MARYLAND DEPARTMENT OF TRANSPORTATION

TRANSPORTATION RESILIENCE IMPROVEMENT PLAN

2024

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EXECUTIVE SUMMARY

The Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law, was signed into law in November 2021. The law authorizes $1.2 trillion for transportation and infrastructure spending, with $550 billion designated for "new" investments and programs. Within the IIJA, $8.7 billion was designated for the creation of the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) program.

PROTECT is administered by the U.S. Department of Transportation (USDOT) Federal Highway Administration (FHWA). In total, the PROTECT Formula Program offers $7.3 billion in funding, and the PROTECT Discretionary Grants Program offers $1.4 billion in competitive grants for the years 2022 to 2026. Maryland is expected to receive $107 million in federal cost-share formula funding through the 5-year authorization period. The main distinction between the two funding mechanisms is that Formula Program funds are distributed directly to states, whereas eligible recipients under the Discretionary Grant Program must compete for the approximate $1.4 billion in discretionary funds. The purpose of both programs is to help states and communities improve the resilience of their surface transportation infrastructure to natural hazards. Specifically, the PROTECT funds support resilience-focused activities across four main areas:

- **Planning:** Resilience planning activities to assess surface transportation infrastructure vulnerabilities from the impacts of natural hazards.
- **Resilience Improvements:** Improve the ability of existing surface transportation infrastructure to withstand extreme weather events and other natural hazards to support rapid recovery.
- **Community Resilience and Evacuation Routes:** Strengthen and protect evacuation routes, including community resilience, to support continued or rapid recovery from weather events and natural disasters.
- **At-risk Coastal Infrastructure:** Harden, stabilize, elevate, or relocate existing surface transportation infrastructure to improve resilience. Enhance natural infrastructure systems to protect surface transportation infrastructure while improving ecosystem conditions.

The PROTECT Formula Program requires each state to use a minimum of 2% each fiscal year for planning-related activities, including the development of a resilience improvement plan, resilience planning, predesign or design, technical capacity building, and evacuation planning and preparation.

For over a decade, Maryland has been at the forefront of identifying and deploying a variety of climate resilience strategies. Together, the State of Maryland and the Maryland Department of Transportation (MDOT) have sought resilience measures through strategic investments in projects, programs, and at-risk infrastructure. MDOT will continue to work with partners to ensure expanded alignment of resilience measures. It is important to note that project-related work under the PROTECT program must comply with *Code of Federal Regulations* **Title 23 requirements**.

In alignment with these efforts, MDOT has developed this Transportation Resilience Improvement Plan (TRIP) to guide strategic investments in critical infrastructure, proactively identify and address actions, and align adaptation and mitigation efforts with MDOT's resilience objectives. This plan adheres to federal requirements in 23 USC 176 and guidelines outlined in the 2022 FHWA PROTECT Formula Program Implementation Guidance, specifically Section G (3) (FHWA 2022b), which focuses on the development of resilience improvement plans. MDOT's approach to the TRIP development aimed to be inclusive of other modes of transportation, ensuring that interdependencies, as well as potential co-benefits of projects, were addressed.

This TRIP represents a crucial progression in MDOT's resilience strategy. It offers insight into MDOT's current position within various resilience initiatives, outlines the agency's desired direction, identifies opportunities and next steps, and presents an overview of the agency's existing processes, available data, technical information, and growth prospects. Through the TRIP, MDOT is setting a clear path to inform both present and future endeavors. Even though some modal administrations are not eligible for PROTECT funds, these administrations can use the TRIP as a guide for how to incorporate resilience into their practices. Furthermore, MDOT is in the process of developing a Climate Action Plan, which will focus on both carbon reduction and system resilience. The Climate Action Plan will expand upon initiatives outlined in the TRIP and in MDOT's approved **Carbon Reduction Strategy**.

Appendix A: TRIP Alignment with Federal Requirements; identifies where in the plan the required components can be found

Appendix B: Family of Plans Alignment with TRIP; provides explanations as to how the other Maryland plans align with the TRIP

Appendix C: Vulnerability Assessment Summary; a cohesive narrative and highlight of key findings from the modal administrations vulnerability assessments which provides a more comprehensive perspective of the scope of vulnerability for MDOT assets.

Appendix D: Process Workflow for PROTECT Project Identification, Evaluation and Prioritization; visual representation of the phases and steps that MDOT follows to fund projects under PROTECT

Appendix E: MDOT Climate Focused Funding Portal - Project Solicitation Application; the application that was used in the Spring 2024 project solicitation process

Appendix F: DRAFT Project Evaluation Process and Methodology for PROTECT projects; provides the general process, criteria and specific methodology used in the evaluation of projects.

Appendix G: Acronyms and Abbreviations

1 INTRODUCTION AND OVERVIEW

The Maryland Department of Transportation's (MDOT) Transportation Resilience Improvement Plan (TRIP) provides a guide for strategic investment in Maryland's critical infrastructure and proactively identifies actions that can be taken to align adaptation and mitigation efforts throughout MDOT. The TRIP follows guidance from the Federal Highway Administration (FHWA) related to Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) funding and considers ways to include other transportation modes when addressing resilience to strive towards achieving MDOT's resilience-related objectives and goals. Through the development of the TRIP, other MDOT plans and processes were considered and incorporated to ensure a holistic, comprehensive approach has been outlined.

1.1 Background

Climate resilience is a longstanding area of emphasis within MDOT because of the state's coastal location and the multiple natural threats that can impede normal operations, including hurricanes, extreme weather events, and winter storms. Between 2011 and 2021, Maryland experienced 10 federally declared climate disaster declarations, ranking it 18th out of 50 states in terms of Federal Emergency Management Agency (FEMA) and U.S. Department of Housing and Urban Development post-disaster relief spending (referenced in Stebbins 2023). In addition, a recent FEMA case study revealed that a 100-year flood event, which has a 1% probability of occurrence in any given year, could result in over $8 billion in economic losses to the state (FEMA 2021). Another study completed in 2021 by the Pew Foundation noted that approximately 20% of state-maintained roadways in Maryland are prone to flooding (Fuchs 2021). Of the 2,771 flood-related incidents reviewed for this study, 78% happened outside of the 100- and 500-year FEMA mapped flood zones, indicating that MDOT may have vulnerabilities in areas not currently anticipated.

To address the rising concern of transportation system resilience nationwide, in July 2022, the U.S. Department of Transportation (USDOT) FHWA released guidance for the new PROTECT program. This initiative provides $7.3 billion in formula funding, in addition to $1.4 billion allocated for discretionary or grant funding during federal fiscal years (FFY) 2022 to 2026. PROTECT's primary objective is to assist states and communities in their efforts to prepare for and respond to severe weather events and the effects of climate change. This first-of-its-kind program addresses the impacts of extreme weather and climate change on the nation's surface transportation infrastructure, such as roads, bridges, and rail lines. The program originates from the Infrastructure Investment and Jobs Act (IIJA), a $1.2 trillion legislative package passed by the U.S. Congress and implemented by the Biden-Harris Administration in 2021. Subsequently, in April 2023, USDOT issued a Notice of Funding Opportunity, authorizing $848 million in discretionary grants for FFY 2022 and 2023 (USDOT n.d.).

The PROTECT Formula Program designates specific funding allocations to states for the period spanning FFY 2022 to 2026 intended to facilitate the planning and implementation of resilience improvements for surface transportation assets and vulnerable highway infrastructure (FHWA 2022a). Based on formula funding alone, Maryland anticipates receiving approximately $107 million in total, including at least 2% for eligible planning activities each fiscal year. Maryland also has the option to pursue PROTECT discretionary grants available through the PROTECT program.

This TRIP serves as a roadmap for a data-driven investment strategy to address the resilience of critical infrastructure by proactively identifying and managing risks through adaptation and mitigation measures that will support MDOT's overall resilience goals. The TRIP was prepared in alignment with federal requirements and guidelines established in the PROTECT Formula Program Implementation Guidance released by the FHWA (2022b). Specifically, the TRIP was developed in accordance with Section G (3), which outlines the development of resilience improvement plans. The TRIP's alignment with these federal requirements is provided in **Appendix A**.

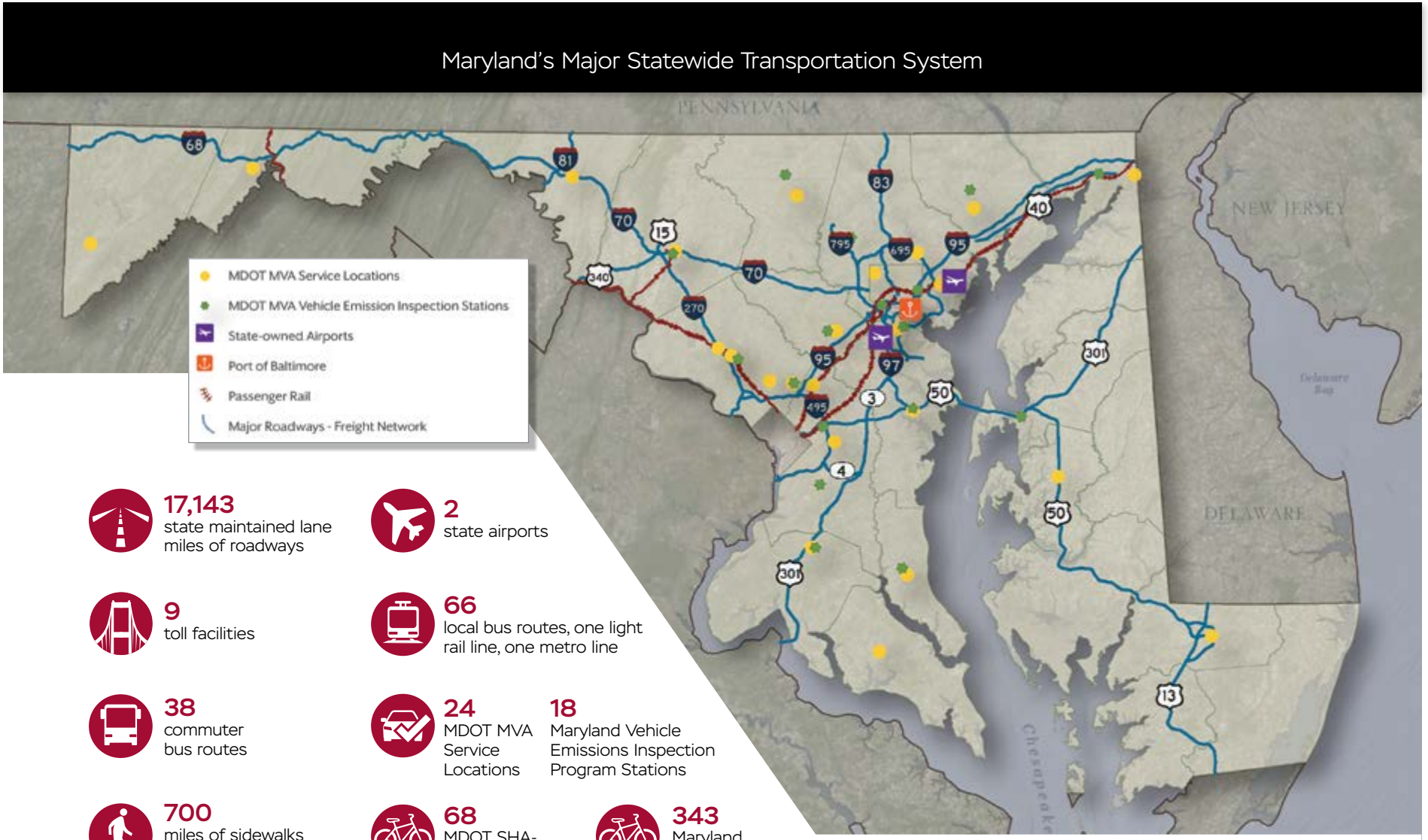
The MDOT TRIP's primary purpose is to establish the framework to expand upon existing workflows and tools to embed climate and extreme weather considerations into project planning and design, investment, prioritization, and life-cycle planning across all modal administrations to support Maryland's sustainable transportation future. MDOT also aims to integrate climate risk assessment into decision making across all critical asset classes and project life cycles and to provide strategies for defending against, accommodating, or planning for transformative adaptation from climate related hazards.

Sections 1.2 through **1.5** provide an overview of MDOT's transportation system, identify key threats to the system, and discuss the critical interdependencies among infrastructure sectors. In addition, a comprehensive list of acronyms and abbreviations used throughout the TRIP is provided in **Appendix G**.

1.2 Overview of the MDOT Transportation System

MDOT oversees and manages the state's comprehensive transportation system, which encompasses a range of transportation modes, infrastructure, and services that facilitate the movement of people and goods within Maryland. This system includes highways and roads, bridges and tunnels, public transit, short line freight rail and regional commuter rail, ports and harbors, airports, toll facilities, bicycles and pedestrian infrastructure, and light rail. **Figure 1.1** provides a high-level overview of MDOT's transportation system.

Figure 1.1: Overview of Maryland Department of Transportation's System



MDOT also supports 33 public use airports in the State through federal grant programs, provides technical assistance for transit systems in 23 counties, and is a funding partner of the regional Washington Metropolitan Area Transit Authority (WMATA).

Source: *MDOT, 2019. | MVA = Motor Vehicle Administration | SHA = State Highway Administration*

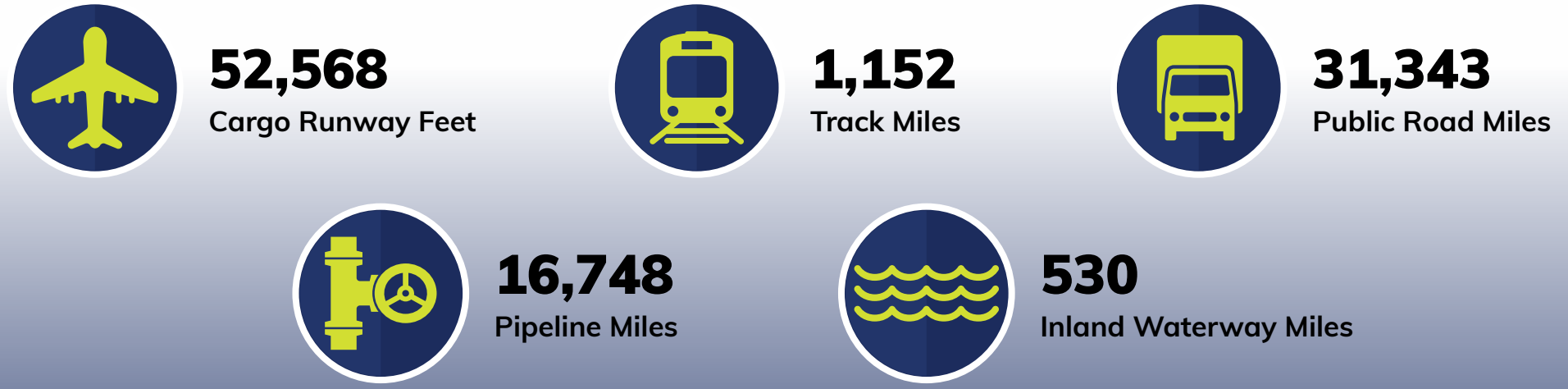
The State of Maryland ranks as the 42nd largest state in landmass but the 19th most populous state in the United States. Between the 2010 and 2020 census, Maryland's population increased 7%. As population increases, there is generally an increase in demand for products and services that influence goods movement. As a result, goods moving into, out of, and within Maryland have been continuously growing. An overview of the State's freight network is provided in **Figure 1.2**. Freight moving to, from, or within Maryland amounted to nearly 281 million tons, valued at nearly $376 billion in 2020 (MDOT 2022). By 2050, freight tonnage is expected to increase by 53% to nearly 429 million tons, at an estimated value of $781 billion. These estimates do not reflect pass-through freight, which has historically accounted for nearly two thirds of the total goods carried via Maryland's multimodal freight transportation system (MDOT 2022). Maryland's roadways collectively handled approximately 78% of the total freight tonnage and 76% of the total freight value, worth approximately $286 billion (MDOT 2022). These statistics demonstrate the sheer size of MDOT's freight network and demonstrate the potential impacts to freight movement that could occur during major natural hazard events.

