Metropolitan Government of Nashville and Davidson County

CLIMATE ADAPTATION AND RESILIENCE PLAN

SEPTEMBER 2023

CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

BUILDING A BETTER AND MORE RESILIENT CITY FOR FUTURE GENERATIONS: A LETTER FROM MAYOR COOPER

Nashville's *Climate Adaptation and Resilience Plan* (Plan) marks the consummation of years of thought leadership by more than fifty (50) Metro departments and hundreds of community stakeholders to identify and carry out concrete steps to improve Nashville's climate responsibility and readiness. It also represents our city's first effort to approach the climate crisis from a stance of resilience, recognizing that the earth's climate has already changed and that the time is here to adapt, harden, and prepare for the inevitable impacts that will continue to challenge our way of life.

In the past four years, we have witnessed multiple extreme weather events—a tornado, multi-day extreme cold and winter weather events, a derecho and numerous high wind events, extreme heat emergencies and multiple flooding incidents—wreaking havoc on Nashville's infrastructure and communities, resulting in loss of life and damage to property. This Plan takes a significant step towards adapting our city to climate change. It sets forth strategies that will transform our infrastructure, community and culture, natural environment, economy, and public safety systems such that we are better prepared to withstand, recover from, and thrive in spite of climate events. The Plan is centered on people, recognizing that inequality of access to opportunities, resources, and a healthy environment has placed a disproportionate burden on many of our communities and requires targeted intervention and correction of historic wrongs.

In the past four years, we have also taken significant strides toward creating a more equitable and prosperous city. Together, we have made transformational investments in our schools, built environment, public and emergency services, and green spaces. We have demonstrated our commitment to climate action by encoding greenhouse gas emissions reduction targets and pursuing numerous programs to increase our renewable energy base. We have improved the stability and efficiency of our buildings, taken advantage of technological innovations in lighting and transportation, and gained a better understanding of our climate vulnerabilities. It is my hope that the achievements we have realized together will be carried forward and multiplied in the coming years.

As a companion document to the Sustainability Advisory Committee's 2021 Climate Action Plan, this Plan better equips Nashville to execute its mitigation and adaptation commitments under the Global Covenant of Mayors for Climate & Energy. With these plans as a foundation, our city must commit to implementation, focusing on innovative investments that create a low-emission and climate-resilient future for generations to come.

Mayor John Cooper

ACKNOWLEDGEMENTS

Dear Readers,

This Climate Adaptation and Resilience Plan (CARP) was developed during the Spring and Summer of 2023 by the Office of Mayor John Cooper in collaboration with representatives of Metro Nashville departments and myriad stakeholders representing diverse and multidisciplinary interests across the community. It builds upon significant work and extensive outreach completed by Mayor Cooper's Sustainability Advisory Committee as part of its climate adaptation planning effort in 2020-2021, and prior comprehensive planning efforts for the city, including but not limited to Imagine East Bank, Nashville Next, Plan to Play, the Metro Nashville Transportation Plan, and nMotion. It is an intensely collaborative work product, which would not have been possible without the contributions of many.

In particular, we want to thank the Metro departments and offices and their staff who took part in a series of workshops and served as architects for the roadmap contained in this Plan and the internal resiliency toolkit that supports it:

- Office of Emergency Management
- Finance
- Planning
- General Services
- Health
- Information Technology Services
- Mayor's Office
- Metro Water Services
- Metro Waste Services
- Nashville Department of Transportation and Multimodal Infrastructure (NDOT)
- Parks and Recreation
- Social Services
- WeGo.

We especially appreciate Metro Water Services, General Services, and NDOT for their willingness to pilot specific templates and/or commit to leading creation of procedures that will become part of the evolving toolkit for use across Metro government.

The Wond'ry Innovation Center at Vanderbilt University served as a phenomenal host for the workshop series. Their energetic and capable staff, including Social Innovation Director Jaclyn Mothupi, and coordinators Dan Drogosh, Sarah Saeed, and Karol Sadkowski, graciously facilitated these important conversations, assisted with event preparation, and kept us focused and inspired.

Janey Camp and Jaclyn Mothupi, both with Vanderbilt University and members of the Sustainability Advisory Committee, created the foundation for this plan in the adaptation chapter they drafted for the 2021 Climate Action Plan. Their efforts gave us a head start on identifying the most significant hazards and vulnerabilities. Our appreciation is also extended to the entire Sustainability Advisory Committee for their review and feedback on impact chains, support in

identifying adaptation strategies, and reviewing the draft CARP prior to its release for public review.

The Environmental Law Institute's Linda Breggin, Margaret Badding, and Sarah Backer researched and summarized best practices in local and state climate action and resilience planning, allowing us to greatly expedite aspects of the adaptation strategy roadmap.

Gratitude is sincerely extended to the U.S. Department of Housing and Urban Development's Community Compass technical assistance program for enabling an expert review of the draft CARP. The insight and knowledge of Janice Barnes and Scott Davis is reflected throughout this document.

Zachary Wampler, who served as a Resilience and Sustainability Intern with the Mayor's Office during the spring of 2023, contributed his knowledge and authored pieces of this Plan related to heat and to green gentrification, in the midst of completing a Bachelor of Science thesis at Vanderbilt University on heat vulnerability and the consequences of development in urban settings.

And finally, sincere thanks to the FUSE Corps Program for their commitment to public sector work that builds equity and accelerates systems change, and to the Community Foundation of Middle Tennessee. Without their joint support this intensive year of resilience work would not have been possible.

We are privileged to have worked with many capable, committed, and intelligent individuals as part of this process and thank Mayor Cooper for his dedication to building a stronger Nashville in the face of a changing climate.

To a resilient future,

Kristin Stroup
FUSE Corps Executive Fellow, Building Resilience in City Operations
Office of Mayor John Cooper

Kendra Abkowitz
Chief Sustainability and Resilience Officer
Office of Mayor John Cooper
kendra.abkowitz@nashville.gov

EXECUTIVE SUMMARY

Nashville and communities across the globe are experiencing the effects of climate change. Locally, we are facing more extreme heat days, severe storms, and flooding that is taking a toll on our community. Our need to be prepared for climate hazards is abundantly clear. Absent thoughtful, intentional, and forward-thinking planning and investments, we will see continued loss of life and property, and decline of wellbeing, due to climate change.

To prepare Nashville and ensure its citizens' ability to thrive for years to come, the Office of Mayor John Cooper, in partnership with Metro Nashville departments and the Mayor's Sustainability Advisory Committee (SAC), have developed this Climate Adaptation and Resilience Plan (CARP). The intent of the Plan is to guide future Metro investment and actions in both hard and soft infrastructure, and to improve the city's resilience to climate-driven hazards, in an equitable and transparent way. Key Goals of the CARP are listed in Figure 1 below.

Figure 1. Key Goals of Metro's Climate Adaptation and Resilience Plan.

Recognizing that social inequality is a persistent reality, the CARP places an emphasis on identifying and addressing the structural and institutional factors that have placed racial and ethnic

minority groups on the front lines of climate change. It recognizes that climate change is a risk multiplier, and without careful and targeted intervention, climate change will continue to have disproportionate impacts on these communities.

This Plan comprises Metro's first climate-focused risk assessment. Risk should be understood as the sum total of all potential impacts or consequences resulting from a particular event, based on its characteristics, probability, and magnitude. There are two determining factors for how the event unfolds in context: Exposure and vulnerability. The ability of a built asset, system, or living thing to adapt when exposed to a hazard will either decrease or amplify the magnitude of the impact, and therefore the outcome. Assets, systems, and living beings that are vulnerable prior to the impact occurring are less likely to be able to adapt, survive, and thrive. Therefore, improving adaptability is dependent upon reducing vulnerability.

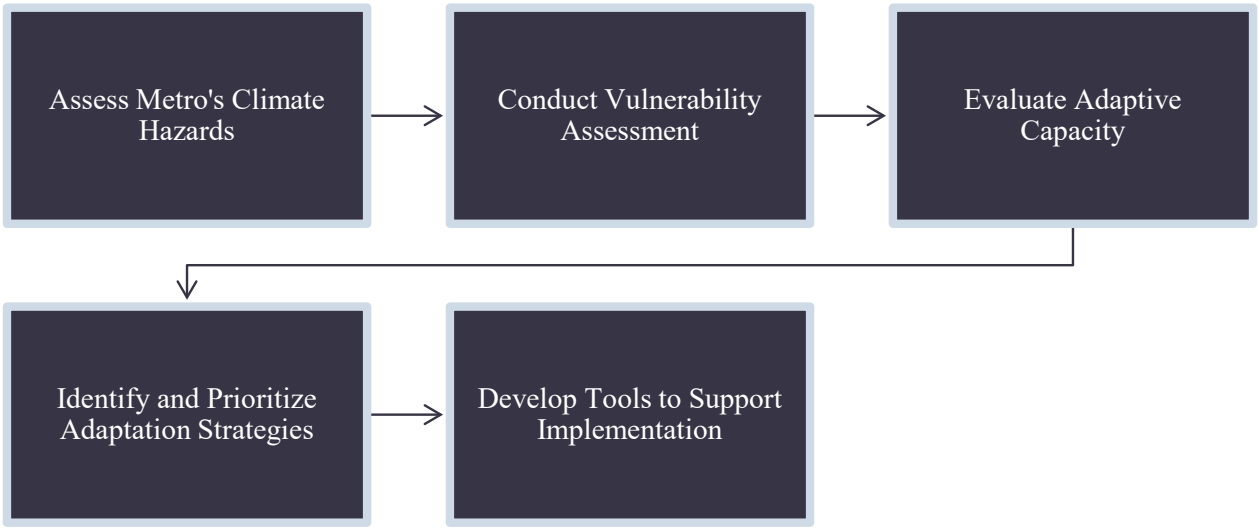
There are two key points in this regard:

1. Throughout this Plan *risk* and *vulnerability* are terms that may be used interchangeably;
2. Risk and exposure are not the same. Metro's adaptation and resilience strategies must be targeted to assets, systems, and most importantly, communities and individuals whose baseline level of vulnerability starts out higher than others with similar levels of exposure.

While the focus of this report is climate-related risks, the concept of resilience also contemplates preparation and recovery in the face of other risks, including hazardous materials incidents, communicable diseases, cyber threats, and terrorism. Strategies contemplated in the CARP are intended to be co-beneficial in building resilience to non-climate-related risks, and achieving returns beyond the environmental.

The adaptation planning process taken by Metro includes five primary steps, each of which is summarized in the following sections. An illustration of the planning process follows in Figure 2.

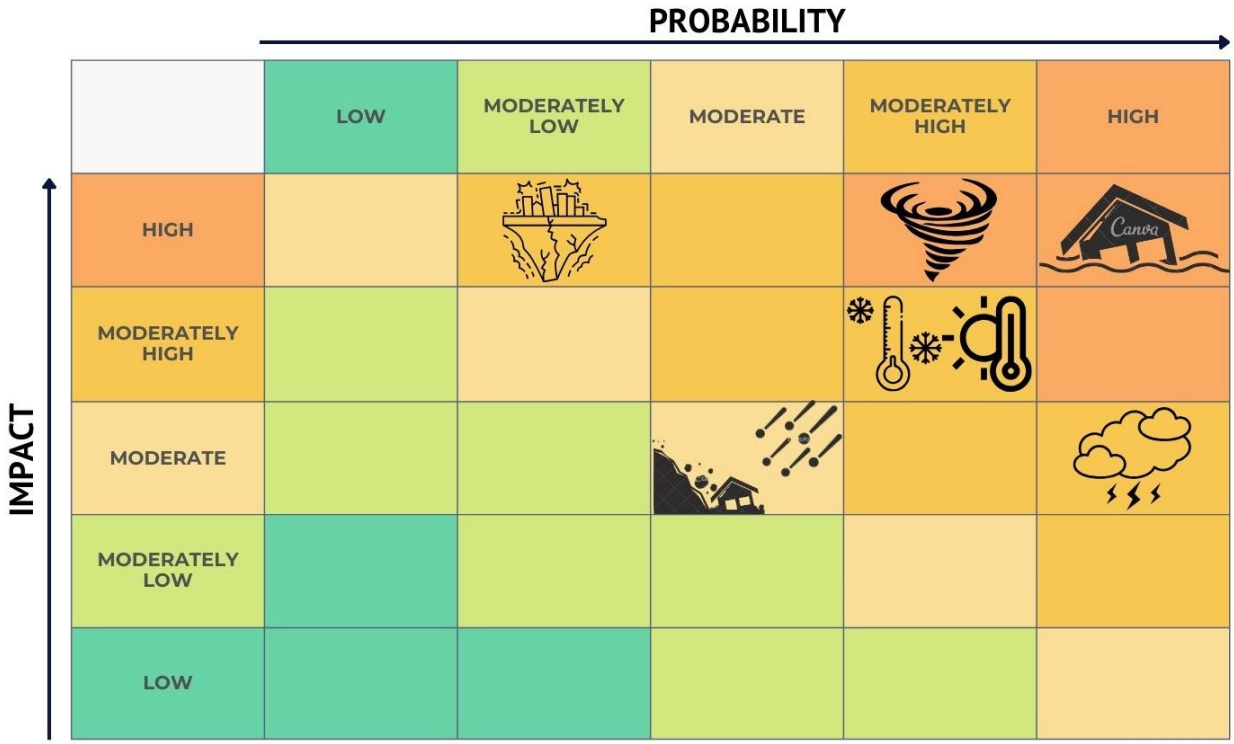
Figure 2. Metro's Adaptation Planning Process.



STEP 1: ASSESS METRO'S CLIMATE HAZARDS

Assessing Nashville's climate risk started with an identification of its top climate hazards, which is based on frequency and severity of historical climate events, projections for future climate trends, and a review of available data, including considerations of exposure and vulnerability. This assessment revealed that Metro's most significant climate hazards are flooding (riverine and pluvial), tornadoes, extreme heat, extreme cold/winter weather, and severe thunderstorms, followed by earthquakes, landslides, and hail. A mapping of probability and potential impact of Metro's climate hazards is depicted in Figure 3 below.

Figure 3. Metro's Climate Hazards, Ranked.



Due to both resource and time limitations, the CARP focuses on the top five hazards for near-term planning, and recommends that the next iteration include, at minimum, seismic risk and the city's significant non-climate risks as part of a comprehensive risk assessment and resilience plan.

STEP 2: CONDUCT SYSTEMS-BASED VULNERABILITY ASSESSMENT

Prior to the development of this Plan, Metro had not conducted a comprehensive climate risk assessment, which is a key aspect of any adaptation and/or resilience plan. A full evaluation of risk requires an understanding of how climate-related hazards—both individual events, or shocks, and longer-term trends, or stressors—affect or could potentially affect all aspects of life in the city. This includes the built environment, the social and cultural characteristics of society, and the economy, as well as the interdependencies and cascading impacts between these systems. For this

reason, and to fully understand opportunities to build equity and target interventions to address specific baseline vulnerabilities, Metro has chosen to evaluate its risks from a systems approach.

As noted above, the CARP is necessarily limited and is offered as a starting point and a catalyst. Resources did not permit a detailed audit of Metro's infrastructure, services, natural resources, and community needs and priorities, neither did it allow for a gaps analysis that would ensure a full reflection of existing opportunities. Rather, the aim is to establish a framework that Metro departments can use to evaluate their own specific assets, programs and services, consider their own risks, shape their future plans and budgets, and inform their community outreach and engagement, all with the aim of building Metro's resilience to climate risks.

To conduct the vulnerability assessment, Metro worked through several steps. First, Metro developed a system "map" to delineate and characterize all aspects of its ecosystem, based on five pillars and their sub-components. Then, each sub-component in the map was paired with each of the top climate hazards to determine the (1) level of hazard risk based on the severity of potential impact and (2) level of vulnerability based on the existing or potential adaptive capacity. Ultimately, recognizing that cascading impacts lead to significant overlap, and to distinguish exposure from risk, an impact chain approach was employed and conducted jointly by representatives from Metro departments. This multi-step approach supported Metro's aim to identify the aspects of its ecosystem that are at highest risk, and to consider intervention strategies that target both the outcomes and root causes for that risk, within a human- and equity-centered lens.

Table 1. Metro's System Map.

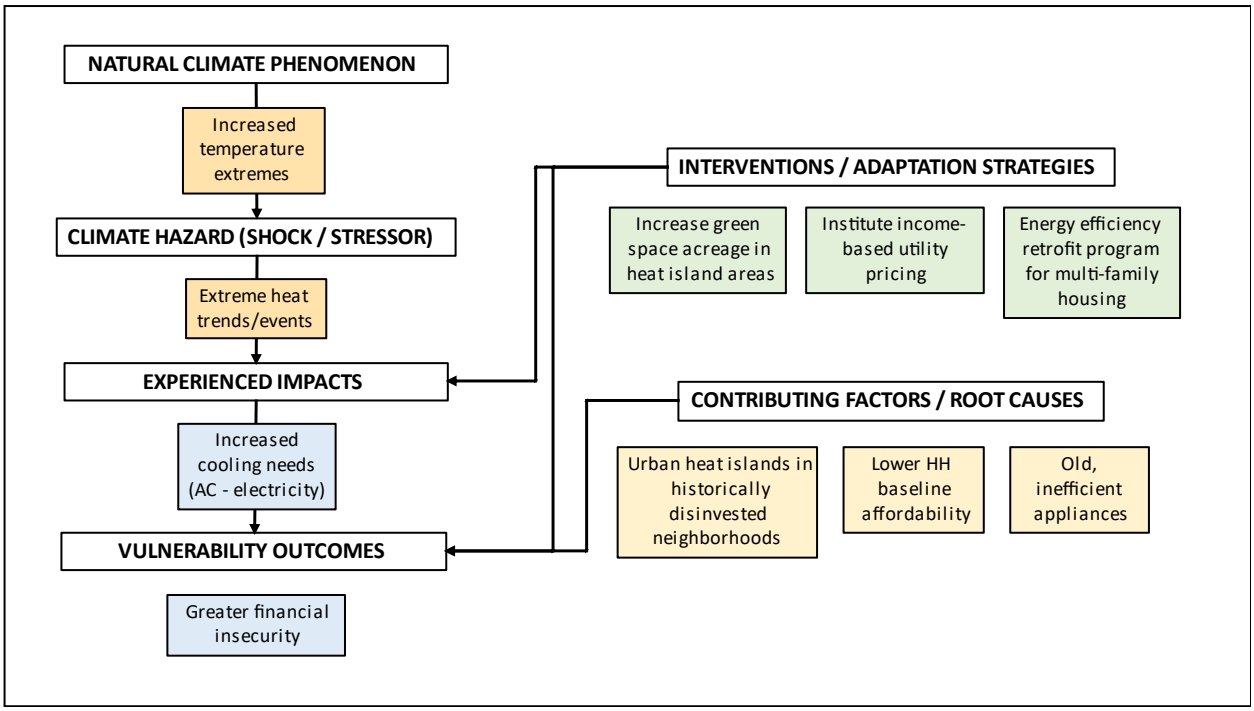
									
Community & Culture		**Natural Environment**		**Infrastructure**		**Economy**		**Public Safety**	
A	Livelihood and affordability	D	Ecosystem services	H	Energy generation	N	Agriculture	Q	Emergency services
B	Health and wellbeing	E	Flora/forests/ trees	I	Energy transmission	O	Supply chain	R	Law and order
C	Access to goods and services	F	Watersheds/ hydrology	J	Water supply	P	Business continuity	S	Government Services
		G	Fauna/native species	K	Storm/waste-water and waste management			T	Community Safety
				L	Communications				
				M	Transportation				
Crosscutting: Equity									

STEP 3: EVALUATE ADAPTIVE CAPACITY

Once the most critical areas of vulnerability had been identified, Metro sought to identify specific focal areas for intervention toward development of an adaptation plan. That is, the aim was to identify the adaptive capacity of the affected system sub-component. The impact chain allowed for the start of that work.

An impact chain is a conceptual framework that breaks down a risk into its multiple parts. Starting from the natural phenomenon, it asks the evaluator to think from the occurrence of the hazard through the immediate, direct impacts to the indirect impacts or vulnerability outcomes. It then asks the evaluator to identify the factors that exacerbate both the direct and indirect impacts. Once the full context of the impact is understood, the evaluator can begin to identify potential interventions and adaptation strategies. An example for extreme heat, and one direct impact, is given in Figure 4 below.

Figure 4. A Brief Impact Chain Example.



Once Metro had confirmed its priority focal areas, a suite of potential strategies was developed based on a review of best practices in other cities, states, and countries. Ultimately, a database of 60 potential strategies was composed, including links to guidance documents and other city examples. Of these 60 strategies, 24 (40%) represent an opportunity to scale up or expand initiatives Metro already has underway. In other words, the adaptation plan contained in this document can be launched to some extent today, without a need for the next budgetary cycle.

STEP 4: IDENTIFY AND PRIORITIZE ADAPTATION STRATEGIES

The next step in the adaptation planning process was prioritization of the adaptation strategies and development of an implementation plan. Metro focused on those strategies that:

1. Will make the biggest impact;
2. Are within Metro's control;
3. Target the livelihoods and wellbeing of Metro's frontline and vulnerable communities; and
4. Are achievable in the near term without requiring substantial capital infusion.

Following a workshopped prioritization exercise, the authors developed an Implementation Roadmap. In recognition of the uncertainty that characterizes the climate crisis, the rapid pace of technological advancement, and the need for a more robust technical and scientific risk analysis, the Roadmap is primarily focused on the near term. It includes a timeframe and identifies the Metro department(s) responsible for executing each strategy. It is organized under four main goals that focus on Nashville's people, infrastructure, natural environment, and the mission of its government. Figure 5 on the next page provides an overview of the Roadmap's main goals and their corresponding objectives.

Metro also endeavored to develop a set of metrics for measuring the progress of each goal. Generally, these metrics can be grouped into seven main categories, which are tailored for the goals to which they apply:

- Outreach and training conducted on climate adaptation and resilience;
- Metro-budgeted dollars allocated and spent on equitable climate adaptation and resilience;
- Grant-sourced dollars secured for equitable climate adaptation and resilience;
- Number of departments with climate adaptation and resilience plans;
- Number of staff directly focused on equitable climate adaptation and resilience;
- Number of policies, ordinances, codes and other new requirements related to equitable climate adaptation and resilience; and
- Acres of green space added.

The indicators are only intended to kickstart Metro-wide performance tracking. The next iteration of the CARP must include absolute, not relative, targets tracked using metrics that will measure the outcomes of the adaptation or resilience strategy. To truly track climate resilience and to confirm that the benefits of Metro's adaptation and resilience work are accruing to the populations that need and deserve it most, a suite of equity-focused, location-specific indicators need to be included. These should be chosen in concert with representatives of the relevant communities and local community-based organizations, to ensure the indicators address the necessary exposures and corrective targets.

Goals	1						2			3		4		
	Ensure Nashville is equitable, safe, accessible, and affordable for all residents in the context of a changing climate						Improve and protect public infrastructure and services from growing climate risks			Protect and preserve nature for future generations		Make equitable climate resilience a standard operating procedure for Metro Government		
Objectives	Educate and Empower	Improve Access to Necessities and Services	Increase Stability of the Residential Environment	Ensure Habitability of the Ambient Environment	Create Equitable Economic Opportunity	Protect and Prepare	Plan and Adapt	Asset Management and Optimization	Build Redundancy and Strengthen Defenses	Preserve and Expand Green and Wild Spaces	Support Nature's Inherent Attributes	Require, Encode, and Ingrain	Quantify, Measure and Track	Train and Instill a Culture of Readiness
Strategies	Conduct climate-specific outreach and capacity building	Create affordability plans for utility services	Retrofit, weatherize, and green-cool buildings	Enhance development controls and protections in flood zones	Remedy climate injustice	Develop strategies for extreme temperature protection	Adaptation Planning for Critical Infrastructure and Services	Review and Optimize Asset Management Programs	Improve Robustness and Redundancy of critical services and facilities	Finance and require more green and less grey	Employ natural flood mitigation strategies	Optimize codes, zoning ordinances, and design standards	Map hazards and vulnerability for public information and internal decision-making	Conduct Resilience and Readiness Training Exercises and Drills
	Enable community resiliency hubs	Make health care affordable and accessible	Optimize codes, zoning ordinances, and design standards	Expand greenery and deploy other strategies for heat control	Prevent green gentrification	Expand emergency shelters at the community level	Facility Energy Management Planning	Creative approaches to valuation of public assets	Identify and correct single points of failure	Empower the public to protect the environment	Incentivize and control upstream practices	Develop and embed standard operating procedures into planning processes	Department-level risk assessments and master planning	Improve Field Staff Safety Standards
	Incentivize to innovate and build resilience	Improve safety, efficiency, and multimodality of public transportation	Identify safety issues before they occur	Scale up low-impact approaches for stormwater management	Create climate-focused workforce development programs		Contingency planning for financial resources and the supply chain			Incentivize the private sector	Control Invasive Species	Integrate Resilience criteria into Budgets		Ensure Comprehensive Disaster Planning, Monitoring, Documentation and Communication
		Grow urban gardens and food forests		Address historic and current harms from traffic			Leveraging regional partnerships and assets					Adopt smarter procurement policies		
							Synthesizing policy							

Figure 5. Metro's Climate Adaptation and Resilience Goals.

STEP 5: DEVELOP TOOLS TO SUPPORT IMPLEMENTATION

As a companion initiative to the CARP, Metro developed the framework for an internal (e.g. non-public) Climate Resiliency Toolkit to build the understanding of Metro department leadership and staff and their capacity to implement the initiatives contained in this Plan. The objective of the toolkit is to ingrain a climate resilience lens within each of Metro's 53 departments' existing strategic planning and budgeting processes, in line with Goal 4 of the CARP. The initial version of the toolkit includes foundational primers, an internal action plan to supplement the Implementation Roadmap contained herein, simple templates for sustainability and resilience tools such as audits and hazard vulnerability assessments, training materials, and a directory of departmental points of contacts working on sustainability and resilience (which comprises the working group that developed this Plan).

Similar to this Plan, the toolkit is intended to be a 'living' resource that is improved and expanded upon as it is implemented. Ultimately, with additional effort, the Toolkit could form the basis of a public-facing, community-oriented Resiliency Toolkit deployed by partner organizations. Metro could also consider peer learning with sister cities that might be looking to develop similar resources.

CRITICAL NEXT STEPS

Development of the CARP has built significant momentum, which should be harnessed to ensure the city's climate resilience work continues. Nashville is already seeing the impacts of a changing climate, and it is imperative that the city take action to prepare and protect its residents. While the Implementation Roadmap outlines numerous actions that should be taken in the coming months and years, and the subsequent section addresses evaluation and communication to follow the CARP's release, there are five urgent next steps as summarized below.

1. Ensure continuity amidst administration change through delegation of climate work to at least one staff person in the Mayor's Office, appointing members to the Sustainability Advisory Committee formed by Ordinance BL2023-2004, and formation of a Climate Working Group.
2. Continue engaging with the public on climate adaptation and resilience, and incorporate feedback received on the draft version of the CARP.
3. Include climate adaptation and resilience in budgeting processes.
4. Identify performance indicators for climate adaptation and resilience.
5. Build climate adaptation and resilience strategies into the 2024 Multi-Hazard Mitigation Plan update.

OVERVIEW OF PLAN STRUCTURE

The CARP is organized into three main sections, and the links in Table 2 below are provided for ease of navigation (quick links may also be found throughout this Plan).

Table 2. Structure of the Plan.

Part One: The Beginning of the Road	Introduction and Statement of Purpose
	Background
Part Two: The Process	Step 1: Assess Metro's Climate Hazards
	The Heart of the Matter (Equity)
	Step 2: Conduct Systems-Based Vulnerability Assessment
	Step 3: Evaluate Adaptive Capacity
	Step 4: Identify and Prioritize Adaptation Strategies
Part Three: The Road Ahead	The Implementation Roadmap
	Measuring Progress
	Bringing More Voices to the Table
	What Needs to Happen Next

ACRONYMS

ATSDR	Agency for Toxic Substances and Disease Registry
BAS	building automation systems
CAP	Metro's Climate Action Plan
CARP	Metro's Climate Adaptation and Resilience Plan
CDC	Centers for Disease Control and Prevention
CEMP	Metro's Comprehensive Emergency Management Plan
CERT	Metro's Community Emergency Response Team
CIB	Metro's Capital Improvements Budget
CMIP5	Coupled Model Intercomparison Project Phase 5
C-PACER	Commercial Property Assessed Clean Energy + Resiliency
CPT	Metropolitan Nashville-Davidson Community Planning Team
CWG	Climate Working Group
DG	distributed generation
DGS	Metro Department of General Services
EAL	Expected Annual Loss (FEMA Risk Index)
EJ	environmental justice
EMAP	Emergency Management Accreditation Program
EOC	emergency operations center
EPA	Environmental Protection Agency
EPP	Environmentally Preferable Purchasing
EV	electric vehicle
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FSF	First Street Foundation
GCOM	Global Covenant of Mayors for Climate and Energy
HIRA	Hazard Identification and Risk Assessment
HOLC	Homeowners' Loan Corporation
HVRI	University of South Carolina, Hazards and Vulnerability Research Institute
BRIC	Baseline Resilience Indicators for Communities (HVRI)
ICLEI	Local Governments for Sustainability
IEQ	indoor environmental quality
ITS	Information Technology Services
KPI	key performance indicator
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
LID	low-impact development
MAC	Metro Action Commission
MDHA	Metro Development and Housing Agency
MHMP	Metro Nashville's Multi-Hazard Mitigation Plan
MNPS	Metro Nashville Public Schools
MO	Metro Mayor's Office
MSS	Metro Social Services

MW	megawatt
MWS	Metro Water Services
NDOT	Nashville Department of Transportation and Multimodal Infrastructure
NEJI	Nashville's Environmental Justice Initiative
NES	Nashville Electric Service
NIMBY	"not in my backyard"
NOAA	National Oceanic and Atmospheric Administration
NRI	National Risk Index for Natural Hazards
NWS	National Weather Service
OEM	Metro's Office of Emergency Management
OHS	Metro's Office of Homeless Services
PACE	property assessed clean energy
PIRS	Plan Integration for Resilience Scorecard
PPA	power purchasing agreement
PPE	personal protective equipment
PRI	Proactive rental inspection
RCPS	Representative Concentration Pathways
SAC	Metro's Sustainability Advisory Committee
SAFE	Situational Awareness for Flooding Events
SBA	Small Business Administration
SFHA	Special Flood Hazard Area
SVI	Social Vulnerability Index (HVRI)
THIRA	Threat and Hazard Identification and Risk Assessment
TSU	Tennessee State University
TVA	Tennessee Valley Authority
UGL	Urban Green Lab
USD	Urban Services District
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WEGO	Metro's Transit Authority

PART ONE: THE BEGINNING OF THE ROAD

INTRODUCTION AND STATEMENT OF PURPOSE

Climate change is arguably today's single greatest threat to our society. Our survival and access to basic needs, such as food, water, and shelter, are being and will continue to be affected by the changing climate. Today, Nashville's inhabitants are exposed to multiple climate stressors and shocks, including heat waves, severe storms, and flash flooding, and global impacts that reach our doorsteps include increased food insecurity, supply chain volatility and food price fluctuations, and displacement of populations from locations they have called home for decades. Tragic climate-driven events that have occurred just in the summer of 2023 have pointed to the significant gaps between planning and real-time readiness in several U.S. cities, with the consequence being loss of life and significant damage to built infrastructure. No Nashvillian should be asked to accept that such casualties are inevitable.

To prepare Nashville and Davidson County and ensure its citizens' ability to thrive for years to come, the Office of Mayor John Cooper, in partnership with Metro Nashville departments and the Mayor's Sustainability Advisory Committee (SAC), have developed this Climate Adaptation and Resilience Plan (CARP). **The intent of the Plan is to guide future Metro investment and actions in both hard and soft infrastructure, to improve the city's resilience to climate-driven hazards in an equitable and transparent way.** The CARP serves as a companion document to the 2021 Climate Action Plan (CAP), which focuses on the topic of climate mitigation, or those actions that can be taken by Nashville to prevent or reduce greenhouse gas emissions and associated climate impacts. Because we are already feeling the impacts of a changing climate, it is vitally important to prioritize our response.

Another significant existential challenge facing the United States is social inequality and the underlying history of structural and institutional marginalization and neglect that has left racial and ethnic minority communities on the frontlines of climate change.[1] Without doubt, **climate change is a risk multiplier**. Both locally and globally, the most severe climate harms continue to fall disproportionately upon these communities, whose baseline vulnerability renders them least able to prepare for and recover from external shocks and stressors. Therefore, the CARP's starting point is Nashville's people, in particular those populations that bear the brunt of impacts associated with the changing climate.

This document focuses on climate adaptation and resilience, actions that collectively can help the city adjust to actual or expected climate changes, and ensure that our infrastructure, systems, and community are capable of anticipating, coping with, and bouncing back from expected and unexpected events. It begins with an assessment of Metro's main climate hazards, considering available data and the historical record to gauge the probability and potential severity of climate-

[1] When this Plan refers to "frontline" or "vulnerable" communities, it is in recognition of higher levels of risk burden than the average Nashvillian due to structural, historical, societal, economic, and other drivers of inequity. It is not a judgement on those communities being inherently weaker, lacking innate resilience, or not commanding a seat at the table in identifying and implementing solutions.

driven impacts. It then conducts a high-level vulnerability assessment, mapping Nashville's ecosystem into five main categories covering the built environment, natural environment, people and community, economic systems, and public services, and considering the direct and indirect impacts of climate hazards on those system components. It evaluates their adaptive capacity in order to identify areas of highest risk, and assesses the availability of proactive strategies that can be employed to reduce vulnerability. Finally, it sets forth a roadmap to guide implementation under a structure of four primary goals, their corresponding objectives and strategies.

While this Plan focuses exclusively on adaptation and resilience to address climate hazards, it is worth noting that many actions designed to be responsive to climate hazards also provide benefits for non-climate-related risks, such as hazardous materials incidents, communicable diseases, and manmade disruptions such as cyber threats and terrorism. Metro Nashville has separate plans and processes that are designed to be responsive to these events. However, this broadens the co-benefit of the CARP outside of the climate and environmental realm.

Figure 6 provides the overarching goals of this plan.

Figure 6. The Key Goals of Nashville's Climate Adaptation and Resilience Plan.

While the CARP is Nashville's first climate risk assessment and, as such, represents an important step toward building the city's resilience to natural hazards, it is intended to be only a starting point for Nashville's work in this space, not a destination. Central to the concept of adaptation and resilience are flexibility, learning, and evolution. This document aims to set the stage for Metro departments, businesses, non-profits, institutions, neighborhoods, and individual residents to take steps towards a resilient and livable future. True resilience must address all hazards, not just those driven by the changing climate, and the limited scope of this Plan should not be understood to imply that addressing other risks is not equally important and deserving of their own detailed plans and actions. Nashville's all-hazards assessment and mitigation work is carried out under the umbrella of its Multi-Hazard Mitigation Plan (MHMP), which is updated annually, and will continue to guide the city's multi-hazard mitigation planning efforts.

OVERVIEW OF PLAN STRUCTURE

The CARP is organized into three main sections, and the links in Table 2 below are provided for ease of navigation (quick links may also be found throughout this Plan).

Table 3. Structure of the Plan.

Part One: The Beginning of the Road	Introduction and Statement of Purpose
	Background
Part Two: The Process	Step 1: Assess Metro's Climate Hazards
	The Heart of the Matter (Equity)
	Step 2: Conduct Systems-Based Vulnerability Assessment
	Step 3: Evaluate Adaptive Capacity
	Step 4: Identify and Prioritize Adaptation Strategies
Part Three: The Road Ahead	The Implementation Roadmap
	Measuring Progress
	Bringing More Voices to the Table
	What Needs to Happen Next

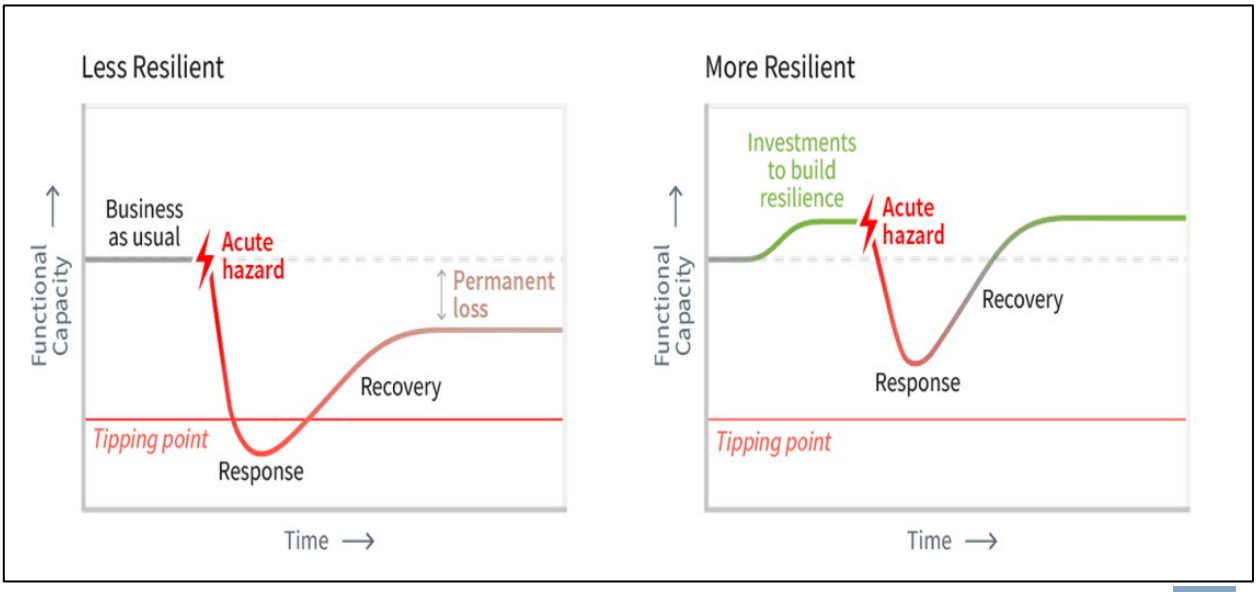
GLOSSARY

Definitions germane to this document include[2]:

[2] With the exception of Equity and Climate Justice, definitions derived directly from or with slight modification from the Global Covenant of Mayors for Climate and Energy Common Reporting Framework Guidance Note, page 69. Accessible at https://www.globalcovenantofmayors.org/wp-content/uploads/2019/08/Data-TWG_Reporting-Framework_GUIDENCE-NOTE_FINAL.pdf.

- Adaptation: The process of adjusting to and reducing actual or expected impacts of climate hazards.
- Adaptive Capacity: The ability of an individual, asset, or system to adjust to a hazard, take advantage of new opportunities, or cope with change.
- Climate Justice: Recognition that the effects of climate change disproportionately affect minority and historically marginalized populations, making targeted interventions a priority.
- Co-benefit: In the context of this Plan, the term refers to benefits that accrue to address economic, social, or non-climate-related vulnerabilities above and beyond the direct target of an action or strategy, without additional effort or cost.
- Equity: Just distribution of and access to opportunities, resources, and healthy environments in a way that recognizes inequality of circumstance, systemic and structural imbalance, and targets equality of outcomes.
- Exposure: The presence of people, the sources of their livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected.
- Hazard: The source of a potential danger or adverse condition that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. Climate hazards are the focus of this document.
- Resilience: The capacity of social, economic, environmental, and other systems to cope with and adapt to a hazardous event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for learning and transformation. See Figure 7 for a demonstration of how resilience is intended to work. This concept applies beyond climate risks; however, resilience in the face of climate risks is the primary focus of this document. Because climate resilience strategies will provide co-benefits in the face of non-climate risks, this document serves to build overall community resilience.

Figure 7. How resilience works (source: NOAA).



- Risk: The potential for often adverse consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Climate risks are the focus of this document.
- Vulnerability: The propensity or predisposition to be adversely affected, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Vulnerabilities in the face of climate events are the focus of this document.

Of importance to this Plan is the understanding between the terms *adaptation* and *resilience*, which are often confused. At its most basic, *adaptation* infers a *change* that better equips a living or inanimate thing to subsist in a new environment, whereas *resilience* infers an achieved *ability* that is based on *anticipating* and *preparing for* unavoidable shocks so that recovery is timely and efficient. Resilience is an outcome of adaptation. The concept of resilience also contemplates preparation and recovery in the face of non-climate-related risks, including hazardous materials incidents, communicable diseases, cyber threats, and terrorism.

It is also important to highlight that some climate-oriented actions, such as increasing the tree canopy (the last example of a mitigation action given in Figure 3 above), have benefits both for abating the processes that are causing the planet to warm and for adapting spaces to make them better equipped to handle heat. Such strategies are considered to have co-benefits, meaning they achieve two (or more) aims with one action or investment. Similarly, strategies that build resilience to both natural and manmade hazards, or deliver both environmental and social or economic returns, are considered to have co-benefits. Identifying and prioritizing actions with co-benefits is important from two perspectives:

1. When resources are limited, prioritizing actions with the highest returns just makes common sense.
2. Resources are always limited, and human beings have different opinions about where priorities should be placed. Addressing climate change is often countered with arguments that doing so will harm the economy, for example. Finding ways to simultaneously (and innovatively) address the climate threat and bolster our economic wellbeing makes any need for such an argument moot.

A KEY TO THE ICONS IN THIS PLAN

Throughout the Plan, icons are used as a shorthand. The below table provides a key.

Table 4. Icons used in this Plan.

