DOWNTOWN SILVER SPRING

Cool Streets Guidelines

August 2022

MARYLAND NATIONAL CAPITAL PARKS AND PLANNING COMMISSION

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Downtown Silver Spring existing conditions

Cool Streets Guidelines

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Executive Summary

Purpose & Need

Impervious surfaces receive direct rays of the sun, heat up quickly, and radiate dangerously hot thermal temperatures throughout the day and night. Dark impervious surfaces such as streets, bicycle lanes, sidewalks, on-street parking, and parking lots are getting hotter and hotter with each passing year due to climate change and extreme temperatures. Dark surfaces emit intensified heat at the pedestrian level effecting air quality, human health, heat island effect, human behavior such as shopping, walking, biking, and more. Extreme heat is Montgomery County's third highest climate hazard , and the number one weather related killer in the United States.

As average temperatures rise, extreme heat days are projected to increase significantly expanding from summer well into the spring and fall. Most of the urban environment is impervious buildings and streetscapes which escalate urban temperatures and a phenomenon called heat island effect. Knowing the cause of exaggerated thermal temperatures and climate forecasts, it becomes essential that communities address these impending streetscape conditions through smart, climate resilient measures that maximize heat mitigation from the effects of climate change.

Reducing the County's extreme heat risks are woven throughout many of the County's recent climate resiliency documents including Montgomery County's Draft Climate Action Plan; Montgomery County's Climate Change Adaptation Plan; and Montgomery County's Hazardous Mitigation Plan. Yet there are no "Cool-Streets Design Guidelines and Standards" addressing extreme heat and the rise of street and surface temperatures. Without clear guidelines, it will be impossible to reduce community risks and avoid unnecessary exposure to extreme heat and its social and economic consequences. This makes communities vulnerable to increased health hazards and can reduce the use of non-automobile transportation modes.

Benefits to the Local Community and Region

Downtown Silver Spring encompasses a heat island. In fact, Silver Spring's high impervious surface ratio (74% in the commercial area), low tree canopy cover (8.85%), dark-colored street surfaces, and lack of shaded open spaces or shaded refuges further exacerbates the extreme heat urban environment. Beyond Downtown Silver Spring, climate change and increases in seasonal temperatures particularly during the summer affects each community in the region. There are no borders. As temperatures rise, mitigation strategies must be integrated into all infrastructure projects in order to maintain equitable healthy communities for all users. Knowing which strategies maximize urban resiliency and mitigation from extreme temperatures will not only benefit Silver Spring, but the Cool-Streets Design Guidelines and Standards could become a template for other jurisdictions and regions so that all communities can be designed for resiliency, equity, health, and a vibrant urban economy.

Findings & Recommendations

Findings from this study is to be used as a resource and reference when designing the streetscape recommendations for the Silver Spring Downtown and Adjacent Communities. The Guidelines contained herein includes an analysis of different surface materials, textures, and colors and their radiating and/or absorption rates; identifies various surface material options that have the lowest radiating heat emissions rates; identifies right-of-way mitigation practices necessary for cooler streetscapes; and identifies how cooler surfaces will contribute to a climate resilient community, sustain continued use of alternative modes of transportation, and support equitable and economically stable communities.

The diagrams on the following pages illustrate the major findings of the study in terms of the analysis of both streetscape surface materials and the implementation of various materials in the streetscape environment.

Material Analysis: Key Takeaways

High Temperatures

On a typical hot summer day, the UTCI can reach as high as 125°F during the hottest time of day which exceeds human comfort by 46°F

Hot Materials

Standard black asphalt and black metal grilles are the “hottest” materials that were tested and can contribute the greatest levels of heat stress

Coolest Strategies

Shade and evaporative cooling are the most effective environmental cooling strategies, providing a 10%- 15% reduction in UTCI during the hottest period of the day

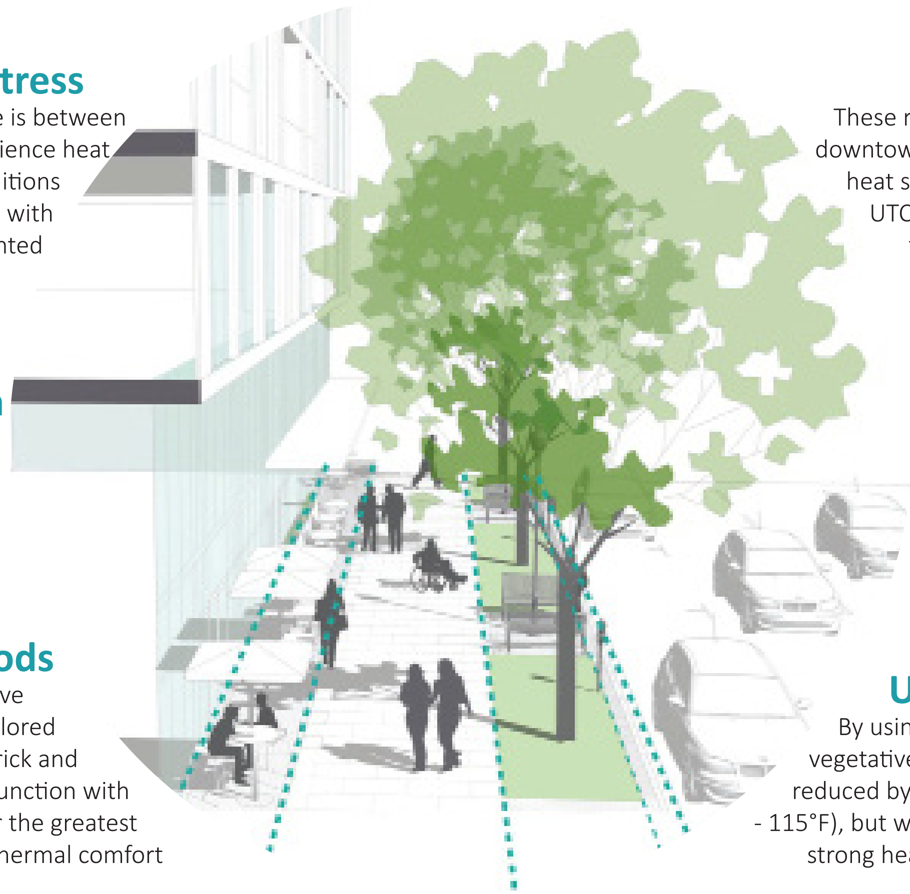
Coolest Materials

Groundcover planting is the material that provides the greatest reduction in heat stress, followed by open-grid paving (e.g. concrete grass lattice)

Cool Combinations

Combining light-colored paving materials with wind, shade, and evaporative cooling can lead to the most significant overall reduction in UTCI. In instances, this can lower the climate index from “very strong heat stress” levels to within the “no thermal stress” range (48°F- 79°F)

Streetscape Design Analysis: Key Takeaways



Reduced Heat Stress
As the "no thermal stress" range is between 48°F- 79°F, people may still experience heat stress during hot summer conditions between 9 A.M. and 3 P.M. even with these design strategies implemented

Greatest UTCI Reduction
Of all the materials tested, vegetative surfaces and open-grid paving provide the greatest reduction in UTCI

Combining Methods
Combining high reflective materials such as light-colored concrete, asphalt, and brick and vegetative surfaces in conjunction with providing shade allow for the greatest improvements in outdoor thermal comfort

Heat Stress
These results indicate that public spaces in downtown Silver Spring experience high levels of heat stress during hot summer days, with the UTCI reaching between 10°F to 25°F hotter than air temperatures (105°F- 125°F)

Natural Features
The addition of wind and street trees to provide shading along the walkway can reduce the UTCI by another 10°F- 15°F (between 100°F - 105°F with baseline materials and between 85°F- 105°F with proposed materials)

UTCI Reduction
By using light-colored paving and vegetative surfaces, the UTCI can be reduced by 5°F- 10°F (between 95°F - 115°F), but will still be within the "very strong heat stress" threshold

Final Conclusion
Achieving an UTCI of less than 79°F during a hot summer day is difficult. However the recommended strategies reduce the UTCI, or "feels like" by 20-25°F compared to a typical baseline streetscape

Downtown Silver Spring existing conditions

Cool Streets Guidelines

Introduction

Overview

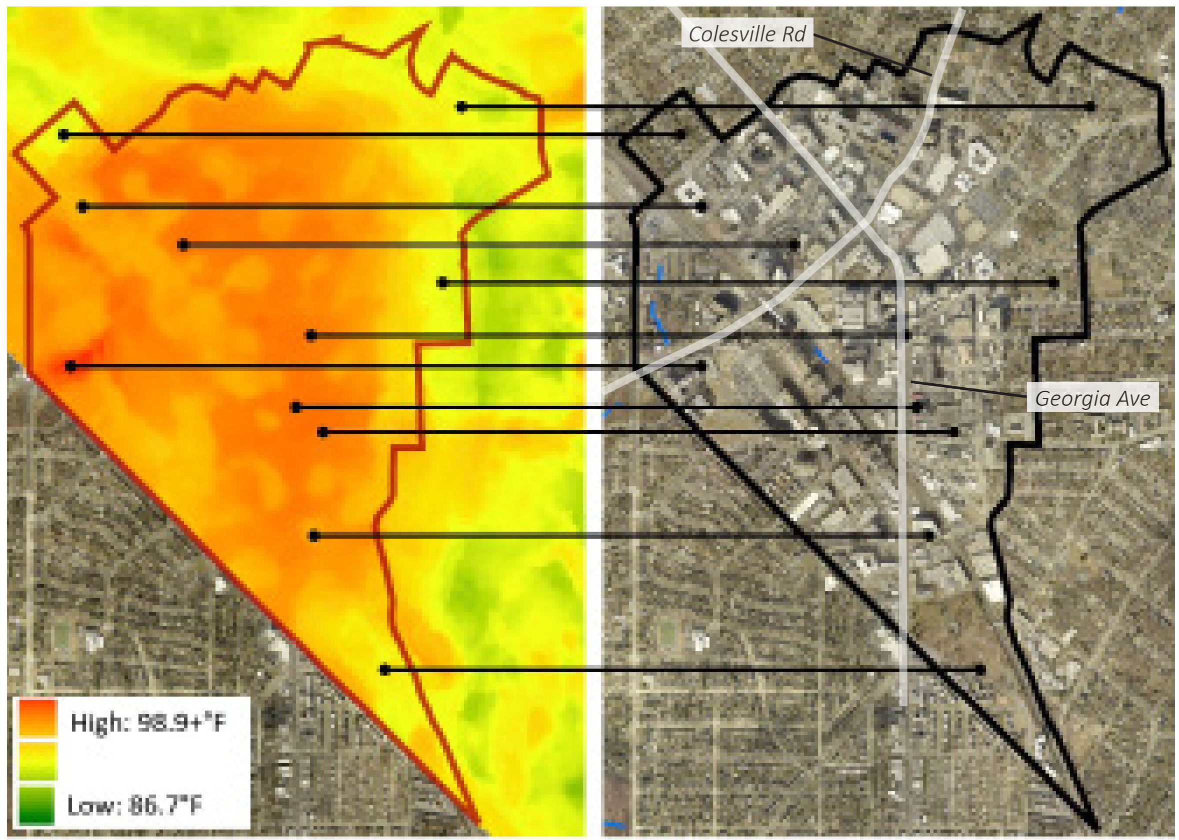
The Cool Street Guidelines creatively and effectively integrate cool streets considerations into the existing streetscape context while retaining the spirit and intent of the existing Silver Spring Streetscape Standards. The approach herein analyzes strategies to reduce urban heat islands and mitigate the impending effects of climate change on the escalating temperatures of the urban streetscape to create a more livable, usable, and tolerable streetscape even in the hottest of seasons. To meet this end, this report analyzes materials and optimizes metrics around the urban heat island effect, green infrastructure, and embodied carbon of materials that help mitigate climate change, improve local air quality, and positively impact human health and wellness.

The analysis has produced a quantitative thermal comfort assessment for the study area and developed clear and forward-thinking performance goals for cooling Silver Spring's streets. The Guidelines and Standards contained will be applied to and coordinated with the appropriate transportation agencies, the Silver Spring Urban District, and private landowners and developers during the design and implementation phases of various projects district-wide.

Climate Conditions

Downtown Silver Spring is a significant urbanized area of the metropolitan region. As such, the density of buildings, roads, and other built features absorb and re-emit the sun's heat more than natural areas that would include more plantings, trees, and water features. Due to this, Downtown Silver Spring is classified as an urban heat island due to its higher temperatures relative to the surrounding context.

Silver Spring experiences relatively low prevailing winds averaging less than 4 mph on average. The area also experiences the highest total hours of sunshine between May and September which are some of the hottest months of the year, with July being the hottest month on average. Temperatures are expected to continue to rise into the future. Maryland's Climate Forecast predicts that the state's average summer and winter temperatures will increase by over 6 degrees Fahrenheit relative to pre-industrial averages. Further signifying the need to preemptively examine opportunities to cool urban environments such as Downtown Silver Spring.



Downtown Silver Spring heat island analysis

Downtown Silver Spring existing conditions

Cool Streets Guidelines

Urban Heat Analysis

Overview

Dark surfaces emit intensified heat at the pedestrian level effecting air quality, human health, heat island effect, human behavior such as shopping, walking, biking, and more. Extreme heat is Montgomery County’s third highest climate hazard , and the number one weather related killer in the United States.

As average temperatures rise, extreme heat days are projected to increase significantly expanding from summer well into the spring and fall. Most of the urban environment is impervious buildings and streetscapes which escalate urban temperatures and a phenomenon called heat island effect. Knowing the cause of exaggerated thermal temperatures and climate forecasts, it becomes essential that communities address these impending streetscape conditions through smart, climate resilient measures that maximize heat mitigation from the effects of climate change.

The intent of this analysis is to determine the efficacy of various design strategies to improve the outdoor thermal comfort of streetscape environments in Downtown Silver Spring, Maryland. A range of different surface materials are tested against baseline conditions to understand which strategies can provide the greatest reduction in heat stress. These results are intended to inform the recommendations provided later in the document.