MDOT's purpose is to deliver safe, sustainable, intelligent, exceptional, and inclusive transportation solutions to connect its customers to life's opportunities. Four goals identified in the 2050 Maryland Transportation Plan (MTP) help MDOT achieve this vision and mission:

- **Enhance Safety and Security:** Protect the safety and security of all residents, workers and visitors.
- **Deliver System Quality:** Deliver a reliable, high-quality, integrated transportation system.
- **Serve Communities and Support The Economy:** Expand transportation options to allow Maryland's diverse communities to access opportunities and to support the movement of goods.
- **Promote Environmental Stewardship:** Minimize and mitigate the environmental effects of transportation.

Figure 1.3 provides the MDOT mission statement.

Figure 1.2: Overview of Freight Network



Source: *MDOT State Freight Plan (2022)*

Figure 1.3: Maryland Department of Transportation Mission Statement

MARYLAND DEPARTMENT OF TRANSPORTATION

MISSION STATEMENT

The Maryland Department of Transportation is a customer-driven leader that delivers safe, sustainable, intelligent, exceptional, and inclusive transportation solutions in order to connect our customers to life's opportunities

Source: *MDOT, n.d.b.*

1.3 MDOT Modal Administrations and Authority

MDOT is composed of the Transportation Secretary's Office (TSO), five modal administrations (Maryland Transit Administration [MTA], Maryland Aviation Administration [MAA], Maryland Port Administration [MPA], State Highway Administration [SHA], and Motor Vehicle Administration [MVA]), and one authority (Maryland Transportation Authority [MDTA]). The five modal administrations and MDTA are each headed by an administrator or executive directly responsible for managing their respective transportation sector programs. A high-level overview of each mode follows:

- **MTA** manages and operates public transit services across the State of Maryland, including buses, light rail, subway, and commuter rail services. MTA oversees the maintenance and development of transit infrastructure and aims to provide safe, reliable, and efficient transportation options to residents and visitors.
- **MAA** oversees and manages Maryland's airports and aviation-related activities, including the state's major airports such as Baltimore/Washington International Thurgood Marshall Airport and Martin State Airport, as well as regional aviation airports. MAA works closely with the Federal Aviation Administration to implement and enforce safety regulations and standards at Maryland's airports.
- **MPA** oversees the administration, operation, and promotion of Maryland's public marine terminals, primarily focusing on the Port of Baltimore. MPA facilitates the efficient and secure movement of cargo throughout these ports and works to contribute to the economic development of the region by attracting new businesses and cargo to the Port of Baltimore.
- **SHA** is responsible for the planning, construction, maintenance, and management of the state's road and highway network. SHA focuses on safety, traffic management, sustainability, and the overall improvement of the state's transportation network to meet the needs of residents and businesses.
- **MVA** manages various aspects of motor vehicle registration, driver licensing, and safety throughout the state. MVA focuses on safety, compliance with state and federal regulations, and providing essential services to the residents of Maryland.
- **MDTA** manages and operates various toll facilities and transportation infrastructure assets, including bridges and tunnels. The MDTA's responsibilities encompass toll collection, infrastructure maintenance, financial stewardship, and various measures to confirm the safety and efficiency of its facilities.

Each modal administration has taken action to assess and improve transportation resilience to climate change. For example, many modal agencies are conducting vulnerability and risk assessments and developing tools and plans to assess and analyze the impacts of climate change on statewide transportation infrastructure.

Across these modes, MDOT has been working to harmonize and incorporate these efforts into business practices to adapt and manage climate risk, as well as to integrate the knowledge into agency-wide decision making. The MDOT Office of Climate Change Resilience and Adaptation (OCCRA), housed within MDOT's TSO, is collaborating with the modal administrations and MDTA to integrate climate change mitigation, resilience, adaptation, and risk management into policies, planning, project and program development, asset management, maintenance, design, construction, and operations. Additionally, OCCRA helps to coordinate funding from the PROTECT program for eligible projects.

1.4 Threats to MDOT's Transportation System

Maryland faces a variety of threats to its transportation system that can impact the safety, functionality, and resilience of the infrastructure. These threats can come from both natural and human caused hazards. The Maryland Department of Emergency Management (MDEM) State Hazard Mitigation Plan (Maryland Emergency Management Agency 2021) identifies potential hazards, vulnerabilities to these hazards, and mitigation strategies to reduce future damages. As part of the plan, MDEM conducted a thorough analysis to identify the current and future hazards that are likely to negatively impact Maryland.

The main threats to MDOT's transportation system identified in MDEM's analysis are included in **Table 1.1**.

Table 1.1: Relevant Hazards for Maryland

Natural Hazards	
Coastal hazards	Thunderstorms
Dam failures	Tornadoes
Drought	Wildfires
Extreme temperatures	Wind
Floods	Winter storms
Soil movement	Public health emergencies
Human-caused Hazards	
Terrorism	Civil unrest
Active shooters	Cyberattacks
Nuclear incidents	Transportation accidents

Source: *Maryland Emergency Management Agency, 2021.*

Following hazard identification, MDEM rated the hazards using a probability assessment. Probability was defined as the likelihood of the hazard occurring, in general descriptors (for example, unlikely, likely, highly likely); historical frequencies; statistical probabilities (for example, 1% chance of occurrence during any given year); and/or hazard probability maps. The hazards probability ratings are included in **Table 1.2**.

Table 1.2: Hazards Probability Rating

Rating	Probability	Maryland Identified Hazards	
1	**Unlikely (hazards generally ranked as low)** Hazard event is likely to occur less than once every 30 years.	N/A*	
2	**Likely (hazards generally ranked as medium)** Hazard event is likely to occur less than once every 5 years but more often than once every 30 years.	• Dam failures • Drought • Extreme temperatures • Human-caused hazards	• Public health emergencies • Soil movement • Tornadoes • Wildfires
3	**Highly Likely (hazards generally ranked as high)** Hazard event is likely to occur more than once every 5 years.	• Coastal hazards • Floods • Thunderstorms	• Winter storms • Wind

Source: *Maryland Emergency Management Agency, 2021.*
**Hazards that were deemed unlikely were screened out during the initial hazard identification planning process phase.*
N/A = not applicable

The threats cited that are most likely to impact MDOT's transportation system include coastal hazards, flood hazards, extreme temperatures, soil movement, and severe weather. A high-level overview of these threats in Maryland is provided in the following sections. The in-depth risk and vulnerability data and analysis conducted for each hazard listed in **Table 1.1** can be found in MDEM's State Hazard Mitigation Plan (Maryland Emergency Management Agency 2021).

1.4.1 COASTAL HAZARDS

Coastal hazards can take many forms, such as tropical depressions, tropical storms, hurricanes, storm surge and tide, coastal floods, nuisance floods, and sea level rise. Maryland's coastal zone encompasses two thirds of the state's land area and is home to almost 70% of Maryland residents; coastal hazards are a top threat to MDOT's system. Maryland also has an extensive shoreline, which is particularly vulnerable to direct impacts from coastal hazards. As such, the state's coast frequently experiences flooding and erosion caused by coastal hazards, which are exacerbated by sea level rise.

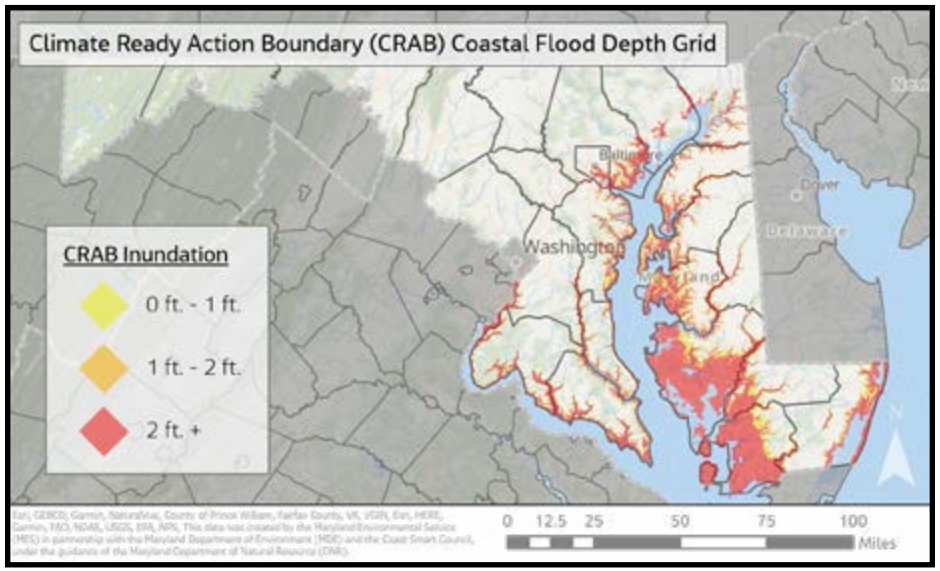
For example, Hurricane Sandy in 2012 was one of the most impactful hurricanes the state has experienced. The immediate effects of the storm were felt for several days throughout the state as it produced heavy rains, strong winds, and snow. It ultimately resulted in loss of life for 11 people and led to significant coastal flooding along the Chesapeake Bay. Although every county suffered some level of damage from the storm, Somerset County was the most impacted. The initial damage estimate in Somerset County was $40 million. The overall damage estimate throughout the state was close to $43 million.

In 2003, Hurricane Isabel caused historic damage to downtown Annapolis, and hundreds of homes and businesses were declared uninhabitable because of major flood damage. The National Weather Service estimated over $400 million in damage statewide. According to an MDEM report, between 1993 and 2010, coastal storm events accounted for $109 million in property damage and $193,215 in crop damage (MCCC n.d.).

Furthermore, Maryland is particularly vulnerable to coastal inundation because of rising seas and sinking land. The state is projected to face an estimated 0.8 meter of sea level rise by 2100, with a likely range of 0.62 meter to 1.08 meters (UMCES 2023). According to SHA, Maryland has approximately 7,920 linear miles of roadways. Of those that are state maintained, 158 miles will be threatened by sea level rise in 2050, and 356 miles will be threatened by sea level rise by 2100 (MCCC n.d.). **Figure 1.4** depicts the overall coastal inundation of Maryland as depicted in the state's Climate Ready Action Boundary (CRAB).

Additionally, communities across coastal zones are experiencing increased disturbances from nuisance flooding, also known as high-tide flooding or sunny-day flooding. This problem is evident by the number of flood days in the cities of Annapolis and Baltimore, which have increased in frequency by 920% since 1960 (Maryland Emergency Management Agency 2021). Additionally, in 2019, the Annapolis and Tolchester Beach (Baltimore) tidal stations broke records for the number of nuisance flood days. The average number of flood days was 2 days in 2000 for each location; in 2019, the record was 18 and 17 days, respectively. By 2030, the National Oceanic and Atmospheric Administration (NOAA) projects that these numbers will increase to 15 days to 25 days at each location and by 2050 to 55 to 170 days in Annapolis and 50 to 160 days in Baltimore (Maryland Emergency Management Agency 2021). Given the density of population and travel in these two major metropolitan areas, the social, environmental, and economic impacts of nuisance flooding is estimated to be substantial.

Figure 1.4: Coastal Inundation Areas



Source: *Maryland Coast Smart, 2023.*
ft = foot (feet)

Coastal hazards impact MDOT's transportation system through damage and accelerated deterioration to roads and bridges, loss of connectivity in transportation routes, disruption to port and harbor operations, and evacuation challenges. Life-cycle cost assessments to reflect the repeated damage or loss of service of such facilities and the full costs of such events are critical to right size investments and assist in establishing risk tolerance thresholds.

1.4.2 FLOOD HAZARDS

Flood hazards can also be categorized in several ways. In Maryland, the main flood hazards include general flooding, flash flooding, and heavy rain events. MDEM defines general flooding as events that come from prolonged, steady rain and tend to affect larger streams and rivers. MDEM defines flash flooding as events that come after short periods of heavy rain and most often affect smaller streams and creeks (Maryland Emergency Management Agency 2021).

Flooding is a major threat to MDOT's system, as Maryland experienced 583 general flooding events, 454 flash flooding events, and 215 heavy rain events from 2016 to 2021 (National Oceanic and Atmospheric Administration [NOAA] n.d.a). Maryland has also experienced three flood-related disasters since 2016. Climate change is exacerbating flooding, making the probability of this threat highly likely in Maryland. **Figure 1.5** displays flood events from Ellicott City in 2018 (top) and from Smith Island (bottom).

Flooding impacts MDOT's transportation system in the form of severe damage, debris blockages, temporary closure of transportation routes, and the potential inability of the stormwater system to handle floodwater during a severe event. Additionally, washed out roads, erosion, and localized landslides can result from flood events and cause further damage. Bridges can be damaged through high-velocity movement of water, including potential risk to bridge piers and abutments, accelerating bridge deterioration or potentially leading to structural integrity concerns. Bridge overtopping is also a concern for Maryland given the increases in rainfall intensity and coastal inundation concerns. Overtopping can damage bridge approach slabs and abutments, leading to physical asset losses, safety concerns, and service disruption.

Figure 1.5: Displays Flood Events From Ellicott City in 2018 (top) and From Smith Island (bottom)

Source: *Climate.gov*

Source: NOAA

1.4.3 EXTREME TEMPERATURES

Extreme temperatures encompass both extreme cold and excessive heat events. Maryland experiences both extremes, which pose threats to critical infrastructure assets and public health. In the northeast United States, it is projected that winters will be milder, with fewer cold extremes, and that the number and duration of summer heat waves will increase in the coming decades. Extreme heat is exacerbated in dense areas, where the built environment can increase temperatures through the urban heat island effect. According to the Maryland Department of Health, the National Weather Service will issue a Heat Advisory when the heat index value is expected to reach 105 to 109 degrees Fahrenheit; the current highest temperature recorded in Maryland history is 109 degrees Fahrenheit. Extreme heat events can impact most infrastructure, including electrical systems found in traffic management systems and transit operations systems, as well as infrastructure structural integrity in materials such as pavements and rail tracks. The potential disruptions to transportation operations can impact essential services and increase public health risks for both Maryland residents and MDOT employees and contractors responsible for service delivery.

Although the probability of increased excessive heat events is more likely in the future, Maryland has a long history of hazardous winter weather, which can take the form of snow, freezing rain, cold temperatures, or a combination of events. Hazards of winter weather include blizzards, wind chill, freezing fog, frost, heavy snow, ice storms, sleet, and winter storms, which all pose threats to MDOT's system. Additionally, Maryland is prone to "nor'easters" because of the region's strong northeast winds. These storms are often accompanied by heavy rain or snowfall and may cause coastal flooding and erosion. **Figure 1.6** displays an ice event at Baltimore Harbor from 2015.

Extreme temperatures and winter weather events impact MDOT's transportation system in the form of damage to roads and bridges, temporary closure of mass transit, power outages, and interruptions to aboveground power and communication systems.

Figure 1.6: Baltimore Harbor Ice Event (2015)

Source: *MPA*

These extreme heat effects on transit rail systems can cause rail tracks to expand, warp, or buckle. Extreme heat can also strain the electrical systems that power transit rail network by overheating wires, substations, and other equipment. Extreme heat can lead to structural impacts on other rail infrastructure, bridges, and tunnels as it causes expansion and contraction of materials. These extreme heat effects on transit systems can lead to derailments, safety hazards, signal failures, and service disruptions.

Furthermore, extreme heat disproportionately affects vulnerable populations, including those who rely on public transit. High temperatures can pose health risks to passengers waiting for buses or trains and may impact passenger comfort, particularly in non-air-conditioned vehicles or stations.

