

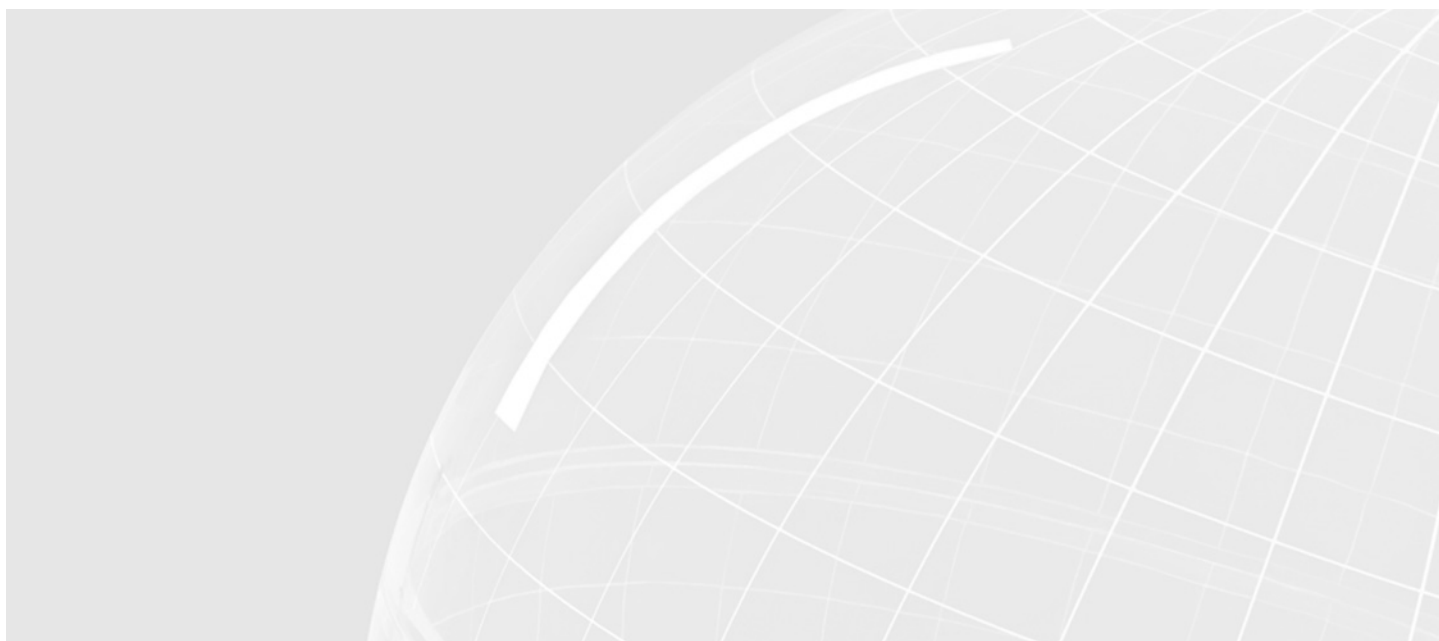
# Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

Delaware Department of Transportation

July 2017



**Delaware Department  
of Transportation**





## Table of Contents

<b>Executive Summary</b> .....	<b>i</b>
<b>1. Introduction</b> .....	<b>1</b>
1.1 Goals and Objectives.....	2
1.2 Project Stakeholders.....	2
1.3 Research Methodology.....	3
1.4 Strategic Implementation Plan.....	3
<b>2. Climate Framework Recommendations for DeIDOT – Status Assessment</b> .....	<b>4</b>
2.1 Incorporate Climate Change into Asset Management.....	4
2.2 Ensure Workforce and Public Health and Safety.....	15
2.3 Support Climate Resilience in Local Communities.....	21
2.4 Identify and Support Policy Initiatives that Reduce Greenhouse Gas Emissions (Climate Mitigation) ....	23
<b>3. Climate Framework Implementation Strategy</b> .....	<b>28</b>
3.1 Implementation Priority Rankings.....	28
3.2 Key Projects, Activities and Policy Changes.....	30
3.3 Implementation Timelines.....	32
3.4 Implementation Costs and Funding.....	33
3.5 Monitoring and Reporting.....	36
3.6 Summary.....	37
<b>4. Sustainability and Resilience Considerations</b> .....	<b>39</b>
4.1 Sustainability.....	39
4.2 Resilience.....	41
4.3 Sustainability and Resilience Strategy Development.....	48
<b>5. Next Steps</b> .....	<b>50</b>

## List of Appendices

<b>Appendix A. Fact Sheets – Climate Framework Recommendations</b> .....	<b>A-1</b>
<b>Appendix B. Reference Material</b> .....	<b>B-0</b>
<b>Appendix C. DeIDOT Interviewees</b> .....	<b>C-2</b>
<b>Appendix D. Alternative Prioritization of Climate Framework Recommendations Using Modified Decision Lens Process</b> .....	<b>D-1</b>
<b>Appendix E. Sample Progress Report Forms</b> .....	<b>E-1</b>
<b>Appendix F. INVEST Case Study</b> .....	<b>F-1</b>
<b>Appendix G. Strategic Planning Workshop Climate Change, Resilience &amp; Sustainability for Transportation</b> .....	<b>G-1</b>
<b>Appendix H. Workshop Presentations by Silvana Croope, Brian Urbanek, and Jim Pappas</b> .....	<b>H-1</b>

### List of Tables and Figures

Table 1: Priority Ranking of Climate Framework Recommendations .....	ii
Table 2: Climate Framework Recommendation Implementation Timeline .....	iii
Table 3: Incorporate Climate Change into Asset Management Recommendations Summary.....	6
Table 4: Ensure Workforce and Public Health and Safety.....	16
Table 5: Support Climate Resilience in Local Communities .....	21
Table 6: Identify and Support Policy Initiatives that Reduce Greenhouse Gas Emissions .....	24
Table 7: Priority Ranking of Climate Framework Recommendations .....	29
Table 8: Climate Framework Recommendation Implementation Timeline .....	33
Table 9: DeIDOT Interviewees.....	C-2
Table 10: Revised Prioritization for Climate Change Resilience and Sustainability .....	D-5
Table 11: Result of DeIDOT Operation and Maintenance INVEST Evaluation .....	F-2
Figure 1: A Sample Quarterly Progress Report .....	37
Figure 2: The Decision Lens Process .....	D-1
Figure 3: Tabled Quarterly Progress Report .....	E-1
Figure 4: Open-Ended Quarterly Progress Report .....	E-2

### List of Project Highlights

SR-9 Comprehensive Assessment.....	12
Bridgeville Maintenance Yard Project.....	19
DTC Secures \$2 million Grant for New Electric Buses. ....	26



# Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

## Acronyms and Abbreviations

AAR	After Action Reviews	DTC	Delaware Transit Corporation
AASHTO	American Association of State Highway and Transportation Officials	DWSRF	Drinking Water State Revolving Fund
ADA	American with Disabilities Act	EMS	Emergency Medical Services
AED	Automated External Defibrillator	EO	Executive Order
AHP	Analytical Hierarchy Process	EPA	Environmental Protection Agency
ASCE	American Society of Civil Engineers	FAST	Fixing America's Surface Transportation
CAD	Computer Aided Dispatch	FEMA	Federal Emergency Management Agency
CCoCAR	Cabinet Committee on Climate and Resilience	FHWA	Federal Highway Administration
CMAQ	Congestion Mitigation and Air Quality	FMA	Flood Mitigation Assistance Program
CM/GC	Construction Manager/General Contractor	FTA	Federal Transit Administration
CPR	Cardiopulmonary Resuscitation	FY	Fiscal Year
CRPG	Community Resilience Planning Guide	GGBFS	Ground Granulated blast furnace slag
CTP	Capital Transportation Program	GHG	Greenhouse gas
CWSRF	Clean Water State Revolving Fund	HMA	Hazard mitigation assistance
DART	Delaware Authority for Regional Transit	HMGP	Hazard Mitigation Grant Program
DeIDOT	Delaware Department of Transportation	HSIP	Highway Safety Improvement Program
DEMA	Delaware Emergency Management Agency	HVAC	Heating, Ventilation and Air Conditioning
DHS	Department of Homeland Security	HUD	Department of Housing and Urban Development
DHSS	Delaware Health and Social Services	GIS	Geographic Information System
DNREC	Department of Natural Resources and Environmental Control	ICNET	Infrastructure and Climate Network
DSHS	Department of Safety and Homeland Security	ICS	Incident Command System
DSP	Delaware State Police	INVEST	Infrastructure Voluntary Evaluation Sustainability Tool
		IPA	Institute for Public Administration
		ISI	Institute for Sustainable Infrastructure

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

LEED	Leadership in Energy and Environmental Design	RWIS	Road Weather Information System
LiDAR	Light Detection and Radar	SCOR	Standing Committee on Research
LoNo	Low or No Emission	SIP	Strategic Implementation Plan
MCA	Multiple-Criteria Decision Analysis	SLTTGCC	State, Local, Tribal, and Territorial Government Coordinating Council
M&O	Maintenance and Operation	SME	Subject Matter Expert
MPO	Metropolitan Planning Organization	SOFA	Strategic Opportunity Fund for Adaptation
NCC	New Castle County	SOP	Standard Operating Procedure
NCHRP	National Cooperative Highway Research Program	SR	State Road/Route
NFIP	National Flood Insurance Program	SRF	State Revolving Fund
NHI	National Highway Institute	SRTS	Safe Routes to School
NIMS	National Incident Management System	STBG	Surface Transportation Block Grant
NIPP	National Infrastructure Protection Plan	SWOT	Strengthens, Weaknesses, Opportunities and Threats
NIST	National Institute of Standards and Technology	TAP	Transportation Alternatives Program
NOAA	National Oceanic and Atmospheric Association	TE	Transportation Enhancements
NPDES	National Pollutant Discharge Elimination System	THIRA	Threat and Hazard Identification and Risk Assessment
OMB	Office of Management and Budget	TMC	Traffic Management Center
P3	Public Private Partnership	TRB	Transportation Research Board
PDM	Pre-Disaster Mitigation Program	TSS	Total Suspended Solids
RAP	Reclaimed Asphalt Pavement	UD	University of Delaware
RAS	Reclaimed Asphalt Shingles	UK	United Kingdom
Rec.	Recommendation	USDOT	United States Department of Transportation
RMS	Risk Management System	WILMAPCO	Wilmington Area Planning Council
RTP	Recreational Trails Program	WMA	Warm Mix Asphalt

## Executive Summary

This Strategic Implementation Plan for Climate Change, Sustainability and Resilience for Transportation (SIP) is the Delaware Department of Transportation's (DelDOT) first attempt to develop a strategic and cohesive plan to promote a more resilient and sustainable transportation system in Delaware. The roots of this initiative are traced back to Executive Order 41 (EO41) that was issued by then Governor Jack Markell in 2013. EO41, *Preparing Delaware for Emerging Climate Impacts and Seizing Economic Opportunities for Reducing Emissions*, directs Delaware agencies to address both the causes and consequences of climate change.

A committee and working groups were established to address the goals of EO41 – f j to reduce greenhouse gas (GHG) emissions that contribute to climate change, to increase resilience to climate impacts, and to avoid/minimize flood risks due to sea level rise. The Climate Framework for Delaware (December 31, 2014), a key report issued under E041, summarizes the 150 recommended actions that were assigned to agencies across the state, including 19 that were assigned to DelDOT. These recommendations are organized into four categories: (1) Incorporate Climate Change into Asset Management; (2) Ensure Workforce Public Health and Safety; (3) Support Climate Resilience in Local Communities; and (4) Identify and Support Policy Initiatives that Reduce Greenhouse Gas Emissions. The SIP documents the progress and next steps for each of the recommendations, provides a strategy for completion of the recommendations that addresses key challenges and requirements, and looks beyond the Climate Framework recommendations to consider the broader context of resilience and sustainability.

Table 1 below lists all of the 19 Climate Framework recommendations that were assigned to DelDOT. The recommendations were analyzed across four categories – Enabler, Impact, Cost, and Ease – reflecting different aspects of implementation, and rated with a score from 1 to 3 in each category. Recommendations were then grouped into three tiers as follows:

- Tier One – Recommendations 1, 3, 9, and 17 were identified as the highest priority. As enablers of other projects/activities, these recommendations are crucial to the overall implementation plan and schedule.
- Tier Two – Recommendations 2, 5, 6, 7, 8, 10 and 16 were identified as second level priorities. These projects are still critical for achievement of Climate Framework goals and objectives but may have fewer connections with other recommendations or less overall impact.
- Tier Three – Recommendations 4, 11, 12, 13, 14, 15, 18 and 19 are also important, but they are less influential on the implementation of other recommendations, less impactful, more expensive, and/or more complex to enact.

Using the priority rankings, stakeholder input, and other considerations, an implementation timeline was constructed and is presented in Table 2. The timeline shows many recommendations already have projects that are underway or planned for this year. The remainder should begin no later than 2019 and all projects should be completed by 2022.

# Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

**Table 1: Priority Ranking of Climate Framework Recommendations**

RECOMMENDATION #	RECOMMENDATION	IMPLEMENTATION CATEGORY				TOTAL	IMPLEMENTATION TIER
		ENABLER	IMPACT	COST	EASE		
Rec #1	Development of geospatial data sets to identify vulnerable areas	3	3	1	2	9	1
Rec #2	Comprehensive Analysis of Critical Infrastructure	3	3	1	1	8	2
Rec #3	Integrate climate resilience into bridge & highway design manuals	3	3	2	1	9	1
Rec #4	Build transportation enhancements to accommodate cc impacts	1	1	1	2	5	3
Rec #5	Identify & assess chronic flooding and erosion problems	2	3	1	2	8	2
Rec #6	Evaluate materials used to reduce the impacts of stormwater runoff	2	1	2	3	8	2
Rec #7	Reevaluate stormwater management approaches	2	2	2	2	8	2
Rec #8	Explore new pavement technology	2	1	2	3	8	2
Rec #9	Incorporate climate change into infrastructure investments	2	3	3	1	9	1
Rec #10	Evaluate catastrophic event insurance	1	3	3	1	8	2
Rec #11	Evaluate worker safety guidelines	1	2	2	2	7	3
Rec #12	Train workers on utilizing resilient materials	1	2	2	1	6	3
Rec #13	Evaluate driving restrictions for air quality events	1	3	2	1	7	3
Rec #14	Revise maintenance schedules in response to air quality	1	1	2	2	6	3
Rec #15	Adjust emergency response strategies for transit	1	2	2	2	7	3
Rec #16	Coordinate with DSHS on strategies for catastrophic events	2	2	3	1	8	2
Rec #17	Support local governments with land use assessment tools	2	3	3	1	9	1
Rec #18	Evaluate low-emission vehicle deployment	1	1	2	3	7	3
Rec #19	Evaluate alternative energy technology in facilities	1	1	2	3	7	3

IMPLEMENTATION PRIORITY TIERS

	TIER ONE		TIER TWO		TIER THREE
---	----------	---	----------	---	------------

# Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

**Table 2: Climate Framework Recommendation Implementation Timeline**

RECOMMENDATION #	RECOMMENDATION	DURATION TO COMPLETION (YEARS)	YEAR						
			2017	2018	2019	2020	2021	2022	2023
1	Continue Development of Geospatial Data Sets that Can Help Identify Vulnerable Areas and Help Estimate the Impact of Reasonably Anticipated Events	2-5	Green	Green	Green	Green			
2	Conduct Comprehensive Assessment of State Roadway Risks and Assets	2-5	Blue	Blue	Blue	Blue			
3	Integrate Climate Resiliency Into Project Development, Traffic, Bridge and Highway	2-5	Green	Green	Green				
4	Build Transportation Enhancements (Pathways, Trails, Roadscapes, etc.) to Accommodate Impacts of Climate Change	2-5			Brown	Brown	Brown	Brown	
5	Identify and Assess Existing Chronic Flooding and Erosion Problems Caused by Sea Level Rise, Frequent Storms, Tidal Forces, Subsidence, and Aging Infrastructure	2-5	Blue	Blue	Blue	Blue	Blue		
6	Evaluate Materials Used to Reduce the Impacts of Stormwater Runoff	2-5		Blue	Blue	Blue	Blue		
7	Reevaluate Stormwater Management Approaches	2-5		Blue	Blue	Blue	Blue		
8	Explore New Pavement Technology	2-5		Blue	Blue	Blue			
9	Incorporate Climate Impacts into Cost-Effective Investments in Infrastructure	0-2	Green	Green					
10	Evaluate Obtaining Insurance to Assist in Recovery from Catastrophic Events	2-5	Blue	Blue	Blue	Blue			
11	Evaluate and Adjust Worker Safety Guidelines	2-5	Brown	Brown	Brown				
12	Provide Training to Improve Worker Knowledge	0-2			Brown	Brown			
13	Evaluate Driving Restrictions For Air Quality Events	2-5		Brown	Brown	Brown	Brown		
14	Develop Revised Maintenance Schedule in Response to Air Quality	0-2			Brown	Brown			
15	Adjust Emergency Response Strategies to Provide Transit as Necessary Without Endangering Drivers or Passengers	2-5			Brown	Brown	Brown		
16	Reevaluate Emergency Response Protocols	0-2	Blue	Blue					
17	Support Local Governments with Land Use Assessment Tools	2-5	Green	Green	Green	Green	Green		
18	Evaluate Low-Emission Vehicle Deployment	2-5	Brown	Brown	Brown				
19	Evaluate Alternative Energy Technology In Facilities	0-2			Brown	Brown			

IMPLEMENTATION PRIORITY TIERS



TIER ONE



TIER TWO



TIER THREE

The rough order-of-magnitude costs to implement all of the recommendations ranges from \$2.5 million to \$7.15 million, with a midpoint estimate of \$4.825 million. Funding is always a constraint, so funding sources, particularly those outside DelDOT and the State of Delaware, are essential for accomplishing the objectives of the Climate Framework. Potential federal and state sources of funding identified include, for example the Federal Emergency Management Agency, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency (via State Revolving Loan Funds), Delaware's Surface Transportation Block Grant (STBG) Set-Aside Program, and the Delaware Department of Natural Resources and Environmental Control.

