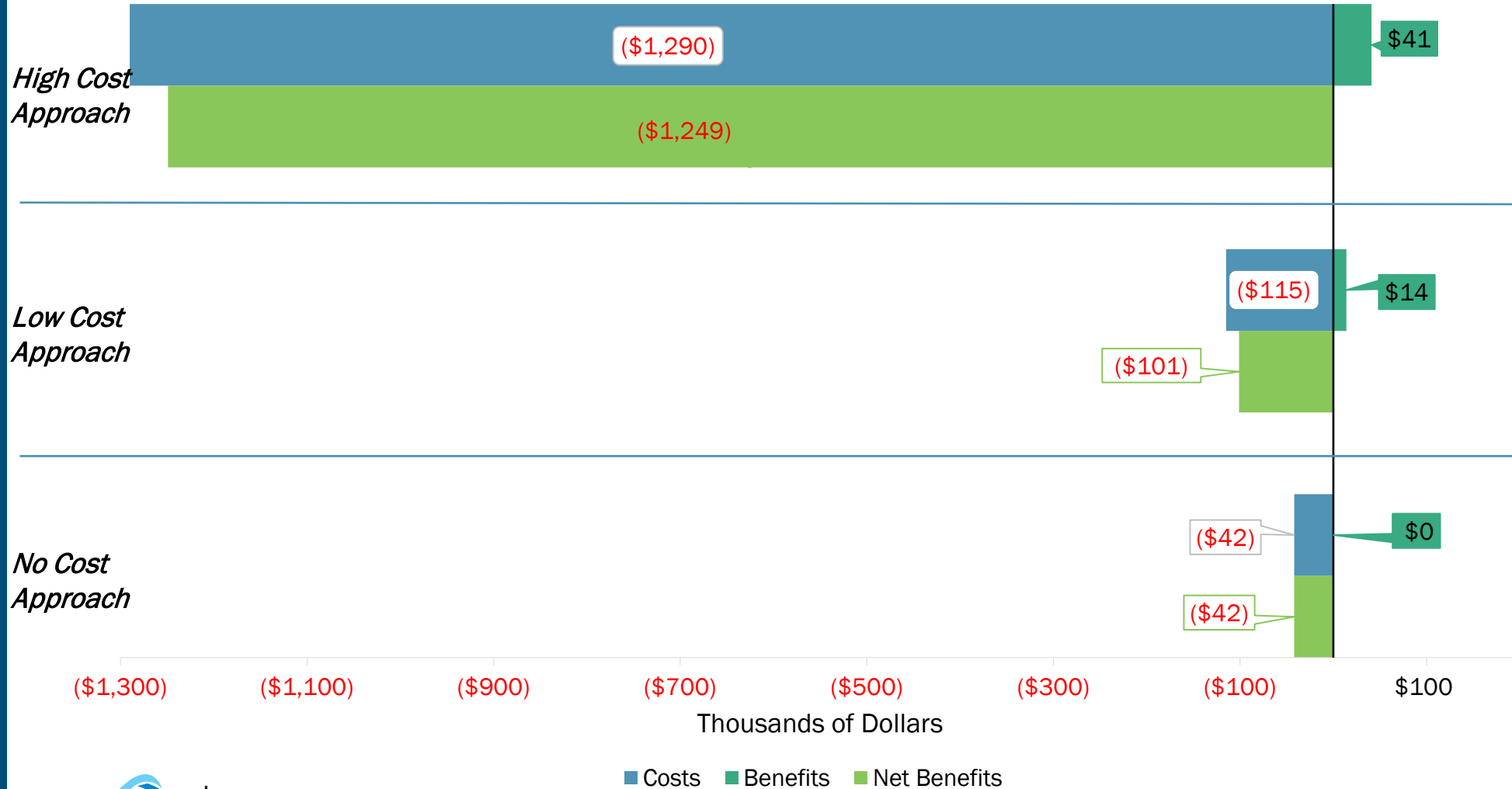
Aerial view, Liverpool Point Road (Google Maps)

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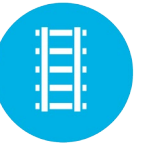


## Cost Comparison, Bridge Investment Approaches (Discounted 3.1%)



A unique result among our case studies, none of the proposed investments for the Liverpool Point Road bridge were estimated to be cost-beneficial.