Outdoor Thermal Comfort Analyses

An effective method for determining and testing outdoor comfort is to perform an outdoor thermal comfort analysis. The analysis accounts for the annual variation in external thermal comfort by combining the hourly effect of radiation, local air speeds, air temperature, relative humidity, and physiological variables such as clothing and metabolic rate. Three outdoor thermal comfort analyses are included within this report, all of which are measured by the Universal Thermal Climate Index (UTCI), which is an outdoor thermal comfort metric and will be discussed further on the following page. The software program Rhinocerous 3D was used to simulate environmental and built streetscape conditions for the analysis contained in this report. The analyses include:

1. Baseline UTCI Climate Analysis

This study examines the hourly UTCI of Silver Spring on a yearly basis (2004-2018) to explore baseline conditions and provide a reference point to understand the impact of temperatures, wind and shade on outdoor thermal comfort.

2. Point-in-time Peak UTCI Analysis

The point-in-time analysis includes a matrix and graphs that compare the effect of various paving materials and environmental conditions on a typical hot summer day (July 24th at 2 P.M.) to assess the impact these factors have during the hottest period of the day.

3. Streetscape Recommendations Design Analysis

The final study included within this section analyzes the UTCI of a representative streetscape in Downtown Silver Spring, also using July 24th as the chosen analysis period. The results of this analysis are spatial UTCI “heat maps” that compare baseline materials, which are reflective of current Silver Spring streetscape standards, with alternative proposed materials. These two cases are tested in conditions representing a hot, still sunny day without wind or shade and a hot, windy sunny day with the addition of street trees.

Silver Spring existing conditions

1. Universal Thermal Climate Index (UTCI)

The metric for outdoor thermal comfort used in this analysis is called Universal Thermal Climate Index (UTCI). The UTCI is an equivalent temperature taken 3 feet above the ground plane for a given combination of wind, radiation, humidity and air temperature. This metric provides a thermal strain index value that is representative of a "feels like" temperature for the human body.

The thermal comfort band for UTCI equivalent temperature is between 48°F and 79°F, depending on the solar radiation, humidity, and wind exposure. Generally, outdoor conditions will be uncomfortable when temperatures exceed 80°F.

Environmental Conditions

While strategies such as incorporating street trees to provide more shading reduce the mean radiant temperature (MRT), wind and evaporative cooling can also impact UTCI. Mean radiant temperature (MRT) is a means of expressing the influence of surface temperatures on occupant comfort and it is measured simply as the weighted mean temperature of the surfaces surrounding the body. Wind provides air movement which causes a desirable cooling effect in the summer. Wind speeds on the chosen day of analysis (July 24th) range from 4.6-13.8 mph from 12- 1PM. On an annual basis, wind speeds in Silver Springs reach as high as 37 mph. Evaporative, or adiabatic, cooling (the use of water features such as fountains and misters to cool the air down to a comfortable temperature) can improve air temperature by adjusting the moisture content of the air and cooling between 60- 90% of the wetbulb temperature. Wet bulb temperature is the lowest temperature at which air can be cooled by the evaporation of water into the air at a constant pressure.

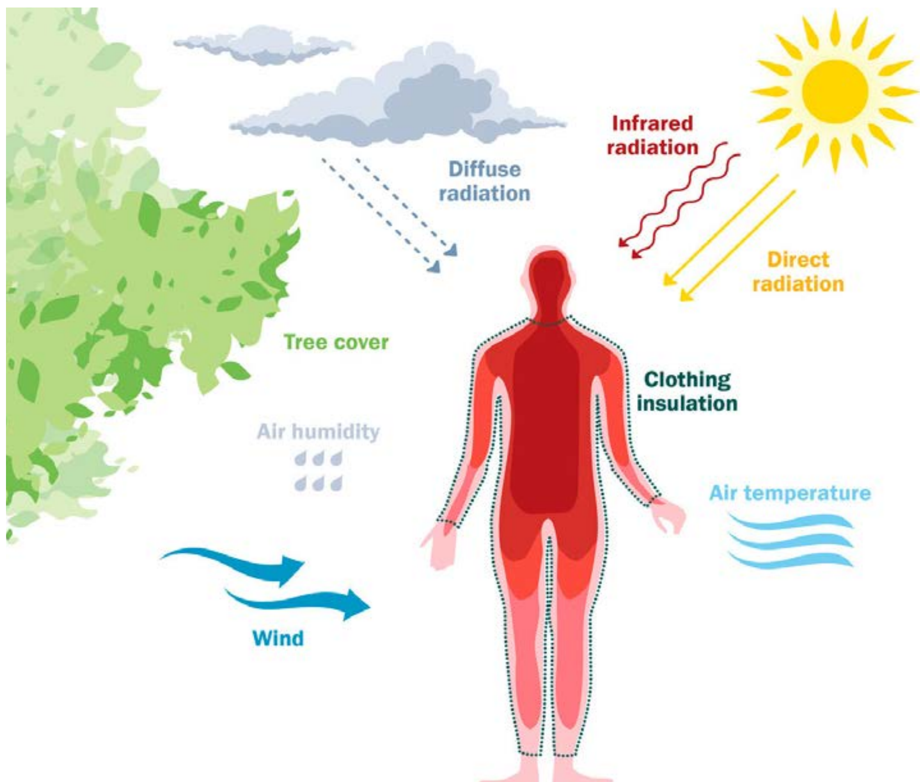
The following are environmental conditions that were tested in the point-in-time peak and streetscape design analyses.

Worst Case Conditions

- No shade provided by street trees
- No wind
- No evaporative cooling

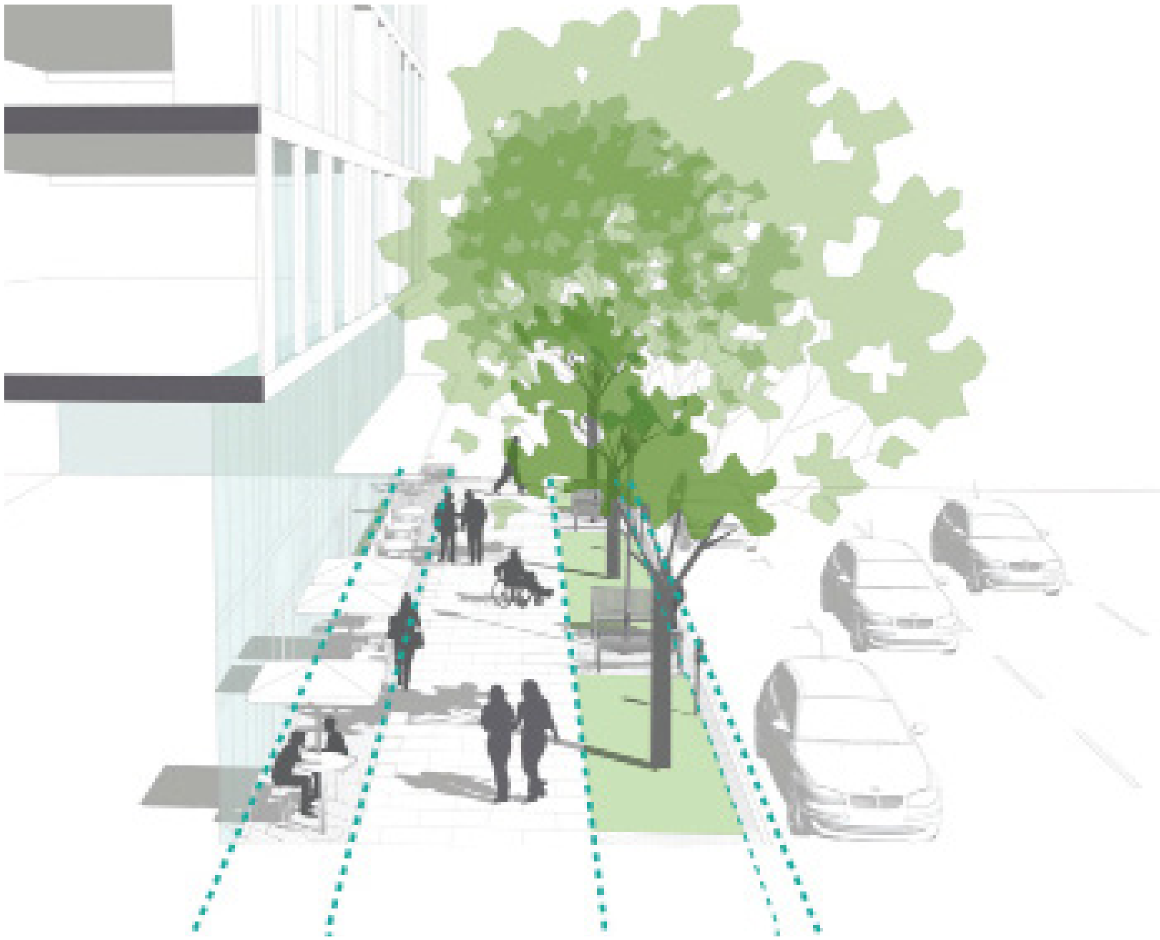
Improved Conditions

- Shade: street trees located every 30 feet. Young, medium, and mature trees are included within the geometry, ranging between 20 and 65 feet tall.
- Wind : wind speed is based on the hourly wind profile from a local weather file (between 4.6 mph and 13.8 mph).
- Evaporative Cooling : spray evaporative cooling with 80% relative humidity, as a mister. Please note, evaporative cooling is a testing strategy in the UTCI matrix, but was not included within the modeled UTCI simulation.



Universal Thermal Climate Index (UTCI) Factors

Materials Analysis



Typical proposed streetscape configuration in Downtown Silver Spring

Materials can greatly impact outdoor thermal comfort since properties like solar reflectance, or albedo, and thermal emittance impact surface temperature. For instance, dark-colored paving absorbs more solar energy throughout the day whereas light-colored materials reflect more radiation and stay cooler. Similarly, a material's thermal emittance determines how much heat it will radiate at a given temperature. Paving that is exposed to radiant energy will heat up until it reaches thermal equilibrium. Therefore a material with high emittance will reach thermal equilibrium at a lower temperature than a surface with low emittance, and will therefore stay cooler throughout the course of the day as the sun gets increasingly hotter.

Nine different surface materials are included in this analysis. The first set represents typical paving in downtown Silver Spring, as per the Silver Spring Streetscape Standards (2019) as well as what exists in the district today. The second set is proposed paving materials that are intended to provide an improvement in outdoor thermal comfort. Please see the appendix to review the complete set of material property assumptions.

Baseline Materials

1. Red brick pavers
2. Concrete pavers with charcoal Tudor finish
3. Black metal grilles
4. Standard asphalt

Proposed Materials

5. Light-colored brick
6. Light-colored concrete
7. Open-grid paving (concrete unit pavers that are 50% open or spaced to include groundcover vegetation)
8. Light-colored asphalt

2. Point-In-Time Peak UTCI Analysis

The point-in-time peak UTCI analysis tests all materials across a range of environmental conditions to examine the effect that these strategies have on outdoor thermal comfort. Point-in-time is a specific hour of the day. This test done to assess the cooling effect these strategies can provide without context such as buildings, to isolate and measure their effect in component parts. The results of this analysis are included in the tables below.

Table 1 shows the UTCI at 2 P.M. on July 24th to measure heat stress reduction potential during a typical hot summer day. Table 2 shows the daily average UTCI on July 24th.

UTCI

- Very strong heat stress
- Strong heat stress
- Moderate heat stress
- No thermal stress
- Slight cold stress
- Moderate cold stress

Table 1. July 24th Peak Temperature (2 P.M.) UTCI Estimates

MATERIALS		Baseline: No Wind or Shade	Wind	Partial Shade	Full Shade	Evaporative Cooling	Shade and Wind	Shade Wind and Evaporative Cooling
Baseline Materials	Standard Asphalt	125	118	118	111	107	106	90
	Black Metal Grate	123	121	115	111	104	109	92
	Red Brick Pavers	123	117	116	109	104	104	88
	Concrete with Charcoal finish	124	117	117	110	104	105	88
Proposed Materials	Light-colored Concrete	122	116	114	107	103	102	86
	Light-colored Brick	121	115	113	106	102	101	85
	Light-colored Asphalt	121	114	112	104	102	100	85
	Open-grid Paving	113	108	108	103	96	99	84
	Groundcover	97	96	91	91	82	90	76

Table 2. July 24th Average Daily Temperature (2 P.M.) UTCI

MATERIALS		Baseline: No Wind or Shade	Wind	Partial Shade	Full Shade	Evaporative Cooling	Shade and Wind	Shade Wind and Evaporative Cooling
Baseline Materials	Standard Asphalt	98	93	95	92	92	88	82
	Black Metal Grate	97	94	94	92	90	89	83
	Red Brick Pavers	97	92	94	91	90	87	81
	Concrete with Charcoal finish	97	92	94	91	90	87	81
Proposed Materials	Light-colored Concrete	97	92	93	90	90	86	80
	Light-colored Brick	96	91	93	90	89	85	80
	Light-colored Asphalt	97	92	93	90	90	86	80
	Open-grid Paving	97	92	93	90	90	86	80
	Groundcover	77	76	75	75	72	74	69

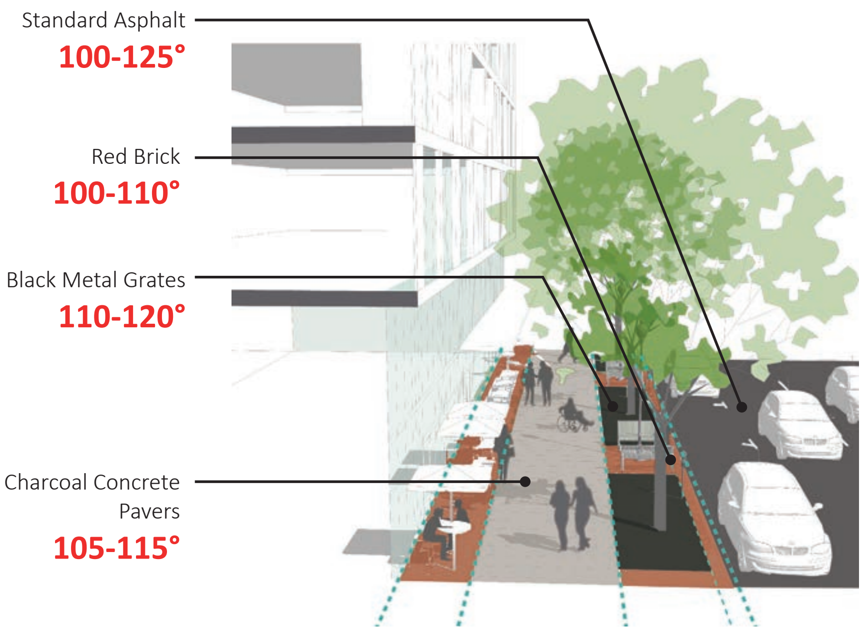
3. Streetscape Heat Analysis

To further inform cool street recommendations, the streetscape design analysis in this section builds upon the point-in-time peak analysis by examining the UTCI of these nine material and six environmental conditions within a built environment that is typical of Downtown Silver Spring.