Climate change is an important example of an external influence on the transportation system, but there are other threats to critical infrastructure, including extreme weather, accidents or technical failures, cyber threats, acts of terrorism, and pandemics. Resilience and sustainability provide the broader context within which these threats can be addressed. For example, sustainable transportation considerations are focused on striking a balance between economic, social, and environmental principles (referred to as the triple bottom line) in a manner that supports the ongoing development, operation, and maintenance of an 'enduring' transportation system. Resilience, on the other hand, encompasses the ability to withstand and recover from an incident in order to provide critical transportation services during the incident and through the recovery process. Transportation resilience considerations therefore must include the people and systems (e.g., telecom, power) that are required to operate the transportation system. One of the challenges DelDOT will face is striking a balance between sometimes incompatible sustainability and resilience objectives.

The next steps highlighted below can form the foundation for DelDOT to establish an integrated program that continues to address climate change issues and promote sustainability and resilience of the transportation system. Such a program will look beyond the Climate Framework recommendations to address other sustainability and resilience considerations described in this SIP. By focusing on these long-term, comprehensive factors, DelDOT can develop requirements and strategies that both anticipate and mitigate future impacts to infrastructure, DelDOT employees, and the general public.

### General

- Review SIP progress on an annual basis and update as necessary.
- Explore additional funding sources to support climate change, resilience & sustainability research and implementation.

### Climate Change

#### Planning

- Continue to monitor, track, and report on the implementation of DelDOT's Climate Framework Recommendations.
- Review current and planned activities within the high priority Recommendations to see if there are any opportunities to expedite implementation.

#### Tools & Resources

- Collect all county and municipal documents related to climate change and mitigation plans, to establish a central depository and to help promote consistency across state and local plans.

### Resilience

#### Planning

- Support NIST Community Resilience Initiative by participating in NIST community resilience planning efforts in the region through coordination with other transportation stakeholders.
- In consultation with FEMA and other relevant stakeholders, prepare a Threat and Hazard Identification and Risk Assessment (THIRA), to identify community-specific threats and hazards and to set capability targets for each core capability identified in the National Preparedness Goal (as mentioned in Presidential Policy Directive 8: National Preparedness).
- Develop tracking and reporting mechanisms for transportation sustainability initiatives.

#### Tools & Resources

- Begin utilizing the NIST Community Resilience Economic Decision Guide for Buildings and Infrastructure Systems (NIST Publication 1197), which supports cost-benefit analysis of alternative capital investments in resilience.
- Utilize the *Critical Infrastructure Threat Information Sharing Framework*, a resource provided by the US Department of Homeland Security, to help critical infrastructure owners and operators, as well as other partners that share threat information, understand the processes and mechanisms currently used to share cyber and physical threat information.
- Explore the options offered by the US Department of Homeland Security Regional Resilience Assessment Program and the criteria for assessment selection.

#### Training

- Continue to train staff on utilization of FEMA's Hazus risk assessment tool and utilize the tool to model different disaster scenarios to help identify and address vulnerabilities.
- Determine the training requirements for relevant programs (including FEMA course IS-2001), on the THIRA process.

#### Finance

- Continue to research financial instruments such as insurance and catastrophe bonds through the innovative RE.bound program.

### Sustainability

#### Planning

- Develop tracking and reporting mechanisms for transportation sustainability initiatives.

#### Tools & Resources

- Utilize FHWA INVEST System Planning and Project Development modules to analyze other areas of DelDOT operations to highlight successes and identify areas for improvement related to sustainability efforts.
- Utilize ASCE/ISI ENVISION rating system and best practices to incorporate sustainability considerations in the development of infrastructure projects.



## 1. Introduction

On September 12, 2013, Delaware Governor Jack Markell issued Executive Order 41: *Preparing Delaware for Emerging Climate Impacts and Seizing Economic Opportunities for Reducing Emissions* (herein after referred to as EO41). This Executive Order directs Delaware agencies to address both the causes and consequences of climate change by developing actionable recommendations to reduce greenhouse gas (GHG) emissions, increase resilience to climate impacts, and avoid or minimize flood risks due to sea level rise.

Executive Order 41 called for the creation of a cabinet-level committee to oversee the development and implementation of recommendations that respond to EO41. Thus, the Cabinet Committee on Climate and Resilience (CCoCAR) was established, featuring Secretaries of seven state departments, and Directors of four other state agencies.<sup>1</sup> Work Groups were created in the three main topic areas of: Mitigation, Adaptation, and Flood Avoidance. The work to date and recommendations from the three Work Groups were summarized in a report, entitled [The Climate Framework for Delaware](#), which was published on December 31, 2014.

The Climate Framework Report identified more than 150 actionable recommendations that should be implemented by the 11 agencies represented on the CCoCAR. Nineteen of the 150 total recommendations contained within the Climate Framework Report were assigned to the Delaware Department of Transportation (DeIDOT). These recommendations are organized into four categories:

- Incorporate Climate Change into Asset Management
- Ensure Workforce and Public Health and Safety
- Support Climate Resilience in Local Communities
- Identify and Support Policy Initiatives that Reduce Greenhouse Gas Emissions (Climate Mitigation)

The Climate Framework Report notes: “Increasing Delaware’s resiliency to climate change encompasses a wide range of strategies to improve the state’s preparedness and ability to adapt to current and future climate impacts.” Two areas of progress to date relate specifically to DeIDOT:

“DeIDOT manages a wide range of technologies for monitoring traffic flow, road conditions, and potential hazards. Transportation engineers are evaluating ways to expand the existing systems by adding sensors that measure water levels, speed, and volumes, as well as reviewing the roadway weather information system parameters and quality data to support climate analysis. By improving data collection and analysis, planners will be able to make better predictions of flooding hazards and

---

<sup>1</sup> CCoCAR is comprised of the secretaries and directors of 11 state agencies and departments, including the departments of: Natural Resources and Environmental Control; Agriculture; Education; Health and Social Services; Safety and Homeland Security; State; and Transportation. Other agencies are: the Delaware Economic Development Office; Delaware State Housing Authority; Office of Management and Budget; and Office of State Planning Coordination.



precipitation patterns, provide early-warning information to local emergency managers, and prepare for adjustments to traffic flows, such as detours and evacuation routes.

Increasing resiliency of Delaware's transportation infrastructure is critical to the state's economy and to public safety. The Department of Transportation is working on multiple fronts to apply a risk and resilience management approach to respond to current and upcoming challenges from climate change. This includes improving capacity for data analysis, use of GIS systems, and increasing the use of risk assessment tools. DeIDOT provides staff training in the use of Hazus, a risk assessment tool supported by the Federal Emergency Management Agency." (*Climate Framework Report, pg. 14*)

In response to the 19 recommendations assigned to DeIDOT by the Climate Framework Report, DeIDOT has directed the preparation of this document, the *Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation (SIP)*. The SIP documents the progress DeIDOT has made towards implementing these recommendations, and identifies the challenges and resources required to promote successful completion. It also proposes potential paths forward for achieving the overall goals of DeIDOT and the State of Delaware within the broader context of resilience and sustainability.

## **1.1 Goals and Objectives**

High level goals and objectives of this SIP are summarized as follows:

- Prioritize DeIDOT Climate Framework Report recommendations to support funding and scheduling decisions related to implementation of projects and activities to support these recommendations.
- Coordinate implementation of Climate Framework recommendations in the broader context of sustainability & resilience to ensure long term support.

## **1.2 Project Stakeholders**

There are a number of project stakeholders and have been instrumental in the development of the SIP, including representatives from the following DeIDOT divisions & external agencies:

- Office of the Secretary
- Planning
- Maintenance & Operations (M&O)
- Finance
- Delaware Transit Corporation (DTC)
- Transportation Solutions, including the Transportation Management Center (TMC)
- Technology and Innovation

Other Stakeholders:

- Office of State Planning Coordination
- DNREC

### **1.3 Research Methodology**

The research team gathered and reviewed numerous reports, plans, policies, procedures, and other documentation in the preparation of the SIP. This includes Delaware-specific information, information from sister agencies that are dealing with similar issues, as well as information from federal, international, and other sources. Stakeholder interviews were conducted with 24 DeIDOT stakeholders representing seven divisions within DeIDOT. Fact Sheets were developed for each of the 19 Climate Framework Recommendations assigned to DeIDOT. These Fact Sheets, which are found in Appendix A, were developed based on the literature review, stakeholder interviews, and SWOT analysis (Strengths, Weaknesses, Opportunities, & Threats) of each recommendation.

After finalizing the first draft of the Fact Sheets, the research team organized a strategic planning workshop with the DeIDOT stakeholders on Wednesday, July 27, 2016. At that workshop, a group of 15 DeIDOT employees representing various divisions and sections across DeIDOT discussed the strategic planning process and reviewed/updated the Fact Sheets developed for each of the 19 Climate Framework recommendations tasked to DeIDOT under EO41. The workshop included presentations on the status of EO41, potential impacts of climate change on DeIDOT maintenance and operations, and the incorporation of important climate change, resilience and sustainability considerations into DeIDOT's strategic planning process. A summary of the workshop and the presentations given during the workshop are provided in Appendix G and Appendix H respectively.

### **1.4 Strategic Implementation Plan**

The following chapters cover the current status of the Climate Framework recommendations, the prioritization of recommendation implementation, additional factors that can impact resilience and sustainability of the transportation system, and the next steps for DeIDOT. Chapter 2 provides a status assessment of the 19 DeIDOT recommendations from the Climate Framework, highlighting current and planned activities, key stakeholders, challenges and other considerations related to implementation of each recommendation. Chapter 3 takes a strategic look at the Climate Framework recommendations, including prioritization, costs, potential funding sources, and a recommended critical path schedule for implementation. Chapter 4 looks beyond climate change and considers other factors that can impact resilience and sustainability of the transportation system. Chapter 5 of the SIP summarizes next steps for DeIDOT to fully implement the Climate Framework recommendations and to further develop other aspects of sustainability and resilience for Delaware's transportation system.

## 2. Climate Framework Recommendations for DeIDOT – Status Assessment

This chapter provides a status assessment of the 19 DeIDOT recommendations from the Climate Framework, highlighting current and planned activities, key stakeholders, challenges and other considerations related to implementation of each recommendation.

### 2.1 Incorporate Climate Change into Asset Management

#### 2.1.1 Overview

DeIDOT is responsible for 90% of the roads and most of the traffic signals in the state, and operates the transit system. This places DeIDOT on the front lines of Delaware’s efforts to identify and address the infrastructure effects of any potential climate change impacts on the state’s transportation infrastructure. As the Climate Framework Report for Delaware states:

“Sea level rise, temperature extremes, flooding, and heavy precipitation will affect the condition, operability, and life cycle of transportation assets. Impacts include damage to asphalt, corrosion, contraction, and expansion of materials. Maintenance of stormwater management and vegetation along roadways will also be affected. Design and construction of bridges, roadways, and other structures may need to be revised, through updates to design manuals and to specific project designs.”<sup>2</sup>

By improving its asset management practices, through the incorporation of climate resiliency into planning, design, materials usage, and siting guidelines for transportation infrastructure, DeIDOT enhances the state’s ability to better manage adverse climate change impacts associated with the transportation network. The collection and mapping of locations with climate impact projections provides for a growing database that can inform planning, design and construction.

There are 10 recommendations contained within the DeIDOT portion of the Climate Framework Report that seek to incorporate climate change into asset management:

1. Continue development of geospatial data sets that can help identify vulnerable areas and help estimate the impact of reasonably anticipated events (such as a Category 3 hurricane)
2. Conduct a comprehensive analysis of the state’s roadways, bridges, and other infrastructure to identify critical infrastructure that may be vulnerable to climate impacts
3. Integrate climate resiliency into its bridge and highway design manuals strategies to address climate impacts, including sea level rise, for short-term, medium-term, and long-term anticipated effects
4. Build transportation enhancements (pathways, trails, roadscapes, etc.) to accommodate impacts of climate change

<sup>2</sup> *Climate Framework for Delaware*, DNREC, December 31, 2014, pg. 32.

5. Identify and assess existing chronic flooding and erosion problems that affect transportation infrastructure
6. Evaluate and qualify materials used to reduce the impacts of stormwater runoff
7. Reevaluate stormwater management approaches for improved resiliency and drainage
8. Evaluate new technologies in asphalt and concrete pavement composition to mitigate melting of road surfaces or other damage
9. Incorporate climate impacts into cost-effective investment in infrastructure
10. Evaluate whether to obtain insurance to assist in recovery from catastrophic events

Table 3 contains all of the recommendations under the Asset Management umbrella. The table highlights key activities, and provides a summary dashboard that presents estimated costs, duration, and status for each of the 10 recommendations in this category. The subsections below the table provide additional details regarding current activities, opportunities, and challenges associated with implementation of each of these recommendations.

**Table 3: Incorporate Climate Change into Asset Management Recommendations Summary**

Recommendation		Key Activities	Summary Dashboard
#	Description		
1	Continue development of geospatial data sets that can help identify vulnerable areas and help estimate the impact of reasonably anticipated events	<ul style="list-style-type: none"> <li>There is currently a project to take inventory of roadway assets using light detection and radar (LiDAR).</li> <li>DeIDOT Planning is conducting data collection based on Federal Emergency Management Agency (FEMA) Hazus tool for loss estimation and impact assessment.</li> </ul>	<p><b>Status:</b> Gauge showing 100% completion (Completed).</p> <p><b>Cost:</b> Stacks of coins representing &lt;\$100k.</p> <p><b>Estimated Duration (years):</b> Arrow pointing to 2-5.</p>
2	Conduct comprehensive assessment of state roadway risks and assets	<ul style="list-style-type: none"> <li>DeIDOT and DNREC are coordinating on “First Map”, a statewide planning effort using GIS mapping. Preliminary maps from this project are already in use and providing value in planning.</li> </ul>	<p><b>Status:</b> Gauge showing 100% completion (Completed).</p> <p><b>Cost:</b> Stacks of coins representing \$100k - \$250k.</p> <p><b>Estimated Duration (years):</b> Arrow pointing to 2-5.</p>
3	Integrate climate resiliency into project development, traffic, bridge, and highway design	<ul style="list-style-type: none"> <li>Language has been added to DeIDOT’s Bridge Design Manual that requires consideration of future sea level rise &amp; climate change resiliency when scoping a project. The Office of Performance Management will insert appropriate language into manuals as they are being updated.</li> </ul>	<p><b>Status:</b> Gauge showing 75% completion (Completed).</p> <p><b>Cost:</b> Stacks of coins representing \$100k - \$250k.</p> <p><b>Estimated Duration (years):</b> Arrow pointing to 2-5.</p>
4	Build transportation enhancements (pathways, trails, roadscapes, etc.) to accommodate impacts of climate change	<ul style="list-style-type: none"> <li>DeIDOT is conducting a review of the following resources: University of Delaware’s Institute for Public Administration (IPA) Toolkit for a Healthy Delaware, ASCE/ ISI Envision system, FHWA’s INVEST system, and NIST’s Community Resilience Planning Guide for Buildings and Infrastructure Systems.</li> </ul>	<p><b>Status:</b> Gauge showing 75% completion (Completed).</p> <p><b>Cost:</b> Stacks of coins representing \$100k - \$250k.</p> <p><b>Estimated Duration (years):</b> Arrow pointing to 2-5.</p>

**Table 3: Incorporate Climate Change into Asset Management Recommendations Summary**

Recommendation		Key Activities	Summary Dashboard
#	Description		
5	Identify and assess existing chronic flooding and erosion problems caused by sea level rise, frequent storms, tidal forces, subsidence, and aging infrastructure	<ul style="list-style-type: none"> <li>DeIDOT has an extensive inventory and database of major infrastructure that contains condition data that can be used to review and monitor conditions over time.</li> <li>The Statewide Weather and Flooding Strategic Plan was completed in May 2016. This plan helps define the location, type and quantity of weather and flood monitoring systems that are still needed for the state.</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>
6	Evaluate materials used to reduce the impacts of stormwater runoff	<ul style="list-style-type: none"> <li>DeIDOT M&amp;O has been reaching out to other states, participating in conferences such as AASHTO Extreme Events Symposium and Clear Roads, and performing training through the University of Wisconsin, to learn about best practices and new technology to reduce salt use in winter operations.</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>
7	Reevaluate stormwater management approaches	<ul style="list-style-type: none"> <li>DeIDOT approves their own plans to reduce stormwater discharge and runoff. Models are updated in a dynamic manner to reflect changes in environmental conditions over time (e.g., rain curves).</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>
8	Explore new pavement technology	<ul style="list-style-type: none"> <li>Increased usage of beneficial use materials such as Reclaimed Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS) in asphalt pavements. Continuous review of new research and lessons learned from national and regional partners.</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>

# Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

**Table 3: Incorporate Climate Change into Asset Management Recommendations Summary**

Recommendation		Key Activities	Summary Dashboard
#	Description		
9	Incorporate climate impacts into cost-effective investment in infrastructure	<ul style="list-style-type: none"> <li>DeIDOT Planning/DTC utilize the Pipeline Process, a prioritization process that solicits nomination for projects from the Council on Transportation and Metropolitan Planning Organizations (MPOs). This process is used to determine which projects will be funded in the Capital Transportation Program (CTP).</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>
10	Evaluate obtaining insurance to assist in recovery from catastrophic events	<ul style="list-style-type: none"> <li>DeIDOT is self-insured, but has insurance in place to protect revenue streams (e.g., tolling facilities).</li> <li>DeIDOT is in contact with financial advisors to see how insurance may apply to catastrophic systematic damage; preliminary research suggests some level of insurance may be needed for catastrophic events, resilience and sustainability.</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>



### **2.1.2 Activities**

Table 3 highlights the initiatives and actions that are already underway or have recently taken place, across the 10 asset management recommendations. DeIDOT is currently working with a consultant to inventory all Delaware roadway assets, using light detection and radar (LiDAR). In addition, a scenario-based analysis for estimating post-disaster debris amount was completed in May 2016 by the University of Delaware (under contract to DeIDOT). Both of these initiatives will help the development of data that can help identify areas susceptible to climate change called for in Rec. #1, as will ongoing data collection based on the FEMA Hazus tool for loss estimation and impact assessment. This may also help address Rec. #2, which proposes an analysis of transportation infrastructure that supports essential services (such as hospitals and emergency shelters) for potential impacts of climate change. The development of “First Map”, a statewide GIS planning effort, will aid in the identification of areas where critical facilities are at risk of significant climate change impacts.

