



U.S. Department
of Transportation
**Federal Highway
Administration**

Delaware Division

September 7, 2023

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In Reply Refer To:
HDA-DE

The Honorable Nicole Majeski
Secretary
Delaware Department of Transportation
800 Bay Road
Dover, DE 19901

Dear Secretary Majeski:

This letter serves as the Federal Highway Administration's (FHWA) determination that the Delaware Department of Transportation (DelDOT) Resiliency Improvement Plan (DRIP) meets all the minimum requirements provided in 23 U.S.C. 176(e)(2).

As noted in the Delaware Resiliency Improvement Plan, DelDOT intends to update the DRIP once every four years with consideration for an earlier update as Delaware implements resiliency measures to ensure consistency with statewide directives.

For future updates FHWA requests a 30-day notification to review any updates to the plan.

When requesting project approval in the Fiscal Management Information System (FMIS): Please include a note identifying which projects you wish to apply a 3% and/or 7% reduced federal share. The note should include a reference to the date FHWA determined the plan to be complete, whether the Resilience Improvement Plan is incorporated in the current Long-Range Statewide Transportation Plan, and whether the project is included on a prioritized project list within the Resilience Improvement Plan.

We would like to commend you and your staff for participating in the development and implementation of the Resiliency Improvement Plan.

If you have any questions, please contact Enos Han (Enos.Han@dot.gov) at (302) 273-4018.

Sincerely,

Douglas S. Atkin
Federal Highway Administration
Division Administrator

cc: Shanté Hastings, DelDOT
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Delaware Resilience Improvement Plan



Executive Summary

The U.S. Department of Transportation’s Federal Highway Administration (FHWA) released the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program guidance in July 2022, providing funding for states and communities to prepare for extreme weather and climate change. The program includes \$7.3 billion in formula funding and \$1.4 billion in discretionary grants for 2022-2026, focusing on enhancing the resilience of transportation infrastructure. Delaware has received approximately \$30 million in formula funding and may also pursue further PROTECT discretionary grants.

The Delaware Department of Transportation (DelDOT) has developed this *Delaware Resilience Improvement Plan* (DRIP) to serve as a roadmap for thoughtful investment in critical infrastructure, to proactively identify and address action items, and to tailor both adaptation and mitigation measures towards the agency’s resilience goals. The DRIP was prepared in alignment with federal requirements and guidelines established in the PROTECT Formula Program Implementation Guidance released by the FHWA in 2022 (INFORMATION: Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Formula Program Implementation Guidance (dot.gov)). Specifically, the DRIP was developed in accordance with Section G (3) focused on the development of Resilience Improvement Plans.

Section 1 of the DRIP provides an overview of Delaware’s transportation system, identifies threats, and highlights ongoing resilience planning efforts. Section 2 presents DelDOT’s framework for integrating resilience into all project phases (illustrated in Figure ES-1 below), including strategies to mitigate weather and prepare for changing conditions, such as sea level rise and increased flood risk. Incorporating resilient measures into DelDOT’s projects is vital for withstanding and recovering from hazards.



Figure ES-1. DeIDOT Framework for Resilience Integration.

Section 3 outlines Delaware’s risk assessment efforts, including a workshop and development of a risk assessment for frequently flooded roadways. Section 4 describes DeIDOT’s PROTECT investment strategy, considering factors such as equity, criticality, evacuation needs, route redundancy, and project readiness. The investment strategy aims to meet federal requirements and contribute to the Justice40 Initiative Goals.

The proposed investment strategy involves a continuous feedback loop, incorporating risk models and prioritization factors like community size, route importance, project bundling, and timeliness. The prioritization factors discussed in this section aim to provide a safer, more resilient, and more equitable transportation system for everyone using the transportation network in Delaware, supporting DeIDOT’s mission of providing Excellence in Transportation for Every Trip, Every Mode, Every Dollar and Everyone. Finally, Section 5 provides DeIDOT’s planned process for updating the DRIP and next steps in the resilience planning process.

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1. Background Information

In July 2022, the U.S. Department of Transportation's Federal Highway Administration (FHWA) released guidance for the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program. The PROTECT Program includes \$7.3 billion in formula funding, as well as \$1.4 billion in discretionary or grant funding for Federal Fiscal Years (FFY) 2022-2026 to help states and communities prepare for and respond to extreme weather events and the effects of climate change. This first-of-its-kind program addresses the impact of extreme weather and climate change to America's transportation infrastructure such as roads, bridges, and rail lines. The program stemmed from the \$1.2 trillion Infrastructure Investment and Jobs Act (IIJA) passed by Congress and enacted by the Biden-Harris Administration in 2021. On April 21, 2023, a Notice of Proposed Funding (NOFO) was announced authorizing \$848 million in discretionary grants for FFY 2022 and 2023 (U.S. DOT, 2023).

The PROTECT Formula Program provides focused funding to states for FFY 2022-2026 to plan for and implement resilience improvements to transportation assets and at-risk highway infrastructure (U.S. DOT, 2022). Through the PROTECT program, Delaware has been allocated approximately \$30 million in Formula Funding between FFY 2022-2026 to increase the resilience of its transportation system. Delaware also may pursue PROTECT discretionary grants available through the PROTECT Program.

The Delaware Department of Transportation (DelDOT) understands the importance of resilience planning and stands behind responsible environmental stewardship as noted in our [Strategic Implementation Plan for Climate Change, Sustainability and Resilience for Transportation](#) published in 2017. More recently, in 2021, the agency created a unique Division of Transportation Resilience and Sustainability (TR&S) that reports directly to the Secretary of Transportation and has its own dedicated funding. DelDOT has developed this *Delaware Resilience Improvement Plan* (DRIP) to serve as a roadmap for thoughtful investment in critical infrastructure, to proactively identify and address action items, and to tailor both adaptation and mitigation measures towards the agency's resilience goals.

The DRIP was prepared in alignment with federal requirements and guidelines established in the PROTECT Formula Program Implementation Guidance released by the FHWA in 2022 (INFORMATION: Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Formula Program Implementation Guidance. Specifically, the DRIP was developed in accordance with Section G (3) focused on the development of Resilience Improvement Plans.

The DRIP's primary purpose is to embed climate and extreme weather considerations into project planning and development, prioritization, and life cycle planning to ensure the

sustainable financing of infrastructure assets. DeIDOT also aims to integrate climate risk assessment into decision-making across all asset class and project life cycles and to provide strategies for defending against, accommodating, or planning for managed retreat from climate-related hazards.

The development of this DRIP has intentional timeframes for the various components included. In the short term (<5 years), DeIDOT will be addressing the immediate and critical flooding needs across the state of our road and bridge inventory. Details of our approach are found later in this DRIP but as our Asset Management program matures, additional assets will be folded into this work including drainage structures, overhead sign structures, pedestrian infrastructure, traffic operations equipment, and other various infrastructure components required for an effective multi-modal transportation network. The incorporation of the DRIP into DeIDOT's Long Range Transportation Plan will also happen within this timeframe.

In the median term (<10 years), DeIDOT will continue to address the remaining list of vulnerable transportation infrastructure assets as well as any newly identified resiliency challenges within the network. In addition, DeIDOT plans to have added managed retreat as a viable flood mitigation option through policy and/or state legislation. DeIDOT has initiated this sensitive conversation, recognizing that this proactive strategy will ensure the safety of the public, conservation of natural resources, and the sustainability of its investments. These policy discussions on managed retreat will require in-depth, multi-faceted discussions that will involve many state agencies, diverse partners and stakeholders, and the public.

For the long-term horizon (>10 years), the planning studies that have been initiated for SR 1, SR 9, and SR 299 will be progressing through design to the point of construction for these critical corridors. Interim projects will be completed as needed in the short-term to maximize the operational capacity and safety for these critical corridors.

DeIDOT has drafted this DRIP with a focus on the segments of the transportation network that are most vulnerable to flooding across the state. The current prioritization process involves the review and evaluation of our road and bridge network. As we mitigate the flooding on those prioritized segments, focus will then shift to our multi-modal transportation network including public transit and our extensive bicycle and pedestrian network including sidewalks, bike trails, and multi-use paths. This wider ranging systematic approach will look at other natural hazards beyond flooding and envelop other climatic stressors such as temperature extremes, urban heat island effect, and how our planning decisions across the entire transportation network can be incorporated for the best outcome for our state.

The remainder of this section provides an overview of the State of Delaware and DeIDOT's transportation system, identifies key threats to the system, provides definitions of importance from a risk and resilience perspective and highlights the resilience planning efforts that are taking place in Delaware.

1.1 Overview of Delaware & DeIDOT's Transportation System

DeIDOT is responsible for managing and maintaining the state's transportation system which includes a range of assets, including roadways, bridges, public transit, and bicycle and pedestrian facilities. DeIDOT maintains an extensive network of roadways including interstate highways, state routes, local roads, and subdivision streets.