Nashville's System Map		Natural Hazards	
Icon	**Meaning**	**Icon**	**Meaning**
	Community and Culture		Earthquake
	Natural Environment		Extreme Cold / Winter Storm
	Infrastructure		Extreme Heat / Heat Wave
	Economy		Flooding
	Public Safety		Hail
			Landslide
			Thunderstorm
			Tornado

BACKGROUND

METRO SUSTAINABILITY AND RESILIENCE INITIATIVES TO DATE

Metro has a rich history of engaging in planning for and committing to sustainability and resilience across the city. It has multiple departments that share responsibility for activities and programming that support both mitigation of and adaptation to climate change, several of which have completed impactful projects, some of which are highlighted herein. In more recent years, Nashville has taken steps to sign on to various multi-municipality commitments to act against climate impacts, including the Mayor's Climate Protection Agreement (2009), the Compact of Mayors (2014), the Global Covenant of Mayors GCoM) (2015 and 2019), and Race to Resilience (2021). The city has also engaged in multiple greenhouse gas emissions inventories that quantify greenhouse gas emissions for the city and municipal operations over time (2005, 2011, 2014, 2017, and 2019). Recent mayoral administrations have likewise convened their own ad hoc bodies to advise Metro on environmental, sustainability, and resilience topics. Each of these bodies has produced a report that summarizes recommendations for the respective administration.[3]

THE SUSTAINABILITY ADVISORY COMMITTEE

In early 2020, shortly following Mayor Cooper's rejoining of the Global Covenant of Mayors, Mayor Cooper established a Sustainability Advisory Committee, comprised of more than 50 community members with a ride range of experience, to advise him on a range of sustainability issues. The group was charged with the following objectives:

- Identify the highest potential mitigation actions based on local, national, and international best practices; specific expertise of Committee members; and prior Nashville initiatives.
- Provide a detailed list of additional mitigation actions, including low-cost actions, which can be included in the City's climate action plan.
- Explore and make recommendations on crosscutting challenges, including financing mitigation actions, ensuring environmental equity, and identifying potential leadership initiatives.

Over the course of a year, this group organized into sub-committees that met and developed a CAP for the city, which included nearly 300 individual strategies across 6 topic areas. These strategies were consolidated into 40 narrative policy areas and priority actions intended to highlight strategies that will produce the greatest carbon reductions. Each of the policy areas also included a recommended target to measure progress (see Table 4 below). Cross-cutting equity, leadership initiatives, and lock-in effects were also identified within the plan.

[3] See Making Nashville Green of 2009 (GRC_Report_090701.pdf (carbonn.org)), Livable Nashville recommendations (Livable Nashville Draft Recommendations | Nashville.gov) for reports produced prior to the current administration.

Table 5. Sustainability Advisory Sub-Committee Targets.

Sub-Committee/Topic	Target
Energy	Reduce community-wide and Metro GHG emissions by 80% by 2050.
Green Buildings	
Mobility	Reduce drive-alone rates from 79% to 40% by 2050; Increase EV adoption rate to 40% by 2050.
Waste Reduction	Achieve zero waste (≥ 90% diversion) by 2050
Natural Resources	Increase resilience by focusing on heat and flood adaptations, particularly for vulnerable populations
Adaptation	(Draft chapter produced but not finalized)

The SAC's CAP has served as the blueprint informing much of Metro's sustainability and climate mitigation work in recent years. It should be noted that many of the targets recommended in the CAP, some of which have been addressed through statutory action, contain co-benefits for efforts toward hazard mitigation and increased climate resilience.

OFFICIAL TARGETS

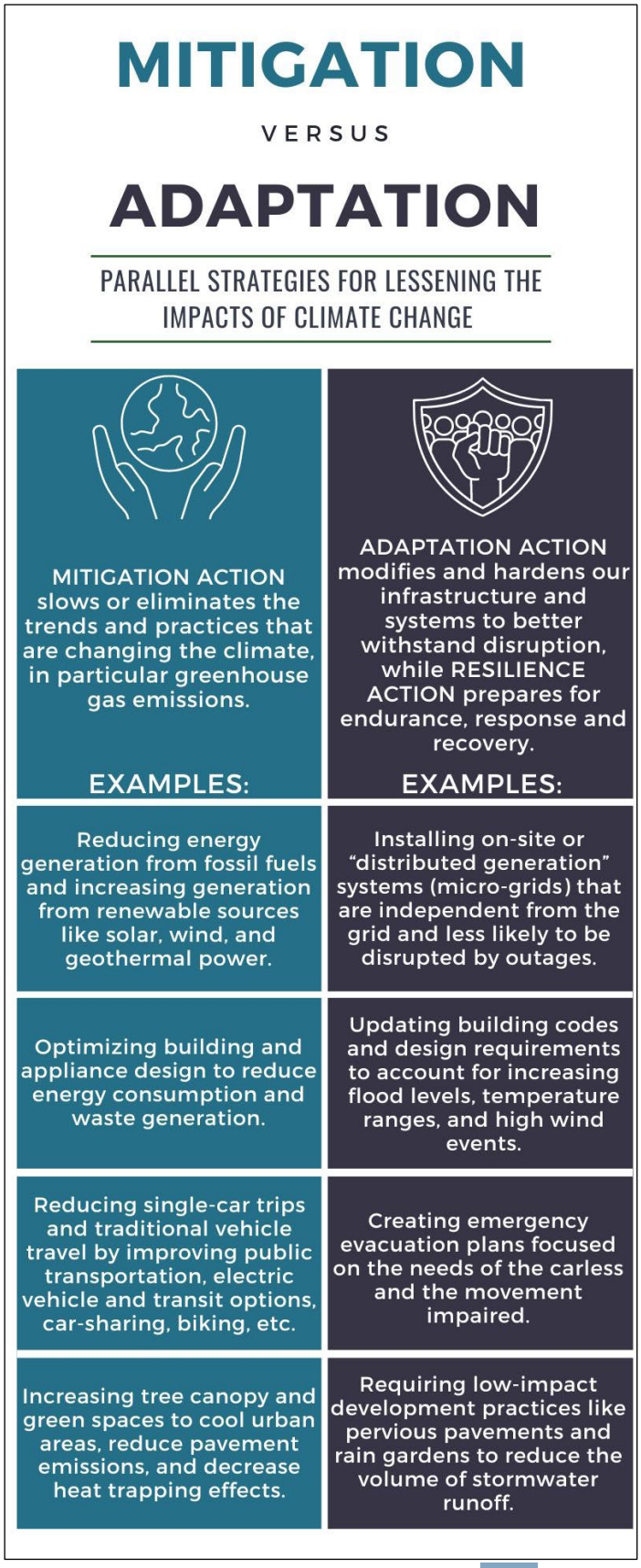
Setting targets for climate action can serve as a foundation for collective action, continuous improvement, and establishment of pathways for reducing emissions and increasing adaptive capacity. Nashville has taken the important step of establishing several, formal targets that set aggressive goals or requirements for climate mitigation and that can be used for measuring progress.

- Metro Code 2.32.065 establishes a fleet electrification program overseen by the department of general services and requires that the metro general government fleet transition to 100 percent zero emissions by 2050. Emergency response vehicles are exempted from this program and transition requirement.
- Metro Code 2.32.070 requires the department of general services to develop a strategic energy management plan for reducing energy and water use across metro-owned buildings. The plan should aim to achieve at least 20 percent reductions in average energy and greenhouse gas emissions.
- Metro Code 2.32.080 establishes a renewable energy portfolio standard overseen by the department of general services that requires metro general government operations to source 100 percent of its energy from renewable energy resources by 2040.
- Metro Code 16.60 requires metro government facilities to pursue LEED certification (gold for buildings in the Urban Services District (USD) and silver for buildings outside of the USD) for new construction and additions exceeding five thousand gross square feet of occupied space.
- RS2022-1358 adopts a community-wide and metro government target of an 80 percent reduction in annual greenhouse gas emissions from 2014 levels by 2050 and regular progress reporting.

- RS2023-2393 adopts a community-wide and metro government target of a 50 percent reduction in food waste from 2017 levels by 2030.

The figure at right illustrates the difference between climate actions that address mitigation and those that address adaptation or resilience.

Beyond these targets that specifically relate to climate mitigation, there are numerous Metro policies that have the benefit of reducing greenhouse gas emissions. Examples include but are not limited to the Downtown Code Bonus Height Program, tree density requirements on public and private properties, multimodal access studies, and more. To date Metro Nashville has not adopted any official goals relating solely to climate adaptation.



KEY ACHIEVEMENTS TO DATE

In the last four years, Mayor John Cooper and Metro have achieved or set in motion numerous key accomplishments, many of which were included as recommendations in the SAC's report, briefly summarized here. While not exhaustive and inclusive of all actions taken, the most significant and impactful items are highlighted.

Growing Nashville's leadership, commitments and partnerships supporting the environment, sustainability, and resilience:

- Joining the Global Covenant of Mayors for Climate & Energy, demonstrating Nashville's commitment to climate action (2019);
- Appointing environmentally conscious board and commission members;
- Forming a SAC, bringing together local sustainability leaders to shape Nashville's future through development of a robust Climate Action Plan (2020-2023);
- Hiring of Chief Sustainability & Resilience Officer to establish leadership of

environmental topics within the Mayor's Office (2021-current);
- Adopting a Metro government and community-wide target of 80% reduction in greenhouse gas emissions from 2014 levels by 2050 and regular progress tracking to keep Nashville on a path for a low carbon future (2022);
- Publishing an Environmental Indicators Dashboard (2022);
- Establishing a Sustainability Advisory Committee in Metro Code (2023);
- Infusing sustainability and resilience across departments through development of a framework and toolkit for departments to use to bring sustainability and resilience into their plans, programs, and activities (2022-2023 [ongoing—as further outlined below]); and
- Development of this Climate Adaptation and Resilience Action Plan to compliment the SAC's Climate Action Plan (2023).

Increasing investment in clean energy through:

- A renewable energy standard that serves as a foundation for metro's use of carbon-free energy, requiring Metro general government to source 100% of its energy from carbon free sources by 2041 (2019);
- A subscription for 40 megawatts (MW) of solar energy through the Tennessee Valley Authority (TVA)'s Green Invest program (2020);
- Solar installations across metro facilities to support carbon-free energy, resiliency, and cost savings, including 2.31 megawatts installed onsite, 0.06 megawatts in community generation, and 2.69 megawatts to be commissioned by the end of 2024; and
- Performance of a solar cost benefit analysis that identifies around 110 MW of potential solar installations on Metro properties (2021-2023 [ongoing]).

Reducing environmental impacts of Nashville's built environment by:

- Adopting 2018 International Energy Conservation Code to upgrade the efficiency and resiliency of buildings (2020);
- Ensuring Metro buildings lead by example with LEED certifications;
- Establishing an "Energy Savings Program" and annual benchmarking to improve efficiency of Metro facilities (2020 and 2022, respectively);
- Launching a local C-PACER program to unlock low-interest and long-term financing for sustainable and resilient commercial development (2023);
- Engaging in a heat mapping campaign and developing a heat story map that identifies where Nashville's most heat vulnerable communities are (2022-2023); and
- Harnessing LED and smart photocell technology for streetlight conversions to decrease energy costs by $20 million over 10 years as well as reduce maintenance costs and greenhouse gas emissions, while increasing visibility, outage repair efficiency, and public safety (2023).

Strengthening Nashville's tree canopy and increasing access to green space by:

- Increasing protections for trees on public property to ensure Nashville realizes environmental, economic, and social benefits from tree canopy (2020);

- Creating the Root Nashville campaign to plant 500,000 trees by 2050 and a dedicated revenue stream to support tree canopy restoration and maintenance on private properties, extending stewardship of natural resources across the community (2021);
- Joining the Trust for Public Land's 10 Minute Walk Campaign designed to increase access to parks across the city (2022);
- Becoming an Urban Bird Treaty Program City (2023); and
- Providing an $85 million record investment in Metro Parks to expand access to greenspace and enhance park experiences (2021-2022).

Reducing transportation emissions and increasing mobility:

- Releasing a metro Nashville transportation plan (2020) and establishing a Department of Transportation and Multimodal Infrastructure (2021);
- Adopting a Vision Zero initiative and plan for the city (2022);
- Issuing an update to the WalknBike plan (2022);
- Supporting WeGo neighborhood and regional transit centers and hubs in Green Hills, North Nashville, Antioch, Donelson Station, and the East Bank and expansion of bus services (2020-2023);
- Submitting a $5.87 million grant application for publicly accessible EV infrastructure to spur EV adoption across the city (2023);
- Adopting a multimodal transportation analysis that evaluates the impact of a proposed development on the safety, operations, and condition of the adjacent transportation network, and identifies transportation mitigations necessary to offset the impact caused by additional trips generated to the proposed development (2023); and
- Seeking federal funding to support acquisition of 15 all-electric school buses and supporting MNPS participation in the TVA Electric Fleet Advisor program (2023);

Reducing the impacts of the City's waste by:

- Increasing frequency of curbside recycling collection from once per month to once every other week (2023);
- Serving as a participant in the Middle Tennessee Solid Waste Strike Force, focused on creating reduction, diversion, and responsible management solutions for the region's materials (2023);
- Establishing a food waste diversion target for Metro government and the community of 50 percent reduction from 2017 levels by 2030 (2023);
- Directing Metro to evaluate costs and benefits of creating a dedicated department for waste management and related issues (2023); and
- Piloting curbside collection of organics to plan for future larger scale organics diversion (2023).

PUBLIC OUTREACH AND CONSULTATION ON MITIGATION EFFORTS

Mayor Cooper's SAC formed its recommendations using feedback from the public. In drawing from a diverse, multidisciplinary group of stakeholders both external and internal to Metro government, the SAC itself and its work products are informed by many perspectives. While both

the timeframe for submission of the CAP and the COVID-19 pandemic limited in-person meetings for gathering public input, the SAC referenced results of engagement conducted during planning efforts preceding the SAC's development of the CAP, including NashvilleNext, Nashville's Transportation Plan, Plan to Play, nMotion, and more. The SAC also partnered with the Mayor's Youth Council to survey Nashville's youth about sustainability priorities. Upon its completion, the CAP was released to the public, providing an additional opportunity for comment.

Following the release of the CAP, in coordination with the Civic Design Center and with support from a Southeast Sustainability Directors Network Community Collaboration Microgrant, the Mayor's Office led a climate action survey from April to June 2022, asking Nashvillians about climate priorities that were included in the CAP. The survey gathered input from approximately 3,500 participants and responses are being used to inform how Metro prioritizes climate actions to be responsive to community-identified needs.

The SAC has also established working groups which aim to gather feedback on opportunities to collaborate on climate action with the private sector and businesses as well as with organizations that represent disadvantaged communities. Leveraging these partnerships in the future will be critical to ensuring sustainable and equitable climate mitigation and adaptation for all populations.

FURTHERING COMMITMENTS UNDER THE GLOBAL COVENANT OF MAYORS FOR CLIMATE AND ENERGY

As noted earlier, the SAC was formed in February 2020, shortly after Mayor Cooper signed onto GCoM, an alliance of thousands of cities and local governments that have made voluntary commitments to reduce their carbon footprints. GCoM requires participating cities to develop within three years a climate action plan that includes a greenhouse gas emissions target and emissions reductions actions to meet the target. Given the importance and timeline of the climate action plan, the Mayor's SAC focused primarily on the mitigation component of the plan. GCoM also requires development of an adaptation plan. While an adaptation chapter was drafted as part of the SAC's efforts, it was not finalized. Therefore, this work product focuses on fulfilling the adaptation requirements under GCoM and folds in the important concepts of resilience and equity while developing adaptation strategies.

In early 2023, GCoM added to its Common Reporting Framework the Energy Access and Poverty Pillar, in alignment with the United Nation's Sustainable Development Goals. The pillar requires an assessment covering energy security, sustainability, and affordability together with indicators and targets. It was not possible to expand the scope of this Plan to cover energy access in sufficient detail to meet the requirements of this latest pillar. Therefore, it is recommended that such an assessment be carried out as a next step.

THE CLIMATE RESILIENCY TOOLKIT

As a companion initiative to the CARP, the Mayor's Office, through the lead authors of this Plan and the working group assembled to support it, has undertaken the development of an internal (e.g. non-public) Climate Resiliency Toolkit in calendar year 2023 to build the understanding of Metro department leadership and staff and their capacity to implement climate resilience-focused

initiatives. The objective of the toolkit is to ingrain a climate resilience lens within each of Metro's 53 departments' existing strategic planning and budgeting processes, in line with Goal 4 of the CARP, such that each investment addresses risks and leverages budgetary spending to the greatest extent feasible. Additional detail on the toolkit is given in the Adaptation Strategy XC1: Develop a Climate Resiliency Toolkit and Training Resources. Similar to this Plan, the toolkit is intended to be a 'living' resource that is improved and expanded upon as it is implemented. The toolkit has its own objectives and roadmap that should be pursued by Metro departments in support of and in parallel to the Roadmap contained in this Plan.

The initial version of the toolkit includes foundational primers, an internal action plan to supplement the Implementation Roadmap contained herein, simple templates for sustainability and resilience tools such as audits and hazard vulnerability assessments, training materials, and a directory of departmental points of contacts working on sustainability and resilience (which comprises the working group that developed this Plan). Ultimately, the Toolkit could form the basis of a public-facing, community-oriented Resiliency Toolkit deployed by partner organizations. Metro could also consider peer learning with sister cities that might be looking to develop similar resources. Like the CARP, the Toolkit represents a first step and living resource that could and should be scaled up and leveraged.

PART TWO: THE PROCESS

METRO NASHVILLE'S CLIMATE RISK ASSESSMENT

Weather and climate are the background to daily life. The architecture and buildings of communities throughout the world respond first and foremost to their established climate and variable weather. The regular patterns of a region's climate, along with day-to-day variation in weather, create expectations about precipitation, temperature, and humidity that are built into the fabric of cities, because they must provide protection from weather extremes each year. The challenge presented by the changing climate is twofold: (1) Baselines are shifting, a phenomenon that is hard to notice from day to day since individual people and societies have different reference points; and (2) extremes are becoming more extreme. As the climate changes and unsettles old patterns, with increasing severity, more people are becoming vulnerable, often without noticing how it is making daily struggles for survival even harder. Built infrastructure and the assets and systems that societies depend upon are also weakening; by the time the proverbial cracks appear, it is sometimes too late to avert disaster.

This Plan comprises Metro's first climate-focused risk assessment. Risk should be understood as the sum total of all potential impacts or consequences resulting from a particular event, based on its characteristics, probability, and magnitude. There are two determining factors for how the event unfolds in context: Exposure and vulnerability. The ability of a built asset, system, or living thing to adapt when exposed to a hazard will either decrease or amplify the magnitude of the impact, and therefore the outcome. Assets, systems, and living beings that are vulnerable prior to the impact occurring are less likely to be able to adapt, survive, and thrive. Therefore, improving adaptability is dependent upon reducing vulnerability.

There are two key points in this regard:

3. Throughout this Plan *risk* and *vulnerability* are terms that may be used interchangeably;
4. Risk and exposure are not the same. Metro's adaptation and resilience strategies must be targeted to assets, systems, and most importantly, communities and individuals whose baseline level of vulnerability starts out higher than others with similar levels of exposure.

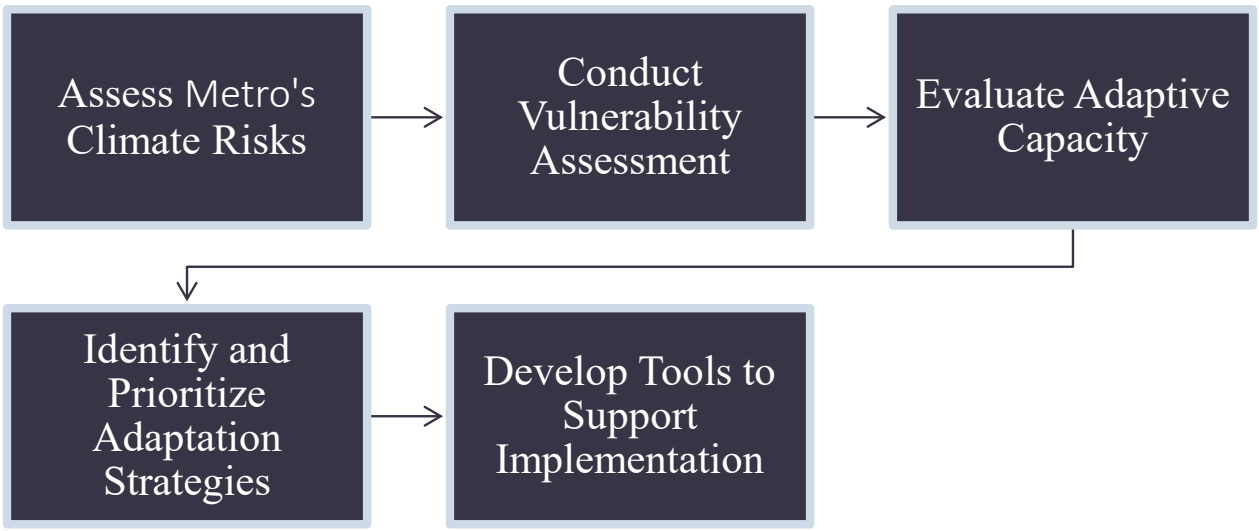
As noted in earlier sections of this document, Nashville has made important gains and commitments in recent years to improving the city's sustainability and climate responsiveness. Under the current administration, its signing on to the Global Covenant of Mayors, in late 2019, signaled a commitment to produce plans that addressed both climate mitigation and adaptation within a 3-year timeframe. The production of this Plan was therefore a priority action to complete following the publication of the city's mitigation-focused Climate Action Plan in 2020.

Unfortunately, Nashville did not have funds available to support the development of either Plan, and has therefore relied on the thought leadership and contributions of its partners and its own staff, where other cities have been able to produce much more comprehensive plans by bringing in external experts and consultants. Instead, the Mayor's Office brought together 12 key departments for a series of workshops to develop the framework of two work products: This Climate Plan and a companion Climate Resiliency Toolkit, referenced herein. They are inter-related and inter-dependent work products. Within a very short timeframe these plans came together with the aim of establishing a basic understanding of the city's risks and adaptive

capacities related to the changing climate, and a high-level framework for action, in order to provide a starting point. A true risk assessment and mitigation plan requires consideration of all possible hazards and scenarios over a defined planning horizon; the CARP represents a local prioritization based on a current understanding of probabilities and urgent needs, and limited resources.

Figure 8 below provides an overview of the process that was followed, each step of which will be further detailed in the following sections.

Figure 8. Metro's Adaptation Planning Process.



ASSESSING METRO'S CLIMATE HAZARDS

Assessing Nashville's climate risk started with an identification of its top climate hazards. This review was based on frequency and severity of historical climate events, projections for future climate events, and a review of available data, including consideration of exposure and vulnerability. Multiple sources, including but not limited to Metro Nashville's Multi-Hazard Mitigation Plan (MHMP)[4], the draft Tennessee State Hazard Mitigation Plan for 2023-2028, FEMA's National Risk Index for Natural Hazards (NRI), peer reviewed research, and the previously available Temperate software[5], have informed the selection of hazards considered in this Adaptation Plan. More detail on the primary resources referenced (FEMA and MHMP) are provided in Appendix 1.

[4] Available at Emergency Planning for Metropolitan Government | Nashville.gov.

[5] Temperate was an adaptation planning app that guided users through the process of creating a plan for their city (https://temperate.io, discontinued in 2023).

This Plan ranks Metro's top climate hazards on a scale of one to five, or low to high, in terms of impact and probability, as shown in the below table and figure, to arrive at an assessed level of risk. It is worth reiterating what some of the terms mean (see Glossary for the complete list). In this context, a hazard refers to the source of a climate-driven event that has the potential to result in loss of life, damage to assets, and/or other adverse outcomes. Impact considers the consequence of the hazard occurring, or the effect and level of severity of the outcomes. Probability considers the likelihood or chance that the hazardous event will occur. In the context of climate change impacts, risk is a function of the interaction between the hazard, the level of exposure of the system to the hazard, and the baseline vulnerability of the affected system—its propensity or predisposition to be adversely affected due to its lack of ability to adapt. Each of these ingredients is subject to uncertainty as regards its magnitude and likelihood of occurrence, and each may change over time and space due to both natural and human-driven factors.[6] Therefore, it is important to keep in mind that while this Plan bases its ranking on available data, historical occurrence, and lived experience, it cannot make any assurance as to the accuracy of its rankings from a predictive standpoint.

This Plan will focus on the five hazards with the highest combined ranking for consequence and probability, namely flooding (both fluvial, or produced by rivers and streams [also referred to as riverine], and pluvial, or produced by rainfall), tornadoes, extreme temperatures (hot and cold), and thunderstorms (including high winds, lightning and hail). The assessment first evaluates the direct, experienced impacts of these hazards on Nashville's people, natural environment, infrastructure, economy, and public services. It then considers the indirect or cascading impacts, which is where distinctions of equity emerge. Equity considerations for each of these climate hazards are assessed in terms of vulnerability outcomes in subsequent sections.

Graphically, the risk matrix shown below illustrates where each climate hazard falls on the scale of 1-5 when both potential impact and probability are considered. The ranking of floods and tornados as the top hazards is in alignment with Metro's Multi-Hazard Mitigation Plan and to some extent with FEMA's National Risk Index (two versions were sourced in 2023; see Appendix 1). However, the two

Table 6. Metro's Primary Climate Hazards.

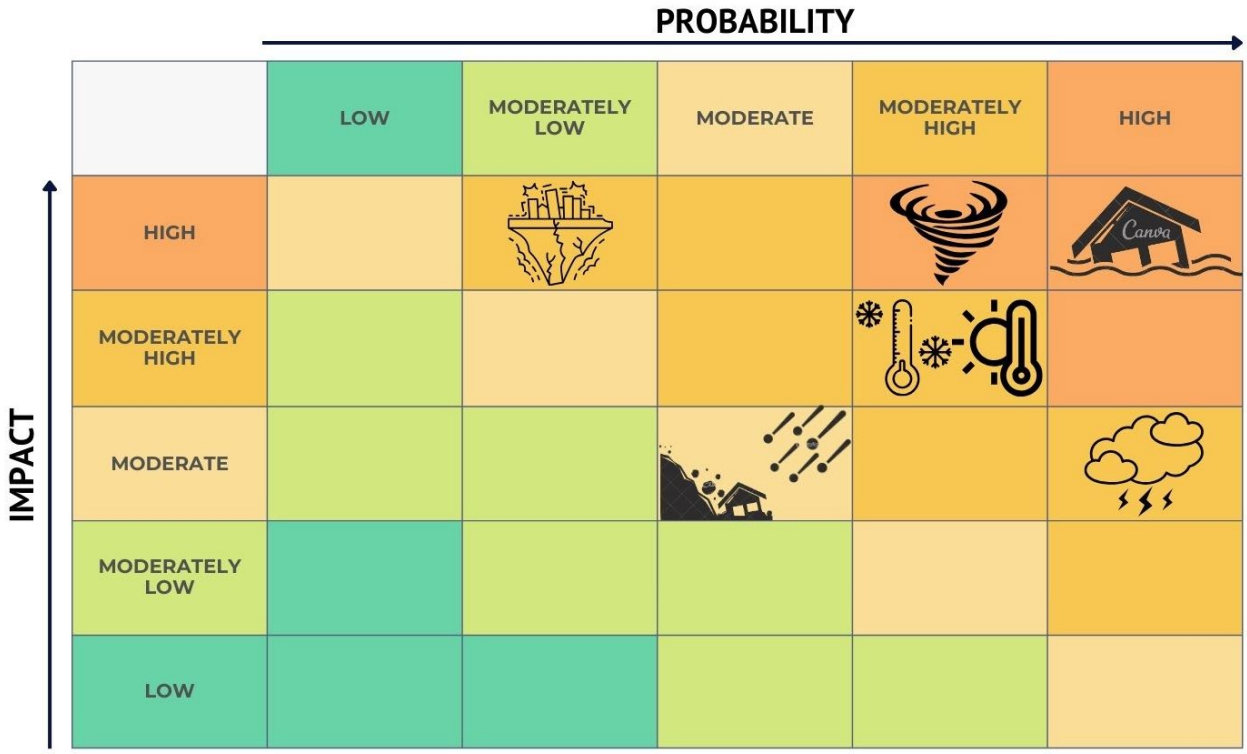
Climate Hazard	Impact	Probability
Flooding	High	High
Tornado	High	Mod. High
Extreme heat / heat wave	Mod. High	Mod. High
Extreme cold / winter storm	Mod. High	Mod. High
Thunderstorm / high winds	Moderate	High
Earthquake	High	Mod. Low
Hail	Moderate	Moderate
Landslide	Moderate	Moderate

[6] For detailed definitions, refer to the Intergovernmental Panel on Climate Change, Annex 1 of its 2023 Synthesis Report: IPCC_AR6_SYR_AnnexesIndex.pdf.

indices differ somewhat in the ranking of the other hazards considered here.

FEMA's most recent NRI update ranked Earthquakes as the third highest hazard for Nashville, while it falls at the bottom of Metro's ranking. The difference is in how both sources calculate risk, but both consider the probability of a seismic event to be relatively low, while the impact of an earthquake is considered to be quite potentially high in terms of losses, costs, and damage. Again, probability is a tricky (and risky) game, and the very recent [September 2023] 6.8-6.9 magnitude earthquake in Morocco makes that point very clearly. Earthquakes are covered by some of the strategies in this Plan related to building codes and zoning reviews, but should be considered further and from an all-hazards perspective in the next iteration of the CARP. This Plan concentrated on conditions that are exacerbated by the changing climate, have a high probability of frequent occurrence, and, when considered on the basis of their compounded impact over time, represent significant stressors to Nashville's way of life.

Figure 9. Metro's Climate Hazards, Ranked.



In Figure 9, a score of 5 or "high" is color-coded red, and as the scale moves toward the low end it transforms to orange, then yellow, then to green. In general, red indicates a score of relatively "worse," while green indicates a score of relatively "better." Refer to the Report Key for icon definitions.

HISTORICAL CLIMATE DISASTERS AND PROJECTED TRENDS

In consideration of its climate hazard ranking, Metro reviewed historical events that triggered federal and/or state disaster declarations[7] within the planning area of Nashville and Davidson County. Disaster declarations are granted when the severity and magnitude of the event's impact surpass the ability of the local government to respond and recover. Within Nashville and Davidson County there were ten federal disaster declarations between 1994 - 2019 related to flooding, severe storms/tornadoes, and ice storms, and these are documented in Metro's MHMP.

Most recently, Major Disaster Declarations were issued for Severe Thunderstorms and Possible Strong Tornadoes (4712-DR) that occurred March 1-3, 2023 resulting in multi-day power outages, and the Severe Winter Storm (4691-DR) that occurred over December 22-27, 2022, resulting in multi-day power outages and water main breaks. Two Major Disaster Declarations were issued in 2021, for Severe Storms, Straight-line Winds, and Tornadoes (December 2021, 4637-DR), and Severe Storms, Tornadoes, Winds, and Flooding (March/April 2021 [4601-DR], when some areas of Middle Tennessee received between 7" and 9" of rainfall in a 24-hour-period). In 2020, the City of Nashville and Davidson County endured multiple disasters, including an EF3 tornado in early March, a derecho in May, and the Christmas Day bombing. The federal government may issue a disaster declaration through the U.S. Department of Agriculture (USDA) and/or the Small Business Administration (SBA), as well, and 23 such declarations are documented in Metro's MHMP, for Excessive Rainfall, Flooding, Severe Storms, Tornadoes, Drought and Excessive Heat, and Freezing Temps.

CLIMATE EXPLORER

Another resource Metro consulted is The Climate Explorer, a tool that furnishes historic and projected climate data for any county in the U.S. It is a key component of the U.S. Climate Resilience Toolkit curated by the United States Global Change Research Program.[8] Data in The Climate Explorer are from a worldwide climate modeling effort known as CMIP5 (Coupled Model Intercomparison Project Phase 5). These models use past temperature and precipitation to project future conditions based upon a set of four scenarios that account for potential atmospheric changes. The scenarios are called Representative Concentration Pathways (RCPs). The results from these models are downscaled to the county level, making them more useful in local applications.

Climate Explorer provides temperature and precipitation data which offers insight into Metro's future flooding, drought, extreme heat, and extreme cold potentials. It also offers nuance such as projected days above heat warning thresholds and projected changes in net precipitation. The Climate Explorer was used to produce images and quantify magnitude of change in event trends for several of the hazard descriptions below.

[7] A declared state disaster does not become a federal disaster until the governor declares that needs have exceeded county and state resources. The same incident could be responsible for several disaster declarations.

[8] The Climate Explorer. Accessible at https://crt-climate-explorer.nemac.org/.

FIRST STREET FOUNDATION

A new modeling effort became available in late July 2023 from the First Street Foundation[9] (FSF), a non-profit research and technology group that quantifies flood, fire, heat, strong wind, and other weather hazards to conduct property-specific risk assessments. The new modeling purports to result in greater precision and accuracy, particularly in regard to flooding. FSF analyzed NOAA's existing methodology (Atlas 14 publication, which is used as the standard for estimating precipitation frequency) for modeling rainfall data, together with the methodology FEMA uses for its Special Flood Hazard Area (SFHA) designation, and found that neither predicts flooding risk accurately. (Updates are underway by NOAA, expected to be available in 2027.) This is because NOAA's methodology excludes 'outlier' precipitation events to calculate rainfall averages, and does not account for climate change (increasing temperatures and their resultant projected impacts on rainfall intensity). FEMA's SFHA is based on riverine and coastal effects only, and does not account for precipitation or climate change, which may exclude significant source of flooding risk.

Using NOAA's data, FSF undertook its own modeling of the last 20 years, inclusive of outlier precipitation events and projected climate trends, and, considered together with FEMA's riverine and coastal modeling, found that over half of the U.S. population lives in a county where severe [1-in-100–year] flooding is twice as likely to occur as that designation suggests, and nearly 15% of the population is five times more likely to experience 1-in-100–year flooding. In other words, FSF suggests that what is currently called a 1-in-100–year event will be experienced every 50 years for 51% of the U.S. population, and every 20 years for 13.3%. FSF's conclusion is that flood risk has changed significantly, and will continue to change in the near and long-term future.

FSF's updated modeling could only be reviewed at a high level for the purposes of this Plan, and the information provided below is based on data from Climate Explorer (managed by NOAA's Climate Program Office). However, FSF's modeling warrants further consideration as it could improve Metro's understanding, particularly as it concerns pluvial flooding risks.

The following sections were informed by multiple sources and consider both historical events and projected trends.

FLOODS

There are two types of flooding that are of concern in Nashville: Riverine or fluvial, which occurs near rivers and streams, and pluvial, which can occur in any location following a rain event. While Nashville maintains Flood Insurance Rate Maps (FIRMs) that form the basis for FEMA's Special Flood Hazard Areas, and Metro provide interactives mapping to assist residents to assess their flooding risks on this basis,[10] assessing pluvial risk is more nuanced.

[9] Home - First Street Foundation

[10] See Know Your Flood Hazard | Nashville.gov.

As a city built on the Cumberland River, significant riverine flooding has occurred in Nashville's past. On May 1-2, 2010, Nashville experienced rainfall that exceeded 17 inches total, including 13.5 inches in just 36 hours, the highest in 140 years of recorded history (an approximate 500-year storm). That rainfall caused a devastating flood that resulted in 11 deaths, displacement of approximately 10,000 residents, and over $2 billion in property damage. Nearly 3,000 businesses were impacted, and the event resulted in 12,903 Individual Assistance projects, totaling $87 million, 768 Public Assistance projects, totaling $53 million,[11] and $33 million in HUD Community Development Block Grant Disaster Recovery funds. Then in 2017, some areas of Nashville had over 9" of precipitation in some areas in less than 24 hours from the remnants of Hurricane Harvey, which exceeds the approximately 7" of precipitation in a 24-hour period used for many civil design considerations. Another significant storm in August of 2021 caused severe flash flooding, resulting in four deaths.

Since the May 2010 flood, Nashville has made solid strides in adaptation and preparation for extreme rain events. Recognizing the need for better data, improved coordination, and trained personnel, MWS collaborated with OEM, the Planning Department, the U.S. Geological Survey (USGS), National Weather Service (NWS), and U.S. Army Corps of Engineers to develop the Situational Awareness for Flooding Events (SAFE) system.[12] This GIS-based mapping tool relies on near real-time data from over 20 USGS river and stream gauges that sound an alarm when levels reach NWS flood thresholds. The tool included county-wide updates to stream models and inundation mapping for a range of potential flood events, allowing for the creation of new FIRMs. More than 300 miles of streams were modeled that had never been mapped, which will enable emergency responders to proactively identify critical areas of the county during future rain events.

In addition to the increases in intense precipitation events, Nashville has experienced steady growth in the past decade creating increased levels of impervious surfaces, such as roads, buildings, and parking lots, which contribute to localized pluvial flooding. This has exacerbated stormwater issues such as flooded streets, flooded low-lying areas, and overflowing drainage systems in parking lots and other areas.

The Climate Explorer tool was used to map trends relating to precipitation in Davidson County, specifically total annual precipitation, and number of days per year with more than 3 inches of precipitation.

Figure 10 below illustrates that total annual precipitation is predicted to be above the 1961-1990 observed average in future years in both a lower and higher emissions scenario. For example, in the 2050s, it is projected that there will be 51.5-53.05 inches of precipitation annually. In the 2090s, projected annual precipitation increases to 52.45-54.26 inches. This is compared to the 1961-1990 observed average of 50.47 inches of precipitation annually.

[11] City of Nashville, 2010.

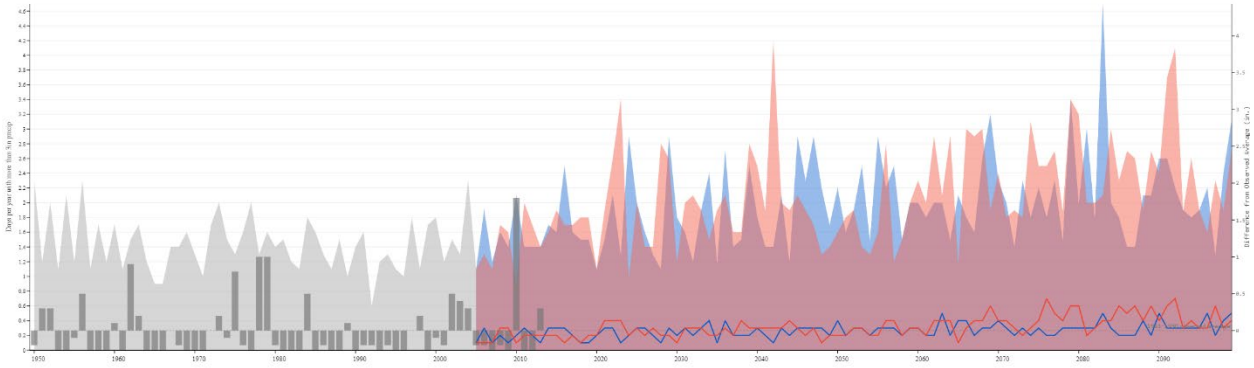
[12] See Nashville_SAFE_NAI_Flood_Warning_CaseStudy_2018.pdf.

Figure 11 shows that the number of days per year with more than 3 inches of precipitation is anticipated to increase from the 1961-1990 observed average of 0.3 days to 0.4 days by the end of the century in both a lower and higher emissions scenario.

It should be understood that the increases just described are stated in *net* terms, and therefore do not adequately capture the severity of individual events that could occur within the averaged annual increases. The reader should note the large dips up and down that are shown in the graphs below to understand the implications for lived experience. "Days with more than 3 inches" (Figure 11) doesn't distinguish between 3.5 inches and 13.5 inches (as in 2010). **The data indicates a near doubling of frequency of multi-day intense rain events.**

Figure 10. Total Precipitation—Historical and Projected. 1950-2090.

Figure 11. Days per Year with More than 3 Inches of Precipitation.



FSF's updated modeling concludes that Metro Nashville's private residences, roads, commercial properties, and infrastructure facilities are all at major risk of flooding over the next 30 years.[13] Social facilities, inclusive of schools, houses of worship, museums, etc. are at moderate risk. Prior

[13] See Nashville-Davidson metropolitan government (balance), TN Flood Factor® Report | Risk Factor.

to FSF's modeling update, residences and roads were considered to be at moderate risk, meaning that the updated rainfall modeling has resulted in recategorization to a higher risk grouping.

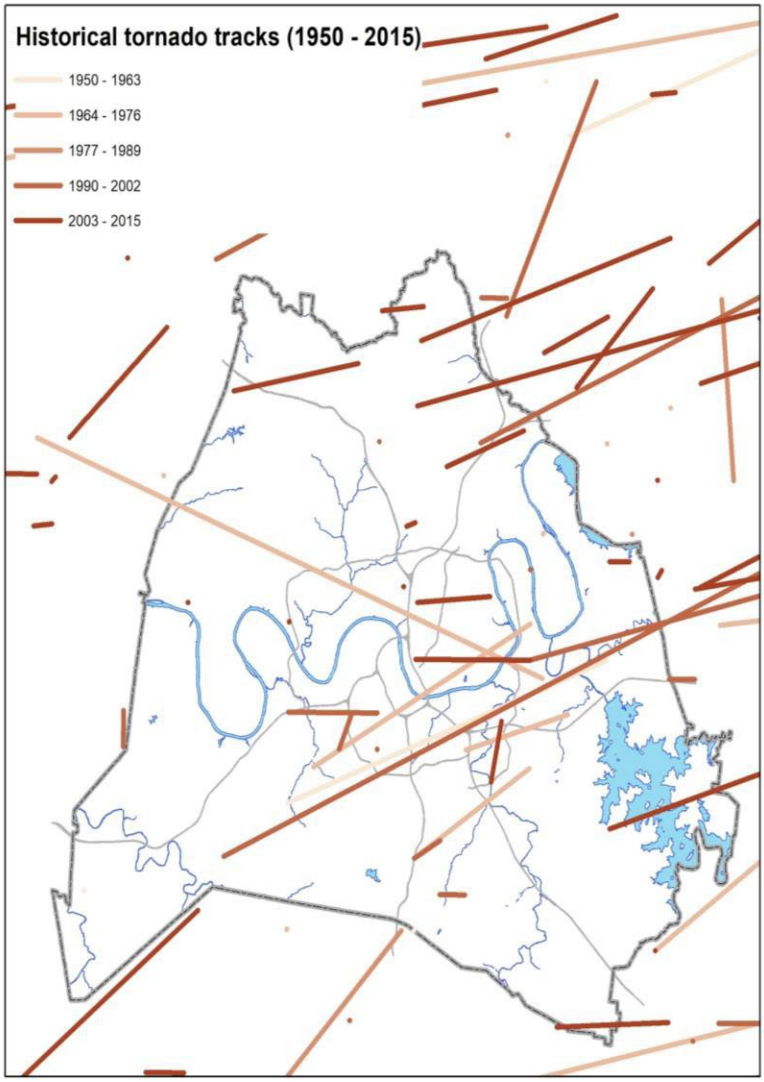
The work referenced above for Nashville's SAFE and NERVE systems will continue to evolve as the city endeavors to update its modeling and understanding of flood risk.