1.4.4 SOIL MOVEMENT

In Maryland, soil movement hazards encompass landslides, sinkholes, and coastal erosion. Of these hazards, coastal erosion is the most likely to occur in Maryland, particularly in communities along the state's coastline. Maryland is especially prone to coastal erosion because of Maryland's location within the Chesapeake Bay watershed, the largest estuary in the United States. NOAA estimates that Maryland has approximately 3,190 miles of coastal and Chesapeake Bay tidal shoreline susceptible to coastal erosion (Maryland DNR 2013).

Rockslides and rockfall are typically caused by natural weathering, freeze-thaw cycles, vegetation, earthquakes, rainfall, and other conditions. Rockfall events often result in significant impacts to the traveling public. Significant safety concerns are posed by large rocks falling near or on vehicles, as well as drivers avoiding these rocks or maneuvering to reroute, creating additional hazards. Maryland has experienced several notable rockfall events in the past, including incidents along Interstate 68 and U.S. Route 40. These events have led to road closures, extensive cleanup efforts, and sometimes injuries. In 2015, Maryland Route 135 was affected by a significant rockfall that left the road operating with one way traffic for a quarter-mile section. A section of the same road experienced another rockfall in 2016, which impacted industrial trucks that frequently travel the road.

Landslides are rare in Maryland but do occur in the mountainous western part of the state. Urban areas where human-caused soil movement has occurred are also prone to landslide activity. Similarly, several areas throughout the state are more prone to sinkholes. As with landslides, sinkholes more often occur in regions west of the Chesapeake Bay. With an increase in heavy rains and flood events, these two hazards may occur more frequently.

Soil movement impacts MDOT's transportation system in the form of damage to roads and bridges, temporary closure of transportation routes, the potential inability of the stormwater system to handle floodwaters, and loss of power.

1.4.5 SEVERE WEATHER

Severe weather hazards encompass thunderstorms, tornadoes, wildfires, and wind events. Thunderstorms, unlike other hazards, impact the entirety of Maryland. Although thunderstorms are more frequent in the summer months, they can occur year-round with damaging hail or lightning events. Thunderstorms are classified as severe when they produce hail that is 1 inch in diameter or larger, wind gusts exceeding 50 knots, a tornado, or some combination of these conditions. In the summer, Maryland averages one thunderstorm event every 5 days.

From 2010 to 2018, a total of 24 weather disasters affected the state. Severe storms were the most prevalent of these events, with a total of 13 affecting Maryland between 2010 and 2018. In 2018 alone, 6, separate billion-dollar disaster events affected Maryland. In May 2018, a derecho event—a widespread long lived windstorm—caused significant high-wind damage in Maryland, New Jersey, New York, Pennsylvania, Virginia, West Virginia, Massachusetts, and Connecticut, with total costs of $1.74 billion (NOAA n.d.b).

Similarly, Maryland is vulnerable to the impacts of tornado events. Maryland averages 10 tornadoes annually, with events affecting all regions of the state. Wildfires also occur throughout the state, with occurrences peaking in the spring. According to the Department of Natural Resources, the Maryland Forest Service responds to an average of 325 wildfires per year, which burn 3,200 acres of land total (Maryland Emergency Management Agency 2021). The future increase in extreme heat temperatures will likely contribute to increased wildfire events and longer fire seasons.

Maryland also experiences wind events across the state and is particularly vulnerable to synoptic scale winds* and thunderstorm winds. Wind events may result in dangerous debris, fallen trees, and disruptions to overhead electrical and communications infrastructure.

Severe weather events impact MDOT's transportation system in the form of fire caused by lightning strikes, roof and vegetation damage from hail, interruptions to aboveground power and communication systems, impacts from blowing debris, and road detours and closures.

Wind patterns occurring on a large scale, typically covering regions of several hundred to 1,500 miles and possessing shorter lifetimes of up to several days.

1.4.6 CLIMATE CHANGE

These potential impacts include increases in extreme precipitation, increases in river and fluvial flooding, increase of tidal waters due to global warming, greater prevalence of heat waves, and exacerbated air quality and impacts to environmental justice communities. To demonstrate the economic impacts of weather and climate-related disasters, the Maryland Commission on Climate Change (MCCC) completed a study in 2022 providing evidence of the recent costs to Maryland, which are presented in **Table 1.3**.

Considering these climate change impacts, it is imperative for MDOT to proactively adapt its strategies and infrastructure planning to ensure the resilience and sustainability of the state's transportation systems for the well-being of Maryland's residents and the continued growth of its economy.

1.5 Critical Interdependencies

Understanding interdependencies and vulnerabilities across infrastructure sectors is vital to confirming the resilience and reliability of transportation systems. Cross-sectoral interdependencies include, at minimum, the following sectors:

- Energy
- Water and wastewater
- Communication
- Public health
- Supply chain
- Critical manufacturing
- Finance
- Government and emergency services

Table 1.3: Increasing Incidence and Damages From Climate and Weather-Related Disasters in Maryland

Time Period	Number of Billion-Dollar Disasters	Events per Year	Cost	Percent of Total Cost
1980s (1980–1989)	7	0.7	$1.0–$2.0 billion	11.2%
1990s (1990–1999)	13	1.3	$2.0–$5.0 billion	17.5%
2000s (2000–2009)	10	1.0	$2.0–$5.0 billion	25.9%
2010s (2010–2019)	27	2.7	$5.0–$10.0 billion	38.9%
Last 5 years (2017–2021)	19	3.8	$2.0–$5.0 billion	13.0%
Last 3 years (2019–2021)	11	3.7	$500 million–$1.0 billion	6.2%
Last Year (2021)	5	5.0	$250–$500 million	2.5%
All Years (1980–2022)*	70	1.6	$10.0–$20.0 billion	100%

Source: *MCCC, 2022.*
** Statistics valid as of October 11, 2022.*

For instance, MDOT's infrastructure relies heavily on energy sources, particularly for fueling vehicles and operating transit systems. Disruptions in the energy sector, such as power outages or fuel supply shortages, can directly impact the operation of MDOT transportation networks, leading to service interruptions, traffic congestion, and reduced mobility.

Because cross-sectoral interdependencies are inevitable, it is important for MDOT to continue conducting comprehensive risk assessments, engaging in contingency planning, and collaborating with other critical infrastructure sectors. Recognizing and addressing these interdependencies can enhance the resilience and adaptability of transportation systems in the face of various threats and challenges.

To help account for these interdependencies in decision making, MDOT has established an initial criteria and screening process to evaluate potential projects for PROTECT funding. The criteria and screening process is based on categories of information, including funding eligibility, scope component evaluation, equity considerations, vulnerable areas, community impact evaluation, and alignment with existing MDOT, metropolitan planning organization (MPO), or state priorities. The screening process and identified criteria development is informed by ongoing processes and will continually be improved as the program and its operations evolve. Establishing a screening process, identifying key touch points, and establishing an approach to resilience incorporation allows MDOT to maximize federal and state funding to receive the most benefit and identify projects that do not have a resilience component but would benefit from one. The approach is intended to provide consistency in how funding is applied to projects while also actively working to support enhanced and expanded resilience integration across MDOT.

It is important to highlight MDOT's Resiliency Task Force, which functions as a community of practice dedicated to enhancing resilience, performance, and collaboration within and between the modal administrations. The Resiliency Task Force supports MDOT's ongoing resilience improvement program by providing a structured platform for identifying efficiencies, interdependencies, documenting vulnerabilities, and identifying resource gaps. Additionally, it recommends strategies and projects for improving resilience and promotes enhanced collaboration to facilitate quicker implementation of resilience measures.

The Resiliency Task Force holds regular meetings and has played a pivotal role in integrating resilience considerations in operations across the modal administrations. In the future, the task force will continue to provide these services and evaluate their approach and outcomes on an annual basis to confirm alignment with the TRIP and best practices adopted across MDOT.

2 TRANSPORTATION PLANNING AND PROGRAMMING ALIGNMENT

The TRIP aims to build upon ongoing planning processes outlined in existing statewide and regional plans and programming documents. These documents identify projects and strategies that enhance the resilience of transportation infrastructure in the State of Maryland. Relevant transportation planning and programming documents are described herein. Each agency, ranging from counties and municipalities, MPOs, and MDOT, has a role in identifying and supporting the development of projects and processes that improve resilience across the transportation systems.

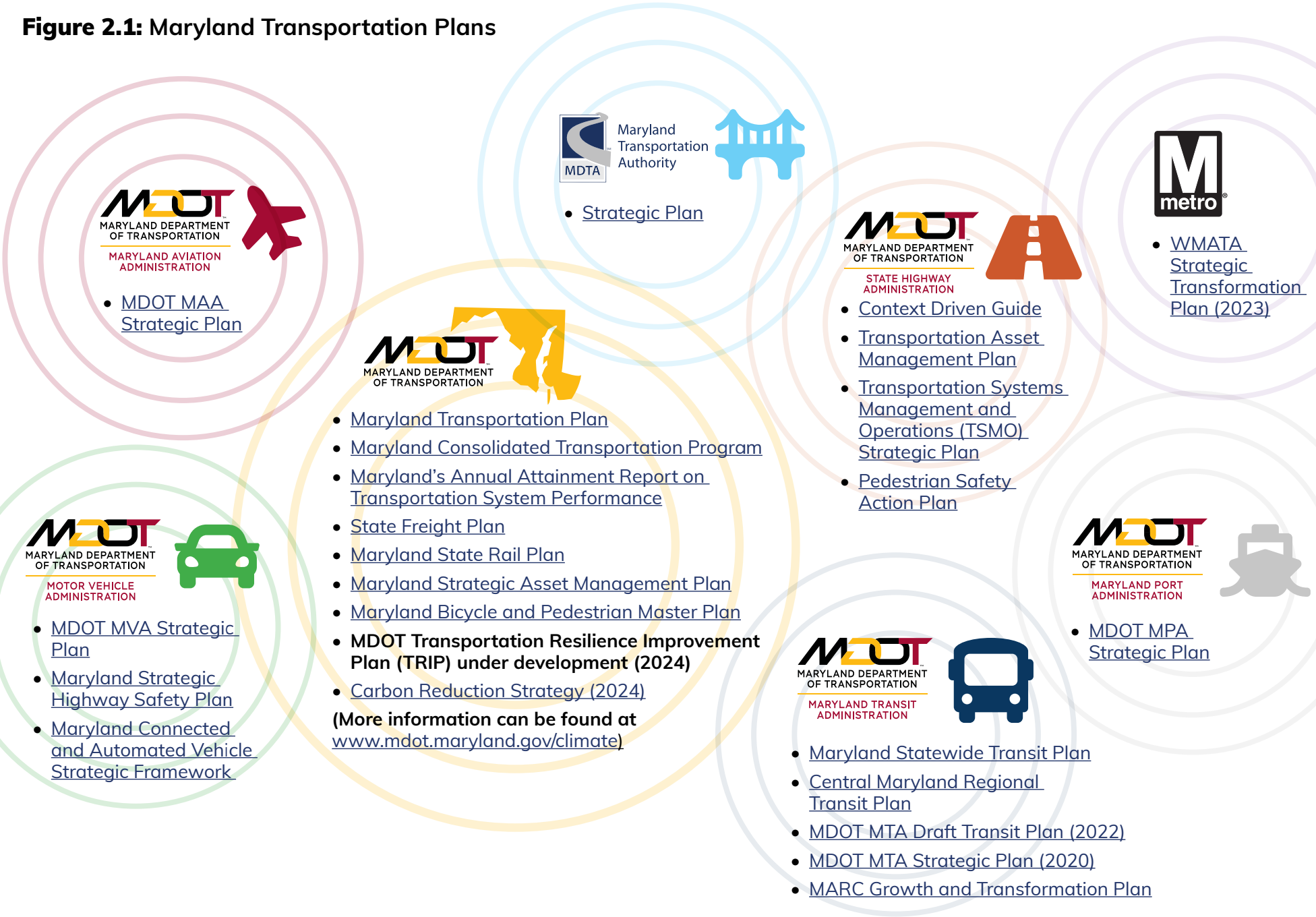
2.1 Statewide

Statewide documents together guide MDOT's priorities and future investments. Integrated long-range and strategic plans, such as the Maryland Transportation Plan (MTP), the Statewide Freight Plan, Statewide Hazard Mitigation Plan, and State Transportation Asset Management Plan, create an opportunity for MDOT to connect statewide goals with its overall mission.

The **Maryland Transportation Plan, or the 2050 MTP** (MDOT 2024) is the new 20-year, long-range statewide transportation plan guiding transportation policies and investment priorities. The MTP's guiding principles, goals, and objectives inform, and are informed by, the transportation reports and plans in Maryland, creating a family of plans. MDOT is poised to develop an updated family of plans better suited to a future governed by new state law and policy priorities for 2023 and beyond.

The current 2050 MTP highlights MDOT's commitment to providing a safe, secure, and resilient transportation system. MDOT identifies several approaches to provide a resilient multimodal system by anticipating and planning for changing conditions and hazards, whether natural or artificial. The MTP provides much of the strategic direction that informed the development of the TRIP, as its scope covers all five modal administrations and the MDTA (**Figure 2.1**).

Figure 2.1: Maryland Transportation Plans



Source: *MDOT, n.d.*
WMATA = Washington Metropolitan Area Transit Authority

The 2050 MTP is consistent with the **2023 MDOT Climate Pollution Reduction Plan**; the TRIP; and other members of the Maryland family of transportation plans. The 2050 MTP Guiding Principles align the mission, values, and capabilities and serve as overarching, cross-cutting ideas that MDOT strives for through each of the goals, as depicted on **Figure 2.2**.

Figure 2.2: Maryland Transportation Plan Strategic Direction

Source: MDOT, n.d.

The **Maryland Consolidated Transportation Program (CTP)** is Maryland's 6-year capital budget for transportation projects and programs across MDOT that is updated annually. A main theme within the CTP is MDOT's effort to maintain its transportation assets in a State of Good Repair by allocating funds toward system preservation first. Each year, the **Attainment Report on Transportation System Performance (AR)** provides an evaluation of the performance of the state's transportation system and reports on progress toward reaching the key goals listed in the current MTP. The CTP, AR, and MTP form the **State Report on Transportation**, also published annually. MDOT's collective statewide planning timeframes for updating these documents related to resilience initiatives are listed in **Table 2.1**.

Table 2.1: MDOT Statewide Planning Timeframes for Documents Related to Resilience Initiatives

Document	Published	Planning Timeframe
Maryland Transportation Plan	2024	2025-2050 (25 years)
Maryland Consolidated Transportation Program	2022	FY 2023–FY 2028 (6-year capital budget)
Maryland Statewide Transportation Improvement Program	2021	FY 2022–FY 2025 (4-year, fiscally constrained, prioritized projects)
State Report on Transportation	2023	2023 (AR, CTP, and MTP)
Attainment Report on Transportation System Performance	2023	2023
Bicycle and Pedestrian Master Plan	2024	2025-2050 (25 years)
Transportation Systems Management & Operations Plan	2018	2018
State Hazard Mitigation Plan	2021	N/A

FY = fiscal year

Projects within the CTP work to expand or significantly improve facilities or services throughout MDOT's transportation system and may involve planning, environmental studies, design, right-of-way acquisitions, construction, or the purchase of essential equipment related to the facility or service. The Maryland Statewide Transportation Improvement Program (STIP) is a 4-year, fiscally constrained, prioritized set of transportation projects that are compiled from statewide, local, and regional plans. The STIP development process includes the Annual Consultation Process, known as the Fall Tour, in which the CTP is presented to each of the local jurisdictions.

MDOT also produces the annual Climate Action Status Report, which illustrates the progress made toward reducing transportation sector greenhouse gases and is submitted to the MCCC and the Maryland General Assembly.