As of 2022, DeIDOT maintains the following transportation assets:

- 12,124 lane miles of roadways,
- 1,782 bridges,
- 1,600 state routes,
- 1 ferry,
- 1,100 traffic signals,
- 300,000 street signs,
- 323 miles of fiber optic cables,
- 150 traffic cameras,
- 700 Intelligent Transportation System (ITS) devices,
- 2,800 pedestrian signal push buttons,
- 1,376 miles of storm drains,
- 3,514 miles of drainage ditches,
- 85,000 drainage structures, and
- 540 storm water management facilities (DeIDOT, 2022).



Figure 1: National Highway System in Delaware
(Source: DeIDOT TAMP, 2022)

This inventory includes Delaware's two interstate highways: I-95 and I-495, shown on **Figure 1**. I-95 runs southwest to northeast from Elkton, Maryland through Newark and Wilmington, Delaware to Pennsylvania in the southeastern part of the state just south of Philadelphia, whereas I-495 serves as a bypass around the City of Wilmington. Roadways maintained by DeIDOT also includes a comprehensive system of state routes that connect various communities and regions within the state. DeIDOT's inventory includes

local roads that serve communities, neighborhoods, and rural areas, as depicted in **Figure 2**.



Figure 2: DeIDOT Transportation Map
(Source: Delaware Transportation Facts 2018)

is evidenced by DeIDOT’s operation and maintenance of approximately 90% of all roadway mileage in the state. This is significant as Delaware has much less county, town, and municipal-owned and maintained infrastructure than other states. DeIDOT is also one of a small number of states with responsibility for maintaining secondary and suburban roads, which are most often managed by local jurisdictions, in addition to state primary or numbered routes (DeIDOT, 2022).

DeIDOT also maintains approximately 1,782 bridge structures. In Delaware, any structure with an opening greater than twenty feet (6 meters) and a minimum vertical clearance of four feet (1.2 meters) is defined as a bridge (DeIDOT, 2022). In addition to structures carrying pedestrian traffic, a “bridge” can include a frame/box culvert, pipe culvert structures, and traditional bridge structures.

It is important to note that specific lane and mileage details may vary over time as DeIDOT continues to develop and maintain the transportation infrastructure in Delaware. Additionally, DeIDOT’s transportation system management is unique when compared to other U.S. states and Departments of Transportation. This is

1.2 Threats to DeIDOT System

In Delaware, climate change primarily takes the form of sea level rise, increasing temperatures, and more frequent intense storms, including heavy precipitation and flooding. As these events become more and more frequent and intense, the structure and operations of portions of our transportation network could be significantly impacted. This DRIP has been developed with the intention of identifying these locations and incorporating the appropriate planning strategies engineering standards to make them more resilient to such events. As DeIDOT addresses these locations across the network, strategies for future efforts can be identified to address other natural hazards beyond flooding.

The Delaware Emergency Management Agency (DEMA) recently released the *Delaware State Hazard Mitigation Plan* to identify potential hazards, vulnerabilities to these hazards, and mitigation strategies to reduce future damages. The plan placed emphasis on the identification and prioritization of potential mitigation actions that will assist Delaware in becoming less vulnerable to the forces of natural and non-natural hazards.

The plan identified twelve natural hazards that could potentially impact Delaware within the next five years. The hazards selected for discussion below and identified in DEMA's plan are the primary threats to DeIDOT's transportation system and include coastal erosion, coastal flooding, inland flooding, and sea level rise. The remainder of the natural hazards identified in the plan includes: dam/levee failure flooding, drought, earthquakes, extreme temperatures, local earth movement, severe thunderstorms and tornadoes, severe winter weather, tropical cyclones, and wildlife (2023).

Coastal erosion describes a variety of shoreline changes such as beach topography, loss of sand from beaches or potential impacts to dunes. Delaware encompasses 381 miles of shoreline, including twenty-four miles along the Atlantic Ocean as shown on **Figure 3** (DEMA, 2023). The state has several "hotspot" beaches that are being monitored and, on average, all erode four feet (1.2 meters) per year. Coastal erosion has a direct impact on DeIDOT's transportation system, especially roads, bridges, and utilities and this erosion rate is expected to continue (DEMA, 2023).



Figure 3: Delaware Water Sources (Source: DEMA's 2023 Plan)

Coastal flooding is defined as a rise in sea level to above-normal levels due to high tides, onshore winds, and/or low atmospheric pressure on land that is adjacent to the ocean or its connected bodies of water. Between 2000 and 2022, Delaware reported forty-eight coastal flood events that resulted in \$49,712,000 in reported property damage (DEMA, 2023). Coastal flooding has a direct impact on DelDOT’s transportation system, especially roads and bridges. Additional challenges are presented when coastal flooding occurs during evacuations or when caused by events that require evacuation (e.g., hurricanes).

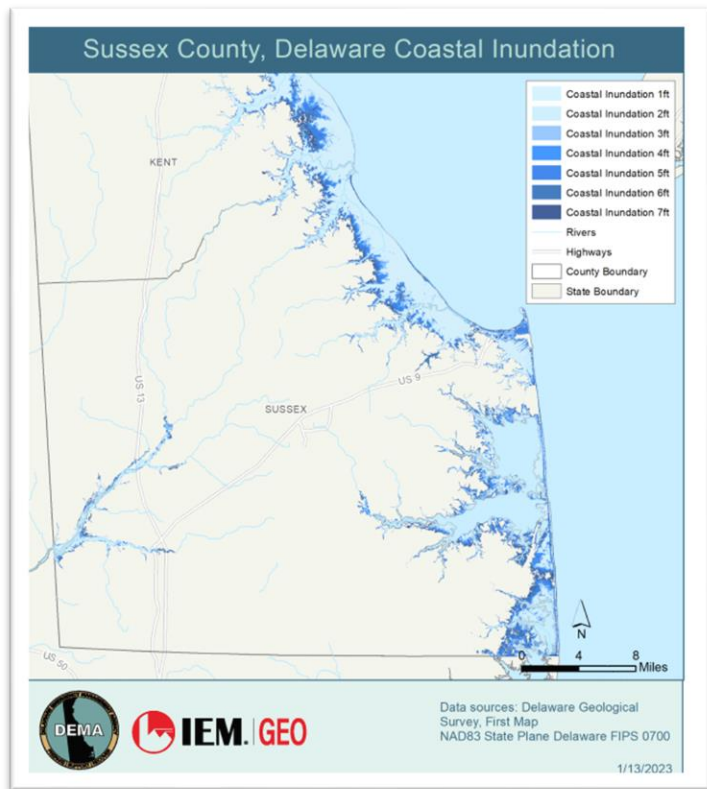


Figure 4: Sussex County Coastal Inundation (Source: DEMA’s 2023 Plan)

Inland flooding, including flash flooding, is defined by any high flow or overflow by water which causes damage. Between 2000 and 2022, Delaware experienced 214 days of inland flooding events (DEMA, 2023). Inland flooding has a direct impact on flooded roads and can cause infrastructure damage or accelerate deterioration. An overview of Delaware’s inland and coastal flooding events from 2000 to 2022 is presented in Table 1.

Table 1: Overview of Flood Events

	Inland Flooding Events between 2000 to 2022	Coastal Flood Events between 2000 – 2022
Number of events	214	48
Cost of events	Qualitative effect (direct impact on flooded roads)	\$49,712,000

Delaware is the state with the lowest mean level elevation (60 feet) in the nation and is particularly vulnerable to the effects of rising sea levels. In fact, the entire state is classified as a coastal zone, as no geographic location within the state is more than eight miles from tidal waters (DEMA, 2023). Sea level rise, a significant effect from climate change, can lead to inundation of wetlands and other low-lying lands, erosion of beaches, intensified flooding, and increased salinity of rivers, bays, and groundwater tables. It is estimated that between 8% and 11% of the state's land area (including wetlands) could be inundated by a sea level rise of 1.5 to 5 feet (0.5 to 1.5 meters) (DEMA, 2023). An example of this is displayed in **Figure 4** on the previous page of coastal inundation in Sussex County. This threat will continue to have a vast impact on DeIDOT's transportation infrastructure for the foreseeable future.

1.3 Definitions of Importance

There are several definitions that are key to define to ensure consistency within DeIDOT and with its partners. Drawing from the recently completed *National Cooperative Highway Research Program Project (NCHRP) 23-09 Scoping Study to Develop the Basis for a Highway Standard to Conduct an All-Hazards Risk and Resilience Analysis*, these definitions are provided in Appendix A as a reference for the reader. Given the relatively new implementation of climate resilience work within the transportation sector, DeIDOT has not formally adopted definitions for their resilience program but is aware of on-going efforts in the industry through the Transportation Research Board (TRB), FHWA, American Society of Civil Engineers (ASCE), American Association of State Highway and Transportation Officials (AASHTO), and other infrastructure organizations to standardize definitions and procedures for assessment. To that end, the terms and definitions provided in Appendix A represent a selection of terms that may be useful to the reader and will be considered by DeIDOT as a launching point for future efforts to establish a more formal glossary of terms to assist staff, partners, and the public to better understand risk-reducing and resilience improvement management and strategies applicable to the transportation sector.