Building heights and frontage are based on coordination with the Montgomery Planning Commission and the recommendations in the 2022 Silver Spring Downtown and Adjacent Communities Plan to represent future development trends. Below are the streetscape surfaces that were used for this study with the corresponding baseline and proposed materials indicated. Proposed cool-street materials include paving materials and vegetative interventions that aim to reduce heat island impacts and ensure the development of tolerable, healthy, and resilient streetscape environments within the Silver Spring Downtown area.

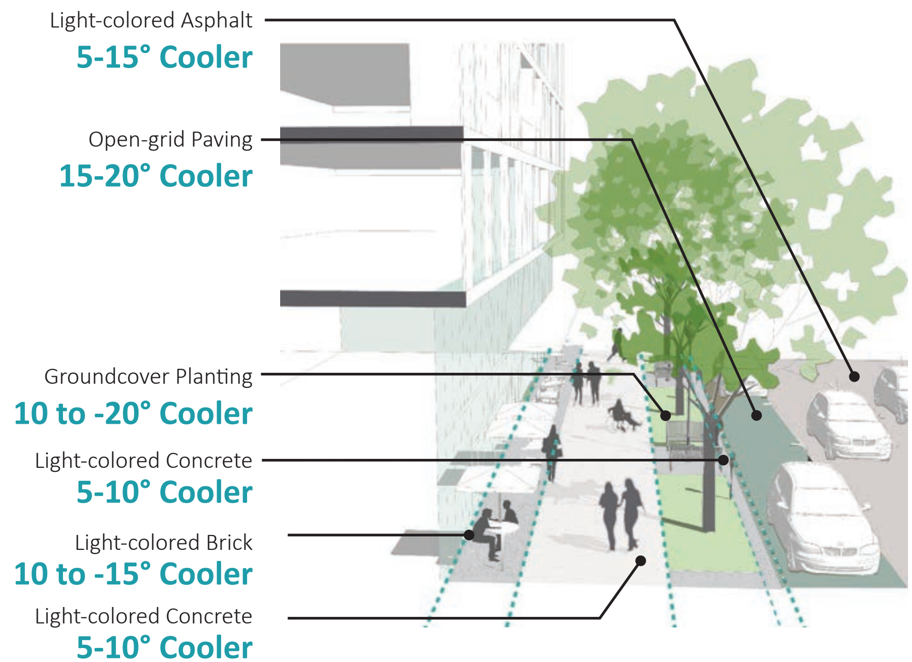
The map on the next page indicates the location along Fenton Street that this analysis is based on. Fenton Street was chosen as it is a major pedestrian through-way. Further, the lower portion of Fenton Street is north-south running which is important as it receives ample sun throughout the day which is an ideal orientation to assess outdoor thermal comfort. Findings are based on average temperatures of July 24th from 2004-2018.

Baseline Materials



Existing Silver Spring streetscape condiitons and average daily temperatures (July 24th)

Proposed Cool-Street Materials



Cool-street recommendations including temperature differences compared to existing conditions

Streetscape Heat Analysis Results

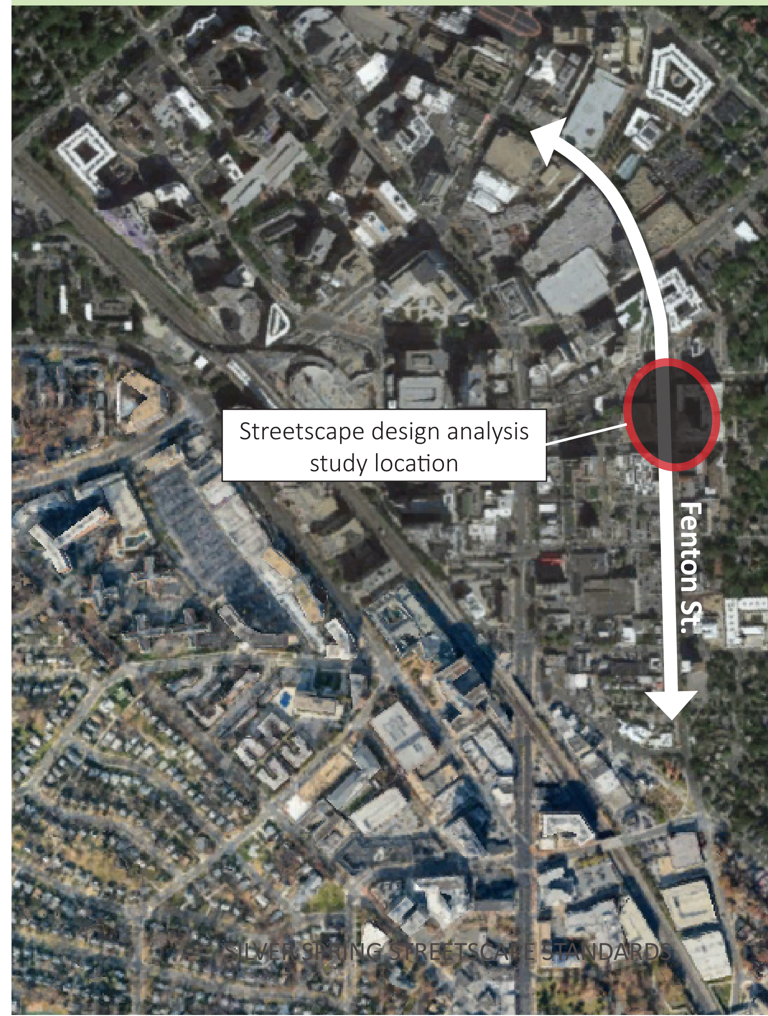
The results on the following pages provide spatial UTCI “heat” maps of the streetscape analysis surfaces comparing baseline materials and proposed materials. The analysis is conducted both with and without wind and shade at 9 A.M., 12 P.M., and 3 PM on July 24th. The first sets of maps on pages 17-21 illustrate average temperatures for all three analysis periods.

This is included to provide a measurement of UTCI temperatures during key times of the day when pedestrians are typically occupying public spaces. These maps are also provided individually on page 21 for reference to get a sense of how the UTCI increases throughout the day.

The analysis testing iterations include:

1. Baseline materials on a still, sunny day without shade (No wind, no shade)
2. Proposed materials on a still sunny day with-out shade (No wind, no shade)
3. Baseline materials on a windy sunny day with street trees (Wind and shade)
4. Proposed materials on a windy sunny day with street trees (Wind and Shade)

Lush streetscape planting with integrated stormwater management



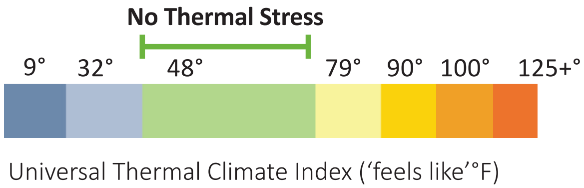
Results - No Wind and No Shade

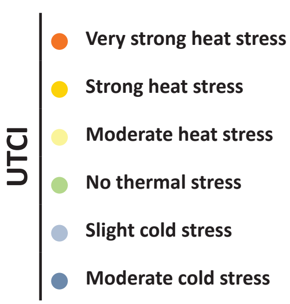
July 24th

Air Temperature - 91°- 96°F

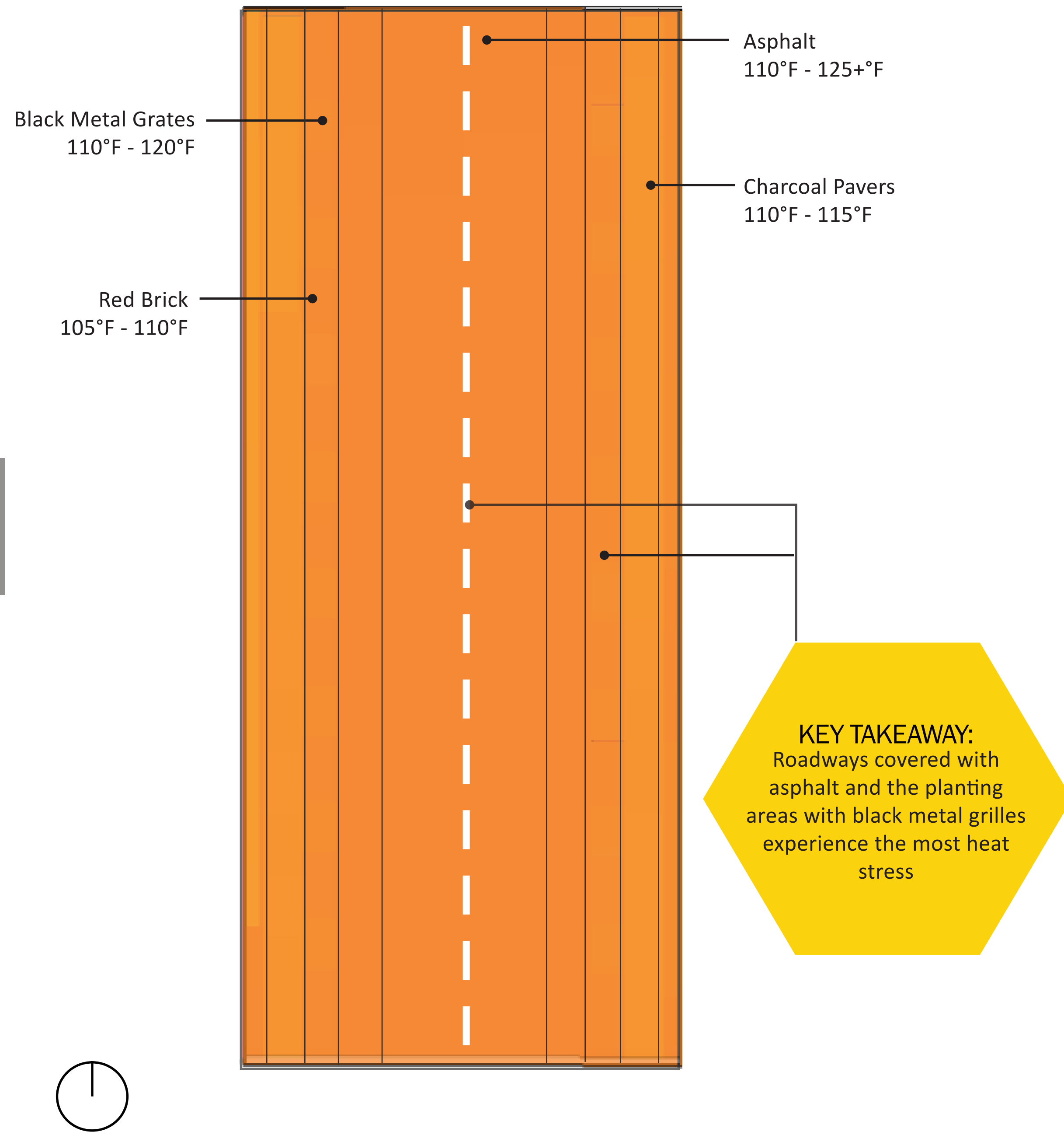
On a hot sunny and still day, all outdoor open space experience heat stress between 9 A.M. and 3 P.M. Even though alternative materials can lower the UTCI between 5°F- 10°F, much of the surface area is above 100°F and is still considered "very strong heat stress".

