REGIONAL EXTREME HEAT ANALYSIS

Draft Results and Toolkit Resources for Transportation Planning in the Face of Extreme Heat

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TPB Technical Committee
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National Capital Region
Transportation Planning Board

Agenda Item #6

Project Objectives

WHERE?

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

WHAT?

Understand potential impacts of extreme heat on transportation systems and users

HOW?

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

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

ITEM A – Transit Infrastructure Resilience Analysis

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

Deliverable: Memo on historic and projected heat impacts to rail and bus operations and ridership, including:

- **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

ITEM A – Transit Infrastructure Resilience Analysis

Assess the past, projected, and downstream impacts of extreme heat on rail and bus 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

metro

ITEM A – Transit Infrastructure Resilience Analysis

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

1. Identify case studies
2. Determine impact to ridership

metro

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 and bus 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**

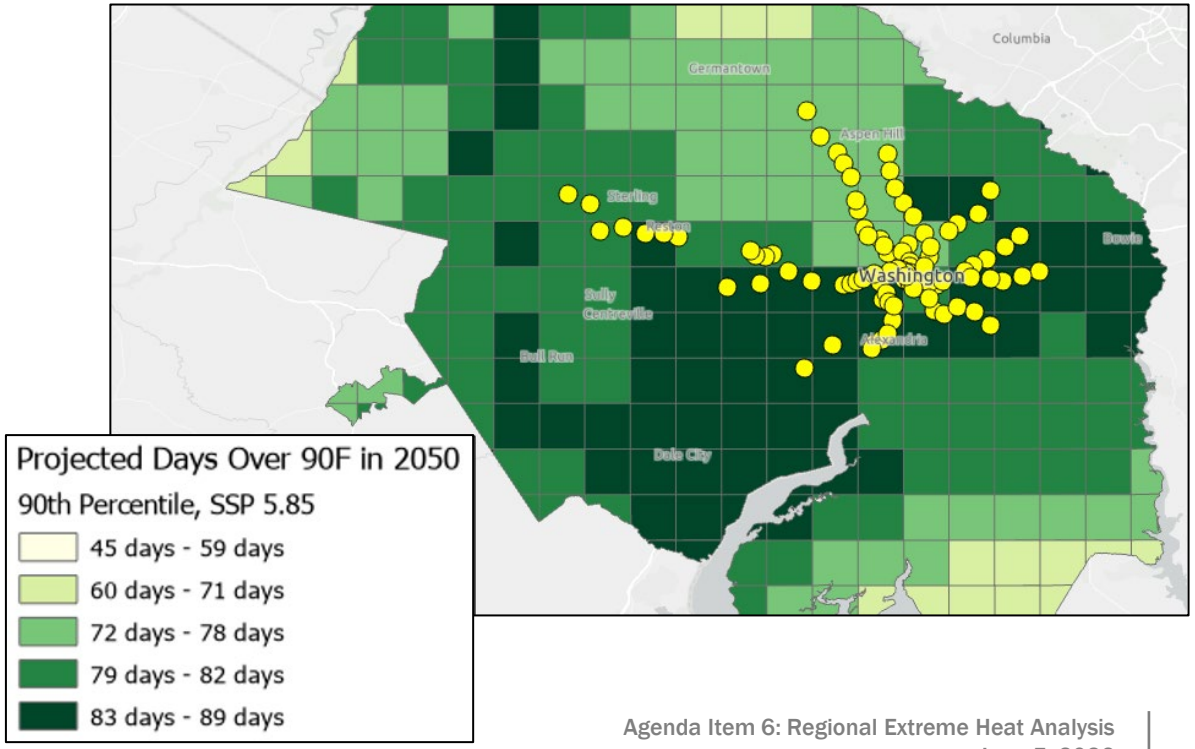
metro

ITEM A – Transit Infrastructure Resilience Analysis

Assess the past, projected, and downstream impacts of extreme heat on rail and bus 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**