1.4 Resilience Planning Efforts in Delaware

As the lowest mean elevation state in the nation, DeIDOT has experienced the impacts of climate change and sea level rise on transportation infrastructure for many years and has been at the forefront in evaluating and addressing these impacts. Tidal flooding often affects infrastructure including roadways that can be further exasperated during storm events. The DeIDOT Secretary of Transportation estimates that the state has \$1 billion dollars of infrastructure vulnerable to the impacts of climate change (AASHTO, 2022).

In 2021, DeIDOT created the Division of Transportation Resilience and Sustainability to ensure full incorporation of resiliency into infrastructure projects statewide and to collaborate with external stakeholders across the state to ensure the resiliency of the state's transportation system. This division plays a crucial role in engaging with DeIDOT's Cabinet Secretary and collaborating with other divisions within the agency to ensure resilience and sustainability considerations are integrated throughout the transportation planning, design, construction, maintenance, and operation processes.

During the design and construction phase, TR&S staff collaborate with engineers and construction teams to incorporate resilient and sustainable practices and technologies into infrastructure projects. The division staff also works closely with the Traffic Operations and Maintenance & Operations Divisions to incorporate resilience measures into the maintenance and operation investments such as developing emergency response plans and implementing climate resilience strategies. This integrated approach helps DeIDOT develop and maintain a resilient, sustainable, and future-ready transportation system.

DeIDOT and the State of Delaware have been striving for environmental stewardship for many years and have several ongoing efforts and initiatives to combat climate change. DeIDOT's key planning activities integrating resiliency and sustainability into its operations and transportation planning include:

- [Strategic Implementation Plan for Climate Change, Sustainability, and Resilience for Transportation, 2017](#)
- [Statewide Long Range Transportation Plan, 2019](#)
- [DNREC's Climate Action Plan, 2021](#)
- [NEVI and state EV plan 2022](#)
- [DTC's Climate Action Plan, 2022](#)
- [Transportation Asset Management Plan, 2022](#)
- Carbon Reduction Strategy (anticipated Fall 2023)
- Congestion Mitigation and Air Quality (CMAQ) Programs State Initiatives (ongoing). Includes target setting, emission calculations and FHWA reporting
- DEMA's State Hazard Mitigation Plan

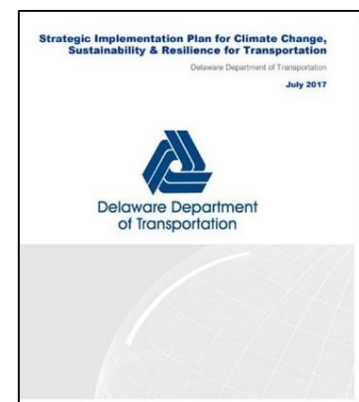


Figure 5: SIP Cover Page

Delaware was one of the first states to develop a strategic and cohesive plan to promote a more resilient and sustainable transportation system (**Figure 5**). [DeIDOT's Strategic Implementation Plan for Climate Change, Sustainability, and Resilience for](#)

[Transportation](#) (SIP) was developed in response to Executive Order 41 issued by Governor Carney in 2013. Executive Order 41 required that all state agencies incorporate measures for adapting to increased flooding and sea-level rise in the siting and design of state-funded projects for new construction and reconstruction of substantially damaged buildings and infrastructure. The SIP recognized the need to mitigate greenhouse gas emissions, adapt to changing climatic conditions, and ensure a reliable and efficient transportation system. Among other objectives, this plan emphasized the need to enhance the resilience of transportation infrastructure to withstand extreme weather events, rising sea levels, and other climate-related hazards. It also included strategies for assessing vulnerability, identifying risks, and implementing measures to enhance infrastructure durability (DeIDOT, 2017).

DeIDOT’s “Innovation in Motion” [Statewide Long Range Transportation Plan](#) (LRTP) was created in 2019 and serves as a comprehensive guide for the future development of Delaware’s transportation system. The LRTP is currently being updated and will further integrate sustainability and resilience considerations into transportation planning processes by focusing on creating a well-connected, multimodal transportation network that enhances safety, addresses climate change impacts, and promotes environmentally responsible transportation choices. The plan will be policy-based and will focus on DeIDOT’s Framework of Excellence, displayed on **Figure 6**, that include:

- Safety,
- Congestion management,
- State of good repair,
- Economic development,
- Equity in transportation,
- Resilience, sustainability and environmental stewardship,
- Transportation innovation,
- Customer service, and
- Employee engagement.

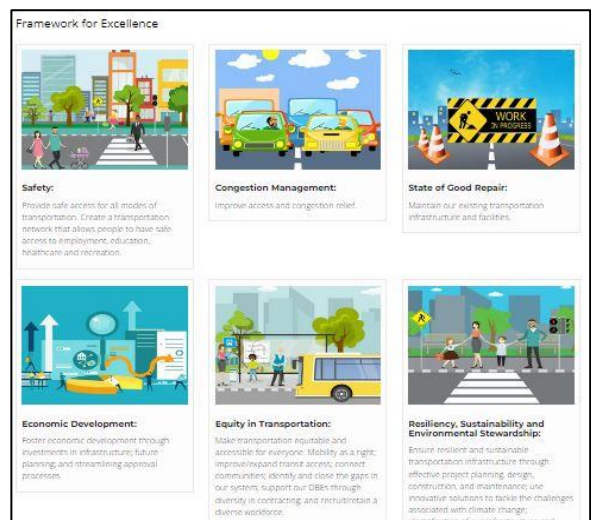
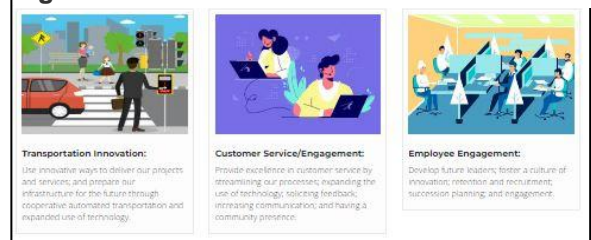


Figure 6: DeIDOT's Framework for Excellence



Recently, in partnership with DeIDOT, the Delaware Department of Natural Resources and Environmental Control (DNREC) developed a statewide plan to address the challenges of a low-lying state. The [Climate Action Plan](#), released in November 2021 outlines strategies and goals to mitigate

greenhouse gas emissions and adapt to the impacts of climate change. The plan addresses various sectors, including transportation, energy, agriculture, and land use. In the transportation sector, the plan aims to reduce vehicle emissions, promote alternative transportation modes, and enhance transportation infrastructure resilience (DNREC, 2023). DeIDOT also worked closely with DNREC for the state's [NEVI Plan and statewide electric vehicle \(EV\) plan](#) to further reduce vehicle emissions in the state.

Building on the Climate Action Plan for the State, DeIDOT has begun the development of its *Carbon Reduction Strategy* to minimize the environmental impact of transportation activities and to align with Delaware's broader sustainability goals. Through this strategy, DeIDOT is actively exploring various initiatives such as promoting alternative fuel vehicles, expanding public transit options, and improving infrastructure to support non-motorized transportation modes. A prioritized list of federal-aid eligible projects anticipates using about \$27 million dollars in Carbon Reduction Program Formula funding for FFY 22-26. This plan will be completed and submitted to the FHWA Division Office by November of 2023.

The Delaware Transit Corporation (DTC) is an operating division of DeIDOT with a mission to design and provide the highest quality public transportation services that satisfy the needs of the customer and the community. In April 2022, DTC released their first [Climate Action Plan](#) to achieve a 50% reduction in its total greenhouse gas emissions by 2030. To reach this target from the 2016 baseline year, DTC established energy efficiency and energy use objectives for its revenue fleet, support vehicles, and facilities (DTC, 2022). DTC's Climate Action Plan and DNREC's Climate Action Plan differ in that DTC's focus is decarbonization of the transportation sector, while DNREC's focus encompasses all polluters in the state including agriculture, industry, transportation, etc.

Additional ongoing resiliency efforts by DeIDOT include the [Transportation Asset Management Plan](#) (TAMP) recently updated in December 2022. This plan guides the management and maintenance of DeIDOT's transportation assets to optimize the performance, safety, and resilience of the transportation infrastructure by incorporating asset management principles into investment decision-making. The TAMP aims to effectively allocate resources, prioritize investments, and enhance the long-term sustainability of the transportation system, serving as a merger of economics with engineering and maintenance to guide strategic infrastructure investment decisions.