7% of area with strong heat stress
93% of area with very strong heat stress

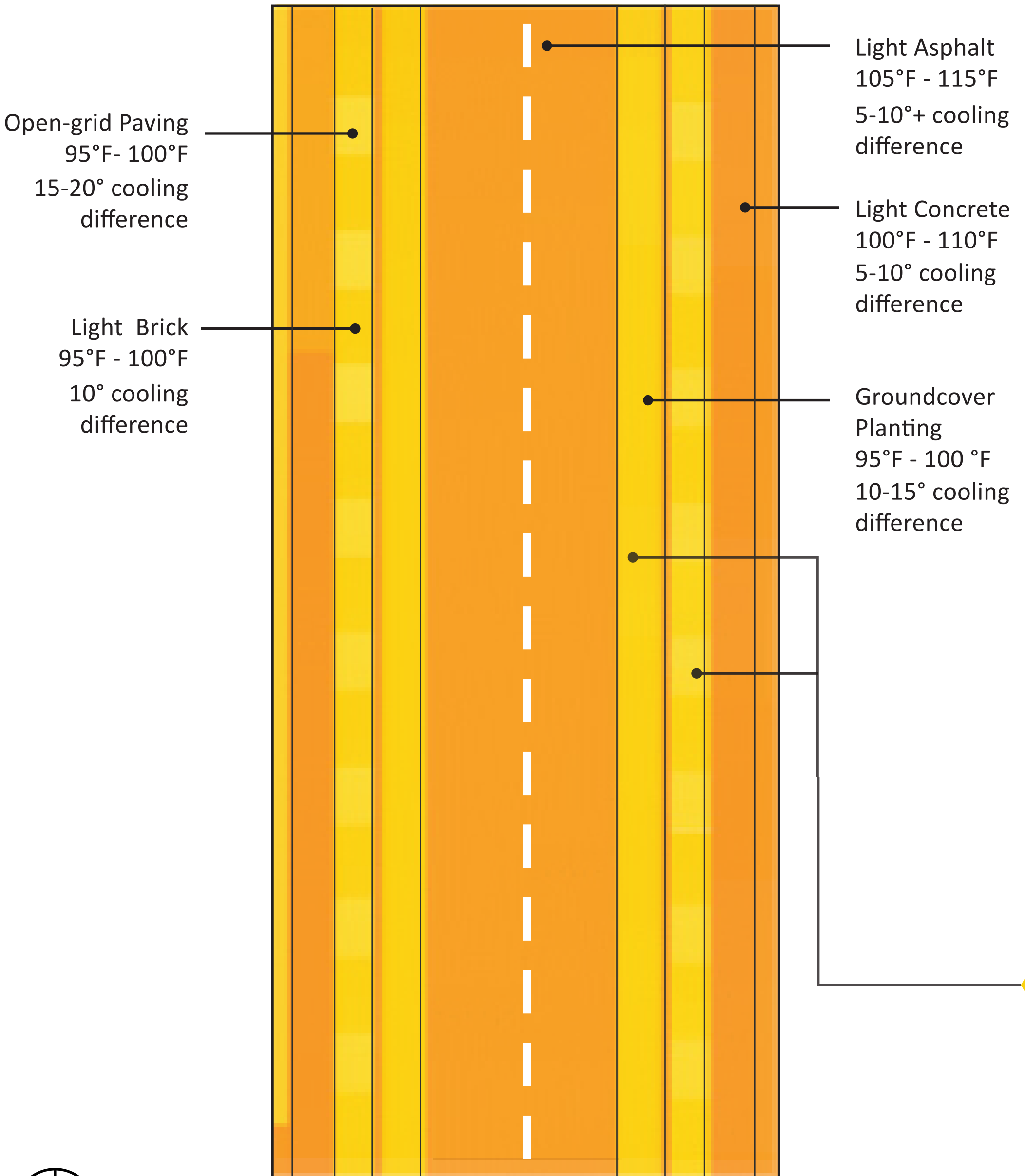


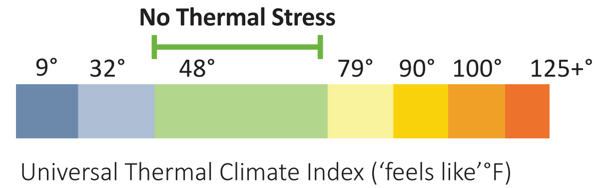


Baseline Materials No Wind, No Shade



Proposed Materials
No Wind, No Shade





UTCI

- **Very strong heat stress**
- **Strong heat stress**
- **Moderate heat stress**
- **No thermal stress**
- **Slight cold stress**
- **Moderate cold stress**

2% of area with moderate heat stress
12% of area with strong heat stress
86% of area with very strong heat stress

(7% of the area is reduced from "strong heat stress" to a lower heat stress category)

KEY TAKEAWAY:
Open-grid paving and vegetation experience less heat stress compared to areas covered with concrete pavement, brick or asphalt, reducing the UTCI by 5°F- 10°F

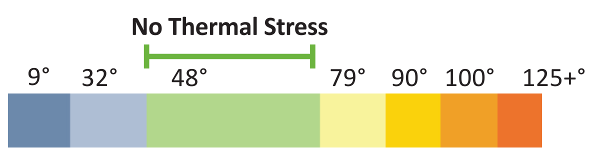
Results - Wind and Shade from Street Trees

July 24th

Air Temperature - 91°- 96°F

Even with baseline materials, shading from street trees provides cooling throughout all hours of the day but requires large trees to provide greater cooling effect. With more deciduous trees and vegetation in the proposed design, outdoor thermal comfort is improved on a hot summer day as areas with “very strong heat stress” reduced from 90 percent to 81 percent of the surface area. Trees can provide solar protection to the open space underneath, whereas vegetation can provide local cooling effect compared to concrete pavers, bricks or asphalt.

10% of area with strong heat stress
90% of area with very strong heat stress

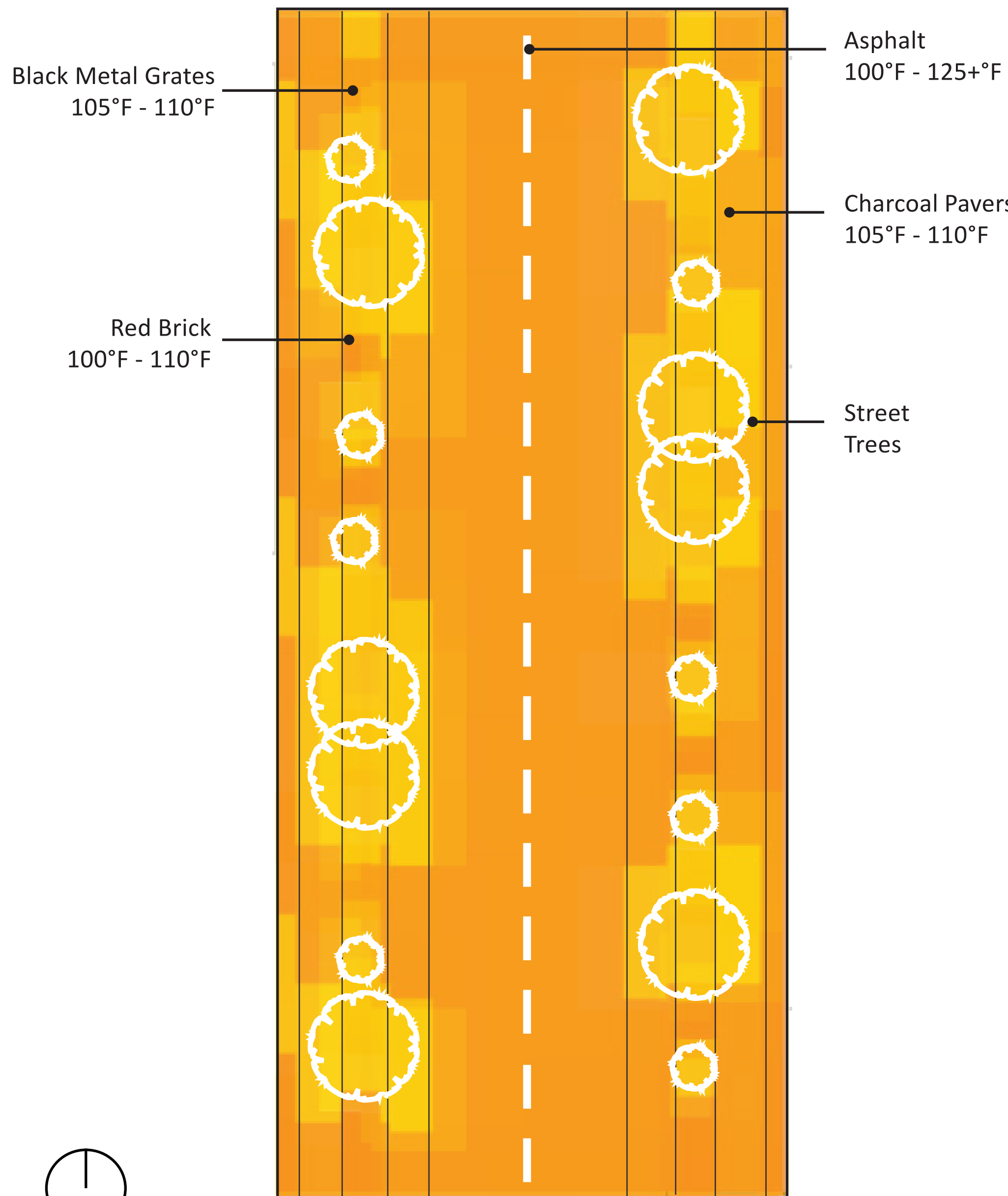


Universal Thermal Climate Index (‘feels like’°F)

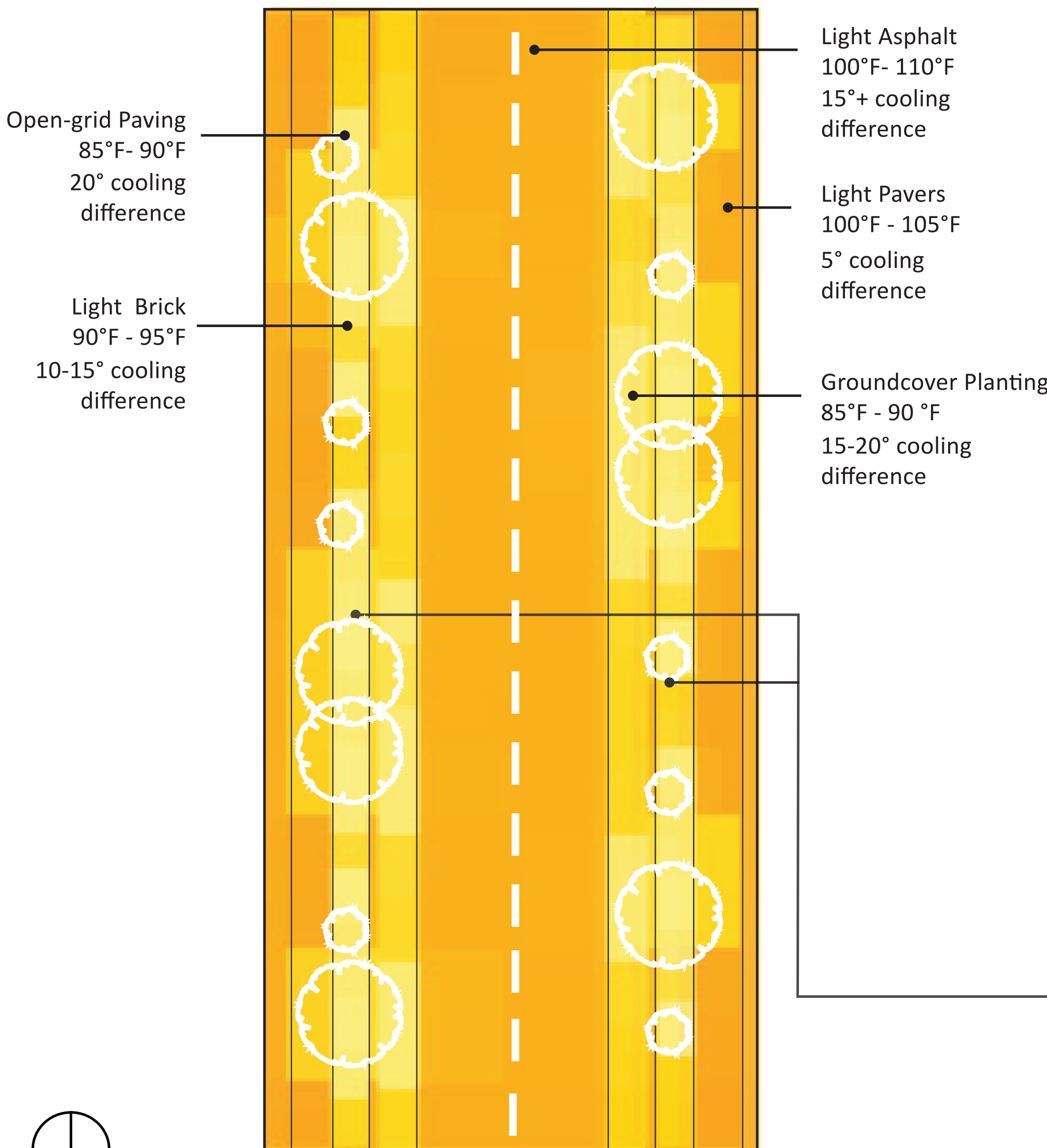
UTCI

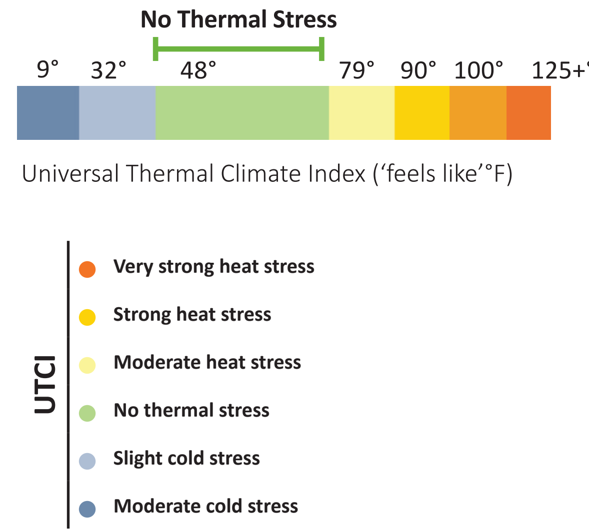
- **Very strong heat stress**
- **Strong heat stress**
- **Moderate heat stress**
- **No thermal stress**
- **Slight cold stress**
- **Moderate cold stress**