ITEM B – Grant Application Support

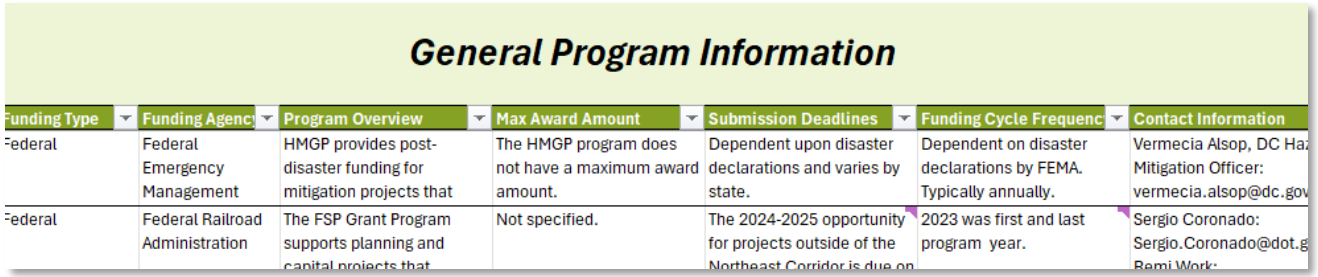
Grant matrix to help agencies identify and develop strong applications for funding opportunities.

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

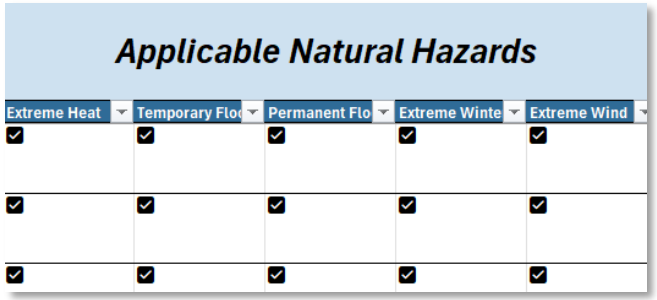
ITEM B – Grant Application Support

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 Haz 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.g Remi Work:

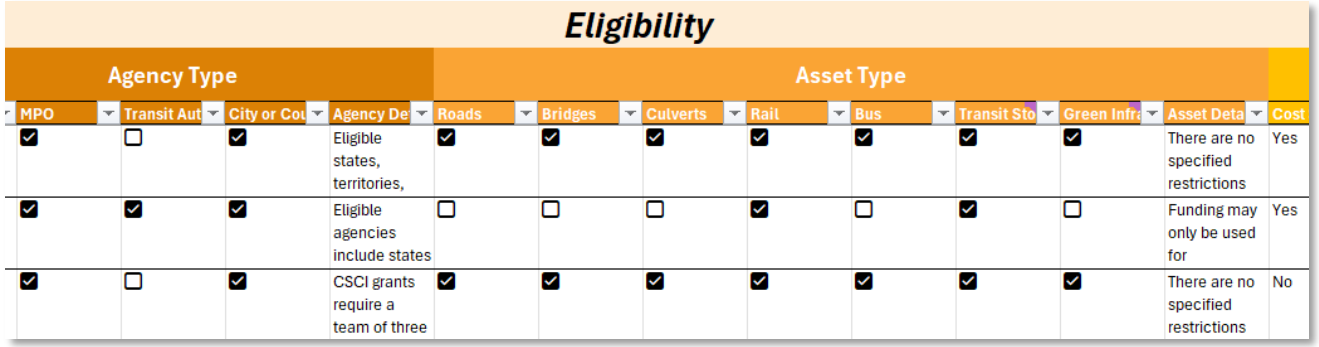


Applicable Natural Hazards

Extreme Heat	Temporary Flo	Permanent Flo	Extreme Winte	Extreme Wind
☑	☑	☑	☑	☑
☑	☑	☑	☑	☑
☑	☑	☑	☑	☑

Applicant Resources

iteria	Past Awards	Win Theme
n evaluation criteria are the State/Territory Grantee unt for alignment with state	Not publicly available	Applications should ad climate hazard vulnera regional hazard mitigat
n review and selection sts of an eligibility review, iew, 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 inc railroad data and quali accessibility improven
re evaluated on seven	All past award recipients are posted on	Applications should ad