TORNADOES

Nashville has seen a drastic increase in tornadic activity in the past few decades. It appears that tornadoes are hitting Nashville more frequently and becoming more severe based upon historical data, likely due to climate change (see Figure at right). As noted above, in March 2020, a devastating tornado (estimated to be an EF3) swept through parts of north and east Nashville continuing east to several other counties. This one event resulted in an estimated $2.7 billion in damages.[14] Across Tennessee, 25 individuals lost their lives that month due to multiple tornadoes (Bliss 2020). The one that cut across Nashville was noted as following a similar path as previous tornadoes in 1933 and 1998 (Awasthi 2020).

A key concern here is the potential for shifts in the spatial location of tornado frequency, as shown in Figure 13. Research has identified evidence of a "Dixie Alley," which represents an eastward extension of the traditional "Tornado Alley" in the central Great Plains. These findings are preliminary and have not yet been confirmed (Gensini & Brooks, 2018), but seem consistent with projections

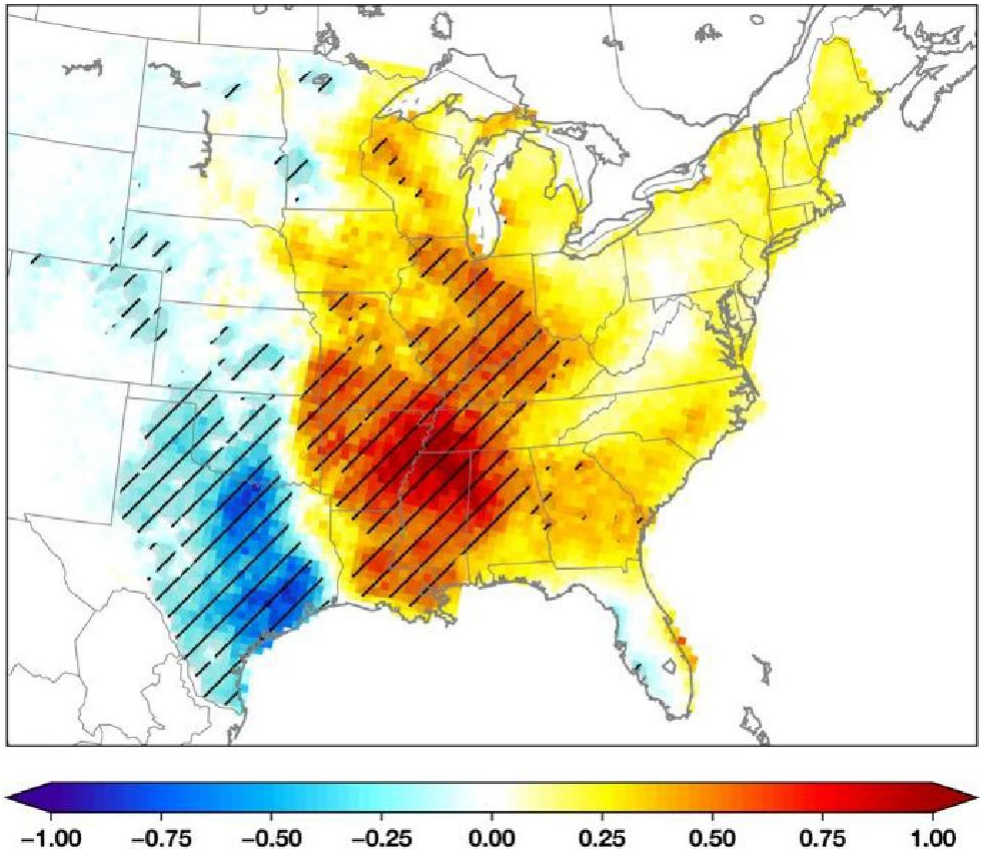
Figure 12. Historical tornado tracks (Data Source: DHS 2020).



[14] Events | Billion-Dollar Weather and Climate Disasters | National Centers for Environmental Information (NCEI) (noaa.gov)

for increased intensity of storms in Tennessee.[15]

Figure 13. Visual representation of the potential shift in tornado alley to southeast from 1979 - 2017.*



* Blue areas signify a decline in tornado activity. Red areas signify an increase in tornado activity.

INCREASING BASELINE HEAT, EXTREME HEAT, AND HEAT WAVES

Extreme heat, also referred to as "heat waves," is defined as a period of high heat and humidity with temperatures above 90°F for at least 2 to 3 days. Extreme heat is the leading cause of death in the United States among all hazardous weather events[16] and produces more premature deaths than all other hazardous weather events combined. According to the Tennessee Department of Health, from 2010 to 2021, there were 3,009 documented heat-related hospitalizations and emergency department visits in Davidson County.

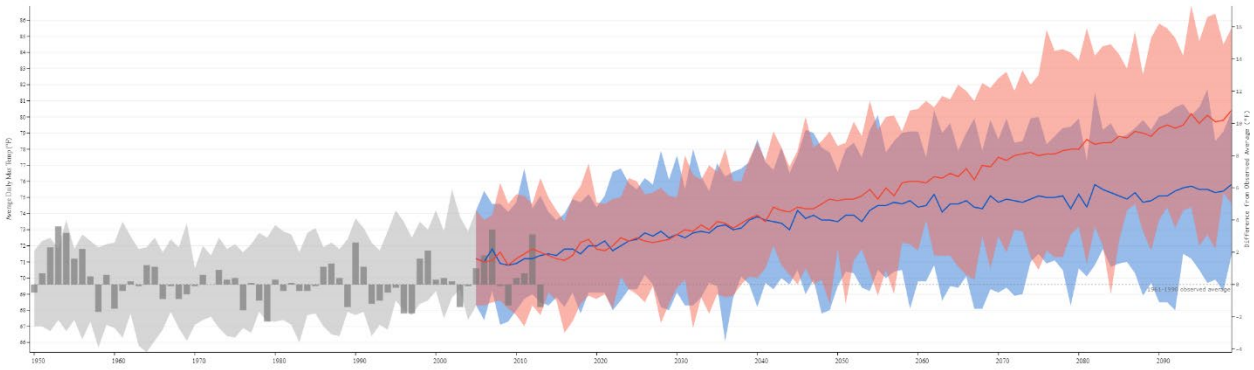
[15] https://www.nature.com/articles/s41612-018-0048-2.

[16] See NWS Weather Related Fatality and Injury Statistics

Extreme heat days and prolonged heat waves in Nashville and the surrounding region are becoming more frequent, intense, and long-lasting as climate change worsens. June 29, 2012, saw Nashville's hottest day in 141 years of record keeping, when the temperature reached 109 degrees Fahrenheit. The June 2012 heat wave pushed the Tennessee Valley Authority (TVA) to provide a nearly record 31,099 megawatts for its 8.7 million residents (TVA's record of 33,482 megawatts was set on Aug. 16, 2007, just before the 2008 recession (Sohn 2012).) It is estimated that increasing temperatures will create $74.9 million in additional energy costs for Tennesseans each year during the summer months by the year 2053 relative to 2023 energy costs (First Street Foundation, The 6th National Risk Assessment Report: Hazardous Heat). FSF's current modelling ranks Davidson County's heat risk as major, with 99% of homes at risk. FSF predicts the number of annual "hot days" (which it considers days above 106°F) will increase by 186% over the next 30 years (from 7 days/year to 20 days/year).

The Climate Explorer tool was also used to map trends relating to heat. Figure 14 shows that the average daily maximum temperature is projected to increase from an observed average over the 1961-1990 period of 69.6 degrees Fahrenheit to 74.2 and 75.3 degrees Fahrenheit in a lower and higher emissions scenario, respectively.

Figure 14. Average Daily Maximum Temperature.



As noted at the beginning of this section, climate change is a function of both a shifting of the baseline and a widening of extremes. It is important to observe in the above graph that not only are the extremes reaching ever wider, but the baseline or average is also shifting upward, with a near-tripling in the number of hot days by mid-century. These two functions require different preparation and response, and significant health risks are presented from even moderate heat, dependent upon a person's baseline health.

Anyone who spends time outdoors in the summer or works in non-air-conditioned settings knows that heat effects are felt at lower temperatures than on "hot" or "very hot" days. Fatigue and dehydration can result from prolonged exposure under from 80 degrees, and sunstroke can happen

once temperatures reach 90 degrees.[17] The below figure shows the increase in days with temperatures over 90 degrees Fahrenheit. The projection suggests Nashville will have as many as 133 days per year that are over 90 degrees—that is a full third of the year under heat stress. Figure 16 provides Nashville's projected cooling degree days, which demonstrates the amount of energy Nashvillians will need to use to cool their dwellings, when outdoor mean temperatures (the average of highs and lows for the day) exceeds 65 degrees Fahrenheit. Under a high emissions scenario, usage is projected to double from 2012 levels. Heat will have a significant impact on Nashville's people, their health and financial wellbeing.

Figure 15. Days with maximum temps above 90 degrees F.

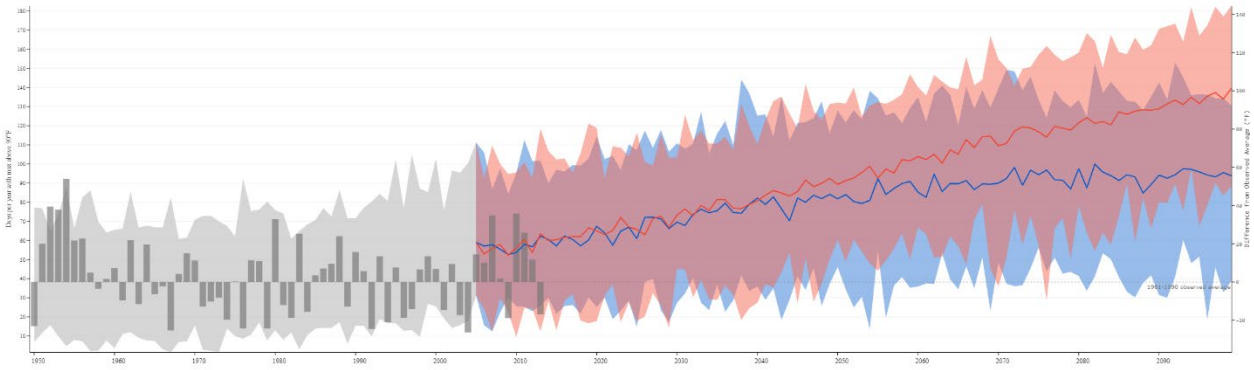
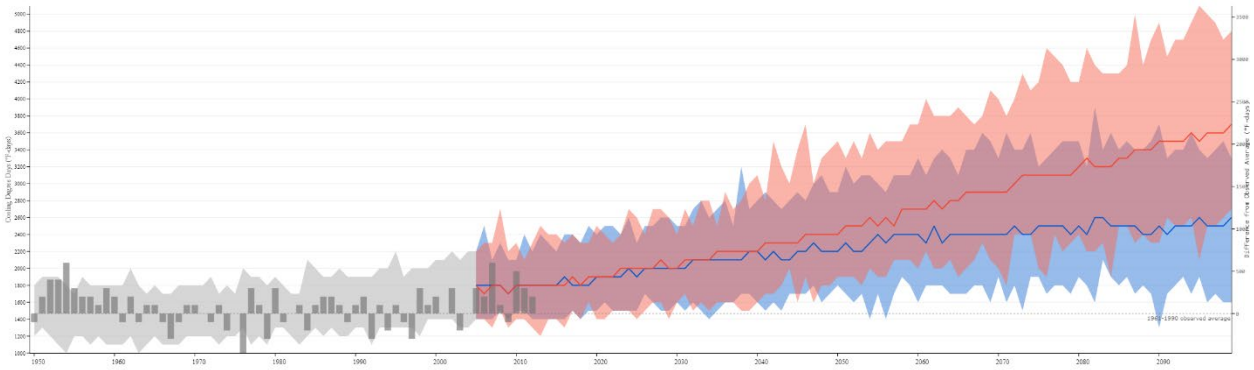


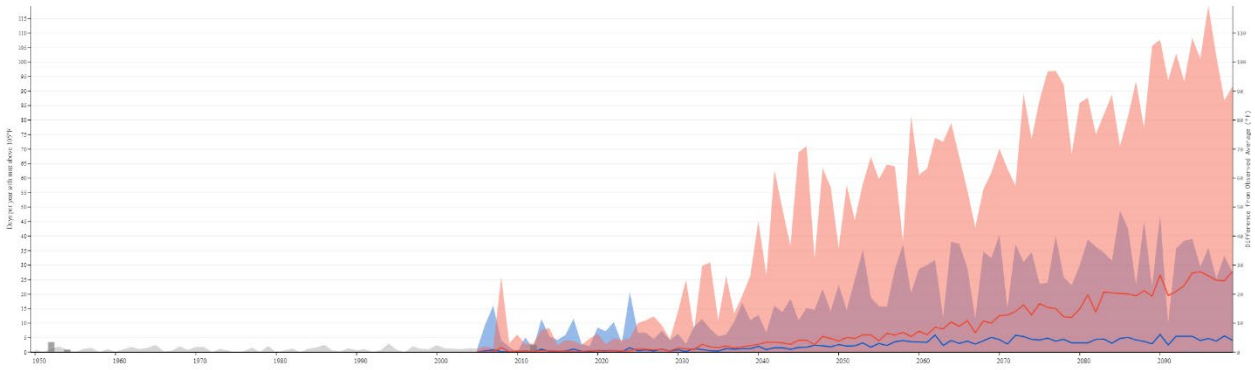
Figure 16. Projected Cooling Degree Days.



Finally, Figure 17 below illustrates how the number of days with maximum temperatures exceeding 105 degrees Fahrenheit will significantly increase in future years in both a lower and higher emissions scenario. Compared to FSF, this prediction is more conservative and projects in the 2050s that there will be anywhere between 2.8 and 5.4 days per year with maximum temperature more than 105 degrees in Davidson County in a lower and higher emissions scenario, respectively. This is compared to the 1961-1990 observed average of zero days.

[17] See NOAA's Heat Index Chart (heatindex_chart_rh.pdf (noaa.gov)).

Figure 17. Days with Maximum Temperature > 105 degrees.



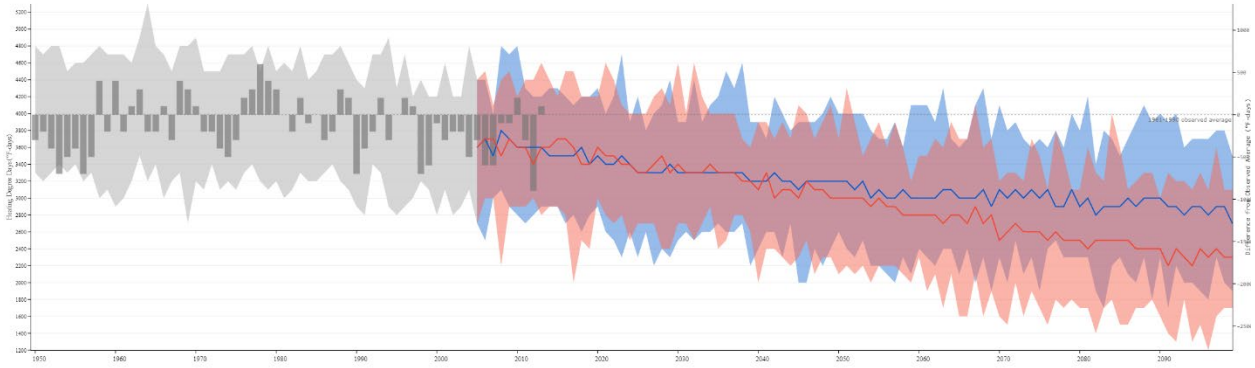
EXTREME COLD

While extreme heat is more common in Nashville, and represents the greater climate threat over time, extreme cold is also a concern, which was particularly evident over the winter holidays of 2022, when Winter Storm Elliott hit much of the eastern continental U.S., including the Metro Nashville area, which experienced power outages and rolling blackouts. Though the region and its service providers were able to prepare for the storm, its speed and intensity exceeded expectations. The middle Tennessee region had not seen temperatures that low or for that many days in a row since February 1996, and TVA set multiple energy demand records, including hitting the highest 24-hour electricity demand in TVA's 90-year history. This extraordinary demand, coupled with generating equipment failures (coal, gas, and independent power producers), resulted in TVA having to implement emergency load curtailment procedures in order to stabilize the system, also a first in its history. The outcome of the failures and blackouts included financial impacts on TVA of approximately $170 million.[18]

The below figure provides Nashville's projected heating degree days, which reflects the amount of energy it will take to heat an indoor environment when temperature falls below 65 degrees Fahrenheit. The projected energy usage is projected to decrease by roughly 30-40% dependent upon the emissions scenario.

[18] 14125_149056454 (webdamdb.com)

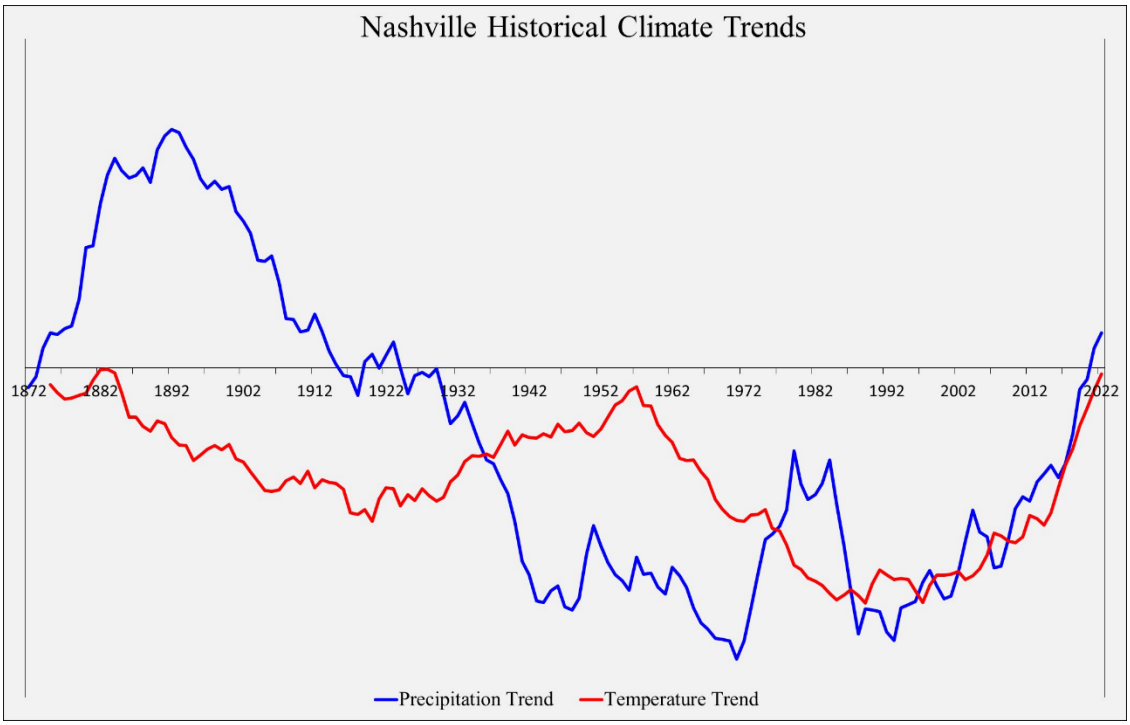
Figure 18. Projected Heating Degree Days.



A NOTE ON HISTORICAL CLIMATE TRENDS AND THE PLANNING HORIZON

The authors recognize that a more comprehensive evaluation of temperature and precipitation trends for the City is necessary. While we have used climate projection tools and available data to inform evaluation of probability of certain climate events, there is local data available that can provide a more nuanced picture of how climate is changing in Middle Tennessee over the long term. Convening a panel of technical experts to evaluate long-term local temperature and precipitation data, and establish planning thresholds, would provide a greater understanding of whether current extreme weather experiences are part of a cyclical pattern that has been observed in the past, or whether our recent and current experiences are extraordinary. In general, based on local historical climate records, Middle Tennessee climate varies between warmer or cooler than average, and wetter or drier than average. The below figure illustrates average temperature trend and the average precipitation trend for Nashville using weather records dating back to the 1870s.

Figure 19. Nashville's Historical Climate Trends (source: NOAA).



Regardless of whether Nashville's past and current climate aligns with cyclical trends, the authors believe that preparing for a changing climate is an approach that is beneficial for our city.

NON-CLIMATE–RELATED RISKS

This Plan is exclusively focused on climate threats, and its resilience planning is specific to that focal area. Preparation and resilience planning for non-climate threats, including cyber security and the coronavirus pandemic, requires different expertise and is addressed by separate Metro efforts. Metro's MHMP (refer to Appendix 1) includes non-climate-related risks in its Threat and Hazard Identification and Risk Assessment (THIRA), namely hazardous materials incidents, communicable diseases, and manmade disruptions (technological/terrorism). The 2023 THIRA update ranked communicable diseases within the top five risks as compared to the 2019 assessment, which reflects the impacts of the Coronavirus disease in the intervening timeframe. This adjustment in the ranking caused extreme temperatures to be bumped down under thunderstorms to number six, but is still considered a significant risk.

The 2023 update also recognized other natural and man-made incidents that occurred after the publication of the 2019 THIRA, including, in the latter regard, the 2020 bombing downtown and the significant population and building increases that have occurred in recent years, which had an influence on impact and vulnerability scoring. It is beyond the scope of the CARP to address non-climate-related risks, though many of them (including the impacts of Nashville's exponential growth on communities) have been considered as contributing factors. As noted in earlier sections of this document, many strategies recommended for addressing climate risks can also support Metro's efforts to respond to non-climate risks.

SOCIOECONOMIC INEQUALITY IN METRO NASHVILLE

Socioeconomic inequality—a disparity in the distribution of wealth and opportunities for betterment among people belonging to different groups—is one of the main determining factors of a person's or community's overall vulnerability. People and communities that face challenges on a status quo basis are disproportionately impacted by climate change, as they are already more likely to live in areas vulnerable to natural disasters such as flooding, live in proximity to highways and industry leading to polluted air, suffer from a higher incidence of chronic health conditions as a result, and reside in neighborhoods characterized by historic and/or ongoing under-investment. This is why, from a climate perspective, such communities are considered to be on the "frontline" [19] of climate impacts. It is also why equity—which, it bears repeating, is defined herein as the just distribution of and access to opportunities, resources, and healthy environments in a way that recognizes inequality of circumstance, systemic and structural imbalance, and targets equality of outcomes—is considered a critical and cross-cutting component of Metro's adaptation and resilience planning.

In order to achieve equity of outcomes, it is necessary to first understand how and why climate hazards affect people in unequal ways, as well as why adaptation strategies may inadvertently benefit some groups over others if they are not carefully targeted. **It is important to emphasize that when this Plan refers to "frontline" or "vulnerable" communities, it is in recognition of higher levels of risk burden than the average Nashvillian due to structural, historical, societal, economic, and other drivers of inequity. It is not a judgement on those communities being inherently weaker, lacking innate resilience, or not commanding a seat at the table in identifying and implementing solutions.**

Examples of frontline and vulnerable communities include:

- Communities residing in areas that are geographically prone to climate disaster, such as those living in the 100-year floodplain;
- People living in dwellings that are at higher risk for damage or impact, such as mobile homes or substandard housing, which are less likely to withstand severe storms like tornados and are more susceptible to overheating than standard houses or those meeting safety codes;
- People who work outdoors and are exposed to severe weather and extreme temperatures on a daily or near-daily basis, or those who work in un-conditioned indoor environments;
- People and communities located in close proximity to historical or current sources of pollution, hazardous waste, and other safety hazards;
- Historically marginalized populations living in situations of ongoing injustice and compounded trauma;

[19] "Communities that are both highly exposed to climate risks and have less capacity or political power to respond to these risks are often referred to as "frontline communities" in the existing literature on equitable adaptation." (Deas et al. 2017, GCC 2017).

- New American and immigrant populations experiencing language and cultural barriers as well as legal complexities associated with accessing employment, financial resources, and education;
- People of very young or of advancing age, those with chronic health conditions, and those with physical or mental disabilities who require assistance with mobility and to access resources;
- People with medical conditions that require electrically powered medical devices or refrigerated medicines;
- Single-parent households, households lacking a vehicle, those experiencing un- or under-employment, and those subsisting at minimum wage;
- The unhoused population.

Often, vulnerable people and communities experience multiple of these characteristics, which, whether singular or compounded, can exacerbate other larger-scale challenges such as the rising costs of housing and healthcare, and neighborhood gentrification.

To understand Metro's baseline human vulnerabilities, the CDC's Social Vulnerability Index (SVI) provides a useful starting point. (It should be noted that this is the Index FEMA uses for its National Risk Index, referenced in earlier sections.) According to the SVI, Metro Nashville scores at medium to high level in vulnerability overall at 0.6989 out of a range of 0 (lowest vulnerability) to 1 (highest vulnerability), meaning that the populations of close to 70% of other U.S. counties are less vulnerable than Davidson County. This vulnerability score includes variables related to socioeconomic status, household characteristics, racial and ethnic minority status, and housing type and transportation, as shown in the Figure at right. However, this figure represents an average, and certain census tracts within the city have overall vulnerability scores very close to 1 (see Appendix 3 for the county maps).

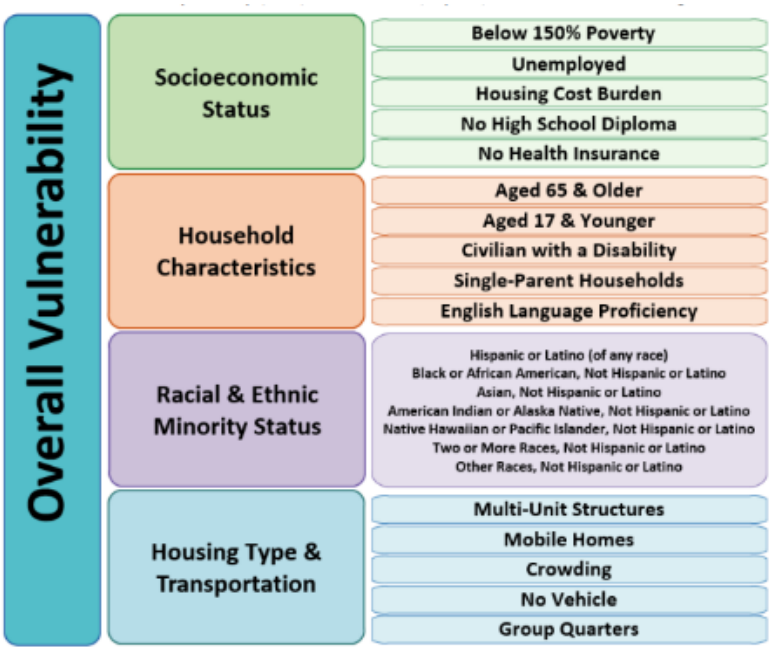


Figure 20. CDC Social Vulnerability Index variables.

Nashville's socioeconomic vulnerability score is moderately low at 0.4149. In terms of household characteristics, it scores at 0.2872. However, it's racial and ethnic minority status score is highly vulnerable, at nearly 0.9574. Similarly, the City's residents are highly vulnerable in terms of housing type and transportation, scoring nearly 0.9468.

The areas of Metro Nashville that score highest on the vulnerability index are concentrated in the City's north, northwest, northeast, and southeast perimeters, as shown in Appendix 3. Not surprisingly, this geographic distribution corresponds to the City's history of redlining (detail also

provided in Appendix 3) and "urban renewal", which is further represented by the location of its major highway corridors.[20] It also represents areas where the City is currently experiencing extraordinarily rapid growth, with the concomitant dual threats of gentrification and displacement.

It is beyond the scope of this Plan to carry out an in-depth review of Nashville's socioeconomic vulnerability, do justice to the severity or urgency of the need, or adequately examine the causes for the enduring inequity and poverty that persists among certain communities today. While Metro has begun to use the SVI as a reference when prioritizing focal areas for projects, as well as the EPA's EJScreen[21] for redressing historical environmental injustice, there is much more work that needs to be done, and not only by Metro government. For now, two additional recent reports bear mention.

In May 2023, the Tennessee Commission on Children and Youth released its county profiles on child well-being,[22] and Davidson County ranked 88th out of the state's 95 counties overall. The annual profiles look at 52 indicators and rank counties in vital areas affecting child development: Economic well-being, education, health, and family and community. One of the worst areas for Davidson County is education (Metro scores 94th out of 95 counties), and the report states that one in five children in Nashville lives in poverty. Part of this is due to severe housing cost burden—15% of Metro's families spend at least half of their income on housing alone.

During the same week, the Milken Institute released its Best-Performing Cities Index, ranking Nashville number four based on job growth, wage gains, high-tech industries, broadband access, and housing costs based on 2021 data. The main driver of this ranking was job growth and the city's strong job market, which was ranked more highly than ever before in the study's 25-year existence. However, housing affordability was found to have worsened, ranking at the median for the country's 200 largest metro areas (91 out of 200). The two indicators are at odds—as more people move to Nashville for jobs, particularly in the tech industry, housing costs will only worsen. Meanwhile, Nashville's minimum wage remains at $7.25/hour—significantly below the federal poverty level.

These indicators emphasize the need to consider how historic and ongoing inequity, together with the city's exponential growth, are placing severe burdens on a significant portion of the county's residents. Vulnerability must be considered within the nuanced context of Nashville's rapidly changing socioeconomic landscape. Affordability, particularly in the housing sector, must be a critical focus of any equity-driven poverty reduction plan. While it may seem that a focus on poverty reduction and equity does not belong in a Climate Adaptation and Resilience Plan, it is

---

[20] See the Tennessee State Library and Archives resource Mapping the Destruction of Tennessee's African American Neighborhoods at Mapping the Destruction of Tennessee's African American Neighborhoods (arcgis.com). See also the Nashville Environmental Justice Initiative's Examples of Environmental Racism in Nashville at Nashville Environmental Justice Initiative - Urban Green Lab.

[21] See EJScreen (epa.gov).

[22] Davidson2023.pdf (tn.gov)

certainly a determining factor of whether resilience is achievable for those carrying the highest climate burden.

ADDRESSING GENTRIFICATION AND DISPLACEMENT

It is important that efforts made to address climate risks do not inadvertently further inequity but rather identify parallel strategies to strengthen the underlying socioeconomic wellbeing of communities that have already been burdened by decades of negligent policy-making. In general, Nashville must confront the impact its rapid growth is having on its low-income populations and, as a priority, take steps to protect neighborhoods against disinvestment and displacement.

Climate equity is not only concerned with the siting of climate resilient interventions and the remediation of historically polluted or under-resilient areas, but also with who reaps the benefits of site-level interventions. As temperature s rise, flooding and extreme precipitation become more frequent, and the climate becomes generally more volatile, resilience with be financialized and become an important factor in real estate markets. In the past few decades, social scientists have begun to explore the relationship between climate resilient projects and green infrastructure more generally, and residential displacement pressures leading to gentrification.[23] [24] [25] [26] Climate gentrification can occur through myriad pathways, but most relevant to this Plan is the process through which investment in a neighborhood's built environment, often tied to a "green" or "climate resilience" discourse, contributes to rising real estate prices and the displacement of lower-income residents who can either no longer afford area rents or the associated property taxes on their higher-valued homes.[25]

Further, displacement as a result of gentrification may compound environmental risk for vulnerable groups and contribute to the distribution of climate risks.[27] There is consensus that the health consequences of gentrification disproportionately affect low-income black, indigenous, and people of color.[28] The negative health consequences of gentrification are not isolated to those displaced from gentrifying neighborhoods who have been documented to have higher rates of emergency department and hospital visits (mostly due to mental health), but also affect those who

[23] Anguelovski, I., Connolly, J. J., Garcia-Lamarca, M., Cole, H., & Pearsall, H. (2018). New scholarly pathways on green gentrification: What does the urban 'green turn' mean and where is it going?. Progress in Human Geography.

[24] Isabelle Anguelovski et al, Green gentrification in European and North American cities, Nature Communications (2022).

[25] Jesse Keenan et al, Climate Gentrification: From Theory to Empiricism in Miami-Dade County, Florida, Environmental Research Letters (2018).

[26] Shokry, G., Connolly, J. J., and Anguelovski, I. (2020). Understanding climate gentrification and shifting landscapes of protection and vulnerability in green resilient Philadelphia. Urban Clim. 31, 100539.

[27] Wilson, B., and Chakraborty, A. (2019). Mapping vulnerability to extreme heat events: lessons from metropolitan Chicago. J. Environ. Plan. Manag. 62, 1065–1088.

[28] Smith G.S., Breakstone H., Dean L.T., Thorpe R.J. Impacts of gentrification on health in the US: A systematic review of the literature. J. Urban Health. 2020;97:845–856.

remain through the alteration of neighborhood resources and social practices.[28] Increased feelings of social isolation due to gentrification and population turnover for those who remain in gentrifying neighborhoods is particularly relevant given that one of the most vulnerable groups, elderly residents, are often those most likely to remain in gentrifying and gentrified areas such as North Nashville (Hightower and Fraser).

Additional information is given in Strategy CC6.

EQUITY AND CLIMATE RISK

In climate adaptation, equity means that all residents have the opportunity to benefit from climate action and are not unequally burdened by climate impacts and hazards. There are three key aspects to equity, including procedural equity, distributional equity, and structural equity (Foster et al, 2019).

Procedural equity requires that those who are most burdened by environmental injustices and climate change are identified and engaged in planning and implementation processes. Decision-making power regarding climate adaptation planning must be shifted to frontline communities, or those who have been most affected by environmental injustices, to ensure that the solutions developed are effective and long-lasting. Steps to advance procedural justice include forming an environmental justice advisory committee, developing a screening tool to evaluate policies through an equity lens, defining equity metrics and objectives to track progress, and conducting community engagement with a focus on low- income communities and communities of color.

While procedural equity is central to achieving equitable climate action, *distributional* equity is also necessary to ensure that the benefits and burdens associated with climate adaptation planning are allocated equitably across the city's communities. Emphasizing fair and just distribution of outcomes of climate action is especially important as climate change threatens to widen existing inequalities. Low-income areas and neighborhoods of color in Nashville are already more likely to lack trees, transit, green infrastructure, jobs, and sidewalks, making them more vulnerable to climate hazards. Prioritizing low-income areas and neighborhoods of color in climate action will help Nashville to reduce existing vulnerabilities and prevent climate change impacts from exacerbating health, economic, and racial disparities. These disparities are felt in numerous ways—from a lack of home or renter insurance to recover from extreme weather events, to increased asthmatic cases, increased lead poisoning incidents, and a higher probability of living in a food desert.

Structural equity, the third equity framework, requires recognizing and addressing the role the government has played in creating and perpetuating systems and policies that have caused low-income communities and communities of color to be underserved and underrepresented. Nashville must acknowledge its institutional racial bias and historically discriminatory policies that have upheld economic, racial, and social inequities and reform its structures and decision-making processes. Educational measures, such as racial justice training, can assist in the realization of structural change.

FLOODING

Historically, communities of color are more likely to reside in low-lying flood prone areas as a consequence of redlining and housing segregation policies that began in Nashville in the 1930s. These government policies led black families to be denied mortgages in nicer areas of Nashville, pushing them into more hazardous, flood-prone areas. Flooding is also more likely to impact low-income neighborhoods, where residents have fewer resources to prepare for and recover from flood damage to properties. Lack of flood insurance among low-income residents only compounds the problem. Low-income residents are also more likely to live in substandard housing, which is at greater risk for mold, mildew, and poor indoor air quality following a flooding event. Because low-income neighborhoods and communities of color face a greater risk of flooding and flood damage, climate change hazards like flooding will magnify existing social, economic, and health inequities.

TORNADOES

Residents with low incomes, often in communities of color, are disproportionately threatened by tornadoes because low-income households are more likely to reside in substandard housing that is more susceptible to being damaged. Additionally, the recovery and rebuilding process for low-income residents is challenging due to a lack of insurance and financial means to recover or relocate after disasters. Research indicates that recently, during the tornado in March 2020, damage in North Nashville (which included the HBCU Tennessee State University) did not receive as much public attention or investment (GCC 2017, Deas et al. 2017).

As households in frontline communities struggle to rebuild their homes after they have been damaged by tornadoes (and any destructive event), developers have been known to buy up damaged homes and flip properties, causing displacement of low-income families and persons of color and increasing gentrification. The city recognizes that climate change extreme weather hazards threaten to exacerbate these social inequalities, which are rooted in income inequality, redlining, racism, neighborhood disinvestment, and political disenfranchisement (GCC 2017). Climate adaptation efforts serve as an opportunity to reduce social inequities by prioritizing historically underserved and underrepresented populations.

EXTREME HEAT

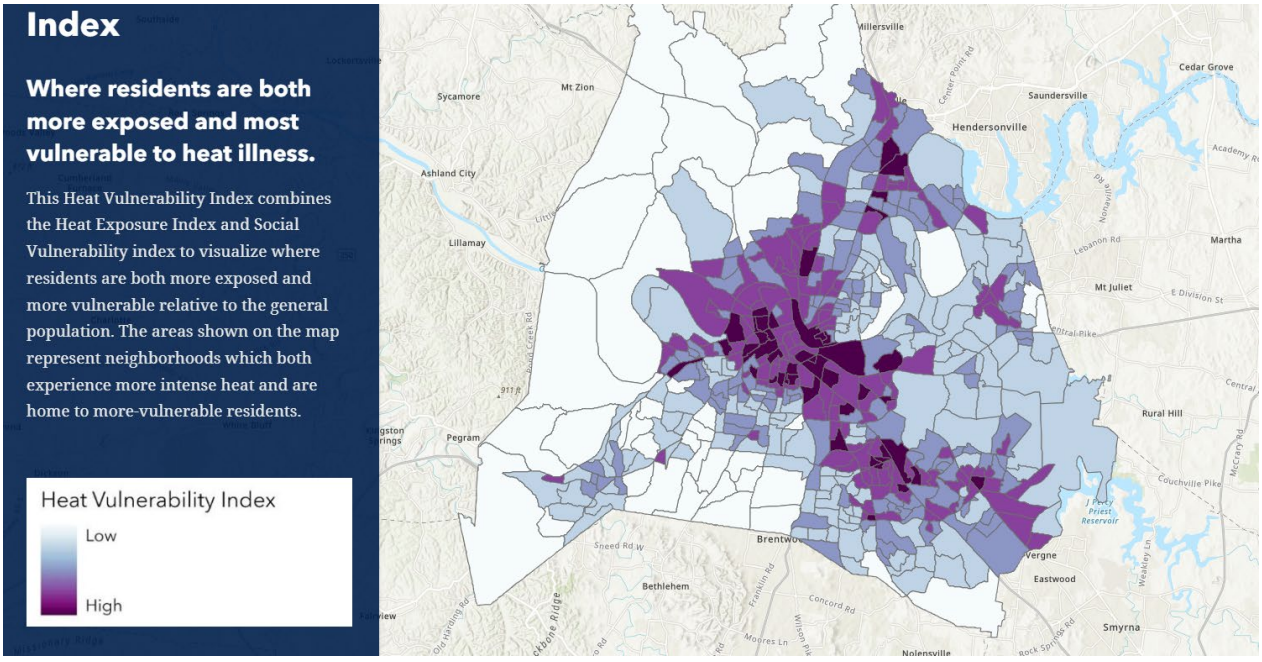
While extreme heat events affect all Nashvillians, some populations are particularly susceptible to its impacts and have a reduced ability to adapt or recover. Health impacts due to extreme heat will disproportionately affect older adults, young children and infants, people with physical or mental health conditions, lower-income communities, communities of color, and immigrants and refugees.

Marginalized communities, such as low-income communities and communities of color, are more susceptible to the impacts of extreme heat, such as heat-related illnesses and deaths, as a consequence of social and economic inequalities. First, low-income communities and communities of color are more likely to live in urban areas which lack sufficient park space and tree canopy—or urban heat islands—where the extent of extreme heat is magnified. Low-income households may also be unable to afford air conditioning and are more likely to live in neighborhoods with

high crime rates where leaving windows or doors open to cool the house feels unsafe, further increasing their risk of heat illness.

In Summer 2022, local experts, nonprofits, and researchers teamed with community scientists to measure temperatures and humidity across Nashville and Davidson County during a one-day heat mapping campaign supported by NOAA. The data revealed the warmest and coolest neighborhoods in the city. Metro used this data and other available demographic and public health datasets to develop a StoryMap[29] that identifies which neighborhoods are most exposed to heat risk. Unsurprisingly, in Nashville, formerly redlined, historically Black neighborhoods such as North Nashville, Edgehill, and parts of East Nashville are some of Nashville most heat vulnerable communities, as shown in the below figure, which demonstrates Nashville's Heat Vulnerability Index, a combination of areas that experience more intense heat and are home to more vulnerable residents.

Figure 21. Nashville's Heat Vulnerability Index.