The level of inter-agency cooperation required in the development of a Delaware “First Map” demonstrates the amount of resources that DeIDOT is devoting to improve the quality and quantity of geographically based datasets. Another excellent example of coordination among agencies is the SR-9 Comprehensive Assessment, which is a collaboration among DeIDOT, DNREC, Wilmington Area Planning Council (WILMAPCO) and the federal agencies of NIST (National Institute of Standards and Technology) and FHWA (Federal Highway Administration), to determine the best course of action for Delaware State Road 9 (SR-9), a key roadway which regularly floods. If successful, the DNREC grant DeIDOT received for the comprehensive review of the SR-9 corridor can serve as a blueprint for identifying and analyzing other assets. For more information about the SR-9 project, see the showcase at the end of this section.

The outcomes produced by the SR-9 project may also respond to Rec. # 3, the integration of climate resiliency into project development and highway design. DeIDOT has already added language into both the Bridge Design and Project Development Manuals that require consideration of future sea level rise and climate change resilience when scoping a project. Further examples of the new focus on the changing climate are the Prime Hook and Old Corbett Road projects, which seek to balance short-term improvements with the long-term realities of continual flooding and potential sea level rise.

In response to Rec. #4, which states that DeIDOT should include features that provide resiliency to extreme weather conditions in the Transportation Alternatives Program (TAP), DeIDOT is conducting a review of a number of resources. For example, the University of Delaware Institute for Public Administration Toolkit for a Healthy Delaware; the ASCE/Institute for Sustainable Infrastructure Envision rating system; FHWA INVEST system; and NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems. The review was finalized in calendar year 2016, and will help guide infrastructure investments in this area.

While DeIDOT has an extensive database of information gleaned from many roadway and bridge infrastructure projects that contain condition data and former inspection results, DeIDOT has also been investing in broader initiatives, such as the Statewide Weather and Flooding Strategic Plan, completed in May 2016. This plan helps define what, where, and how many weather and flooding



monitoring systems are still needed in the state for different coverage scenarios (Rec. #5). Both the project-specific and wider datasets will help inform future efforts aimed at enhancing DeIDOT's infrastructure in the face of potential climate change impacts.

Rec. #6 and Rec. #7 concern stormwater management materials and methods. Rec. #6 specifically asks DeIDOT to evaluate materials and chemicals used to treat roads to meet current standards for environmental impacts to vegetation, rivers, and streams. The Climate Framework Report suggests that DeIDOT should develop new stormwater management alternatives and use low impact chemicals, or no chemicals, to reduce the impacts of stormwater runoff. Rec. #7 proposes that DeIDOT should coordinate with DNREC and the Office of State Planning Coordination to guide state stormwater management approaches toward resiliency. In particular, enhancing groundwater recharge and increased efficiency drainage should be balanced to accommodate increased stormwater runoff. The Climate Framework Report recognizes that it may be appropriate to make changes to DeIDOT's design standards and regulatory requirements for subdivision development.

DeIDOT has held an NPDES Phase 1 permit for stormwater regulations since 2001, and has held a Phase 2 permit since 2003. The stormwater management programs of the Phase I and II permits are designed to prevent harmful pollutants from being washed by stormwater runoff into the storm sewer system and then discharged from the storm sewer system into local water bodies. Phase 1 sets requirements for urban areas with populations of 100,000 or more and Phase 2 covers smaller urbanized areas. DeIDOT works with New Castle County and other municipalities under Phase 1 permits to implement the Stormwater Pollution Prevention and Management Program that covers stormwater runoff on New Castle County roadways. The Phase 2 permit covers the smaller areas of Kent and Sussex Counties, Dover, and Delmar respectively. Under the Phase 1 and Phase 2 permits of NPDES regulations, DeIDOT is responsible for salt used during snow and ice events to treat roadways. DeIDOT Maintenance & Operations is continuously striving to efficiently manage the application of salt during snow and ice events in an effort to reduce the amount of salt used while ensuring the safety of the travelling public.<sup>3</sup>

Similar to Rec. #6, Rec. #8 directs DeIDOT to explore new materials and technology that would be more resilient to climate change impacts, including extreme temperatures and moisture impacts. It is recommended that alternative materials and substrates be explored that can withstand climate-change impacts and lengthen the current lifecycle of paved surfaces. DeIDOT is always reviewing new research and lessons learned from national and regional partners about new pavement technologies and innovations. DeIDOT Materials & Research has incorporated increased usage of Reclaimed Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS) into its asphalt pavement mixes. RAP and RAS utilize reprocessed materials consisting of asphalt and aggregates, thus, mixes require a reduced amount of virgin materials. Materials & Research has allowed up to 35% of RAP and 4% RAS in pavement mixes. Since 2009, Materials & Research has also experimented with using warm mix asphalt (WMA) which is produced at lower temperatures than hot mix asphalt (between 190°F and 250°F). The lower temperatures require less energy use for suppliers, resulting in lower

---

<sup>3</sup> *New Castle County/DeIDOT Phase I Permit Fact Sheet*, DNREC Division of Water, 2013.

emissions. This also saves DeIDOT money because the supplier incurs less energy cost. Warm mix asphalt has been used on asphalt paving projects since 2009.<sup>4</sup>

Rec. #9 directs DeIDOT to reevaluate the prioritization process for projects in the Capital Transportation Program (CTP). The process should evolve to incorporate the cost/benefit of building more resilient structures to mitigate the effects of climate change. DeIDOT and DART projects are prioritized based on the six-year CTP prioritization process that solicits nominations for projects from the Council on Transportation and Metropolitan Planning Organizations (MPOs). The CTP is developed in collaboration among DeIDOT, WILMAPCO, the Dover/Kent County Metropolitan Planning Organization, the Salisbury/Wicomico MPO and Sussex County. The prioritization process is based on several criteria, stemming from DeIDOT's mission, vision, and goals. The weighting of the criteria was formulated through the Decision Lens prioritization and resource optimization software. Currently only one criterion, environmental impact/stewardship, considers the effect of the transportation system on energy use and the environment, which accounts for 6.5% of the prioritization scoring.<sup>5</sup> Appendix D of the SIP details an alternative prioritization process that involves the addition and recalibration of criteria to prioritize projects in the CTP with additional consideration for climate change, resilience and sustainability.

The final recommendation for this section, Rec. #10, entails the evaluation of alternative insurance mechanisms for DeIDOT that could assist in the recovery from catastrophic events. The recommendation proposes that DeIDOT should work with the Office of Management and Budget (OMB) and the Insurance Coverage Office to evaluate insurance policies that could provide funds to help recover from catastrophic events and prolonged loss of roadways, bridges, and equipment within the transportation system. DeIDOT is currently self-insured for catastrophic events. However, DeIDOT does have insurance in place to protect revenue streams such as tolling facilities. DeIDOT is in contact with financial advisors to see how insurance may apply to catastrophic systemic damage. Preliminary research suggests some level of insurance may be needed for catastrophic events as a component of the State's resilience and sustainability strategy.

These recommendations will help improve asset management in three ways: gathering information on assets (Rec. #1, 2, 5, 6, 8); improving structural and functional resiliency (Rec. #3, 4, 7); and promoting financial and economic resilience (Rec. #9, 10).

---

<sup>4</sup> *Recycled Materials and New Pavement Technologies*, Delaware Department of Transportation Design Teams, September 1, 2009.

<sup>5</sup> *DeIDOT Project Prioritization Criteria*, Delaware Department of Transportation.

### SR-9 Comprehensive Assessment



SR-9 near Port Penn floods during high tide and rain events, Middletown Transcript

In order to address the persistent flooding that plagues Delaware SR-9, a number of different, federal and state, transportation and environmental agencies, are involved with multiple projects, which will serve to comprehensively assess the issues facing SR-9, determine the root causes of flooding, and begin the process of providing short and long term solution sets. Such an effort requires a systems engineering approach to the issues facing SR-9, with multiple grants, a multi-year perspective, parallel projects, and an interdisciplinary outlook.

The following projects are relevant to the SR-9 comprehensive assessment:

- DeIDOT received a SOFA (Strategic Opportunity Fund for Adaptation) grant from DNREC for the SR-9 comprehensive assessment that includes an overall evaluation examining how infrastructure will be impacted by sea level rise and climate change, and determining what strategies should be employed to plan, design, construct, and maintain the critical SR-9 corridor.
- DeIDOT Planning is working towards the creation of a Transportation Risk Map, showing which roadways are susceptible to various hazards (such as climate change).
- The Scope of Work for the NIST (federal National Institute of Standards and Technology) *Community Resilience Economic Decision Guide for Buildings and Infrastructure Systems* includes steps for evaluating the economic ramifications of contemplated resilience investments.

Reference:

*SR-9 Comprehensive Assessment: Systems Engineering Approach – Comprehensive Management 2016*, Delaware Department of Transportation

#### 2.1.3 Opportunities

While DeIDOT has made great progress in the area of asset management, there are additional activities that support identification of “at-risk” infrastructure and strategies to enhance resilience. One of the largest and most comprehensive projects is the development of a statewide Transportation Risk Map, which will help determine which roads, bridges, or other important transportation assets are vulnerable (Rec. #1 and #2). DeIDOT Planning is processing a task for a consultant to support this

work and is exploring other partners and funding opportunities, similar to the SR-9 project partnerships.

Another potential partnership proposed for Rec. #5, is with the TRB's NCHRP FloodCast Project<sup>6</sup>, which requires \$250k in current funding, but may result in \$4 million in possible research funding. DeIDOT will explore the NCHRP's approach to calculating the cost impacts of climate change on transportation. Other options include an interagency forum for climate change on transportation, and the Infrastructure & Climate Network. More concretely, DeIDOT also has plans to deploy portable equipment by trailer to collect weather and flood data from locations that are not covered by existing monitoring sites. Installing weather stations in key locations will facilitate improved data collection and analysis.

In order to further integrate Climate Resiliency into Project Development, Traffic, Bridge and Highway Design (Rec. #3), DeIDOT will add language to the Road Design and Subdivision Design Manuals for planning/engineering that considers the impacts of climate change and sea level rise on roadway and subdivision design. DeIDOT will also update Standards and Specifications for consistency with changes in the Design Manuals, and re-design processes and procedures within the Planning Division to identify and address challenges that can impact final design.

In the area of Transportation Enhancements (Rec. #4), there is a plan for incorporating requirements for non-invasive plants and other approaches to minimize stormwater runoff into the TAP. In addition, DeIDOT can evaluate the current TAP application and identify areas where additional pressure could be put on project sponsors to help maintain or improve transportation system resilience.

DeIDOT anticipates reducing the use of abrasives to treat roadways in snow events, in order to reduce total suspended solids (TSS) in Delaware's waterways. DeIDOT is also in collaboration with the Infrastructure and Climate Network (ICNET), a network of academics and practitioners who aim to understand how climate change will impact transportation infrastructure and more. DeIDOT should engaging one of the region's universities to research and develop alternative designs to stormwater management that consider innovative techniques to capture runoff and pollutant discharge to promote the objectives of Rec. #6 and #7.

DeIDOT is interested in incorporating other beneficial uses and recycled materials with minimal detriment to enhance the performance of the pavement mix (Rec. #8). Emerging pavement technology is considered based on demonstrated successful use in other areas with similar climates. Once selected, new pavement mixes can be tested at DeIDOT's own research labs. These labs allow for testing of new cement and asphalt binders. DeIDOT has labs for soil and aggregate, asphalt, concrete, and chemical testing. Incorporating new pavement mixes into the standard requires a holistic approach and collaboration from all divisions of DeIDOT. Different types of pavement may impact the types of vehicles using the system, and may also impact revenue and maintenance cost.

---

<sup>6</sup> *FloodCast: A Framework for Enhanced Flood Event Decision Making for Transportation Resilience*, NCHRP Project No. 20-59(53).

DeIDOT is seeking to incorporate environmental impact criteria into Decision Lens, an online software tool that utilizes multiple criteria for prioritization and resource optimization. See for example, the Alternative Prioritization process described in Appendix D. A change of this nature would require approval by the council on Transportation. DeIDOT is also looking to utilize the Municipal Street Aid Fund to encourage municipalities to consider climate impacts in infrastructure investments. Through the Municipal Street Aid Fund, the State Legislature appropriates a portion of the Delaware Transportation Trust Fund within the CTP to each of the 57 municipalities. The funds are to be used for the maintenance of municipal maintained streets as prescribed in Title 30, Ch. 51, Subchapter III of the Delaware Code. The distribution is based on two factors: Population (40%) and Mileage (60%).<sup>7</sup> DeIDOT should consider hosting workshops/information sessions for municipalities to learn about incorporating cost-effective infrastructure enhancements for climate change resilience through this fund.

There is also an opportunity to learn from other states that are beginning to insure against catastrophic risks. DeIDOT plans to contact New Jersey Transit and the San Francisco Municipal Transportation Agency for insurance lessons learned from their experience with catastrophe insurance. When the emergency I-495 bridge closure occurred in 2015, DeIDOT was able to leverage federal emergency funds (a \$50 million line of credit) to repair the bridge. In the event of a catastrophic event that affects utilities, damages incurred by utility companies may be fully reimbursable by DeIDOT. However there is concern that if disasters strike in quick succession and DeIDOT does not have insurance, this could result in loss of FEMA funds. The Finance office is knowledgeable of the risk and is researching different insurance products that are available.

#### **2.1.4 Challenges**

In addition to the opportunities identified above, there were several challenges noted for asset management-related recommendations. A number of DeIDOT stakeholders have noted that funding can be limited, especially for work that is not specifically mandated by current rules and regulations. This is one of the drivers for partnerships that can spread the cost across multiple departments, agencies, and private partners.

There was also discussion of the lack of training climate change, resilience and sustainability, and how this might affect DeIDOT's and Delaware's transportation investments. DeIDOT needs to continue developing capabilities within the department, establish continuity and succession plans, and better understand how advances in technology can support and facilitate work in this area. Furthermore, staff needs better direction regarding the aspects of climate change that should be explored and considered, as long-term goals and objectives may not be in line with shorter-term budgetary priorities. Finally, organizational and institutional hierarchies that can produce data silos and difficulties in cross-divisional coordination need to be addressed to facilitate better inter-agency cooperation.

---

<sup>7</sup> Title 30. State Taxes, Part IV. Commodity Taxes, Chapter 51. Motor Fuel Tax, Subchapter III. State Aid to Municipalities for Streets, Delaware Code Online.

When researching new chemicals and surface treatments, DeIDOT must carefully balance concerns regarding environmental impacts of products used to treat roadways during snow and ice events with public safety concerns of roadway users.

Research for new pavement technologies requires consideration of the material source locations. For example, a new pavement mix may require an aggregate found on the west coast and may be too costly to transport across the country to test and implement. It is important that DeIDOT continue to review national research of pavement technologies, but keep the cost and feasibility of materials in mind.

In many areas of Delaware, the current stormwater management infrastructure is outdated; and existing funding is focused on reaching current standards. It may be necessary to increase this funding to incorporate climate impacts. As sea level rises, invert sizing and capacity of swales will need to be reevaluated. This is only one example of how climate change impacts can change the design standards for stormwater infrastructure. Including cost-effective infrastructure enhancements for climate resilience requires new approaches and funding paradigms that need to be supported by state policy to avoid liability and/or competitiveness issues.