Eligibility

Agency Type				Asset Type								
MPO	Transit Aut	City or Cou	Agency De	Roads	Bridges	Culverts	Rail	Bus	Transit Sto	Green Infra	Asset Deta	Cost
☑	☐	☑	Eligible states, territories,	☑	☑	☑	☑	☑	☑	☑	There are no specified restrictions	Yes
☑	☑	☑	Eligible agencies include states	☐	☐	☐	☑	☐	☑	☐	Funding may only be used for	Yes
☑	☐	☑	CSCI grants require a team of three	☑	☑	☑	☑	☑	☑	☑	There are no specified restrictions	No

ITEM C – Best Practice Design Guidance

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**

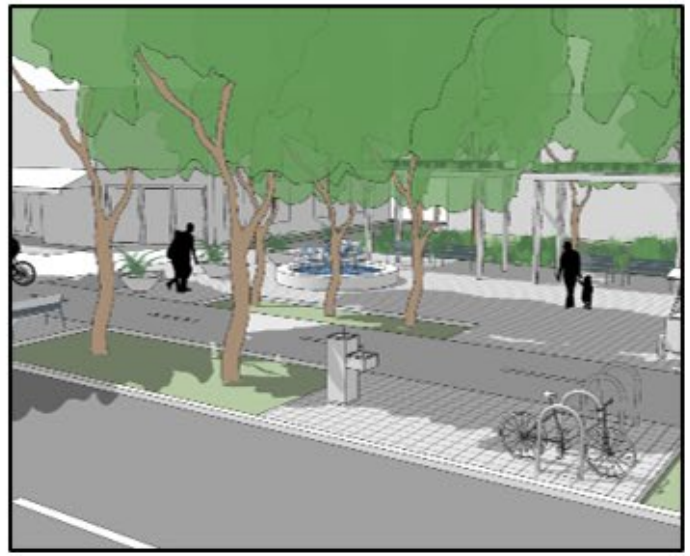
ITEM C – Best Practice Design Guidance

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

Trees

Regularly spaced trees are the most effective cooling strategy for streetscapes. Spacing tree specimens to minimize canopy overlap will maximize shading potential.

Key Guidance

- **Spacing:** Plant trees 20 to 30 feet apart from each other, on center, minimizing overlap and gaps between canopies, to maximize their cooling potential.
- **Dense Canopies:** Select species with high leaf-area index scores to maximize shading and evaporative cooling potential.
- **Resilient Species:** Select trees expected to thrive in current and future climate conditions and plant a variety of species within a district to promote species diversity.

Paving

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.

Key Guidance

- **Application:** Paving must be functional, durable, and accessible to work in a streetscape setting. Portland cement and light-colored pavers are suitable for pedestrian through-zones. Permeable pavers have gaps between units to enable infiltration and are best left for set-out areas and locations with lower travel.

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 [8].

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 [8]. 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