# Case Study: Rail Segment Silver Line in Dulles

## Impacts of Extreme Heat on Rail Commuters

### Inputs:

- Ridership
- Heat days
- Value of travel time

### Solutions:

- No Action
- Low-Cost – existing rails are painted white
- High-Cost – installation of heat-resistant rails

Transportation Resilience
Infrastructure: Railway

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**Case Study**

**Overview:** The National Capital Region Transportation Planning Board (TPB) is conducting five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

**Study Site:** The focus of this case study is the Washington Metropolitan Area Transit Authority (WMATA) Metrorail section between Loudoun Gateway and Washington Dulles International Airport. This section of the Silver Line sees roughly 5,000 passengers per day through Dulles Station.<sup>1</sup>

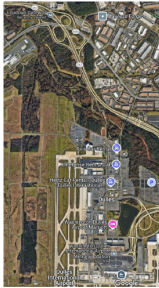
**Context:** The outdoor sections of the WMATA metro are at significant risk from extreme heat.<sup>2</sup> A sun kink occurs when the metal rails expand in high temperatures and prolonged direct sunlight. Sun kinks pose a safety hazard because they can lead to warping of the track and in extreme cases, train derailments. To avoid these impacts, there are strict speed limits imposed on trains traveling during extreme heat events to mitigate track stress and increase safety.<sup>3</sup> These enforced slowdowns generate delays and increase travel time which can severely impact commuters and passengers traveling to the airport.

**Results:** BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)\* benefit-cost ratios of 1.21 and 0.13, respectively. These results imply that for every \$1 invested, the low-cost solution will return about \$1.21 in heat damage prevention benefits. The high-cost solution would result in about \$0.13 in heat damage benefits per dollar invested.



**Methods:** The analysis assumes that heat events severe enough to require trains to operate at slower speeds represent about 20% of the 80 annual heat event days the area experiences on average. Based on several years of temperature data captured at the Dulles Airport Station, this number of heat event days is expected to increase by 3.61%.

**Key Takeaways**

- Extreme heat poses a risk of track warping, necessitating metro and rail car slowdowns that cause delays and increase travel time.
- Based on this analysis, investment in a low-cost rail painting solution could lead to benefits at a rate of \$1.21 per dollar invested.
- Similar action could be taken at a regional level for key or at-risk metro- or rail-lines, significantly reducing the impacts of extreme heat days on public transit riders in the National Capital Region.



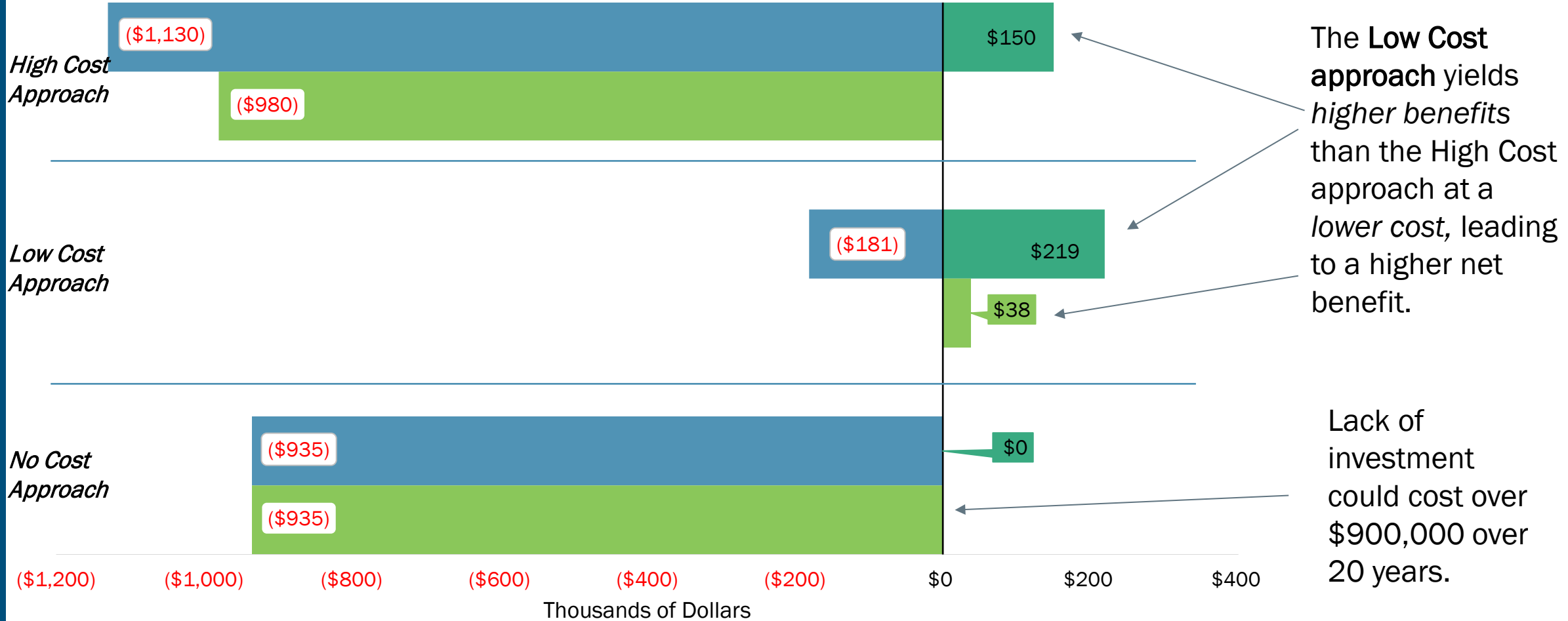
Metrorail Silver Line Near Dulles Airport Station (Google Maps)