While traditional approaches facilitate the evaluation of probable events, it is important that DeIDOT also evaluate how catastrophic events can impact transportation infrastructure. Currently, critical thresholds and types of events that can cause failure and permanent loss of productivity have not been identified. In order to make a commitment to this approach DeIDOT needs to better understand the benefits and costs.

## **2.2 Ensure Workforce and Public Health and Safety**

### **2.2.1 Overview**

In addition to incorporating climate change into asset management, it is critical that DeIDOT also address the health and safety impacts of climate change, both to department workers and to the general public. To accomplish this objective, there are six recommendations contained within the Climate Framework Report that seek to identify and mitigate potential health and safety challenges:

11. Evaluate and adjust worker safety guidelines
12. Provide training to improve worker knowledge
13. Evaluate driving restrictions for air quality events
14. Develop revised maintenance schedules in response to air quality
15. Adjust transit service in emergencies
16. Reevaluate emergency response protocols

Table 4 contains all of the recommendations under the Worker and Public Health and Safety umbrella. The table highlights key activities, and includes a summary Dashboard that illustrates estimated costs, duration and status for each of the six recommendations in this category. The subsections below the



# Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

table provide additional details regarding current activities, opportunities, and challenges associated with implementation of each of these recommendations.

**Table 4: Ensure Workforce and Public Health and Safety**

Recommendation		Key Activities	Summary Dashboard
#	Description		
11	Evaluate and Adjust Worker Safety Guidelines	<ul style="list-style-type: none"> <li>• DNREC Division of Energy and Climate hosted “Workforce Safety Pilot Project”.</li> <li>• DeIDOT has hosted Workforce Safety breakfasts.</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>
12	Provide training to improve worker knowledge utilizing materials for roadway maintenance	<ul style="list-style-type: none"> <li>• Not Started</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>
13	Evaluate driving restrictions for air quality events	<ul style="list-style-type: none"> <li>• Not Started</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>
14	Develop revised maintenance schedule in response to air quality	<ul style="list-style-type: none"> <li>• DeIDOT M&amp;O doesn’t mow on red ozone days.</li> </ul>	<p><b>Status:</b></p> <p><b>Cost:</b></p> <p><b>Estimated Duration (years):</b></p>

**Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation**

**Table 4: Ensure Workforce and Public Health and Safety**

Recommendation		Key Activities	Summary Dashboard
#	Description		
15	Adjust emergency response strategies to provide transit as necessary without endangering drivers or passengers	<ul style="list-style-type: none"> <li>DTC provides alternative transit service, under the direction of the TMC during state of emergency.</li> <li>DTC has participated in DEMA emergency response exercises, and is working with DEMA on revised emergency evacuation procedures.</li> </ul>	
16	Reevaluate emergency response protocols	<ul style="list-style-type: none"> <li>TMC has conducted full-scale exercises on various topics including detour plan implementation, active-shooter, radiological drills, and Computer-Aided-Dispatch (CAD-to-CAD) integration with Delaware State Police (DSP).</li> </ul>	

**2.2.2 Activities**

A number of initiatives and actions are already underway or recently completed, particularly those aimed at state employees. Worker health and safety are a very high priority for DeIDOT; as such, standards are always being evaluated and updated. In April of 2014, for example, DeIDOT Maintenance and Operations published revised mowing guidelines for operational adjustments, based on air quality and climate conditions. In accordance with these guidelines, DeIDOT does not conduct mowing operations on Red Ozone days, thereby reducing GHG emissions and worker exposure on poor air quality days (Rec. #14).

DeIDOT understands the critical role it plays in emergency situations, and strives to maintain the highest level of preparedness. The DeIDOT TMC has conducted tabletop, functional, and full-scale exercises on various topics including detour plan implementation, active shooter, radiological drills, and CAD integration with DSP, all of which are related to Rec. #16, which calls for a reevaluation of the strategies for responding to significant catastrophic events and current short-term evacuation policies. DeIDOT is also developing a Transportation Homeland Security Plan, and will integrate National Incident Management System (NIMS) best practices and Incident Command System (ICS) forms and strategies.



Another example of DelDOT's commitment to worker safety is the construction of a new Bridgeville Maintenance Yard that replaced the previous facility that was prone to frequent flooding. More information about the Bridgeville Maintenance Yard can be found in the showcase below at the end of this section. For the activities that are not started (Rec. #12 and 13), the Fact Sheets identify opportunities, recommend next steps and acknowledge the challenges to implement the recommendations. These opportunities and challenges are described in Section 2.2.3 and 2.2.4 below.

## Bridgeville Maintenance Yard Project

In order to address flooding and replace outdated facilities, a new DeIDOT South District Area 2 Maintenance Yard was recently constructed (2016), though the vision for a new yard started over 15 years ago. The Area 2 Yard was formerly located in Seaford, near Duke's Lumber, but was relocated to this new facility on Route 404, near Route 13. The buildings at the old Seaford Yard averaged 61 out of 100 on a recent building assessment survey. The new facility office includes over 500 square feet of office space and 1,200 square feet of crew area with a folding partition, projector, drop down screen, and kitchenette. The office is heated and cooled with a two-zone, closed-loop geothermal system to save energy, while the shop utilizes an in-slab radiant heat system, the first of its kind in DeIDOT.



*Above:* Flooding of old Bridgeville facility,  
*Below:* Aerial view of the new DeIDOT Bridgeville  
Maintenance Yard

The three equipment storage buildings provide an additional 7,200 square feet over the storage facilities at Seaford, allowing the yard to more effectively store and organize materials and equipment necessary for daily operations. The future salt barn will be 2,000 square feet larger than the one in Seaford, increasing storage to more than 4000 tons.

When the idea for Bridgeville was first conceived, the vision was to have a “standard” yard that included all the necessary facilities for daily operations. There have been a number of projects that have included some of these “standard buildings,” but this is the first site to have all of these standard facilities at one location. Bridgeville was developed using LEED design standards and should serve as a model for future maintenance facilities in Delaware.

Reference:

*SR-9 Comprehensive Assessment: Systems Engineering Approach – Comprehensive Management 2016*, Delaware Department of Transportation

### **2.2.3 Opportunities**

In addition to the activities above, DeIDOT personnel are planning or considering more activities that address worker safety and public health. New employee safety guidelines are being discussed, to address the impacts of extreme events. For example, if sustained winds are measured at greater than 40 mph, workers may be taken off the road (Rec. #11). Training guidelines for applying resilient roadway maintenance materials and processes (Rec. #12) will have to be developed once the new materials and processes are identified.

Some recommendations require further investigation and discussions, such as Rec. #13, which calls for DeIDOT to evaluate the costs, benefits, and feasibility of “reduced driving days”, when air quality is particularly poor. While there are examples of these “road rationing” schemes in a few locations around the globe (London, Mexico City, Seoul, Sao Paulo), the results have been uneven, and may not be applicable to what is envisioned in Rec. #13.<sup>8</sup> Therefore, further study is needed, such as whether telecommuting by state employees can be increased (which could reduce driving demand). Rec. # 16 also requires more research, in this case in conjunction with the Department of Safety and Homeland Security, to develop resilience and sustainability strategies for long-term recovery from catastrophic events.

### **2.2.4 Challenges**

For this group of recommendations a number of challenges were identified by stakeholders. For example, the collective bargaining agreements that DeIDOT holds with the various employee unions can make it difficult to change work hours, even in response to extreme weather (Rec. #11). Similarly, there is a limit to how much maintenance work can be done at night, despite air quality concerns (Rec. #14). The most common challenge mentioned, however, is a lack of resources, the scarcity of which means DeIDOT employees lack the ability to devote the time and effort required to develop solution sets that can effectively respond to the recommendations.

Another challenge worth noting is demonstrated in two recommendations (#11 & #12) that call for contractors / outside construction firms to follow DeIDOT-approved guidelines for worker safety and training in those areas. Stakeholders noted that enforcing such a mandate can be difficult and time-consuming, and may have legal complications. In addition, while most of the recommended actions related to Worker and Public Safety and Health are directed solely at DeIDOT and its divisions, some involve coordination among one or more other state agencies, meaning ultimate success is not necessarily under DeIDOT’s control. Rec. #13 (Governor’s Office, DNREC, DHSS) and #16 (DHSS) explicitly call for inter-departmental cooperation, while several other recommendations include activities that involve coordination with other departments and external entities.

---

<sup>8</sup> *The Effects of Driving Restrictions on Air Quality: Theory and Empirical Evidence*, C.-Y. Cynthia Lin Lawell et al., August 2015.

## 2.3 Support Climate Resilience in Local Communities

### 2.3.1 Overview

Creating a climate-resilient Delaware involves state agency and local government collaboration for the implementation of climate adaptation initiatives. DeIDOT is constantly working with local governments to manage the transportation network in local communities. An example presented in the Climate Framework for Delaware is DeIDOT’s collaboration with the Office of State Planning Coordination and local governments to share geospatial mapping and infrastructure assessment tools to help inform communities about climate change impacts. Rec. #17, “Support local governments with land use assessment tools”, states that DeIDOT should continue its work with the Office of State Planning, Municipalities, and Counties to develop new strategies for better resilience. Table 5 below highlights other ongoing activities that involve collaboration with local governments to strengthen their resilience to climate change impacts.

**Table 5: Support Climate Resilience in Local Communities**

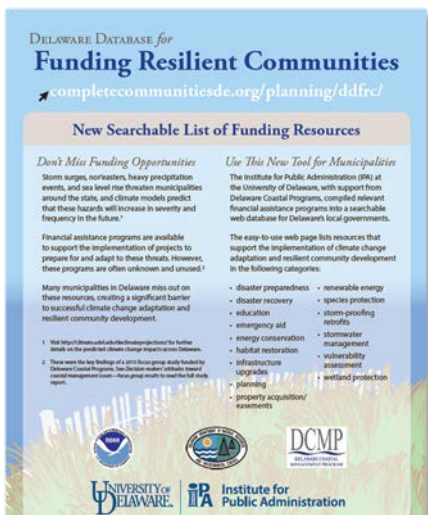
Recommendation		Key Activities	Summary Dashboard
#	Description		
17	Support local governments with land use assessment tools	<ul style="list-style-type: none"> <li>DeIDOT has supported the development of the University of Delaware Institute for Public Administration (IPA) toolkit for community development that includes an approach to resilience.</li> <li>DeIDOT has also supported IPA’s development of the <i>Transportation Improvement District (TID) Guide</i>, a document that helps local governments establish TIDs, which are alternatives to Traffic Impact Studies. TIDs are an innovative funding method for financing the construction and maintenance of transportation infrastructure, in a more sustainable manner.</li> <li>DeIDOT Planning is working with the National Institute of Standards and Technology (NIST) using the <i>Community Resilience Planning Guide for Buildings and Infrastructure Systems</i>, which provides a six-step process to help communities improve resilience for their prevailing hazards.</li> <li>DeIDOT Planning is also working with the American Society of Civil Engineers (ASCE) and the Institute for Sustainable Infrastructure (ISI) utilizing the ENVISION system which provides guidance on sustainable best practices for evaluating sustainable infrastructure.</li> </ul>	<p><b>Status:</b> A gauge showing progress from 'NOT STARTED' (red) to 'COMPLETED' (green). The needle is positioned in the green section, indicating the project is nearly completed.</p> <p><b>Cost:</b> Four stacks of coins representing cost ranges: &lt; \$100k, \$100k - \$250k, \$250k - \$1M, and &gt; \$1M. The highest cost range (&gt; \$1M) is highlighted with a larger stack of coins.</p> <p><b>Estimated Duration (years):</b> A horizontal bar chart with markers for 0-2, 2-5, 5-10, and 10+ years. A red triangle points to the 2-5 year mark, indicating the estimated duration.</p>

# Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

## 2.3.2 Activities

DelDOT is supporting local communities with climate resilience in a number of ways. DelDOT has supported the development of the University of Delaware IPA toolkit for community development. The IPA helps municipalities, counties, and state agencies with a variety of comprehensive planning services such as land use planning and land use ordinance development and updates. IPA combines its professional planning experience and research skills of its staff with the resources of the University of Delaware to provide service and assistance to local governments. In January 2016, the IPA published “Creating Flood-Ready Communities, A Guide for Delaware Local Governments” in collaboration with the School of Public Policy & Administration, and the College of Arts & Sciences.

The IPA has also supported the University of Delaware and Delaware Coastal Programs in an expansive review of financial assistance programs that pertain to the implementation of resiliency building plans and projects in Delaware. The findings were gathered into an accessible and comprehensive online index called the Delaware Database for Funding Resilient Communities. The search prioritized funding programs that support the implementation of costly activities such as infrastructure improvements, facility retrofitting, construction, and land acquisition.



Delaware Database for Funding Resilient Communities, University of Delaware/ IPA

DelDOT Planning also incorporates methodologies from the NIST Community Resilience Planning Guide (CRPG). The CRPG provides guidance on bringing together all of the relevant stakeholders to create performance standards for infrastructure and services in the event of catastrophic events. Utilizing the CRPG, local governments and other local stakeholders can put long-term plans in place to make their communities more resilient to catastrophic events.

## 2.3.3 Opportunities

DelDOT routinely provides input to different land use agencies on proposed plans and intends to incorporate wording about climate change resilience and sea level rise into the Development Coordination Manual. Generally, input is related to impacts on the transportation network (e.g., right-of-way). DelDOT’s comments have yet to include climate change considerations, and it is up to each land use agency to determine how much they want to incorporate climate change into their planning.

Currently, there are three county-level and 57 incorporated municipalities in Delaware. Smaller cities and towns (those with a population under 2,000) are required to develop a municipal development strategy, while larger cities and towns are required to develop more detailed Comprehensive Land Use Plans. To incorporate climate change into the DelDOT comment process, land use agencies will need to be informed about the effects of climate change and DelDOT’s role in providing comments concerning climate change. If DelDOT pursues this method, it is recommended that DelDOT meet with each agency to discuss recommendations and requirements. It may also be useful to conduct workshops at the county level for local governments to attend and share lessons learned.

#### 2.3.4 Challenges

To fully engage this recommendation, specific action items need to be identified. DeIDOT staff have been working on initiatives in this area but not specific to climate change, resilience, or sustainability. New action items must be created and funding allocated to local government outreach. Even so, once local governments are informed, have comprehensive long-range resilience plans in place, and are provided geospatial-mapping tools, they may still allow development in vulnerable areas. These developments will still need access to the transportation network, but to build and maintain roads in a flood prone area that gets worse every year can become costly. In these instances, DeIDOT may need the ability to tell local governments “If you choose to develop in these areas we will not provide/maintain access impacted by extreme events.” This capability would need to be supported by state policy and regulations.

### 2.4 Identify and Support Policy Initiatives that Reduce Greenhouse Gas Emissions (Climate Mitigation)

#### 2.4.1 Overview

The Climate Framework for Delaware states that Delaware was one of the first states to join the Regional Greenhouse Gas Initiative (RGGI), an initiative that uses a “cap and invest” model to reduce emissions and promote alternative energy deployments in the region. According to the [Delaware Greenhouse Gas Inventory published by DNREC's Division of Air Quality](#),<sup>9</sup> the transportation sector is responsible for 34% of greenhouse gas emissions. This puts DeIDOT in a critical position to mitigate the effects of climate change by introducing initiatives that will reduce emissions.

There are 2 recommendations from the framework that address climate mitigation:

- Evaluate low emission vehicle deployment (Rec. #18)
- Evaluate alternative energy technology in facilities (Rec. # 19)

Rec. #18 directs DeIDOT to re-evaluate the purchase of low or no emission vehicles, which has been challenging in the past due to high cost, maintenance, and state bidding rules. The recommendation does not state that vehicles must be purchased, but that DeIDOT should explore options for the low or no emission vehicle and the feasibility of deployment. Rec. #19, similar to Rec. #18, asks DeIDOT to reevaluate alternative energy technologies in building facilities. Table 6 below highlights some of the key activities that are ongoing for Rec. #18 and #19.

---

<sup>9</sup> <http://www.dnrec.delaware.gov/Air/Pages/RegionalGreenhouseGasInitiative.aspx>



**Table 6: Identify and Support Policy Initiatives that Reduce Greenhouse Gas Emissions**

Recommendation		Key Activities	Summary Dashboard
#	Description		
18	Evaluate low-emission vehicle deployment	<ul style="list-style-type: none"> <li>DTC received a \$2 million grant from the Federal government to purchase six electric buses.</li> <li>DeIDOT fleet managers participate in the Delaware Clean Cities, a group who advocates for deployment of alternative fueled vehicles.</li> </ul>	
19	Evaluate alternative energy technology in facilities	<ul style="list-style-type: none"> <li>Following Executive Order 18 for Energy Conservation and Efficiency, DeIDOT targets to meet LEED Silver certification requirements for design of new facilities.</li> <li>DTC is building new transit station in Newark and Claymont using LEED Silver concepts; will include bike stations and ADA improvements.</li> </ul>	

**2.4.2 Activities**

In 2010, following Executive Order 18: *Leading by Example Towards a Clean Energy Economy & Sustainable Natural Environment*, DeIDOT endeavored to meet Leadership in Energy and Environmental Design (LEED) Silver Certification requirements for design of new facilities.<sup>10</sup> This includes upgrading lights, roofs, windows, and HVAC systems to improve energy efficiency. Construction of a DeIDOT maintenance facility in Bridgeville in Sussex County was completed in 2016. The new facility replaces a maintenance yard in Seaford that was outdated suffered from flooding issues. The new centrally located facility will be more resilient to increased flooding and sea-level rise. The facility incorporates sustainable technology such as geothermal technology in the crew quarters and radiant heating in the maintenance shop. More information about the new facility can be found at the end of section 2.2.2.