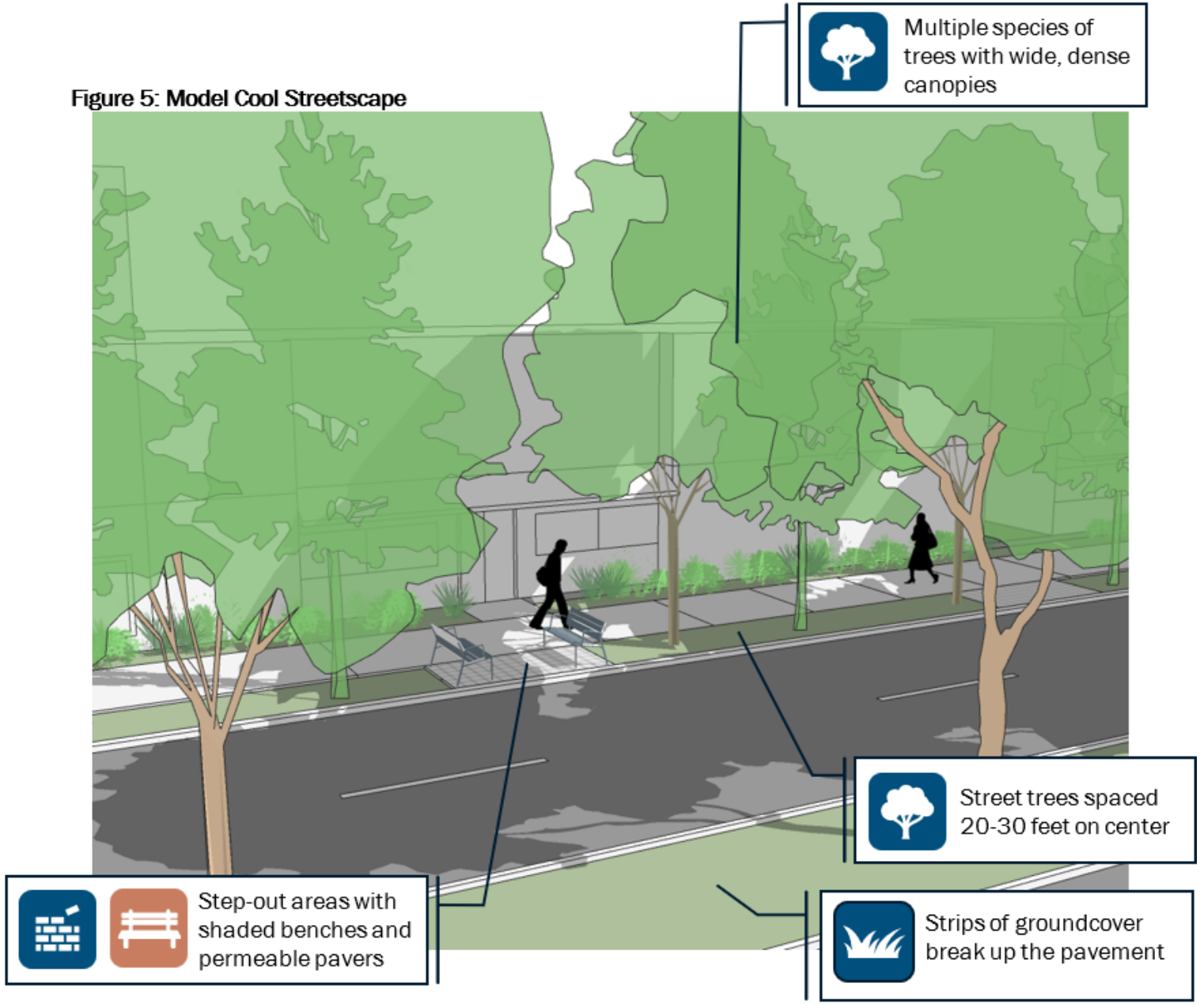
- Liquidambar rotundiloba (Fruitless sweetgum)
- Platanus occidentalis (American sycamore)