Baseline Materials



Proposed Materials Wind & Shade Trees



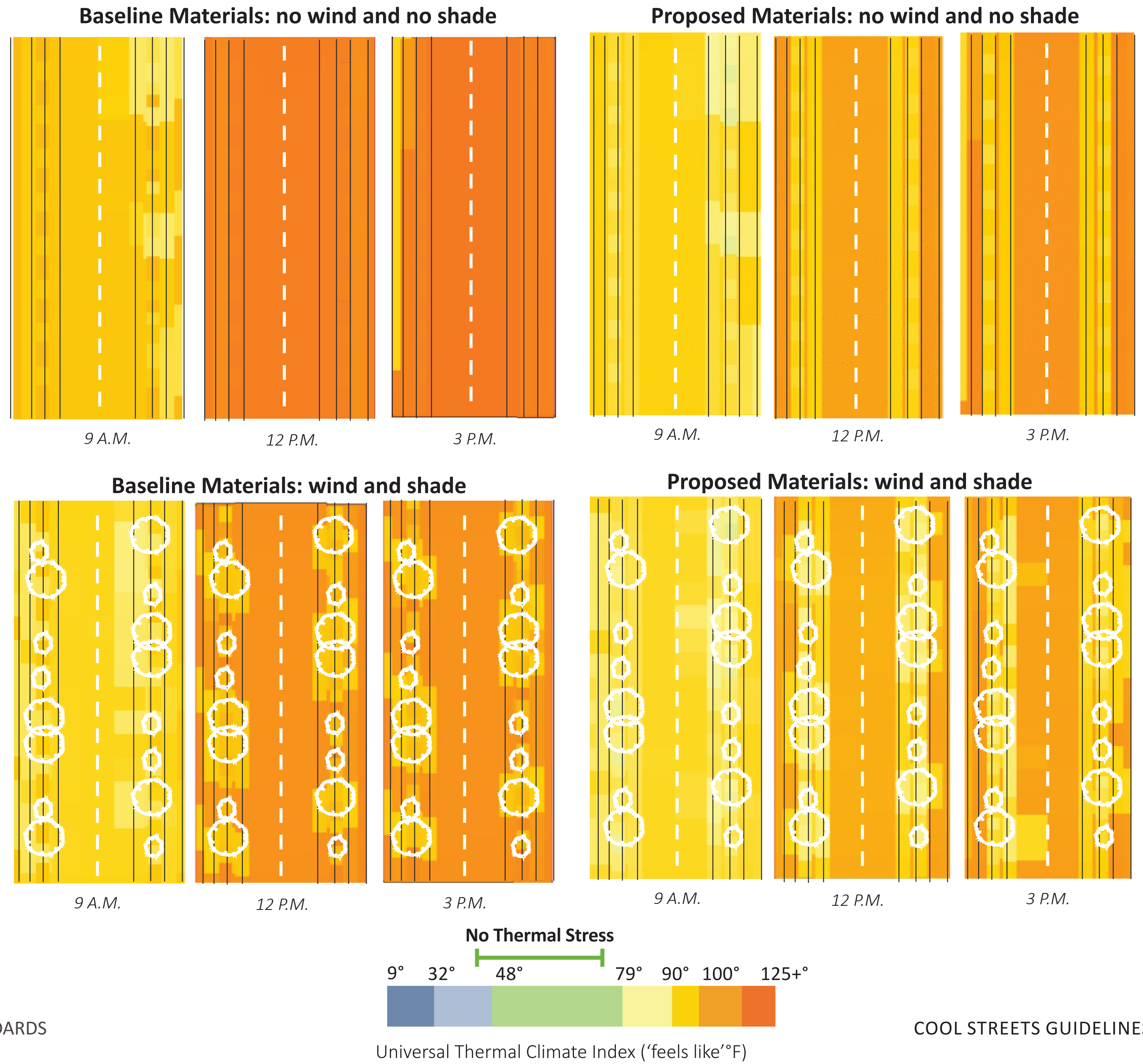


3% of area with moderate heat stress
16% of area with strong heat stress
81% of area with very strong heat stress

(9% of the area is reduced from "strong heat stress" to a lower heat stress category)

KEY TAKEAWAY:
Combining light-colored or vegetative surfaces with shading and wind reduces heat stress from 110°F- 115°F in the baseline to 80°F- 90°F in the proposed case

Individual Streetscape Design Analysis Results



The graphics shown illustrate increases in the UTCI throughout the day comparing baseline and proposed materials in varying environmental conditions. See the key takeaways from this analysis on the next page

Material Analysis: Key Takeaways

High Temperatures

On a typical hot summer day, the UTCI can reach as high as 125°F during the hottest time of day which exceeds human comfort by 46°F

Hot Materials

Standard black asphalt and black metal grilles are the "hottest" materials that were tested and can contribute the greatest levels of heat stress

Coolest Strategies

Shade and evaporative cooling are the most effective environmental cooling strategies, providing a 10%- 15% reduction in UTCI during the hottest period of the day

Coolest Materials

Groundcover planting is the material that provides the greatest reduction in heat stress, followed by open-grid paving (e.g. concrete grass lattice)

Cool Combinations

Combining light-colored paving materials with wind, shade, and evaporative cooling can lead to the most significant overall reduction in UTCI. In instances, this can lower the climate index from "very strong heat stress" levels to within the "no thermal stress" range (48°F- 79°F)

Cool Streets Recommendations

Given the results of the three analyses included within the report the following recommendations are provided to further inform the Cool Streets “elements”. Recommendations are provided for materials, landscape and vegetation, shading, and other strategies.

Material Recommendations

- Increase usage of an open-grid pavement system (at least 50% unbound) on private streets and public spaces wherever feasible
- Use light-colored paving including concrete, asphalt, pavers, and brick with a three-year aged solar reflectance (SR) value of at least 0.28 or an initial SR of 0.33. Solar reflectance is the ability of a material to reflect, and not absorb, energy from the sun. Other materials to consider include painted asphalt with a three-year aged solar reflectance (SR) value of at least 0.28 or an initial SR of 0.33

Vegetation Recommendations

- Incorporate vegetative surfaces such as grass or groundcover where ever possible
- Strategically create localized areas of respite using light-colored or vegetative thermal mass, especially in areas where trees can be used to shield them from direct sun during hot periods. Provide these microclimate areas of respite every 500 feet (0.1 miles)
- Integrate deciduous trees or seasonal/dynamic outdoor shading to provide seasonal balance of solar protection and solar access.
- Where possible, locate gathering areas near irrigated or mature vegetated zones, which will provide a thermal buffer of passive cooling
- The conservation of large, mature trees should be prioritized as they provide a greater area of shading

Shading Recommendations

- Provide shade with structures covered by energy generation systems, such as solar thermal collectors or photovoltaics
- Provide shade in public spaces by using awnings and other architectural shading devices, such as street canopies or shading installations, with a SR value of at least 0.28 or an initial SR of 0.33

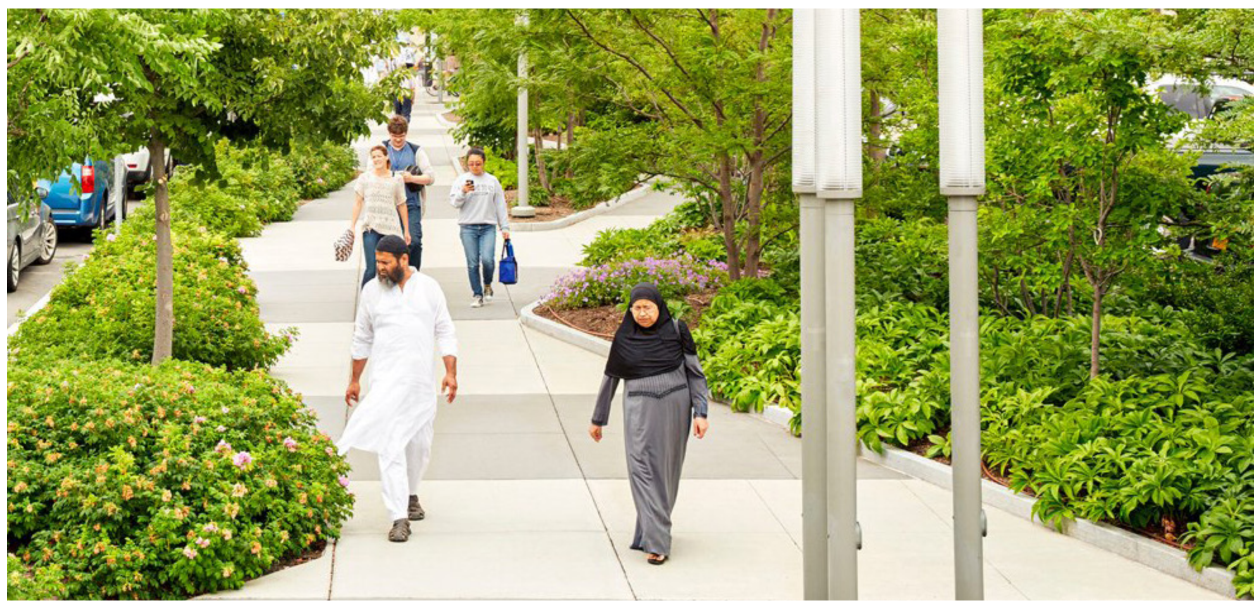
Other Recommendations

- Explore additional strategies such as using a spray evaporative cooling device in key public areas in the summer to provide even greater cooling
- Where possible, avoid building barriers that block prevailing southern and western winds in the summer.
- Solar protection, wind access, and natural ventilation will make outdoor spaces more comfortable in summer
- Cooler surface temperatures and natural evaporative cooling (the use of water features such as fountains and misters to cool the air down to a comfortable temperature) occurring in the landscape will improve the radiant environment during the warm period.

Additional Considerations

There are several additional factors to consider to further contextualize the recommendations included within this report. First, it should be noted that in the winter, wind protection and access to solar radiation can improve winter thermal comfort by increasing UTCI. As such, planting with deciduous trees that shed their leaves seasonally is recommended to provide balanced outdoor thermal comfort year round.

Similarly, as northern winds are prevailing in the winter, adding vegetated wind buffers to the north



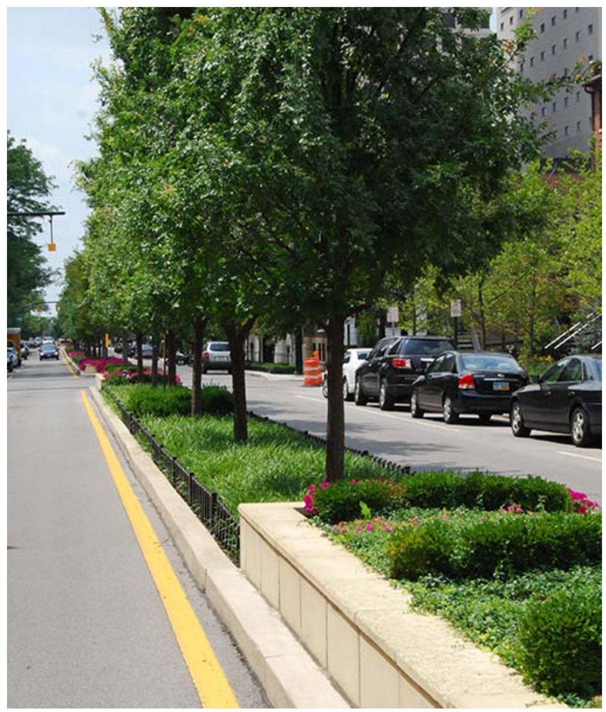
Lush streetscape planting including street trees and groundcover vegetation will allow for wind protection in the cool season while allowing prevailing south and west wind to provide air movement and cooling in the summer.

Further, since climate change is expected to cause temperatures to rise, “cooling” strategies will become even more important over the coming decades as winters become milder and summers become even hotter with more frequent heat waves. As such, first reducing paving then incorporating strategies such as using light-colored paving and providing shade should take precedent. This approach also encourages low-carbon site design as paving materials are some of the most carbon intensive materials used within site development. Reducing paving therefore provides benefits from an outdoor thermal comfort and embodied carbon perspective.

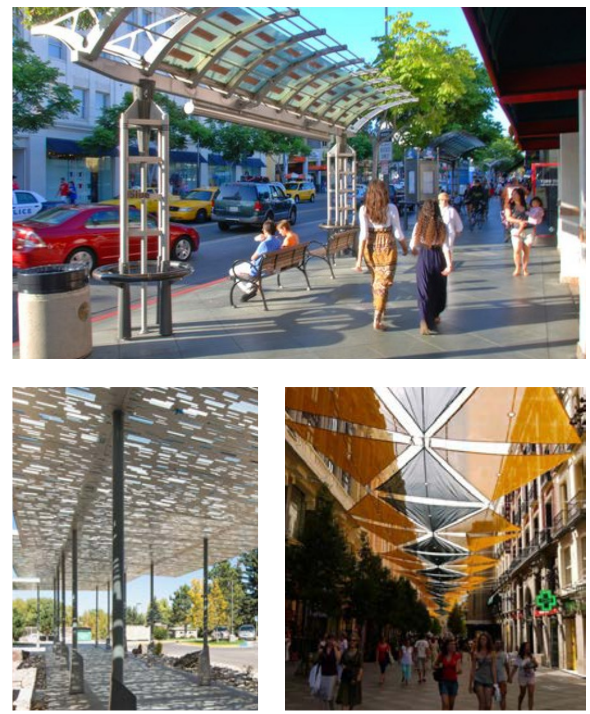
It is also important to consider the supplemental benefits that these strategies can provide in an more urban setting. While this report focuses on outdoor thermal comfort in micro-climates, these strategies also reduce urban heat island effect on a district-level when used widely and coupled with light-colored roofs and minimized paving. Open-grid paving and vegetative surfaces provide additional benefits to stormwater management as well. Increasing the tree canopy will improve air quality and provide residents with biophilic benefits.

The development of surrounding buildings can also play a role in reducing urban heat island effect and creating more comfortable exterior environments. Green roofs, light-colored roofs, and roofs with photovoltaic arrays that mitigate urban heat island effect should be included in new construction and major renovations whenever feasible.

Movable planters can be used to provide groundcover vegetation



Planted medians may be considered to shade asphalt roadways



Architectural shade structures can be used to improve pedestrian comfort

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Street trees that provide shaded pedestrian amenities

Cool Streets Guidelines

Methodologies for Cool Streets

Cool Street Elements

This section identifies implementable recommendations that build upon the previous section analysis of varying materials within the public realm. Nine thematic recommendations are defined that are comprised of both nature-based and built-environment elements as shown in the diagram below. Each element is further detailed including a descriptive overview as well as:

1. Effectiveness: Each element is ranked on a scale from one to three using symbology. Elements with one symbol are less effective in cooling streetscape environments but are desired or naturally occurring. Up to three symbols are most effective for cooling temperatures within the public realm based on findings from the materials analysis conducted as part of this study as well as industry best practices.

2. Costs: Implementation costs will vary greatly per element and on a project-by-project basis. Each element includes a general cost scale with one symbol indicating lower likely costs. Up to three symbols indicate higher likely cost for implementation.

Implementation

Concluding this section is the identification of implementation opportunities that may be applied throughout Downtown Silver Spring to implement Cool Street recommendations.