<sup>10</sup> *Executive Order 18: Leading By Example Towards A Clean Energy Economy & Sustainability Natural Environment*, Office of the Governor, February 17, 2010.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

In 2011, Ameresco, a company that provides energy efficiency and renewable energy solutions for facilities in North America and the UK, came to DeIDOT to propose solar installation on the roofs of DeIDOT facilities. Unfortunately, the payback period for the solar installation was estimated to be about 100 years, so the project did not move forward. However, since that time there have been innovations in solar technology that make it a more viable alternative energy solution so it may be worth revisiting in the future.

DTC is currently building new transit stations in Newark and Claymont using LEED Silver concepts. The Claymont station will include bike stations and American with Disabilities Act (ADA) improvements. In July of 2016, the Claymont station project received a \$10 million grant from the US DOT and is expected to be finished by 2020. The rebuilt and expanded Newark station is estimated to cost \$26 million and will provide access to University of Delaware's STAR campus.<sup>11</sup> The DTC has also secured a \$2 million grant to purchase six zero-emission buses for use in Dover. Further information about the purchase and deployment of the vehicles can be found in the showcase below.

---

<sup>11</sup> *Newark Train Station to be improved with \$10 million federal grant*, University of Delaware, June 22, 2012.



### DTC Secures \$2 million Grant for New Electric Buses

In July of 2016, the Delaware Transit Corporation (DTC) was awarded a \$2,029,300 grant from the Federal Transit Administration (FTA) for purchasing six battery-electric buses. The grant was awarded through the competitive FY 2016 Low or NO Emission Bus and Bus Facilities grant program. The new electric buses average 17.5 MPGe (miles per gallon gasoline equivalent) compared to the current diesel fleet of buses that average 4 MPG, and have a lifetime fuel cost of \$81,000 compared to \$378,000 for diesel-fueled buses. The electric buses have a range of about 30 miles and fully charge in 5 minutes.



Proterra showcases new zero emission buses in Rehoboth, James Dawson Delaware Public Media

The buses are being manufactured by Proterra, a leader in the zero-emission battery-electric bus design and manufacturing. The grant also includes the purchase of the infrastructure required to power and maintain the buses including en-route fast charging stations, depot plug in chargers, and maintenance training needs. The six new buses are set to arrive in 2018. Current plans call for the electric buses to be used in the downtown area of Delaware's capital, Dover, and the surrounding areas of Kent County. The DTC has long-term goals to expand the operation of electric buses to Wilmington and Rehoboth once the Lewes Transit Center is complete. On August 11<sup>th</sup> and 12<sup>th</sup> of 2016, the DTC gave a public demonstration of the zero-emission buses in Rehoboth.

Reference:

*Delaware Transit Corporation Awarded \$2 Million for Electric Buses –Press Release July 25, 2016, Delaware Department of Transportation*

#### 2.4.3 Opportunities

To support informed decision-making, DeIDOT should conduct an economic analysis for electric and alternative-fuel vehicles, including maintenance and infrastructure (e.g., charging and fueling stations). Electric fueling station at DeIDOT facilities would be one way to promote this opportunity by making it easier for employees to charge electric vehicles while at work. Delaware is a small state, which enables electric vehicles travelling within the state will be able to reach their destination on one charge.

The Federal Transit Administration (FTA) Low or NO Emission (LoNo) program provides funding for transit agencies for capital acquisition and leasing of zero emission and low-emission transit buses. This includes the acquisition, construction, and leasing of required supporting facilities such as recharging, refueling, and maintenance facilities.<sup>12</sup> DART is currently exploring opportunities to leverage this funding source. Other opportunities include the following:

- Exploring partnerships with governmental and non-governmental organizations that can promote infrastructure developments for lower emission vehicles.
- Re-timing traffic signals to reduce congestion & emissions.

DeIDOT should reengage energy service companies to evaluate alternative energy solutions for DeIDOT facilities. If a straight cost-benefit analysis may fail to justify alternative energy solutions, DeIDOT may need to incorporate external benefits in its evaluation. Additionally there may be opportunities for Public-Private Partnerships (P3) to help fund alternative energy installations.

#### **2.4.4 Challenges**

Given current market conditions and cost constraints, it may be difficult to develop the infrastructure needed to accommodate alternative fuel vehicles. This is due to current cost of alternative energy solutions relative to fossil fuels and other traditional energy sources. DeIDOT must continue to follow developments in alternative energy technologies and explore innovative opportunities to meet these recommendations.

---

<sup>12</sup> *Low or No Emission Vehicle Deployment Program (LoNo Program) Webinar*, Federal Transit Administration, March 27<sup>th</sup>, 2014.

### 3. Climate Framework Implementation Strategy

While the preceding chapters detail the current efforts aimed at addressing the recommendations contained within the Climate Framework, DelDOT does not yet have a comprehensive strategy for identifying and responding to the recommendations. Tremendous work is already underway in a variety of areas, but resources are limited. In order to get the greatest return on investment, it is necessary to prioritize the recommendations. We do this first by identifying which projects, activities, and policy changes can impact multiple recommendations, and therefore need to begin (or continue) before others (Section 3.1). Next, the recommendations are analyzed to determine the priority order of implementation, based on four critical categories (Section 3.2). Using the resultant rankings, and other critical factors, an implementation timeline was constructed, and is included in Section 3.3. Funding sources, particularly those outside DelDOT and the State of Delaware, are essential for accomplishing the objectives of the Climate Framework, and these are explored in Section 3.4.

While the approach described above was used to prioritize the Climate Framework recommendations assigned to DelDOT, an alternative method was also explored. This involved modifying the existing Decision Lens process, a qualitative and quantitative rating system to measure projects against established priorities, by including climate change mitigation and resilience criteria. The results of this exercise are summarized detailed in Appendix D. Finally, any strategy requires a method of monitoring and reporting to ensure that resources are deployed as efficiently and productively as possible, and this is included in Section 3.5.

#### 3.1 Implementation Priority Rankings

The 19 Climate Framework recommendations were analyzed across four categories – Enabler, Impact, Cost, and Ease – reflecting different aspects of implementation, and rated with a score from 1 to 3 in each category as described below:

1. “Enabler”
  - Some recommendations are linked to others, and may require certain actions to be performed first. Recommendations that must be completed before others can begin are given a higher score in this category.
2. “Impact”
  - The overall impact of the recommendation on climate mitigation and adaptation. The larger the potential impact, the higher the score in this category.
3. “Cost”
  - The estimated financial cost of implementing the actions required to fully respond to the recommendation. A lower cost of implementation will result in a higher score.
4. “Ease”
  - Recommendations that require coordination with other Delaware state agencies (e.g., DNREC, Office of Insurance), other governmental agencies (e.g., FEMA, local

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

governments), or non-governmental agencies (e.g., construction contractors) may take additional time and effort, resulting in a lower score.

Table 7, Priority Ranking of Climate Framework Recommendations, presents the results of this qualitative analysis. A higher total score indicates that a recommendation is a higher priority for implementation; a lower score indicates that the recommendation is a lower priority for implementation. The four recommendations with the highest score (9) were placed into Tier One, the seven recommendations with the next highest score (8) were placed into Tier 2, and the remaining eight recommendations into Tier 3. This table can be used as a guide for DeDOT planners when allocating scarce resources for the implementation of these recommendations.

**Table 7: Priority Ranking of Climate Framework Recommendations**

RECOMMENDATION #	RECOMMENDATION	IMPLEMENTATION CATEGORY				TOTAL	IMPLEMENTATION TIER
		ENABLER	IMPACT	COST	EASE		
Rec #1	Development of geospatial data sets to identify vulnerable areas	3	3	1	2	9	1
Rec #2	Comprehensive Analysis of Critical Infrastructure	3	3	1	1	8	2
Rec #3	Integrate climate resilience into bridge & highway design manuals	3	3	2	1	9	1
Rec #4	Build transportation enhancements to accommodate cc impacts	1	1	1	2	5	3
Rec #5	Identify & assess chronic flooding and erosion problems	2	3	1	2	8	2
Rec #6	Evaluate materials used to reduce the impacts of stormwater runoff	2	1	2	3	8	2
Rec #7	Reevaluate stormwater management approaches	2	2	2	2	8	2
Rec #8	Explore new pavement technology	2	1	2	3	8	2
Rec #9	Incorporate climate change into infrastructure investments	2	3	3	1	9	1
Rec #10	Evaluate catastrophic event insurance	1	3	3	1	8	2
Rec #11	Evaluate worker safety guidelines	1	2	2	2	7	3
Rec #12	Train workers on utilizing resilient materials	1	2	2	1	6	3
Rec #13	Evaluate driving restrictions for air quality events	1	3	2	1	7	3
Rec #14	Revise maintenance schedules in response to air quality	1	1	2	2	6	3
Rec #15	Adjust emergency response strategies for transit	1	2	2	2	7	3
Rec #16	Coordinate with DSHS on strategies for catastrophic events	2	2	3	1	8	2
Rec #17	Support local governments with land use assessment tools	2	3	3	1	9	1
Rec #18	Evaluate low-emission vehicle deployment	1	1	2	3	7	3
Rec #19	Evaluate alternative energy technology in facilities	1	1	2	3	7	3

IMPLEMENTATION PRIORITY TIERS

	TIER ONE		TIER TWO		TIER THREE
--	----------	--	----------	--	------------

While a qualitative approach was utilized to rank the Climate Framework Recommendations in this SIP, DeIDOT has adopted a more systematic approach to project prioritization for funding purposes, referred to as an Analytical Hierarchy Process (AHP). Decision Lens is the AHP solution currently being used at DeIDOT. The process uses both a qualitative and quantitative rating system to measure projects against established priorities. The criteria used in the prioritization process are based on several factors: DeIDOT's Mission Statement, Vision, and Goals; provisions from Title 29 Chapter 84 § 8419 of the Delaware Code; provisions from the Federal Authorization Bill Map-21; the 2010 Long Range Transportation Plan, and remnants of the old 1998 prioritization process. The current method enables a comparison of different project types through a data driven approach, which the old 1998 process lacked.

It is noteworthy, however, that climate change, sustainability, and resilience considerations are largely absent from the current process. The only criterion within the Decision Lens process that indirectly considers climate change impacts is "Environmental Impact/Stewardship," which accounts for 6.5% of the overall weighted score. To more effectively incorporate climate change, resilience, and sustainability considerations, it is recommended that DeIDOT consider introducing new criteria into the Decision Lens process. Appendix D provides an alternative to the existing Decision Lens Model that combines the criteria currently used in the model with criteria adopted from the "Efforts and Outcomes" section of the Climate Framework Report. This approach would incentive project champions to include project elements that effectively address these important climate change, resilience, and sustainability considerations in the project planning process in order to elevate their projects in the project prioritization process. See Appendix D for additional details regarding the suggested modifications to the Decision Lens model, as well as a discussion regarding incorporation of risk and uncertainty in the modeling process.

### **3.2 Key Projects, Activities and Policy Changes**

This section highlights the strategic importance of Tier One recommendations in the overall Climate Framework implementation strategy.

Rec. #1, which calls for the development of geospatial data sets, is perhaps the most important DeIDOT recommendation, as it has the potential to impact a number of other recommendations. Recommendations 2, 3, 4, 5, 9, 11, 13, 14, and 17 are all, to varying degrees, dependent on the information that will be produced by the rigorous examination and application of rainfall and storm surge models to assess the potential impacts on infrastructure from extreme events and sea level rise in the State of Delaware.

DeIDOT has already begun implementing the actions contained within Rec. #3. This includes adding language to the Bridge Design Manual that requires consideration of climate change impacts, and the development of this Strategic Implementation Plan that includes resiliency and sustainability considerations for transportation. There are also plans for adding language into DeIDOT's Road Design Manual for planning/engineering to consider impacts of climate change and sea level rise in roadway design, and re-designing processes and procedures within DeIDOT Planning to minimize

challenges that can impact final design. While these efforts will take time to develop and implement, the potential impact on climate change resilience could be significant.

Rec. #9 calls for DeIDOT to reevaluate the prioritization process for projects in the Capital Transportation Program (CTP), which could have an effect on many (if not all) of the recommendations, because the implementation of every recommendation will eventually involve some level of capital funding and thus inclusion into the CTP. Currently, DeIDOT utilizes the Decision Lens process to prioritize projects in the CTP, however climate resilience is not among the criteria for scoring the projects. An alternative method of prioritization for DeIDOT projects that includes climate resilience is presented in Appendix D.

Rec. #17 calls for DeIDOT to support local governments with land use assessment tools. This will involve working with external agencies including the Delaware Office of State Planning and counties and municipalities in the state on land use planning. Today, some comprehensive land use plans include climate change factors, while others do not. DeIDOT can provide assistance, through the transfer of climate data, technical guidance, and other information sharing, to enable local and regional planners to develop better land use plans that include climate change sustainability and resilience considerations.

### 3.3 Implementation Timelines

The “Estimated Duration” was developed for each recommendation in isolation, without consideration given to how the actions would fit together or how many DeIDOT could address simultaneously. The Implementation Ranking Tiers and Estimated Durations presented in the Fact Sheets were integrated to create an Implementation Timeline. This timeline attempts to provide a framework for addressing the DeIDOT Climate Framework recommendations, and completing the activities and actions necessary to adequately respond to these recommendations.

While all Tier One recommendations are scheduled to begin by 2017, a mix of Tier Two and Tier Three recommendations can also take place in 2017. The Implementation Priority Tier is only one of the factors used to create the schedule, along with organizational capacity and the presence of interrelated activities. Organization capacity refers to the number of recommendations that are tasked to an individual DeIDOT division; the more actions that the division (or agency, if outside DeIDOT) is required to enact, the more likely that one or more of the recommendations must wait until others are completed (or underway). Similarly, other recommendations that are lower in the Implementation Priority Tier rankings, but involve a DeIDOT division that has relatively fewer recommendations tasked to it, can begin (or continue) as soon as possible. Absent any resource restrictions, actions that address the Climate Framework recommendations should begin as soon as possible.

As the Timeline shows, all recommendations will be fully addressed by 2023. This goal is within DeIDOT’s capacity, but unexpected and unforeseen outside factors may impact plans and schedules. The most significant potential event could be a natural disaster (or series of natural disasters) that would cause funding to be diverted to necessary short and long-term recovery efforts. Less dramatic, but still a significant potential risk, would be a budget crisis, within DeIDOT or the State of Delaware, that could draw resources away from climate change mitigation and resilience efforts, including actions that respond to the Climate Change Framework Recommendations. Finally, political changes may lead to adjustments in governmental priorities, both at the federal or state level. Any of these developments could result in the Implementation Timeline changing, or being pushed outwards, past 2023.



**Table 8: Climate Framework Recommendation Implementation Timeline**

RECOMMENDATION #	RECOMMENDATION	DURATION TO COMPLETION (YEARS)	YEAR						
			2017	2018	2019	2020	2021	2022	2023
1	Continue Development of Geospatial Data Sets that Can Help Identify Vulnerable Areas and Help Estimate the Impact of Reasonably Anticipated Events	2-5	Green	Green	Green	Green			
2	Conduct Comprehensive Assessment of State Roadway Risks and Assets	2-5	Blue	Blue	Blue	Blue			
3	Integrate Climate Resiliency Into Project Development, Traffic, Bridge and Highway	2-5	Green	Green	Green				
4	Build Transportation Enhancements (Pathways, Trails, Roadscapes, etc.) to Accommodate Impacts of Climate Change	2-5			Brown	Brown	Brown	Brown	
5	Identify and Assess Existing Chronic Flooding and Erosion Problems Caused by Sea Level Rise, Frequent Storms, Tidal Forces, Subsidence, and Aging Infrastructure	2-5	Blue	Blue	Blue	Blue	Blue		
6	Evaluate Materials Used to Reduce the Impacts of Stormwater Runoff	2-5		Blue	Blue	Blue	Blue		
7	Reevaluate Stormwater Management Approaches	2-5		Blue	Blue	Blue	Blue		
8	Explore New Pavement Technology	2-5		Blue	Blue	Blue			
9	Incorporate Climate Impacts into Cost-Effective Investments in Infrastructure	0-2	Green	Green					
10	Evaluate Obtaining Insurance to Assist in Recovery from Catastrophic Events	2-5	Blue	Blue	Blue	Blue			
11	Evaluate and Adjust Worker Safety Guidelines	2-5	Brown	Brown	Brown				
12	Provide Training to Improve Worker Knowledge	0-2			Brown	Brown			
13	Evaluate Driving Restrictions For Air Quality Events	2-5		Brown	Brown	Brown	Brown		
14	Develop Revised Maintenance Schedule in Response to Air Quality	0-2			Brown	Brown			
15	Adjust Emergency Response Strategies to Provide Transit as Necessary Without Endangering Drivers or Passengers	2-5			Brown	Brown	Brown		
16	Reevaluate Emergency Response Protocols	0-2	Blue	Blue					
17	Support Local Governments with Land Use Assessment Tools	2-5	Green	Green	Green	Green			
18	Evaluate Low-Emission Vehicle Deployment	2-5	Brown	Brown	Brown				
19	Evaluate Alternative Energy Technology In Facilities	0-2			Brown	Brown			

IMPLEMENTATION PRIORITY TIERS



TIER ONE



TIER TWO



TIER THREE

### 3.4 Implementation Costs and Funding

Implementation costs were estimated for each of the DeIDOT recommendations and reported in the Fact Sheets. These rough order-of-magnitude estimates were developed through an iterative process

and confirmed by the stakeholders at the Climate Framework Workshop. Individual cost estimates were then combined to develop an overall cost for the program. These costs, which are intended for planning purposes, are reported below. The “Low” estimate represents the sum of the lower bound for all of the recommendations, the “medium” estimate represents the sum of the midpoints, and the “High” estimate represents the sum of the upper bound.