DeIDOT also worked closely with DEMA to update the Delaware State Hazard Mitigation Plan to ensure the document referenced the existing and potential hazards, vulnerabilities, and mitigation strategies to reduce future damage to our transportation

infrastructure and related assets. Consistent with DeIDOT's risk and resilience analysis, DEMA's plan identified the primary threats to DeIDOT's transportation system include coastal erosion, coastal flooding, inland flooding, and sea level rise. For the short-term, these are the threats that the DRIP is currently focused. The remainder of the natural hazards identified in DEMA's plan includes: dam/levee failure flooding, drought, earthquakes, extreme temperatures, local earth movement, severe thunderstorms and tornadoes, severe winter weather, tropical cyclones, and wildlife (2023). From a long-term perspective, DeIDOT will continue to enhance future resiliency improvement plans to address these less frequent but no less important potential natural threats.



To complement and enhance DeIDOT's resiliency strategies, DeIDOT has also developed an Equity Analysis Tool that incorporates census and residential land use data to identify neighborhood block groups in which the department should more keenly focus to ensure the equitable distribution of funding and appropriate public outreach. The identification of these "Equity Focus Areas" will help DeIDOT to make data-driven investment decisions, provide data for public outreach and engagement, and establish a standardized tool to be used Department and state wide. DeIDOT's Equity Analysis Tool utilizes established methodologies from WILMAPCO's Transportation Justice Analysis and Massachusetts' Disadvantaged Communities Analysis to create its Tool. This a step above what other state agencies have done to define vulnerabilities, disadvantaged and/or underserved communities as DeIDOT's Tool is much more granular and able to focus on the specific locations of these communities. More specifically, it speaks to the fact that many of the underserved areas of Delaware are along local roads and not eligible for federal funding investments. As such, it will allow DeIDOT to identify what other benefits can be experienced through federal funding investments in adjacent projects (such as multi-modal infrastructure, electric vehicle charging, etc.). Benefits from these investments include: (1) better air quality, since electric vehicle chargers make the use of electric vehicles more accessible, (2) work force development in and near disadvantaged communities from investment programs and projects, and (3) overall emission reductions. At implementation, DeIDOT plans to incorporate the data resulting from this analysis into the capital project prioritization process and for all other sections of the Department to utilize for strategic decision making such as outreach, investments, and analysis. DeIDOT is already using

this data in the prioritization of frequently flooded roadway segments that are eligible for PROTECT formula funding.

From the state perspective, DeIDOT has taken the lead in this initiative in response to the requirements of Executive Order 14008 implementing Justice40 and the Delaware's 151st General Assembly House Concurrent Resolution 40 that created an oversight committee to study and make findings and recommendations regarding environmental justice in Delaware. Since Delaware does not have a formal definition of "disadvantaged communities", DeIDOT is sharing the data and analysis from its Equity Analysis Tool with other Delaware state agencies to ensure the equitable distribution of funding and benefits.

DeIDOT is committed to advancing resiliency and sustainability within its transportation system. Through these initiatives, DeIDOT aims to create a more resilient, sustainable, and future-ready transportation network for the benefit of Delaware's residents, businesses, and the environment. **Figure 7** demonstrates the relationship between these ongoing studies, and how the DRIP is drawing from previously completed studies and will be integrated into future editions of the LRTP, TAMP, and other relevant plans. **Figure 8** also provides insight into the efforts being taken at DeIDOT to incorporate quantitative risk assessments into future editions of the DRIP and support other plans such as the 2026 TAMP. DeIDOT will utilize a GIS-based model to track investments over time in system resilience and update climate risk to assets as investments are made to protect assets via PROTECT funding or traditional asset management strategies.

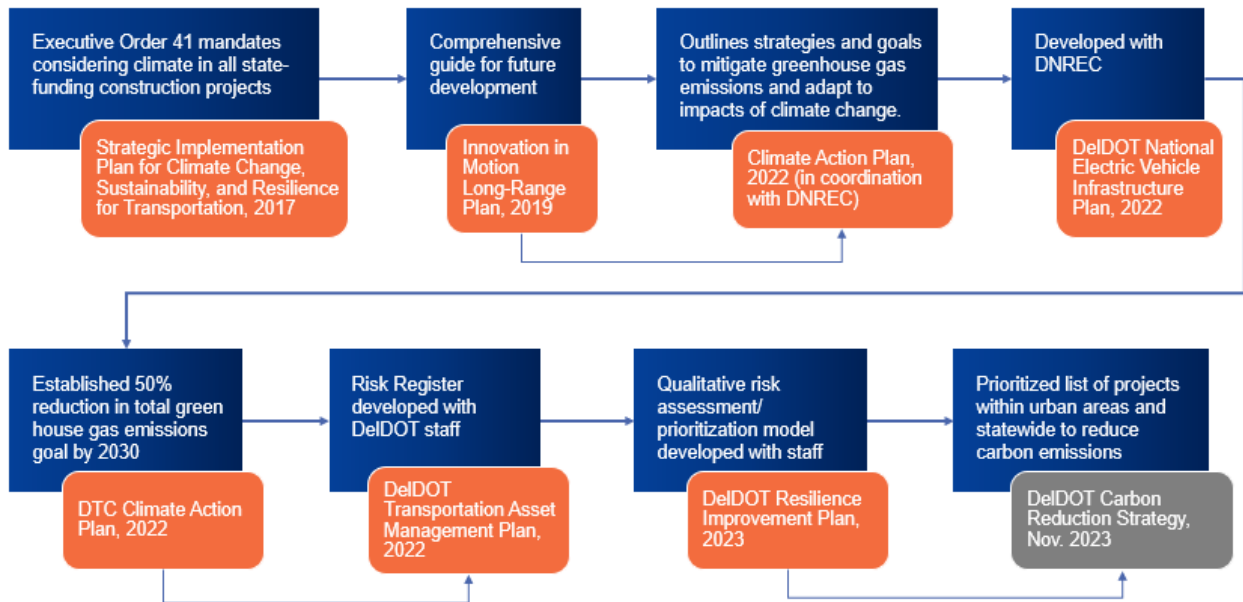


Figure 77: Relationship between Ongoing Studies and the DRIP

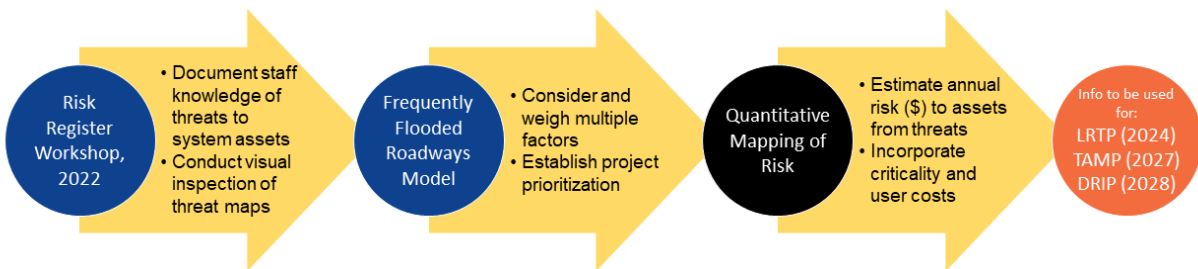


Figure 88: Process to Incorporate Risk into Future Planning Documents

These efforts by DeIDOT have supported Delaware’s recent Bond Rating Review. In the review, Delaware’s actions on climate resilience were lauded, including a nod to the state’s stable finances and strong management and governance of its public infrastructure. DeIDOT’s creation of the Division of Transportation Resilience and Sustainability, as well as its fiscally responsible capital investment program for fiscal years 2023-2028, were noted as significant measures (S&P Global, 2022) and contributed to the agency’s high bond rating.

The Delaware Resilience Improvement Plan will be the first of many on a proposed four-year reporting cycle. The anticipated completion of the DRIP will enable findings to be directly incorporated and referenced in DeIDOT’s LRTP with the intention to further support climate responsibility and resiliency into project considerations and prioritizations while integrating these suggestions and thought processes into the long-range planning process. As with anything that is first of its kind, at the end of the first four-year period,

this will serve as a benchmark for future endeavors that will determine if we build on the initial framework, or pivot based on lessons learned.

1.5 Innovative Climate Response & Leadership Efforts at DeIDOT

While many planning efforts have recently been completed or are in development to address climate resilience and incorporate these concepts into practice, DeIDOT's Division of TR&S is actively engaged to identify and address resilience needs now. Of note, DeIDOT is conducting several flood studies throughout the state with three key coastal studies, State Route 1 (SR 1), State Route 9 (SR 9), and State Route 299 (SR 299) as well as working to enhance the coastal resilience of several local street networks.