MDOT is in the process of finalizing a Resiliency Policy to be integrated in and guide agency operations. The policy is being informed by the regulatory landscape at the state, MDOT, and needs identified by the modal administrations, providing a critical piece of the scaffolding needed to move effectively on resilience initiatives cohesively across the agency.

2.1.1 MARYLAND TRANSIT ADMINISTRATION RESILIENCE PLANNING EFFORTS

MTA published the **A Regional Transit Plan for Central Maryland (RTP) in 2020**, a 25-year plan for improving public transportation in central Maryland by addressing traditional transit service and exploring new mobility options and technologies. Within the plan, MTA encourages Maryland transit agencies to identify and protect vulnerable assets to provide continuity of service through flooding and other climate events. These projects are among several public transit projects that are currently being considered for PROTECT formula funds. MTA published Maryland's first draft **Statewide Transit Plan** in January 2022, which provides a 50-year vision of coordinated local, regional, and intercity transit across the state.

2.1.2 MARYLAND PORT ADMINISTRATION RESILIENCE PLANNING EFFORTS

The 2019 **MPA Strategic Plan** provides an overview of cargo and non-cargo goals metrics, sector conditions, and recommended actions. Two identified recommended actions are to implement guidelines for MPA climate change resilience and to study the feasibility of parking structures to add capacity for automobiles and roll-on/roll-off cargo ships.

The **Hurricane Preparedness Plan**, published in 2022, establishes procedures for protecting personnel and securing MPA property and equipment in preparation for hurricane or tropical storm force weather. The goal is to minimize potential deaths, injuries, and property damage and return MPA facilities to normal operations as quickly as possible after a hurricane impacts the Baltimore area.

2.1.3 MARYLAND RAIL RESILIENCE PLANNING EFFORTS

The 2022 **Maryland State Rail Plan** is a 25-year plan outlining investment needs for public and private passenger and freight rail in Maryland while also emphasizing the need for a resilient rail system that anticipates and plans for changing natural or artificial conditions and hazards, including future climate impacts.

2.1.4 RESILIENCE FREIGHT PLANNING EFFORTS

The 2022 **Maryland State Freight Plan** assesses Maryland freight movements and reflects new requirements introduced by IIJA, including freight resilience and environmental impacts. MDOT emphasizes a focus on enhancing the state's multimodal transportation infrastructure resilience as part of a comprehensive approach that includes understanding and assessing transportation system vulnerabilities and integrating climate adaptation and resilience into MDOT's business processes.

2.1.5 INCORPORATING RESILIENCE INTO ASSET MANAGEMENT PLANS

MDOT's 2019 **Strategic Asset Management Plan** establishes a commitment to principles for managing assets including a holistic approach to operations asset management. The MDOT Asset Management Program relies on cross-functional collaboration of knowledgeable staff from each modal administration and MDTA. The program supports MDOT's goals of system preservation, safety and security, quality of service, and fiscal responsibility by committing appropriate resources to asset management. The **Transportation Asset Management Plans** for each mode strategically manage assets through asset inventory, condition assessment, and minimum data standards for assets. The planning timeframes for these plans are provided in **Table 2.2**.

2.1.6 STATEWIDE HAZARD PLANNING

The **State Hazard Mitigation Plan** works to reduce loss of life and property by minimizing the impact of disasters. A set of mitigation strategies are organized into long-term solutions to increase the resilience of the state's assets. Mitigating hazards and their capacity for system disruption supports a resilient and sustainable transportation system. Future investments, such as electric vehicle charging infrastructure, can simultaneously align with and function as hazard mitigation measures.

MDOT participates in and works closely with partners in the Maryland Resiliency Partnership. The partnership works to improve the resiliency of Maryland communities to flood and climate hazards through education, training, outreach, and coordinated project implementation.

Table 2.2: MDOT Modal Administrations Planning Timeframes

Document	Agency	Published
A Regional Transit Plan for Central Maryland	MTA	2020
Statewide Transit Plan	MTA	2022 (draft)
Climate Action Initiatives Summary Report	MTA	2022
MPA Strategic Plan	MPA	2019
Hurricane Preparedness Plan for Marine Terminals	MPA	2022
State Freight Plan	MDOT	2022
State Rail Plan	MDOT	2022
Statewide Truck Parking Study	MDOT	2020
Strategic Asset Management Plan	MDOT	2019
Asset Management Plan	SHA	2021

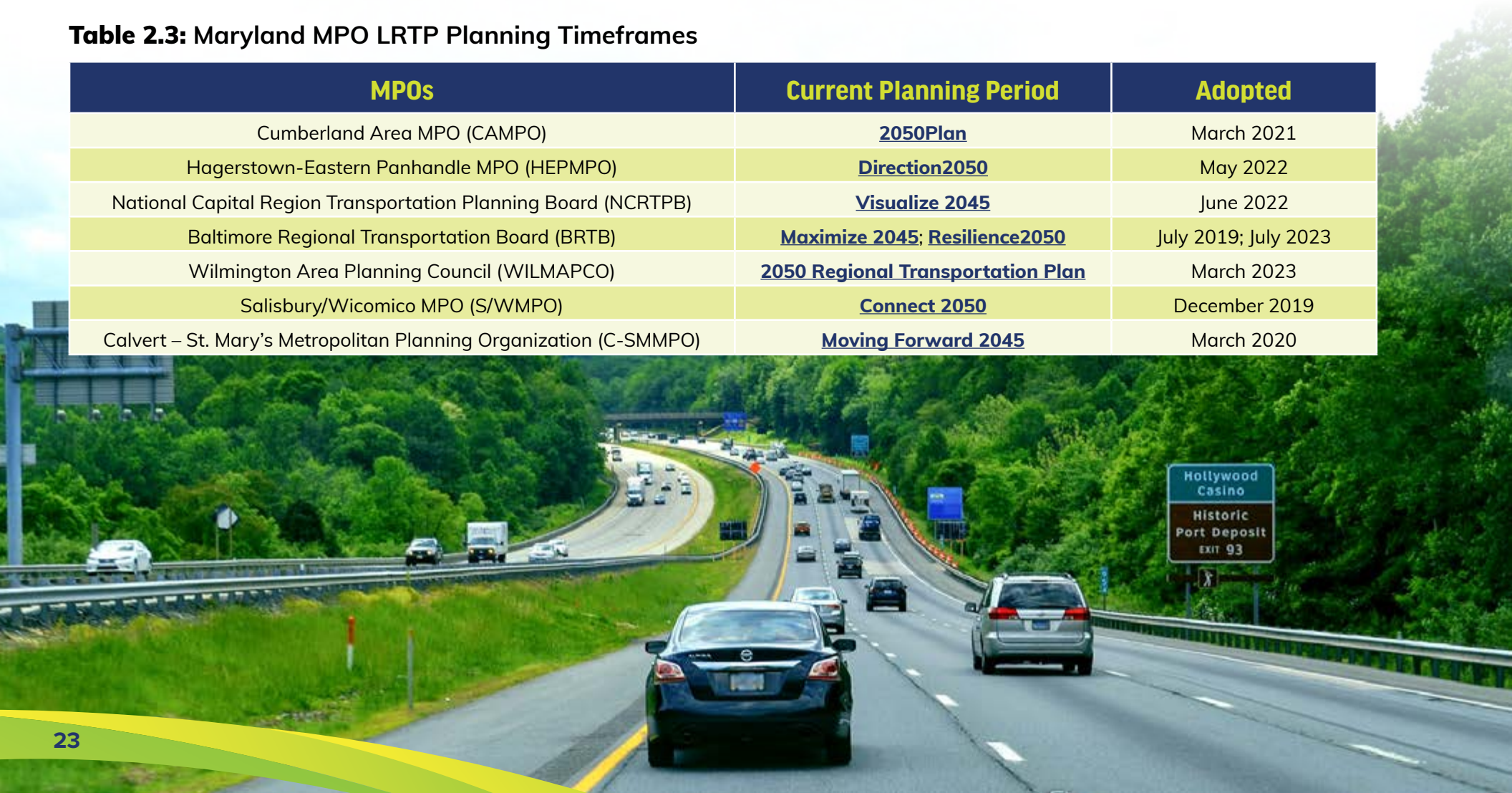
2.2 Regional

MDOT recognizes the need for a coordinated regional approach to provide maximum benefits of resilience initiatives. The significant regional planning activities led by the MPOs provide an existing structure and partnership network for MDOT to collaborate with and confirm that there is alignment in making the investments required to enhance transportation resilience. Each MPO has its own mission, vision, and goals for how to accomplish its priorities, and MDOT works closely with each of them to confirm alignment in approach, decision making, goals, and identifies commonalities when possible.

Long-range transportation plans (LRTPs) provide information on the region's transportation goals and policies, as well as socioeconomic, environmental, and other factors that affect the operation of the transportation system over 20- to 30-year periods. LRTPs include a list of planned major federally funded capital projects, their estimated costs, and the revenues reasonably expected to be available to fund these projects. LRTPs are generally updated every 4 years by their respective MPOs. Through continued engagement and coordination with the MPOs, the MDOT TRIP will be incorporated into the LRTPs by reference. **Table 2.3** highlights the current LRTP for each of Maryland's MPOs.

Table 2.3: Maryland MPO LRTP Planning Timeframes

MPOs	Current Planning Period	Adopted
Cumberland Area MPO (CAMPO)	2050Plan	March 2021
Hagerstown-Eastern Panhandle MPO (HEPMPO)	Direction2050	May 2022
National Capital Region Transportation Planning Board (NCRTPB)	Visualize 2045	June 2022
Baltimore Regional Transportation Board (BRTB)	Maximize 2045; Resilience2050	July 2019; July 2023
Wilmington Area Planning Council (WILMAPCO)	2050 Regional Transportation Plan	March 2023
Salisbury/Wicomico MPO (S/WMPO)	Connect 2050	December 2019
Calvert – St. Mary's Metropolitan Planning Organization (C-SMMPO)	Moving Forward 2045	March 2020



Transportation Improvement Programs (TIPs), which are generally updated every year, provide a 4-year listing of federally funded transportation projects. The TIP is the programming element of the LRTP, listing projects with committed funds and schedules. **Table 2.4** highlights the current TIP for each of Maryland's MPOs.

Table 2.4: Maryland MPO TIP Planning Timeframes

MPO	Current Planning Period	Adopted	Update Planning Period
CAMPO	FY 2022–2025	March 2021	FY 2023–2026
HEPMPO	FY 2023–2026	May 2022	FY 2025–2028
NCRTPB	FY 2023–2026	June 2022	FY 2024–2027
BRTB	FY2024–2027	July 2023	FY 2025–2028
WILMAPCO	FY 2023–2026	May 2022	FY 2024–2027
S/WMPO	FY 2023–2026	December 2022	FY 2024–2027
C-SMMPO	FY 2021–2024	June 2020	FY 2024–2027

Coordination is ongoing between MDOT and the MPOs to identify preferred PROTECT-eligible projects to prioritize for funding. Ultimately, a project must be included in the STIP or an MPO TIP, or both, for PROTECT funding to be obligated. Together, the LRTP and TIP provide an overview of each MPO's transportation planning and programming efforts.

Annually, each county in Maryland and Baltimore City submits a letter of their **Transportation Priorities** to MDOT, highlighting transportation needs and opportunities for their jurisdiction. MDOT reviews these priority letters and kicks off an annual tour in the fall to meet with each county and Baltimore City and share the draft CTP. The CTP is revised based on the priority letters, state needs, state goals, and funding availability. These priority letters provide an important opportunity for identification of local priorities and an understanding of the future needs and opportunities for eligible resilience projects.

In addition to the TIP and annual MDOT CTP tour season, MPOs lead working groups centered on resilience planning and climate change mitigation. For instance, **Metropolitan Washington Council of Governments' Transportation Resilience Working Group** is composed of regional stakeholders that provide input and feedback on key milestones during the development of the Transportation Planning Board's TRIP. The working group collaboratively works toward the completion of a vulnerability assessment, requests resilience project proposals for inclusion in the TRIP, completed a 2023 Resiliency Forum to build knowledge of climate risks and develop resilience solutions, and will draft and finalize the TRIP.

The Maryland Department of Natural Resource developed a **Nuisance Flood Plan Development Guidance** recognizing that communities throughout the State of Maryland face increasing disturbances from episodic nuisance flooding, which can cause roads to be temporarily closed because of high water, overwhelm engineered and natural drainage, and inundate fields and yards.

In addition to the State Hazard Mitigation Plan (Maryland Emergency Management Agency 2021), there are local hazard mitigation plans under the Disaster Relief and Emergency Assistance Act that provide local context, with practical knowledge and strategies that empower citizens, first responders, and government officials to prepare for and respond to natural disasters. MDEM tracks all local hazard mitigation plans and nuisance flood plans on a public facing **map**.

3 DESCRIPTION OF RISK-BASED VULNERABILITY ASSESSMENT

Risk-based vulnerability assessments are a crucial component of well-informed and effective resilience decision making. MDOT and its modal administrations have been conducting vulnerability assessments since 2010. Although these efforts have not consistently followed the same approach or scope, they collectively aim to assess the vulnerability of the transportation system to climate stressors and extreme weather events and identify opportunities for mitigation measures. Additionally, the vulnerability assessments support the development tools and resources that can inform subsequent assessments. Although no single vulnerability assessment can provide all the essential information, when reviewed and evaluated collectively, they can paint a comprehensive picture of MDOT's needs.

As evidence of this, MDOT has worked with its modal administrations to incorporate climate change-based decision making, which are outlined in the sections below. MDOT is in the process of developing standard operating procedures (SOP) that will outline steps, responsible parties, intended outcomes, and timelines to identify and fund PROTECT eligible projects. The SOP will help ensure consistency and compliance with federal programs, funding, and MDOT goals across the modal administrations. The SOP is anticipated to be finalized in summer 2024.

3.1 Maryland Transit Administration

MTA published a **Climate Action Initiatives Summary Report** in 2022 that highlights an Adaptation and Resiliency Toolbox (ARToolbox), designed to aid in implementing adaptation measures at sites previously identified as priority locations in **MTA's Climate Change Vulnerability Assessment** (2016, re-evaluated in 2019 to 2020). The ARToolbox provides a central repository for all efforts leading to the implementation of adaptation and resilience measures that may be applied to MTA assets. In addition, the toolbox provides a comprehensive database of potential adaptation measures that can be implemented at the asset level, assisting designers, planners, engineers, and maintenance staff with the resources needed to establish a proactive approach to a changing climate.

3.2 Maryland Port Administration

The MPA underwent a vulnerability assessment for their port assets in 2010. The conclusions of this assessment were three-pronged: (1) migrate marine terminal infrastructure away from floodplains when possible, (2) elevate MPA facilities above the floodplains, and (3) mitigate damage by improving their resilience to flooding events. MPA is currently updating this vulnerability assessment using funds awarded as part of the Building Resilient Infrastructure and Communities grant.

3.3 State Highway Administration

SHA adopted a similar approach as MPA in 2016 for an adaptation and vulnerability assessment of their own, scoring roadway assets on their vulnerability to different threats, such as storm surge and sea level rise. In 2018, SHA took part in the FHWA **Asset Management, Extreme Weather, and Proxy Indicators Pilot program**. SHA refined and expanded their vulnerability assessment of state assets and implemented specific opportunities to integrate the results into existing asset management, planning, and other processes. The assessment identified 33 bridges highly vulnerable to sea level changes, 172 bridges highly vulnerable to storm surge, and 102 bridges highly vulnerable to precipitation change. SHA currently maintains the **Climate Change Vulnerability Viewer**, an online tool that analyzes a variety of threats, such as coastal sea level rise, storm surge, and nuisance inundation, across multiple assets. Though its primary focus is to inform stakeholders, the viewer also serves as a powerful reminder of what MDOT has already accomplished for risk and resilience planning, along with stakeholder outreach. This tool, however, is just the first step in an overarching plan to move from qualitative risk assessments to quantitative risk assessments.