- Total Cost of Implementing All Recommendations (Low): \$2,500,000
- Total Cost of Implementing All Recommendations (Medium): \$4,825,000
- Total Cost of Implementing All Recommendations (High): \$7,150,000

Again, while this range should only be used for planning purposes, it demonstrates that many of the recommendations can be implemented with limited funding. Even if every recommendation was accomplished at the high end of the cost spectrum, the total amount required is just over \$7 million, which represents less than 1% of the total DelDOT budget in FY2016.

In order to fund the activities contained within the recommendations, and continue the efforts already underway, it is critical to identify any available funding resources. These resources can come from a variety of sources, including direct allocation from state and federal governments, grants, and non-governmental agencies. Below are a few of the potential sources of funding for projects that address the Climate Framework recommendations.<sup>13</sup>

#### 3.4.1 Federal Funding

- *Federal Emergency Management Agency (FEMA) – Hazard Mitigation Assistance Grant Program.* FEMA’s Hazard Mitigation Assistance (HMA) grant program provides funding for mitigation activities that reduce disaster losses and protect lives and properties from future disaster impacts. There are three HMA grant programs:
  - Hazard Mitigation Grant Program (HMGP): HMGP funds help communities implement hazard-mitigation measures following a major disaster. States can apply for funds and can then disburse these funds to sub-applicants, usually local governments. In Delaware, the Delaware Emergency Management Agency (DEMA) administers these funds. Delaware local governments can apply for these funds for long-term mitigation activities such as upgrades to infrastructure, land acquisition, flood proofing, and the elevation of properties. To be eligible, a jurisdiction must first adopt a jurisdiction-wide hazard-mitigation plan.
  - Pre-Disaster Mitigation Program (PDM): The PDM program can assist local communities in implementing a sustained pre-disaster natural hazard–mitigation program that reduces the overall risk of future hazard events on populations and structures. States submit PDM grant applications to FEMA, and local communities can apply for funds from the state.

<sup>13</sup>For a more complete and updated list of funding resources, the University of Delaware Institute for Public Administration, with support from DNREC and National Oceanic and Atmospheric Administration (NOAA), created the Delaware Database for Funding Resilient Communities. <http://www.completecommunitiesde.org/planning/ddfrc/>

- Flood Mitigation Assistance Program (FMA): The FMA program aims to reduce or eliminate claims under the National Flood Insurance Program (NFIP) by providing funds to communities for measures that reduce or eliminate the long-term risk of flood damage to NFIP-insured structures. Funding is available for flood hazard mitigation projects, plan development, and management costs. Sub-applicants, such as local governments, can submit mitigation planning and project applications to the state, which would then submit an FMA grant application to FEMA. Eligible applicants are funded based on criteria such as cost-effectiveness of the project.
- *National Oceanic and Atmospheric Administration (NOAA) – Regional Coastal Resilience Grant Program.* NOAA's Regional Coastal Resilience Grant Program supports regional efforts that strengthen coastal communities' resiliency to extreme weather events, climate hazards, and changing ocean conditions. The grant program supports planning and implementing mitigation and adaptation actions that increase economic and environmental resiliency. Proposals that demonstrate regional coordination among project stakeholders, leveraging of resources, and potential economic and environmental benefits for coastal communities will be most successful. Grants range anywhere from \$500,000 to \$1 million.

#### **3.4.2 Federal / State Funding**

- *Environmental Protection Agency (EPA), via State Revolving Loan Funds.* The Clean Water State Revolving Fund (CWSRF) and Drinking Water State Revolving Fund (DWSRF) Programs are federal/state partnerships designed to finance the cost of infrastructure needed to achieve compliance with the Clean Water Act. Through the State Revolving Funds (SRFs), states maintain revolving loan funds to provide low-cost financing for a wide range of water quality infrastructure projects, such as traditional municipal wastewater treatment and collection systems, nonpoint source program implementation projects, wetlands restoration, groundwater protection, innovative storm water runoff and estuary management projects, drinking water treatment and conveyance systems, and source water protection. Funds to establish or capitalize the SRF programs are provided through EPA grants to the states, along with state matching funds (equal to 20 percent of federal government grants).

#### **3.4.3 State Funding**

- *Delaware Department of Transportation (DelDOT) – Surface Transportation Block Grant (STBG) Set-Aside Program.* Since 1991, the biggest sources of funding for bicycle and pedestrian projects have been:
  - Transportation Enhancements (TE) program,
  - Surface Transportation Program (STP),
  - Congestion Mitigation and Air Quality (CMAQ) Program,
  - Recreational Trails Program (RTP), and
  - Safe Routes to School (SRTS) Program.

- In 2012, Moving Ahead for Progress in the 21st Century (MAP-21) combined the TE, SRTS and RTP programs into one Transportation Alternatives Program (TAP). In December 2016, President Obama signed into law the Fixing America's Surface Transportation (FAST) Act. Under the FAST Act, the STP was renamed the Surface Transportation Block Grant (STBG) program, and the TAP becomes a set-aside program of this block grant. Walking and bicycling projects remain an eligible activity for the larger STBG as well as CMAQ and the Highway Safety Improvement Program (HSIP). DeIDOT continues to administer this program, which is funded by the Federal Highway Administration (FHWA) and provides up to 80 percent of the proposed project costs to successful applicants.
- *DNREC – Resilient Community Partnership.* Through the Resilient Community Partnership, DNREC's Delaware Coastal Programs partners with one community for one year to initiate formal resiliency planning, offering direct staff support, policy expertise, technical assistance, and funding throughout the planning process. Communities are eligible, regardless of where they are in the resiliency process. Coastal Programs administers up to \$75,000 in NOAA funds for contracted services, such as cost-benefit analyses and engineering designs. Matching funds are encouraged but not required. Any incorporated municipality or county is eligible for the partnership; unincorporated communities must acquire county sponsorship before applying.

### 3.5 Monitoring and Reporting

It is important to monitor, document and report on the status of DeIDOT's climate framework recommendations in support of EO41. This helps DeIDOT to highlight successes and to identify areas that require additional focus, resources and support for planning purposes.

The Climate Framework for Delaware does not recommend a specific method of which to monitor and report the ongoing status of recommendation activities. However, Executive Order 41 states:

“The Secretary of Natural Resources and Environmental Control shall serve as chair of (CCoCAR) and, with the cooperation of other state agencies, is responsible for managing and tracking implementation of this Order.”

It is CCoCAR's responsibility to check in with state agencies and report the progress of recommendation activities. The *Climate Action in Delaware: 2016 Progress Report* is the first of these updates highlighting activities across Delaware state agencies.

For consistent reporting, DeIDOT is advised to assign a Champion for each recommendation to report on progress, planned activities, and constraints/issues. These reports would be assembled on a quarterly basis utilizing the format below or similar (see Appendix E for alternative Progress Report formats).

CLIMATE CHANGE RECOMMENDATION QUARTERLY PROGRESS REPORT			
Point of Contact _____		Division _____	Date _____
Rec #	Recent Progress	Planned Activities	Constraints/Issues
Ex. 1	1	Completed Lidar project	Meeting with DNREC 6/8
Ex. 2	5	Continuity of Ops Plan complete	Submit Cont. of Ops Plan for review

Figure 1: A Sample Quarterly Progress Report

In example 1 of the sample report, the completion of the Lidar project that takes inventory of roadways assets, is recorded as recent progress for Rec. #1. The report points out an upcoming meeting with DNREC as a planned activity and the need for a GIS planner as a constraint to progress.

Every other Quarterly Progress Report should coincide with a semi-annual Climate Change meeting that consists of champions for each recommendation, and other stakeholders as appropriate. In this meeting, stakeholders and champions would discuss activities and issues related to the Climate Framework recommendations. Ideally, the meetings would have a similar size and make-up of the Climate Change Workshop conducted on July 27, of 2016.

The next semi-annual meeting would coincide with the CCoCAR annual report. DeIDOT would use the Quarterly Progress Reports and any documents from the semi-annual meetings to submit as an update to CCoCAR.

### 3.6 Summary

All of the Recommendations contained in the Climate Framework are necessary and important for the long-term environmental and economic health of Delaware. Both staffing and funding resource constraints, must be recognized, as DeIDOT has many competing priorities to address. Therefore, a prioritization process is important in determining the appropriate allocation of staff and financial resources toward fulfillment of these recommendations. Nineteen recommendations were prioritized in three tiers, with the high priority 'Tier One' recommendations listed below.

#### 1. Tier One

- Recommendation (Rec.) #1: Continue Development of Geospatial Data Sets that Can Help Identify Vulnerable Areas and Help Estimate the Impact of Reasonably Anticipated Events
- Rec. #3: Integrate Climate Resiliency Into Project Development, Traffic, Bridge and Highway Design

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

- Rec. #9: Incorporate Climate Impacts into Cost-Effective Investments in Infrastructure
- Rec. #17: Support Local Governments with Land Use Assessment Tools

The aggregate cost for implementation of all 19 recommendations is estimated at \$4.85 million, with a lower bound estimate of \$2.5 million and upper bound estimate of \$7.15 million. Based on prioritization and consideration of implementation timelines for the various Climate Framework recommendations, it is estimated that all will be completed within the next 5 years, by 2022. A monitoring and reporting process is provided to track DelDOT's progress toward achievement of its Climate Framework recommendations.

## 4. Sustainability and Resilience Considerations

The first three chapters of this SIP focus on activities to address issues and concerns related to climate change as part of the Climate Framework for Delaware. This chapter expands the focus beyond climate change, broadening the context to include sustainability and resilience considerations. For example, sustainability involves balancing environmental concerns with social and economic principles, while resilience encompasses a wide array of threats beyond just the threats associated with climate change. Threats to critical infrastructure identified in the National Infrastructure Protection Plan 2013 (NIPP)<sup>14</sup> The remainder of this chapter expands on these concepts, highlighting the many opportunities and challenges DeIDOT faces in the development of a more sustainable and resilient transportation system in Delaware.

### 4.1 Sustainability

The Brundtland Commission of the United Nations in 1987 defined sustainable development as “development which meets the needs of current generations without compromising the ability of future generations to meet their own needs.” Another way to define sustainability is the capacity to endure. Sustainable transportation considerations are focused on striking a balance between economic, social, and environmental principles (referred to as the triple bottom line) in a manner that supports the ongoing development, operation, and maintenance of an ‘enduring’ transportation system. These principles are illustrated in the FHWA’s guidance that a sustainable approach to transportation should consider:

- Access (not just mobility),
- Movement of people and goods (not just vehicles),
- Provision of transportation choices, such as safe and comfortable routes for walking, bicycling, and transit,
- Efficient use of funding,
- Incentives for construction quality,
- Regional air quality and climate change, and
- Environmental management systems, among other considerations.

To support states and local transportation agencies in evaluating the sustainability of their current and planned programs and projects, the FHWA developed a tool to help organizations effectively assess and take action to balance these principles and promote sustainability. As noted on their web site, “FHWA’s INVEST (INfrastructure Voluntary Sustainability Tool) is a web-based self-evaluation tool comprised of voluntary sustainability best practices, called criteria, which cover the full lifecycle of transportation services, including system planning, project planning, design, and construction, and continuing through operations and maintenance. FHWA developed INVEST for voluntary use by transportation agencies to assess and enhance the sustainability of their projects and programs.”<sup>15</sup> INVEST can be used at any stage in the project lifecycle to assess sustainability progress and identify

<sup>14</sup> *National Infrastructure Protection Plan 2013 – Partnering for Critical Infrastructure Security and Resilience*, US Department of Homeland Security, page 8.

<sup>15</sup> FHWA INVEST Web site: <https://www.sustainablehighways.org/100/about.html>



areas for improvement. As of June 2016, there were projects in 31 states and the District of Columbia being implemented by 15 state DOTs (including DeIDOT), 20 MPOs, 23 Federal Land Units, and 6 other transportation agencies in the US that are using INVEST.

DeIDOT used INVEST to evaluate the DeIDOT Pavement and Rehabilitation Program as well as other Operation and Maintenance (OM) activities. The analysis utilized the INVEST OM module to score its sustainability efforts and to identify areas for improvement. The evaluation was conducted by subject matter experts from within the agency, including representatives from Planning, Traffic Safety, Business Management, Maintenance and Operations, and Engineering Support. Two INVEST categories where DeIDOT scored highly were 'Pavement Management System' and 'Bridge Management System,' thanks in part to pavement and bridge management systems that DeIDOT developed to track performance and conditions across the state. A category where DeIDOT did not score highly was 'Recycling and Reuse,' because DeIDOT has not established any formal mandates or objectives for recycling, despite recognizing that DeIDOT has been recycling for decades.

The INVEST evaluation helped DeIDOT highlight successes and identify opportunities to enhance the agency's OM sustainability efforts. DeIDOT continues to assess and pursue these improvements, as reflected in the activities summarized in the Climate Framework Fact Sheets. DeIDOT also plans to conduct subsequent evaluations of its programs with the INVEST System Planning and Project Development modules. For additional details and lessons learned from the DeIDOT INVEST Case Study see the full case study summary provided in Appendix F.

While sustainability is one of the buzz words of the day, DeIDOT, to its credit, has been considering sustainable transportation development for many years. In 1991, DeIDOT began participating in the Corridor Capacity Preservation Program, which began as a voluntary pilot program administered by FHWA. Based on the success of this pilot project, the Delaware General Assembly in 1996 passed legislation<sup>16</sup> enabling DeIDOT to establish the Delaware Corridor Capacity Preservation Program, the goals of which are to:

- Maintain a road's ability to handle traffic safely and efficiently,
- Minimize the impacts of increased economic growth,
- Preserve the ability to make future improvements,
- Prevent the need to build an entirely new road, and
- Separate local and through traffic.<sup>17</sup>

Twenty years later, this DeIDOT program continues and the residents of Delaware and those passing through the state on these corridors continue to benefit from these sustainability efforts. The INVEST analysis and Corridor Capacity Preservation Program are just two examples of sustainability efforts being undertaken by DeIDOT. Others include current and planned actions highlighted in the Fact Sheets such as:

- Improvements in travel modelling allow the user to see the impacts of population growth on emissions projections (Rec. #1).

<sup>16</sup> Delaware Code, Title 17, Section 145.

<sup>17</sup> *The Corridor Capacity Preservation Program, Strategies to Delay System Expansion, Focus Development and Preserve Quality of Life*, DeIDOT, 2001.

- A high-level vulnerability assessment by DNREC is partially completed, requiring refinement for engineering project level (Rec. #1).
- Portable RWIS and movable Flooding Systems projects are scheduled to begin in Fiscal Year 2017 (Rec. #2).
- Language associated with sea level rise and climate change will need to be added to Subdivision Design Manual (Rec. #3).
- The completed Phase 1 for adding flooding monitoring capabilities for roadways for 10 sites looking at water levels, discharge, and velocity for streams and tides (Rec. #5).
- DelDOT fleet managers participate in the Delaware Clean Cities, a group who advocates for deployment of alternative fueled vehicles (Rec. #18).
- DelDOT is tracking energy use data in DelDOT facilities through Energy Star to track the energy savings from energy efficient solutions (Rec. #19).

DelDOT is also becoming more open to alternative contracting mechanisms (e.g., design-build, construction manager / general contractor, P3) that can help to spur the development of innovative projects and partnerships in this area. Through these efforts, DelDOT will continue to take a leadership role in the State of Delaware's sustainability efforts.

## 4.2 Resilience

Resilience is defined in the Oxford English Dictionary as “the capacity to recover quickly from difficulties; toughness.”<sup>18</sup> The AASHTO Standing Committee on Research (SCOR) in 2016 notes that “The transportation system is a complex network of infrastructure, vehicles, power sources, communications, and human capital. When we speak of resilience in the transportation sense, we mean the ability of the transportation system to recover and regain functionality after a major disruption or disaster.”<sup>19</sup>

Resilience is not a new or novel concept; resilience concerns have, however, increased considerably following the terrorist attacks on the World Trade Center on September 11, 2001. Since that time, there has been a heightened focus on critical infrastructure protection, a key driver for today's resilience efforts at the federal, state, and local level. In 2013, President Obama issued a Policy Directive on Critical Infrastructure Security and Resilience that assigns joint responsibility to the US Department of Homeland Security (DHS) and US Department of Transportation (DOT), underscoring the importance of protecting our nation's transportation infrastructure. In order to make our transportation infrastructure more resilient, it is important to consider and address a variety of different characteristics of resilience, including the following:

- Space Capacity – this requires back-ups or alternatives when core systems fail,
- “Safe Failure” – prevention of failure from causing further impacts to cascade across the system,

<sup>18</sup> Resilience [Def. 1]. *Oxford Living Dictionaries*. <https://en.oxforddictionaries.com/definition/resilience>.