EXTREME COLD

People with existing physical or mental health conditions, homeless individuals, low-income populations, communities of color, and low English proficiency populations have less access to resources and may be more sensitive to very low or very high temperatures. Without intentional policies and programs, climate change hazards will increase existing social inequities. For instance, extreme cold will heighten the challenges that low-income communities in Nashville

[29] See Nashville Heat Impacts StoryMap (arcgis.com).

face, including high energy burden, food insecurity, and chronic stress. More information on vulnerability outcomes is given in the next sections.

ASSESSING RISK FROM A SYSTEMS PERSPECTIVE

Risk should be understood as the sum total of all potential impacts or consequences resulting from a particular event, based on its characteristics, probability, and magnitude (severity and scale). The challenge of assessing and prioritizing risk mitigation lies in how such impacts are characterized, and they cannot be considered in isolation of the particular exposures of certain geographic areas, system, assets, or communities, and the specific vulnerabilities (sensitivity, condition, ability to withstand, and ability to adapt) of each system and its assets. The ability to adapt or lack thereof will either decrease or amplify the magnitude of the impact, and is therefore a determining factor.

Prior to the development of this Plan, Metro had not conducted a comprehensive climate risk assessment, which is a key aspect of any resilience plan. A full evaluation of risk requires an understanding of how climate-related hazards—both individual events, or shocks, and longer-term trends, or stressors—affect or could potentially affect all aspects of life in the city. This includes not only the built or physical environment but also the social and cultural characteristics of society as well as the basis of the economy. It also includes an assessment of systems interdependencies and cascading consequences, which is pre-requisite to understanding hazard-specific social and structural vulnerabilities and ensuring adaptation strategies are effectively targeted and equitable.

This Plan seeks to build upon the risk assessment contained in Metro's MHMP by identifying, characterizing, and prioritizing climate risk. While it was not possible to *map* risk as part of the CARP, due to resource constraints, climate hazard mapping is targeted as a near-term intervention and will assist Metro departments in geographically identifying frontline communities needing priority support. The intention is for the information contained in the CARP to assist Metro's departments to conduct their own detailed risk assessments and build out mitigation and adaptation strategies that meet our community's most urgent needs rather than addressing resilience on an ad hoc and project-by-project basis.

As noted elsewhere, this Plan does not reflect a comprehensive risk assessment that includes a detailed audit of Metro's infrastructure, services, natural resources, and community needs, priorities, and adaptive capacity. Rather, the aim is to establish the framework and a roadmap that will provide a springboard for department-level, specific audits, assessments, and adaptation plans, and that will further provide Metro and its partners with a basis for community outreach and engagement toward development of future community-specific resilience plans.

Metro has chosen to evaluate its risk and specific vulnerabilities from a systems approach that draws on best practices as well as FEMA's community lifelines as they are applied in Metro's

MHMP.[30] Using this approach allows Metro to identify specific system vulnerabilities and consequently, priority areas for intervention, while ensuring that it integrates seamlessly with Metro's hazard mitigation planning and emergency response. Metro has broken its system map down into five pillars that comprise the major components of daily life, which are further described by sub-components. Those that correspond directly to FEMA's community lifelines are highlighted in green in the below Table 7.

Table 7. Metro's System Asset Classes.

									
Community & Culture		**Natural Environment**		**Infrastructure**		**Economy**		**Public Safety**	
A	Livelihood and affordability	D	Ecosystem services	H	Energy generation	N	Agriculture	Q	Emergency services
B	Health and wellbeing	E	Flora/forests/ trees	I	Energy transmission	O	Supply chain	R	Law and order
C	Access to goods and services	F	Watersheds/ hydrology	J	Water supply	P	Business continuity	S	Government Services
		G	Fauna/native species	K	Storm/waste-water and waste management			T	Community Safety
				L	Communications				
				M	Transportation				
Crosscutting: Equity									

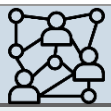
Each pillar's sub-components are briefly described below.

[30] FEMA defines the community lifelines as "the most fundamental services in the community that, when stabilized, enable all other aspects of society" and "provide an outcome-based, survivor-centric frame of reference that assists responders with root cause analysis, interdependencies, prioritization, and ease of communication." Prior to July 2023, the lifelines consisted of seven pillars with associated components; they have since been updated to eight.

COMMUNITY AND CULTURE

The Community and Culture category refers to the people who make up Metro Nashville's population of approximately 716,000,[31] their quality of life, physical and mental health and wellbeing, and access to the goods and services that support their quality of life.

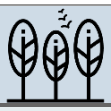
Table 8. Community and Culture Sub-Components.

		 **Community & Culture**
A	Livelihood and affordability	The ability of Nashville's residents to afford the necessities that support a basic level of material wellbeing.
B	Health and wellbeing	The physical and mental health and wellbeing of Nashville's residents, including access to care and the medical supply chain, public health services, and the protection of human rights, dignity, and cultural heritage for all persons.
C	Access to goods and services	The ability of Nashville's residents to access basic necessities including housing/shelter, food, and water, and the proximity of essential services including transportation, medical care, veterinary care, education, and recreational opportunities.

NATURAL ENVIRONMENT

The Natural Environment category refers to Metro Nashville's environment, inclusive of air, water, flora, fauna, wild spaces, and hydrology, and the vital services those assets provide to support daily life.

Table 9. Natural Environment Sub-Components.

		 **Natural Environment**
D	Ecosystem services	The basic building blocks of life, such as clean air, water, plant life, and the regulating functions of ecosystems upon which human life depends.
E	Flora/forests/ trees	Plant life, inclusive of trees, forest cover, and all vegetation but in particular those species endemic to middle Tennessee.
F	Watersheds/ hydrology	The lands that support the rivers, streams, lakes, and other water bodies on which Metro Nashville depends.
G	Fauna/native species	Animal life, in particular species endemic to the middle Tennessee area.

[31] Source: Tennessee State Data Center (draft THMP 7-28-23).

INFRASTRUCTURE

The Infrastructure category refers to Nashville's built environment and the critical services upon which society is dependent. It is important to note that when considering the potential vulnerability and adaptive capacity of the infrastructure pillar, its complete system is taken into account, inclusive of the physical hardware, operational software, and the personnel who keep it operational.

Table 10. Infrastructure Sub-Components.

		 **Infrastructure**
H	Energy generation	The equipment, materials, fuels, and systems required for production of electricity from various energy sources such as fossil fuels, hydropower, and solar panels.
I	Energy transmission	The equipment, materials and systems required for the transport of electricity from its place of production to place of consumption.
J	Water supply	The equipment, materials and systems required for the provision of potable water inclusive of treatment, storage, and transmission through pipelines.
K	Storm/wastewater and waste management	The equipment, materials and systems required for the routing and capture of polluted rainwater run-off and the transmission, treatment, and discharge of this wastewater, sewer and grey water at municipal treatment plants; the collection, sorting, and disposal of household and commercial waste including landfill and recycling services.
L	Communications	The means that facilitate information exchange, including the physical infrastructure and other resources that support telecommunications, radio, and print media.
M	Transportation	The equipment, materials and systems required to move people and goods, inclusive of roadways, bridges, sidewalks, bikeways, airports, rail lines, fueling and charging infrastructure, cargo carriers, and public transportation in all forms.

ECONOMY

The Economy category refers to the key aspects of Nashville's prosperity and financial wellbeing, inclusive of agriculture, the global supply chain, and the building blocks and resources necessary to keep both the public and private sectors functional and thriving.

Table 11. Economy Sub-Components.

		Economy
N	Agriculture	The production of food and natural goods, including the practices and systems of crop cultivation and animal husbandry/livestock care.
O	Supply chain	The global network consisting of raw materials, manufacturing, quality control, and delivery systems and processes that move goods and services to consumers.
P	Business continuity	The ability of both the private and public sectors to operate, generate revenue, and deliver services without interruption, inclusive of banking services and electronic payment processing systems.

PUBLIC SAFETY

The Public Safety category refers to Nashville's systems and services that are essential to keep its communities and individuals safe, and critical lifelines accessible.

Table 12. Public Safety Sub-Components.

		Public Safety
Q	Emergency services	The public organizations, inclusive of their equipment, facilities, and personnel, that coordinate and directly respond to emergencies such as emergency operations centers (EOCs), police, firefighting, ambulance, search and rescue, and disaster recovery services.
R	Law and order	The public organizations, inclusive of their equipment, facilities, and personnel, that maintain a safe and orderly functioning of society through enactment and enforcement of laws.
S	Government Services	Distinct from the Infrastructure category, this refers to the essential services provided by Metro government inclusive of equipment, facilities, and personnel, that keep services running and resources available during both blue (normal) and grey (disruptive or abnormal) skies.
T	Community Safety	Distinct from the sub-components above, this refers to flood control (levees) and other mitigation and control actions in place to respond to climate hazards (such as warning systems like tornado sirens) and to safely manage and store hazardous materials.

In the following sections, this system map and its component definitions will be used to describe a systems-wide risk profile for Metro's main climate hazards.

METHODOLOGY

A recent, widely used approach to climate risk assessment comprises pairing climate hazards with specific assets or asset classes—in recognition of the fact that adaptation and resilience are both stress- and site-dependent—and ranking their potential levels of risk based on the severity of potential impact and the existing or potential adaptive capacity of that asset or system. This helps planners to prioritize potential interventions.

Metro initially followed this approach and the lead authors undertook a ranking of each climate hazard's potential impact alongside an assessment of the system or its sub-component's adaptive capacity. The exercise was guided by the following definition of impact:

- Potential level of loss to the system and its functionality or wellbeing;
- Likelihood that the climate event will cause a disruption in functionality or operations;
- Potential severity of the disruption or damage;
- Potential magnitude or extent of an area that could be impacted (e.g., is the likely impact localized or widespread);
- Most vulnerable aspect or sub-population within the system, based on static factors such as geography.

A very high-level review of the systems' adaptive capacity considered their existing as well as potential capacity—the availability of best practices that can be employed—and the risk assessment was based on both factors. The results of this hazard-system component pairing are given in Appendix 2, and are presented separately for each of the five climate hazards under consideration in this Plan. (This information is provided only for reference, as it was determined to not be the best approach.)

The question of adaptive capacity also considers whether mitigation and adaptation strategies exist to address a particular climate hazard. In some cases, adaptation is limited by practical, technological, or financial feasibility. For example, there are few strategies available to improve the adaptive capacity of wildlife to extreme weather events. Therefore, though wildlife are at increasing risk of negative impacts from climate change, that risk was determined to be a low priority for the Adaptation Plan beyond those strategies were co-benefits exist.[32]

[32] Where the practical or technological availability of an adaptive strategy is lacking, the risk may not be surmountable. This is where Nashville can play its global part in mitigation actions, such as increasing renewable energy generation to reduce greenhouse gas emissions, that seek to prevent worsening weather conditions in order to preserve the natural environment that exists today. Metro's Climate Action Plan was oriented at these "fork in the road" or highest-impact interventions. The focus of this Plan is to develop a roadmap for adaptation for the natural hazards we face today, and their projected shifts in future. Therefore, this Plan will focus on those areas at greatest risk of suffering consequential impacts where interventions exist to lessen the severity or extent of impact.

THE IMPACT CHAIN APPROACH

Following this initial analysis, the lead authors formed a working group composed of leadership and staff from the Mayor's Office and twelve Metro departments considered to play frontline roles either in directly addressing the impacts of climate change or institutionalizing systemic change.

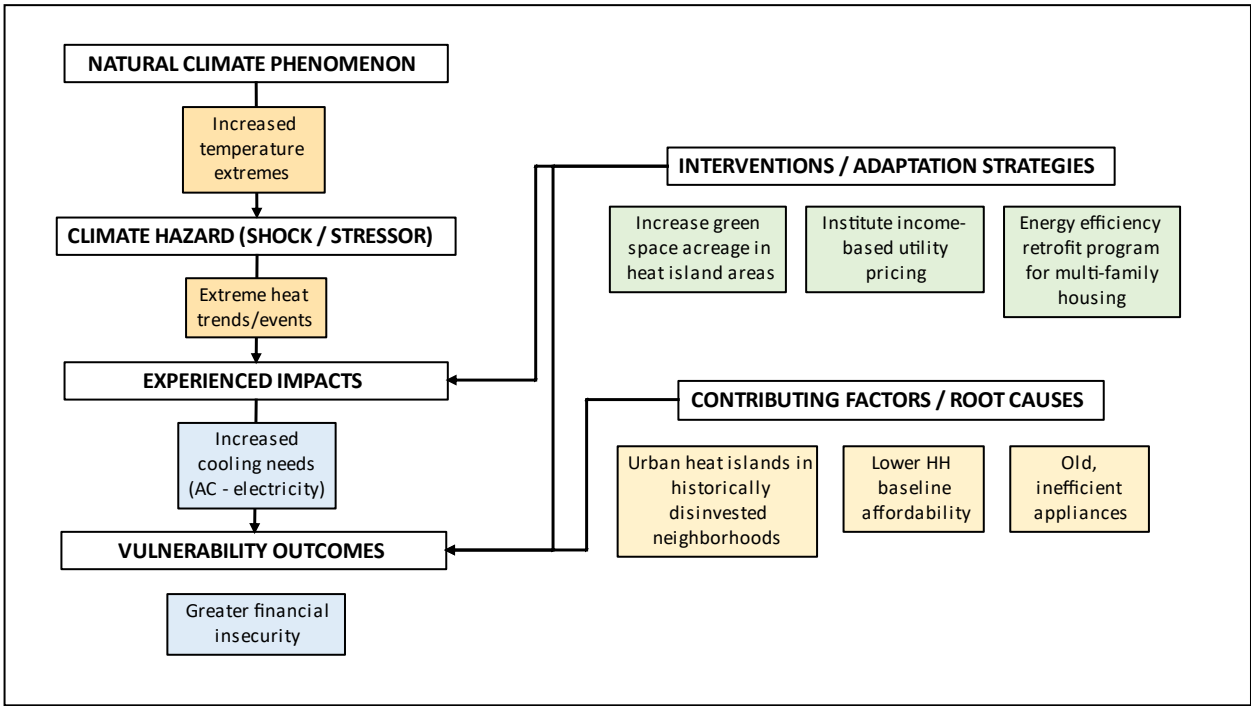
Rather than work through the pairings and individual hazard-system rankings with the group, Metro chose to take a slightly different approach in order to achieve a more equity-sensitive analysis: By developing impact chains. The use of an impact chain conceptual framework has been used when distinguishing exposure from risk is the primary objective.[33] It identifies the immediate or direct experienced impact of a climate shock or stressor and then asks (i) what contributing factors exacerbate that impact from a biophysical standpoint (e.g. land use patterns), (ii) what are the cascading impacts on human and social vulnerability, and (iii) what socioeconomic and/or historical contributing factors and root causes contribute to the vulnerability outcomes. This allows the evaluator to consider intervention strategies that target both the outcomes and root causes within a human- and equity-centered lens.

The below figure provides a simple example of an impact chain that considers extreme heat trends and events. In this example, one experienced universal impact is increased electric power consumption due to an increased need for air-conditioned interior spaces. This increased consumption has ripple effects across the system—in particular, cascading service disruptions caused by failures of the electric utility, which may struggle to meet increased demand or encounter decreased capacity due to technical issues such as short circuits in aging infrastructure. The ripple effects are felt most acutely by vulnerable individuals and households, who may have limited or no expendable income to cover higher electric bills. That lower baseline affordability is a significant contributing factor that results in greater financial insecurity as an outcome of the climate event. Many lower-income households also live in areas that lack green spaces, where Nashville's Heat Mapping study found that heat island effects can make outdoor temperatures up to 12 degrees higher than in leafy, suburban neighborhoods of the same city.[34] They may also live in older, less efficient housing with outdated appliances that consume more energy. These factors combined mean these urban households may have even higher electric bills during an extreme heat event than their wealthier neighbors. In order to reduce climate-driven vulnerability outcomes, equity-centered adaptation strategies should therefore consider socioeconomic contributing factors in the delivery of targeted interventions.

[33] See Menk et al for one review of applications (Climate Change Impact Chains: A Review of Applications, Challenges, and Opportunities for Climate Risk and Vulnerability Assessments in: Weather, Climate, and Society Volume 14 Issue 2 (2022) (ametsoc.org)).

[34] See Nashville's Heat Storymap at Understanding Nashville Heat.

Figure 22. Simple impact chain for extreme heat events.



The content of the following sections and the Plan this document presents are the product of a series of Metro group work sessions where impact chains were developed, analyzed, and refined, and intervention strategies identified and prioritized. The Plan also reflects the review and/or input of the Sustainability Advisory Committee, Nashville's Multi-Hazard Mitigation Plan Community Planning Team, the Nashville Environmental Justice Initiative, and limited community discussion sessions.

POTENTIAL IMPACTS AND VULNERABILITY OUTCOMES

As a reminder, there are two principal risk characteristics for all assets (including people): Exposure and vulnerability. Put simply, risk is the consequence of the hazard interacting with these two asset characteristics. As noted in previous sections of this Plan, a household's baseline vulnerability is a determining factor of their level of risk, and can be multiplied by climate hazards.

For each of the five system pillars, the following sections provide an overview, first, of potential immediate or experienced impacts, including a screening for cascading vulnerability outcomes for each impact. This impact assessment allowed Metro to then identify the main areas of exposure and vulnerability within its system map, and pair these with focal areas for intervention.

COMMUNITY AND CULTURE

Metro's assessment of potential climate impacts on Community and Culture, and the three components that describe its composition, are given in Figure 23 below. Every single one of the impacts in this category are assessed to have cascading impacts on vulnerable populations.

Figure 23. Potential Climate Impacts on Community and Culture.

Applicable Hazards	Potential Impacts: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Cascading Vulnerability Outcome(s)?
		A	B	C	
	Damage or destruction to property, homes and small businesses with associated repair, replacement, and/or relocation costs	X	X	X	YES
	Chronic housing quality issues such as mold, resulting from climate-related damages	X	X		YES
	Increased cost for or loss of property (home, car, flood, etc.) insurance	X		X	YES
	Increased energy costs due to extreme temperatures, rising demand	X		X	YES
	Loss of goods (refrigerated foods and medicines) due to power surge or outage.	X	X	X	YES
	Missed work, reduced productivity and profitability due to both direct impacts (heat waves, flooded roads) and indirect impacts (fatigue, memory and attention issues, poor sleep)	X	X		YES
	Missed school and reduced educational outcomes	X			YES
	Loss of life or bodily injury.	X	X		YES
	Worsening pre-existing health conditions: • Asthma and cardiovascular disease caused by air pollution; • Heat-related illness (heat rash, heat exhaustion, and heat stroke) and death, including cardiovascular failure; • Respiratory allergies and asthma resulting from increasing allergens;		X		YES

Applicable Hazards	Potential Impacts: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Cascading Vulnerability Outcome(s)?
		A	B	C	
	• Changes in vector ecology and water quality impacts leading to increased incidence of diseases such as Lyme disease and leptospirosis; • Increased physical and mental stress as a result of exposure to hazardous conditions and post-disaster recovery efforts.				
	Disruption in supply chain resulting in scarcity or high cost of goods including medicines.	X	X	X	YES
	Inability to leave the home or receive support.	X	X	X	YES
	Inability to access good and services for those lacking air-conditioned personal or public transportation; increased travel risk for those who go regardless		X	X	YES
	Impacts on the aesthetics of living spaces.		X		YES
	Increased costs of maintaining a livable space during extreme temperature events.	X			YES

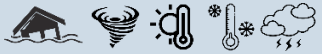
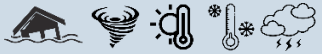
For an example of cascading impacts, let's consider the first listed impact: *Damage or destruction to property, homes and small businesses with associated repair, replacement, and/or relocation costs*. An all-too-common outcome is seen following a significant flooding event, when a family that has put all of their savings and the majority of their income into home ownership suffers significant damage to the home, rendering it unlivable. They may not have been able to pay for expensive flood insurance or may not have thought they needed it because their property was not shown to be at significant risk on the flood maps that were consulted when they bought the property. As a result, repairs to the home must come out of their expendable income, which is limited, on top of the mortgage payments. Eventually, after shelter or hotel stays, they make the decision to give up the property and move in with family members, where conditions are crowded. Saving up enough money to become homeowners again or putting their limited income into renting an apartment in the same neighborhood at current rates is now beyond their reach. They therefore become stuck in a situation of dependence, which does not support an ability to thrive in work or school. The impacts that continue to follow can be long-term, occur as a vicious cycle, and devastating for the family in this example.

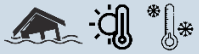
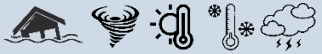
Adaptation and resilience strategies must therefore often be targeted to communities or households whose level of vulnerability starts out much higher than those with similar levels of hazard exposure, resulting in greater levels of risk (e.g., more and/or worse cascading and longer-term consequences). This is the equity aim—to drive equality of resilience outcomes by addressing disproportionate impacts with weighted support.

NATURAL ENVIRONMENT

Metro's assessment of potential climate impacts on the Natural Environment, and the four components that describe its composition, are given in Figure 24 below. The majority of these impacts also have been assessed to result in disproportionate impacts.

Figure 24. Potential Climate Impacts on the Natural Environment.

Applicable Hazards	Potential Impacts: Natural Environment	Ecosystem Services	Flora/ Forests/ Trees	Watersheds/ Hydrology	Fauna/ Native Species	Cascading Vulnerability Outcome(s)?
		D	E	F	G	
	Damage or destruction of plants and trees, including tree canopy and associated benefits, and crops.	X	X	X	X	YES
	Injury or death of animals, reptiles, birds, and/or insects.	X			X	YES
	Erosion and surface run-off, increasing pollution and reducing water quality in streams, lakes and reservoirs.	X	X	X	X	YES
	Loss of slope integrity, leading to landslides and erosion.	X		X		YES
	Changes to landscapes, leading to cascading ecosystem changes such as in spawning habitats, changes in the timing of life cycles, and disruptions to migratory routes.	X	X	X	X	NO
	Habitat destruction and displacement of fauna, including aquatic life (fish kills)	X	X	X	X	NO
	Reduced water availability (drought) for flora, including crops, and fauna, including livestock	X	X	X	X	YES
	Drying out of wetlands, reducing flood protections	X	X	X	X	YES
	Increased incidence of forest fires	X	X		X	YES
	Reduced biodiversity, with cascading ecosystem impacts	X	X	X	X	NO

Applicable Hazards	Potential Impacts: Natural Environment	Ecosystem Services	Flora/ Forests/ Trees	Watersheds/ Hydrology	Fauna/ Native Species	Cascading Vulnerability Outcome(s)?
		D	E	F	G	
	Change in vector ecology, resulting in introduction of new diseases	X	X	X	X	YES
	Expansion of floodplain due to high velocity of river and stream flow during flood events			X		YES
	Toxicity to air, water, and/or soil due to hazard-induced hazardous material leaks or incineration.	X	X	X	X	YES
	Reduction in air quality	X	X		X	YES
	Reduced water quality as a result of increased algae growth (warmer temperatures lead to decreased levels of dissolved oxygen in the water, changes in water column, and eutrophication).	X	X	X	X	YES

INFRASTRUCTURE

Metro's assessment of potential climate impacts on the city's infrastructure, and the six components that describe its composition, are given in Figure 25 below. Not surprisingly, all of these impacts are expected to result in disproportionate impacts.

Figure 25. Potential Climate Impacts on Infrastructure.

Applicable Hazards	 Potential Impacts: Infrastructure	Energy Generation	Energy Transmission	Water Supply	Storm/ Wastewater & Waste Mgmt	Communications	Transportation	Cascading Vulnerability Outcome(s)?
		H	I	J	K	L	M	
	Damage to electricity generating infrastructure: • Submersion (flooding); • Extreme temperatures and temperature changes can overwhelm aging infrastructure, cause breakage in certain materials (metals, plastics, sealants, and lubricants), trips in breakers and relays not rated for extreme temperatures, and freezing of other components such as natural gas wellheads; • Icing and snow on wind turbines and solar panels can disrupt generation; • Connected systems (e.g. power purchasing agreements [PPAs]) unable to contribute generation due to primary outage (cascading failure).	X	X	X	X	X	X	YES
	Spikes in power demand that exceed capacity can result in trips and automatic shutdowns in addition to prompting intentional load curtailment and rolling blackouts.	X	X	X	X	X	X	YES
	Damage to transmission and/or distribution infrastructure from submersion (substations), falling trees and limbs, high velocity flash floods, build-up of snow and ice, overloading/short circuits, and intrusion of animals seeking warmth.		X	X	X	X	X	YES
	Combined sewer and wastewater system overflows due to extreme rainfall and flooding events, high water table following repeat events.				X		X	YES
	Loss of water and storm/wastewater functioning: • Flood waters back up into systems and prevent drainage, leading to overflows;			X	X			YES

Applicable Hazards	Potential Impacts: Infrastructure	Energy Generation	Energy Transmission	Water Supply	Storm/ Wastewater & Waste Mgmt	Communications	Transportation	Cascading Vulnerability Outcome(s)?
		H	I	J	K	L	M	
	• Blockage of stormwater systems due to debris buildup; • Freezing temperatures, frost heave, freeze/thaw cycles, and resulting ground settlement can cause pipelines to break; • Accumulation of ice and frozen slush can block valves and restrict intakes in water supply systems.							
	Loss of landline, cellular, cable, and fiber communication networks, other information technology functions from fallen trees, submersion, extreme heat, and other damage leading to cascading failures. Overwhelm of communication systems due to intensity of demand can also lead to failures.					X		YES
	Repair crews are hindered by extreme weather, prolonging outages.	X	X	X	X	X	X	YES
	Blockage of roadways and disruption of transportation systems and services: • Flooding cuts off evacuation routes, vital arteries, and bridges with standing water, reducing redundancy and increasing traffic volume; • Ice and snow on roadways impacts the viability and safety of travel; • Power outages affect the operation of traffic lights and overhead street lights; • Extreme heat as well as extreme cold and ice increase the risk of rail track breakage and reduce rail traction; • Debris, accumulating waste (service disruption) piles up along roadways; • Embankment failure can block roadways.						X	YES
	Shortened life and increased maintenance requirements of roadways (subgrades, pavements, binders, sealants), foundations and structures						X	YES

Applicable Hazards	 Potential Impacts: Infrastructure	Energy Generation	Energy Transmission	Water Supply	Storm/ Wastewater & Waste Mgmt	Communications	Transportation	Cascading Vulnerability Outcome(s)?
		H	I	J	K	L	M	
	due to extreme temperatures (changes or increases in freeze/thaw cycles can result in potholes and shorten the life or structural integrity of asphalt and concrete surfaces including roadways and airport runways, ports and bridges, etc.), heavy/prolonged precipitation or submerging (subgrade damage), or water velocity (bridge pier/abutment scour).							
	Flooding can cause irreparable damage to bridges due to lateral force.						X	YES

Cascading impacts are highly relevant to the consideration of climate impacts on infrastructure. In particular, energy infrastructure is connected to every other type of infrastructure, and a failure in energy generation, transmission, or distribution will lead to cascading failures in water supply, waste management, communications, traffic management, and emergency response. Therefore, addressing energy vulnerabilities must be prioritized.

Households that are considered at greater risk of experiencing disproportionate climate impacts from failures in public infrastructure and services are those living in substandard [unsafe] housing; those lacking vehicle access or are otherwise mobility impaired; those lacking health insurance; people over the age of 65 who live alone; those who are unemployed or under-employed, or for whom housing costs require the majority of their income, and therefore live in poverty; households and individuals with communication barriers whether due to technology or language. Hardening infrastructure first where these criteria indicate pockets of vulnerability is necessary to lessen the cascading impacts and build resilience of the Metro community at large.

ECONOMY

Metro's assessment of potential climate impacts on the city's economy, and the three components that describe its composition, are given in Figure 26 below. Again, all of these impacts have the potential for cascading vulnerability outcomes.

Figure 26. Potential Climate Impacts on the Economy.

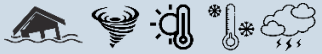
Applicable Hazards	Potential Impacts: Economy	Agriculture	Supply Chain	Business Continuity	Cascading Vulnerability Outcome(s)?
		N	O	P	
	Resource scarcity (loss, damage, delay, and disruption in supply chains from material inputs to delivery and stocking of finished products).	X	X	X	YES
	Increase in operating costs due to damage, outages, scarcity, staff shortages, etc.	X	X	X	YES
	Productivity decreases due to extreme weather in industries reliant on outdoor work or unconditioned indoor (worker protections and illness/availability).	X	X		YES
	Lost service provision, productivity, and profitability due to property damage, downtime following shocks.	X	X	X	YES
	Loss of crops and sickness/death of livestock cause disruptions in food supply.	X	X		YES
	Increase in product costs due to scarcity, damage or loss during transport, higher operating costs, loss in productivity, etc.	X	X	X	YES
	Loss of revenue from street traffic / impact to tourism economy.			X	YES
	Interruptions to banking services due to power outages, other infrastructure damage.		X	X	YES
	Increases in price volatility	X	X	X	YES
	Soil degradation due to changes in precipitation and temperature, leading to reduced crop yields.	X			YES

Applicable Hazards	Potential Impacts: Economy	Agriculture	Supply Chain	Business Continuity	Cascading Vulnerability Outcome(s)?
		N	O	P	
	Pest outbreaks due to changes in precipitation and temperature, leading to reduced crop yields.	X			YES

PUBLIC SAFETY

Finally, Metro's assessment of potential climate impacts on Public Safety, and the four components that describe its composition, are given in Figure 27 below. This list of impacts here appears brief because the vast majority of the impacts described under the four pillars above has a public safety impact and has already been assessed.

Figure 27. Potential Climate Impacts on Public Safety.

Applicable Hazards	Potential Impacts: Public Safety	Emergency Services	Law and Order	Government Services	Community Safety	Cascading Vulnerability Outcome(s)?
		Q	R	S	T	
	Strain on services and personnel due to extent of impacts and high demand, leading to delayed response times.	X	X	X	X	YES
	Poor public perception of responders due to overwhelm.	X	X	X	X	YES
	Increased civil disobedience associated with loss of personal assets and lack of access to goods and services.	X	X	X	X	YES
	Inability of emergency services to physically/logistically reach people in distress.	X	X	X	X	YES
	Lack of functioning potable water systems leading to health impacts.	X		X	X	YES

ADAPTIVE CAPACITY AND FOCUS OF INTERVENTIONS

The development of the above impact chain assessment resulted in an identification of the components of Metro's system that are considered to be most highly vulnerable to one or more of Metro's primary climate hazards. These are highlighted in orange in the below Table 13, and are prioritized below for adaptive capacity intervention.

Table 13. System Asset Classes Identified as Being at Highest Risk / Vulnerability.

									
Community & Culture		**Natural Environment**		**Infrastructure**		**Economy**		**Public Safety**	
A	Livelihood and affordability	D	Ecosystem services	H	Energy generation	N	Agriculture	Q	Emergency services
B	Health and wellbeing	E	Flora/forests/ trees	I	Energy transmission	O	Supply chain	R	Law and order
C	Access to goods and services	F	Watersheds/ hydrology	J	Water supply	P	Business continuity	S	Government Services
		G	Fauna/native species	K	Storm/waste-water and waste management			T	Community Safety
				L	Communications				
				M	Transportation				
Crosscutting: Equity									

These most critical areas of vulnerability have been assessed for their adaptive capacity and paired with focal areas for intervention in Table 14 on the next page. These focal areas have been further distilled into the four overarching goals and their potential strategies that guide this document and are described in the next section and Appendix 4.

Table 14. Pairing Areas of Highest Impact and Vulnerability with Adaptive Capacity and Intervention Strategy.

System Category	Primary Impacts	Vulnerability Outcomes	Adaptive Capacity—Focus of Interventions	Goal/ Objective Reference
Community and Culture				
 **Livelihoods and Affordability**	High costs of repairs and recovery following climate events	• Financial insecurity • Poverty • Housing insecurity • Eviction • Homelessness • Displacement • Food insecurity • Worsening of physical health • Worsening mental health • Stress, worry and depression • Overwork and exhaustion • Injury • Chronic pain • Loss of life • Unaffordable medical bills • Lack of access to necessities • Loss of / bad credit score • Missed work • Unemployment • Missed school / dropout • Lack of educational degree • Limited income opportunities • Increased crime and violence • Incarceration • Decreased neighborhood safety • Reduced quality of life	Outreach programs and communication campaigns that educate and empower; improved access to community centers	1.1
			Improved public services, assistance programs, access to insurance, and affordability plans	1.2
	Rising utility and other subsistence costs		Weatherization and repair assistance programs	1.3
	Unsafe and unaffordable housing		Programs addressing building improvements, substandard rental housing, housing costs, and gentrification	1.3, 1.5
 **Health and Wellbeing**	Unsafe neighborhoods and outdoor spaces		Reduce ambient heat by increasing cooling spaces (green and built) and strategies	1.4
			Resiliency hubs, storm shelters, cooling and warming centers	1.1, 1.6
			Update building codes and development controls	1.3, 1.4, 1.5
			Workforce development programs	1.5
			Improve the local environment and residents' quality of life	1.2, 1.4, 1.5
			Health care affordability and mental health programs	1.2
			Comprehensive disaster preparation and response planning for most vulnerable populations	1.6, 4.3

System Category	Primary Impacts	Vulnerability Outcomes	Adaptive Capacity—Focus of Interventions	Goal/ Objective Reference
Natural Environment				
 **Ecosystem Services**	Damage to flora and reduction of associated co-benefits	• Reduced air quality • Reduced recreation opportunities • Increased ambient pollution due to removal of buffers • Increased heat island effects • Worsening physical health • Worsening mental health • Stress and depression • Injury and/or death of nearby residents • Damage to nearby properties • Increased safety risks for nearby population • Toxicity risks for pets • Reduced quality of life • (see Community and Culture)	Protect natural areas and increase canopy and green spaces (recreational and wild)	1.2, 1.4, 3.1, 3.2
	Injury, death, and stress to fauna, habitat destruction, biodiversity loss, and reduction of associated co-benefits			1.2, 3.1, 3.2
	Changes to landscapes and ecosystems			
	Erosion and surface run-off, loss of slope integrity		Encode and incentivize low-impact development	3.2
	Toxicity to air, water, and/or soil from released hazardous materials		Educate and incentivize more responsible public behavior	2.1, 3.1, 3.2
 **Watersheds/ hydrology**	Reduced water availability, drying out of wetlands			
	Increased risk of forest fires			
	Increased algae growth in reservoirs and lakes		Risk and adaptation planning for critical services	2.1, 3.2, 4.2
	Change in vector ecology and introduction of new diseases			
	Expansion of floodplains		Prioritize flood resilience and riverbank stabilization	1.4, 3.1

System Category	Primary Impacts	Vulnerability Outcomes	Adaptive Capacity—Focus of Interventions	Goal/ Objective Reference
Infrastructure				
 **Cross-Cutting: All**	• Damage to infrastructure • Loss of communications • Loss of function for repair crews • Interruptions in service • Increased maintenance needs	• Cascading failures across the entire system • (see Community and Culture)	Review and update building codes and design standards	3.3, 4.1
			Conduct vulnerability assessment and adaptation planning for all sustaining operations and access to assets	2.1, 2.3, 4.2
			Comprehensive disaster planning	1.6, 2.3, 4.3
			Embed standard operating procedures into planning and budgeting	2.2, 4.1
Energy Generation and Transmission	• Spikes in power demand • Outages due to damage or increased demand • Downed power lines • Increased maintenance needs	• Spoilage of foods and medicines • Interruption to sources of livelihoods • Loss of communications • Cascading failures across the entire system • (see Community and Culture)	Improve robustness and redundancy of electricity services	2.1, 2.2, 2.3
Storm/ wastewater and waste management	• Overflows • Damage • Increased maintenance needs • Interruptions in service	• Damage to structures • Lack of water supply • (see Community and Culture) • Blocked roadways (see below)	Encode and incentivize low-impact development	3.1
Transportation	• Debris accumulation • Blocked roadways • Damage to roadways, bridges, culverts • Increased maintenance needs • Interruptions in service	• Lack of access to goods and services, medical care • Stranding • Dangerous commutes • Damage to personal vehicles • Inability to access work • (see Community and Culture)	Improve multimodal infrastructure and greenway interconnections	1.2, 2.3

System Category	Primary Impacts	Vulnerability Outcomes	Adaptive Capacity—Focus of Interventions	Goal/ Objective Reference
Economy				
 **Supply Chain**	Lack of access to food and necessities	• (see Community and Culture)	Comprehensive disaster planning	1.6, 2.3, 4.3
			Facilitate more urban and community gardens	1.2
			Conduct agricultural outreach and incentivize innovation	1.1
	Resource scarcity		Create regional cooperation mechanisms for resource pooling	2.1, 2.2
	Increase in prices / price volatility			
	Increase in maintenance costs	• Facility and neighborhood disrepair • Interruptions in service • (see Community and Culture)	Conduct vulnerability assessment and adaptation planning for all operations and assets	2.1, 2.3, 4.2
	Loss of revenue		Outreach programs for the business community and workforce development	1.1
 **Business Continuity**	Lack of access to banking services	• Interrupted operations • Loss of revenue • Loss of work • (see Community and Culture)		
	Decrease in productivity		Encode outdoor workforce safety improvements	4.3
	Interruptions in service		Prioritize infrastructure redundancy improvements and weather-proofing	2.3, 4.1, 4.2
	Delays in recovery support		Build financial reserves for recovery efforts	
Public Safety				
 **Community Safety**	[Many of the above impacts, vulnerability outcomes, and interventions are also applicable to the Public Safety pillar, and are not repeated here.]			
	Inability to respond / operate	• Stress of personnel • Trauma response / PTSD	Create regional cooperation mechanisms for resource pooling	2.1, 2.2

System Category	Primary Impacts	Vulnerability Outcomes	Adaptive Capacity—Focus of Interventions	Goal/ Objective Reference
		• Loss of life / exacerbated injury and illness • (see Community and Culture)	Comprehensive disaster preparation and response planning	1.1, 1.6, 2.3, 4.3
	Strain on emergency services and personnel			
	Poor public perception of responders		Improve Metro Government's understanding and capacity for building climate resilience	2.1, 2.3, 4.2
	Increased civil disobedience			

The Implementation Roadmap in the next Section synthesizes the above focal areas for adaptation intervention into four primary goal areas, associated objectives, and strategies, which reference specific best practice approaches described in the [living] Database in Appendix 4. This comprises Metro's Action Plan for Metro's Climate Adaptation and Resilience agenda and establishes timelines and responsibilities for the above identified priority intervention areas.

PART THREE: THE ROAD AHEAD

ADAPTATION AND RESILIENCE IMPLEMENTATION ROADMAP

The intention of this Plan is to set clear, targeted goals and identify actionable, practical strategies to increase Metro's resilience to the present and growing threats of climate change in a way that is both meaningful and measurable. While more detailed vulnerability assessments and adaptation planning are needed at the sector and department level, and specific strategies and actions must be developed to ensure a comprehensive, cross-sector approach to specific climate and non-climate threats, planning and strategy alone is not sufficient. The Roadmap contained herein is equally focused on catalyzing implementation to improve Metro's readiness and preparedness.

While the world has known for quite some time that temperatures would continue to rise as a result of climate change, and those increases have followed the predicted course, the effects have been more severe and frequent than anticipated and have taken many scientists by surprise. This uncertainty itself requires adaptability, and planning for a 'factor of safety' or the 'worst case *then some*'. In parallel, the technological advancements being made that will provide additional options for strengthening climate preparedness will continue to evolve. Therefore, the Roadmap contained in this Plan is heavily focused on the near term, while recognizing that many of the actions needed must be carried out over many years. The intention is that the Plan and its implementation framework be revisited and updated annually, in parallel with carrying out more robust technical and scientific analysis.

The Implementation Roadmap given below identifies the objectives and key adaptation strategies Metro should pursue to reduce its risk of direct climate impacts and vulnerability outcomes, establishes a timeframe for each strategy, and identifies the Metro departments that will lead or share responsibility for carrying them out. It is organized under four main goals that focus on Nashville's people, infrastructure, natural environment, and the mission of its government. Figure 28 provides an overview of the Roadmap's main goals and their corresponding objectives.

It should be noted that ICLEI—Local Governments for Sustainability, the non-governmental organization that facilitates evaluation of local government mitigation and adaptation planning to ensure it aligns with established protocols under GCoM—requires climate adaptation plans to include "actions" as a core element of an adaptation plan. However, the authors have opted to use the term "strategy" for the Roadmap as departments that have been identified as responsible for executing strategies will need to develop their own sets of action steps and associated timelines to fully execute activities contemplated herein. For example, Goal 4, Objective 2 requires departments to conduct their own risk assessments and engage in planning to identify specific actions they can take to support climate adaptation and resilience to implement the strategies identified in this plan. Each Goal is followed by a short list of Action Items, however, that can be targeted for completion over the next year and are already underway.