3.4 Maryland Department of Transportation

Utilizing geospatial information science and digital data stewardship, MDOT is working towards a digitized, geospatial asset inventory that will drive quantitative risk assessments that consider asset location, condition, and design parameters, as well as threat likelihood to support asset level risk assessment. Quantitative risk-based assessments will draw data from existing systems, such as the Climate Change Vulnerability Viewer, Climate Ready Action Boundaries, FEMA Flood Insurance Rate Maps, as well as maintenance records to provide financial risk and system resilience information to support project prioritization. SHA has pilot tested this approach in 2019 along US 50 and MD 450 to further support quantitative benefit cost analyses of a range of engineering strategies for improving system resilience. This pilot provided SHA with a system criticality map (**Figure 3.1**) to better understand which sections of their overall system are most critical from an operations lens taking into account system redundancy, demand, and social vulnerability among other factors. **Figure 3.2** shows the total annual risk costs on MD 450 and US 50, according to this pilot study. Total annual risk is a combination of owner's risk related to asset failures and repairs and user risk related to rerouting around affected assets. Outputs like these are useful tools to understand system risks and help identify potential projects to increase resilience and reduce risk costs to MDOT and travelers.

With threats of climate and hazard-related incidents on the rise, MDOT is committed to using a systematic approach to identify at-risk assets on its system. Furthermore, the envisioned approach will prioritize assets and investments considering annualized risk that incorporate social, economic, and financial impacts such as those derived through the 2019 pilot. The data-driven approach will support enhanced decision-making regarding investments to support benefit-cost assessments of both capital and operationally focused project alternatives.

Figure 3.1: MDOT SHA Roadway Criticality Map

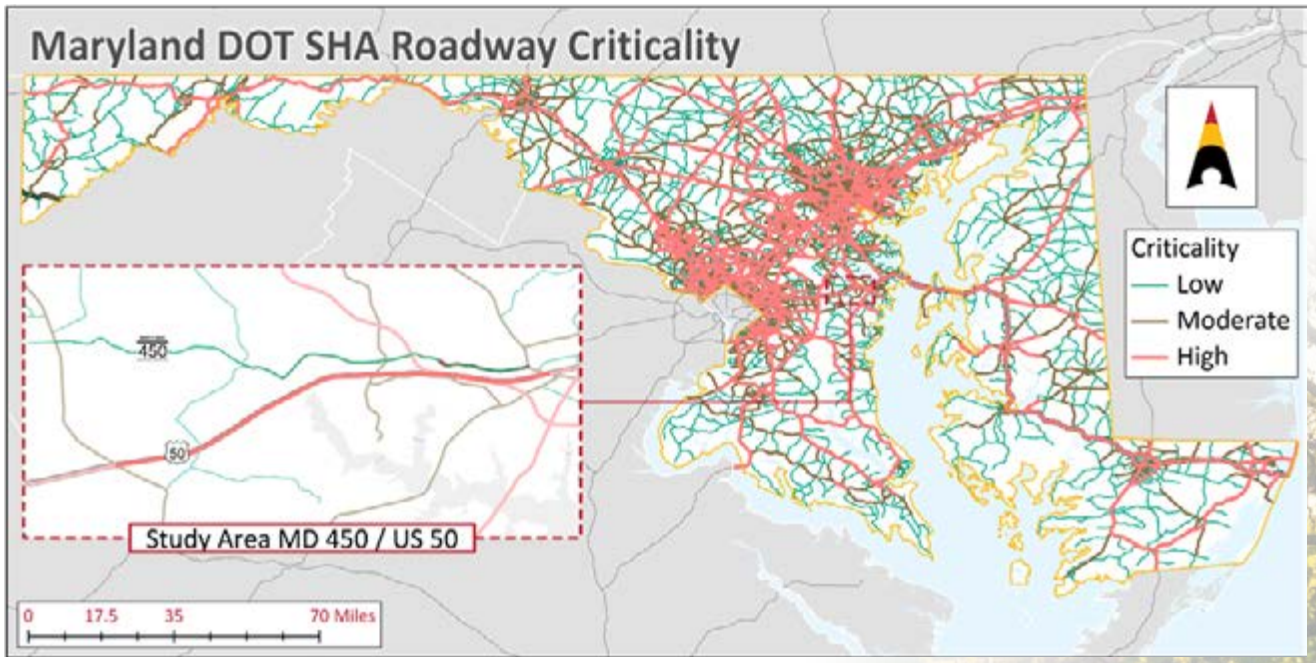
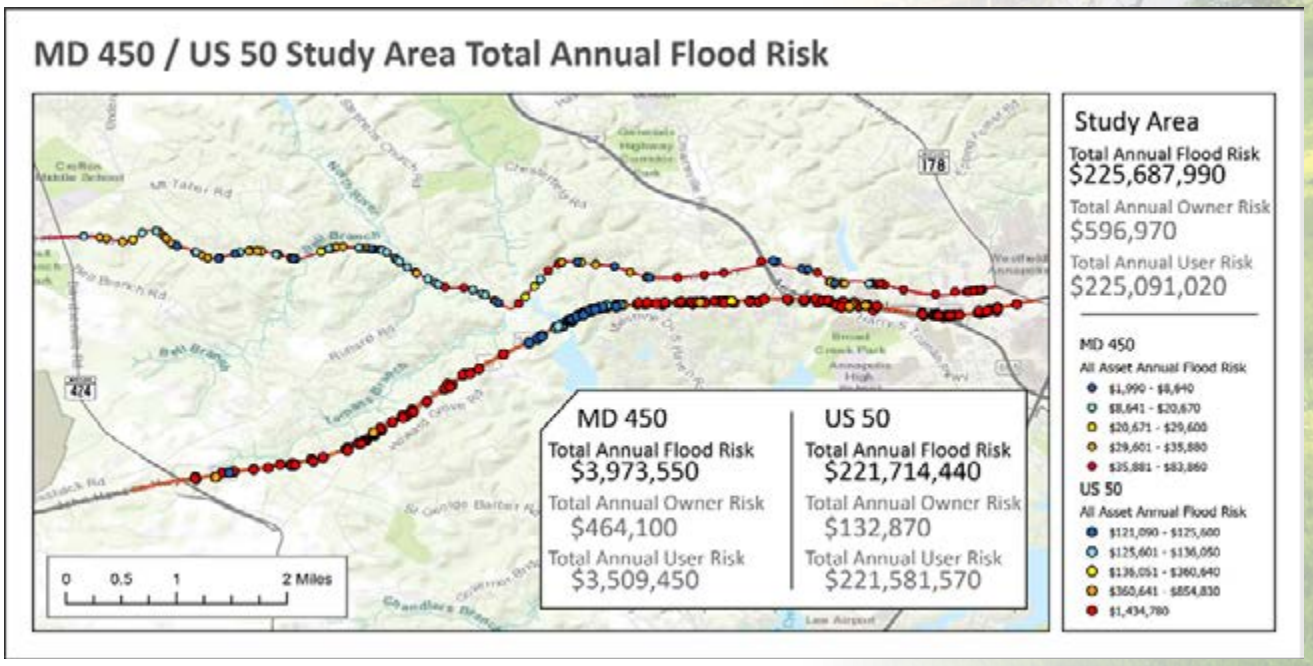


Figure 3.2: Total Annual Flood Risk Costs on MD 450 and US 50



4 RECOMMENDED PRIORITY AREAS FOR RESILIENCE INVESTMENTS

MDOT is committed to promoting resilience through fortifying assets to common threats, implementing natural infrastructure, improving connectivity and redundancy, and confirming resilience incorporation in policy and project development, all while ensuring investments incorporate social and economic considerations.

Maryland has unique geography, which makes the state vulnerable to a wide range of threats. There is no shortage of opportunity to improve resilience, whether it be along the eastern shore to protect from sea level rise, along the Patapsco River to reduce the impacts of riverine flooding, or in Allegany County to reduce threats from rockfall. This unique geography creates a need for thoughtful and creative solutions to prioritize resilience investments.

4.1 Eligible Projects

Activities eligible for PROTECT funds include the following:

- **Planning:** Developing a resilience improvement plan; resilience planning, predesign, design, or the development of data tools to simulate transportation disruption scenarios, including vulnerability assessments; technical capacity building to facilitate the ability of the state to assess the vulnerabilities of its surface transportation assets and community response strategies under current conditions and a range of potential future conditions; or evacuation planning and preparation. States are required to use at least 2% of their PROTECT Formula Program funding each federal fiscal year for resilience-related planning activities, such as developing a resilience improvement plan; resilience planning, predesign, or design; technical capacity building; or evacuation planning and preparation.
- **Resilience Improvements:** Improving the ability of an existing surface transportation asset to withstand one or more elements of a weather event or natural disaster, or to increase the resilience of surface transportation infrastructure from the impacts of changing conditions, such as sea level rise, flooding, wildfires, extreme weather events, and other natural disasters.
- **Community Resilience and Evacuation Routes:** Strengthening and protecting evacuation routes that are essential for providing and supporting evacuations caused by emergency events, including resilience improvements if they will improve evacuation routes and projects to confirm the ability of the evacuation route to provide safe passage during an evacuation and reduce the risk of damage to evacuation routes as a result of future emergency events.
- **At-Risk Coastal Infrastructure:** Strengthening, stabilizing, hardening, elevating, relocating or otherwise enhancing the resilience of highway and non-rail infrastructure, including bridges, roads, pedestrian walkways, and bicycle lanes, and associated infrastructure, such as culverts and tide gates, to protect highways that are subject to, or face increased long-term future risks of, a weather event, a natural disaster, or changing conditions, including coastal flooding, coastal erosion, wave action, storm surge, or sea level rise, to improve transportation and public safety and to reduce costs by avoiding larger future maintenance or rebuilding costs.

To identify eligible projects, MDOT is coordinating with MPOs and the modal administrations to develop a candidate list of resilience activities and projects from the following sources:

- The Consolidated Transportation Program
- The Statewide Transportation Improvement Program
- Long Range Transportation Plans
- Transportation Improvement Program
- Modal-specific asset management plans
- County priority letters
- Direct communication with modal administrations

MDOT will maintain an up-to-date list of eligible projects on the MDOT **Climate Change Website**. The list, provided to FHWA and posted online will include key project information including, but not limited to, project type, location, implementing organization, and a brief scope. The project list will also include the date submitted to FHWA, to ensure MDOT is maximizing the optional federal match reduction.

4.2 Immediate Prioritization Strategies

MDOT is taking an adaptive management approach to PROTECT program implementation, and will incorporate additional prioritization factors as they become feasible. To aid in this, MDOT has established an internal group, including staff from OCCRA and SHA, that will help accelerate PROTECT funding obligations. The Climate Focused Funding Opportunity Strategy, launched in Spring 2024 to optimize identification and funding of agency priorities for both resilience initiatives (PROTECT program) and carbon emissions reduction initiatives (Carbon Reduction Program), includes four phases, from project development through project obligation. This integrated approach will allow for improved identification and evaluation of projects for funding.

MDOT will review projects considering the following factors:

- Project type
- Status of project funding for obligation and inclusion in the STIP/TIP
- Project readiness for implementation
- Asset vulnerability/annual risk to MDOT and users from applicable threats
- Expected asset life cycle
- System resilience and community resilience
- System redundancy, reliability and service needs
- Project advances Justice40 Initiative and regional equity considerations
- Project co-benefits to the health or safety of Maryland's communities
- Community support for project
- Project advances the goals of the Climate Solutions Now Act of 2022
- Project alignment with future land uses

Many strategies exist to address system vulnerabilities from investments that seek to harden assets against relevant threats to the incorporation of nature-based solutions that help reduce impacts, and even planning and operational strategies to better prepare for impending events. MDOT is working to better understand the pros and cons for all project types, including consideration of cost, time to deliver, resources available, and potential co-benefits, to help inform prioritization of projects. Considerations regarding the optimal time for investments to improve resilience based on asset life cycle, criticality to system resilience, and annual risk to both MDOT and users are also under development. MDOT intends to use data from historic events to estimate the potential future cost of damage/loss of service due to climate change. National scale data combined with in-house pay items for original construction, reconstruction, annual maintenance costs, and estimates for user delays and loss of service, can inform not just the future cost of damage, but also whether the proposed resiliency measures will provide a positive return on investment over the asset's life cycle. The methodology, in development at time of publication, is being informed by internal subject matter experts across the modal administrations, along with reviewing federal guidance (e.g. **Benefit-Cost Analysis Guidance for Discretionary Grant Programs**), and industry best practices to ensure the most technically sound approach to life-cycle assessments.

MDOT recognizes both the importance of, and the potential co-benefits from the incorporation of natural based features (NBF) in projects. That is why the agency is working on a methodology that would allow for improved outcomes in screening for potential NBF incorporation, identifying and measuring co-benefits, and ensuring alignment with the state's efforts around NBF. Screening for NBF potential in projects includes overlaying the project location with the Coast Smart Climate Ready Action Boundary (CS-CRAB), the county nuisance flood maps, and any vulnerability dataset provided by the project sponsor. The screening is a critical step to ensure projects will serve the purpose of the PROTECT program, and align with existing State priorities and programs.

Equity is paramount to ensuring a whole-of-community approach to resilience. Maryland utilizes multiple resources to integrate equity considerations into the prioritization process.

- The Maryland Department of Environment **EJ Screening Tool** provides an EJ score as an overall evaluation of an area's conditions, including pollution burden exposure, pollution burden environmental effects, sensitive populations, and socioeconomic indicators.
- The Justice40 Initiative pairs with IIJA to confront and address decades of underinvestment in disadvantaged communities by bringing resources to communities most impacted by climate change, pollution, and environmental hazards. Justice40 is an opportunity to address gaps in transportation infrastructure and public services by working toward the goal that at least 40% of the benefits from many federal grants, programs, and initiatives flow to disadvantaged communities.

4.3 Tracking Progress

A final consideration in prioritizing resilience investments is to align projects with other initiatives at the local, state, and national level. Some of the on-going efforts to incorporate resilience into project development, policy, and standards within Maryland include:

- The Chesapeake Bay Critical Area Protection Program controls future land use development within 1,000 feet of the tidal influence of the Chesapeake Bay.
- The Coast Smart Construction Program requires that, if a State or local capital project meets certain funding criteria and includes the construction of a structure or highway facility, it shall be constructed to withstand a category 2 (Saffir-Simpson hurricane wind scale) storm surge.
- In 2021, the Maryland General Assembly passed the Tree Solutions Now Act to plant and maintain 5 million native trees by 2031, including 500,000 trees in underserved areas. Additional programs include MDOT's **Urban Tree Grant Program** with the Maryland Urban and Community Forest Committee, SHA's **reforestation and tree planting programs**, and several local initiatives.

The listed factors will be considered in MDOT's data-driven, defensible, and transparent project selection process to be deployed in Spring 2024. The process plans for iterative reviews over time that will ensure continued alignment with statewide resilience goals and incorporate the development of quantifiable metrics, including risk reduction, system resilience improvements, and benefit-cost assessments.

Online GIS-based tools will be leveraged to provide for consistent assessment of landscape-based evaluation factors. MDOT intends to bring together GIS data layers and project information to ensure that project selection and development align with the various needs of the communities and transportation system. Informing data sources may include existing system vulnerabilities, the annual risk to MDOT and its users, equity, demographics, Justice40, infrastructure conditions, and more. Project evaluation will also incorporate existing system resilience and annual risk to MDOT and our users as well as return on investment over the life cycle of the project to optimize PROTECT investments once the methodology is finalized.

MDOT is also exploring the capacity to use data sources like those generated by SHA's Coordinated Highways Action Response Team (CHART) and Maryland 511 which assists travelers during weather events and natural disasters. During these events travelers can go to the CHART website for up-to-date information on roadway conditions, traffic incidents, and events, weather data, and view live traffic cameras.