<sup>19</sup> AASHTO Standing Committee on Research, 2016.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

- Rapid Rebound – the capacity to reestablish functionality quickly and avoid long term disruption,
- Flexibility – the ability to change, evolve, and adapt,
- Constant Learning – inclusion of robust feedback loops that allow for new solutions as conditions change over time, and
- Feasibility – includes optimal engineering approaches and alternatives by weighing costs and benefits.

In short, resilience goes beyond critical infrastructure protection and encompasses the ability to recover from an incident in order to provide critical transportation services during the incident and through the recovery process. Transportation resilience considerations therefore must include the people and systems (e.g., telecom and power) that are required to operate the transportation system. Community-based planning and coordination is advocated as part of the process of building more resilience into the transportation system because of the interrelationships among critical infrastructure systems and the variety of stakeholders that manage and rely on these systems.

DelDOT recognizes the importance of resilience, as noted in the Climate Framework report: “Increasing resiliency of Delaware’s transportation infrastructure is critical to the state’s economy and to public safety. The Department of Transportation is working on multiple fronts to apply a risk and resilience management approach to respond to current and upcoming challenges from climate change. This includes improving capacity for data analysis, use of GIS systems, and increasing the use of risk assessment tools. DelDOT provides staff training in the use of Hazus, a risk assessment tool supported by the Federal Emergency Management Agency. Hazus is a system that uses models to assess damage and estimate losses from floods, hurricanes, and disasters.”<sup>20</sup>

The National Infrastructure Protection Plan (NIPP) developed by the US Department of Homeland Security outlines how government and private sector participants in the critical infrastructure community can work together to manage risks and achieve security and resilience outcomes. NIPP recognizes that the community involved in managing risks is wide-ranging, and state transportation agencies are an important member of this community.

The goal of the NIPP is to “Build a safer, more secure, and more resilient America by enhancing protection of the Nation’s critical infrastructure and key resources (CI/KR) to prevent, deter, neutralize, or mitigate the effects of deliberate efforts by terrorists to destroy, incapacitate, or exploit them; and to strengthen national preparedness, timely response, and rapid recovery in the event of an attack, natural disaster, or other emergency.”<sup>21</sup>

NIPP advocates for an integrated approach to manage the risks from significant hazards and threats to critical infrastructure that includes the following elements:

- Identify, deter, detect, disrupt, and prepare for threats and hazards to the Nation’s critical infrastructure,
- Reduce vulnerabilities of critical assets, systems, and networks, and

<sup>20</sup> *Climate Framework for Delaware – Summary of Recommendations*, December 31, 2014, pg. 6.

<sup>21</sup> *National Infrastructure Protection Plan 2009: Partnering to Enhance Protection and Resiliency*, US Department of Homeland Security, 2009, pg. 9.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

- Mitigate the potential consequences to critical infrastructure of incidents or adverse events that do occur.

“The national effort to strengthen critical infrastructure security and resilience depends on the ability of public and private critical infrastructure owners and operators to make risk-informed decisions when allocating limited resources in both steady-state and crisis operations.”<sup>22</sup> The 2013 NIPP also includes a “Call to Action” that advocates for stakeholder collaboration across three broad categories: building upon partnership efforts; innovating in managing risk; and focusing on outcomes. The importance of collaboration among stakeholders is a key emphasis of the NIPP; these collaborations and partnerships among stakeholders can lead to the establishment and pursuit of mutual goals while supporting national priorities in a more efficient and cost-effective manner.

The NIPP Risk Management Framework calls for each sector to identify those functions, assets, networks, systems and people that make up the critical infrastructure and key resources. Here are key considerations from the transportation sector’s perspective:

- **Functions** – the assignments, tasks, and positions in a state DOT that are critical to the performance of continued transportation and service through any hazard or disruption.
- **Assets** – the infrastructure, equipment, resources, tools, vehicles, hardware, roadways, tunnels, and facilities owned and operated by a state DOT to ensure the continued safe transport of goods and people through any hazard or disruption.
- **Networks** – the relationships maintained by a state DOT with local municipalities, contractors, the private sector, and other branches of local, state and federal government to ensure continuity of transportation operations through any hazard or disruption.
- **Systems** – the variety of critical technology platforms and applications, including all software utilities and electronic forms of data, utilized by state DOT personnel to operate assets and infrastructure, support functional continuity, and enable network communication and reliability through any hazard or disruption.
- **People** – the inherently necessary human resources and personnel needed by a state DOT to ensure transportation service is provided through any hazard or disruption.

It is important to consider and understand the interdependencies among each of these categories to build resiliency. It is also important to consider and establish priorities to define the functions, assets, networks and systems to be enhanced through actions intended to promote resilience. Priorities may change over time based on changing conditions, external influences, and emerging threats. To this end, it is critical to establish a knowledge base that will guide how to align data, information, and knowledge management to address changing needs over time.

In USDOT’s 2014 Climate Adaptation Plan, DOT identifies three general areas of vulnerability to be addressed through the Plan. These are (1) Existing Infrastructure Resilience, (2) New Infrastructure Resilience, and (3) System Resilience. This three pronged approach could serve as an organizational framework for DelDOT’s resilience efforts, expanding the focus beyond infrastructure such as roads

---

<sup>22</sup> *National Infrastructure Protection Plan 2013: Partnering for Critical Infrastructure Security and Resilience*, US Department of Homeland Security, 2013, pg. 1.

and bridges to include other elements of the transportation system and the parallel infrastructure that supports these systems (e.g., personnel, communications, and power).

The National Institute of Standards and Technology (NIST) of the US Department of Commerce has developed a series of planning guides and tools to support communities in their resilience efforts. Reliable transportation is a key element of resilience at all levels of government and the tools developed by NIST also provide useful guidance to state agencies such as DeIDOT as they underscore the interdependence among systems such as transportation, power and communications. More importantly, however, they provide transportation agencies with the opportunity to partner with other transportation system stakeholders at the regional, state, and local community level, to develop integrated approaches to transportation system resilience that transcend the boundaries of traditional owner/operator responsibilities.

The following example illustrates how resilience considerations can be applied to risks associated with climate change through a four step process. This process involves determining relevant hazards, assessing vulnerabilities, analyzing risks, and developing strategies to enhance resilience and reduce vulnerabilities as described below:

- *Determine Relevant Hazards*
  - It is important to understand current hazards and to predict future hazards in determining the appropriate allocation of limited resources (time, staff resources, financial resources).
  - Current hazards are identified based on actual events, while future hazards need to be established based on scientific modeling, expert knowledge, and data observation over time. It is important to determine and track key indicators such as, for example, sea level rise.
- *Assess Vulnerabilities*
  - Some vulnerabilities are known based on past performance of the system, others may be determined by modeling future impacts of changing conditions over time. Information sharing and collaboration across geographic boundaries, agency divisions, etc. is important to get the big picture.
- *Analyze Risks*
  - The risks associated with identified hazards and vulnerabilities must be analyzed in a common/consistent manner to help decision-makers appropriately weigh and prioritize competing needs for limited resources to address these risks.
- *Develop a Response to Enhance Resilience and Reduce Vulnerability*
  - This response may include evolving strategies as well as specific targeted actions. In areas where information and data are lacking, stakeholders should consider new approaches to either acquire data or begin collecting data to support improved risk analysis over time. Once risks are known and prioritized, specific action plans should be developed to address these risks and improve system resilience.

#### 4.2.1 Financial Resilience

Physical resilience is a critical component of any resilience plan. It includes (1) construction of resilient infrastructure such as coastal wetlands and levees, (2) reinforcement of existing infrastructure, and (3) resilient design of future infrastructure. However, these approaches are incomplete if they do not consider probability, costs, and benefits associated with investments in physical resilience. A complementary approach to physical resilience is to utilize financial instruments such as insurance or catastrophe bonds to mitigate financial risks associated with potential disasters. A good strategy is one that finds the appropriate balance between these different approaches to resilience. Targeted investments in resilient infrastructure that yield high benefit-cost ratios should be a goal for any transportation agency. For situations where costs are high relative to benefits, and/or the probability of occurrence is so low that it doesn't warrant investment in the infrastructure, then insuring against the potential damage/disaster may be a more appropriate solution.

There is a new program called RE.bound that is attempting to integrate resilient infrastructure project finance with catastrophic bonds, this builds on the work of the RE.invest Initiative, "a collaboration among eight partner cities and leading engineering, law, and finance firms to create new public-private partnerships for resilient infrastructure. Cities across the country are facing serious challenges in rebuilding their aging water, energy, and transportation systems. RE.invest is designed to help cities develop more flexible, sustainable, and integrated networks and use public resources more efficiently to leverage private investment in building stronger communities."<sup>23</sup> A detailed overview of this innovative RE.bound Program can be found in the following report: *Leveraging Catastrophe Bonds as a Mechanism for Resilient Infrastructure Project Finance*.<sup>24</sup>

Since the State of Delaware is the insurer of last resort, it is important to consider the financial implications of potential disasters that are expected to increase in frequency and magnitude over time as a result of climate change, and to explore new and innovative approaches to enhance both physical and financial resilience of the state's transportation system.

#### 4.2.2 Security and Resilience

Closely linked to the concept of Resilience is that of Security. As mentioned above, the NIPP provides overall strategic guidance on the mitigation of resilience and security risks, but more specific recommendations are included with the 2015 Transportation Systems Sector-Specific Plan (TS SSP). The TS SSP is a planning tool for the agencies involved with protecting critical transportation infrastructure, the owners and operators of the infrastructure, and partners at the local, regional, state, and federal levels. The TS SSP guides and integrates efforts to secure and strengthen the security of critical infrastructure, identifies the sector's security and resilience priorities, and describes the approach to managing critical infrastructure risk.

DelDOT representatives are involved with the Department of Homeland Security (DHS) State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC)<sup>25</sup>, which assist in the

<sup>23</sup> <http://www.reinvestinitiative.org/about-reinvest/>

<sup>24</sup> *Leveraging Catastrophe Bonds as a Mechanism for Resilient Infrastructure Project Finance*, The Rockefeller Foundation, April 2015.

<sup>25</sup> <https://www.dhs.gov/sltt-gcc>



development and communication of guidance for implementing and operationalizing the NIPP at the local, state, and regional levels. DeIDOT is also represented on the Mitigation Framework Leadership Group of FEMA<sup>26</sup>, which coordinates and assesses mitigation efforts and capabilities.

DHS also leads the Regional Resiliency Assessment Program (RRAP)<sup>27</sup>, which is voluntary, non-regulatory, and produces a cooperative assessment of specific critical infrastructure within a designated geographic area. A RRAP assessment also includes a regional analysis of the surrounding infrastructure to address a range of infrastructure resilience and security issues that could have regionally and nationally significant consequences. The expected outcomes from an RRAP include:

- Resolves infrastructure security and resilience knowledge gaps,
- Informs risk management decisions,
- Identifies opportunities and strategies to enhance infrastructure resilience, and
- Improves critical partnerships among the public and private sectors.

Each RRAP project typically involves a yearlong process to collect and analyze data on the critical infrastructure within the designated area, followed by continued technical assistance to enhance the infrastructure's resilience. Individual projects can incorporate opportunities for valuable information and data exchanges, including voluntary facility security surveys, first responder capability assessments, targeted studies and modeling, and subject matter expert workshops. The culmination of RRAP activities, research, and analysis is presented in a Resiliency Assessment documenting project results and findings, including key regional resilience gaps and options for addressing these shortfalls. DHS provides the Resiliency Assessment, along with supporting documents and information, to select RRAP participants in the form of a multimedia presentation. RRAP projects are selected each year by DHS's Office of Infrastructure Protection with input and guidance from federal, state, and local partners.

In recent years the risks to critical infrastructure, including in the transportation sector, posed by cyber threats have multiplied and increased in prominence. DeIDOT and its various partners must be vigilant and informed about these threats, and how they have are evolving.

One method for identifying and addressing threats and hazards to transportation assets and programs is to conduct a Threat and Hazard Identification and Risk Assessment (THIRA)<sup>28</sup>. The THIRA process helps communities identify capability targets and resource requirements necessary to address anticipated and unanticipated risks. The THIRA process involves four steps:

- 1) *Identify the Threats and Hazards of Concern* – Based on a combination of experience, forecasting, subject matter expertise, and other available resources, identify a list of the threats and hazards of primary concern to the community.
- 2) *Give the Threats and Hazards Context* – Describe the threats and hazards of concern, showing how they may affect the community.

<sup>26</sup> <https://www.fema.gov/media-library/assets/documents/116787>

<sup>27</sup> <https://www.dhs.gov/regional-resiliency-assessment-program>

<sup>28</sup> <https://www.fema.gov/threat-and-hazard-identification-and-risk-assessment>



- 3) *Establish Capability Targets* – Assess each threat and hazard in context to develop a specific capability target for each core capability identified in the National Preparedness Goal.
- 4) *Apply the Results* – For each core capability, estimate the resources required to achieve the capability targets through the use of community assets and mutual aid, while also considering preparedness activities, including mitigation opportunities.

The THIRA helps the whole community – including individuals, businesses, faith-based organizations, nonprofit groups, schools and academia and all levels of government – understand its risks and estimate capability requirements. The process also helps communities to determine:

- Desired outcomes,
- Capability targets, and
- Resources required to achieve the capability targets.

The THIRA standardizes the risk analysis process that emergency managers and homeland security professionals employ every day, and informs a variety of emergency management efforts, including: emergency operations planning, mutual aid agreements, and hazard mitigation planning. Ultimately, the THIRA process helps communities answer the following questions:<sup>29</sup>

- What do we need to prepare for?
- What shareable resources are required in order to be prepared?
- What actions could be employed to avoid, divert, lessen, or eliminate a threat or hazard?

It is important to remember that while federal oversight, technical guidance, and financial support are essential elements of an efficient and effective infrastructure security program, it is vital that agencies and organizations at the local and state level take a collaborative approach to the identification and mitigation of climate change-related security risks to transportation infrastructure. The threat posed by climate change and the need for enhanced cross-agency cooperation makes it important to work on efforts that involve multiple stakeholders, at various levels of government. Maintaining the transportation infrastructure system may be primarily the responsibility of state DOTs and regional MPOs, but any potential risk to the system would be felt across the entire economy, as almost every aspect of daily life depends on an efficient and functional transportation network.

While the impacts may be felt most acutely at the local level, transportation assets, programs, and investments typically cross jurisdictional boundaries. This dichotomy between the cost of the resources required (typically spread across an entire state or metropolitan region, with the federal responsible for a portion) and the impacts of system failure (typically experienced most negatively at the local level) means that communities and their governmental components must collaborate on security and resilience issues. This also requires the involvement of the private sector, as public resources are scarce and technological advances that can aid in risk assessment are typically produced by private enterprises. Furthermore, the private sector, as almost every part of society, is highly dependent on a functional and resilient transportation network.

---

<sup>29</sup> *Threat and Hazard Identification and Risk Assessment Information Sheet*, FEMA, November 14, 2013.

### 4.3 Sustainability and Resilience Strategy Development

The *NIPP 2013 Supplemental Tool: Incorporating Resilience into Critical Infrastructure Projects* provides useful recommendations for promoting sustainability and resilience considerations in infrastructure investments. When making investment decisions and selecting infrastructure projects, decision makers are encouraged to use these recommended steps listed below to the fullest extent applicable and possible:<sup>30</sup>

- Incorporating projected climate change impacts into the decision-making process. [Rec. # 3, 7, 9]
- Measuring both the direct and indirect costs and benefits of developing the project to gain a holistic picture of the impact of the project (e.g., the financial and opportunity cost of losing infrastructure functions and services, the societal impacts of developing the project, environmental costs and benefits).
- Examining demographic trends and using the anticipated demographics to predict the future demand for infrastructure.
- Consulting with FEMA on the best available data pertaining to flood risk (e.g., the FEMA Map Service Center to access current flood maps). [Rec. # 5]
- Referring to available science and predictive tools on future trends and risks when selecting a location (e.g., the NOAA Sea Level Rise and Coastal Flooding Impacts Viewer tool, etc.). [Rec. # 1, 5]
- Considering applicable standards and best practices for incorporating resilience into asset and system design. [Rec. # 3, 4, 6, 7, 8]
- Conducting vulnerability assessments that can identify where the infrastructure is vulnerable to known and future risks. [Rec. # 2, 5]
- Utilizing available risk assessment and scenario planning tools to make risk-informed decisions (e.g., the Department of Homeland Security-sponsored Owners Performance Requirements tool, which enables owners to develop several scenarios for a project to help select the optimal combination of performance levels for energy, environmental, safety, security (including blast; ballistic; and chemical, biological, and radiological protection), sustainability, durability, operational, and cost-effectiveness attributes to meet their needs).
- Identifying key dependencies and interdependencies and ways in which this critical infrastructure asset, system, or network could impact other components of critical infrastructure systems, whether within the same sector or across sectors.
- Mapping potential cascading effects from potential infrastructure disruptions.
- Working with partners to develop a picture of how this infrastructure investment will fit into the regional landscape of critical infrastructure.