The *SR1 Coastal Corridor Resilience Study* focuses on assessing and enhancing the resilience of the SR1 coastal corridor. This study aims to identify vulnerabilities and develop strategies to address potential climate change impacts, such as sea-level rise and increased storm intensity. The goal is to ensure the long-term viability and resilience of the SR1 corridor, which is vital for coastal communities and economic activities (DeIDOT, no date) within the state.

Delaware is also undertaking efforts to improve the resilience of SR 9 between New Castle and Little Creek as this corridor is vulnerable to flooding and other climate-related challenges. Through infrastructure enhancements, such as raising road elevations, improving drainage systems, and incorporating resilient design features, the aim is to increase the corridor's resilience to climate impacts, ensuring reliable transportation and reducing disruptions.

Additionally, Delaware is enhancing the resilience of SR 299 east of Odessa as this roadway has experienced flooding and other climate-related issues making it impassable at times. Efforts are underway to improve the road's resilience through infrastructure upgrades, flooded roadway safety signage, and a long-term study of the area to ensure its availability during high water events. These measures will enhance the corridor's ability to withstand climate-related events and maintain reliable transportation access.

DeIDOT is also actively seeking innovative solutions for climate-challenged low-lying areas that service small coastal communities and one-way in, one-way out roadways. One such example is South Bowers Road, a small, local facility serving approximately thirty-six homes. The roadway was experiencing roadway overtopping during high tide and small rainfall events. Multiple challenges including surrounding wetlands and roadway settlement concerns spurred DeIDOT TR&S to seek an innovative solution for the facility. The short-term solution included utilizing fabric wrapped stone and two layers of porous asphalt installed over the existing grade and existing asphalt, as shown in **Figures 9 and 10**.



Figure 99: Installation of Fabric Wrapped Stone

The roadway was experiencing roadway overtopping during high tide and small rainfall events. Multiple challenges including surrounding wetlands and roadway settlement concerns spurred DeIDOT TR&S to seek an innovative solution for the facility. The short-term solution included utilizing fabric wrapped stone and two layers of porous asphalt installed over the existing grade and existing asphalt, as shown in **Figures 9 and 10**.

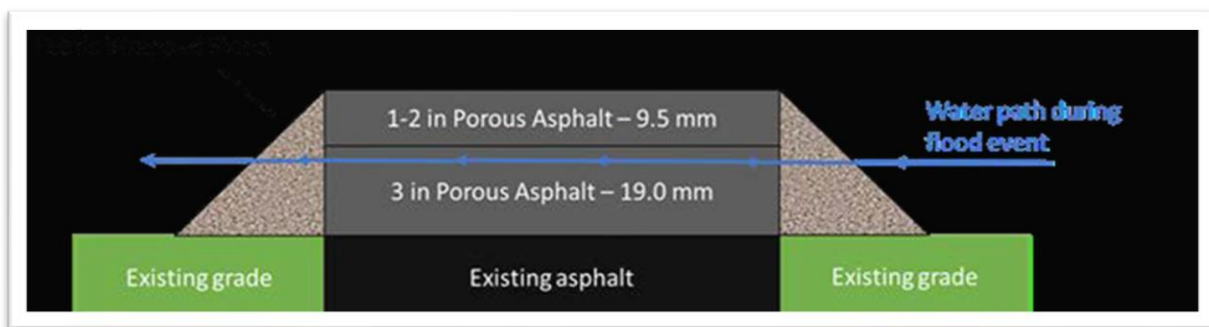


Figure 1010: Display of Porous Asphalt Solution

DeIDOT also recognizes the need for operational resilience and is working to improve community resilience in Woodland Beach, another one-way in, one-way out coastal community serving approximately forty-eight homes. This small community is serviced by Woodland Beach Road and has also experienced frequent periods of flooding. Short-term solutions generated with the UD included deploying low-cost sensors and “Water on Road” warning systems (**Figures 12, 13 & 14**). These operational warning signs are also being expanded to include live updates on DeIDOT’s Traffic Management website and DeIDOT App to notify travelers when conditions are poor, or travel impeded on the facility.



Figure 1111: Dewatering Efforts along South Bowers Road Prior to Paving Demonstrating High Water Levels Encountered

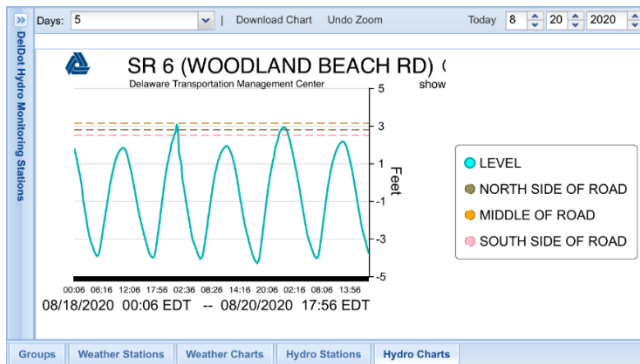


Figure 1213: "Water on Road" Warning Sign System

The “Water on Road” warning sign system example on Woodland Beach Road demonstrates how DeIDOT uses technology to monitor and communicate flooded roadway concerns to travelers. The current system, monitored through DeIDOT’s Traffic Management Center uses an extensive network of tide gauge monitors throughout the state to send that information to the public. DeIDOT has also started discussions with NOAA about using machine learning to predict and communicate roadway flooding



Figure 1123: One-way In, One-way Out Access to Woodland Beach

through the analysis of live, traffic camera feeds. That discussion is ongoing, but DeIDOT is excited about the use of this technology to assist in the efficient analysis of operations during future weather or tidal events so our planning and response can be effective for the safety of the public.

Nationally, DeIDOT staff are active members in AASHTO's Committee on Transportation System Security and Resilience (CTSSR) and multiple TRB NCHRP Panels. These types of engagements with peer industry leaders provide an opportunity for information exchange and exposure to emerging research and practices.

These initiatives highlight Delaware's commitment to addressing climate change impacts and promoting sustainability throughout the transportation network. By conducting specific studies, such as the SR 1 Coastal Corridor Resilience Study, and prioritizing resilience improvements along SR 9 and SR 299, Delaware aims to enhance infrastructure resilience, reduce vulnerabilities, and ensure a more sustainable and resilient transportation system. The DRIP aims to serve as an additional tool to support a more robust prioritization and decision-making process for resilience management.

2. Framework for Resilience Integration

DeIDOT is working toward a future where resilience and sustainability are fully considered and integrated into the project lifecycle, from planning to development, design, construction, operations, and maintenance. Incorporating resilient measures into DeIDOT's projects is crucial for mitigating the impacts of future damage and ensuring the infrastructure is capable of withstanding and recovering from various hazards.

The framework for resilience integration will aid DeIDOT in developing the following strategies to mitigate the impacts of weather events and natural disasters and prepare for changing conditions, such as sea level rise and increased flood risk:

- Conduct vulnerability assessments;
- Integrate resilience into planning;
- Establish design standards and guidelines;
- Foster collaboration and coordination;
- Integrate resilience criteria into project development and selection; and
- Provide resilience training; and monitor and evaluate resilience measures.

These efforts above are on-going across the Department. The newly established Water Resource Engineer position has been tasked with creating design standards associated with climate change and establishing sea level rise design standards for the Department and state. We envision a draft of this design standard in 2023 with deployment in 2024. Once design standards are developed and approved, there will be extensive outreach across the Department for all designers to become aware and use the standards and guidance for the design of a resilient transportation network.

This framework is illustrated in **Figure 15** and each of the strategies is described in further detail on the following pages.



Figure 1414: "Water on Road" Warning Sign System



Figure 15. DeIDOT Framework for Resilience Integration.

Conduct Vulnerability Assessments

DeIDOT has begun assessing the vulnerability and associated risks of highway assets through both existing documents such as the *Part 667 Twice Damaged Assets Report* submitted to FHWA and the most recent TAMP. In addition, DeIDOT worked with its District Staff to identify frequently flooded roadways using a qualitative rating matrix as outlined in Table 2 in the following section of the DRIP.

The information gathered through this effort helped to identify those areas of concern on the roadway network based on qualitative and empirical information drawn from the experience and expertise of the DeIDOT Maintenance & Operations field staff. In addition, DeIDOT has mapped these identified areas to help establish project areas to begin to strategically invest in improving the overall system resilience.

For bridges, DeIDOT conducts inspections and prepares a [State of Good Repair \(SOGR\)](#) assessment annually that provides an inventory and condition assessment – based on National Bridge Inventory Condition Ratings – that is used to identify and prioritize bridge projects for funding and serves as an important input to the TAMP.

Building on the qualitative matrix used to identify frequently flooded roadways, and the SOGR report used to identify and prioritize bridge projects, DeIDOT has initiated a quantitative risk-based study to quantify the annual risk to highway assets and the traveling public from probable flooding threats. Continuing to analyze risks while conducting vulnerability assessments will be vital to laying the framework. DeIDOT envisions utilizing both the qualitative matrix and the output from the quantitative risk assessment to support their overall strategic resilient investment plan for PROTECT Formula Funding.