Goals	1 Ensure Nashville is equitable, safe, accessible, and affordable for all residents in the context of a changing climate						2 Improve and protect public infrastructure and services from growing climate risks			3 Protect and preserve nature for future generations		4 Make equitable climate resilience a standard operating procedure for Metro Government		
Objectives	**Educate and Empower**	**Improve Access to Necessities and Services**	**Increase Stability of the Residential Environment**	**Ensure Habitability of the Ambient Environment**	**Create Equitable Economic Opportunity**	**Protect and Prepare**	**Plan and Adapt**	**Asset Management and Optimization**	**Build Redundancy and Strengthen Defenses**	**Preserve and Expand Green and Wild Spaces**	**Support Nature's Inherent Attributes**	**Require, Encode, and Ingrain**	**Quantify, Measure and Track**	**Train and Instill a Culture of Readiness**
Strategies	Conduct climate-specific outreach and capacity building	Create affordability plans for utility services	Retrofit, weatherize, and green-cool buildings	Enhance development controls and protections in flood zones	Remedy climate injustice	Develop strategies for extreme temperature protection	Adaptation Planning for Critical Infrastructure and Services	Review and Optimize Asset Management Programs	Improve Robustness and Redundancy of critical services and facilities	Finance and require more green and less grey	Employ natural flood mitigation strategies	Optimize codes, zoning ordinances, and design standards	Map hazards and vulnerability for public information and internal decision-making	Conduct Resilience and Readiness Training Exercises and Drills
	Enable community resiliency hubs	Make health care affordable and accessible	Optimize codes, zoning ordinances, and design standards	Expand greenery and deploy other strategies for heat control	Prevent green gentrification	Expand emergency shelters at the community level	Facility Energy Management Planning	Creative approaches to valuation of public assets	Identify and correct single points of failure	Empower the public to protect the environment	Incentivize and control upstream practices	Develop and embed standard operating procedures into planning processes	Department-level risk assessments and master planning	Improve Field Staff Safety Standards
	Incentivize to innovate and build resilience	Improve safety, efficiency, and multimodality of public transportation	Identify safety issues before they occur	Scale up low-impact approaches for stormwater management	Create climate-focused workforce development programs		Contingency planning for financial resources and the supply chain			Incentivize the private sector	Control Invasive Species	Integrate Resilience criteria into Budgets		Ensure Comprehensive Disaster Planning, Monitoring, Documentation and Communication
		Grow urban gardens and food forests		Address historic and current harms from traffic			Leveraging regional partnerships and assets					Adopt smarter procurement policies		
							Synthesizing policy							

Figure 28. Metro's Climate Adaptation and Resilience Goals.

The development of this Plan and its companion internal Toolkit has been led by the Office of Mayor Cooper, but both resources have been shaped and expanded by stakeholders internal and external to Metro. The work that must now be undertaken will require ongoing leadership and commitment at all levels. Part of the strategy behind this Plan's development is that it belongs to all of Metro. Its publication and the inclusion of this Roadmap signals the commitment of the Mayor's Office and the departments identified herein. Ultimately, the authors hope that Metro might establish a formal internal mechanism for driving the Plan's implementation and monitoring, if not a standalone department (see Strategy XC3: Create a Structure and/or Processes that Enhance Collaboration on Sustainability and Resilience Topics Within and Across Metro Departments).

Each objective given in the Roadmap contains a number of potential specific strategies that are linked to Appendix 4, where they are described and additional resources are provided. Each strategy has a corresponding timeframe for initiation and implementation, which is delineated over the near (years 1-3), medium (years 4-7) and long term (years 8-10) planning horizon. While some of the strategies given in the Roadmap below represent new initiatives, many (40%) are already in progress so the aim would be to scale it up or to incorporate a climate resilience focus or lens. These "in-process" strategies are indicated below.

It bears repeating that the suite of adaptation strategies provided below and in Appendix 4 is neither exhaustive nor fixed, but represents a potential catalogue of options that could be considered to meet Metro's goals and objectives.

1

#	Objectives	Strategies	Builds on Existing Prog.	Planning Horizon			Lead / Other Responsible Department(s)
				Near (1-3)	Med. (4-7)	Long 8-10)	
Goal I: Ensure Nashville is equitable, safe, accessible, and affordable for all residents in the context of a changing climate							
1.1	**Educate and Empower**	**1.1.1 Conduct climate-specific outreach and capacity building** 1) CC1/PS6. Climate-Specific Outreach and Empowerment 2) CC22. Food Safety Public Service Announcements	X	▶▶▶			1) OEM / MHMP CPT 2) Health / MWS waste
		1.1.2 Enable community resiliency hubs 1) CC2. Community Resiliency Hubs		▶▶▶			OEM
		1.1.3 Incentivize to innovate and build resilience 1) EC1. Private Sector Outreach and Incentives to Build Resilience 2) EC2. Agricultural Outreach and Innovation			▶▶▶		1) Finance / Planning / OEM / MWS / Codes 2) AgExtSvc / TBD
1.2	**Improve Access to Necessities and Services**	**1.2.1 Create affordability plans for utility services** 1) CC3. Affordability Plans / Variable Rate Structures and Energy Use Subsidies for Low-Income Residents	X		▶▶▶		MAC / MSS / MWS incl waste / NES / MDHA
		1.2.2 Make health care affordable and accessible 1) CC16. Low-Cost or Free Mental Health Services		▶▶▶	▶▶▶		Health / MSS & OHS / MAC
		1.2.3 Improve safety, efficiency, and multimodality of public transportation 1) CC18. Reduce Transit Wait Times and Improve Shelters 2) IN6. Scale Up Complete Streets and Multimodal Transportation Initiatives including Greenway Interconnections	X	▶▶▶			1) WeGo / NDOT 2) NDOT / Parks
		1.2.4 Grow urban gardens and food forests 1) CC19. Urban Farming, Community Gardens and Food Forests	X	▶▶▶	▶▶▶		Parks / MDHA / MNPS

#	Objectives	Strategies	Builds on Existing Prog.	Planning Horizon			Lead / Other Responsible Department(s)
				Near (1-3)	Med. (4-7)	Long 8-10)	
1.3	**Increase Stability of the Residential Environment**	**1.3.1 Retrofit, weatherize, and green-cool buildings** 1) CC4. Weatherization / Building Retrofits / Cool and Green Roofs	X	►►►	►►►		Planning / MDHA
		1.3.2 Optimize codes, zoning ordinances, and design standards 1) CC5. Review and Update Building Codes, Zoning Criteria, and Design Standards		►►►	►►►		Planning / Codes / MDHA / MWS
		1.3.3 Identify safety issues before they occur 1) CC17. Proactive Rental Inspection Program		►►►	►►►		Codes / Health
1.4	**Ensure Habitability of the Ambient Environment**	**1.4.1 Enhance development controls and protections in flood zones** 1) CC7. Addressing Development in Flood Plains	X	►►►			MWS / Planning
		1.4.2 Expand greenery and deploy other strategies for heat control 1) CC13. Strategic Tree and Vegetation Enhancement for Shade and Ambient Heat Control	X	►►►	►►►		MWS / Planning / Parks / NDOT
		1.4.3 Scale up low-impact approaches for stormwater management 1) CC14. Pervious Surface Management	X	►►►	►►►		MWS / Planning / NDOT
		1.4.4 Address historic and current harms from traffic 1) CC15. Traffic and Corridor Management, Fleet Electrification, and Community Reconnection	X	►►►	►►►		NDOT / MNPS / WeGo / DGS (fleet electrification) / Health
1.5	**Create Equitable Economic Opportunity**	**1.5.1 Remedy climate injustice** 1) CC21. Delivering Environmental and Climate Justice		►►►	►►►		MWS incl waste / Planning / NDOT / All
		1.5.2 Prevent green gentrification and displacement 1) CC6. Combatting Gentrification		►►►	►►►		Planning / Parks / MDHA

#	Objectives	Strategies	Builds on Existing Prog.	Planning Horizon			Lead / Other Responsible Department(s)
				Near (1-3)	Med. (4-7)	Long 8-10)	
		1.5.3 Create climate-focused workforce development programs 1) EC5. Climate-Focused Workforce Development Programs		►►►	►►►		MO / MAC / WeGo / MWS
1.6	**Protect and Prepare**	**1.6.1 Develop strategies for extreme temperature protection** 1) CC8. Extreme Heat Strategy & Accessible Community Education 2) CC10. Extreme Cold Strategy		►►►			1) OEM / MSS / OHS / Health 2) OEM / MSS / OHS / Health
		1.6.2 Expand emergency shelters at the community level 1) CC9. Cooling Centers/Summer Emergency Shelters 2) CC11. Warming Centers/Winter Emergency Shelters 3) CC12. Community Storm Shelters	X	►►►			OEM / MSS & OHS

The majority of the strategies given above are identified as priorities for the near-term planning horizon. Table 15 contains a recommendation for those strategies that, at minimum, should be considered near-term Action Items, for which KPIs need to be identified by the lead and responsible departments, and progress tracked between the publication of this Plan and its review and update in 2024. Importantly, the Action Items identified below reflect concerns regarding current barriers to Nashville's programs that offer extreme heat protections, and the growing threat of gentrification and displacement, that were identified as urgent needs by community members and youth representatives during public outreach efforts in the late stages of this Plan.

Table 15. Goal 1 Recommended Action Items.

#	Strategy	Action	Lead/Other Responsible Departments
1	Conduct climate-specific outreach and capacity building (1.1.1)	Develop scope, identify format, and confirm timeline for launch of broad resilience-focused public communication campaign.	OEM / MHMP CPT
		Develop mapping dashboard, "Know Your Climate Risk," to assist Metro residents in taking proactive, location-based measures to protect their homes and businesses.	ITS / Planning
2	Improve safety, efficiency, and multimodality of public transportation (1.2.3)	Complete and roll out the Complete Streets Implementation Guide and Pedestrian Crossing Policy.	NDOT
3	Optimize codes, zoning ordinances, and design standards (1.3.2)	Review current land use planning procedures through the Ecological Design Studio for an incorporation of a climate resilience lens.	Planning
4	Remedy climate injustice (1.5.1)	Conduct assessment and develop pilot community engagement program to guide approach for addressing frontline community impacts.	MWS Waste Svcs
		Identify responsible parties/working group and develop approach for a potential program addressing gentrification-driven displacement concerns among vulnerable communities (see Key Performance Indicators, below).	MO
6	Develop strategies for extreme temperature protection (1.6.1)	Review current programs for scale-up or improvement opportunities (e.g. LIHEAP, Fan and Air Conditioner Program, protections for the unhoused) and identify lead for development of extreme heat and cold strategies.	MAC / MDHA / MO

There are three key metrics that Metro will track to assess the success of Goal I over the near-term planning horizon. These are given in Table 16 below.

Table 16. Goal I Key Performance Indicators.

#	Key Performance Indicator	Description	Example Measure	Trend Objective	Initial Assessment Year
1	External outreach or training	Resources, instructional materials, information campaigns, web sites, and/or training programs and activities that build knowledge and skills in the areas of climate adaptation and resilience.	• Number of outreach resources developed; • Number of people who accessed outreach resources; • Hours of training delivered; • Number of people trained.	Increase from baseline	FY2027
2	Capital spending dollars incorporating vulnerable community-focused resilience elements	Investments in projects, public goods, or assets for vulnerable communities that increase public green space, deploy heat reduction or flood mitigation strategies, improve the safety and resilience of residential or commuter areas and/or infrastructure, or redress environmental injustice.	• Number of dollars allocated; • Number of dollars spent.	Increase from baseline	FY2027
3	Grant dollars secured for vulnerable community-focused resilience elements	Funding from federal, state, or other sources that will improve climate resiliency outcomes for Metro's vulnerable communities.	• Number of dollars allocated; • Number of dollars spent.	Increase from baseline	FY2027

GOAL II: IMPROVE AND PROTECT PUBLIC INFRASTRUCTURE AND SERVICES FROM GROWING CLIMATE RISKS.

#	Objectives	Strategies	Builds on Existing Prog.	Planning Horizon			Lead / Other Responsible Department(s)
				Near (1-3)	Med. (4-7)	Long 8-10)	
2	**Goal II: Improve and protect public infrastructure and services from growing climate risks**						
2.1	**Plan and Adapt**	**2.1.1 Adaptation Planning for Critical Infrastructure and Services** 1) IN5/PS3. Develop Adaptation Plan for Critical Infrastructure and Services		►►►	►►►		All
		2.1.2 Facility Energy Management Planning 1) IN8. Facility Energy Management Plans	X	►►►	►►►		DGS
		2.1.3 Contingency planning for financial resources and the supply chain 1) EC4. Creative Financing, Strategic Reserves, Resource Hedging, and Contingency Planning	X	►►►	►►►		Finance / Law / DGS
		2.1.4 Leveraging regional partnerships and assets 1) PS5. Building Regional Consensus Around Hazard Vulnerabilities, Needs and Risks		►►►	►►►		MO / Finance / OEM / DGS
		2.1.5 Synthesizing policy 1) XC7. Policy Synthetization		►►►	►►►		Planning / All
2.2	**Asset Management and Optimization**	**2.2.1 Review and Optimize Asset Management Programs** 1) IN4/PS4. Review and Optimize Asset Management Programs	X	►►►	►►►		ITS / DGS / NDOT
		2.2.2 Creative approaches to valuation of public assets 1) EC6. Public Asset Mapping and Valuation			►►►	►►►	Finance / Planning / ITS

#	Objectives	Strategies	Builds on Existing Prog.	Planning Horizon			Lead / Other Responsible Department(s)
				Near (1-3)	Med. (4-7)	Long 8-10)	
2.3	**Build Redundancy and Strengthen Defenses**	**2.3.1 Improve Robustness and Redundancy of critical services and facilities** 1) IN1. Improve Robustness and Redundancy of the Energy Grid 2) IN2. On-site or Distributed Energy Generation for Critical Facilities	X	►►►	►►►		1) NES / MWS 2) DGS / OEM / All
		2.3.2 Identify and correct single points of failure 1) EC3. Build Redundancy through Alternative Supply and Transportation Options	X	►►►	►►►		Finance / OEM / NDOT / DGS / ITS

Again, the majority of the strategies given above are identified as priorities for the near-term planning horizon. Table 17 identifies those that should be considered near-term Action Items and a mechanism for tracking progress put in place.

Table 17. Goal 2 Recommended Action Items.

#	Strategy	Action	Lead/Other Responsible Departments
1	Adaptation Planning for Critical Infrastructure and Services (2.1.1)	Develop simple hazard vulnerability assessment protocol for facilities and pilot with DGS-managed facilities.	DGS
2	Review and Optimize Asset Management Programs (2.2.1)	Develop criteria and checklists to infuse a climate resilience focus into Metro's ongoing rollout of the CityWorks asset management program.	ITS / NDOT / DGS
3	Improve Robustness and Redundancy of critical services and facilities (2.3.1)	Complete feasibility study and initiate procurement procedures for the installation of rooftop solar on selected Metro facilities.	DGS

There are three key metrics that Metro will track to assess the success of Goal II over the near-term planning horizon. These are given in Table 18 below.

Table 18. Goal II Key Performance Indicators.

#	Key Performance Indicator	Description	Example Measure	Trend Objective	Initial Assessment Year
1	Number of departments with completed climate adaptation and resilience plans	Number of Metro departments that have completed climate vulnerability assessments and developed actionable and resourced adaptation and resilience plans.	• Number of departments	Increase from baseline	FY2027
2	Capital spending dollars incorporating infrastructure resilience elements	Investments in projects, programs, and/or hard or soft infrastructure that build redundancy, robustness, or readiness in the face of anticipated climate stressors and hazards.	• Number of dollars allocated; • Number of dollars spent.	Increase from baseline	FY2027
3	Grant dollars secured to increase infrastructure resilience	Funding from federal, state, or other sources that will improve climate resiliency outcomes for the Metro department or the communities it serves.	• Number of dollars allocated; • Number of dollars spent.	Increase from baseline	FY2027

GOAL III: PROTECT AND PRESERVE NATURE FOR FUTURE GENERATIONS.

#	Objectives	Strategies	Builds on Existing Prog.	Planning Horizon			Lead / Other Responsible Department(s)
				Near (1-3)	Med. (4-7)	Long 8-10)	
3	**Goal III: Protect and preserve nature for future generations**						
3.1	**Preserve and Expand Green and Wild Spaces**	**3.1.1 Finance and require more green and less grey** 1) NE1. Increase Green Spaces, Tree Canopy, and Conservation	X	►►►	►►►		MWS / Planning / Parks / DGS / NDOT / Codes
		3.1.2 Empower the public to protect the environment 1) NE2. Conduct Educational Campaigns on Protecting the Natural Environment	X	►►►	►►►		MWS / Parks / MNPS / NDOT / MWS incl waste
		3.1.3 Incentivize the private sector 1) NE3. Financial Incentives for Conservation and Ecosystem Service Preservation	X		►►►		MWS / Finance
3.2	**Support Nature's Inherent Attributes**	**3.2.1 Employ natural flood mitigation strategies** 1) NE4. Natural Flood Mitigation and Strategic Expansion of Floodplains 2) NE6/IN7. Require and Increase Low-Impact Development (see also Objective I-4) 3) IN10. Stormwater Basins and Water Plazas/Circles/Squares	X	►►►	►►►		1) MWS / Planning 2) MWS / Planning 3) MWS / Parks
		3.2.2 Incentivize and control upstream practices 1) NE5. Floodproofing Incentive Programs and Pollutant Controls		►►►	►►►		1) MWS incl waste / NDOT 2)
		3.2.3 Resilience-focused vegetation management 1) NE7. Prohibit or Remove Invasive Species	X	►►►	►►►		MWS / DGS / Parks / Codes

Table 19 identifies those strategies given above that should be considered near-term Action Items and a mechanism for tracking progress put in place.

Table 19. Goal 3 Recommended Action Items.

#	Strategy	Action	Lead/Other Responsible Departments
1	Finance and require more green and less grey (3.1.1)	Increase number of trees planted on Metro properties and right-of-ways, and identify opportunities to expand plantings on private properties.	MWS Stormwater
		Identify opportunities to increase the utilization of green stormwater infrastructure, beginning with Metro properties.	
2	Employ natural flood mitigation strategies (3.2.1)	Design an East Bank Flood Resilience Framework including a riparian strategy for flood risk reduction and a nature-based stormwater system.	Planning

There are three key metrics that Metro will track to assess the success of Goal III over the near-term planning horizon, as given in Table 20 below.

Table 20. Goal III Key Performance Indicators.

#	Key Performance Indicator	Description	Example Measure	Trend Objective	Initial Assessment Year
1	Acres of publicly accessible green space	An area consisting of natural (wild) or cultivated vegetation, grass, and/or trees that is accessible to all and creates environmental, climate resiliency, and social benefits.	• Acres of green space, as measured by the National Land Cover Database[35]	Increase from baseline	FY2027
2	Capital spending dollars incorporating natural	Investments in projects, programs, and/or LID (green infrastructure) that	• Number of dollars allocated; • Number of dollars spent.	Increase from baseline	FY2027

[35] Available here: National Land Cover Database | U.S. Geological Survey (usgs.gov).

#	Key Performance Indicator	Description	Example Measure	Trend Objective	Initial Assessment Year
	environment resilience elements	expand Metro's green spaces or increase the capacity of its natural environment to withstand anticipated climate stressors and hazards.			
3	Grant dollars secured for natural environment resilience	Funding from federal, state, or other sources that will increase green spaces and/or improve ecosystem services.	• Number of dollars allocated; • Number of dollars spent.	Increase from baseline	FY2027

GOAL IV: MAKE CLIMATE RESILIENCE A STANDARD OPERATING PROCEDURE FOR METRO GOVERNMENT

#	Objectives	Strategies	Builds on Existing Prog.	Planning Horizon			Lead / Other Responsible Department(s)
				Near (1-3)	Med. (4-7)	Long 8-10)	
4	**Goal IV: Make climate resilience a standard operating procedure for Metro Government**						
4.1	**Require, Encode, and Ingrain**	**4.1.1 Optimize codes, zoning ordinances, and design standards** 1) IN3/PS7. Review and Update Building Codes, Zoning Criteria, and Design Standards (see also Objective I-3)		►►►	►►►		DGS / Planning / Codes
		4.1.2 Develop and embed standard operating procedures into planning processes 1) XC1. Develop a Climate Resiliency Toolkit and Training Resources 2) XC3. Create a Structure and/or Processes that Enhance Collaboration on Sustainability and Resilience Topics Within and Across Metro Departments	X	►►►			MO
		4.1.3 Integrate resilience criteria into Budgets 1) XC2. Integrate Resilience into Capital Improvement Program and Operating Budget		►►►	►►►		Planning / MO
		4.1.4 Adopt smart procurement policies 1) XC6. Adopt Environmentally Preferable Purchasing (EPP)		►►►	►►►		Finance / MWS incl waste / MO
4.2	**Quantify, Measure and Track**	**4.2.1 Map hazards and vulnerability for public information and internal decision-making** 1) XC4. Hazard and Vulnerability Mapping	X	►►►	►►►		Planning / ITS
		4.2.2 Department-level risk assessments and master planning 1) XC5. Sustainability and Resilience Master Planning	X	►►►	►►►		All

#	Objectives	Strategies	Builds on Existing Prog.	Planning Horizon			Lead / Other Responsible Department(s)
				Near (1-3)	Med. (4-7)	Long 8-10)	
4.3	**Train and Instill a Culture of Readiness**	**4.3.1 Conduct Resilience and Readiness Training Exercises and Drills** 1) PS1. Conduct Resilience and Readiness Training Exercises and Drills	X	►►►			OEM
		4.3.2 Improve Field Staff Safety Standards 1) IN9/PS2. Review and Improve Field Staff Department Safety Standards		►►►			HR / All
		4.3.3 Ensure Comprehensive Disaster Planning, Monitoring, Documentation, and Communication 1) IN11. Integrated Hazard Monitoring and Communication 1) CC20. Comprehensive Disaster Evacuation Planning	X	►►►	►►►		OEM / MSS

Table 21 identifies those strategies given above that should be considered near-term Action Items and a mechanism for tracking progress put in place.

Table 21. Goal 4 Recommended Action Items.

#	Strategy	Action	Lead/Other Responsible Departments
1	Develop and embed standard operating procedures into planning processes (4.1.2)	Form Climate Working Group (CWG) to roll out, implement, and scale up Climate Resiliency Toolkit (see Monitoring and Evaluation, and XC1).	MO
2	Department-level risk assessments and master planning (4.2.2)	Develop and implement a Sustainability Master Plan inclusive of equity and climate resilience goals.	MWS
3	Conduct Resilience and Readiness Training Exercises and Drills (4.3.1)	Develop CERT Lite Program inclusive of a climate hazard mitigation and resiliency lens for training of Metro staff.	OEM

There are four key metrics that Metro will track to assess the success of Goal IV over the near-term planning horizon, as given in Table 22 below.

Table 22. Goal IV Key Performance Indicators.

#	Key Performance Indicator	Description	Example Measure	Trend Objective	Initial Assessment Year
1	FTEs with specific climate resilience responsibilities	Full-time Metro employees (FTEs) whose assigned duties include tasks, targets, and/or management oversight specifically focused on improving the climate resilience of Metro's facilities, equipment, operations, and services.	• Number of FTEs	Increase from baseline	FY2027
2	New policies, procedures and legal requirements aimed at improving Metro's climate resilience	Number of climate resilience-oriented policies, standard operating procedures, codes, ordinances, design standards, training modules, and/or tools that have been developed and officially incorporated into Metro department requirements and operations.	• Number of new policies, procedures and legal requirements	Increase from baseline	FY2027
3	Internal staff training	Resources, instructional materials, templates, databases, mapping tools, and/or training programs and activities that build knowledge and skills in the areas of climate adaptation and resilience.	• Number of new Web-based or written materials developed; • Number of people who accessed said resources; • Hours of training delivered; • Number of people trained.	Increase from baseline	FY2027
4	Operational spending dollars directly aimed at increasing Metro's climate resilience	Investments in Metro staffing, program or policy development, hard or soft assets, and/or training and readiness that build and improve Metro's climate resilience.	• Number of dollars allocated; • Number of dollars spent.	Increase from baseline	FY2027

KEY PERFORMANCE INDICATORS

Each Goal set out above contained its own set of metrics for measuring progress, but they can be grouped into seven main categories:

- Outreach and training conducted on climate adaptation and resilience;
- Metro-budgeted dollars allocated and spent on equitable climate adaptation and resilience;
- Grant-sourced dollars secured for equitable climate adaptation and resilience;
- Number of departments with climate adaptation and resilience plans;
- Number of staff directly focused on equitable climate adaptation and resilience;
- Number of policies, ordinances, codes and other new requirements related to equitable climate adaptation and resilience; and
- Acres of green space added.

The baseline for most of these indicators is unknown Metro-wide or stands at or close to zero as of the writing of this Plan, with the exception of Metro's existing green space. Currently, the Office of Performance Management initiated by Mayor Cooper does not track KPIs specifically focused on equitable climate resilience. Therefore, one of the goals of this Plan is that Metro, through its Mayor's Office, Finance Department, or Planning Department (or through a cooperation between multiple departments) establish a mechanism for measuring baseline values and tracking progress over the Plan's implementation.

Each strategy identified in this Plan should include its own specific metric or KPI that is tracked by the implementing department. The indicators included above represent an initial start at Metro-wide performance tracking but are by no means intended to be exhaustive. It is also recognized that tracking dollars is not an adequate mechanism for measuring success, since low-cost interventions can also have a high impact. The KPIs that were chosen for the first iteration of this Plan were chosen because Metro can start measuring outcomes on this basis without any new data collection work or outside resources. The next iteration of this Plan should include a more carefully assessed data proposal.

To truly track climate resilience and to confirm that the benefits of Metro's adaptation and resilience work are accruing to the populations that need and deserve it most, a suite of equity-focused, location-specific indicators need to be included as a near-term next step. These should be chosen in concert with representatives of the relevant communities and local community-based organizations, to ensure the indicators address the necessary exposures and corrective targets. Some of the indicators that should be considered are given in Table 23 below.

Table 23. Potential Equity-Focused Indicators.

Indicator	What it Could Track (Not an Exhaustive List)
Health insurance coverage	Number of people or households with (or without) health insurance.
Flood insurance coverage	Number of households in flood-prone areas with (or without) flood insurance.
Disease prevalence	Incidence of asthma, heart disease, cancer, type 2 diabetes, and other indicators of climate-driven disease burden.
Percentage of green surface	Tree canopy coverage, access to parks and green spaces, pervious surface, heat island exposure.
Safety and walkability	Sidewalk coverage, number of crosswalks, transit accessibility
Exposure to environmental hazards	Proximity to high-volume traffic corridors, lead pipe exposure, particulate matter exposure (PM2.5 levels), proximity to toxic industrial activity, proximity to waste treatment or disposal facilities.
Poverty	People living in poverty, housing cost burden, energy burden, SNAP recipient households
Gentrification	Housing prices, home sales, building permits,
Community Resilience	Presence of community or neighborhood/resident councils/associations/organizations, community plans in place

These indicators need to be considered in concert with available socioeconomic data (population size, age, race and ethnicity, income) and vulnerability data (mobility, English language availability, employment status, education level, individuals with disabilities) for a full understanding of change over time. Such data can also be used to identify changes in neighborhoods that signal gentrifying trends in the early stages, when there is still an opportunity to help existing residents avoid displacement.

EVALUATION AND COMMUNICATION PLAN

STAKEHOLDER AND PUBLIC ENGAGEMENT

The content of this document reflects the aggregation of public input in prior Metro planning efforts referencing this topic and the targeted input of multiple stakeholders as an outcome of consultations, working group efforts, and outreach conducted over calendar year 2023. The authors made an effort to conduct outreach with grassroots community and youth groups, but time prevented any real substantive engagement. There is significant opportunity to broaden and continue engagement so the CARP is a more comprehensive representation of the public's perspective. Too, as a living document, the authors recommend that community engagement be an ongoing process such that stakeholders have ample opportunity to weigh in on climate adaptation and resilience work as it evolves over time.

The CARP is being released together with an online feedback form, both of which will be made available on the Mayor's Sustainability, Resilience, and the Environment Web page at https://www.nashville.gov/departments/mayor/sustainability-resilience-environment. A media release directing interested parties to this electronic access will be Metro's primary vehicle for soliciting public feedback on the document, but citizen or other stakeholder groups wishing to engage in a more direct forum for discussion may make that request to the Mayor's Office. In the near term, Metro will aim to collect public feedback on the Plan between its release and the end of the October 2023. As given below, feedback will be summarized and Metro's response publicly released during the first quarter of 2024, together with a timeframe for incorporating the public's priorities and concerns into concrete Metro climate action.

It is of key importance in this Plan that Nashville's residents are educated and empowered to act on the importance of and means by which individuals and communities may build their resilience, while Metro pursues strategies that better equip Metro departments to deploy safeguards specifically targeting climate adaptation and resilience. The launch of strategies included under the Community and Culture category will provide multiple channels through which the public will be engaged in implementation and future iterations of this Plan. Thoughtful, proactive, inclusive, and motivated public engagement is a key, ongoing piece of building Nashville's resilience.

MONITORING AND EVALUATION

As noted throughout this document, the CARP is being launched in parallel with an internal Climate Resiliency Toolkit, which contains its own Implementation Roadmap for improving internal Metro processes with specific, timebound, department-level action commitments. In the short term, the expectation is that each department will develop their own Roadmaps that incorporate priorities and commitments from both initiatives. It will be the responsibility of the implementing departments to detail out the specific action items, responsible divisions/internal entities, timeframe, budget, and performance metrics required to pursue and monitor those initiatives.

To ensure the goals of both initiatives advance as planned, the following structure for monitoring and evaluation is proposed for the near term, through two main bodies:

1. A Climate Working Group (CWG), composed of department representatives who have previously participated in the Mayor's Sustainability and Resilience Roundtable and/or the Climate Resiliency Toolkit Working Group, or are newly identified for the purposes of the Toolkit and CARP;
2. The Sustainability Advisory Committee (SAC) established by Ordinance BL2023-2004.

Table 24. Annual schedule for CARP implementation and updates.

Year	Quarter	Task
2023	Q4	CWG convenes: • Sets annual department-level goals and reviews implementation progress from Plan publication. Minutes shared with SAC.
		Statutory SAC convenes.
2024	Q1	CWG and SAC convene.
	Q2	CWG and SAC convene.
	Q3	CWG and SAC convene: • The implementation status of the CARP Roadmap is reviewed, and new action items are identified as necessary.
	Q4	CWG and SAC convene. • CARP update released publicly by end-December. Mayor's Office to lead.
2025	Q1	CWG and SAC convene.
	Q2	CWG and SAC convene. • Priority CARP action items are reflected in Metro's Operating Budget and Capital Spending Plan.
	Q3	CWG and SAC convene: • Review and update CARP.
	Q4	CWG and SAC convene. • Release CARP update publicly by end-December.
2026	Q1	CWG and SAC convene.
	Q2	CWG and SAC convene. • CARP reflected in CIB and Operations budgets.
	Q3	CWG and SAC convene: • Review and update CARP.
	Q4	CWG and SAC convene. • Release CARP update publicly by end-December.

The Mayor's Office will maintain the leadership role for ensuring that these quarterly and annual meetings are held and Metro remains accountable for the commitments made in this Plan.

It is imperative that the CARP be utilized as a living guide that improves as it evolves. Its utilization will be improved by converting the database of adaptation strategies given in Appendix 4 into a searchable and expandable database, for ease of customization by specific departments and sector. The database in

particular should be updated as lessons learned and new best practices emerge from the efforts of other cities, states, and countries.

It is also imperative that, with the opportunity of time, its outreach efforts be used to invite more voices to the table and incorporate their ideas into its priorities. In the near term, and at minimum by the time of its update in 2024, its key sections should be translated to expand access beyond the English language.

NEXT STEPS

Building upon the momentum created during the drafting of this plan presents a significant opportunity to ensure this work continues. Nashville is already seeing the impacts of a changing climate, and it is imperative that the city take action to prepare for these effects. While the Implementation Roadmap and the Action Items recommended under each of its four goals outline numerous steps that should be taken in the coming months and years, and the preceding section addresses evaluation and communication requirements to follow the CARP's release, urgent next steps are summarized below.

CONTINUITY AMIDST ADMINISTRATION CHANGE

Shortly following the release of this draft Plan, there will be a change in mayoral administration. This presents the unique opportunity to both continue this deeply impactful work and align it with the priorities of the next cohort of city leaders. Three critical actions to ensuring continuity are:

- Delegation of oversight of implementation of climate action-related work to at least one individual within the Mayor's Office (of the new administration),
- Appointment of the recently established Sustainability Advisory Committee per BL2023-2004, to ensure that work begun by its predecessor ad hoc group is continued and to enable external stakeholders to have a consistent presence in advising on climate-related decision making, and
- Formation of a Metro Climate Working Group comprised of Metro department representatives who have previously participated in the prior administration's climate action efforts (e.g., Sustainability and Resilience Roundtable and/or the Climate Resiliency Toolkit Working Group), or who are newly identified as being employees to be involved in this conversation.
- Online Database of Adaptation Strategies: Metro should take adaptation strategies included in Adaptation Strategies Appendix and the Implementation Roadmap and build an online, searchable, and sortable database to ease identification and navigation of strategies available for pursuit.

ONGOING CLIMATE ADAPTATION AND RESILIENCE ENGAGEMENT

As previously noted, the CARP is being released with an online feedback form, which seeks to gather input from the public on actions included in the Plan. Alternative approaches (e.g., presentations and community meetings, workshops, public displays at events, etc.) will also be pursued where relevant and feasible. Following the feedback period, which will conclude at the close of the calendar year 2023, Metro will prepare a summary of comments received and release a revised version of the plan in early 2024. Strategies included in the Community and Culture category also will provide multiple avenues for public education on climate adaptation and resilience and engagement on CARP implementation. Creating thoughtful, proactive, inclusive, and continuous public engagement is essential to the success of this work.

INCLUSION OF CLIMATE ADAPTATION AND RESILIENCE IN BUDGETING PROCESSES

A primary mechanism for fully ingraining climate adaptation and resilience work into the city's operations is through both the capital and operating budgeting processes. This will ensure that the city is making climate-forward investments that present opportunities to responsibly adapt to risks posed by a changing climate.

It is important to acknowledge that no cost or budget information is provided alongside the Implementation Roadmap or Action Items contained herein. That omission is due both to the short timeframe in which this Plan was produced, and the lack of available resources that would be needed to yield an informed cost estimation. Those include an assessment of the efficacy and barriers of ongoing programs, gap in service assessments, detailed department audits, and other sector-specific risk and asset assessments that are recommended in this Plan. The authors recommend that future Metro efforts to improve its climate understanding and readiness include budgeting for focused, technical, and expert assessments to confirm and better detail the key inputs of this Plan (see also Further Recommendations, below).

IDENTIFICATION OF SPECIFIC PERFORMANCE INDICATORS FOR CLIMATE ADAPTATION AND RESILIENCE

As indicated in the CARP, climate adaptation and resilience, and equity indicators will be developed both at the departmental level and for each strategy contemplated in the implementation roadmap. The authors have suggested potential metrics but recognize that executing departments must have ultimate ownership of performance indicator selection. Too, in many circumstances, a baseline year of data will need to be collected before targets can be established.

INCORPORATION OF CLIMATE ADAPTATION AND RESILIENCE STRATEGIES INTO MULTI-HAZARD MITIGATION PLAN

In 2024 Metro will update its Multi-Hazard Mitigation Plan. Metro should incorporate a climate adaptation and resilience lens, inclusive, to the extent possible, of the strategies prioritized within the CARP, to ensure alignment between planning efforts.

FURTHER RECOMMENDATIONS

This document represents Nashville's first attempt to focus on building climate adaptation and resilience through a systems-based risk assessment. It is intended to be a living document that is revisited, regularly updated, and improved. Throughout the document there is reference to its limitations in terms of breadth of hazards covered and the high-level nature of the vulnerability assessment, given the limited resources and rapid timeline for its development. Nashville should secure the resources necessary to address these limitations in future updates and related efforts.

In addition, the risk assessment in the CARP was unable to include identification of risk tolerances for specific system-asset-event combinations. For example, prolonged exposure to extreme heat may result in more significant impacts to road infrastructure relative to water infrastructure, but the threshold for

unacceptable circumstances may not be seen for years. On the other hand, prolonged exposure to extreme heat will have more severe impacts to outdoor workers and the unhoused community relative to individuals who have access to air conditioning. The threshold for unacceptable conditions will vary considerably across these examples. Developing risk tolerances for specific circumstances will allow Metro to further prioritize where it should take action to mitigate high likelihood, high impact, and low risk tolerance occurrences.

Finally, as stated in the Note on Historical Climate Trends section, a review of risk tolerances should be accompanied by a more comprehensive evaluation of temperature and precipitation trends and thresholds, utilizing local data and expertise, for a more nuanced picture of trends over the long term.

CONCLUSION

Regardless of root cause, it is indisputable that Nashville's future will include impacts associated with a changing climate, which will require the city to think ahead and adapt in order to ensure its citizens not only survive but thrive. As a responsible steward of the city's assets and resources—including its people—Metro must pursue parallel aims: To take the actions identified in its Climate Action Plan and play its part in slowing the pace of climate change by reducing Metro's climate footprint; and to take the lead in preparing for the changes that have already arrived by facilitating adaptation and resilience-building initiatives and infrastructure. Both aims are moral imperatives.

To craft actions that fully achieve these aims, Metro must equip its leadership and staff with the proper knowledge, tools, and resources as a priority. This must be done through a lens of climate justice and equity, recognizing and addressing root causes and vulnerabilities when they are present. It is not enough to recognize what and who is threatened by climate change, we must craft and prioritize solutions for those who are directly jeopardized and continue to shoulder the burdens of our society. This means making informed, consensus-based, and intentional investments in both hard and soft infrastructure that will better equip Metro and communities to react to increasing and more severe natural hazards. It also means building internal and external capacity for adaptation work, informing and actively engaging the public on adaptation, resilience, and equity concepts, and leveraging external partnerships.

To this end, Metro must also look beyond its own boundaries. The current challenge, and opportunity, is to find solutions that engage our entire community—all of the ecosystems within Nashville's local microcosm, and to do so in a way that mobilizes beyond the Metro agencies that govern them. To borrow a definition from one of the great scientific minds of our time, Stephen Hawking stated that "intelligence is the ability to adapt to change." Nature is intrinsically resilient and adaptive: Every species plays a productive role within the ecosystem. It will take scientists, religious leaders, creatives, educational institutions, nonprofits, public and private partnerships, neighborhoods and individuals working in new and different ways to effectively tackle the urgent call to action made in this Plan. Our challenge traverses many sectors; the same must be true of our response.

This Plan represents the city's first step in meeting a new but inevitable moment—building a resilient future for generations to come. It identifies climate hazards, potential probabilities and outcomes, baseline vulnerabilities, foreseeable exposures of assets and systems, and additional equity considerations. Most importantly, it presents a recommended framework and strategies that Metro departments can take forward into their daily operations, to our communities, and to our external partners to ensure the city can endure and bounce back from climate events. It is intended as a catalyst for ongoing planning that is frequently reviewed and revised to reflect Metro department and community needs and capacity, and emerging innovations. It represents a springboard for action by all stakeholders, and is intended to close the gap between planning and real-time readiness. Together, Metro and its partners can build a better and more resilient tomorrow.

APPENDIX 1. REFERENCES FOR METRO'S CLIMATE HAZARDS RANKING

FEDERAL EMERGENCY MANAGEMENT AGENCY: NATIONAL RISK INDEX

FEMA's National Risk Index[36] calculates risk scores based on an equation that combines scores for expected annual loss, social vulnerability, and resilience as follows:

Risk Index = Expected Annual Loss x Social Vulnerability ÷ Community Resilience

Expected Annual Loss scores, representing the average economic loss resulting from natural hazards each year, are calculated based on values for exposure, annualized frequency, and historic loss. Exposure equates to a *consequence factor* that is the representative value of buildings, population, or agriculture potentially exposed to a natural hazard. Building and agriculture loss potentials are measured in dollars, whereas population loss potentials are measured in fatalities and injuries that are monetized using a value of statistical life approach. These values are multiplied by an annualized frequency factor representing the expected frequency or probability of a natural hazard occurring each year, which is further multiplied by a historic loss ratio representing the estimated percentage of the exposed building, population, or agriculture that would be lost in a given year.

Based on this methodology, FEMA identifies Metro's top 10 climate hazards, ranked based on composite score, as follows:

Table 25. FEMA NRI original risk table (early 2023).

Rank	Hazard Type	Risk Rating	EAL Value	Score
1	Cold Wave	Relatively High	$896,851	42.96
2	Riverine Flooding	Very High	$56,584,410	41.98
3	Tornado	Relatively High	$14,279,117	40.57
4	Hail	Relatively High	$2,102,252	25.17
5	Strong Wind	Relatively Moderate	$1,500,068	22.02
6	Heat Wave	Relatively High	$931,372	18.53
7	Ice Storm	Relatively Moderate	$152,978	16.14
8	Landslide	Relatively Moderate	$93,847	15.07
9	Lightning	Relatively Low	$140,325	14.33
10	Earthquake	Relatively Moderate	$7,958,604	13.33

[36] Map | National Risk Index (fema.gov)

Overall, Metro's Risk Index rating is Relatively High at 28.3, compared to a national average of 10.60. This means that over 97% of U.S. counties have a lower Risk Index than Davidson County.

Both Social Vulnerability and Community Resilience are measured using data from the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI),[37] which maintains a Social Vulnerability Index (SVI) and Baseline Resilience Indicators for Communities (HVRI BRIC). Metro Nashville's Social Vulnerability Score is 35.71 compared to the rest of the U.S., which averages 38.35; over 39% of U.S. counties have a lower Social Vulnerability. This makes Metro's Social Vulnerability score Relatively Moderate for all hazards. However, Metro's Community Resilience score is also Relatively Moderate at a value of 55.21, compared to a national average of 54.59 (42.6% of U.S. counties have a higher Community Resilience).

It should be noted that, subsequent to the development of this Plan but prior to its publication, FEMA updated its methodology and some of its data sources, including changing the source for Social Vulnerability data to the Social Vulnerability Index (SVI) published by the Centers for Disease Control and Prevention (CDC) and Agency for Toxic Substances and Disease Registry (ATSDR).[38]. It also updated Census data to 2021, including for population and building valuations for defining exposure values. New datasets were used for characterization of land use and for Coastal Flooding, Tsunami, and Landslide hazard types; the period of record for 15 other hazard types was also updated. Scoring was modified to represent national percentiles and for grouping communities into rating categories. As a result of these changes, Nashville's ranking of main climate hazards changed, and a new overall risk value was assigned to each. The updated ranking is given in the below table.

Table 26. FEMA NRI updated risk table.