Nature-Based Elements

Street Trees	Groundcover Planting	Evaporative Cooling	Wind / Ventilation
■■■	■■	■	■
$	$	$$$	$

Recommended elements when combined, can reduce the UTCI, or "feels like" temperature by 20-25°F compared to existing conditions in Silver Spring

Built Environment Elements

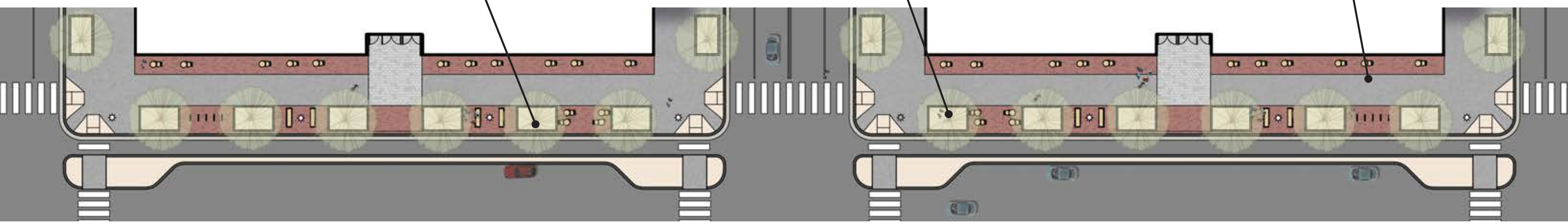
Paving	Pavement Removal	Architectural Shade Structures	Building Massing & Orientation	Evaporative Cooling
■■■	■■■	■■	■■■	■■
$$-$$$	$	$$	$	$-$$

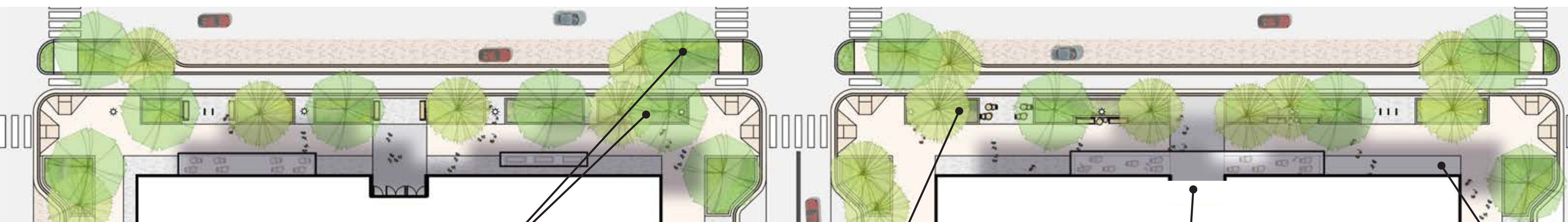
Existing Conditions

Lower Quantities of Trees in Several Areas

Constrained Planting Areas

Dark Pavers, Compacted Soil, Tree Grates, & Lack of Vegetative Surfaces





Street Trees

Groundcover Planting

Wind / Ventilation

Evaporative Cooling

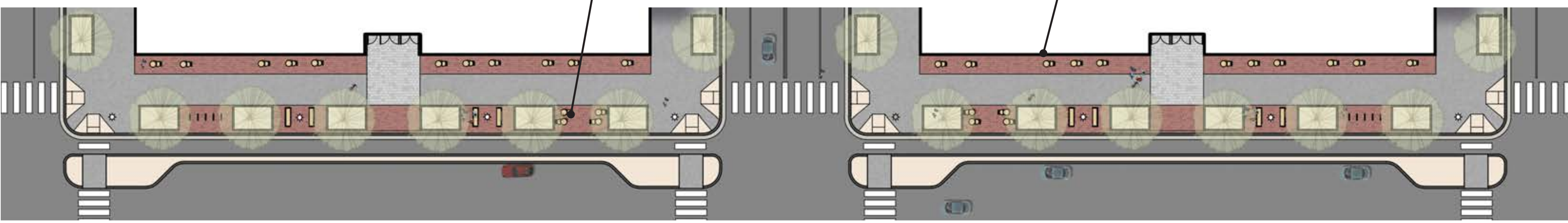
Proposed Cool Streets Elements

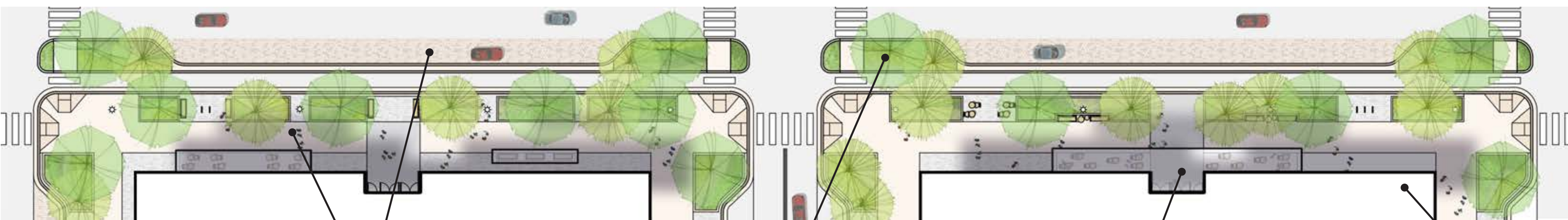
EXPANDED STREET TREE CANOPY

EXPANDED PLANTING AND BIORETENTION AREAS

USE OF NATURAL WIND CIRCULATION TO COOL AIR TEMPERATURES

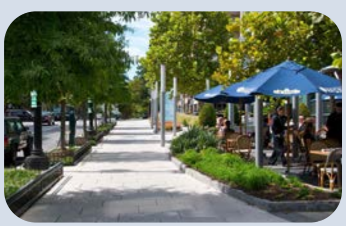
INCORPORATION OF WATER ELEMENTS





Paving

LIGHT-COLORED PAVING MATERIALS

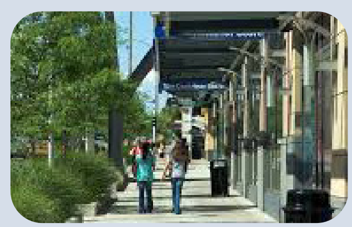


Pavement Removal

REMOVAL OF EXCESSIVE PAVING ALONG STREETS

Architectural Shade Structures

SHADED ROUTES AND RESPITES



Building Massing and Orientation

ORIENTATION OF BUILDINGS TO MAXIMIZE NATURAL VENTILATION AND SHADE

Nature-Based Cool Streets Elements

Street Trees

Effectiveness: ■■■
Order of Magnitude Cost: $

Trees introduces many benefits in the public realm including reduced air and noise pollution, protection of pedestrians from ultraviolet (UV) rays, and overall quality of life enhancement for residents and visitors. Moreover, trees are instrumental elements for creating cooler streetscape environments through shading and evapotranspiration. Trees not only provide shade for sidewalks, but they also shade adjacent roadway pavements and buildings further cooling the overall urban environment. Trees also contribute positively to the overall character and aesthetics of the public realm which can attract business and tourism.

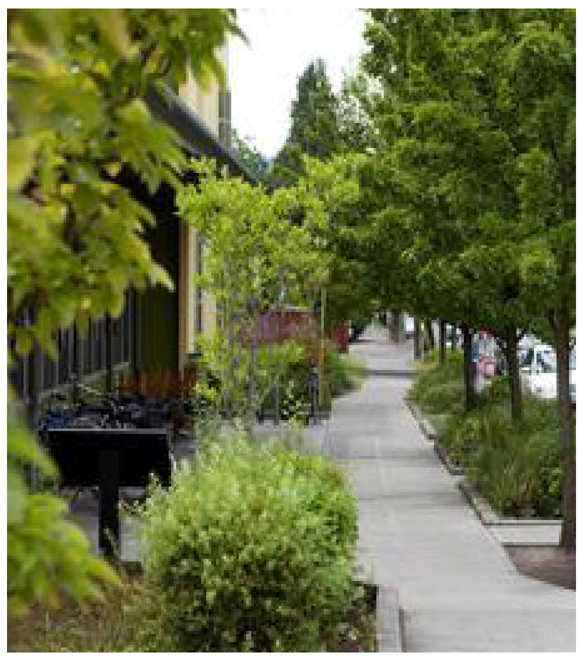
Street trees should be planted at regular intervals of at least 20 feet but no longer than 35 feet apart along both sides of streets, alleys, and medians. Deciduous trees should be planted along streets to optimize year-round comfort as it allows for passive solar heat gain during the winter-- which provides warmth during colder months. The planting of deciduous trees should be prioritized to the south, east, and west.

Groundcover Planting

Effectiveness: ■■
Order of Magnitude Cost: $

Incorporate dense vegetative groundcover where ever possible. Locate gathering areas near irrigated or mature vegetated zones, which will provide a thermal buffer of passive cooling. Curb extensions/bioretention planters are good tools in areas where right of way space is limited. They fit well at four way intersections in neighborhood streets or for mid-block crossings. They reduce the walking distance a pedestrian has to cross and they collect storm water off gutters. Since parking is not allowed at intersection corners, curbs can be extended the full width of a parking bay.

Street trees provide shade and contributes to the overall sense of place along corridors



Groundcover plantings soften the aesthetics of streetscape environments and provide an opportunity to create respites for pedestrians

Permeable paving and curbside bioretention planters as evaporative cooling elements

Pass-through between buildings created by alleys, pedestrian-ways, and streets can increase wind circulation through a site

Natural Evaporative Cooling

Effectiveness: ■

Order of Magnitude Cost: $$$

Cooler surface temperatures and natural evaporative cooling occurring in the landscape will improve the environmental temperatures. Elements that will maximize natural evaporative cooling include the use of permeable pavers and the incorporation of bioretention planters where possible.

Wind / Ventilation

Effectiveness: ■

Order of Magnitude Cost: $

Solar protection, wind access, and natural ventilation will make outdoor spaces more comfortable in summer. Whenever possible, pedestrian gathering spaces should be oriented and located to capture natural prevailing winds and winds enhanced by the built environment (e.g. increased winds between buildings and, along east-west facing streets).

Built Environment Cool Streets Elements

Paving

Effectiveness: ■■■

Order of Magnitude Cost: $$-$$$

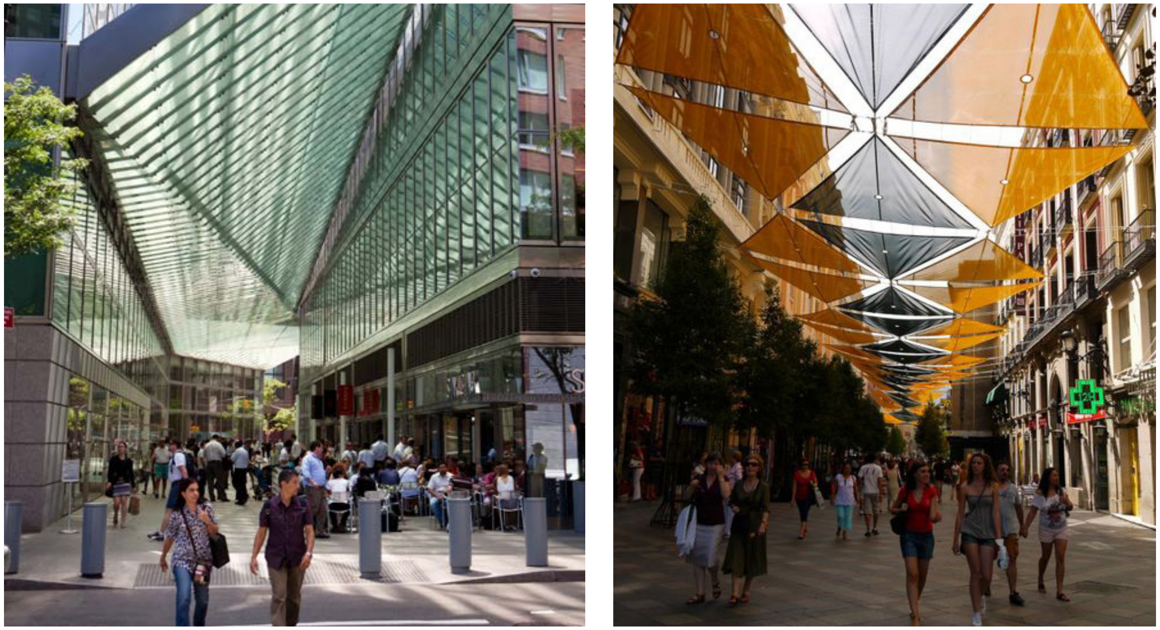
Paving materials comprise the majority of a given streetscape. As shown in the analysis, using light-colored paving, including concrete, asphalt, pavers, and brick with a three-year aged solar reflectance (SR) value of at least 0.28 or an initial SR of 0.33 can significantly reduce streetscape UTCI temperatures. Building upon these findings, it is recommended that streets include light-colored paving that responds to the proposed streetscape configuration contained within the streetscape guidelines. Concepts of primary proposed materials are illustrated on the diagrams to the right as examples of how cool-street recommendations may be implemented in Downtown Silver Spring:

1 Consider a mix of two tones of light-colored concrete unit pavers that is approximate in size to the Silver Spring Special Paver identified in the current Streetscape Standards. Explore opportunities to incorporate an open-grid pavement system (at least 50% unbound) and permeable on private streets and public spaces wherever feasible. The paving layout may be identical to the existing brick pattern and overall configuration recommended in the current Streetscape Guidelines to provide character continuity throughout the district.

2 Paving may include London Pavers in the same pattern and overall dimension of the current Silver Spring Streetscape Standard albeit in light-colored paving material. London Pavers could include a mix of three tones of concrete to provide visual interest and to reduce glare from light-colored concrete.

3 Areas between the curbs (outside of sidewalks) may include a range of material options including seal coatings/overlays, painted asphalt, poured-in-place concrete, or concrete unit pavers with a three-year aged solar reflectance (SR) value of at least 0.28 or an initial SR of 0.33. Material type implemented will depend on the project, budget and overall opportunity identified at the time of design/implementation.