Integrate Resilience into Planning

DelDOT is constantly working to integrate and coordinate their project planning efforts with federal and Metropolitan Planning Organization (MPO) cycles, and the DRIP will support and foster this collaboration and coordination. Integrating resilience into planning involves conducting a comprehensive review of existing planning processes and identifying opportunities to incorporate resilience considerations. This will include long-term planning, corridor studies, and multimodal transportation plans. As noted previously, DelDOT intends to integrate the findings of the DRIP into multiple planning documents and strategies including the anticipated updates of the LRTP in 2024 and TAMP in 2026.

Establish Design Standards and Guidelines

The next strategy involves establishing design standards and guidelines that explicitly account for resilience measures and sea level rise. DelDOT will consider factors like increased rainfall intensity, rising sea levels, and extreme weather events. Provisions for climate adaptation will include, but not be limited to, increased drainage capacity, elevated infrastructure, and the use of nature-based solutions. These standards will outline specific measures to enhance the resilience of transportation infrastructure. DelDOT anticipates conducting a broad review of their design standards and guidance for its staff in SFY 2024 to identify areas within these materials that may need to be updated to reflect climate change and extreme weather event impacts on highway assets and overall system operations.

Foster Collaboration and Coordination

Strategies to improve system resilience also include engagement with various resiliency planning efforts within DelDOT and among federal, state, and local partners. Federal partners include the FHWA and Army Corps of Engineers (ACOE); state partners include DNREC, State Planning Office, and the University of Delaware; and local partners include fifty-seven municipalities, three counties, MPOs, transit partners and first responders. Throughout the resilience integration process, DelDOT will foster and promote collaboration to identify shared goals, align priorities, and pool resources to implement resilient measures.

DelDOT will also look to leverage the opportunities for training and collaboration available through UD's Center for Transportation (UDCT) including its Local and Tribal Technical Assistance Program (LTAP). These include training programs, technical assistance, research and innovation, information resources, and networking/collaboration. These opportunities would provide valuable resources and support to DelDOT in enhancing transportation practices and addressing specific challenges. Engaging with stakeholders will enhance DelDOT's capabilities, improve transportation practices, and contribute to the overall advancement of Delaware's transportation system.

Integrate Resilience Criteria in Project Development and Selection Process

The next step in the overall strategy is for DeIDOT to incorporate resilience criteria as a mandatory component of the project development and selection processes. DeIDOT will develop clear evaluation criteria that include resilience alongside traditional measures such as cost, feasibility, and environmental impact. The criteria will need to be integrated into project scoping, alternatives analysis, and environmental review processes. At the time of this report, discussions are ongoing to consider including a resiliency component in DeIDOT's planning pipeline and decision-making process for capital project nominations used to generate the list of projects for DeIDOT's Capital Transportation Program (CTP).

Provide Resilience Training and Capacity Building

Given the novel concepts of resilience and the state of the practice of models, metrics, and methods, DeIDOT will provide resilience training programs to build capacity with internal staff regarding resilience assessment and implementation. In addition, tools, dashboards, project checklists, etc., will be developed for its staff, leadership, local and state legislators, and potentially the public to help improve the understanding of how the agency intends to build its programs in the areas of climate resilience and incorporate into processes throughout the agency. The Division of TR&S will continue collaborating with external experts and organizations to provide technical assistance and support to staff involved in project planning and development, all the while sharing best practices and lessons learned from successful resilience projects to facilitate knowledge sharing and continuous improvement.

Monitor and Evaluate Resilience Measures

Lastly, DeIDOT will implement a robust monitoring and evaluation framework to track the performance and effectiveness of resilience measures in transportation projects. DeIDOT will regularly assess the resilience of infrastructure assets and projects to identify areas for improvement and ensure the agency meets intended resilience goals. DeIDOT will use feedback and lessons learned to update and refine the resilience assessment methodology and design standards. DeIDOT Maintenance & Operations will be instrumental in collecting data and information from the field to enable DeIDOT to analyze the effectiveness of implemented strategies and to continue to monitor and identify risks to the transportation system.

By implementing the above strategies, DeIDOT can continue their efforts of incorporating resilient measures into project planning and development/selection processes, ultimately enhancing the resilience of transportation infrastructure in Delaware.

3. DeIDOT Risk Assessment Efforts

In addition to DEMA's risk assessment efforts, states are required to regularly evaluate facilities that repeatedly require repair and construction due to emergency events. This level of risk assessment and evaluation is required by the Code of Federal Regulations (CFR) 667 legislation and is reported in DeIDOT's TAMP. The agency conducts a risk workshop and ultimately produces an asset risk register called the Repeatedly Damaged Facility List (RDFL).

The most recent risk workshop was conducted on April 7, 2022, to identify top risks to DeIDOT's goals and vision. The third highest risk identified at the agency was weather-related events or natural hazards. Specific threats identified included high tide flooding leading to pavement washout and storm events that cover roads with either stormwater runoff or tidal waters (TAMP, 2022). This assessment further supports that impacts from extreme weather events have increased significantly in the past few decades in the state, resulting in unanticipated asset costs and threats to DeIDOT's transportation system.

Risk assessment is an ongoing process that updates and informs itself as it evolves. In response to Moving Ahead for Progress in the 21st Century Act (MAP-21) and Fixing America's Surface Transportation Act (FAST Act), DeIDOT has been enhancing asset management process through the publication of the Transportation Asset Management Plan(s) (TAMP) since 2018. As part of these enhancement efforts, DeIDOT has a standard operating procedure in place for asset management that involves regularly updating the risk register. Most recently, DeIDOT's risk management efforts began with a risk workshop, which led to the development of a risk assessment for frequently flooded roadways, as shown in Table 2.

The development of the frequently flooded roadway risk assessment started with input from DeIDOT's four maintenance districts across the state. As they are the most knowledgeable about the conditions in their individual areas, we asked them to identify the roadway segments that flood the most often. As DeIDOT's maintenance management database is not as helpful as it could be at this time for report generation, intimate knowledge from field staff was used for this initial data gathering. After this initial data gathering, a prioritization matrix with weighted factors was established as shown in Figure 2.

As noted in the table, various risk components have been identified including flood evaluation models/studies, traffic volumes, essential/evacuation routes, and critical facility locations such as hospitals, fire stations, DeIDOT maintenance yards, etc. These various components were weighted and we have gone through several weighting iterations to get us to where we are now and sharing the results with our maintenance field staff to "ground truth" the results to ensure our program and project priorities are in line with their needs seen in the field.

As referenced, the frequently flooded roadways risk assessment has gone through several iterations based on feedback and updates from maintenance staff and includes additional data sources. DeIDOT is using these resources to move towards the development of a quantitative risk assessment model using GIS mapping. The initial quantitative risk assessment includes a quantification of the annual risk to DeIDOT's primary infrastructure (i.e., bridges and pavement sections) that are vulnerable to flooding from rainfall and sunny day flooding events. Future iterations of the risk assessment will evaluate additional assets (e.g., culverts) and threats (e.g., tidal flooding, storm surge, wind-driven events).

It is important to note that DeIDOT does have a maintenance management system, Maximo, in which work orders are generated. Currently, the extraction of standardized, credible data from this system is a challenge. DeIDOT has identified plans to incorporate the use and analysis of Maximo data to improve the resilience and sustainability of our transportation infrastructure in our 2022 TAMP. By having reliable, standardized data reporting directly from our maintenance management system, DeIDOT will be able to make more informed, data driven decisions related to the risks and resilience of our transportation assets.

Table 2: Frequently Flooded Roadways Criticality Factors and Weighting.

Dataset	Category	Total Category Score	Weight (%)
Frequently Flooded Roadways	Flood History	50	50%
UD Inundation Study			50%
FEMA Floodplain	Flood Data ²	25	25%
Sea Level Rise ¹			25%
NOAA Flood Frequency			25%
Major River			25%
Traffic Count	Infrastructure/Traffic	15	33%
Road Rating			33%
Essential Routes			33%
Equity Focus Area	Community	10	20%
Essential Facility			20%
Community Size			20%
Employment Density			20%
DTC Ridership			20%

¹ The Sea Level Rise dataset is from the Delaware Geological Survey. Identifying roadway segments that intersect with this dataset provides an indicator of which roadways are at a higher risk of future flooding based on climate change/sea level rise.

² Of the four datasets included in the “Flood Data” category, only the Sea Level Rise dataset includes future projections. Segments that intersect with each of these datasets are assigned a value based on a “yes/no” calculation. For example, if a roadway segment falls within the FEMA Floodplain dataset, the calculation says “yes” and the full set of points are assigned. This is the same for each of the four datasets. The Sea Level Rise dataset is yes/no as well; it does not matter if it’s 1, 2 or 3 feet of sea level rise.