Rank	Hazard Type	EAL Value	Risk Value	Score
1	Riverine Flooding	$65,109,596	$78,040,339	99.7
2	Tornado	$20,924,786	$23,904,935	98.0
3	Earthquake	$27,287,468	$31,857,550	97.5
4	Hail	$1,947,913	$2,178,174	95.0
5	Strong Wind	$2,319,351	2,683,657	94.5
6	Landslide	$175,352	$195,834	92.1
7	Heat Wave	$533,105	$623,608	82.2
8	Cold Wave	$258,510	$302,349	76.2
9	Lightning	$238,683	$269,589	76.0
10	Wildfire	$219,772	$228,730	72.2

[37] BRIC - College of Arts and Sciences | University of South Carolina

[38] CDC/ATSDR Social Vulnerability Index (SVI)

Based on the updated ranking methodology and data, Metro Nashville's Social Vulnerability Score was revised to 69.16 compared to the rest of the U.S., meaning over 69% of U.S. counties have a lower Social Vulnerability score than Metro. This makes Metro's Social Vulnerability score Relatively High for all hazards. Metro's Community Resilience score is also Relatively High at a value of 63.08, meaning 63% of counties have a lower Community Resilience score than Metro. Overall, Metro's Risk Index rating is considered Relatively High at 96.5, meaning nearly 97% of U.S. counties have a lower Risk Index score.

The main impacts of the updated scoring is that Earthquakes moved up the list with a higher risk score, and the distribution of other hazards also changed, with Heat Wave being ranked higher than Cold Wave, both of which moved down the list. For Earthquakes, while the Annualized Frequency score was the same between analyses (0.114% chance per year), the Exposure Value more than doubled with the updated datasets and the Historic Loss ratio moved from Relatively Moderate to Relatively High.

It should be noted that the NRI is a relative index, meaning that the scoring is relative and does not address a county or jurisdiction's risk in absolute terms. That is why a more technical risk assessment needs to be resourced and conducted for Metro in future iterations of this CARP. Nashville's Earthquake risk, its exposure, and potential adaptation strategies should be included in that next iteration.

METROPOLITAN NASHVILLE – DAVIDSON COUNTY: MULTI-HAZARD MITIGATION PLAN

Metro's Multi-Hazard Mitigation Plan (MHMP), prepared in 2019 and updated in 2023, includes a Threat and Hazard Identification and Risk Assessment (THIRA) following the methodology required by FEMA and the Emergency Management Accreditation Program (EMAP), and considering both natural and manmade hazards. The Metropolitan Nashville-Davidson Community Planning Team (CPT) scores risk based on impact, vulnerability, and likelihood (Impact + Vulnerability x Likelihood = Risk). The impact and vulnerability scores consider the following parameters resulting from a hazard event, on a scale of 1-5:

- Geographic Extent
- Duration of the Event
- Environment
- Health Effects
- Displacement and Suffering
- Economy
- Infrastructure
- Transportation
- Critical Services
- Confidence in Government
- Cascading Effects

The scoring parameters are given in the below tables.

Table 27. THIRA Impact and Vulnerability Evaluation Parameters.

Impact & Vulnerability Parameters						
Parameter	***Definition***	***1***	***2***	***3***	***4***	***5***
Geographic Extent	Size of the affected area. Includes areas not damaged but strongly affected by the incidents. For example, areas backed up by a transportation accident.	Single site. One or two blocks.	Single site. Multiple blocks.	Community (downtown, Berry Hill)	City-wide	Regional. (Winter Storms.)
Duration	How long does the acute crisis part of the disaster last?	Less than 24 hours	1-3 days	4-7 days	7-30 days	30+ days
Environment	How damaging is the disaster for the natural environment?	No damage/ temporary minor damage	Degradation of ecosystem that will repair itself	Degradation of ecosystem that requires intervention	Functional loss of ecosystem, but restoration is possible	Permanent loss of ecosystem
Health Effects (Deaths and Injuries)	How dangerous is the disaster for the natural environment?	No deaths or injuries	1-10 deaths and/or 1-100 injuries	11-50 deaths and/or 101-500 injuries	51-500 deaths and/or 501-1500 injuries	Over 501 deaths and/or 1501 injuries
Displacement and Suffering	How likely is the hazard to negatively impact the exposed population in terms of displacement, personal property loss and increased indebtedness?	No displaced people	Vulnerable populations begin to have problems with food, water, access to shelter.	Vulnerable populations having serious difficulties. General population starting to have problems.	251-1000 people displaced. 5-30% of population facing acute shortages.	1000+ displaced people. More than 30% of population facing acute shortages of basic supplies and access to services.
Economy	How does the hazard affect the local economy?	No measurable impacts	No impacts to overall economy but isolated businesses experience hardship.	Entire sectors experience loss of revenue and capital.	Core sectors of economy are affected and unable to generate revenue. Capital losses between 1- 10%	Physical losses equal to 10% to assess value. Loss of ability to generate revenue.
Built Environment (Property, Facilities, Infrastructure)	How does the hazard affect buildings and physical infrastructure? (Includes utilities)	No effects.	1-10 structures uninhabitable (red tagged). Up to 25% loss of one utility.	11-250 structures red tagged. Multiple utilities affected up to 25%.	251-1000 structures red tagged. Multiple utilities affected 25-50%.	1000+ structures red tagged. At least two major utilities degraded at least 50%.
Transportation	How does the hazard affect the ability of residents and workers to access the resources they need?	No effects on mobility	All critical services accessible, but delays reaching work or non essential services	One critical service inaccessible. Degradation of at least one mode. Major corridors open, but minor streets degraded or impassible.	Many critical services inaccessible. One major mode inoperable. One major corridor inoperable.	Most critical services inaccessible. Multiple modes inoperable. Most high volume corridors impassible.

Critical Services (Continuity of Operations and Responders)	How likely is the hazard to reduce the ability of government and business to provide critical services? (Medical, Public Safety, Social, Financial, etc)	No impairment on critical services	Temporary degradation of 1 critical service	Temporary degradation of multiple critical services. Long term degradation of 1 critical service	Temporary degradation of most critical services. Long term degradation of multiple services.	Unable to deliver most critical services.
Confidence in Government	Would public's confidence in government be shaken?	No	(Not used)	Somewhat	(Not used)	Yes
Cascading Effects	How severe and complex will the secondary effects be?	Hazard extremely unlikely to cause secondary hazards. If they occur, would have minor effect.	Secondary hazards may occur, but are likely to be minor compared to primary hazard	Secondary hazards occur that extend the impact of the disaster and hamper response, but are not disasters in their own right.	Secondary effects generated that significantly increase the magnitude of the disaster. Secondary impacts would likely be considered disasters if they occurred by themselves.	Secondary effects generated and rival or exceed primary hazard. Secondary impacts would definitely be disasters in their own right.

Table 28. THIRA Likelihood Parameters.

Hazard Likelihood Parameters		
Measure of likelihood	**Return period in years**	**Rank**
Frequent or very likely	Every 1-3 years	**6**
Moderate or likely	Every 3-10 years	**5**
Occasional, slight chance	Every 10-30 years	**4**
Unlikely, improbable	Every 30-100 years	**3**
Highly unlikely, rare event	Every 100-200 years	**2**
Very rare event	Every 200-300 years	**1**

The scoring results are given in the tables on the following pages. First, the CPT evaluated impact and vulnerability. Then it considered probability of occurrence, to arrive at a total Risk score.

Table 29. Overall Impact and Vulnerability Scoring.

OVERALL Impact & Vulnerability Assessment Scores 2023	Geographical Extent	Duration	Environment	Health Effects	Displacement	Economy	Built Environment	Transportation	Critical Services	Confidence in Govt	Cascading Effects	
Hazard	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Dam & Levee Failure	3.33	3.11	3.00	2.50	2.83	2.78	3.11	3.06	2.44	2.94	2.78	31.89
Flooding	3.35	3.20	2.95	2.55	3.15	2.90	3.40	3.05	2.75	2.58	2.80	32.68
Earthquake	4.10	3.57	2.48	3.05	3.33	3.29	3.81	3.57	2.86	2.30	3.24	35.59
Landslide/Sinkhole	1.30	2.70	2.60	1.75	1.80	1.80	2.00	2.15	1.50	1.47	1.60	20.67
Communicable Diseases	4.40	4.35	1.70	3.95	2.20	2.65	1.40	1.80	2.50	3.42	2.50	30.87
Drought	4.45	4.50	2.75	1.60	1.50	1.65	1.10	1.15	1.50	1.42	2.00	23.62
Wildfire	2.85	2.25	2.95	2.00	2.30	2.05	2.15	2.00	1.60	1.74	1.95	23.84
Extreme Temperature - Cold	4.50	2.70	1.95	2.05	2.20	2.00	1.80	1.50	1.85	1.58	1.95	24.08
Extreme Temperature - Heat	4.50	2.75	2.00	2.10	1.95	1.80	1.45	1.20	1.70	1.58	2.10	23.13
Thunderstorm	3.30	1.55	1.95	1.75	2.00	1.85	1.90	1.70	1.70	1.37	1.85	20.92
Tornado	3.45	2.55	2.95	2.60	3.30	2.95	3.00	2.90	2.75	2.11	2.90	31.46
Winter Storm	4.70	2.75	1.90	1.95	2.05	2.00	1.70	3.25	2.55	1.95	2.25	27.05
Manmade - Technological/Terrorism	3.30	2.80	2.20	2.65	2.65	2.80	2.20	2.45	2.55	3.32	2.35	29.27
Hazardous Materials Incident	2.55	2.55	3.50	2.20	2.65	2.25	1.95	2.05	2.05	2.68	2.40	26.83

Table 30. Total Risk Scores.

OVERALL Total Risk Scores for Davidson County 2023			
Hazard	**Impact & Vulnerability**	**x Likelihood**	**= Risk Factor**
Flooding	32.68	5.35	**174.8**
Tornado	31.46	5.05	**158.8**
Winter Storm	27.05	5.05	**136.6**
Communicable Diseases	30.87	3.95	**121.9**
Thunderstorm	20.92	5.55	**116.1**
Extreme Temperature - Heat	23.13	5.00	**115.6**
Extreme Temperature - Cold	24.08	4.75	**114.4**
Manmade - Technological/Terrorism	29.27	3.90	**114.1**
Hazardous Materials Incident	26.83	4.20	**112.7**
Drought	23.62	4.15	**98.0**
Landslide/Sinkhole	20.67	4.25	**87.9**
Wildfire	23.84	3.35	**79.9**
Dam & Levee Failure	31.89	2.10	**67.0**
Earthquake	35.59	1.71	**61.0**

Focusing only on natural hazards, the CPT's updated 2023 scoring found Nashville's top climate risk to be flooding, with both the highest likelihood and highest impact and vulnerability factors. The top climate hazards are ranked as follows:

1. Flooding
2. Tornado
3. Winter Storm
4. Thunderstorm
5. Extreme Temperatures (Heat/Cold)

This represents a change from the 2019 THIRA, which ranked extreme temperatures higher than thunderstorms.

With consideration of the data used in the FEMA ranking and the other sources referenced herein, Metro prioritized addressing extreme temperatures (cold and heat waves), riverine and pluvial flooding, tornados, and thunderstorms as the most critical natural climate-driven hazards to which its citizens will need to prepare and adapt in the near term.

APPENDIX 2. PAIRING NASHVILLE'S SYSTEM MAP WITH INDIVIDUAL CLIMATE HAZARDS.

This Appendix provides Metro's initial rating of the potential impact of each of its five main climate hazards against the vulnerability and adaptive capacity of its system. Each was individually rated in order to identify Metro's priority areas for intervention. Risk for each sub-component is indicated by color, with the darker shades indicating higher overall risk, and lighter shades indicating lower risk. **This rating system was replaced by the impact chain analysis work as described in the body of the document, is provided for ICLEI reference only, and should not be taken as consequential to the main content in the CARP.**

RIVERINE AND PLUVIAL FLOODING

The below Tables illustrate where each major system category falls at the intersection of impact and adaptive capacity as it relates to flooding.

Table 31. System Vulnerability Scoring for Flooding.

									
Community & Culture		**Natural Environment**		**Infrastructure**		**Economy**		**Public Safety**	
A	Livelihood and affordability	E	Ecosystem services	I	Energy generation	O	Agriculture	S	Emergency services
B	Health and wellbeing	F	Flora/forests/ trees	J	Energy transmission	P	Supply chain	T	Law and order
C	Access to goods and services	G	Watersheds/ hydrology	K	Water supply	Q	Business continuity	U	Transportation system
D	Security of the built environment	H	Fauna/native species	L	Storm/ wastewater management	R	Revenue generation	V	Water infrastructure
				M	Communications				
				N	Transportation				
Crosscutting: Equity									

Table 32. Community and Culture Vulnerability to Flooding.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High			A / B C / D		
	Mod.					
	Mod. Low					
	Low					

Table 33, Natural Environment Vulnerability to Flooding.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High			E / G		
	Mod.				F / H	
	Mod. Low					
	Low					

Table 34. Infrastructure Vulnerability to Flooding.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High		I / K	L	N	
	Mod.			J	M	
	Mod. Low					
	Low					

Table 35. Economic Vulnerability to Flooding.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High			P / Q	O / R	
	Mod.					
	Mod. Low					
	Low					

Table 36. Public Safety Vulnerability to Flooding.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High		V	S / T	U	
	Mod.					
	Mod. Low					
	Low					

TORNADOS

The below Tables illustrate where each major system category falls at the intersection of impact and adaptive capacity as it relates to tornados and severe wind events.

Table 37. System Vulnerability Scoring for Tornados.

Community & Culture		Natural Environment		Infrastructure		Economy		Public Safety	
A	Livelihood and affordability	E	Ecosystem services	I	Energy generation	O	Agriculture	S	Emergency services
B	Health and wellbeing	F	Flora/forests/ trees	J	Energy transmission	P	Supply chain	T	Law and order
C	Access to goods and services	G	Watersheds/ hydrology	K	Water supply	Q	Business continuity	U	Transportation system
D	Security of the built environment	H	Fauna/native species	L	Storm/ wastewater management	R	Revenue generation	V	Water infrastructure
				M	Communications				
				N	Transportation				
Crosscutting: Equity									

Table 38. Community and Culture Vulnerability to Tornados.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High		B	A		
	Mod. High			C / D		
	Mod.					
	Mod. Low					
	Low					

Table 39. Natural Environment Vulnerability to Tornados.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.					
	Mod. Low					E / F G / H
	Low					

Table 40. Infrastructure Vulnerability to Tornados.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High				J / L	
	Mod.			I / K	M / N	
	Mod. Low					
	Low					

Table 41. Economic Vulnerability to Tornados.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.			P	Q	O
	Mod. Low				R	
	Low					

Table 42. Public Safety Vulnerability to Tornados.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.			V	S / T U	
	Mod. Low					
	Low					

EXTREME HEAT

The below Tables illustrate where each major system category falls at the intersection of impact and adaptive capacity as it relates to extreme heat (heat wave shocks, and rising temperature stressors).

Table 43. System Vulnerability Scoring for Extreme Heat.

Community & Culture		Natural Environment		Infrastructure		Economy		Public Safety	
A	Livelihood and affordability	E	Ecosystem services	I	Energy generation	O	Agriculture	S	Emergency services
B	Health and wellbeing	F	Flora/forests/ trees	J	Energy transmission	P	Supply chain	T	Law and order
C	Access to goods and services	G	Watersheds/ hydrology	K	Water supply	Q	Business continuity	U	Transportation system
D	Security of the built environment	H	Fauna/native species	L	Storm/ wastewater management	R	Revenue generation	V	Water infrastructure
				M	Communications				
				N	Transportation				
Crosscutting: Equity									

Table 44. Community and Culture Vulnerability to Extreme Heat.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High			B		
	Mod. High			A		
	Mod.			C		
	Mod. Low			D		
	Low					

Table 45. Natural Environment Vulnerability to Extreme Heat.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.					F / H
	Mod. Low					E / G
	Low					

Table 46. Infrastructure Vulnerability to Extreme Heat.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High		I / J	K		
	Mod.			N		
	Mod. Low			L / M		
	Low					

Table 47. Economic Vulnerability to Extreme Heat.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High				O	
	Mod.			P / R		
	Mod. Low			Q		
	Low					

Table 48. Public Safety Vulnerability to Extreme Heat.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High			V		
	Mod.			U		
	Mod. Low			S	T	
	Low					

COLD WAVES AND EXTREME WINTER WEATHER

The below Tables demonstrate where each sub-component of the five system categories falls at the intersection of impact and adaptive capacity for extreme cold events.

Table 49. System Vulnerability Scoring for Extreme Cold.

Community & Culture		Natural Environment		Infrastructure		Economy		Public Safety	
A	Livelihood and affordability	E	Ecosystem services	I	Energy generation	O	Agriculture	S	Emergency services
B	Health and wellbeing	F	Flora/forests/ trees	J	Energy transmission	P	Supply chain	T	Law and order
C	Access to goods and services	G	Watersheds/ hydrology	K	Water supply	Q	Business continuity	U	Transportation system
D	Security of the built environment	H	Fauna/native species	L	Storm/ wastewater management	R	Revenue generation	V	Water infrastructure
				M	Communications				
				N	Transportation				
Crosscutting: Equity									

Table 50. Community and Culture Vulnerability to Extreme Cold.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High			B		
	Mod. High			A / D	C	
	Mod.					
	Mod. Low					
	Low					

Table 51. Natural Environment Vulnerability to Extreme Cold.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					F / H
	Mod.					E
	Mod. Low					G
	Low					

Table 52. Infrastructure Vulnerability to Extreme Cold.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High		I / J	K / N		
	Mod.					
	Mod. Low			L / M		
	Low					

Table 53. Economic Vulnerability to Extreme Cold.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High			P / Q	O	
	Mod.			R		
	Mod. Low					
	Low					

Table 54. Public Safety Vulnerability to Extreme Cold.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High			S / U V		
	Mod.				T	
	Mod. Low					
	Low					

THUNDERSTORMS, LIGHTNING AND HAIL

The below Tables illustrate where each major system category falls at the intersection of impact and adaptive capacity as it relates to thunderstorms, inclusive of lightning and hail events.

Table 55. System Vulnerability Scoring for Thunderstorms.

Community & Culture		Natural Environment		Infrastructure		Economy		Public Safety	
A	Livelihood and affordability	E	Ecosystem services	I	Energy generation	O	Agriculture	S	Emergency services
B	Health and wellbeing	F	Flora/forests/ trees	J	Energy transmission	P	Supply chain	T	Law and order
C	Access to goods and services	G	Watersheds/ hydrology	K	Water supply	Q	Business continuity	U	Transportation system
D	Security of the built environment	H	Fauna/native species	L	Storm/ wastewater management	R	Revenue generation	V	Water infrastructure
				M	Communications				
				N	Transportation				
Crosscutting: Equity									

Table 56. Community and Culture Vulnerability to Thunderstorms.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.				B	
	Mod. Low				C	
	Low				A / D	

Table 57. Natural Environment Vulnerability to Thunderstorms.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.					
	Mod. Low					F / H
	Low					E / G

Table 58. Infrastructure Vulnerability to Thunderstorms.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.			I / J L	M	
	Mod. Low			K / N		
	Low					

Table 59. Economic Vulnerability to Thunderstorms.

		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.					
	Mod. Low					
	Low					O / P Q / R

Table 60. Public Safety Vulnerability to Thunderstorms.

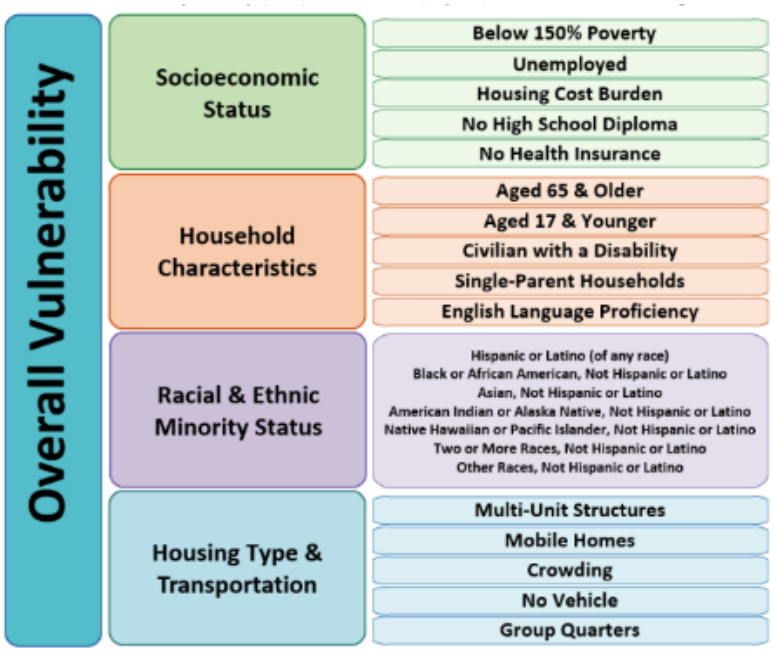
		Adaptive Capacity				
		High	Mod. High	Mod.	Mod. Low	Low
Potential Impact	High					
	Mod. High					
	Mod.					
	Mod. Low			U / V		
	Low					S / T

APPENDIX 3. METRO NASHVILLE'S SOCIAL VULNERABILITY INDEX AND HISTORIC REDLINING.

According to SVI, Metro Nashville scores fairly high in vulnerability overall at nearly 75%, meaning that nearly three-quarters of other U.S. counties are less vulnerable than Davidson County. This vulnerability score includes variables related to socioeconomic status, household characteristics, racial and ethnic minority status, and housing type and transportation, as shown in the box at right.

Nashville's socioeconomic status score is moderately low at 42%. In terms of household characteristics, it scores at 29%. However, it's racial and ethnic minority status score is highly vulnerable, at nearly 96%. Similarly, the City's residents are highly vulnerable in terms of housing type and transportation, scoring nearly 95%.

The areas of Metro Nashville that score highest on the vulnerability index are concentrated in the City's north, northwest, northeast, and southeast perimeters, as shown in the figures below. Not surprisingly, this geographic distribution corresponds to the City's history of redlining, which is further represented by the location of its major highway corridors.



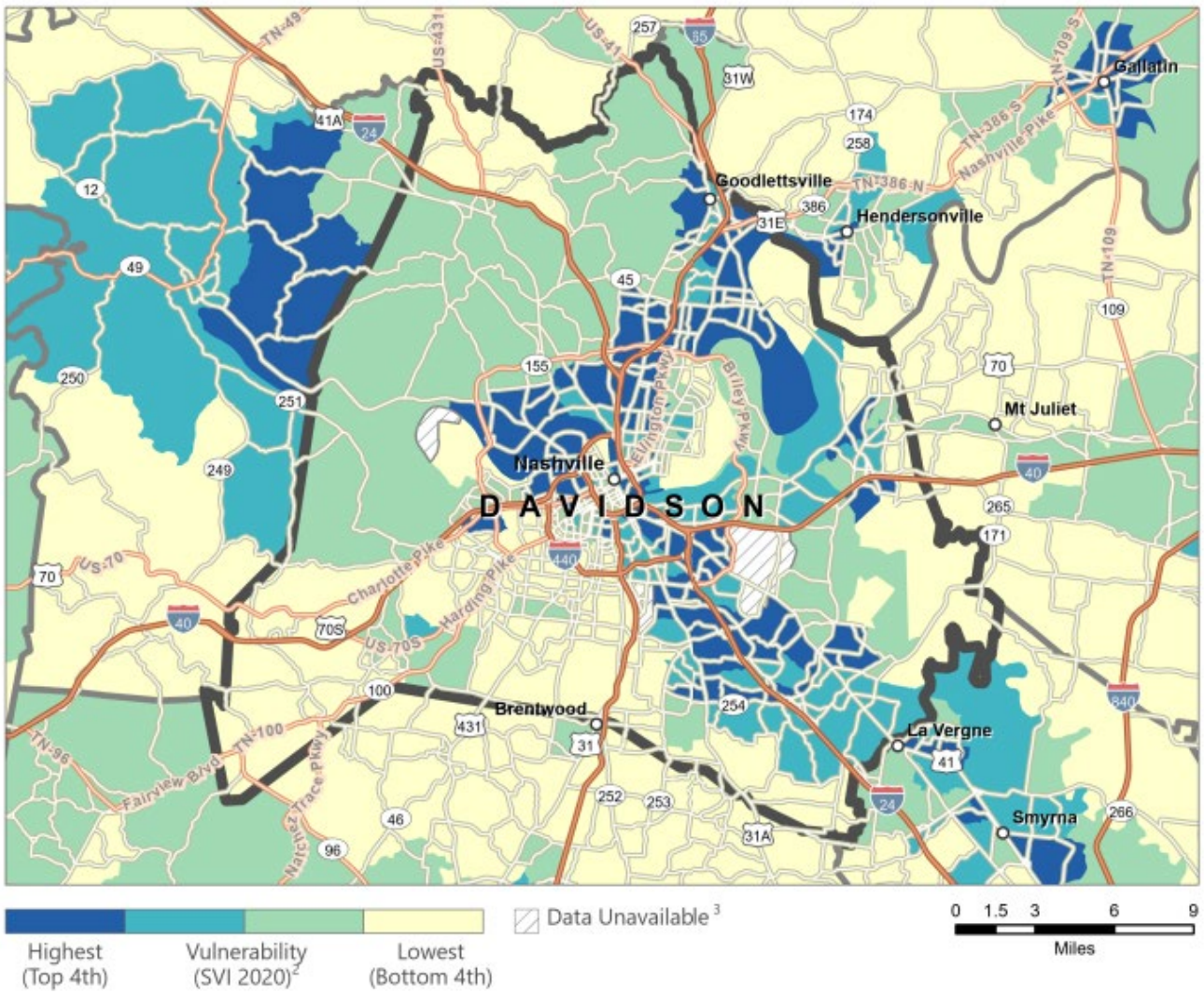


Figure 29. Metro Nashville's Overall Vulnerability as measured by the CDC's SVI.

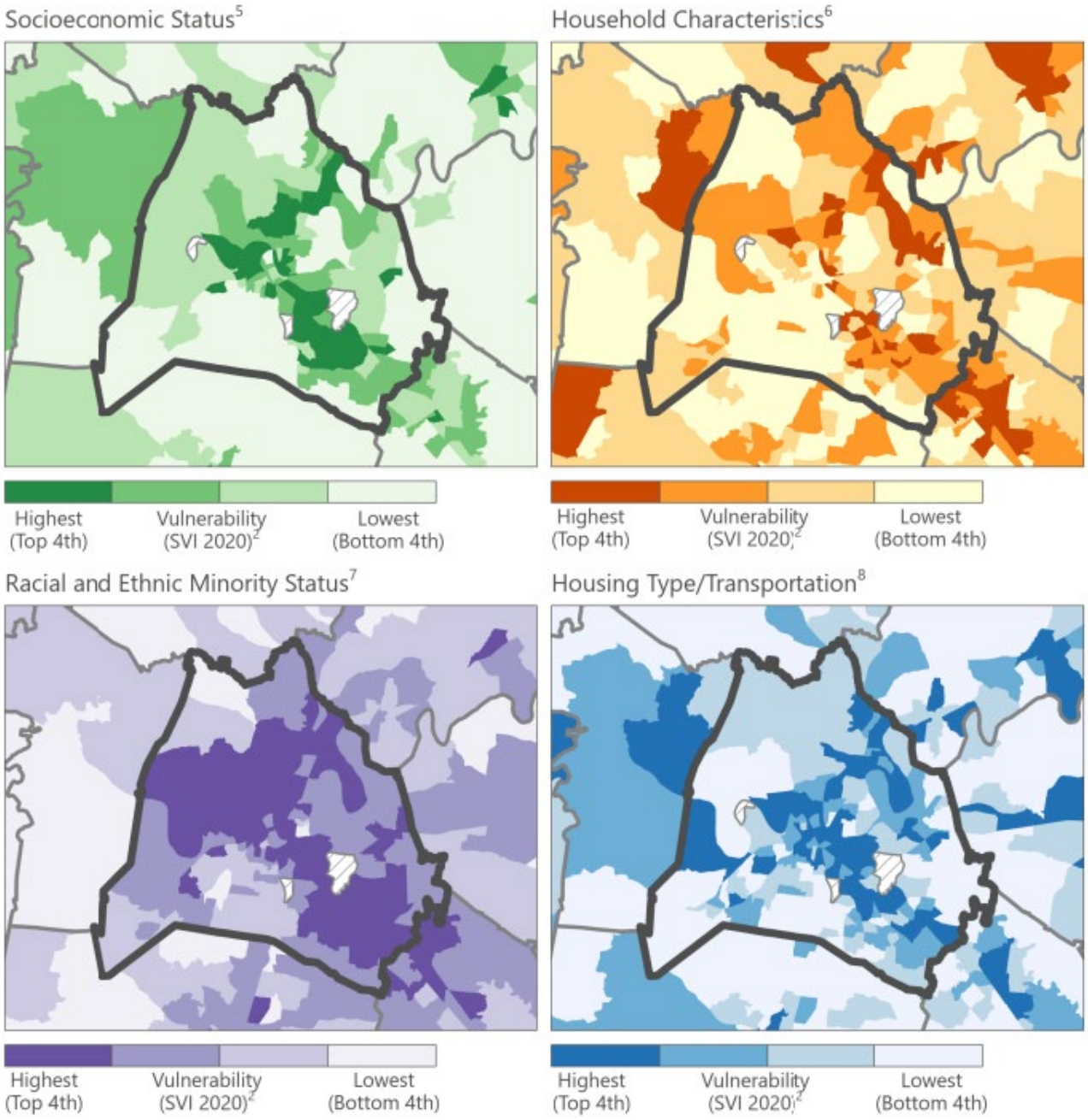


Figure 30. Metro Nashville's individual SVI scores.

Like many other U.S. cities, Nashville subjected its citizens to redlining and housing segregation policies beginning in the 1930s. These government policies led black persons and families to be denied mortgages in nicer areas of Nashville, pushing them into areas characterized by hazards such as natural flood plains and industrial activities, with far fewer resources and a resultant lower quality of life. Redlining was initiated by the federal government's Home Owners' Loan Corporation (HOLC) between 1935 and 1940, when residential neighborhoods were assigned grades reflecting their “mortgage security” from A or best (green) to D or hazardous (red). This grading system was used by banks and other mortgage lenders to

determine who should receive loans. Courtesy of the University of Richmond's Mapping Inequality project, Nashville's HOLC map in shown in the Figure below.[39] Not surprisingly, the areas graded as "hazardous" correspond with many of today's most vulnerable neighborhoods. Those neighborhoods are recently facing a second threat—gentrification.

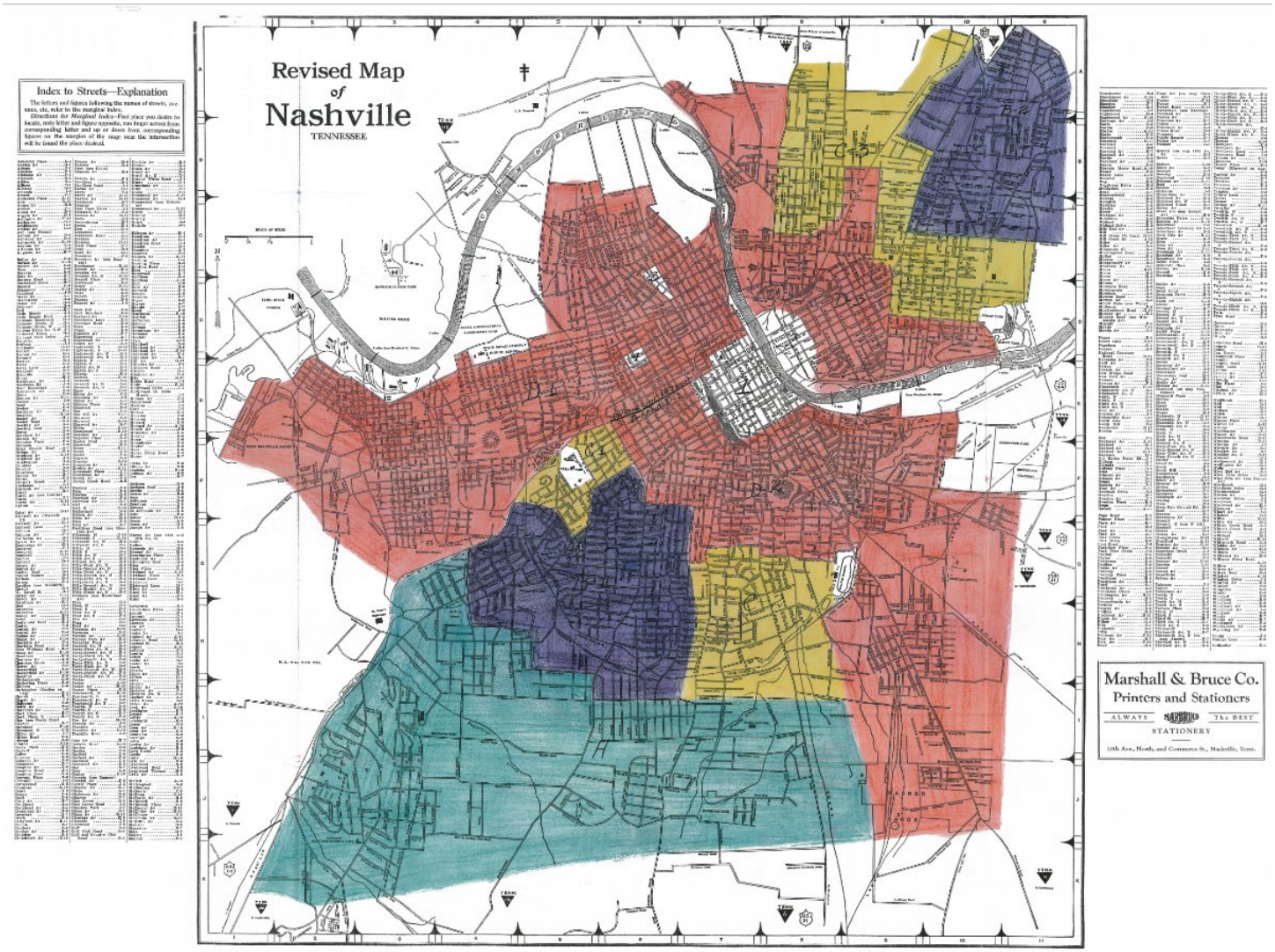


Figure 31. Metro Nashville's HOLC map, showing "best" to "worst" neighborhoods

[39] Mapping Inequality (richmond.edu)

APPENDIX 4. DATABASE OF POTENTIAL CLIMATE ADAPTATION AND RESILIENCE STRATEGIES.

COMMUNITY AND CULTURE

Figure 32. Potential Adaptation Strategies for Community and Culture.

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	**CC1. CLIMATE-SPECIFIC OUTREACH AND EMPOWERMENT** Description: The best strategy to ensure Nashville's public service and emergency response capabilities meet the need is to prioritize building the resilience of individuals, households, businesses, and communities, so that they are prepared and capable of withstanding climate-driven disasters themselves and do not add unnecessary burden or detract from supporting frontline communities when disasters occur. One of the biggest ways the city can help people reduce their vulnerability and risk is through the acquisition of insurance—especially health insurance and flood insurance. As a priority, Metro should begin to identify creative ways it can substantially expand insurance among low-income households, particularly those in the floodplain. At no cost, it can begin with education and pointing people to the right resources. It should go beyond that. Through its Office of Emergency Management (OEM), Nashville currently provides the public with resources and training related to all-hazards preparation and recovery. Nashville's Multi-Hazard Mitigation Plan and its Community Planning Team (CPT) has proposed to expand these efforts with a multi-hazard, seasonal Public Awareness Program (Action 2-1) that provides citizens and businesses with accurate information describing the risk and vulnerability to natural hazards. This expansion program might be combined with efforts to	X	X	X	**Universal & Targeted**

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	develop Resilience Hubs in the most vulnerable communities (see Strategy CC2), and could also include development of community-specific Climate Adaptation and Resilience Action Plans. Metro might also conduct a review of its current outreach efforts and consider whether any gaps exist within communication channels or as concerns people with special needs (e.g., those who live alone, are homebound, or face other obstacles to disaster response). In early 2023, Metro launched a Cultural Ambassadors program that is a joint cooperation between OEM and the Tennessee Language Center focused on helping the city's New American and Immigrant communities prepare for climate disasters and gain access to existing disaster preparedness resources. This is a low-cost, innovative, and targeted approach that could be replicated for other communities and risks (e.g. communities in floodplains, specific Environmental Justice initiatives). Communities, particularly frontline ones most exposed to climate hazards, should be engaged to inform Metro-led planning that identifies specific risks and vulnerabilities, conducts resilience and adaptation planning, and provides resources to help community members be prepared. The aim of this strategy (in concert with IN11 and XC1) should include the development of a common set of standards for communication of information to the public, to improve Metro's communication efforts overall and ensure accuracy, use of shared branding across departments, easy to understand infographics, and adoption of a plain language standard. Outreach efforts should be multi-modal and universal as well as targeted. A Resilience Program could utilize channels such as mobile phone campaigns and alerts, schools (both public and private), utility-led communication, specific programs conducted as part of special events, and services-based (such as integrated into support services for the elderly or unhoused). They can also be as simple as signage—for example, Metro				

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	Water Services (MWS) installed signs in floodplain properties it has acquired that show how high the 2010 flood waters reached. It is important to note that several local non-governmental organizations engage in climate action education and empowerment, including but not limited to Cumberland River Compact, Tennessee Immigrant Refugee Rights Coalition, The Nature Conservancy, Southern Alliance for Clean Energy, Tennessee Interfaith Power & Light, and Urban Green Lab. Leveraging these existing successful efforts to enhance climate outreach and empowerment, and continuing to build a network of partnerships that is geographically, socioeconomically, and racially diverse, is a critical component of this strategy. Resources: • FEMA, Building Alliances series City/State Examples: • King County, WA: Community Engagement and Co-Creation • San Francisco, CA: San Francisco Climate and Health Profile (see Education and Outreach materials) • New York, NY: Be a Buddy extreme heat strategy • Cleveland, OH: Racial Equity Tool				
	CC2. COMMUNITY RESILIENCY HUBS Description: Community-focused facilities that are augmented to support residents, coordinate communication, distribute resources, and achieve climate resilience goals during both blue and grey skies, Resiliency Hubs may also serve as Cooling Centers, Warming Centers, or Storm Shelters (see CC9, CC11 and CC12, respectively, below), or take the form of mobile support that is deployed to existing multi-use community facilities at designated times. Metro's Comprehensive Emergency Management Plan (CEMP) includes a plan to utilize public school facilities and buses for response and shelter, as well as Parks' and Libraries' facilities. Metro Nashville may consider utilizing existing NGO/CBO-		X	X	Targeted

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	based disaster response volunteer networks to develop a proactive community resiliency outreach program as a first phase. Metro could also consider as a first step toward Resiliency Hubs, scaling up an existing Cultural Ambassadors program described in CC1 above. If resiliency hubs are developed in fixed locations (recommended), they should be located along transit lines.				
	Resources: • Resilience Hubs (resilience-hub.org)				

	City/State Examples:
	• Baltimore, MD: City Community Resiliency Hub Program
	• Multi City:
	  ○ Vibrant Hawaii
	  ○ Oregon Community Resilience Hubs				

	CC3. AFFORDABILITY PLANS / VARIABLE RATE STRUCTURES AND ENERGY USE SUBSIDIES FOR LOW-INCOME RESIDENTS				
	Description: Ensuring that electricity, drinking water, public transportation, waste- and stormwater, and waste services are affordable for all of Nashville's communities is a key aspect of achieving sustainability and resilience for our community. Many cities have instituted income-based utility pricing as part of affordability plans that ensure equitable access to public services. Other approaches include "opt-in" and "opt-out" aggregation whereby utility services are purchased by a government body or other organization on behalf of a member group or aggregation of customers. When energy costs are unaffordable, low-income households may need to sacrifice other necessities such as food or medical care because they know losing service could be detrimental to their physical and economic health. Prices are	X			Targeted

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	even greater during increased demand from extreme temperatures. Nashville currently helps residents apply to federal programs such as LIHEAP, but could also consider affordability plans or variable rate structures for drinking water and other critical services for households meeting threshold criteria, which would be applicable regardless of weather conditions. MWS, as part of its 2023 Strategic Plan and Sustainability and Resilience Master Plan (under development), has identified a number of action steps it will carry out over the next fiscal year to establish an Affordability Plan. As a parallel initiative, Metro may consider setting policies in place to freeze or suspend code violation enforcements, utility bills, and other measures that could create punitive financial burden during disaster recovery periods. Nashville Electric Service (NES), the local power company serving Nashville businesses and residents, has implemented a round-up initiative for ratepayers that supports low-income homeowners in completing home energy retrofits that lower energy costs and make homes more inhabitable. NES also has a robust temporary utility bill assistance program. To incentivize efficiency and responsible consumption, and to finance affordability plans for lower-income customers, NES may also want to consider graduated pricing, with surcharges for higher energy use in larger homes. One way to make public transportation more affordable is to work with the city's larger employers and encourage financial support of public transit by making bus rides free for employees. Finally, the federal Affordable Connectivity program provides home internet discounts to qualifying individuals and households that can significantly reduce or eliminate internet costs. In recognition of the role affordable internet plays in expanding opportunities and resilience, Metro ITS, Libraries, and hubNashville				

Applicable Hazards	 Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	are working with partners including Metro Digital Inclusion, Black Churches for Digital Equity, and CivicTN to raise awareness of this program. Resources: • Administration for Children & Families, LIHEAP and Extreme Heat City/State Examples: • California, Income-based Utility Pricing • Ohio Aggregation Program				
	CC4. WEATHERIZATION / BUILDING RETROFITS / COOL AND GREEN ROOFS Description: Cities can invest in weatherization programs, home energy retrofits, and distribution of climate resilience-targeting resources to improve energy efficiency and indoor thermal comfort. They can also invest in climate resilient design for new buildings that serve the community, including passive cooling building features. Cool roofs (white roofs, green planted roofs, and solar roofs) comprise one strategy that has been employed in major cities at a relatively low cost. Targeting older housing stock (identified through property tax records, homestead exemptions, and local surveys) for stabilization could also be considered. The TVA Home Energy Uplift Program deployed by NES is one example of a program that pertains to this strategy. A second example is the federal Weatherization Assistance Program, locally administered by MDHA. The Barnes Fund supports weatherization retrofits for single-family homes as well. (also see CC6) Resources: • UNEP, A Practical Guide to Climate-resilient Buildings and Communities • UNEP, Beating the Heat: A Sustainable Handbook For Cities ("Energy-Efficient and Thermally Efficient Buildings", P. 122) • Environmental Protection Agency, Reducing Urban Heat Islands: Compendium ofStrategies - Green roofs • Green Roofs For Health Cities, Green Roof and Wall Policy in North America:Regulations, Incentives, and Best Practices (2019)	X	X		**Universal & Targeted**

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & C	Targeted (Vulnerable Population) or Universal?