## Cost Comparison, Rail Segment Investment Approaches (Discounted 3.1%)



The **Low Cost** approach yields *higher benefits* than the High Cost approach at a *lower cost*, leading to a higher net benefit.

Lack of investment could cost over \$900,000 over 20 years.





# Case Study: Road Segment Anacostia Freeway in Washington

## Impacts of Flooding on Road Users

### Inputs:

- Average Annual Daily Traffic
- Frequency and duration of roadway flooding
- Value of travel time
- Cost of road closure

### Solutions:

- No Action
- Low-Cost – semi-permanent deployable flood barrier
- High-Cost – permanent raising of road

**Transportation Resilience** **Road Segment**

**Case Study**

**Overview:** The National Capital Region Transportation Planning Board (TPB) is conducting five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

**Study Site:** The focus of this case study is the portion of the Anacostia Freeway in Washington, DC, between 11th Street and Pennsylvania Avenue. This section coincides with interstate 295, an auxiliary highway connecting major roadways in Maryland and Washington, D.C. This key access point serves roughly 128,000 vehicles per day and has been identified as at high risk for flooding impacts.<sup>1, 2, 3, 4</sup>

**Context:** The South-bound and West-bound section of the Anacostia Freeway that ultimately crosses the bridge over the Anacostia River is at high risk of flooding, particularly in sections close to the Anacostia Recreation Center. Flooding in this section, particularly during morning rush hour traffic can snarl access into the city, which has cascading effects throughout the region. Flooding impacts on limited access freeways are particularly troublesome because there are few opportunities to exit the road and slowdowns can extend for miles.

**Results:** BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)<sup>5</sup> benefit-cost ratios of 8.40 and 1.49, respectively. These results imply that for every \$1 invested, the low-cost solution could return about \$8.40 in flooding benefits, and the high-cost solution could result in about \$1.49 in benefits per dollar invested. Net benefits for the low- and high-cost solutions are estimated at around roughly \$6 to \$11 million discounted at 3.1%.

**Methods:** This analysis examines flooding across three discrete scenarios: nuisance flooding, 100-year events, and 500-year events. The analysis assumes that nuisance flooding occurs 2 times per year, with 100- and 500-year events occurring at an annual return interval of 1% and 0.2%, respectively. For nuisance flooding, the analysis assumes that a 1-hour event partially closes the road.

**Key Takeaways**

- Flood impacts pose a significant risk to commuters, particularly on limited access roads where flooding cannot easily be avoided.
- Over 20 years, non-investment could result in nearly \$17.3 million in flood related impacts at the Anacostia Freeway location.
- Results suggest a 1.5:1 ROI for proactive investment in a high-cost flooding solution, and 8.1 ROI for the low-cost solution.
- Similar action could be taken at a regional level to address infrastructure concerns in the National Capital Region.