The current iteration of the risk assessment approach includes:

- Defining project objectives, risk thresholds, and system resilience goals.
- System criticality metrics for evacuation routes.
- Quantitative risk-based assessment of bridge and pavement assets:

- Risk assessment factors include owner costs (e.g., replacement costs for pavement types and bridges) and roadway user costs (e.g., road users unable to use the system or required to take a detour route, vehicle operating costs, value of time).
- Probability of threats (e.g., bridge embankment erodibility, roadway flooding, bridge flooding, debris potential).
- Modeling will be performed for individual assets, which can be evaluated on an individual or corridor-wide basis.

As a result of this initial risk assessment, 250+ miles of frequently flooded roadways have been identified across the state network. With this assessment and data now available, we have started to scope, plan, design, and even construct roadway resiliency projects to mitigate the observed roadway flooding. We are also packaging a project now for bidding this fall/winter and construction in early 2024 using PROTECT funds for a short-term mitigation project along the SR 9 coastal corridor from New Castle to Little Creek in Kent County. Based upon the risk assessment completed, the scope of the project will be to raise the roadway for several miles to increase its operational efficiency.

Outputs of the risk model are used as part of DeIDOT's larger resilience investment strategy, as discussed in the following section.

4. PROTECT Investment Strategy

To make the most strategic use of PROTECT funds, a multifaceted investment approach is needed to incorporate the transportation risk assessment being developed externally from the DRIP as well as prioritization factors such as equity, criticality, evacuation needs, route redundancy, and project readiness. Some of these prioritization factors are a result of DelDOT's risk register workshop and assessment of frequently flooded roadways. The investment strategy must meet the federal requirements for use of PROTECT formula funding and will make progress toward Justice40 Initiative goals.

The outcome of the transportation risk assessment described in the previous section is a prioritized list of the most at-risk/most critical assets. For this iteration of the assessment, this includes a prioritized ranking of bridges and roadways in response to potential inland flooding events.

The risk ranking is an important piece of the investment strategy but should include additional criteria to provide the greatest benefit to the transportation system in Delaware. The following factors could be included to develop the investment strategy:

- *Route Criticality* – Higher criticality is placed on roads identified as evacuation routes. Hurricanes and other severe storms may create a need to evacuate citizens and visitors in a timely and efficient manner. Depending on the location of the storm, travelers from Virginia and Maryland may need to utilize Delaware's transportation network to evacuate, further highlighting the need for coordination and resilient infrastructure.
- *Route Importance for Essential Facilities* – Significant importance is placed on roads with critical infrastructure such as hospitals, emergency response stations, evacuation shelters, and DelDOT maintenance facilities.
- *Equity* – DelDOT's equity tool incorporates demographics such as race and income compared to other state averages to help prioritize investments.
- *AADT/Traffic Counts* – The amount of traffic factors into criticality and importance. Funds should be used on roads that are highly traveled. This information is available through the DelDOT gateway portal, as well as County by County TOMP (Transportation Operations Management Plan), based on the states ITMS program which collects and monitors real-time traffic data.
- *DTC Ridership* – Like AADT, ridership information should influence investment fund areas.

- *Community Size* – Focus should be placed towards population, employment, and travel centers. In addition to the routes used to travel, the demand centers should be emphasized.
- *Employment Density* – During non-emergent threats, people need to be able to travel to work. Having resilient assets in areas with high employment density is critical to Delaware's economy.
- *Project Readiness* – This is a qualitative measure focused on project selection. If immediate funds are available, projects already on capital improvement project lists are likely to be more ready for design and construction than conceptual projects.
- *Project Bundling* – Grouping similar projects on the same route can help achieve enhanced system redundancy or improve evacuation routes. This is a qualitative measure or final logic check of project recommendations.
- *Project Timeliness and Consideration of Other Capital Projects* – If recent work has been performed on an asset, it will likely be removed from resilience specific upgrades. To make efficient use of funds, recently constructed and rehabilitated assets will not be improved upon.

The risk model and prioritization factors for the investment strategy are part of a continuous feedback loop. When selecting which assets to fund for resilience improvements, knowing their prioritized risk ranking is not enough to ensure a truly optimal investment strategy. It is possible that many assets on the same corridor will be highly ranked in terms of risk and bundling these projects may make more sense than simply selecting the highest-ranked assets for improvements. The prioritization factors above help improve upon the investment strategy and help provide a safer, more resilient, and more equitable transportation system for everyone using roads and bridges in Delaware.

As the risk assessment matures, the investment strategy should mature as well. Currently, the transportation risk assessment is evaluating the impacts of inland flooding on bridges and roadways. As more threats and assets are assessed, risk modelling can take higher importance with less weight placed on the prioritization factors.

This focus is exclusively on hardening transportation assets. There are, however, other potential projects that may be considered as part of DeIDOT's overall resilience investment strategy. DeIDOT may invest in a diverse range of projects that address different aspects of resilience aside from infrastructure upgrades, including nature-based solutions, community education and outreach, emergency management systems, and

climate adaptation planning. A diversified portfolio ensures a holistic and comprehensive approach to building resilience:

- *Incorporate nature-based solutions* – Emphasize the integration of nature-based solutions in investment strategy. Nature-based solutions, such as coastal wetland restoration, dune stabilization, and green infrastructure can provide multiple benefits including storm surge protection, habitat preservation, etc. DeIDOT has a project in design now for a living shoreline project along Port Mahon Road and recently started discussions with the Department of Defense and University of Delaware to extend the living shoreline project beyond the current limits. Since there is a fuel depot along this roadway that supplies fuel for the Dover Air Force Base, this roadway is considered mission critical for the Department of Defense so they may have funding available for this work.
- *Collaborate and partner* – Seek opportunities for collaboration and partnerships with other federal, state, and local agencies, non-profit organizations, research institutions, and private sector entities. Leverage their expertise, resources, and networks to maximize the impact and effectiveness of PROTECT investments. This includes coordination with Maryland and Virginia for evacuation planning along the shared Eastern seaboard.

Within the state, DeIDOT works very closely with DNREC, the Office of State Planning Coordination, and DEMA on many resiliency-focused projects. While neither agency work directly with our transportation network, they lead the initiatives working with local governments and communities as well as within related industry to that aid in the education and strategic planning towards overall resiliency.

- *Leverage co-funding and match requirements* – Explore opportunities for leveraging co-funding from other sources to maximize the available resources. Many funding programs, both federal and non-federal, can complement PROTECT funding. Also consider state or local match requirements to ensure the availability of necessary funding for project implementation.

5. Updating the DRIP and Next Steps

DeIDOT plans to update the DRIP once every four years with consideration for an earlier update as Delaware implements resiliency measures to ensure consistency with statewide directives. As part of this iterative process, DeIDOT will continue to review and update the frequently flooded roadways risk assessment based on feedback and input from DeIDOT Maintenance & Operations staff. This will include additional data sources as well as increased coordination with local partners to help identify risks around the state that may be targeted for specific project development and investments. DeIDOT will

continue to utilize these resources and data sources to develop a robust quantitative risk assessment using GIS mapping. Future iterations of the risk assessment could evaluate additional assets and threats for inclusion in subsequent updates to the DRIP.

As the DRIP is finalized and put into action, coordination will continue within DeIDOT and the state, with close collaboration occurring between asset management and Transportation Resilience & Sustainability with a goal to ensure that the DRIP and TAMP documents are closely integrated. Additional risk assessment modeling is possible as the state continues to enhance its processes and prioritization planning. Future work could include incorporating additional threats and assets to the risk model and refining vulnerabilities for DeIDOT assets and well as incorporating lifecycle of assets.

DeIDOT is actively working toward a future where resilience and sustainability are fully considered and integrated into the project lifecycle, from planning to project development, design, construction, operations, and maintenance. Incorporating resilient measures into DeIDOT's projects is crucial for mitigating the impacts of future damage and ensuring infrastructure is capable of withstanding and recovering from various hazards. We look forward to future collaboration both within DeIDOT as well as with other trusted partners and sister/brother agencies across the country as we continue to address these important resilience and sustainability objectives.