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

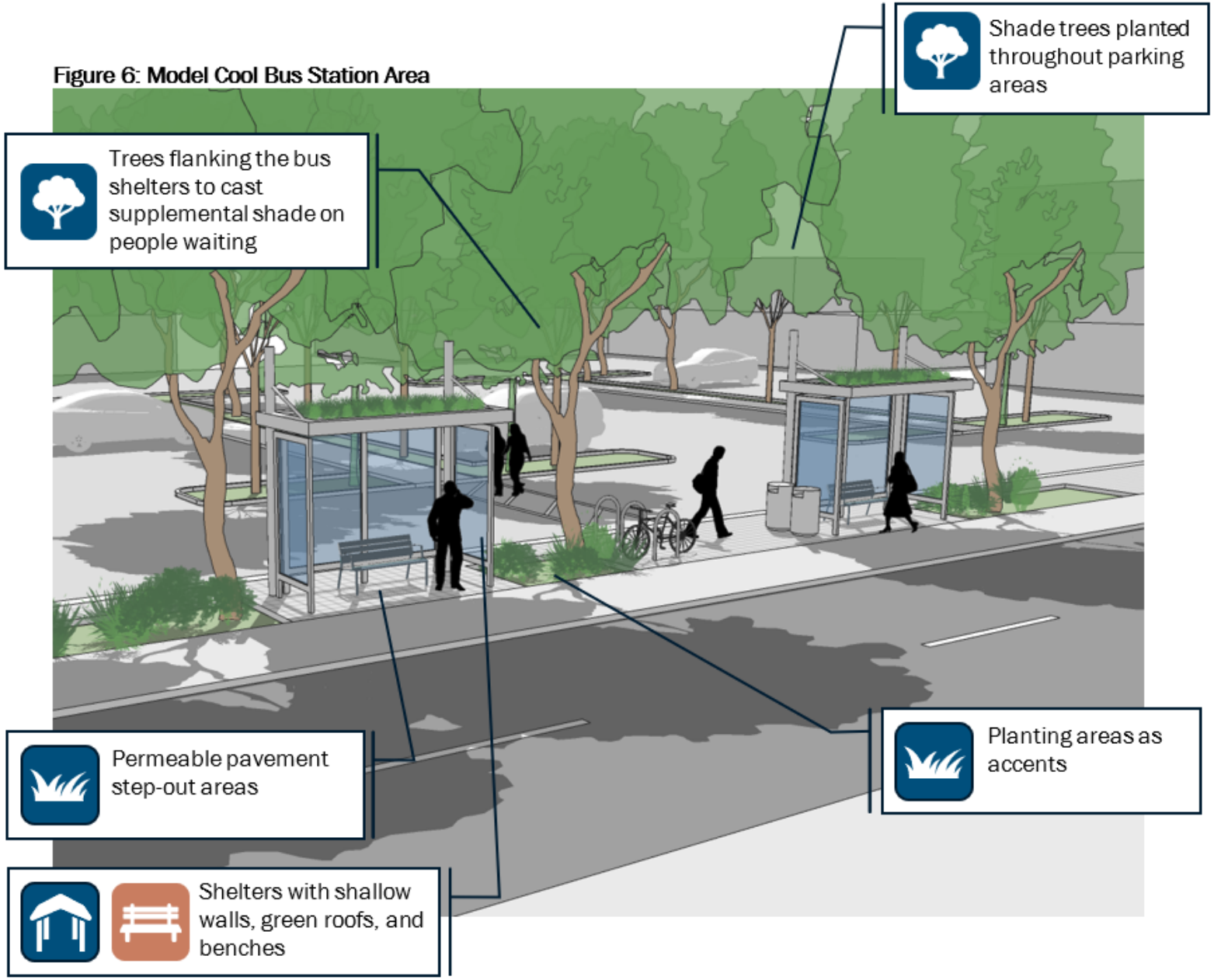
	Suburban Arterial Road	Mixed-Use Arterial Road	Constrained Urban Street
Regional Example	 Richmond Highway, Fairfax County, VA	 Wisconsin Avenue, Bethesda, MD	 Campbell Avenue, Arlington, VA
Trees	• Continuous landscape strips with shade trees planted on sides of streets and in medians	• Street trees spaced at projected full canopy distance, in continuous strips, individual tree planting beds, and bioretention areas as context allows	• Continuous landscape strips with shade trees on sides of streets with selective trees in medians where street cross-sections allow
Pavement	• Continuous light-colored concrete sidewalks	• Light-colored two-toned pavers • Permeable paver step-out areas for street furniture and bus stops between tree planting beds	• Continuous light-colored concrete sidewalks • Permeable paver step-out areas for street furniture and bus stops between tree planting beds
Groundcover	• Can be dictated by other project needs and goals	• Native grasses and low shrubs in tree planting beds and along building footprints	• Native grasses and low shrubs in tree planting beds and along building footprints
Seating	• Located regularly along streets, co-located with other heat mitigation and management elements	• Located regularly along streets, co-located with other heat mitigation and management elements	• Located regularly along streets, co-located with other heat mitigation and management elements

ITEM C

Bus Station Areas:

- Trees
- Groundcover
- Shade Structures
- Seating

Figure 6: Model Cool Bus Station Area

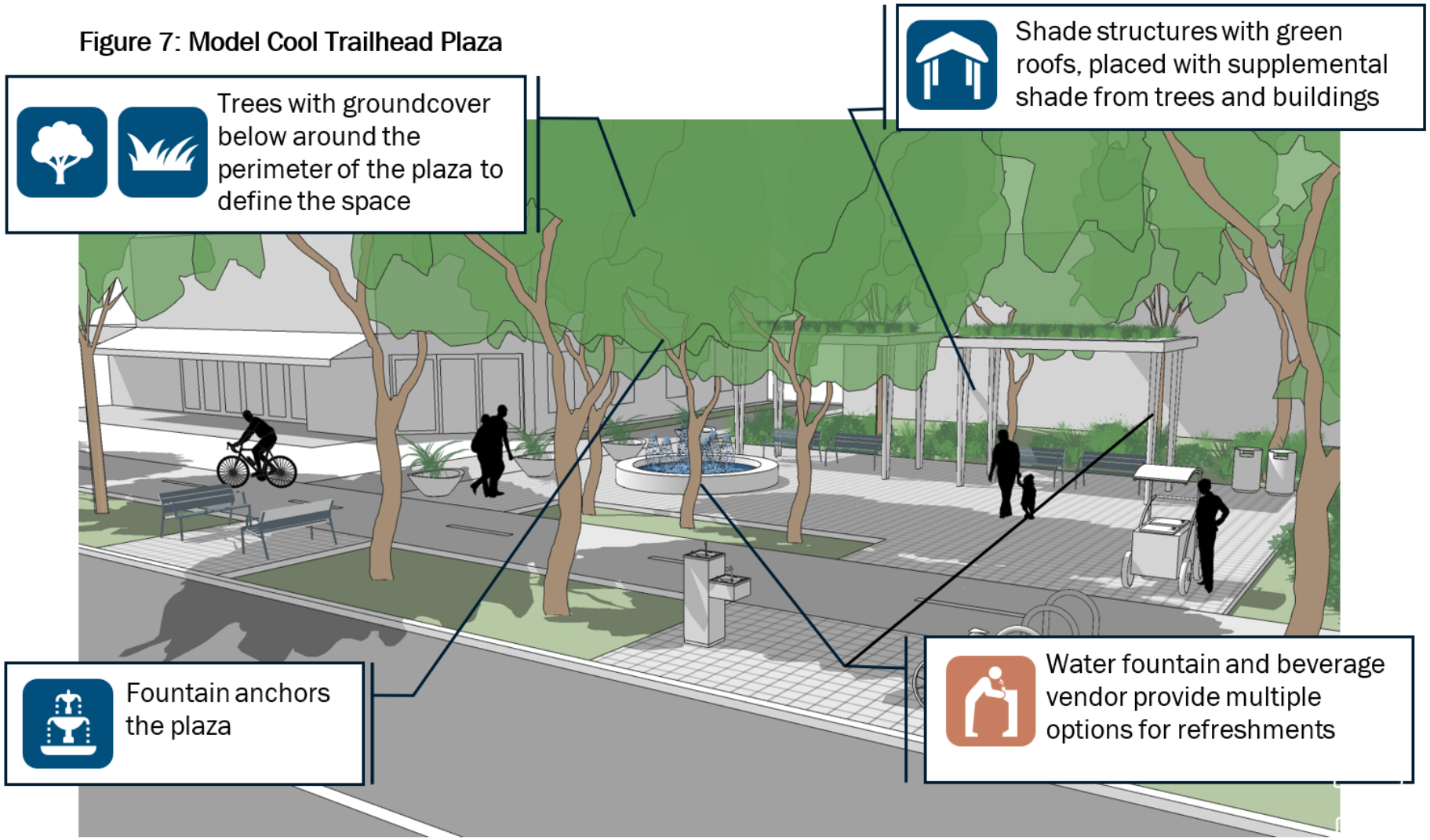


ITEM C

Trailhead Plaza:

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

Figure 7: Model Cool Trailhead Plaza



ITEM D – Policy, Planning, and Design Considerations

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

How to Use this Toolkit of Resources

ITEM A – Transit Infrastructure Resilience Analysis

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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.