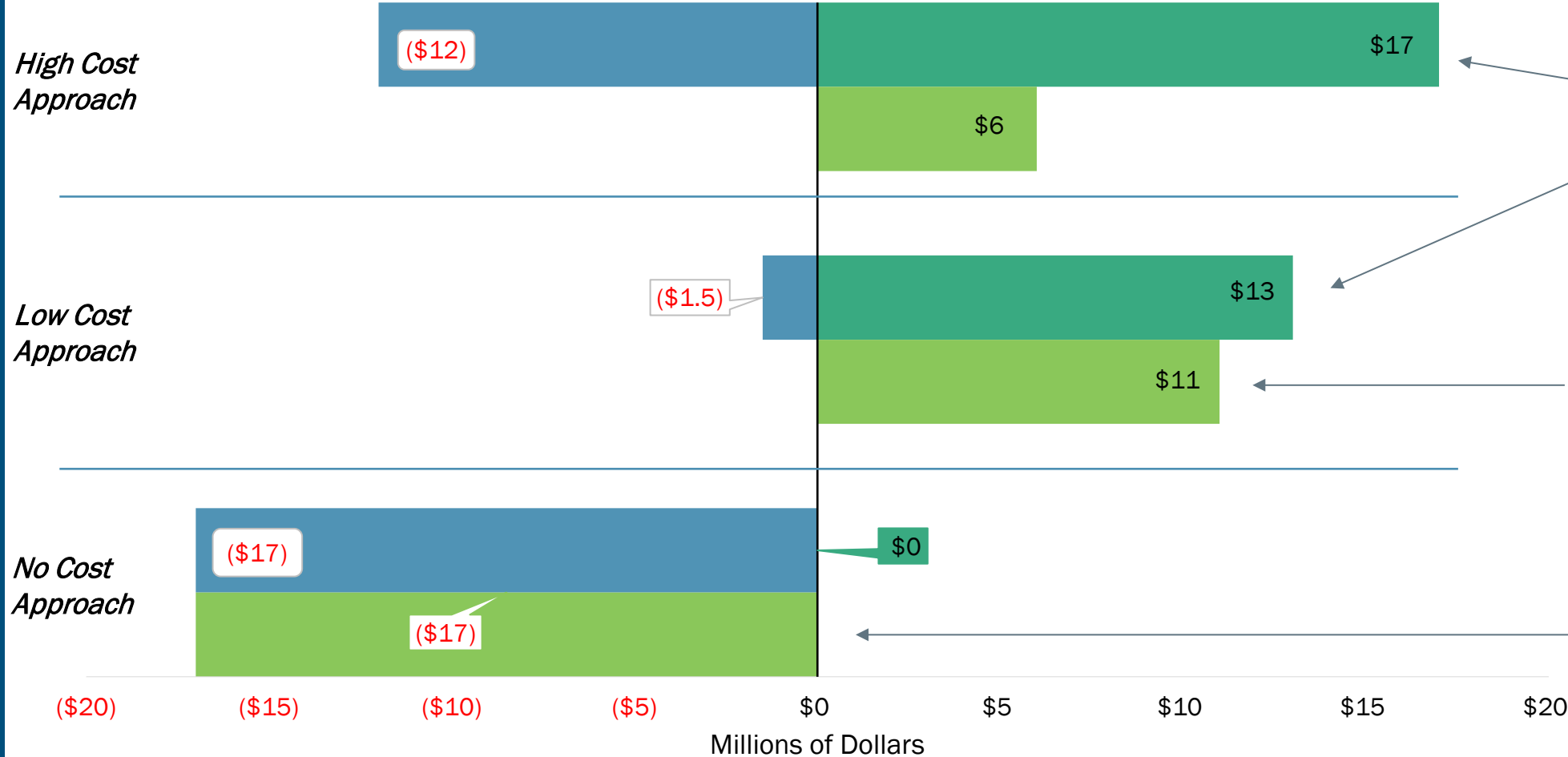
Aerial view, Anacostia Freeway (Google Maps)

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## Cost Comparison, Roadway Investment Approaches (Discounted 3.1%)



The **Low Cost approach** yields similar benefits to the High Cost approach at a lower cost.

The **Low Cost approach** also has the highest net benefits.

Lack of investment could cost \$17 million over 20 years.



# Poll

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**Do any of these results surprise you?**

**Which ones?**



# Case Studies Summary

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## Key Takeaways

- Taking no action for known climate risks is costly; as much as \$17.2 million over 20 years (discounted 3.1%) in health, repair, and lost time costs at just one of our study locations
- Lower-cost investments often produce similar or more benefits than higher-cost options
- Return on investment, dollar-for-dollar, for low-cost solutions ranges from 1.5:1 to 6:1, depending on the approach taken and the infrastructure type.
- For all infrastructure types studied, taking similar action across the National Capital Region could lead to significant health savings and avoided costs.



# Where do we go from here?

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- We now have five indicative case study BCAs regionally that can help make the case for resilience investment not only at those locations, but for similar projects in other locations or at-risk assets around the region
- Framework to help members walk through the process on their own, all five individual models should members like to analyze similar assets
- Helped showcase the importance of BCAs by highlighting the type of information they can provide, can aid with grant applications and board presentations
- Potential to analyze more assets or project examples
- Can help guide other economic analyses / model for other parts of TPB's work program (e.g. safety improvements using a similar approach)



# Thank You

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