Streetscape comprising of light-colored concrete paving



Pedestrian ways between buildings may include shade devices that can increase comfort and user experience

Building Massing & Orientation

Effectiveness: ■■■

Order of Magnitude Cost: $

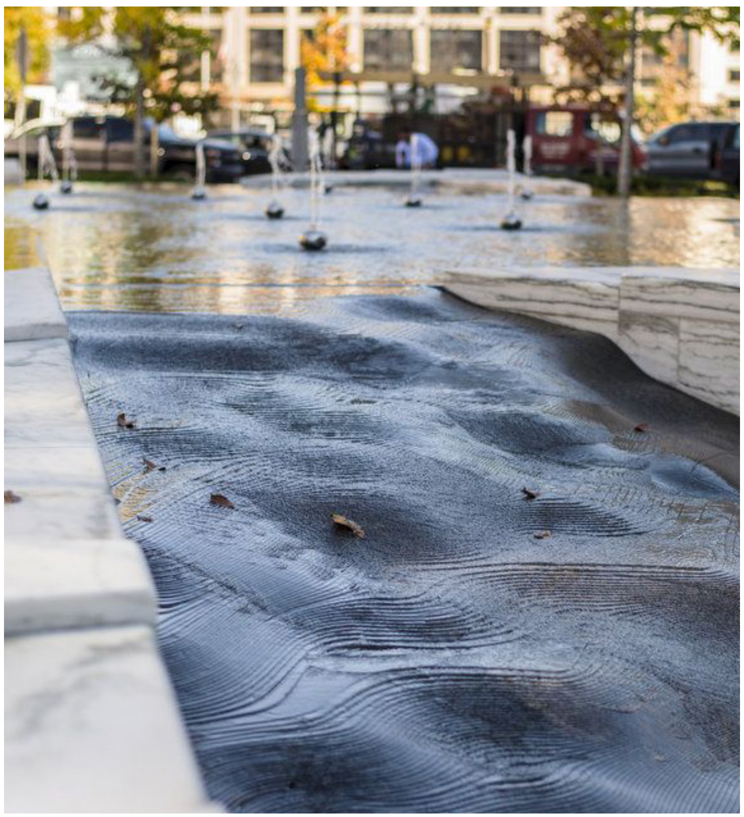
Where possible, avoid building barriers that block prevailing southern and western winds in the summer. Solar protection, wind access, and natural ventilation will make outdoor spaces more comfortable in summer. Explore opportunities during site design to incorporate pedestrian passageways and other building massing breaks to provide additional site circulation and opportunities for natural ventilation of public spaces/streetscapes.

Breaks and cut-through in building massing can increase pedestrian and wind circulation

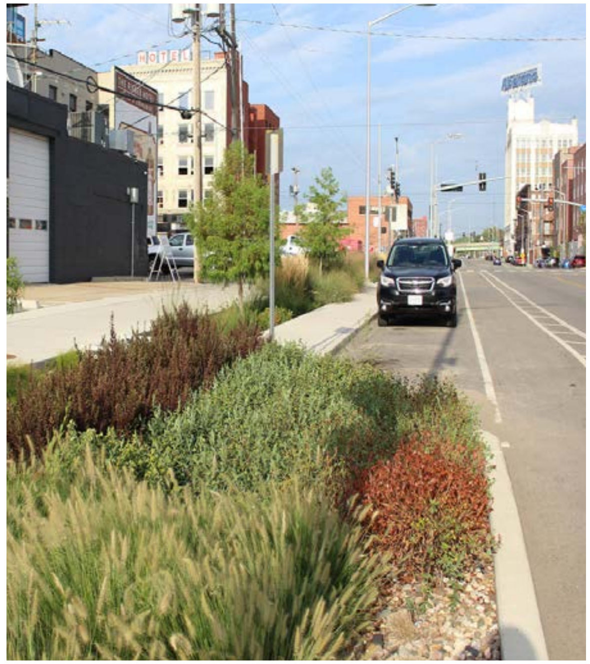
Built Environment Cool Streets Elements

Evaporative Cooling
Effectiveness: ■■
Order of Magnitude Cost: $-$$

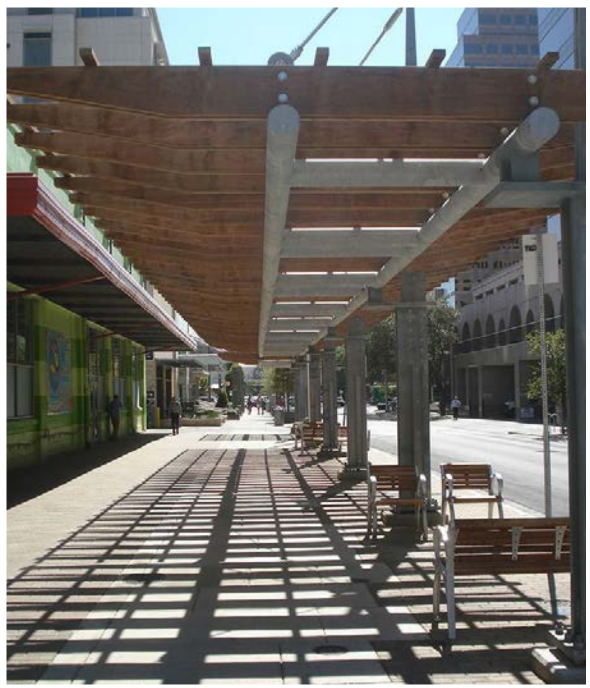
Explore opportunities to incorporate spray evaporative cooling devices such as misting stations in key public areas to provide even greater cooling in the summer months. Water features such as fountains and scrims can also provide evaporative cooling benefits.



Misters and fountains can increase evaporative cooling opportunities in the public realm



Underutilized hardscape areas can be converted to planted areas to reduce heat island effect



Shade structures can supplement tree canopies to create comfortable pedestrian environments

Pavement Removal

Effectiveness: ■■■
Order of Magnitude Cost: $

One of the simplest techniques for increasing permeable surfaces is to remove impervious surfaces. This technique is appropriate to implement in areas with excessively wide sidewalk zones, along major arterials, and at intersections where more paving exists than is necessary for pedestrian movement. Areas where pavement removal is implemented should be planted with groundcover vegetation and trees. Low impact development systems should be considered within these areas as feasible to increase opportunity for evaporative cooling.

Architectural Shade Structures

Effectiveness: ■■
Order of Magnitude Cost: $$

Shade structures may include transit structures, building awnings/canopies, and freestanding shelters. These structures can contribute to establishing a network of shaded routes that can provide respites for pedestrians in hot weather and shelter from precipitation. Shade structures can incorporate energy generation systems such as solar thermal collectors or photovoltaics.

Shade structures comprise a variety of materials, including fabric canopies, pergolas, and shelters. Shelter design should respond to context and reinforce local identity and sense of place.

Shade structures should include a SR value of at least 0.28 or an initial SR of 0.33.

Implementation

The implementation and long-term maintenance of cool street elements in Silver Spring may require funding from many resources due to the broad reach of opportunities that range in scale and type. The following list outline opportunities that could be investigated to implement cool street strategies.

Implementation Opportunities

Maintenance Projects

Community infrastructure projects related to underground utility maintenance, roadway resurfacing, and sidewalk replacement and infill present excellent opportunities for implementing cool street recommendations throughout Silver Spring.

Pilot/Demonstration Projects

These projects create excitement and provide an opportunity to test cool street installation techniques and maintenance considerations before wide-scale implementation. In addition, pilot projects can be used for public education about cool street tools and to create excitement in the community to rally support for larger-scale implementation of projects.

Site Development Projects

Downtown Silver Spring is a district that is continuing to evolve as there are several redevelopment projects underway, planned, or possible in the future throughout the area. Redevelopment of sites presents a great opportunity to encourage developers to implement cool street recommendations in the public realm and as part of the overall site development of these projects. MNCPPC staff should work with developers early in the site planning and design process to ensure measures such as appropriate building orientation and other site planning elements are considered. Incentives such as awards and recognitions to developers could be an effective way to bring awareness to innovative cool street implementation.

Capital Improvement Projects (CIP)

CIP funds may be used to implement many recommendations within the public rights-of-way. MNCPPC staff should coordinate cool street opportunities with major community infrastructure projects such as streetscape projects, roadway reconfigurations, park improvements, utility reconstructions, and other related projects.

Long-Term Considerations

Maintenance of Facilities

The implementation of all cool-street projects should be supported through long-term commitments to maintenance, ensuring that elements remain functional and aesthetically appealing.

Public Education

The Silver Spring community has expressed interest in cooling the area's public realm. The Cool Streets Guidelines contained herein represents a significant first step to realizing that interest. Overtime, t is important to keep the community engaged and updated as cool street projects are considered and implemented. Continually educating the public on the need and importance of cool street projects will help further increase project support.

Appendix

Appendix A: Analysis Tools & Resources

The material and streetscape design analysis included several tools and resources including:

Software

Rhino 6 was used for the 3D modeling in this analysis and Grasshopper with OpenStudio and Honeybee plugins were used for the climate simulations.

Weather File and Analysis Period

An EPW weather file developed by the United States Department of Energy (DoE) which is an industry standard for climate analysis. The EPW used for this analysis is comprised of data from the Baltimore/Washington International Thurgood Marshall Airport. The weather file represents the latest data from the DoE which includes the 'average' temperature between 2004-2018.

July 24th is used for the analysis period as it represents a typical hot summer day in this climate, which has dry bulb temperatures ranging from 78°F- 96°F, humidity at 41%- 82%, and full sun. The representative hot summer day used in the analysis, reaches peak temperatures between 12 P.M. and 3 P.M. during which it is 96°F. Therefore, we wanted to include those two periods to capture peak conditions.

Geometry

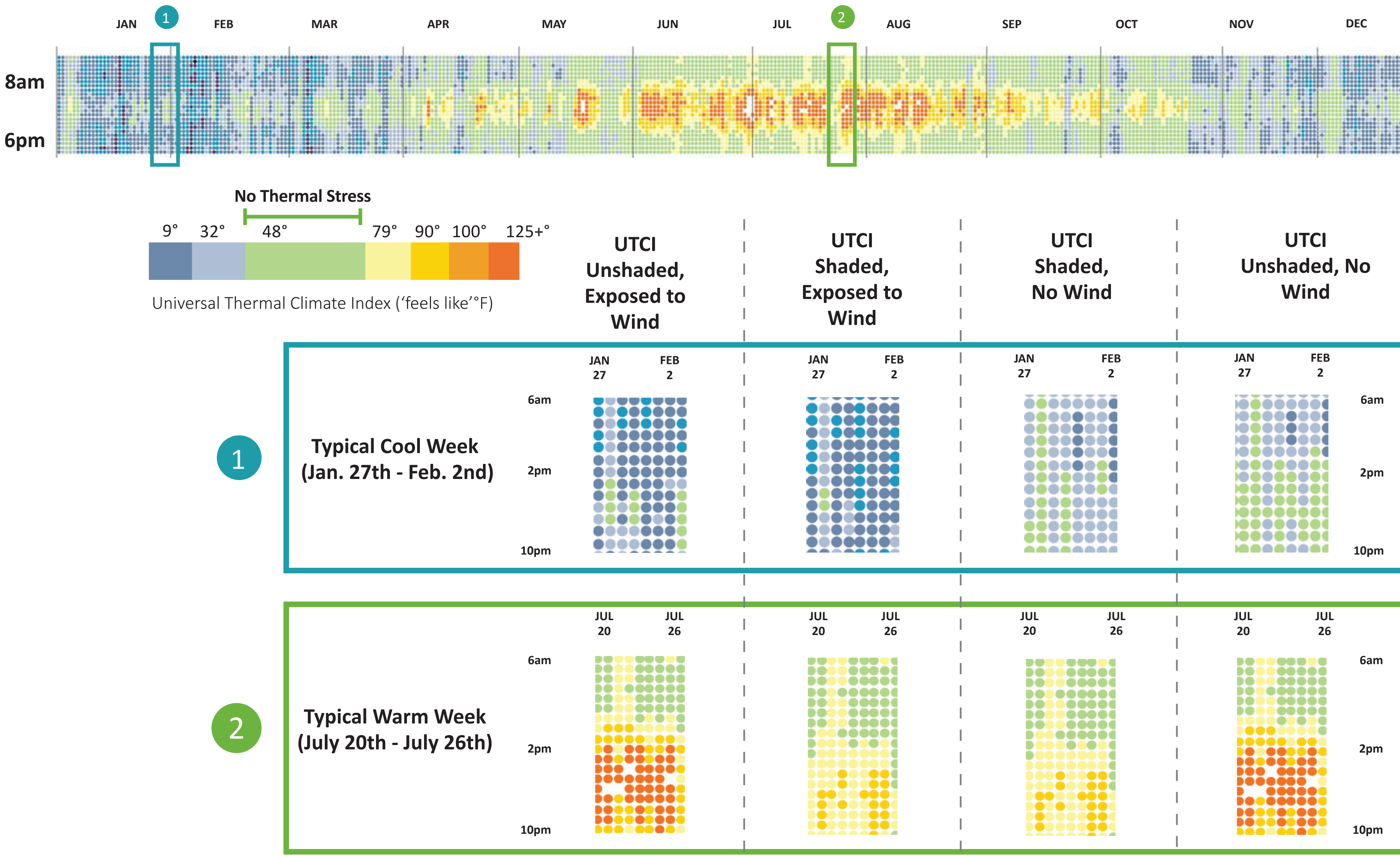
For the UTCI matrix, simple box geometry was used for each of the nine material types. This was done to estimate the UTCI of the environment when using different paving materials in isolate from any surrounding context such as buildings or street trees that provide additional shading or block the sun.

In the spatial UTCI analysis, a 3D model was developed as a representative streetscape in Downtown Silver Spring. This streetscape section is based on the typical conditions along Fenton

Street that was shared in a Sketch Up model received on 3/17/2022 by MNCPPC staff. Building and street tree heights were assumed based on coordination with MNCPPC as well.

Model Assumptions	
Simulation Engine	Rhino with Grasshopper
Weather File	Baltimore/Washington International Thurgood Marshall Airport EPW
Context	Representative section of downtown Silver Spring based on Sketchup model provided on 03/17/2022 and coordination on building heights and street trees.
Building Heights	Buildings on the east side of Fenton are between 30-65 feet tall and the buildings to the west are up to 130 feet tall but have two-story setbacks.
Tree Heights	A mix of young, medium, and mature trees are included with height varying between 20-65 feet tall. Canopy is assumed 75% leaf coverage and 25% open to the sky.
Analysis Period	Annual Hourly UTCI: Hourly 1/1- 12/31 UTCI Matrix: Hourly July 24th 12 A.M.- 11 P.M. UTCI Spatial Mapping: July 24th 9 A.M., 12 P.M., 3 P.M.