MDOT is developing a Climate Action Plan (CAP) which brings together the entire MDOT climate portfolio (emissions reductions and adaptation and resilience strategies), to inform a coordinated and intentional approach to achieving all climate goals. At the time of writing, MDOT is still evaluating the best method for sharing updates, with internal and external partners, but are committed to transparency in climate action transparency including all actions outlined in the TRIP.

Beyond identifying existing projects in various stages of planning or design, MDOT may develop projects individually or in collaboration with the modal administrations, local agencies, nonprofits, or other organizations. This will serve to create unique uses of PROTECT funds and incorporate co-benefits beyond resilience improvements. MDOT may use such projects as examples of what is possible with the new sources of funding and demonstrate a commitment to Maryland residents. Examples that MDOT may wish to explore include nature-based features such as coastal wetlands, marshes, dunes, oyster reefs, living shorelines, bioswales, urban tree canopies, and permeable pavements.

5 IMPLEMENTATION AND NEXT STEPS

As described throughout the TRIP, MDOT understands the importance of institutionalizing resilience across the state and is working closely with each of the modal administrations. Additionally, MDOT recognizes the value in confirming the strategies outlined in the TRIP are aligned with and incorporated into regional and other statewide planning documents and processes, including the MTP, LRTP, TIP, State Hazard Mitigation Plan, and other plans outlined on ***Figure 2.1****. MDOT will continue coordinating with SHA regarding their recently published Climate Change Resilience Strategy to ensure best practices are shared between both efforts.*

MDOT recognizes the importance of workforce development in the resiliency space to equip staff with the necessary skills and tools to understand and successfully address disruptions caused by natural hazards. MDOT is working to identify opportunities for training available through resources, such as the National Highway Institute, and is encouraging staff participation in new course work. MDOT is also working to develop training that will support critical decision making related to the design of resilient systems, the use of nature-based solutions, and the implementation of economic assessment methods to support the analysis of design alternatives.

Training is especially vital for project and fund managers, as they play a crucial role in confirming the effective planning, execution, and management of transportation projects. The anticipated training will help them anticipate potential risks and vulnerabilities and develop proactive strategies to mitigate them. This approach could safeguard project timelines and budgets while enhancing MDOT's ability to maintain critical transportation infrastructure, providing continued mobility and safety for the public.

MDOT plans to revise the TRIP at least once every 4 years, with interim updates as needed. Serving as a coordinator across the modal administrations and statewide resilience planning efforts, MDOT will work closely with key partners and stakeholders to confirm alignment and coordination among resilience planning documents and processes. This coordination will include the efforts underway through the modal administrations, as well as those happening through MPOs, such as the Metropolitan Washington Council of Governments Transportation Resilience Work Group and the Baltimore Metropolitan Council (BMC). BMC has developed three key resources to support regional resilience efforts: (1) the **Climate Change Resource Guide** and accompanying toolkit, (2) the **Climate Resilience Guidance for Local Jurisdictions**, and (3) **Recommendations for Interjurisdictional Coordination**. This holistic approach to the development of the TRIP and subsequent updates will allow MDOT to ensure the best use of resources to address transportation system resilience.

MDOT will work with partners to identify and select projects and activities that leverage PROTECT funding and improve transportation resilience. The analysis described throughout the TRIP outlines the process, tools, and methodology MDOT will use to identify priority projects or activities eligible for funding under PROTECT, including planning, enhancing community resilience, and improving overall transportation infrastructure resilience and ability to withstand extreme weather events and other natural hazards. As described in **Section 4**, MDOT will actively coordinate with MPOs and modal administrations to develop a list of potential resilience activities and projects that are eligible and priorities for using PROTECT funding.

MDOT is also aware that the field of resilience is evolving and will monitor research initiatives and best practices so that future iterations of the TRIP incorporate these innovations and others, including additional analysis and potential weighting for social vulnerabilities and other co-benefits.

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APPENDIX A

TRIP Alignment with Federal Requirements

Appendix A: TRIP Alignment with Federal Requirements

TRIP Requirements	Section(s) in TRIP	Additional Comments
Will do the following:		
Encompass immediate and long-range planning activities and investments	Sections 4 and 5	N/A
Demonstrate a systemic approach to surface transportation system resilience	Sections 3 and 4	N/A
Be consistent with state and local hazard mitigation plans	Sections 2 and 5	These sections describe the relationship between the TRIP and other Statewide and MDOT planning efforts related to resilience and sustainability. The TRIP will be integral to these planning efforts in Maryland.
Include a risk-based assessment of vulnerabilities to current and future weather events and natural disasters	Section 1 and 3	N/A
Will, as appropriate, do the following:		
Describe improved ability to respond promptly to impacts of weather events and natural disasters and be prepared for changing conditions	Section 3	N/A
Describe codes, standards, and regulatory framework	Sections 2 and 5	N/A
Consider natural infrastructure	Section 4	N/A
Assess resilience of other community assets, including buildings and housing	N/A	Some related information is provided in Section 4.
Use a long-term planning method	Sections 4 and 5	N/A
Include other information	Sections 1 and 2	Ensures collaboration and coordination with federal, state, and local partners

Appendix A: TRIP Alignment with Federal Requirements (Continued)

TRIP Requirements	Section(s) in TRIP	Additional Comments
Will, as appropriate, do the following:		
Evacuation routes	Appendices C and E	N/A
Emergency response plans	N/A	Though a major consideration for resilience planning, this information is not specifically included in this version of the TRIP.
Resilience-related policies	N/A	This will be addressed in MDOT's Climate Action Plan.
Investment plan and prioritized projects	Section 4	Section 4 describes MDOT's strategy for prioritization of projects, including eligibility criteria, risk-based vulnerability assessments, equity considerations, and alignment with other MDOT initiatives.
Use of science and data, including sources of data and methodologies	Appendices C, D and F	This is an overarching theme for many references and information discussed within the TRIP, including the Appendices C through F.

MDOT = *Maryland Department of Transportation*
N/A = *not applicable*
TRIP = *Transportation Resilience Improvement Plan*

APPENDIX B

Family of Plans Alignment with TRIP

Appendix B: Family of Plans Alignment with TRIP

Plan	Relation to Climate Change Resilience and the TRIP
Maryland Transportation Plan	The 2050 MTP highlights MDOT's commitment to providing a safe, secure, and resilient transportation system. The MTP provides much of the strategic direction that informed the development of the TRIP. The 2050 Maryland Transportation Plan (MTP), the "Playbook," will improve how we move goods and services and connect people to the places where they live, work and play. The Playbook clearly outlines Maryland's vision to provide safe, reliable, accessible, equitable, and sustainable transportation options to Marylanders across the State. The TRIP is guided by the Playbook and will help to further the goals and strategies laid out in the Playbook.
Maryland Consolidated Transportation Program	The CTP highlights the investments made for MDOT for next six fiscal years. A main theme within the CTP is MDOT's effort to maintain its transportation assets in a State of Good Repair by allocating funds toward system preservation first. The Consolidated Transportation Program (CTP) is Maryland's six-year capital budget for transportation projects. The Capital Program includes major and minor projects for the Maryland Department of Transportation (MDOT) modal administrations: the Secretary's Office (TSO); the Maryland Aviation Administration (MAA); the Maryland Port Administration (MPA); the Motor Vehicle Administration (MVA); the State Highway Administration (SHA); the Maryland Transit Administration(MTA) – and authorities that are a part of MDOT, including the Maryland Transportation Authority (MDTA) and the Washington Metropolitan Area Transit Authority (WMATA). The CTP provides the funding for projects that advance the state of good repair of transportation assets, as well as for projects that advance the goals laid out in the TRIP.
Maryland's Annual Attainment Report	The Annual Attainment report provides an evaluation of the performance of the stat's transportation system and reports on progress toward reaching the key goals listed in the current MTP. The AR helps to identify where areas of the transportation sector are succeeding as well as areas where more investment are needed. The most recent AR contains a new resilience metric aimed at tracking the percentage of roadway and railway miles susceptible to future flooding.
Maryland Statewide Transportation Improvement Program	The STIP is a 4-year, fiscally constrained, prioritized set of transportation projects that are compiled from statewide, local, and regional plans. The STIP will include the prioritized projects that will implement the goals within the TRIP.
State Hazard Mitigation Plan	The State Hazard Mitigation Plan is a federally required 5-year plan that identifies potential hazards, vulnerabilities to these hazards, and mitigation strategies to reduce future damages. The TRIP is aligned with the hazard mitigation plan and includes the hazards that are most likely to impact the transportation system. Additionally, the TRIP will help to advance the mitigation strategies outlined in the hazard mitigation plan to increase the resilience of states assets.

Appendix B: Family of Plans Alignment with TRIP (Continued)

Plan	Relation to Climate Change Resilience and the TRIP
Transportation Systems Management and Operations (TSMO) Strategic Plan	The Transportation Systems Management and Operations Strategic plan outlines the goals, objectives, and strategies to effectively manage and operate existing facilities and systems to maximize their full-service potential. The TRIP will help to implement the TSMO goals and strategies to provide a more reliable transportation system. The goals outlined in the TSMO plan help to improve transportation management, asset management, and operations, all with the goal of improving transportation reliability.
State Freight Plan	The State Freight Plan assesses Maryland freight movements, multimodal networks, and related details to supplement and support the overarching vision, goals and long-range transportation planning initiatives. The freight plan includes freight resilience strategies, an analysis of freight route conditions, freight resilience performance measures, and freight movement needs. The TRIP will help to advance the freight resilience strategies and help to improve freight resilience and movement.
State Rail Plan	The Maryland State Rail plan is a 25-year plan outlining investment needs for public and private passenger and freight rail in Maryland while also emphasizing the need for a resilient rail system that anticipates and plans for changing natural or artificial conditions and hazards, including future climate impacts. The TRIP will help to advance these goals, while also setting the table for future revisions to further incorporate resilience principles and strategies, all to increase the resilience of rail in Maryland. Additionally, the new performance measure will help to track the percentage of railway mileage susceptible to future flooding to help identify the areas for mitigation strategies.
Strategic Asset Management Plan	The Strategic Asset Management Plan establishes a commitment to principles for managing assets including a holistic approach to operations asset management. The SAMP incorporates resilience focusing on the goals that were outlined in the 2040 Maryland Transportation Plan. The TRIP will help to further incorporate resilience into asset management plans to increase the resilience of transportation assets.
Maryland Bicycle and Pedestrian Master Plan	The 2024 Bicycle and Pedestrian Master Plan identifies goals and strategies for improving active transportation access across the state and helps advance the Maryland Department of Transportation (MDOT) vision to provide safe and convenient active transportation that supports equitable access for all. The BPMP incorporates goals from the 2024 Playbook and outlines recommendations to increase the resilience of active transportation and build resilient communities. The TRIP will help implement recommendations from the BPMP, PROTECT funds can be used to implement active transportation projects.

Appendix B: Family of Plans Alignment with TRIP (Continued)

Plan	Relation to Climate Change Resilience and the TRIP
MPA Hurricane Preparedness Plan	The 2022 Hurricane Preparedness Plan establishes procedures for protecting personnel and securing MPA property and equipment in preparation for hurricane or tropical storm force weather. The plan lays out how to recover from hurricane events to further resilience the port. The plan could be used as a guide for other modal agencies and for other hazards the port identifies as a threat. The TRIP will serve as the overarching guide for how to increase resilience across the modes.
Transportation Asset Management Plan	The TAMP is a federally required document to develop a risk-based asset management plan for the National Highway System to improve or preserve the condition of the asset and the performance of the system. Identifying vulnerable assets and identifying risk is critical to the implementation of the TRIP, particularly in prioritizing assets for mitigation projects. A required element of Resilience Improvement Plans is a risk-based vulnerability assessment, the TRIP built off the vulnerability assessments conducted across the modal administrations.
SHA Asset Management Plan	The SHA Asset Management Plan guides the vision to employ tactical maintenance strategies with a goal of achieving and maintaining a State of Good Repair for all SHA assets. The TRIP will help to build upon asset management efforts to better understand assets risk, criticality, and vulnerability to increase the state of good repair and to increase the resilience of SHA assets.
Truck Parking Study	The Maryland Statewide Truck Parking Study inventoried truck parking locations, identified factors affecting truck parking demand, identified and prioritized undesignated truck parking, conducted outreach with public and private sector freight stakeholders, and identified recommendations to address truck parking needs. The study was undertaken due to the national shortage of truck parking, trucks parked in undesignated areas can increase the exposure of risk to not only themselves but to other roadway users. The recommendations as a result of the study can help to reduce the exposure of the risk and help to meet the goals of the MTP.
Statewide Transit Plan	The Statewide Transit Plan currently in draft, provides a vision for improving public transportation over the next 50 years, with attention to regional context and mobility needs across the state. The TRIP includes goals and strategies for implementing resilience planning as a transit provider. Additionally, the plan lays out potential steps to help advance the strategies listed in the plan and become a more resilient transit services provider.

Appendix B: Family of Plans Alignment with TRIP (Continued)

Plan	Relation to Climate Change Resilience and the TRIP
Central Maryland Regional Transit Plan	The Central Maryland Regional Transit Plan outlines a plan for improving public transportation in the region for the next 25 years. The plan includes goals and strategies to improve public transportation. Multiple goals include connections to resilience, by using resilient design to reduce the risk from extreme weather events, and to minimize impacts during flooding events. The TRIP will serve as a guide for the strategies outlined in the plan to increase reliability in public transportation, minimize customer impacts, and increase resilience of the system.
MDOT MPA Strategic Plan	The 2019 MPA Strategic Plan provides an overview of cargo and non-cargo goals metrics, sector conditions, and recommended actions. The plan identifies two recommendations for resilience, one to implement guidelines for MPA climate change resiliency, and another for studying parking structures as a resilience measure that also serves to add capacity for autos and RoRo. The TRIP will help to implement these recommendations and highlights how MDOT can implement resilience measures and tracking across the modes.
Climate Change Status Reports	The Greenhouse Gas Reduction Act required that MDOT submit an annual report to MDE and the general assembly that highlighted the actions taken to make progress towards the act. The report primarily focuses on the emissions reduction measures that MDOT implemented in the past year, but also highlights resilience initiatives implemented. These reports will help to highlight the work that is implemented through the TRIP.
Carbon Reduction Strategy	The Carbon Reduction Strategy required under the Federal Carbon Reduction Program, documents strategies, programs, and projects to further address transportation sector emissions. Similarly to the CPRP the CRS is designed to ensure that emissions reduction projects are resilient to climate change impacts. MDOT is developing a Climate Action Plan that will combine and build upon the TRIP and the CRS.
Climate Pollution Reduction Plan	The MDOT Climate Pollution Reduction Plan presents MDOT's approach to support the requirements of the Climate Solutions Now Act of 2022. MDOT worked with MDE and stakeholders to develop sector-specific strategies to reduce transportation emissions. The plan incorporates resilience throughout the plan to help ensure that strategies and projects that reduce carbon emissions also ensure that transportation infrastructure is resilient to the impacts of a changing climate.

APPENDIX C

Vulnerability Assessment Summary

Appendix C: Vulnerability Assessment Summary

This appendix includes an overall summary of the components of the many vulnerability assessments completed by the modal administrations. These assessments have helped elevate climate resilience as a concern within the organization. For example, SHA has developed a Climate Change Resilience Strategy to describe how SHA will be addressing key vulnerabilities and increasing its resilience to expected extreme weather events and projected climate variations, including sea level change, storm surge, heavy precipitation, and other extreme weather events. This includes action items and improvements directly related to the vulnerability assessment findings (e.g., updating the SHA Climate Change Vulnerability Viewer (CCVV), The CCVV houses climate data from the assessment; training on how to use the CCVV to identify vulnerable locations and supports informed decision-making processes.