Acronyms

AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ACOE	Army Corps of Engineers
ASCE	American Society of Civil Engineers
CFR	Code of Federal Regulations
CMAQ	Congestion Mitigation and Air Quality
CTP	Capital Transportation Program
CTSSR	Committee on Transportation System Security and Resilience
DelDOT	Delaware Department of Transportation
DEMA	Delaware Emergency Management Agency
DNREC	Division of Natural Resources and Environmental Control
DRIP	Delaware Resilience Improvement Plan
DTC	Delaware Transit Corporation
EV	Electric Vehicle
FFY	Federal Fiscal Year
FHWA	Federal Highway Administration
IIJA	Infrastructure Investment and Jobs Act
ITS	Intelligent Transportation System
LRTP	Statewide Long-Range Transportation Plan
LTAP	Local and Tribal Technical Assistance Program
MPO	Metropolitan Planning Organization
NCHRP	National Cooperative Highway Research Program
NEVI	National Electric Vehicle Implementation
NOFO	Notice of Proposed Funding
PROTECT	Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation Formula Program
RDFL	Repeatedly Damaged Facility List
SFY	State Fiscal Year

SIP	Strategic Implementation Plan for Climate Change, Sustainability, and Resilience for Transportation
TAMP	Transportation Asset Management Plan
TRB	Transportation Research Board
TR&S	DeIDOT's Division of Transportation Resilience and Sustainability
UD	University of Delaware
UDTC	University of Delaware's Center for Transportation
WILMAPCO	Wilmington Area Planning Council

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Appendix A: Sample Terms and Definitions

Annual Exceedance Probability (AEP)

“The estimated probability that an event of specified magnitude will be exceeded in any year.” (Technical Committee on Risk Assessment and Management Glossary of Risk Assessment Terms, 2004)

Critical Infrastructure

“The incapacity or failure of which would have a debilitating impact on national or regional economic security, national or regional energy security, national or regional public health or safety, or any combination of those matters.” (Public Law 114-94, Fixing America's Surface Transportation Act, 2015)

Asset Criticality

“A measure of the importance of an asset to the resilience of an overall system.” (CDOT, 2020)

Extreme Weather Events

“Weather events that can include significant anomalies in temperature, precipitation and winds and can manifest as heavy precipitation and flooding, heatwaves, drought, wildfires, and windstorms (including tornadoes and tropical storms). Consequences of extreme weather events can include safety concerns, damage, destruction, and/or economic loss. Climate change can also cause or influence extreme weather events.” (Flannery, Pena, & Manns, 2018)

Climate Change

“Refers to any significant change in the measures of climate lasting for an extended period of time. Climate change includes major variations in temperature, precipitation, or wind patterns, among other environmental conditions that occur over several decades or longer. Changes in climate may manifest as a rise in sea level, as well as increase the frequency and magnitude of extreme weather events.” (FHWA, 2014)

Economic Impacts/Loss

“For risk management at two levels: (1) the financial consequences to the organization; and (2) the economic consequences to the regional metropolitan community the organization serves.” (ASME, 2009)

Emergency Management

“The process through which America prepares for emergencies and disasters, responds to them, recovers from them, rebuilds, and mitigates their future effects.” (FEMA, 2001), citing FEMA Strategic Plan)

Equitable Access

“The ability of the system to provide the opportunity for access across the entire community during a shock or stress and when the system is undisrupted.” (Weilant, Strong, & Miller, 2019)

Frequency

“The rate of occurrence of an event measured in terms of the number of a particular type of event expected to occur in a particular time period of interest, usually one year, or in a particular number of iterations, e.g., one defect per million products.” (AWWA, 2014)
Hazard

“A condition, which may result from either an external cause (e.g., earthquake, flood, or human agency) or an internal vulnerability, with the potential to initiate a failure mode. It is a source of potential harm or loss.” (ASME, 2009)

Infrastructure

“In transit systems, all the fixed components of the transit system, such as rights-of-way, tracks, signal equipment, stations, park-and-ride lots, but stops, maintenance facilities. 2) In transportation planning, all the relevant elements of the environment in which a transportation system operates. (TRB1) 3) A term connoting the physical underpinnings of society at large, including, but not limited to, roads, bridges, transit, waste systems, public housing, sidewalks, utility installations, parks, public buildings, and communications networks.” (FHWA, 2017)

Likelihood

“The chance, frequency, or degree of belief that a particular outcome or event will occur in a specific time frame, usually one year.” (ASME, 2009)

Mitigation

“Any action taken to eliminate or reduce the long-term risk to human life and property from natural hazards. Mitigation actions are accomplished by:

- Acting on the hazard. Seeding hurricanes or triggering avalanches may eliminate a hazard before a disaster occurs.
- Redirecting the hazard. A seawall or dune restoration program helps keep water away from people by redirecting the impact areas away from vulnerable locations.

- Interacting with the hazard. Seismic safety provisions incorporated into building codes result in structures that are more able to withstand impacts and earthquakes.
- Avoiding the hazard. “River corridor projects create multiple beneficial uses of the floodplain while relocating structures to less vulnerable locations.” (FEMA, 1999)

Natural Events/Hazards/Threats

“These include floods, snowstorms, extreme wind, wildfire, landslide, tsunami, and earthquake. While probabilities and return periods of these events may be understood, it cannot be predicted when exactly the next event will occur. These events cannot be controlled, although an agency can prepare and mitigate against the effects in advance.” (AASHTO, 2013)

Owner Costs

“Owner costs are the replacement value of each asset and may include the asset life-cycle cost in more comprehensive Risk and Resilience (R&R) analyses.” (Kemp, Flannery, & Krimmer, 2017)

Qualitative Risk Analysis/Assessment

“An appraisal of risk that uses linguistic terms and measurements to characterize the factors of risk. Wherever possible, qualitative analyses should be couched in terms of a consistent measure that allows comparisons between assets. Qualitative measures can be linguistic, e.g., high, medium, low, or quantified, e.g., a scale of 1 to 10.” (AWWA, 2014)

Quantitative Risk Analysis/Assessment

“An analysis based on numerical values of the probability, vulnerability, and consequences, and resulting in a numerical value of the risk.” (Technical Committee on Risk Assessment and Management Glossary of Risk Assessment Terms, 2004)

Redundancy

“Defined as duplicative or excess capacity that can be used in times of emergency. adding redundant highway capacity generally falls outside the practice of asset management. However, sound management of the assets on detour and emergency evacuation routes increases a highway system’s redundancy.” (FHWA, 2013)

Resilience

“Resilience or resiliency is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.” (FHWA, 2014)

Resilience Management

“The deliberate process of understanding resilience as both a function of loss of infrastructure components and the ability of the community to cope with the loss and recover in the shortest practical time. Resilience management includes the ability to model the interdependencies of infrastructure components and decide upon and implement actions that will increase the resilience of the community given the loss of a subset of infrastructure.” (AWWA, 2014)

Risk

“A function of consequences, hazard frequency or likelihood, and vulnerability, which with point estimates, is the product of the terms. It is the expected value of the consequences of an initiating event weighted by the likelihood of the event’s occurrence and the likelihood that the event will result in the consequences, given that it occurs. Risk is based on identified events or event scenarios.” (AWWA, 2014)

Risk Management

“The deliberate, cyclical process of understanding risk based on a risk analysis and deciding upon, implementing, and managing action, e.g., security countermeasures or consequence mitigation features, to achieve an acceptable level of risk at an acceptable cost. Risk management is characterized by identifying, measuring, estimating, and controlling risks to a level commensurate with an assigned or accepted value, monitoring and evaluating the effectiveness of implementation and operation of the selected options (with corrective actions as needed) and periodic repetition of the full risk management cycle.” (AWWA, 2014)

Risk Tolerance

“Organization’s readiness to bear the risk after risk treatments in order to achieve its objectives.” (DRI International, Inc., 2021)

Sustainability

“Sustainability entails meeting human needs for the present and future while preserving environmental and ecological systems, improving quality of life, promoting economic development, and ensuring equity between and among population groups and over generations.” (Zeitman & Ramani, 2011)

Threat

“A man-made or natural event with the potential to cause harm. In malevolent risk analysis, threat is based on the analysis of the intention and capability of an adversary (whether insider or outsider) to undertake actions that would be detrimental to an asset.

Threats may also arise from natural hazards or dependency hazards (interruptions of supply chains or proximity to dangerous or hazardous sites).” (AWWA, 2014)

Threat Analysis/Assessment

“A systematic process of estimating threat likelihood determined based on historical frequencies or predictions from scientific tools and expert opinion.” (CDOT, 2020)

Transportation Asset Management

“A strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the life cycle of the assets at minimum practicable cost.” (FHWA, 2020)

Twice Damaged Assets (“Repeatedly damaged facilities”)

“Repeatedly damaged facilities are roads, highways, and bridges that have required repair and reconstruction activities on two or more occasions due to natural disasters or catastrophic failures resulting in emergencies declared by the Governor of the State or the President.” (23 CFR 667.1).

User Costs

“Those costs realized by the users of a facility. In life cycle-cost analysis, user costs could take the form of delay costs or of changes in the vehicle operating costs associated with various alternatives.” (TRB, 2004)

Vulnerability

“An inherent state of a system (e.g., physical, technical, organizational, cultural) that can be exploited by an adversary or impacted by a natural hazard to cause harm or damage. Such weaknesses can occur in building characteristics, equipment properties, personnel behavior, locations of people, equipment, and buildings, or operational and personnel practices. Vulnerability is expressed as the likelihood of an event’s having the estimated consequences, given that the event occurs.” (AWWA, 2014)