Appendix B: Annual Hourly Universal Thermal Climate Index (Baseline Climate Condition - Unshaded, Exposed to Wind)



Appendix C: Material Assumptions

CASE	MATERIAL	Location	THERMAL CONDUCTIVITY [Btu-in/h-ft2-°F]	SPECIFIC HEAT [Btu/lb.-°F]	DENSITY [LB./FT3]	THERMAL ABSORPTANCE/ EMISSIVITY	SOLAR ABSORTANCE	DESIGN BUILDER MATERIAL ASSUMPTION	A10 NOTES
BASELINE MATERIALS	Red brick pavers	Frontage and furnishing zones	4.99	0.20	119.86	0.9	0.68	"Brick"	*Adjusted solar absorptance by +0.08 based on additional reference*
	Black Metal Grate	Planting zones	388.35	0.13	468.21	0.9	0.90	"Metals - iron, cast"	
	Concrete unit pavers with charcoal Tudor finish	Pedestrian Zones	6.66	0.20	124.86	0.9	0.75	"Interlocking 'antique Cobble' pavers (grey)"	*Adjusted solar absorptance by +0.15 to account for charcoal finish*
	Standard Asphalt	Roadway, parking lane, and curb	4.85	0.24	131.10	0.9	0.85	"Asphalt"	*N/A*
PROPOSED MATERIALS	Light-colored brick with SRI of 82 or higher	Frontage zone	4.99	0.20	119.86	0.9	0.50	"Brick"	*Adjusted solar absorptance by -0.02*
	Light-colored concrete pavers with SRI of 82 or higher	Pedestrian Zones	6.66	0.20	124.86	0.9	0.58	"Concrete, cast - heavyweight Dry"	*Adjusted thermal conductivity to match concrete unit pavers*
	Light-colored asphalt with SRI of 82 or higher	Roadway and curb	8.32	0.41	143.58	0.9	0.60	"Asphalt - reflective coat"	*N/A*
	Open-grid Paving with Light-colored concrete pavers with SRI of 82 or higher	Furnishing zone and parking lane'	6.66	0.20	124.86	0.9	0.58	"Concrete, cast - heavyweight Dry"	*Open-grid concrete is 50% unbound with grass*

Appendix D: Climate Assumptions - July 24th

TIME OF DAY	DRY-BULB TEMPERATURE [°C]	DRY-BULB TEMPERATURE [°F]	WIND SPEED [M/S]	RELATIVE HUMIDITY [%]
12:00 AM	26.1	79.0	3.1	77.0
1:00 AM	26.1	79.0	3.1	77.0
2:00 AM	25.0	77.0	2.6	82.0
3:00 AM	25.0	77.0	4.1	82.0
4:00 AM	25.0	77.0	3.6	79.0
5:00 AM	25.6	78.1	3.1	76.0
6:00 AM	28.3	82.9	3.6	65.0
7:00 AM	28.3	82.9	3.6	65.0
8:00 AM	32.2	90.0	5.1	54.0
9:00 AM	33.3	91.9	3.1	51.0
10:00 AM	33.9	93.0	3.6	49.0
11:00 AM	34.4	93.9	4.6	45.0
12:00 PM	35.6	96.1	6.2	42.0
1:00 PM	35.6	96.1	6.2	42.0
2:00 PM	36.1	97.0	5.1	41.0
3:00 PM	35.6	96.1	5.1	43.0
4:00 PM	33.9	93.0	4.6	46.0
5:00 PM	34.4	93.9	4.1	46.0
6:00 PM	31.1	88.0	5.1	57.0
7:00 PM	27.2	81.0	3.1	72.0
8:00 PM	25.0	77.0	1.5	84.0
9:00 PM	23.9	75.0	1.5	90.0
10:00 PM	23.3	73.9	2.1	94.0
11:00 PM	22.8	73.0	0.0	94.0

Appendix E: Point-in-time Peak Analysis - Results Graphs Plotted by Environmental Condition

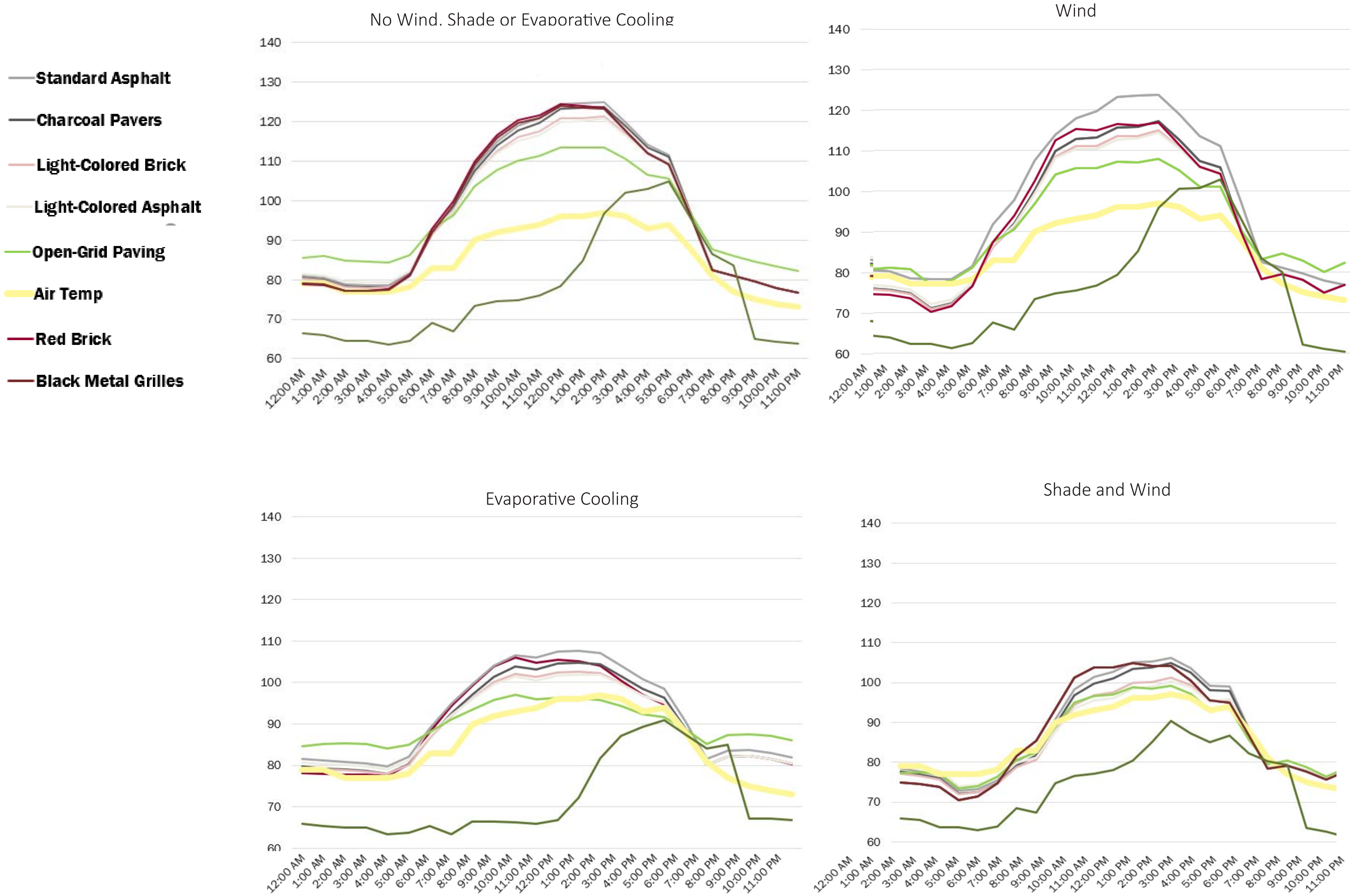


Figure 6. Point-In-Time UTCI Result Graphs

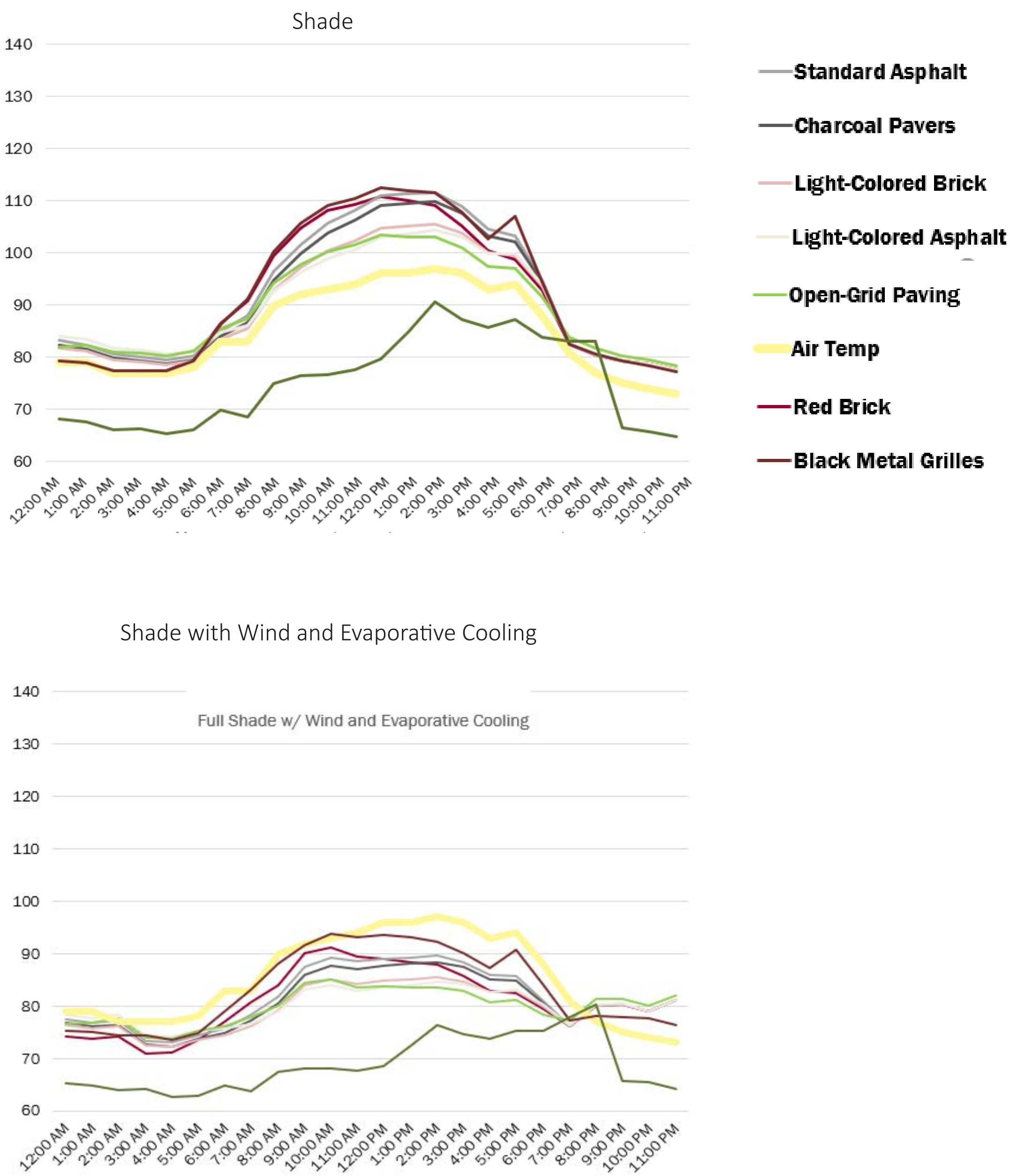


Figure 6. Point-In-Time UTCI Result Graphs

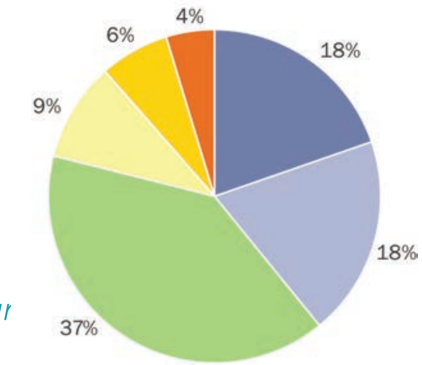
Appendix F: Annual Summary - Percentage of Hours within Comfort Bands

The graphs to the left, further explores typical hot week between July 20th- July 26th and the typical cool week between January 27th and February 2nd across a range of environmental conditions, demonstrating the cooling effect that wind and shade can provide.

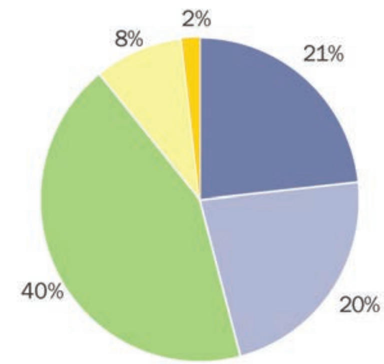
During the analysis it was observed that providing wind and solar protection increases hours with 'no thermal stress' from 37% to 60% of hours annually and reduces "very strong heat stress".

The analysis on this page is for annual UTCI and therefore has a range of wind speeds, based on hourly wind data per year. The highest wind speed captured in this analysis is 37 miles per hour. A separate analysis would be needed to determine the minimum wind speed needed to reduce UTCI.

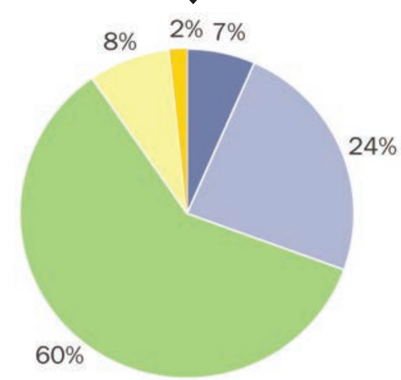
Annual Summary - Percentage of Hour within Comfort Bands



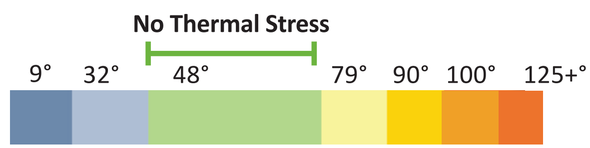
(Percent of Hours within Comfort Bands: Unshaded, Exposed to Wind)



(Percent of Hours within Comfort Bands: (Shaded, Exposed to Wind)



(Percent of Hours within Comfort Bands: (with Shade & Wind Protection)



Universal Thermal Climate Index ('feels like'°F)