The vulnerability assessment results have been used primarily in a qualitative role to inform conversation and discussions at the planning level (e.g., informing the development of the CTP, MTP, and TAMP). For example, MPA used their vulnerability assessment to determine that stormwater infrastructure improvements would be required under projected storm surge and sea level rise, which is now incorporated in their TAMP under their planned Stormwater Resiliency Management Program.

Table 1: Vulnerability Assessment Components

Modal Admin	Date	Climate Hazards Included	Assets Included	Vulnerability Assessment Overview and Output
SHA	2014	Sea level rise (SLR), storm surge	Coastal highways (including local roads), statewide	**Hazard Vulnerability Index (HVI):** Risk score for all roadways in the state (roads scored at the segment-level), on a scale of 1-4 (low-high). Score based on indicators of exposure and criticality. Asset-level risk scores
	2019	SLR, storm surge, precipitation change/inland flooding	Bridges (National Bridge Inventory only)	**Vulnerability Assessment Scoring Tool (VAST):** Risk score for all bridges in the state, on a scale of 1-4 (low-high). Scores based on indicators of exposure, sensitivity, and criticality.[1] Asset-level risk scores
	2020	Coastal flooding (high tides, SLR, storm surge), inland flooding	Roadways, roadside assets (guardrail, lighting, signage)	Impacts to safety, reduced capacity and functionality of freight movements due to flooding, restricted access to St. George Island. Information provided in the Extreme Weather Trends Assessment Memo.

[1]*The VAST tool uses the term "adaptive capacity" as the third component of vulnerability, but the indicators are related to the criticality of the asset to the overall transportation system (e.g., functional classification, annual average daily traffic).*

Appendix C: Vulnerability Assessment Summary (Continued)

Modal Admin	Date	Climate Hazards Included	Assets Included	Vulnerability Assessment Overview and Output
SHA	2020	Inland flooding	Roadway, bridge, culvert, and pipe assets within the corridor	**MD 450 Risk and Resilience (R&R) Pilot**: Annualized monetary risks of flooding (in dollars) at the asset and corridor level for the MD 450 / US 50 corridor. Asset-level risk scores
MTA	2016	SLR, storm surge, inland flooding	Facilities and assets associated with light rail, freight, Metro, MARC, and commuter bus	Asset-level risk ratings for 75 facilities and assets across 5 modes: Light rail, freight, Metro, MARC, and commuter bus, on a scale of low to very high. Scores are based on likelihood (sensitivity and adaptative capacity) and consequences. Asset-level risk scores
MPA	2010	SLR, storm surge, storms frequency and intensity	Buildings, structures, piers, and associated port infrastructure	Site-level qualitative risk assessment for each port facility/project, with detailed discussion of asset risks Site-level risk summary
	2020	Flooding from extreme rain events or storm surge, extreme temperature, SLR, heavy winds and erosion	Operational impacts, stormwater infrastructure, terminals, workforce, customer service	Potential for weather impacts to negatively impact sedimentation of the channel and impacting port operations, increased occupational exposure and reduced workforce capacity to accommodate extreme temperatures, worsening of seen impacts of undersized stormwater infrastructure, increased frequency of air-draft issues. Information provided in the Extreme Weather Trends Assessment Memo.

Appendix C: Vulnerability Assessment Summary (Continued)

Modal Admin	Date	Climate Hazards Included	Assets Included	Vulnerability Assessment Overview and Output
MVA	2020	Significant Snowstorm, Flooding, Huge Storm (Hurricanes and tornadoes), Wind Gusts, Extreme temperature	Customer service operations (drivers testing, MVA services, VEIP), location assets (MVA facilities), pavement, sidewalks	Assessment identified loss of productivity, loss of customer service, safety issues (visibility, flooded roadways, etc.) and damage to agency and customer assets, at varying levels across the five extreme weather impacts. Information provided in the Extreme Weather Trends Assessment Memo.
	2020	Inland flooding, "huge storm" (hurricane and tornadoes), extreme heat, snowstorm, wind	Facilities (branch locations)	High-level qualitative discussion of vulnerabilities Qualitative assessment
MAA	2020	Hurricanes, earthquakes, extreme heat, extreme cold, flooding (SLR and storm surge)	Fuel storage infrastructure, pavement, lighting systems, on-site drainage systems, operations, off-airport land use	Potential for fuel system failure due to extreme weather, and under-sizing of asset, impacts on airport operations (safety of runways, delay in flights (snow removal, etc.), increased runway length necessitated by temperatures, potentially undersized drainage systems based on future projected rainfall. Information provided in the Extreme Weather Trends Assessment Memo.
MDTA	NA	NA	NA	None

Appendix C: Vulnerability Assessment Summary (Continued)

Table 2: Climate Change Hazards Addressed by Modal Administration

	SLR	Hurricane storm surge	Inland flooding/ precipitation changes	Extreme heat	Significant snowstorm	Wind gust	Landslides
SHA 2014[2]	Yes	Yes	Yes	Yes	No	No	No
SHA – HVI	Yes	Yes	No	No	No	No	No
SHA – VAST	Yes	Yes	Yes	No	No	No	No
MTA	Yes	Yes*	Yes*	No	No	No	No
MPA	Yes	Yes	Yes*	No	No	No	No
MVA*	No	Yes	Yes	Yes	Yes	Yes	No
MAA	NA	NA	NA	NA	NA	NA	NA
MDTA	NA	NA	NA	NA	NA	NA	NA

MDOT considers resilience through the lens of a coordinated approach to risk mitigation and management across the transportation system. This perspective reduces the risk at the asset level while acknowledging the potential for cascading impacts. Many services and systems depend on each other to provide the highest level of service, leading to functional or level of service impacts, where a disruption to one system can cause or exacerbate a disruption in another part of the system. For example, the loss of a major roadway or bridge can impact port facilities capabilities by reducing the capacity for roadways to handle freight movement, drastically reducing the port's productivity, having cascading impacts outside of transportation assets (i.e. supply and demand of goods and workforce income). To address critical interdependencies MDOT works with its partners to understand risks, identify and implement redundant systems, and ensure communication processes are well established. Table 3 highlights some of the interdependencies for three locations in Baltimore City, shown in the image on the right.

[2]*Prior to developing the more detailed, asset-level HVI and VAST assessments for roads and bridges, respectively. SHA conducted a higher-level analysis to prioritize risks across hazards and asset types. This indicates which hazards were included in that analysis.*

Appendix C: Vulnerability Assessment Summary (Continued)

Table 3: Critical Interdependencies

Site	Roadway Maintenance	Hospital Access	FEMA Evacuation Route	MDTA Asset	MTA Bus Routes	Port Access	Freight Route AADT (2017)	Vulnerable
1	City	Yes	Yes	No	Yes	Yes	1135	No
2	MDTA	Yes	Yes	Yes	Yes	Yes	3191	Yes
3	SHA	Yes	Yes	No	Yes	No	551	No

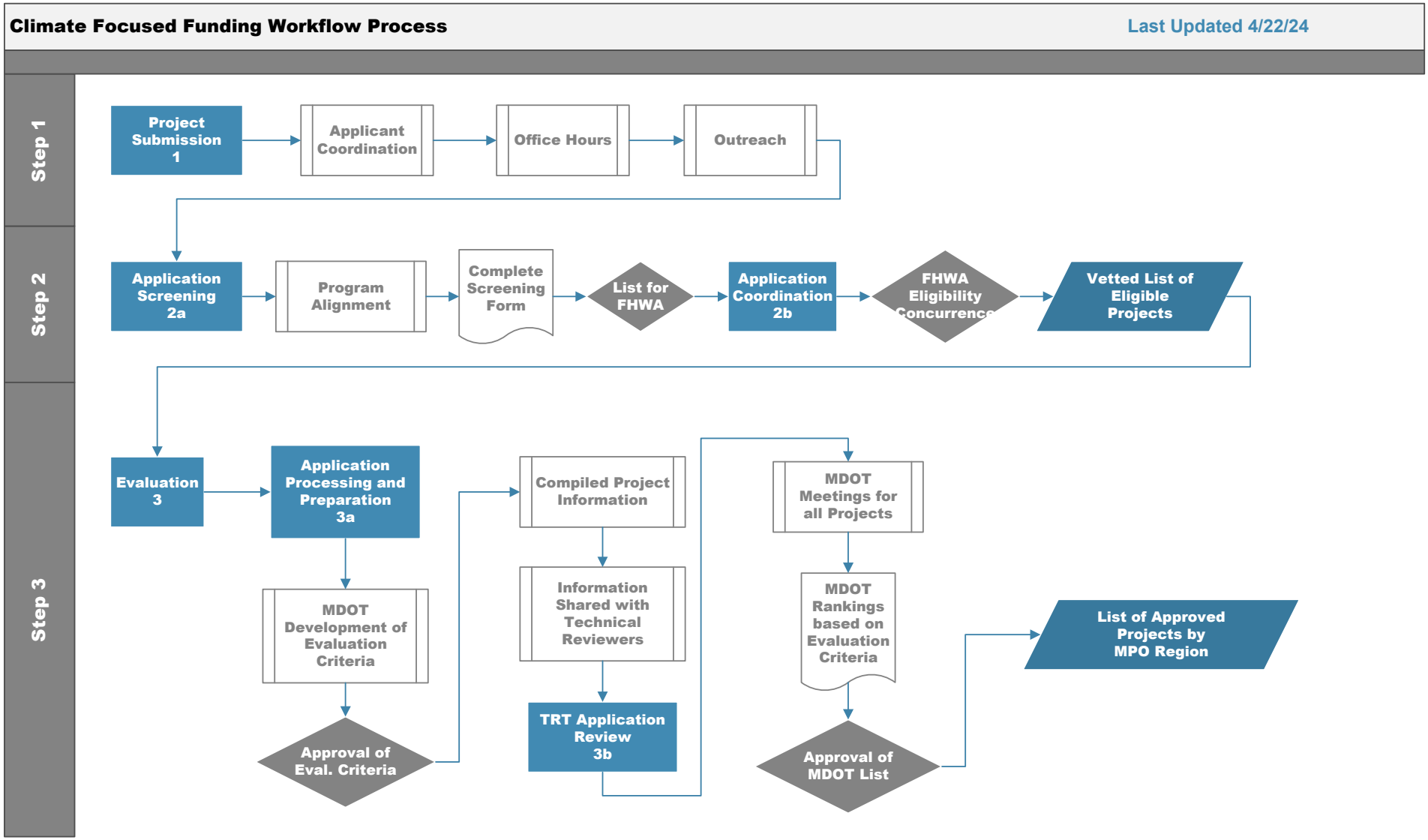
When looking specifically at the example above, location 2 would be prioritized first. MDOT would reach this determination because a flooding event would disrupt freight travel, impact bus routes, and would limit access to community facilities and evacuation routes, therefore having the most significant impact on Maryland. MDOT recognizes the importance of interdependency analysis and is continually working to better understand, collect data on, and integrate the considerations into decision making both on a project-by-project basis, and looking system and statewide.

APPENDIX D

Process Workflow for PROTECT Project Identification, Evaluation and Prioritization

Appendix D: Process Workflow for PROTECT Project Identification, Evaluation and Prioritization

The process diagram shown here for the Standard Operating Procedures includes the workflow for the Carbon Reduction Program as well as the PROTECT program. In support of our incorporated approach to addressing climate issues, deployed a “Climate Focused Funding” program that would encompass both CRP and PROTECT now, and be flexible enough to expand to other program opportunities, should they become available. This approach ensures MDOT prevents the creation of silos, and supports a whole system, whole agency, whole climate approach to addressing the needs of the state.



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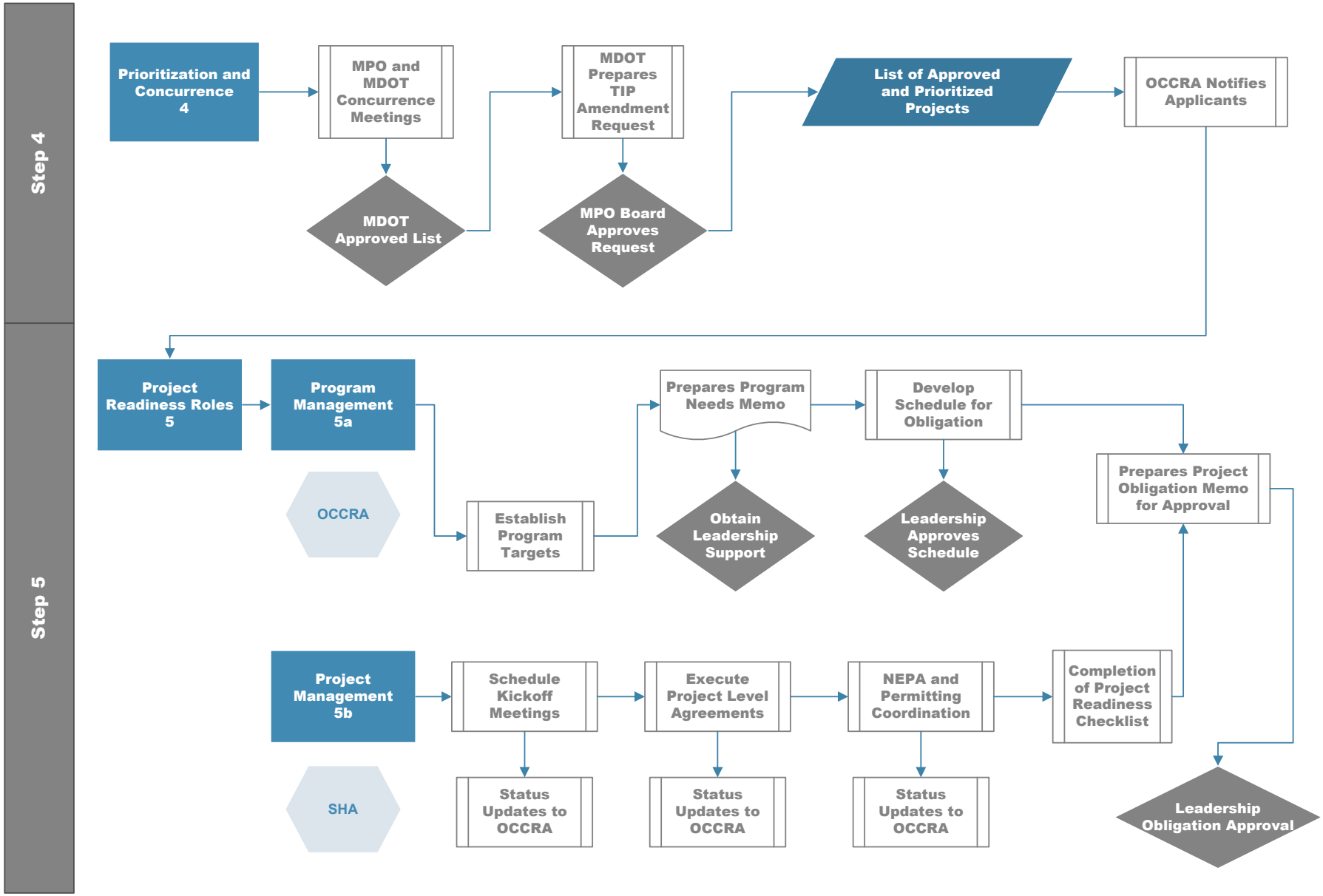
Appendix D: Process Workflow for PROTECT Project Identification, Evaluation and Prioritization (Continued)