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Appendix

ITEM D – Policy, Planning, and Design Considerations

Use Case 1: Goals and Vision Statements

Why?
Integrating extreme heat preparedness language into goals and vision statements can help jurisdictions **prioritize and embed extreme heat (or other key hazards of concern) into their decision-making and planning.**

How?
Add clear heat preparedness and resilience vision statements and goals to key planning documents, like **comprehensive plans, land use plans, hazard mitigation plans, resilience plans, and climate action plans.**

EXAMPLES | *References*

- Ivy City (DC) Climate Resilience Strategy
- Montgomery County's Climate Action Plan – Fiscal Year 2025 Annual Report
- Keep Cool DC: The District of Columbia's Extreme Heat Adaptation Strategy
- City of Phoenix planPHX
- NYC Cool Neighborhoods

ITEM D – Policy, Planning, and Design Considerations

Use Case 2: Land Use and Zoning Policy

Why?
Policies that encourage preserving and expanding the tree canopy can help **make heat mitigation a routine consideration in (re-) development decision-making.** This is particularly important in areas where the built environment and low canopy cover contribute significantly to urban heat island conditions.

How?
Insert considerations like tree canopy targets, native species requirements, shade requirements, and minimum planting standards into documents like **zoning ordinances and development codes, environmental and technical manuals, and development review checklists.**

EXAMPLES | *References*

- Fairfax County Landscaping and Screening Zoning Ordinance Amendment
- Prince George's County Climate Action Plan
- Henrico County Zoning Ordinance
- Philadelphia Tree Plan
- City of Salem (VA) Urban Forest Overlay District
- Montgomery County Community Resilience and Adaptive Capacity Checklist and climate screening process

ITEM D – Policy, Planning, and Design Considerations

Use Case 3: Design Standards for Cooling Strategies

Why?

Updates and additions to design standards and manuals can **support easier implementation of cooling strategies, mainstream heat mitigation, ensure that projects reduce heat exposure for multimodal users.**

How?

Specify requirements for tree spacing, transit stop shading, and permeable paving into key implementation documents like **design guidelines, right-of-way design manuals, roadway and streetscape standards, transit facility design criteria, construction specifications, public-space design guidelines, and related capital project manuals.**

EXAMPLES | *References*

- Arlington (VA) Design Standards & Guidelines
- County of Fairfax Urban Design Guidelines
- Downtown Silver Spring (MD): Cool Streets Guidelines
- City of Richmond (VA) Cool Kit
- City of Cambridge (MA) Green Factor Standard
- FTA Transit Resilience Guidebook

ITEM D – Policy, Planning, and Design Considerations

Use Case 4: Worker Heat Safety Policies

Why?
Developing formal policy language for worker safety during extreme heat can help jurisdictions **move from informal practices to consistent protocols that reduce heat exposure and health impacts, limit project disruptions, and maintain continuity of critical transportation operations.**

How?
Develop and implement **worker heat safety policies**, such as adjusting working hours, requiring shade and hydration breaks, and integrating heat protocols into maintenance and capital project delivery schedules.

EXAMPLES | *References*

- OSHA Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings
- Maryland Heat Stress Illness Prevention Standard
- Virginia heat illness legislation
- California Outdoor (T8CCR 3395) and Indoor (T8CCR 3396) Heat Illness Prevention Standards
- City of Phoenix Heat Worker Safety ordinance
- Montgomery County Extreme Temperature Plan
- Washington State Be Heat Smart!

ITEM D – Policy, Planning, and Design Considerations

Use Case 5: Contract Language to Maximize Use of Cooling Strategies

Why?
Developing contracting and procurement language that encourages the use of cooling strategies can **ensure that these features are prioritized and considered early in project planning and would signal that reducing heat stress is a priority outcome.**

How?
Develop **contracting language that requires a "best effort" to incorporate cooling strategies** or establishes minimum or performance-based standards related to heat mitigation—for example, percent shaded sidewalk, transit stop coverage, tree canopy targets along corridors, and use of permeable materials.

EXAMPLES | *Language*

"Proposers shall evaluate and incorporate shading and cooling strategies, as feasible, to reduce heat exposure and improve thermal comfort for users of the project area.

Strategies may include, but are not limited to, tree canopy, engineered shade structures, material selection, and site design features that reduce direct solar exposure and heat absorption."