	• Nashville.gov, Green Roofs
	City/State Examples:
	• Boston, MA:
	  ○ Heat Resilience Solutions for Boston (Strategies include "Home Cooling Resources Distribution;" "Home Energy Retrofits;" and "Affordable Housing Resources and Retrofits" at p. 223)
	  ○ Building Resilience in Boston: "Best Practices" for Climate Change Adaptation and Resilience for Existing Building (p. 70)
	  ○ Strategies to Advance Energy Efficiency in Boston (energyperformance improvements for affordable housing)
	• NYSERDA: Climate Resilience Strategies for Buildings in New York State
	• Chicago, IL
	  ○ The 2008 Chicago Climate Action Plan set a goal of having 6,000 green roofs installed throughout the city by 2020
	  ○ NRDC, Chicago, Illinois: A Case Study
	  ○ Environmental Protection Agency, Chicago, IL Uses Green Infrastructure toReduce Extreme Heat
	• London, UK
	  ○ C40 Cities, Good Practice Guide Cool Cities (p. 9)
	  ○ C40 Cities, Greening the BIDs: Private-public collaboration to deliver greeninfrastructure opportunities				

	CC5. REVIEW AND UPDATE BUILDING CODES, ZONING CRITERIA, AND DESIGN STANDARDS (SEE ALSO IN3) Description: Establishing standards and adopting building and site codes, particularly for multi-family residential buildings, that address current and projected climate risks is a key aspect of keeping the community safe. Metro should also explore whether zoning overlays can be utilized to further resilience goals(see IN11), Nashville has already advanced its data and monitoring of floodplains, but could also consider emerging research and modeling that takes	X	X		Universal

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	into account new rainfall analyses. Nashville should also consider adopting new zoning and permitting standards related to heat and seismic risk. There are already multiple efforts underway that could be utilized to introduce new standards and/or development ordinances related to climate resilience. One is Nashville's East Bank Plan, which contains multiple climate resilience strategies from transit-oriented development to innovative flood management approaches. Another is the Department of Planning's recent launch of an Ecological Design Studio, with an aim of designing for greater equity and resiliency by incorporating consideration of natural resources, environmental risks and assets, cultural diversity, and climate resilience into land use decisions. Such approaches could become Nashville's new norm and include climate resilience principles in terms of building design, energy and stormwater management, and community safety. There are multiple ways that community safety can be improved through codes, zoning, permitting, and other regulatory strategies. The first step Metro should take is to establish a cross-department working group and develop an actionable plan for incremental action.				
	Resources: • Delivering_Resilient_Building_Codes_and_Standards.pdf (iccsafe.org) • Urban Land Institute, Enhancing Heat Resilience and Equity in the Wedgewood-Houston and Chestnut Hill Neighborhoods • HUD, Resilient Building Codes • American Planning Association, Urban Heat Resilience				
	City/State Examples: • Norfolk, VA: Resilience Overlay Districts • Boston, MA: Boston Heat Resilience Plan, Chapter 6 (pp. 223-231) and Climate Resiliency Guidance				

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	• Philadelphia, PA: City of Philadelphia Office of Sustainability, Philadelphia Climate Action Playbook, "Climate Informed Planning" (p. 35)				
	CC6. COMBATTING GENTRIFICATION Description: Many of the strategies and targets included in this document are focused on achieving greater quality of life for Nashville's residents, through providing safer and more efficient access to public transportation, increasing green space, and improving neighborhood amenities. Unfortunately, such initiatives often unintentionally result in gentrification and displacement. While Metro has recognized this very real risk in current initiatives including NDOT's Transit Oriented Development policy work, Metro should consider opportunities to go farther and encode protections in its planning and land use policies. Nashville is experiencing an extraordinary period of development, with property values and associated property taxes soaring, along with increasing heat and stormwater management challenges as more and more impervious surfaces are added to the city. Strategies Nashville could consider scaling up to combat these forces and achieve greater racial and economic equity include creating additional affordable housing, incentivizing or requiring mixed-use development, and instituting programs focused on improving vulnerable households' capacity to build their assets through home ownership. Another strategy is a community land trust, which preserves land and affordable housing for communities living in areas vulnerable to gentrification. There are more than 300 community land trusts across the U.S. dating back to the 1970s. Nashville's Barnes Housing Trust Fund has invested nearly $93 million to date and leveraged over $933 million of federal and private funding to increase affordable housing development and preservation. The Barnes Fund also participated in the creation of a Community Land Trust focused on protecting local residents from displacement.				

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	Nashville's East Bank Plan represents a landmark urban development initiative aimed at building affordable housing through mixed-use development, building flood resilience through strategic use of natural and recreational green spaces, and connecting communities through greenways and smart transit. Resources: • "The Green Divide" documentary • CLT Case Studies • Center for Community Land Trust Innovation (cltweb.org) City/State Examples: • Atlanta, GA: Atlanta BeltLine • Houston, TX: Community Land Trust • Montgomery County, MD: Innovative affordable housing approach				
	CC7. ADDRESSING DEVELOPMENT IN FLOOD PLAINS Description: Reducing vulnerability to flooding is done most easily by avoiding or restricting development of flood-prone areas and of areas buffering waterbodies and wetlands that support flood control. One option is to develop an open space acquisition, reuse, and preservation program targeting hazard areas, and acquire properties at risk of flooding or experiencing repetitive flood damage, through a buyout program, for example. Bans on unanchored floatable materials in floodplains can also be adopted. Nashville already prohibits new development in the floodway and regulates development in the floodplain, including requiring preservation of 50% of an undeveloped floodplain, through permitting processes. In addition, new residential development is required to be four feet above the base flood elevation and commercial is required to be one foot above. Additional protections should be pursued. Nashville's Metro Water Services has a Home Buyout Program that has relocated over 400 pre-existing homes from the floodway, to date, primarily with FEMA resources that are now limited. The program should be scaled up through alternative sources of financing, and evaluated to consider including an equity component to insure relocated low-income households do not end up	X	X		Universal

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	worse off than they were before. Metro's Planning Department is in the early stages of developing an Urban Design Framework that will examine how development interacts with natural resources and policies that can enhance the city's existence with these assets.				
	Resources: • Wetlands Watch, Floodplain Management • Marsh McLennan, Staying Above Water: A Systemic Response to Rising Flood Risk				
	City/State Examples: • Fort Collins, CO (class 4 NFIP rating): Floodplain Management • Brevard, NC: No Adverse Impact Floodplain Management Certification (see Sec. 34-22 of Code) • Kansas City, MO: ASCE Library, Kansas City's Stream Setback Ordinance: A Case Study on theBenefits of Stream Buffers in Urban Areas • Washington, DC: Flood Zone Building Permits				
	CC8. EXTREME HEAT STRATEGY & ACCESSIBLE COMMUNITY EDUCATION				
	Description: Cities can establish an early warning system and preparedness plan for extreme heat events in order to coordinate emergency response and to reduce health impacts on vulnerable populations. Plans can also incorporate educational initiatives to inform residents of the dangers of extreme heat and actions to take to stay cool. Approaches can include, among others: Creating spaces to encourage air flow, street wetting, traffic reduction/car-free zones, pop-up heat relief, development of pocket parks, expanded drinking fountain networks (with water way-finding), and smart hospitals. Boston's Heat Resilience Solutions guide provides actionable strategies for many of these approaches. One key area this strategy should address is the lack of air conditioning on public school buses. Depending on the route, some school children spent over an hour		X		Targeted

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	riding the bus between home and school twice daily, and bus drivers spend multiple hours daily on buses that can exceed internal temperatures of 100 degrees. Metro Nashville departments have existing protocols that are activated during extreme heat events. There are also ongoing programs to provide relief to residents (for example, MAC's Air Conditioning program). These programs should be scaled up where possible, waiting lists cleared, and barriers removed that may prevent access. This strategy would seek to build out these protocols and programs into a comprehensive extreme heat plan.				
	Resources: • Environmental Protection Agency, Excessive Heat Events Guidebook • World Health Organization, Heat–Health Action Plans: Guidance • C2ES: Resilience Strategies for Extreme Heat • European Climate Adaptation Platform Climate-ADAPT, Using water to cope withheat waves in cities				
	City/State Examples: • New York, NY: 2023 Extreme Heat Policy Agenda (weact.org) • Boston, MA: Heat Resilience Solutions for Boston • Washington, DC: Heat Emergency Plan • Los Angeles, CA: Beat the Heat, "City Poolsand Splash Pads" & "Hydration Stations" • Washington, DC: Find a Pool • Cape Town, South Africa: Spray Parks Have Been Helping To Keep Cape Town Cool				
	CC9. COOLING CENTERS/SUMMER EMERGENCY SHELTERS				
	Description: Cities can use existing cool/cooled public facilities, such as air-conditioned libraries and recreation centers, as "cooling centers" during heat waves and develop new cooling centers for specific community members. Permitted		X		Targeted

Applicable Hazards	 Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	activities and uses should be advertised for these cooling centers as the needs of residents may be different. For example, some spaces may serve as temporary cooling spaces for pedestrians while others may permit eating and sleeping and may be prioritized for unhoused residents. Metro should consider sensitizing the public to the vulnerabilities and needs of the unhoused population as part of this strategy. Metro Nashville already activates cooling centers, but may want to consider ways these can be combined with Resilience Hub initiatives (described in CC2) or expanded to meet additional needs. Similar to Resilience Hubs, cooling centers need to be located along transit lines.				
	Resources: Centers for Disease Control and Prevention, The Use of Cooling Centers to PreventHeat-Related Illness: Summary of Evidence and Strategies for Implementation				
	City/State Examples: • Baltimore, MD: Baltimore City Health Department, Code Red Extreme Heat, "Cooling Centers" • Los Angeles, CA: Ready LA County, Extreme Heat, "Cooling Centers (Public)" • Get Cool NYC | MNN				
	CC10. EXTREME COLD STRATEGY Description: Cities at risk of extreme winter weather can establish a cold weather emergency response plan activated in the event of extreme weather, including a localized warning system and educational messaging to residents. Targeted measures should be established for people experiencing homelessness, given increased risk for cold weather injuries. Metro Nashville departments have existing protocols that are activated during extreme cold events. This strategy would seek to build out these protocols into a comprehensive extreme cold plan. Resources: • National Collaborating Centre for Environmental Health, Mobilizing extreme coldresponse plans for people experiencing homelessness		X		Targeted

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	City/State Examples: • City of Toronto, Canada: Cold Weather Response Plan				
	CC11. WARMING CENTERS/WINTER EMERGENCY SHELTERS Description: Cities can create warming centers for anyone in need of a place to warm up. Metro Nashville already activates warming centers during extreme cold events, but may want to consider ways these can be combined with Resilience Hub initiatives (described in CC2) or expanded to meet additional needs in specific local areas. Similar to Resilience Hubs, warming centers need to be located along transit lines. Resources: • National Collaborating Centre for Environmental Health, Mobilizing Extreme ColdResponse Plans for People Experiencing Homelessness City/State Examples: • Oak Park, IL: Warming Centers Offer Relief From Cold • Chicago, IL: Family & Support Services - Warming Areas • Toledo, OH: Warming Shelters		X		Targeted
	CC12. COMMUNITY STORM SHELTERS Description: Community storm shelters can provide refuge during tornados and protect residents from injury and death. Shelters should have backup power and be stocked with supplies. In locating community shelters, particular attention should be paid to highly vulnerable areas and populations, including mobile home communities. Metro activates regional Disaster Centers through its Office of Emergency Management. The focus of this strategy would be to locate community-specific shelters in areas where residents are most vulnerable or would experience difficulty accessing the larger regional Centers. Resources: • FEMA, Storm Shelters: Selecting Design Criteria		X		Targeted

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	• FEMA, Design Guidance for Shelters and Safe Room City/State Examples: • Jefferson County, Alabama: Storm Shelter Information				
	CC13. STRATEGIC TREE AND VEGETATION ENHANCEMENT FOR SHADE AND AMBIENT HEAT CONTROL Description: Trees and other vegetation help to cool the environment through producing shade and transpiration cooling. Shade can significantly reduce experiential temperatures for residents and reduce heat-related impacts on sidewalks and other critical infrastructure. Effective shade management in transportation, leisure, and consumer corridors will decrease public health impacts and make the city more livable for Nashvillians as temperatures continue to rise due to climate change. Targeted populations for shade management strategies should include the unhoused, public transportation users, and outdoor workers. Metro and property owners should consider benefits of and opportunities to plant trees in clusters to enhance cooling. Species selection should take into account nativity, heat tolerance, drought tolerance, and water usage. Metro should also work closely with utilities and providers on opportunities to better coordinate tree planting in the public right of way. Where tree planting is not possible, other shade producing structures should be employed, including fabric shades and other permanent installations like bus shelters with green or living roofs, which can also contribute to biodiversity goals. Metro Nashville has robust standards for tree planting on public properties. Root Nashville is the city's initiative to plant 500,000 trees by 2050. This strategy would seek to deploy strategic tree selection and placement approaches as part of Metro plantings, Root Nashville plantings, and with private property owners. Resources:	X	X		Targeted

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	• Environmental Protection Agency, Reducing Urban Heat Islands: Compendium of Strategies: Tree and Vegetation • California OSHA, Shade and Other Cooling Measures • USDA/USFS: Urban Forests and Climate Change City/State Examples: • Houston, TX: The Million Trees + Houston program, ACEE, Cool Policies for Cool Cities: Best Practices for Mitigating Urban Heat Islands in North American Cities (at p. 23) and Chapter 33, Houston Code of Ordinances • New York, NY: MillionTreesNYC: The Integration of Research and Practice • Charlotte, NC: TreesCharlotte/NeighborWoods Program (latter focuses on communities with little existing tree buffer • Phoenix, AZ: Cool Corridors Program • Germantown, NY: Shade Structures in Public Places Policy				
	CC14. PERVIOUS SURFACE MANAGEMENT Description: Impervious surfaces such as roads, sidewalks, and building materials absorb high heat loads, which increases ambient temperatures in built-up areas. Large expanses of impervious surface also worsen flooding by increasing runoff and overwhelming stormwater infrastructure during extreme precipitation events. By de-paving unused parking lots or other public properties, encouraging use of pervious surfaces during development, and utilizing green stormwater management strategies, the city can both decrease urban heat and improve stormwater runoff control. Toward this end, Metro Water Services (MWS) requires low-impact development (LID) on development projects; Volume 5 of' MWS' Stormwater Management Manual provides guidance on choosing, designing, and implementing green infrastructure practices to achieve LID. As a key resilience strategy, and particularly in light of its main climate threats, Metro should consider increasing green infrastructure on previously developed properties. Multiple studies are underway to assess impervious surfaces and develop strategic approaches to	X	X		Targeted

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	stormwater management. Local non-governmental organizations, for example the Cumberland River Compact, have been important partners in pursuing de-paving and green infrastructure projects. Use of cool pavements, which utilize materials that reflect more solar energy, enhance water evaporation, or have otherwise been modified to remain cooler than conventional pavements, is another management option for reducing ambient temperatures. Cool pavement reflects between 40-50% of sunlight, whereas regular pavement reflects 10%. NDOT launched a pilot in 2023 to pilot a cool seal pavement product at its headquarters. If the pilot is successful, Metro will consider using it in the hottest areas of the city.				
	Resources: • EPA, Using Cool Pavements to Reduce Heat Islands • Parking Lots to Pavement (Portland, OR), How to depave: The Guide to Freeing Your Soil • Environmental Protection Agency, Reducing Urban Heat Islands: Compendium ofStrategies, Cool Pavements • Global Cool Cities Alliance & R20 Regions of Climate Action, A Practical Guide toCool Roofs and Cool Pavements • Environmental Protection Agency, Stormwater Best Management Practice: Permeable Pavements • NRDC, The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value • NOAA: A Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction				
	City/State Examples: • Charleston, SC: Charleston Rainproof • Pacoima, CA: GAF Cool Community Project • Phoenix, AZ: Cool Pavement Program • Los Angeles, CA: Cool Streets LA				

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability **A**	Health & Wellbeing **B**	Access to Goods & **C**	Targeted (Vulnerable Population) or Universal?

	• Shoreview, Minnesota
	  ○ Concrete Construction, Designing Pervious: A Minnesota city eschews stormdrains for pervious streets
	  ○ CrossRoads, Pervious Concrete Pavement Reduces Runoff Into Shoreview Lake				

	CC15. TRAFFIC AND CORRIDOR MANAGEMENT, FLEET ELECTRIFICATION, AND COMMUNITY RECONNECTION Description: In Nashville, as in many cities, air pollution is a problem of both climate change and social justice. Low-income and historically marginalized communities tend to be located in densely urban areas near major traffic corridors and therefore higher levels of air pollution and heat-trapping emissions. Addressing these health and quality of life impacts of traffic, including public service traffic, is a key part of correcting historical environmental injustice. In addition to transitioning fleets to zero emission alternatives and promoting the use of electric vehicles (EVs), traffic management policies can contribute to these goals through the smart design of through-ways, high-traffic corridors, and signal coordination. Other "road diet" strategies, including central turn lanes, can be employed to improve road safety and traffic efficiency. Congestion charges have been used in multiple cities to incentivize public transportation and achieve cleaner air. When done properly, with the target community at the forefront, reconnecting communities bisected by highways can also right historic wrongs. Strategies such as the use of fleet telematics can help utilities and service providers track the routes and miles travelled, and the fuel consumed, of industrial combustion engine vehicles (such programs are under development for electric vehicles). This can help to identify inefficiencies and operator error, cut down on idling time, reduce maintenance requirements, and cut down on fuel consumption and exhaust fumes. Cities like Ft. Lauderdale that have used such programs have reduced idling time by 20% or more and have gained operational efficiencies by		**X**		**Universal**

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	reducing vehicle downtime by up to 30%. Nashville's Metro Water Services department is initiating a fleet telematics program in FY24. Metro set an official goal of transitioning its general government fleet to 100% zero-emission vehicles by 2050, and has begun expanding its light-duty fleet of EVs. MTA/WeGO is in the process of developing a Zero Emissions Fleet Transition Plan, and MNPS is participating in the TVA EV Fleet Advisor program to develop an approach to fleet electrification. It also participated in a grant application for electrification of 15 school buses. Metro has submitted a $5.8 million grant application to the Federal Highway Administration's Charging and Fueling Infrastructure Discretionary Grant Program in 2023, to add multiple new EV charging stations around the city. WeGo is pursuing route and service enhancements via the Better Bus Program and build out of new transit hubs. NDOT also administers the city's Transportation Demand Management program, called Nashville Connector. This strategy would seek to further coordinate and leverage each of these efforts to minimize air pollution impacts across the city. Resources: • Reconnecting Communities Pilot: RCN - Resources | US Department of Transportation • Road Diets (Roadway Reconfiguration) | FHWA (dot.gov) City/State Examples: • Philadelphia, PA: Air pollution and idling regulations				
	CC16. LOW-COST OR FREE MENTAL HEALTH SERVICES Description: Research has shown that climate change negatively impacts the mental health of people worldwide. Climate exposures including extreme heat, intense rainfall, drought, wildfires, and floods are associated with psychological distress, grief, worsened mental health, disorientation, vascular dementia, and higher mortality among people with pre-existing mental health conditions. These impacts are disproportionately high in communities that have been systematically		X		Targeted

Applicable Hazards	 Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	disadvantaged. Thoughtful programs aimed at reducing this public health threat are an important part of climate resilience. Taking stock of or expanding existing mental health resources provided by Metro entities (such as MNPS[40]) and community partners which could help address climate related mental health issues could establish a firm foundation. Building local community connections and resilience through Resiliency Hubs (see CC2) is also a key starting point of building constructive solutions. These hubs can serve as the base for specific community support groups. Preparedness plans for individuals and families should also include strategies that foster a sense of optimism and comfort. Finally, ensuring mental health services are available and used by populations most at risk—including the unhoused—could comprise publicly-financed services including free crisis hotlines, mobile crisis teams, and virtual treatment options.				
	Resources: • Climate Change and Mental Health: A Scoping Review • Mental Health and Our Changing Climate: Impacts, inequities, responses				
	City/State Examples: • ThriveNYC				
	CC17. PROACTIVE RENTAL INSPECTION PROGRAM Description: Proactive rental inspection (PRI) programs offer a standardized way to address substandard rental housing and introduce climate resilience and safety standards for frontline communities. Unlike complaint-based rental inspection programs, PRI programs perform inspections on a regular schedule, and thereby	X	X		Targeted

[40] See You Matter - Metro Nashville Public Schools (mnps.org).

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & C	Targeted (Vulnerable Population) or Universal?
	also reduce the risk that renters will be evicted or illegally punished for reporting hazards. Many cities have introduced such programs, including Boston, Seattle, Syracuse, and Tulsa. When combined with updates to building codes and other improvements to development regulation (see CC5), PRI programs offer a powerful tool to protect vulnerable communities. Metro has considered such a program in the past and should re-evaluate the costs (potential negative outcomes) and benefits associated with deployment of a PRI approach to determine whether it is feasible and beneficial at this time. Resources: • A Guide to Proactive Rental Inspections City/State Examples: • Boston, MA: Rental Inspection Requirements • Seattle, WA: Rental registration and inspection code • Grand Rapids, MI: Rental certification program				
	CC18. REDUCE TRANSIT WAIT TIMES AND IMPROVE SHELTERS Description: Time spent waiting outdoors for the bus, including transfers, in hazardous weather conditions can be reduced with greater bus frequency. This is not only achieved with more buses but also with strategies such as bus-only lanes, route planning that avoids long routes, and smartphone apps with real time bus information. Ensuring that bus shelters are adequately sized and provide shade and refuge from the rain is also critical to protect transit riders. Bus shelters also provide the opportunity for ad revenue, which can be funneled back into programs that improve transit safety and equity. The Mayor's Youth Council has developed an approach to use transit hubs as farmers' markets, which could also incorporate a climate resilience approach and create co-benefits. Finally, reducing wait times and improving transit riders' experiences at transit hubs contributes to increased use of public transportation, reduced congestion, and improved air quality.		**X**	**X**	**Targeted**

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	Nashville's East Bank Plan includes dedicated rapid bus lanes and provides a promising model of transit-oriented development. WeGo's Better Bus Program identifies opportunities to enhance the transit system through longer service hours, more frequent buses, new connections, new transit centers, upgraded bus stops, and access improvements. Funding and executing these measures are critical to achieving this strategy.				
	Resources: • NACTO Transit Street Design Guide • Perception of Waiting Time at Transit Stops and Stations • Best Practices: Enhancing Shelter and Stop Amenities for Riders | Mass Transit (masstransitmag.com)				
	City/State Examples: • New York, NY: M15 Select Bus Service				
	CC19. URBAN FARMING, COMMUNITY GARDENS AND FOOD FORESTS				
	Description: Community gardens can provide urban residents with the opportunity to grow their own fresh food, helping to improve food sovereignty and address volatile prices of goods and access constraints. They also add green space and accompanying soil and carbon benefits to areas with heat island effects. Finally, gardens provide quality of life benefits as urban sanctuaries, places for community and connection, and for teaching the younger generation. One local example is the Nashville Food Project, which benefits over 80 community gardeners. Shared gardens and food strategies can be done in many contexts, including in public housing, on rooftops, on school grounds, and in flood-prone areas not suitable for other development; and scopes, including chicken keeping. The Austin, TX example provided below takes an innovative approach at addressing the root causes of chronic homelessness and building a sustainable, cohesive community inclusive of urban food systems.	X	X	X	Targeted

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	Planting food forests (e.g. fruit and nut trees) on public land can create a free food source for humans and wildlife, and provide soil and carbon benefits. Nashville has an existing example of an 8-acre food forest in Two Rivers Park. Currently, Nashville encourages community gardens on their floodplain buyout properties, and could examine other opportunities to use Metro owned properties for community gardens and to support community gardens on non-Metro properties.				
	Resources: • Nashville Trap Garden (includes a Nashville Garden Locator) • How Urban Gardening Is Helping to Fight Poverty • Urban Gardens Can Increase Biodiversity and Help Create Sustainable Cities				
	City/State Examples: • Austin, TX: Community First Village • Atlanta, GA: Largest Food Forest in the US • New York, NY: Edible Schoolyard NYC • New Orleans, LA: Edible Schoolyard				
	CC20. COMPREHENSIVE DISASTER EVACUATION PLANNING Description: All cities, including Nashville, have established emergency evacuation and sheltering plans as part of their Emergency Management Plans. However, most cities are dependent upon private vehicles and public transportation to move people during disaster events. Due to the potential scale of climate-driven natural disasters, it is imperative to have comprehensive evacuation plans in place that both account for the potential impact of future disasters and recognize the needs of the carless and special needs populations. The tragedies that can occur when special evacuation needs are not adequately anticipated was made clear during Hurricane Katrina in 2005. One of the strategies that can be considered to improve evacuation capabilities is the creation of bus-only lanes on major routes. These bus-only lanes are also				

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability A	Health & Wellbeing B	Access to Goods & Services C	Targeted (Vulnerable Population) or Universal?
	used by emergency responders and such lanes can significantly improve response times during both blue and grey skies.				
	Resources: • Best-Practices-Emergency-Access-in-Healthy-Streets.pdf (nacto.org) • evacuatingspecialneedspopulation.pdf (fema.gov) • Most Major U.S. Cities Lack Plans for Evacuating Carless Residents, Study Finds - Stormwater Report (wef.org)				
	City/State Examples: • New Orleans, LA				
	CC21. DELIVERING ENVIRONMENTAL AND CLIMATE JUSTICE				
	Description: Much of the country's historical urban development pattern can be traced to the 1949 Housing Act and the Urban Renewal Program, which prescribed the demolition of communities deemed "blighted" for the construction of public housing and other public amenities. However, these same programs also saw massive displacement of black and other minority communities in favor of commercial and private sector initiatives, and resulted in the intentional or neglectful placement of roads and undesirable (NIMBY) projects (particularly waste facilities) in these same marginalized communities. Nashville has its own history of environmental injustice, including the North Nashville community and the construction of I-40 right through its epicenter; the Bordeaux community and the siting of the Bordeaux Landfill; and the Cayce Homes public housing community's health impacts from I-24 and other factors, that have resulted in the highest rates of asthma in Davidson County. It is critical that environmental justice (EJ) programs be targeted for these and other communities that have and may continue to experience negative outcomes as a result of public development. Nashville's Environmental Justice Initiative (NEJI), through a partnership with Tennessee State University (TSU) and Urban Green Lab (UGL), has worked to identify specific needs for EJ learning, develop targeted education and training solutions, and educate community stakeholders as a first step toward addressing				

Applicable Hazards	Adaptation Strategies: Community and Culture	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	Nashville's environmental injustice. Going forward, Metro's departments should identify specific strategies and projects that deliver concrete EJ returns relevant to their facilities and services, and prioritize those climate-resilience initiatives that include EJ co-benefits. One example is identifying how zero waste initiatives can be designed to provide direct benefits to communities living adjacent to landfills. Including EJ communities in the design of such projects is critical and will ensure their acceptance and long-term viability. Another way Nashville could prioritize EJ is to incorporate a systematic screening mechanism for program and project planning. Currently, Metro departments choose when to use tools such as the CDC's Social Vulnerability Index (SVI), EPA's EJ Screen, and various other resources to identify locations or populations which may display characteristics of a disadvantaged community. However, there currently is no consistent process used across departments to identify or prioritize when EJ issues should be considered.				
	Resources: • EPA: Environmental Justice • The Justice40 Initiative • Nashville Environmental Justice Initiative (NEJI)				
	City/State Examples: • National City, CA and Senate Bill No. 1000**, now mandated for all CA cities through** CEJA • MA: The link between environmental justice and landfills • Framingham, MA: An Environmental Justice initiative in South Framingham				
	CC22. FOOD SAFETY PUBLIC SERVICE ANNOUNCEMENTS				
	Description: Cities can issue public service announcements detailing which foods are safe for consumption after power blackouts to reduce food safety risks and intentionally incorporate this information into a variety of education and outreach materials. Such outreach should also be geared toward reducing food spoilage from a waste reduction perspective.	X	X		Universal

Applicable Hazards	 **Adaptation Strategies: Community and Culture**	Livelihood & Affordability	Health & Wellbeing	Access to Goods &	Targeted (Vulnerable Population) or Universal?
		A	B	C	
	Resources: • CDC, Food Safety for Power Outages • Foodsafety.gov, Food Safety During Power Outage • USDA, Keep Your Food Safe During Emergencies: Power Outages, Floods & Fires				
	City/State Examples: • Chicago, IL: Recommendations to the City of Chicago For Winter Adaptation Measures andan Indicator Suite For Climate Change Metrics				

NATURAL ENVIRONMENT

Figure 33. Potential Adaptation Strategies for the Natural Environment.

Applicable Hazards	Adaptation Strategies: Natural Environment	Ecosystem Services	Flora/ Forests/ Trees	Watersheds/ Hydrology	Fauna/ Native Species	Targeted (Vulnerable Population) or Universal?
		D	E	F	G	
	NE1. INCREASE GREEN SPACES, TREE CANOPY, AND CONSERVATION Description: As also considered in strategy CC13, increasing green spaces as recreational areas and conservation land, reforestation efforts, and urban tree planting will all contribute to Nashville's climate resilience by reducing urban heat island effects, preserving biodiversity, protecting watersheds and better managing floodplains, stabilizing steep slopes and river banks, and increasing stormwater infiltration. It also improves quality of life and health outcomes for Nashville's residents, as described in strategy CC19. It is important to ensure that there are both "activated" areas (those targeted for recreational opportunities) and undeveloped areas that can serve as wildlife habitat and contain tree cover. Planting native species and pollinators (grasses, wildflowers, shrubs and trees) in strategic areas has multiple benefits for wildfire resilience as well as for native and endangered species, ecosystem services, and achieving low-maintenance carbon. In Metro's NashvilleNext Plan, one of the actions prioritized under the Natural Resources & Hazard Adaptation element is *NR 1.4, Preserve and expand upon Nashville's existing tree canopy including urban trees, street trees, and larger tracts of forested lands*. This comprises implementation of tree planting programs and enacting ordinances to increase open spaces and preservation land. The city could also consider developing a median planting policy that increases carbon capture and reduces or eliminates maintenance requirements. Tree plantings along busy corridors should be done in a way to minimize the risk of storm-related damage and injury from fallen limbs.	X	X	X	X	Targeted

	Metro departments and several external NGO partners, such as The Nashville Parks Foundation, Friends Groups, Greenways for Nashville, Cumberland River Compact, Trust for Public Land, The Nature Conservancy, Tennessee Environmental Council, Nashville Tree Conservation Corps, and Nashville Tree Foundation have a variety of existing programs and initiatives that seek to increase and enhance green space, tree canopy, and natural resource habitat. This strategy would seek to further support and coordinate these efforts. Resources: • Climate Adaptation Conservation Planning Database • Climate Change and Potential Impacts to Wildlife in Tennessee • USDA/USFS: Urban Forests and Climate Change • Eastern Forest Environmental Threat Assessment Center City/State Examples: • See CC13. • Root Nashville					
	NE2. CONDUCT EDUCATIONAL CAMPAIGNS ON PROTECTING THE NATURAL ENVIRONMENT Description: Education is key to conservation. As famously said by Senegalese forestry engineer Baba Dioum, "In the end we will conserve only what we love, we will love only what we understand, and we will understand only what we are taught." As part of Metro externally facing programs and services, Metro organizations should conduct educational campaigns as part of community events, newsletters, social media, etc., that provide information to communities on how they can better protect the natural resources upon which all Nashvillians depend, particularly in light of anticipated climate changes. Many Metro departments and offices already engage in such educational campaigns. Examples include General Services' Socket program, the Zero Waste Program and Urban Green Lab's Sustainability in the City monthly event, the Tennessee Smart Yards program, and the Sustainability Advisory Committee's family sustainability plan. This effort would seek to support and expand climate focused educational offerings (see CC1, CC19, and NE1) across multiple departments. The NashvilleNext Plan also identifies this strategy as a priority under *NR 3.2, Establish a wide-ranging green education campaign that focuses on the "why" and "how" for water*	**X**	**X**	**X**	**X**	**Universal**

	conservation, energy efficiency and reductions, recycling and waste reduction, natural resources preservation, and outdoor activity. Resources: • EPA: Getting in Step: A Guide for Conducting Watershed Outreach Campaigns City/State Examples: • Ohio Watershed Network					
	NE3. FINANCIAL INCENTIVES FOR CONSERVATION AND ECOSYSTEM SERVICE PRESERVATION Description: Nashville should explore financial incentives that could be used by landowners who agree to leave undeveloped natural land resources as is or to restore, enhance, or create them. This is particularly valuable where wetlands and floodplains can protect surrounding lands and communities if they are left in their natural state. Various financial incentives can be utilized to encourage values other than development of every parcel as the highest and best use. Nashville's existing Conservation Assistance Fund is one example. Another is tax credits and incentives, as in the examples provided below. Resources: • USFS Conservation Finance Toolkit City/State Examples: • Arkansas: Tax Credits for Wetlands • Oregon: Riparian Lands Tax Incentive	**X**	**X**	**X**	**X**	**Universal**
	NE4. NATURAL FLOOD MITIGATION AND STRATEGIC EXPANSION OF FLOODPLAINS Description: Cities can reduce the risk of flooding and erosion through nature-based approaches, such as stream and wetland restoration and extended detention wetlands, and incorporate nature-based solutions in local planning, zoning, regulations, and built projects. Through use of green infrastructure and mass grading strategies that extend the flood plain in areas adjacent to the river—a design strategy that is being employed in the Imagine East Bank Project in Nashville, the ability of flood-prone areas to absorb flood waters is increased and the safety of nearby neighborhoods is improved. Hydraulic modeling and engineering analyses are required to identify areas where the strategy is feasible and most urgently needed based both of historical floods and climate projections. Nashville should consider opportunities to deploy or incentivize nature-based solutions. Resources:	**X**		**X**		**Targeted**

	• Naturally Resilient Communities, Using Nature to Address Flooding • Environmental Protection Agency, Incorporating Wetland Restoration and Protection in Planning Documents • American Rivers, Daylighting Streams: Breathing Life into Urban Streams and Communities City/State Examples: • Washington State: Floodplains by Design • Rehabilitation of the South Platte River in urban Denver, Colorado ("The River Mile"). • Lake County, Illinois: Lake County, IllinoisStormwater Commission Develops a Tool to Support Wetland Restoration Planning					
	NE5. FLOODPROOFING INCENTIVE PROGRAMS AND POLLUTANT CONTROLS Description: Pollution of neighborhoods and water bodies with litter and debris following flood events reduces human quality of life (neighborhood aesthetics) and contributes to negative health outcomes for fauna. One frequent culprit that pollutes streets and ends up in waterways is single use plastic, which Americans consume at greater rates than all other countries other than Australia.[41] There are multiple strategies for reducing or eliminating the use of single-use containers that could and should be considered in Nashville. Other frequent pollutant sources are pesticides, fertilizers, and other chemicals that are used on residential and commercial lawns, and can degrade biodiversity and contaminate water bodies in addition to causing human health issues. Cities can consider banning their use or conducting educational campaigns to encourage smart alternatives. Provision of technical and financial assistance for floodplain management can promote awareness of homeowners in floodplains and facilitate adaptive measures that protect neighbors and resources downstream. Strictly regulating and monitoring land use within floodways can also reduce the types and amount	**X**	**X**	**X**	**X**	**Universal**

[41] Here Is Who's Behind the Global Surge in Single-Use Plastic - The New York Times (nytimes.com)

	of waste that end up in waterways following extreme rain and flooding events. Though Nashville currently monitors flood zone use through its Metro Water Services department, both outreach to new property owners and enforcement of penalties for violators could be improved. Rainwater harvesting also reduces pollutants and run-off in urban areas and permits water storage for later use. Metro Nashville has undertaken efforts to encourage rainwater harvesting, but may benefit from a review of scale-up opportunities and related efforts. Metro Water Services and multiple NGOs take an active role in this space. This strategy seeks to amplify existing efforts.					
	Resources: • NRDC, Capturing Rainwater from Rooftops: An Efficient Water Resource Management Strategy that Increases Supply and Reduces Pollution					
	City/State Examples: • South Holland, IL: Flood Assistance Rebate Program • Vermont: Emergency Relief Assistance Fund • Wisconsin: Municipal Flood Control Grant Program • City of Tucson, AZ: Rainwater Harvesting Ordinance and Rainwater Harvesting Rebate • Hamilton, Canada: Strategy to Reduce Single-Use Plastics • Asheville, NC: Single-Use Plastic Reduction					
	NE6. INCREASE LOW-IMPACT DEVELOPMENT Description: Nashville can improve its heat and flood resilience through permitting, zoning, or other policy and/or incentives, as considered in multiple strategies in this Plan. Currently, Nashville requires low-impact development as part of the new MS4 permitting process. The City could consider other ways to increase low-impact development practices on existing properties with stormwater risks or in areas with a high percentage of permeable surfaces in the form of green stormwater infrastructure, permeable surfaces, green spaces, or conversion of a percentage of existing impermeable surfaces. Metro Water Services has initiated a stormwater master planning process to study existing stormwater infrastructure and develop alternatives to reduce or abate flooding throughout the Metro service area. This plan will focus at a basin level and create capital improvement plans to inform stormwater priorities where	**X**		**X**		**Universal**

	they are most needed based on a variety of considerations, including flood reduction and environmental, economic, and social factors. This master plan should consider recommendations for zoning and/or permitting requirements. Resources: • Banking on Green: A look at how green infrastructure can save municipalities money and provide economic benefits community-wide • Environmental Protection Agency, Green Infrastructure for Climate Resiliency • Environmental Protection Agency, Stormwater Best Management Practice Bioretention (Rain Gardens) City/State Examples: • Washington, DC: Environmental Impact Bond • Philadelphia, PA: Rain Gardens • King County, WA: Be RainWise: Rebates for rain gardens & cisterns					
	NE7. PROHIBIT OR REMOVE INVASIVE SPECIES Description: Efforts to responsibly manage invasive wildlife and plants in protected and other areas, including through volunteer initiatives, can help to preserve the health of ecosystems and native species, and prevent biodiversity loss. On both public and private properties, efforts could include programs incentivizing cultivation of functional landscaping and use of natives, both approaches that can prevent erosion, improve stormwater management, and potentially improve wildfire resilience. Educating the public on this topic could be combined with Strategy NE2. Metro departments and NGO partners are already active in this space, including through the Urban Bird Treaty and the Weed Wrangle. DGS maintains an approved list of vegetation for the Metro facilities it manages and prioritizes planting native and drought-tolerant species. This strategy would seek to support and further these efforts. Resources: • USDA: National Invasive Species Information Center: Tennessee • NWF: Combatting Invasive Species City/State Examples: • Cape Town, South Africa: Framework for managing invasive species	**X**	**X**	**X**		**Universal**

INFRASTRUCTURE

Figure 34. Potential Adaptation Strategies for Infrastructure.