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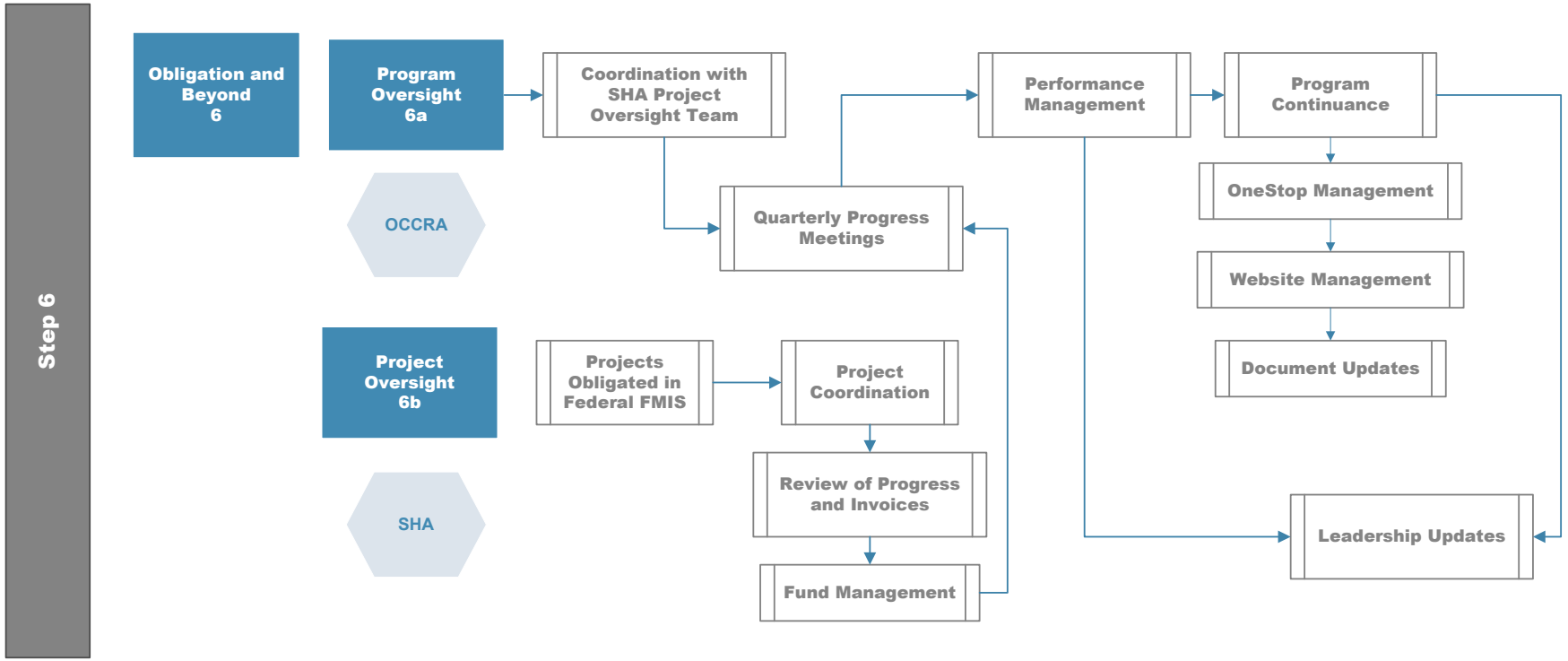
Appendix D: Process Workflow for PROTECT Project Identification, Evaluation and Prioritization (Continued)



APPENDIX E

MDOT Climate Focused Funding Portal – Project Solicitation Application

Application Questions

This document provides an overview of the climate focused funding portal application. Bold text represents the questions in the application and the italicized text represents additional instructions. For any questions on the application please contact **abreitenother@mdot.maryland.gov**.

Legend:

- Bold Text – Application Questions
- Italicized Text – Additional Instructions
- *Required Questions (both PROTECT and CRP)

SECTION 1: PROJECT COMPONENTS

1. ***Project Name**
2. **Project ID or Number** – *this is a unique project ID for your organization, if you do not have a unique ID, leave it blank.*
3. ***Project Sponsor** – *Two-part answer:*
   - You will select the organization type from provided options
   - Short answer to provide your organization or agency's full name.
4. ***Select the MPO Region your project is located in** – *to check your MPO region, please see the map here:* **roads.maryland.gov/mdotsha/pages/index.aspx?PageId=508**
5. ***Project Point of Contact** – *Please provide the name, title, email, and phone number for the contact who can best answer project specific questions (i.e. a Project Manager or Project Engineer)*
6. ***Would you like to provide a secondary contact?** - *Please provide the name, title, email, and phone number of the secondary contact.*
7. ***Does the project manager have prior experience with federal aid funded projects, the federal procurement process, and federal regulations?** – *The answer to this question will not exclude you from receiving funding under this opportunity. This question will provide MDOT with important information to inform support and coordination needs for the program.*
   - **If yes, please select which program(s) the project manager has experience with and provide a brief summary of your experience managing federal funds.**

     Please select which program(s) the project manager has experience with. When possible, provide details of the experience with federal aid funded projects.

     - ☐ Bridge Program
     - ☐ TA/Rec Trails
     - ☐ Safe Routes to School
     - ☐ Other
   - **If no, please describe your organizational structure that exists to manage sub-recipient funding and how it will allow you to receive and utilize federal funding under this opportunity.**

Project Location

8. ***Is your project location specific?**
   - ***If yes, required: County, City /Optional: Route and Mile Points**
     - ***Provide a Google Map link or map upload of your specific project location.**

- **If no, please describe the location(s), region or distribution of your proposed project.**
  - **Provide a Google Map link or map upload of your specific project location.**

9. ***Is your project located in an identified vulnerable area (e.g. CS-CRAB, Community Flood Risk Area, slope failure location, etc.?)** – *Vulnerable area determination can be made via one of the suggested tools or a tool as identified by you. See the Resources Guide for additional tool suggestions.*

- **If yes, please provide a brief explanation as to how you determined your area was vulnerable. Provide information on the adaptation measures you will take to mitigate the risk.**

Project Type and Phase

10. ***Project Phase**

- **Planning**
- **Design – please select Preliminary (Pre-NEPA) or Final (Post-NEPA)**
- **Right of Way**
- **Construction/Utilities**
- **Other (This includes any non-construction projects such as equipment purchases, lighting upgrades, etc.) – Please provide details about the phase your project is in.**

Project Cost and Matching funds

11. ***Overall Project Cost**

12. ***Please upload an estimate for the cost of your project. Be sure your upload includes cash-flows for all years you are requesting funding, and any match available.**

Project Readiness

13. ***Project Readiness** - *Upload your "project Readiness" Form and any relevant permit documentation. In the box below, you may provide any additional or key details relating to your project's readiness for obligation.*

14. ***Will your project require any Right-of-way acquisition?**

- **If yes, please provide status and when you expect ROW to clear.**

15. ***Is your project listed in the most recent STIP/TIP?**

- **If yes, please provide the STIP/TIP ID, including the control number.**

16. ***Does your project support a priority need identified by the modal administration, MPO, or locality?**

- **If yes, please list which priority(ies) the project supports.**

SECTION 2: EMISSIONS REDUCTION COMPONENTS (OPTIONAL FOR PROTECT APPLICATION)

The following section will collect information on the scope of your project and collecting details on the specific decarbonization and emissions reducing components of your project.

17. **Project Scope – Provide an overview of your project scope. The description should include a clear identification of purpose and need, and the proposed approach to addressing that need.**

Project Components

Select all project components present in your proposed project. An answer box will appear for every component selected. In those boxes, please provide an explanation as to how that project component presents in your project and how it is expected to reduce emissions or contribute to decarbonization.

18. **Select all project components present in your proposed project.**

- ☐ Traffic monitoring, management, and control facility or program
- ☐ Public transportation projects under 23 U.S.C. 142
- ☐ On-road and/or off-road pedestrians and/or bicycle trail facilities
- ☐ Advanced transportation and congestion management technologies in 23 U.S.C. 503 (c) (4)(E)
- ☐ Infrastructure-based Intelligent Transportation Systems (ITS)
- ☐ Energy-efficient Street lighting and traffic control device replacement
- ☐ Congestion pricing and transportation demand management (TDM)
- ☐ Efforts to reduce environmental and community impacts from freight movement
- ☐ Projects to support deployment of alternative fuel vehicles, including electric vehicles
- ☐ Diesel engine retrofits
- ☐ Projects to improve traffic flow under CMAQ (23 U.S.C. 149 (b)(5) and 175(c)(1)(L)
- ☐ Projects that reduce transportation emissions at port facilities
- ☐ Public transit projects
- ☐ Other

19. **It is encouraged, when possible, for you to provide the estimated emissions reduction from implementing this project. Please provide the assumptions used to calculated the emissions reduction and the output from any tools used. Providing an estimate of greenhouse gas emissions can help your project and its evaluation. In the resources document there is a list of recommended tools by project type to help estimate the greenhouse gas emissions benefit.**

- **Upload estimated emissions reduction and assumptions documentation.**

SECTION 3: RESILIENCE COMPONENTS (OPTIONAL FOR CRP APPLICATIONS)

20. **Which category(ies) does your project fall into?** – *for each category selected a pop-up box will appear, please provide details on the category.*

- ☐ **Planning**
- ☐ **Resilience Improvement**
- ☐ **Evacuation Planning**
- ☐ **At-Risk Coastal Infrastructure**

21. **Please Indicate which hazards have been identified that may impact the safety, functionality, and resilience of existing infrastructure/ assets, check all that apply.**

- ☐ **Flood Hazards (Coastal, Riverine, Nuisance, Flash Flooding)**
- ☐ **Extreme Temperatures (Extreme Cold, Excessive heat) / Drought**
- ☐ **Severe Weather (Tornadoes, Thunderstorms, Winter Storms, Wildfires, Wind Events)**
- ☐ **Soil Movement (Landslides, Rockfall, Slope/Dam failure, Subsidence)**
- ☐ **Other – Please describe the "other" hazard(s).**

Project Scope

22. **Describe project components which will reduce the impacts from identified threats. Please be sure to include any natural or nature-based features that exist in your site location, or that are included in the design of the project.**

23. **Is there any critical infrastructure included in the scope of this project?**

    - **If yes, please identify what critical infrastructure is included in the scope of this project?**

24. **Does your organization have a climate resilience checklist or similar document to upload as a part of this application?**

    - **If yes, please upload your organizations climate resilience checklist.**

Resilience Metrics

25. **Will this project help meet the identified resilience targets in the long-range transportation plan (LRTP) or other agency plan.**

    - **If yes, please identify the plan and the resilience metric your proposal supports.**

26. **Is your project prioritized within the current MDOT Transportation Resilience Improvement Plan (TRIP)?**

Design Life & Components

27. **Timeframe: What is the anticipated design life for your project?**

    - **Short-term project (design life <25 years)**
    - **Medium-term project (design life between 25-50 years)**
    - **Long-term project (design life between 50-100 years)**
    - **Very long-term project (design life > 100 years)**

28. **Does your project include assumptions for level of service requirements throughout the design life?**

    - **If yes, please describe the assumptions for level of service requirements.**

29. **Does your project consider long-term maintenance and operations needs throughout the design life?**

SECTION 4: ADDITIONAL PROJECT DETAILS AND REVIEW

30. **Please provide any additional information you feel is relevant to the review and evaluation of your project.**

31. **Please upload any additional documents you would like to include with your application.**

APPENDIX F

DRAFT Project Evaluation Process and Methodology for Identifying PROTECT Projects

Appendix F: DRAFT Project Evaluation Process and Methodology for Identifying PROTECT Projects

PROCESS

Applications will pass through an Initial Screening process to evaluate the application for completeness and eligibility. All applications will then transition to the Initial Evaluation process, where a Technical Review Team will evaluate the applications by the provided criteria (subject to change, draft as of 04.30.24).

METHODOLOGY

1. **Criticality**

This scoring is informed by criticality ranking at MDOT (Critical Asset Viewer – Internal). This criterion provides a better understanding of the impact of a disruption to operations should an event occur. A higher impact to the agency's operations would receive a higher score.

Score	Standards
1	No Impact – Low Criticality
2	Low to Medium Impact – Low-Mid Criticality
3	Medium Impact – Mid Criticality
4	Medium High Impact – Mid-High Criticality
5	High Impact – High Criticality

2. **Vulnerability**

This score assesses the asset vulnerability to current and future conditions and hazards. MDOT is working towards an expanded vulnerability assessment that includes the risk to asset users.

Score	Standards
0	Asset is not vulnerable to current or future conditions or hazards
1	Asset is vulnerable to future hazards/conditions
2	Asset is vulnerable to current hazard/conditions
3	Asset is vulnerable to current and future hazards/conditions
4	Asset is vulnerable to multiple current and future hazards/conditions

Score	Standards
0	Asset is outside the CRAB Inundation Zone
1	Asset is located within the 0-to-1-foot Inundation Zone
2	Asset is located within the 1-to-2-foot Inundation Zone
3	Asset is located in the greater than 2-foot Inundation Zone

3. **Equity/Environmental Justice**

Environmental Justice will be assessed using the federal Justice40 tool and the MDE EJ Screening tool.

Score	Standards
0	Project is not located in a Justice40 area or identified by MDE as an EJ community
1	Project is partially within a Justice40 area or MDE EJ community
2	Project is located fully within a Justice40 area or MDE EJ Community
3	Project is located fully within both a Justice40 area and a MDE EJ Community

4. **Co-benefits**

This measure will assess if the project implements co-benefits to Maryland communities. Examples of co-benefits could include economic development, health and safety improvements, carbon reductions, etc.

Score	Standards
1	Project does not implement co-benefits
2	Project implements one additional co-benefit
3	Project implements two additional co-benefits
4	Project implements three or more additional co-benefits

5. **Priority Alignment**

The priority project alignment will be assessed based on the priority alignment identified on the application, and additional alignment as identified by the Technical Review Team(s).

Score	Standards
4	Project is listed on 4 or more local, regional, or state plans as a priority.
3	Project is listed on 2-3 local, regional, or state plan as a priority
2	Project is listed on one local, regional, or state plan as a priority
1	Project is not listed on a local, regional, or state priority plan

APPENDIX G

Acronyms and Abbreviations

Appendix G: Acronyms and Abbreviations

Abbreviation	Description
AR	Attainment Report on Transportation System Performance
ARToolbox	Adaptation and Resiliency Toolbox
BMC	Baltimore Metropolitan Council
BRTB	Baltimore Regional Transportation Board
C-SMMPO	Calvert – St. Mary's Metropolitan Planning Organization
CAMPO	Cumberland Area Metropolitan Planning Organization
CRAB	Climate Ready Action Boundary
CTP	Consolidated Transportation Program
EJ	Environmental Justice
FEMA	Federal Emergency Management Agency
FY	Fiscal Year
FFY	Federal Fiscal Year
FHWA	Federal Highway Administration
HEPMPO	Hagerstown/Eastern Panhandle Metropolitan Planning Organization
IIJA	Infrastructure Investment and Jobs Act
LRTP	Long-Range Transportation Plan
MAA	Maryland Aviation Administration
MCCC	Maryland Commission on Climate Change
MDEM	Maryland Department of Emergency Management
MDOT	Maryland Department of Transportation

Abbreviation	Description
MDTA	Maryland Transportation Authority
MPA	Maryland Port Administration
MPO	Metropolitan Planning Organization
MTA	Maryland Transit Administration
MTP	Maryland Transportation Plan
MVA	Motor Vehicle Administration
N/A	Not Applicable
NCRTPB	National Capital Region Transportation Planning Board
NOAA	National Oceanic and Atmospheric Administration
OCCRA	Office of Climate Change Resilience and Adaptation (MDOT TSO)
PROTECT	Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation
RTP	Regional Transit Plan
SHA	State Highway Administration
STIP	Statewide Transportation Improvement Program
S/WMPO	Salisbury/WICOMICO Metropolitan Planning Organization
TIP	Transportation Improvement Program
TRIP	Transportation Resilience Improvement Plan
TSO	Transportation Secretary's Office
USDOT	U.S. Department of Transportation
WILMAPCO	Wilmington Area Planning Council

TRANSPORTATION RESILIENCE IMPROVEMENT PLAN

2024

MDOT MARYLAND DEPARTMENT OF TRANSPORTATION