Applicable Hazards	Adaptation Strategies: Infrastructure	Energy Generation	Energy Transmission	Water Supply	Storm/ Wastewater & Waste Mgmt	Communications	Transportation	Targeted (Vulnerable Population) or Universal?
		H	I	J	K	L	M	
	IN1. IMPROVE ROBUSTNESS AND REDUNDANCY OF THE ENERGY GRID Description: Nashville Electric Service is the city's local power company with responsibility for transmission and distribution of electricity. NES should collaborate with partners, including TVA and Metro to pursue multiple grid modernization approaches and technologies—from grid hardening and smart grid technologies to distributed energy resources, virtual power plants, redundant storage capacity, and system segmentation—all of which can increase the resilience of electricity infrastructure to extreme weather, making power more reliable and decreasing the costs. Segmenting the energy grid to allow for isolating sections that become damaged can reduce outages and cascading impacts. Though costly, moving electric lines underground in areas with specific vulnerabilities can save money on repairs and outages over the long run. Demand response programs relieve pressure on generation and transmission systems by reducing or time-shifting energy usage, particularly during peak periods. It can also reduce price volatility and financial burdens on customers. NES has instituted a voltage reduction program to address limited generating capacity and rising costs, and has initiated other renewable and efficiency gains—most recently, by legislating the overhaul of streetlights with smart LED bulbs—but should review other opportunities to improve the robustness of Nashville's energy services. Incentivizing residents to participate in demand response programs (for example, by pre-	X	X					Universal

	warming homes ahead of severe winter weather) would be one low-cost opportunity that begins with outreach and education. Where Nashville can contribute to sustainability and climate resilience goals related to energy generation is installation of solar power on Metro facilities, and sourcing its generation from non-carbon sources. Metro is currently performing a solar cost benefit analysis that has identified around 110 MW of potential solar installations on Metro properties. Resources: • NREL: Grid Modernization • Summer energy surge: The importance of demand response programs in grid resilience • Discovering Unexpected Synergies Between Energy Efficiency and Demand Response • C2ES, Resilience Strategies for Power Outages City/State Examples: • New York, NY: Smart Distributed Generation (DG) Hub-Resilient Solar Project • Anaheim, CA: Underground Conversion • Chicago, IL: Recommendations to the City of Chicago for Winter Adaptation Measures andan Indicator Suite for Climate Change Metrics							
	IN2. ON-SITE OR DISTRIBUTED ENERGY GENERATION FOR CRITICAL FACILITIES Description: This strategy entails the installation of on-site or distributed energy generation and/or back-up emergency generation at critical locations and facilities such as emergency management and utility command centers, treatment plants, police and fire stations, community shelters/resource centers, and cell towers. While Metro incorporates energy resiliency planning in new construction through its General Services Department and has already ensured this redundancy at many of its critical facilities (and some departments like MWS have achieved this with clean, renewable energy), NES and the city (DGS, OEM, and Planning) should conduct a gap analysis to identify where back-up capabilities are lacking and devise a strategy on this basis that addresses weak points and ensures an integrated system including for integrated communications. The DOE-funded ARCHER project that NES, Metro, and other partners are engaging in may develop relationships and frameworks that could further these resiliency strategies.	**X**	**X**	**X**	**X**	**X**	**X**	**Universal**

	In addition to ensuring physical system redundancy, Metro should consider supply chain constraints and volatility, and seek to diversify its Metro facility energy portfolio, including through the installation of onsite rooftop or ground-mount solar where feasible and economically sound. Metro embarked on a solar cost benefit analysis that identified potential of 110 MW of solar installed across Metro properties. Utilizing renewable energy and battery storage to meet this objective will further Metro's sustainability goals. Incentivizing distributed generation for households and businesses can help keep the public safe and the economy functioning when grid outages and damage do occur. Metro should work with NES and TVA to evaluate opportunities with an aim to increasing resilience. Resources: • Renewable Energy: Distributed Generation Policies and Programs | Department of Energy • Unlocking the Potential of DERs_Power system opportunities and best practices (windows.net) City/State Examples: • NY State: Dashboards and Incentives - NYSERDA							
	IN3. REVIEW AND UPDATE BUILDING CODES, ZONING CRITERIA, AND DESIGN STANDARDS (SEE ALSO CC5) Description: Across the board, Metro must prioritize the adoption of building codes and design standards that build climate resilience and adaptive capacity to current and projected future risks. While Metro Nashville is considered a "resistant jurisdiction" by FEMA based on its NFIP standing and Metro Council's adoption, in November 2020, of the 2018 International Building Codes, both building codes and flood models are based on historical data. Adopting specific codes and requiring adherence to design criteria that reduce heat island effects and account for more recent pluvial modeling would increase Nashville's resilience. Current codes should also be subjected to expert review as concerns seismic risk. Metro Code 16.60 requires government facilities to pursue LEED certification (gold for buildings in the USD and silver outside of the USD), which incorporate sustainable and resilient design standards. DGS is also actively working on developing internal standards on a number of specific measures	**X**		**X**	**X**	**X**	**X**	**Universal**

	(e.g,, landscaping, solar PV, lighting, etc.) that will be applied to projects as they are initiated. In addition to these efforts, Metro should consider incorporating sustainable and resilient design standards for existing Metro buildings. Another recommended strategy would be to build a triple-bottom-line or cost-benefit-analysis tool that would help departments evaluate up-front and lifecycle costs against environmental, social, and resilience indicators to make the most informed investments from a resilience, equity, and community safety perspective. While requiring sustainable and resilient building practices of the private sector is likely to be met with resistance in the near term, Nashville could consider tax breaks or other incentives for development that incorporates renewable energy and energy efficiency, low-impact development, climate resilient design, and other features.							
	Resources: • HUD, Resilient Building Codes • FEMA, Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards, • Buildings and Structures | U.S. Climate Resilience Toolkit • Pathways to climate resilience: the central role of building codes in climate adaptation and mitigation | PreventionWeb • A Practical Guide to Updating Local Regulations for Climate Resilience (planning.org) • The_Precipitation_Problem_Presentation_Slides.pdf (mcusercontent.com)							
	City/State Examples: • New York, NY: Climate Resiliency Design Guidelines • City of Marlborough, MA, Updating City Ordinances for Climate Resiliency • Infrastructure Canada - Climate-Resilient Buildings and Core Public Infrastructure Initiative • City of Houston, Cool Roof Code • Boston, MA: Article 37 Green building and climate resiliency guidelines and Climate Resiliency Guidance • New Orleans, LA: ○ Hazards Mitigation Plan, Severe Thunderstorms-High Winds (“Create insurance credit for fortified roofs to incentivize builders to useresilient materials and methods.”)							

	○ Tornadoes - NOLA Ready, "Relevant Actions"							
	IN4. REVIEW AND OPTIMIZE ASSET MANAGEMENT PROGRAMS Description: Efficient and consistent asset management is fundamental to achieving readiness, redundancy, and recoverability. Readiness planning will help to identify areas where readiness criteria or redundancy are lacking so that procurement of missing equipment can be prioritized. Reviewing historical facility and maintenance data can help to identify assets with previous climate or weather-related impacts/repeat failures that need addressing or a change in procurement strategy. Finally, disinvesting in assets that face too great a risk should be pursued where appropriate. Currently each department maintains its own systems for asset management with some centralized through DGS (e.g., fleet). Metro Nashville is in the process of implementing a department-wide, digital and GIS-based asset management system that will streamline and improve efficiencies of current asset management practices. Incorporating a climate resilience lens into the roll-out of this program and the data it tracks should be implemented at the outset. This could be piloted by NDOT and DGS, based on the timeframe for roll-out of the program. Increasing the robustness of asset management programs could also include introducing rapid detection and recovery programs, supply chain resilience planning (cross-Metro or regionally), and aerial inspections (e.g. use of drones to monitor transmission lines). Developing a comprehensive, location-based inventory of department-managed disaster preparation and response assets is recommended to enhance cooperation and efficiency of deployment.	**X**	**X**	**X**	**X**	**X**	**X**	**Universal**
	Resources: • Infrastructure Pathways: Guidance on climate-resilient infrastructure (includes guidance on multiple phases including policy and planning, prioritization, design, procurement, construction, etc.) • Managed Retreat Toolkit » Design Modifications and Asset Protection - Georgetown Climate Center • Addressing Resilience to Climate Change and Extreme Weather in Transportation Asset Management (dot.gov) • UNDRR: Disaster Resilience Scorecard for Cities							
	City/State Examples:							

	• Federation of Canadian Municipalities: Guide for integrating climate change considerations into municipal asset management							
	IN5. DEVELOP ADAPTATION PLAN FOR CRITICAL INFRASTRUCTURE AND SERVICES Description: In line with and as an outcome of Strategy IN4 above, Metro departments responsible for provision and maintenance of utility and public services should work together to develop actionable strategies and plans to harden energy, water, wastewater, and transportation infrastructure and services, and to create climate risk-specific plans focusing on building resilience to extreme temperatures and flood waters, and improving readiness. Resources: • NREL Energy Resilience Assessment Methodology • USDOT/FHWA: Adaptation Decision-Making Assessment Process City/State Examples: • Colorado Department of Transportation Risk and Resilience Analysis Procedure • North New Jersey: Sustainability and Resilience Planning	**X**	**X**	**X**	**X**	**X**	**X**	**Universal**
	IN6. SCALE UP COMPLETE STREETS AND MULTIMODAL TRANSPORTATION INITIATIVES INCLUDING GREENWAY INTERCONNECTIONS Description: Nashville's Department of Transportation and Multimodal Infrastructure (NDOT), in its 2020 Transportation Plan, and 2022 Vision Zero Action Plan and Walknbike Plan, identified the "complete streets" approach—one that considers safe movement and streetscapes for all uses, not just cars—as a key priority for the city. Currently NDOT is working on a Complete Streets Implementation Guide and Pedestrian Crossing Policy to guide NDOT and Metro's Transit Authority (WeGo), Planning, Water Services, Development and Housing Authority, and other departments. In parallel, following Metro Parks' 2017 Plan to Play Parks and Greenways Master Plan, Metro invested a record $85 million to expand access to green space, greenways, and parks in 2021 to further enhance connectivity and provide safe biking and walking options in Nashville's urban core. These complete and green streets and greenway initiatives represent relatively low-cost but high-impact ways to improve the health and wellbeing, and quality of life of Nashville's residents including through the indirect benefits of carbon capture and reduction in heat island effects. They should continue to be						**X**	**Universal**

	prioritized in Metro budgeting and to the extent feasible, scaled up, including through modifications in zoning. Resources: • Designing for Green and Complete Streets in Nashville | Nashville.gov • Green Streets Handbook (epa.gov) City/State Examples: • Buffalo, NY: Green Code Unified Development Ordinance • Phoenix, AZ: Complete Streets Design Guidelines							
	IN7. REQUIRE LOW-IMPACT DEVELOPMENT (SEE NE6) Description: Where feasible, Metro requires that all new development include low-impact development in the form of green stormwater infrastructure, permeable surfaces, green spaces, and other strategies to better manage stormwater and heat. Such requirements could be expanded to include existing properties or to apply to additional categories of projects. Metro Water Services has initiated a stormwater master planning process to study existing stormwater infrastructure and develop alternatives to reduce or abate flooding throughout the Metro service area. This plan will focus at a basin level and create capital improvement plans to inform stormwater priorities where they are most needed based on a variety of considerations, including flood reduction and environmental, economic, and social factors. This master plan should consider recommendations for zoning and/or permitting requirements. Resources: • Banking on Green: A look at how green infrastructure can save municipalities money and provide economic benefits community-wide • Environmental Protection Agency, Green Infrastructure for Climate Resiliency • Environmental Protection Agency, Stormwater Best Management Practice Bioretention (Rain Gardens) City/State Examples: • Washington, DC: Environmental Impact Bond • Philadelphia, PA: Rain Gardens • King County, WA: Be RainWise: Rebates for rain gardens & cisterns	X	X	X	X	X	X	Universal
	IN8. FACILITY ENERGY MANAGEMENT PLANS Description: To complement the above-described efforts to improve energy system redundancy and generation source diversification, Metro should continue			X	X	X	X	Universal

	to target improved efficiency and to set updated standards and requirements for the equipment and supplies it purchases (see XC6). Currently, Metro's Department of General Services (DGS) monitors energy consumption in all 85+ of its facilities and manages energy use through building automation systems (BAS) in about 60 thereof. The Department aims to reduce energy use to comply with BL2019-1599 and RS2022-1358 in its existing facilities through optimizing occupied/ unoccupied scheduling, LED lighting and HVAC upgrades, and envelope improvements, all while optimizing indoor environmental quality (IEQ) for occupants' health and comfort. Energy conservation measures are identified, quantified, prioritized, and implemented with guidance from ASHRAE Level 2 or 3 audits for each facility and assistance from third party vendors as needed. DGS has some tools and materials it could roll out now to assist other departments to improve their facility energy management and should evaluate what a wider cooperation program might also include. Resources: • Comprehensive Energy Management | ENERGY STAR City/State Examples: • Toronto, Canada: Energy Management • Bend, OR Strategic Energy Management							
	IN9. REVIEW AND IMPROVE DEPARTMENT FIELD STAFF SAFETY STANDARDS Description: Outdoor workers across the public and private sectors bear the brunt of increasing heat and are put on the frontline of other climate risks as a result of their job duties. They are often the least paid and protected. This strategy comprises a review of existing standards, equipment, personal protective equipment (PPE), and practices for outdoor public service and utility workers to ensure they are adequate to protect worker health and safety during extreme weather events, and in light of projected changes. While OSHA was directed in 2021 to set new federal heat protection standards in light of the changing climate, Metro should review its policies and protections for Metro staff in parallel and set expectations for the private sector as well. Resources: • California OSHA, Shade and Other Cooling Measures City/State Examples: • DOSH - Heat related illness prevention and information (ca.gov)	**X**	**X**	**X**	**X**	**X**	**X**	**Universal**

	• Oregon Occupational Safety and Health : Oregon OSHA adopts rules protecting workers against high heat, wildfire smoke : 2022 News : State of Oregon • Washington State: Ambient Heat Exposure Protections							
	IN10. STORMWATER BASINS AND WATER PLAZAS/CIRCLES/SQUARES Description: Cities can employ stormwater basins to store runoff and release it at a controlled rate while maintaining a level of ponded water. Pollutants and sediment loads are reduced as the runoff is retained in the basin. Cities can also construct water plazas—recreational areas that store rain, in order to reduce neighborhood flooding. In the near term, Nashville could consider such an approach where retrofitting existing properties for better and greener stormwater management is being pursued or is deemed feasible. Resources: • Environmental Protection Agency, Stormwater Best Management Practice WetPonds City/State Examples: • Normal, IL: Normal's uptown water circle				X			Targeted
	IN11. INTEGRATED HAZARD MONITORING AND COMMUNICATION Description: Nashville has made solid strides in adaptation and preparation for extreme rain events since the May 2010 flood. Recognizing the need for better data, improved coordination, and trained personnel, MWS collaborated with OEM, the Planning Department, the U.S. Geological Survey (USGS), National Weather Service (NWS), and U.S. Army Corps of Engineers to develop the Situational Awareness for Flooding Events (SAFE) system. This GIS-based mapping tool relies on near real-time data from over 20 USGS river and stream gauges that sound an alarm when levels reach NWS flood thresholds. The tool included county-wide updates to stream models and inundation mapping for a range of potential flood events, allowing for the creation of new Flood Insurance Rate Maps. More than 300 miles of streams were modeled that had never been mapped, which will enable emergency responders to proactively identify critical areas of the county during future rain events.					X		Universal

	In August 2022, Metro also embarked on a heat mapping campaign, which revealed the hottest parts of the city and county. This tool could and should also be used to proactively identify critical areas of the city for proactive response planning during extreme heat events. There is a need to tie together the knowledge of and response plans for Nashville's specific climate hazards into a comprehensive climate monitoring and communication plan, to ensure that all vulnerabilities and risks have been considered and contingency plans put in place and communicated to the public. For example, the Christmas Day bombing in 2020 revealed the vulnerability Metro and many other municipalities face as a result of reliance on cellular communications. The AT&T switch facility that was damaged caused communication outages as far away as Alabama, and was revealed to be a single point of failure. Creating a robust communication and coordination plan oriented at specific climate-driven scenarios will form the key link tying hazard mitigation planning and climate adaptation together to make Metro a resilient city. This Plan sets forth the initial steps that Metro should take to improve its planning and preparation for severe weather events. In order to track the city's progress implementing these steps, it will be critical to consistently document the dollars invested in resiliency as well as the costs incurred following climate-related disasters.							
	Resources: • NAI How-to Guide for Flood Warning & Response Case Study: Nashville's SAFE & NERVE Flood Forecasting & Response Tools • Nashville Heat Impacts Storymap							
	City/State Examples: • San Francisco, CA: Integrate Hazard Mitigation and Climate Adaptation							

ECONOMY

Figure 35. Potential Adaptation Strategies for the Economy.

Applicable Hazards	Adaptation Strategies: Economy	Agriculture	Supply Chain	Business Continuity	Targeted (Vulnerable Population) or Universal?
		N	O	P	
	EC1. PRIVATE SECTOR OUTREACH AND INCENTIVES TO BUILD RESILIENCE (SEE ALSO CC1) Description: Considering that buildings and construction contribute roughly 40% of global GHG emissions, Nashville's private, for-profit sector has a large role to play in advancing the city's sustainability and resilience goals, as the Mayor's Office has recognized in its current sustainability initiatives. Nashville should continue to work with its business community, boards and commissions (such as the Industrial Development Board) and identify ways to incentivize greater energy efficiency and low- or zero-carbon practices. These could include incentivizing minimum LEED standards, participating in the Nashville Carbon Challenge (Nashville has a hub in the Carbon Leadership Forum), and use of embodied carbon building materials, as well as establishing minimum thresholds for pervious surfaces, and other code and permitting improvements (see NE6). While the larger businesses stand to most improve their triple bottom line and Nashville's environmental outlook by adopting greener principles, the small businesses are at greater risk of financial insecurity if they overlook vulnerabilities due to climate hazards. Metro should also consider supporting small and minority-owned businesses to conduct climate vulnerability assessments including supply chain risks, and provide financial assistance to invest in physical hardening of assets, weather proofing, and contingency planning to prevent costly damage and further business continuity aims. Metro could consider partnering in this work with Urban Land Institute and other organizations with a Nashville presence that leverage business networks and include outreach in their climate resilience work. Resources:		X	X	Targeted

	• U.S. Climate Resilience Toolkit • NOAA: Implementing the Steps to Resilience: a Practitioner's Guide • FEMA: Local Mitigation Planning Handbook City/State Examples: • St. Louis, MO: Building Energy Performance Standard Targets • New York, NY: NYC Carbon Challenge				
	EC2. AGRICULTURAL OUTREACH AND INNOVATION Description: Educating farmers and urban gardeners on the risks presented by climate change and the potential resilience benefits of adaptation strategies such as choosing new types of seeds, diversification of crops, and soil sequestration, could help reduce crop losses and preserve livelihoods. Development of a regional network to build capacity and share resilient practices, through cooperation with university agriculture extension services and local agricultural experts, may be one strategy for Metro to pursue. Another could be working through the Nashville Food Project, which would achieve multiple co-benefits. Resources: • Adaptation Workbook | A Climate Change Tool for Land Management and Conservation City/State Examples: • USDA: Third Sector New England	**X**	**X**		**Targeted**
	EC3. BUILD REDUNDANCY THROUGH ALTERNATIVE SUPPLY AND TRANSPORTATION OPTIONS Description: Supply chains are increasingly being disrupted by unforeseen circumstances, and the CoVID-19 pandemic was the most extreme recent example, but supplier and macro issues—severe weather, extreme temperatures and global market disruptions from regional conflict and/or trade barriers—also factor among leading causes. Localized disruptions in transportation due to severe weather can cause food and medicine shortages that are felt just as acutely. Currently, Metro, through its General Services Department, maintains a strategic inventory of fuel and other critical supplies but continued supply chain issues stymie operational and resiliency goals particularly in terms of fleet electrification. Adding flexibility and redundancy can reduce these strains. Such a strategy can be as simple as having back-up suppliers for key necessities, proactively assessing the capacity of suppliers particularly for items and		**X**	**X**	**Targeted**

	services that are in high demand, and increasing the number of potential suppliers Metro has access to (contracting relationships with) for goods and services. Breaking down silos and fostering collaboration between Metro departments, to ensure transparency of supplies and to ensure resources are put to the highest and best use (see XC3 and IN4), and building similar transparency and agreements with regional partners provides a further layer of redundancy. Finally, identifying local sources for key supplies, which have less transportation and value chain vulnerabilities, should be considered as part of triple bottom line analyses, assigning value on the basis of greater resilience in the face of the changing climate. Resources: • How Exposed Is Your Supply Chain to Climate Risks? (hbr.org) • Supply Chain Security | U.S. Climate Resilience Toolkit City/State Examples: • Agriculture, transportation and climate change: Considering the future of agricultural freight transport in the Upper Mississippi River Valley				
	EC4. CREATIVE FINANCING, STRATEGIC RESERVES, RESOURCE HEDGING, AND CONTINGENCY PLANNING Description: A number of strategies could be employed to create the necessary funding to build up Metro's climate resilience as a city and to bolster the preparedness, safety, and adaptive capacity of its most vulnerable communities as well as address historical environment injustice (see CC21). Such strategies include establishing dedicated climate funds through ballot-dependent business or sales tax increases (see first two City/State Examples, below), the use of property assessed clean energy (PACE) programs to incentivize building efficiency upgrades (which Nashville launched in 2023, to unlock low-interest and long-term financing for sustainable and resilient commercial development), trusts that provide funding based on future revenue or savings, and strategic public-private partnerships. Multiple departments have and continue to utilize resources both from federal grant programs and Metro's capital improvement budget to implement resiliency-focused initiatives, for example the Energy Savings Revolving Fund managed by DGS. In addition to creative and forward-thinking financing, partnerships could be leveraged to increase redundancy and strengthen regional resilience. Supply chain disruptions can be minimized by building regional collaboration, which could take a variety of forms including regional purchasing agreements for critical supplies.	**X**	**X**	**X**	**Universal**

	Resources: • How US cities are finding creative ways to fund climate progress | Brookings				
	City/State Examples: • Portland, OR: Portland Clean Energy Community Benefits Fund • Denver, CO: Climate Protection Fund • Washington, DC: The Green Bank • Los Angeles, CA: Green New Deal				
	EC5. CLIMATE-FOCUSED WORKFORCE DEVELOPMENT PROGRAMS				
	Description: To ensure that the economic benefits of the current landmark federal investments in clean energy accrue to Metro's frontline communities and youth, funds that have and will continue to flow to Nashville as departments access IRA/BIL grant opportunities, Metro should scale up its development of workforce development programs and consider including a focus **on climate resilience and clean energy jobs. This could include building climate sustainability and resilience curricula into existing workforce development programs, or creating new ones. Apprenticeship programs that build skills and offer advancement opportunities should be of particular focus.** WeGo and MWS already have apprenticeship programs, and these departments, together with MAC, could serve as the lead departments for this initiative. MWS, a leader in renewable energy generation, zero energy building, and sustainable process technologies, plans a climate-focused internship program to include recruitment in frontline communities. Partnering with other departments engaged in outreach activities (see CC1, NE2, and EC2) could provide a meaningful avenue for engaging potential applicants/employees.				
	Resources: • Equitable Adaptation Legal & Policy Toolkit » Workforce Development and Training Programs - Georgetown Climate Center • Green Building Workforce Development Initiatives | Department of Energy • Develop a Climate- and Sustainability-Focused Workforce | Federal Sustainability Plan | Office of the Federal Chief Sustainability Officer				
	City/State Examples: • Boston, MA: Resilient Green Infrastructure and Workforce Development				

	• Northern Manhattan, NY: Worker Training | WE ACT for Environmental Justice				
	EC6. PUBLIC ASSET MAPPING AND VALUATION Description: Creating a database of public, government-owned assets with accurate valuation is the first step toward utilizing public land value for community benefit. This can take the form of creating Urban Wealth Funds to drive economic development. Land value capture can also be pursued, whereby public acquisition of private property for utility use, or private development of urban land, funnels a portion of the profit into redevelopment initiatives. Metro has initiated first steps with a real estate-focused internal audit and could investigate opportunities to leverage these efforts for adaptation and community resilience investment purposes. Resources: • IMF: Mapping the Unknown and Unlocking Public Wealth • How Land Value Capture Can Help Developing Cities | World Resources Institute (wri.org) City/State Examples: • Salt Lake County, UT: Urban3 Case Study	**X**	**X**	**X**	**Universal**

PUBLIC SAFETY

Figure 36. Potential Adaptation Strategies for Public Safety.

Applicable Hazards	Adaptation Strategies: Public Safety	Emergency Services	Law and Order	Government Services	Community Safety	Targeted (Vulnerable Population) or Universal?
		Q	R	S	T	
	PS1. CONDUCT RESILIENCE AND READINESS TRAINING EXERCISES AND DRILLS Description: Management and staff of relevant agencies need to be educated and trained in Metro's climate risks and anticipated impacts, including planning for extended power outages and curtailment scenarios, and participation in table-top exercises and specific scenario drills. OEM currently offers a Community Emergency Response Team (CERT) training, which could be replicated in a more condensed, climate resilience-focused version for Metro staff (CERT Lite) and include proactive identification of vulnerable communities and infrastructure. Development of a CERT Lite program is included as an initiative in Metro's Climate Resiliency Toolkit (see XC1). Resources: • Climate Hazard Readiness Toolkits: https://www.ready.gov/business • FEMA Exercise and Preparedness Tools City/State Examples: • City of Austin, TX: Get Involved: CERT Training	X	X	X	X	Universal
	PS2. REVIEW AND IMPROVE FIELD STAFF DEPARTMENT SAFETY STANDARDS (SEE IN9) Description: Outdoor workers across the public and private sectors bear the brunt of increasing heat and are put on the frontline of other climate risks as a result of their job duties. They are often the least paid and protected. This strategy comprises a review of existing standards, equipment, personal protective equipment (PPE), and practices for outdoor public service and utility workers to ensure they are adequate to protect worker health and safety during extreme weather events, and in light of projected changes. While OSHA was directed in 2021 to set new federal heat protection standards in light of the	X	X	X		Universal

	changing climate, Metro should review its policies and protections for Metro staff in parallel and set expectations for the private sector as well. Resources: California OSHA, Shade and Other Cooling Measures City/State Examples: • DOSH - Heat related illness prevention and information (ca.gov) • Oregon Occupational Safety and Health : Oregon OSHA adopts rules protecting workers against high heat, wildfire smoke : 2022 News : State of Oregon • Washington State: Ambient Heat Exposure Protections					
	PS3. DEVELOP ADAPTATION PLAN FOR CRITICAL INFRASTRUCTURE AND SERVICES (SEE IN5) Description: In line with and as an outcome of Strategies IN4 and IN5 above, Metro departments responsible for emergency management and response should work together to develop actionable strategies and plans to harden their infrastructure, equipment, and personnel resources, and to create climate risk-specific plans focusing on building resilience to extreme temperatures and flood waters, and improving readiness. Resources: • NREL Energy Resilience Assessment Methodology USDOT/FHWA: Adaptation Decision-Making Assessment Process City/State Examples: • Colorado Department of Transportation Risk and Resilience Analysis Procedure North New Jersey: Sustainability and Resilience Planning	**X**	**X**	**X**	**X**	**Targeted**
	PS4. REVIEW AND OPTIMIZE ASSET MANAGEMENT PROGRAMS (SEE IN4) Description: Efficient and consistent asset management is fundamental to achieving readiness, redundancy, and recoverability. Readiness planning will help to identify areas where readiness criteria or redundancy are lacking so that procurement of missing equipment can be prioritized. Reviewing historical facility and maintenance data can help to identify assets with previous climate or weather-related impacts/repeat failures that need addressing or a change in procurement strategy. Finally, disinvesting in assets that face too great a risk should be pursued where appropriate.	**X**	**X**	**X**	**X**	**Universal**

	Metro Nashville is in the process of implementing a department-wide, digital and GIS-based asset management system that will streamline and improve efficiencies of current asset management practices. Incorporating a climate resilience lens into the roll-out of this program and the data it tracks should be implemented at the outset. This could be piloted by NDOT and DGS, based on the timeframe for roll-out of the program. Increasing the robustness of asset management programs could also include introducing rapid detection and recovery programs, supply chain resilience planning (cross-Metro or regionally), and aerial inspections (e.g. use of drones to monitor transmission lines).					
	Resources: • Infrastructure Pathways: Guidance on climate-resilient infrastructure (includes guidance on multiple phases including policy and planning, prioritization, design, procurement, construction, etc.) • Managed Retreat Toolkit » Design Modifications and Asset Protection - Georgetown Climate Center • Addressing Resilience to Climate Change and Extreme Weather in Transportation Asset Management (dot.gov) UNDRR: Disaster Resilience Scorecard for Cities					
	City/State Examples: • Federation of Canadian Municipalities: Guide for integrating climate change considerations into municipal asset management					
	PS5. BUILDING REGIONAL CONSENSUS AROUND HAZARD VULNERABILITIES, NEEDS AND RISKS Description: In line with Strategy EC3, climate resilience is bolstered and supply chain disruptions are minimized by building regional collaboration, which could take a variety of forms including regional purchasing agreements for critical supplies, and regional planning committees for scenario and response planning. As a first step, the Mayor's Office could reach out to sustainability and resilience offices in sister cities to understand the current level of resiliency planning in the region, and map out potential scopes for strengthening individual plans. Longer term, Nashville should develop a formal partnership with its sister cities focused on actions such as maintaining a regional GHG emissions inventory, a regional assessment of climate risks and vulnerabilities, and adoption of shared, regional goals for improving sustainability and resilience. There are numerous examples of such partnerships worldwide, especially the EU, where a more regional, multi-level governance approach has offered an opportunity to foster more	**X**	**X**	**X**	**X**	**Targeted**

	ambitious and widespread action on climate change and more holistically address trans-boundary climate-related issues such as transportation and waste. Collaboration between local governments also offers a significant economy of scale and eases burdens on municipal resources. Resources: • Regional Adaptation Collaborative Toolkit | U.S. Climate Resilience Toolkit City/State Examples: • Chicago, IL: Greenest Region Compact • Lessons in Regional Resilience: Case Studies on Regional Climate Collaboratives | U.S. Climate Resilience Toolkit					
	PS6. CLIMATE-SPECIFIC OUTREACH AND PLANNING (SEE CC1) Description: The best strategy to ensure Nashville's public service and emergency response capabilities meet the need is to prioritize building the resilience of individuals, households, businesses, and communities, so that they are prepared and capable of withstanding climate-driven disasters themselves and do not add unnecessary burden or detract from supporting frontline communities when disasters occur. Through its Office of Emergency Management (OEM), Nashville currently provides the public with resources and training related to all-hazards preparation and recovery. Nashville's Multi-Hazard Mitigation Plan has proposed to expand these efforts with a multi-hazard, seasonal Public Awareness Program (Action 2-1) that provides citizens and businesses with accurate information describing the risk and vulnerability to natural hazards. This expansion program might be combined with efforts to develop Resilience Hubs in the most vulnerable communities (see Strategy CC2), and could also include development of community-specific Climate Adaptation and Resilience Action Plans. Metro might also conduct a review of its current outreach efforts and consider whether any gaps exist within communication channels or as concerns people with special needs (e.g., those who live alone, are homebound, or face other obstacles to disaster response). In early 2023, Metro launched a Cultural Ambassadors program that is a joint cooperation between OEM and the Tennessee Language Center focused on helping the city's New American and Immigrant communities prepare for climate disasters and gain access to existing disaster preparedness resources. This is a low-cost, innovative, and targeted approach that could be replicated for other	**X**	**X**	**X**	**X**	**Universal**

	communities and risks (e.g. communities in floodplains, specific Environmental Justice initiatives). Communities, particularly frontline ones most exposed to climate hazards, should be engaged to inform Metro-led planning that identifies specific risks and vulnerabilities, conducts resilience and adaptation planning, and provides resources to help community members be prepared. Providing compensation for time spent will result in better participation and outcomes. Outreach efforts should be multi-modal and universal as well as targeted. Channels could include mobile phone campaigns and alerts, schools (both public and private), utility-led communication, specific programs conducted as part of special events, and services-based (such as integrated into support services for the elderly or unhoused). They can also be as simple as signage—for example, Metro Water Services (MWS) installed signs in floodplain properties it has acquired that show how high the 2010 flood waters reached. It is important to note the several local non-governmental organizations engage in climate action education and empowerment, including but not limited to Cumberland River Compact, Tennessee Immigrant Refugee Rights Coalition, The Nature Conservancy, Southern Alliance for Clean Energy, Tennessee Interfaith Power & Light, Urban Green Lab, and others. Leveraging these existing successful efforts to enhance climate outreach and empowerment is a critical component of this strategy.					
	Resources: • FEMA, Building Alliances series					
	City/State Examples: • King County, WA: Community Engagement and Co-Creation • San Francisco, CA: San Francisco Climate and Health Profile (see Education and Outreach materials) • New York, NY: Be a Buddy extreme heat strategy • Cleveland, OH: Racial Equity Tool					
	PS7. REVIEW AND UPDATE BUILDING AND SITE CODES, ZONING CRITERIA (SEE CC5)					
	Description: Establishing standards and adopting building and site codes, particularly for multi-family residential buildings, that address current and projected climate risks is a key aspect of keeping the community safe. This strategy should be pursued in parallel with creating zoning overlay districts with	**X**			**X**	**Universal**

	requirements that exceed base zone standards to meet resilience requirements – particularly with regard to riverine and pluvial flooding. Nashville should consider current FEMA floodplain requirements as well as emerging research and modeling that takes into account new rainfall analyses (see IN11). Nashville should also consider adopting new zoning and permitting standards related to heat and seismic risk. There are already multiple efforts underway that could be utilized to introduce new standards and/or development ordinances related to climate resilience. One is Nashville's East Bank Plan, which contains multiple climate resilience strategies from transit-oriented development to innovative flood management approaches. Another is the Department of Planning's recent launch of an Ecological Design Studio, with an aim of designing for greater equity and resiliency by incorporating consideration of natural resources, environmental risks and assets, cultural diversity, and climate resilience into land use decisions. Such approaches could become Nashville's new norm and include climate resilience principles in terms of building design, energy and stormwater management, and community safety. There are multiple ways that community safety can be improved through codes, zoning, permitting, and other regulatory strategies. The first step Metro should take is to establish a cross-department working group and develop an actionable plan for incremental action.					
	Resources: • Delivering_Resilient_Building_Codes_and_Standards.pdf (iccsafe.org) • Urban Land Institute, Enhancing Heat Resilience and Equity in the Wedgewood-Houston and Chestnut Hill Neighborhoods • HUD, Resilient Building Codes American Planning Association, Urban Heat Resilience					
	City/State Examples: • Norfolk, VA: Resilience Overlay Districts • Boston, MA: Boston Heat Resilience Plan, Chapter 6 (pp. 223-231) and Climate Resiliency Guidance Philadelphia, PA: City of Philadelphia Office of Sustainability, Philadelphia Climate Action Playbook, "Climate Informed Planning" (p. 35)					

CROSS-CUTTING POLICY AND PROCEDURE ADAPTATION STRATEGIES

Figure 37. Potential Adaptation Strategies Focused on Policy and Procedure.

Applicable Hazards	Cross-Cutting Policy and Procedure Adaptation Strategies	Internal — Decision Support	External – Public Services	Targeted (Vulnerable Population) or Universal?
	XC1. DEVELOP A CLIMATE RESILIENCY TOOLKIT AND TRAINING RESOURCES	X	X	Universal
	Description: Develop a toolkit to embed climate resiliency and sustainability strategies and principles into Metro departments' operations. The toolkit is under development as of the writing of this Plan, and is intended to contain a suite of informational and training resources as well as templates and guidelines for conducting hazard vulnerability and risk assessments, assessing projects based on triple bottom line criteria, understanding the costs and benefits of action or inaction related to climate resiliency and sustainability, developing resiliency- and sustainability-focused metrics and key performance indicators, and other best practices. The development of climate-oriented design guidelines is targeted in later iterations. It is envisioned to be rolled out over multiple years by a collaborative, multi-department stakeholder group (see XC3) and incorporated into Metro's annual budgeting processes (see XC2).			
	Resources that informed the development of toolkit content include: • Plan Integration for Resilience Scorecard • New York City Climate Resiliency Design Guidelines • Racial Equity Tool - Sustainable Cleveland • Checklists to Assess vulnerabilities in Health Care Facilities in the Context of Climate Change (who.int) • https://www.ready.gov/business			
	City/State Examples: • Boston, MA: Aligning climate resilience and public works			
	XC2. INTEGRATE RESILIENCE INTO CAPITAL IMPROVEMENT PROGRAM AND OPERATING BUDGET			

	Description: All municipalities conduct capital investment and asset management planning for infrastructure and facilities, including those vulnerable to the impacts of climate change. Embedding climate vulnerability assessments and adaptive strategies into existing processes is a practical and cost-effective tool that is increasingly being used by municipal governments to protect these assets and the people they serve. The benefits of such an integrated approach include minimizing service disruptions and aligning budget allocation and resilience plans with local community priorities. This Adaptation and Resilience Plan and the internal Climate Resilience Toolkit (XC1) developed as its companion represent solid first steps in Metro's commitment to integrating sustainability and resilience planning into its existing operations and strategic planning processes. The next step should comprise integrating the strategies and tools included in both documents into Metro's Capital Improvements and Operating Budgets through their review and approval processes. At a minimum, mechanisms should be incorporated to prevent approval of expenditures for projects or processes that *increase* Metro's climate vulnerability. Metro's Capital Improvements Budget (CIB) already includes a prioritization methodology that is based on a weighted scoring process covering eight Guiding Principles and 18 criteria drawn from NashvilleNext as well as eight factors under an Efficient Government criteria. As a near-term first step, resilience criteria could be included in line with NashvilleNext into this existing process, and additional mechanisms can be explored for introducing a resilience evaluation lens to Metro's Operating Budget. Ultimately, Metro should require departments to complete a climate vulnerability assessment for all projects or programs above a certain dollar threshold before they can be considered for either budget allocation.			
	Resources: • American Society of Adaptation Professionals' Ready-to-Fund Resilience Toolkit • National Institute of Standards and Technology: Community Resilience Economic Decision Guide for Buildings and Infrastructure Systems			
	City/State Examples: • Eastern Shore communities, MD: Integrating Resilience into Local Capital Improvement Programs • San Francisco, CA: Sea Level Rise Vulnerability and Consequences Assessment			

	• New York, NY:
	  ○ Climate Resiliency Design Guidelines
	  ○ Law 2021/122 amending the administrative code of the city of New York, in relation to the creation of a citywide climate adaptation plan			

	XC3. CREATE A STRUCTURE AND/OR PROCESSES THAT ENHANCE COLLABORATION ON SUSTAINABILITY AND RESILIENCE TOPICS WITHIN AND ACROSS METRO DEPARTMENTS Description: An office, agency, or department focused specifically on identifying and implementing strategies to safeguard Nashville's residents from growing climate threats would help to break down silos between the relevant activities of individual departments and elevate urgent risks. The department could include teams specifically focused on Nashville's greatest threats, namely heat and intensifying precipitation. Under Mayor Cooper, a working group comprised of the Mayor's Office and 12 key departments convened to develop the Climate Resiliency Toolkit described above and this Climate Adaptation and Resilience Action Plan. That working group or one including a similar configuration could also be employed to serve in the near term in place of a dedicated department, meeting quarterly and working toward achievement of agreed action items. Alternatively, over the longer term, each Metro department could identify one person to lead that department's climate sustainability and resilience efforts, and these individuals would then constitute a network or virtual department to lead Metro's macro efforts. In its August 1, 2023 meeting, the Metro Council approved ordinance BL2023-2004 establishing a Sustainability Advisory Committee to guide Nashville and Davidson County's efforts to reduce greenhouse gas emissions and increase sustainability and resilience. The Council will be comprised of 15 members representing the non-profit and private sectors, MNPS and higher education, and the public. Ex-officio members will comprise key Metro departments. The Council will meet quarterly and provide direction to Metro department leadership and staff efforts. City/State Examples: • Phoenix, AZ: Office of Heat Response and Mitigation • San Francisco, CA: Office of Resilience and Capital Planning • Lewes, DE: Executive Committee on Resiliency	**X**	**X**	**Universal**

	XC4. HAZARD AND VULNERABILITY MAPPING Description: Creation of a GIS-based dashboard containing climate hazard and socioeconomic vulnerability data can help Metro Government make informed policy and program decisions and educate the public about preparing for climate shocks and stressors. It can also help Metro to ensure adequate resources are planned and/or staged for communities where climate risk and vulnerability is the highest. Nashville undertook a heat mapping campaign in 2022 that has been publicized through a Heat Impacts Story Map. This effort represents a solid first step and should be carried forward to create a more comprehensive mapping database fed by up to date data. Resources: • The National Integrated Heat Health Information System, Mapping Campaigns • National Oceanic and Atmospheric Administration (NOAA), NOAA and communities to map heat inequities in 14 U.S. cities and counties • Climate Mapping for Resilience and Adaptation Assessment Tool City/State Examples: • New York, NY: Columbia Climate School, Data Dive, Heat Mapping New York City andEnvironmental Justice • Raleigh, NC: Mapping Urban Heat Islands and Heat Watch Report • Jacksonville, FL: Jacksonville Heat Map • Colorado DOT Resilience StoryMap	X	X	**Universal**
	XC5. SUSTAINABILITY AND RESILIENCE MASTER PLANNING Description: Metro Water Services has undertaken a Sustainability and Resilience Master Planning initiative in late FY23 that will result in a five-year implementation plan to enhance its Sustainability and Resilience practices, procedures, and programs starting in FY24. The process and resulting Master Plan could serve as a guideline and template for other departments to develop similar plans. In addition, the Master Plan will result in tools, such as for evaluating the triple bottom line of potential capital improvement projects, that would benefit other departments.	X	X	**Universal**
	XC6. ADOPT ENVIRONMENTALLY PREFERABLE PURCHASING (EPP) Description: The federal model of EPP is a cost-saving and sustainability-incentivizing program focused on reducing climate impacts, improving the health of frontline communities, and preventing pollution. Metro Nashville could use the	X		**Universal**

	federal model as a guideline to develop its own EPP resource, which would go beyond buying recycled paper and LED light bulbs and help advance resiliency initiatives. The Waste Services division of Metro Water Services has an objective to develop its own EPP model in the near term, which could serve as an example for other Metro departments. Resources: • EPA Recommendations of Specifications, Standards, and Ecolabels for Federal Purchasing • Infrastructure Pathways: Guidance on climate-resilient infrastructure (includes guidance on multiple phases including policy and planning, prioritization, design, procurement, construction, etc.), in particular, Chapter 6 (Procurement) City/State Examples: • State and Local Government – Environmentally Preferable Purchasing Programs and Policies – Institute for Local Self-Reliance (ilsr.org)			
	XC7. POLICY SYNTHETIZATION Description: Metro Nashville has developed dozens of plans that govern land use, economic development, climate action, emergency management, hazard mitigation, transportation, stormwater, parks and greenways, and other sectors. Ensuring that these plans align to achieve macro resilience and equity objectives can remove inefficiencies, eliminate contradictions, and provide a valuable exercise for prioritizing investment of resources. Creating a policy matrix can also assist Metro staff in decision-making and help the public better understand Metro initiatives. Finally, synthesizing policies can help Metro identify gaps where new policies need to be developed. The Plan Integration for Resilience Scorecard (PIRS) approach has been used specifically for flooding and heat risk considerations in multiple cities and has recently been adopted by the American Planning Association as an integration standard for achieving resilience and building capacity in resource-constrained communities. Resources: • Plan Integration for Resilience Scorecard • Plan Integration for Resilience Scorecard for Heat Released as Outcome of Heat Risk Team FY21 Competition (noaa.gov) • Resilience Playbook City/State Examples: (see first link above)	**X**	**X**	**Universal**