---

<sup>30</sup> *NIPP 2013 Supplemental Tool: Incorporating Resilience into Critical Infrastructure Projects*, US Department of Homeland Security, 2013, pp. 2-3.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

- Developing a comprehensive incident response plan that includes such components as scenario planning for the most likely risks and clearly articulated roles and responsibilities for all partners. [Rec. # 16]
- Building redundancy into an infrastructure system so it can handle a localized failure.
- Budgeting for infrastructure mitigation during the development of a project to ensure the resilience of the infrastructure to threats and hazards. [Rec. # 9]
- Developing a business continuity plan to ensure rapid recovery from disasters or other disruptions.
- Planning to conduct periodic updates for the infrastructure asset that can incorporate new technologies and/or upgrades that could enhance mitigation.
- Determining whether environmental buffers (e.g., dunes or wetlands) can be incorporated into the infrastructure design to mitigate the effects of natural disasters.
- Ensuring there are manual overrides and physical backups built into automated systems.

It is reassuring to note that many of the current and planned activities being conducted by DeIDOT to address Climate Framework Recommendations are reflected in the steps listed above. Moreover, it underscores the importance of having good data as the basis for informed decision-making. This includes data on demographics, environmental conditions (e.g., rain curves, flood maps, sea level rise projections), costs and benefits of resilience and sustainability efforts, and risk assessment and scenario planning tools available through the US Department of Homeland Security and USDOT. In addition to these quantitative tools, DeIDOT should further evaluate financial mechanisms including insurance and catastrophe bonds to promote financial resilience to complement physical resilience.

## 5. Next Steps

This Strategic Implementation Plan highlights the variety of current and planned activities across virtually every division within DelDOT, geared toward addressing climate change issues while promoting sustainability and resilience of the transportation system across the State of Delaware. The next steps listed below look beyond the Climate Framework Recommendations and consider a path forward to further integrate climate change, sustainability, and resilience considerations in all stages of the transportation system project lifecycle from planning and design to construction, operations, and maintenance.

### General

- Review SIP progress on an annual basis and update as necessary.
- Explore additional funding sources to support climate change, resilience & sustainability research and implementation.

### Climate Change

#### Planning

- Continue to monitor, track, and report on the implementation of DelDOT's Climate Framework Recommendations.
- Review current and planned activities within the high priority Recommendations to see if there are any opportunities to expedite implementation.

#### Tools & Resources

- Collect all county and municipal documents related to climate change and mitigation plans, to establish a central depository and to help promote consistency across state and local plans.

### Resilience

#### Planning

- Support NIST Community Resilience Initiative by participating in NIST community resilience planning efforts in the region through coordination with other transportation stakeholders.
- In consultation with FEMA and other relevant stakeholders, prepare a Threat and Hazard Identification and Risk Assessment (THIRA), to identify community-specific threats and hazards and to set capability targets for each core capability identified in the National Preparedness Goal (as mentioned in Presidential Policy Directive 8: National Preparedness).
- Develop tracking and reporting mechanisms for transportation sustainability initiatives.

#### Tools & Resources

- Begin utilizing the NIST Community Resilience Economic Decision Guide for Buildings and Infrastructure Systems (NIST Publication 1197), which supports cost-benefit analysis of alternative capital investments in resilience.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

- Utilize the *Critical Infrastructure Threat Information Sharing Framework*, a resource provided by the US Department of Homeland Security, to help critical infrastructure owners and operators, as well as other partners that share threat information, understand the processes and mechanisms currently used to share cyber and physical threat information.
- Explore the options offered by the US Department of Homeland Security Regional Resilience Assessment Program and the criteria for assessment selection.

### Training

- Continue to train staff on utilization of FEMA's Hazus risk assessment tool and utilize the tool to model different disaster scenarios to help identify and address vulnerabilities.
- Determine the training requirements for relevant programs (including FEMA course IS-2001), on the THIRA process.

### Finance

- Continue to research financial instruments such as insurance and catastrophe bonds through the innovative RE.bound program.

### Sustainability

#### Planning

- Develop tracking and reporting mechanisms for transportation sustainability initiatives.

#### Tools & Resources

- Utilize FHWA INVEST System Planning and Project Development modules to analyze other areas of DelDOT operations to highlight successes and identify areas for improvement related to sustainability efforts.
- Utilize ASCE/ISI ENVISION rating system and best practices to incorporate sustainability considerations in the development of infrastructure projects.

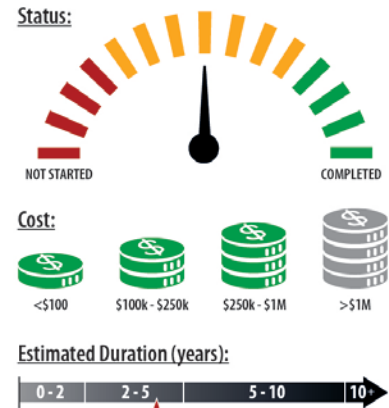
By focusing on these long-term, comprehensive factors, DelDOT can develop requirements and strategies that both anticipate and mitigate future impacts to infrastructure, employees, and the general public.

## Appendix A. Fact Sheets – Climate Framework Recommendations

### 1. Continue Development of Geospatial Data Sets that Can Help Identify Vulnerable Areas and Help Estimate the Impact of Reasonably Anticipated Events

#### Recommendation Summary

DelDOT should work with outside agencies to review and revise current rainfall curves and to develop comprehensive and dynamic rainfall and maximum likely storm surge models to assess impacts to infrastructure (not just transportation) in vulnerable areas. Current models and geospatial data captures only a partial view of the effects of climate change, mostly from a static viewpoint, and not from the effects of major storm surge, periods of heavy rainfall, or other major catastrophic events. Updates to geospatial forecasts incorporating these scenarios will help suggest where to place investments to improve the resilience of our communities (e.g., bury utilities, build sea walls, reinforce dams, etc.). These data will then be used by local jurisdictions to determine land use in comprehensive plans. DelDOT will use previous storm data (i.e., from Superstorm Sandy) as scenario planning data for development of potential risks in these geographically vulnerable areas.



#### Current Progress

- There is currently a project with a consultant to take inventory of roadway assets using Light Detection and Radar (LiDAR). The project is in the data extraction phase.
- Improvements in travel modelling allow the user to see the impacts of population growth on emissions projections.
- Ongoing data collection based on FEMA Hazus tool for loss estimation and impact assessment.
- Updates to GIS dataset of “Roads that Typically Flood” has been reviewed by Districts and it is now available through: <http://firstmap.gis.delaware.gov/inundation/>
- A high-level vulnerability assessment by DNREC is partially completed, requiring refinement for engineering project level.
- Initial scenario-based analysis for debris estimates completed in May of 2016 by the University of Delaware, under contract for DelDOT.
- A new task for the estimation of anticipated events is in negotiation in Planning.
- DelDOT is working to improve location of centerlines in base maps.

#### Next Steps

- Create asset inventory that other agencies can use and update.
- Utilize Synchro and VISIM simulation models for 3D simulation to generate more visibility and understanding of impacts of different catastrophic events.
- Develop a statewide Transportation Risk Map; funding is a major need for addressing data, model and scenario analysis. DelDOT Planning is processing a task for a consultant to support this work and is exploring other partners and funding opportunities.
- FEMA Mitigation Funds being discussed to address risk for an area of interest defined on the New Castle County Mitigation Plans that builds upon recommendations of Sea-Level-Rise recommendations developed with DNREC.

## 1. Continue Development of Geospatial Data Sets that Can Help Identify Vulnerable Areas and Help Estimate the Impact of Reasonably Anticipated Events

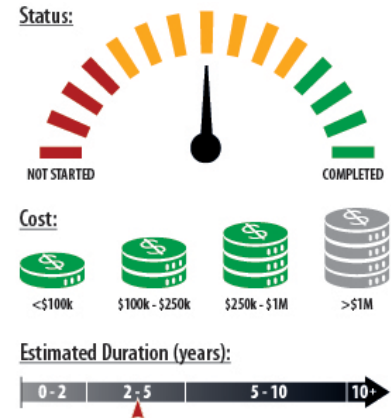
Challenges	Other Considerations
<ul style="list-style-type: none"> <li>Lack of staff with advanced GIS experience.</li> <li>Travel model software code is 20 to 30 years old. Code originally meant for freeways and arterials.</li> <li>Need collaboration and funding among the Delaware First Map stakeholders.</li> <li>Looking at new rainfall curves could add substantial cost.</li> </ul>	<ul style="list-style-type: none"> <li>Pavement Inventory Asset Allocations, projects that allow ability to visualize and model project impacts.</li> <li>Tax parcel information for more refined models on local roads.</li> <li>Climate Change Resilience could be topic at future Utility Summit.</li> <li>Inundation and frequently flooded road maps should be updated on gateway in a defined cycle.</li> </ul>
Strengths	DeIDOT Stakeholders
<ul style="list-style-type: none"> <li>Strong desire of DeIDOT staff to take on new projects.</li> <li>Support from DeIDOT upper management.</li> <li>Ability for DeIDOT staff to organize workshops and industry roundtables.</li> </ul>	<ul style="list-style-type: none"> <li>Bernie Gilbert, <i>Planning - Decision &amp; Data Support</i></li> <li>Mike DuRoss, <i>Planning - Regional System Planning</i></li> <li>Monroe Hite, <i>Transportation Solutions - Right of Way</i></li> <li>Eric Cimo, <i>Transportation Solutions - Utilities</i></li> </ul>



## 2. Conduct Comprehensive Assessment of State Roadway Risks and Assets

### Recommendation Summary

DelDOT proposes to conduct a comprehensive analysis of the state's roadways, bridges, and other infrastructure (stormwater ponds, dams, and dikes) to identify those elements or portions of the transportation system that provide access to essential services, such as hospitals and emergency shelters, and that could be vulnerable to climate change impacts such as flooding. The purpose of this analysis will be to create a plan to improve the resiliency of the transportation system by rendering these essential elements as reliably and predictably available for use in emergency situations as possible given our current knowledge and understanding of the maximum likely events such as extreme weather.



### Current Progress

- DelDOT and DNREC coordinating on GIS mapping "First Map", a statewide planning effort. Preliminary maps already in use and providing value in planning.
- There has been work on the district level with Fire and EMS to keep primary routes to hospitals open during severe weather events.
- DSHS and Department of Education are assessing locations for construction of new facilities with regard to climate change and sea-level rise.
- DelDOT Planning has received a grant from DNREC for a comprehensive review of SR-9.
- SR-9 adjacent roadways improvements and inclusion of a specific location of interest to New Castle County Emergency Managers on the risk assessment together with SR-9 is being considered for funding through DEMA using FEMA's Mitigation Funds because of existing actions included in the New Castle County Mitigation Plans.
- A Strategic Statewide Study for Developing a Weather and Flooding Monitoring System has been completed and approved for publication with FHWA.
- An Implementation Plan inclusive of SOPs for the planning, design, construction and maintenance of new sites for the Weather and Flooding Monitoring System is being developed.
- Portable RWIS and movable Flooding Systems projects are scheduled to begin in Fiscal Year 2017.
- A Transportation Risk Map is being developed through currently funded projects, enabling three complementary perspectives: a governmental perspective through Hazus; an academic perspective through the University of Delaware; and a private sector, insurance industry perspective through a consultant task with Risk Management Services (RMS).
- An agreement has been established with NIST for the implementation of the Community Resilience Planning Guide and use of their Economic Assessment Tool for compliance with FAST Act requirement to include Benefit-Cost Analysis in the development of project level adaptation/resilience strategies.

### Next Steps

- Explore DNREC funding opportunities to support comprehensive vulnerability assessment of Delaware's transportation infrastructure.
- Finish developing and submit proposals to address other environmental needs that impact transportation through the Department of Interior's Cooperative Ecosystem Studies Units Program. This includes work on potable water, land use and transportation infrastructure.

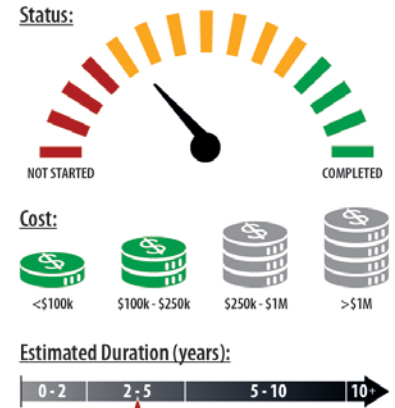
## 2. Conduct Comprehensive Assessment of State Roadway Risks and Assets

Challenges	Other Considerations
<ul style="list-style-type: none"> <li>• Requires change in definition of process and continuous funding.</li> <li>• Comprehensive statewide vulnerability assessment is a major undertaking even for a small state; will require coordination across divisions and districts as well as ongoing funding.</li> <li>• Comprehensive proposal requiring partnership with DNREC, and Department of Economic Development and Housing.</li> </ul>	<ul style="list-style-type: none"> <li>• The four District Engineers should be consulted for information to support the assessment of state roadway risks and assets in their respective districts. For example, District Engineers recently provided maps of frequent flooding areas.                             <ul style="list-style-type: none"> <li>○ Don Weber, <i>North District</i></li> <li>○ Kevin Canning, <i>Canal District</i></li> <li>○ Tom Greve, <i>Central District</i></li> <li>○ Alastair Probert, <i>South District</i></li> </ul> </li> <li>• Stakeholder identification and coordination still needs to be developed.</li> <li>• Ensure that appropriate staff are trained to use the Economic tool from NIST.</li> </ul>
Strengths	DeIDOT Stakeholders
<ul style="list-style-type: none"> <li>• Delaware is a small state and government agencies can mobilize more quickly.</li> <li>• Commitment and determination of DeIDOT and State leadership.</li> </ul>	<ul style="list-style-type: none"> <li>• Jim Pappas, <i>Transportation Solutions - Performance Management</i></li> <li>• Brian Urbanek, <i>Maintenance &amp; Operations - Statewide Support Services</i></li> <li>• Silvana Croope, <i>Planning - Decision &amp; Data Support</i></li> </ul>

### 3. Integrate Climate Resiliency Into Project Development, Traffic, Bridge and Highway Design

#### Recommendation Summary

DeIDOT should integrate into its bridge and highway design manuals strategies for improving the resiliency of the transportation system (including against sea level rise) for short-term, medium-term, and long-term anticipated effects. Current projects are developed with an eye toward present and future traffic flows, safety improvements, and maximum lifecycle value of the asset. New designs will also take into account short-term, medium-term, and long-term effects of climate change, based on geospatial information, to accommodate these effects over the lifecycle of the asset. Project Development will assess the potential cost impacts of these adjustments to determine the efficacy of building to adapt to anticipated climate change impacts. For example, traffic safety and management will evaluate the need to increase and improve roadway messaging, lighting, and retro-reflectivity in their design manuals to accommodate the greater anticipated frequency and severity of rain events.



#### Current Progress

- Added language to DeIDOT’s Bridge Design Manual that requires consideration of future sea level rise and climate change resilience when scoping a project.
- Added language to Project Development Manual.
- DNREC has completed a project with DeIDOT on Prime Hook Road to address recurring flooding issues.
- Old Corbett Road maintenance/repair project is being re-evaluated because of its high cost and low traffic impacts.
- DeIDOT working with New Castle County (NCC) to provide direct link to video feed.
- Working on Strategic Implementation Plan that will include sections for development coordination, local systems improvement, regional systems planning, and data support incorporation, using the processes and procedures for climate resiliency and sustainability.

#### Next Steps

- Add language into DeIDOT’s Road Design Manual for planning/engineering to consider impacts of climate change and sea level rise in roadway design.
- Update Standard Details and Specifications for consistency with changes in the Road and Bridge Design Manuals.
- Need to re-design processes and procedures within the planning division to minimize challenges that can impact final design.
- Installing weather stations in key locations for better weather monitoring and data analysis.
- Traffic may soon adopt LED lighting as the standard. This would involve an updated DeIDOT lighting guide and updated specifications.
- Language associated with sea level rise and climate change will need to be added to Subdivision Design Manual.
- Properly document and format the initial Transportation Risk Map.
- Define and add risk assessment of specific location of interest to New Castle County as defined in their mitigation plans.

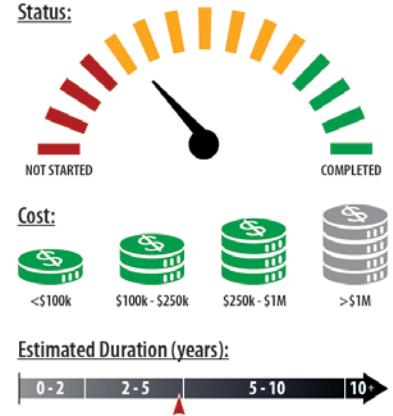
### 3. Integrate Climate Resiliency Into Project Development, Traffic, Bridge and Highway Design

Challenges	Other Considerations
<ul style="list-style-type: none"> <li>• Difficult to abandon roads and bridges in low to near sea level areas, especially if they serve as an evacuation route.</li> <li>• Do not have systematic process in place to deal with frequent flooding roads with low number of vehicles per day.</li> <li>• Implementation costs may be very high.</li> <li>• Staff lacks training/direction regarding consideration of climate change and sea-level rise.</li> </ul>	<ul style="list-style-type: none"> <li>• Need more proactive measures.</li> <li>• Create systematic review of how to deal with frequently flooded roads with low number of vehicles per day.</li> <li>• Additional training requirements.</li> <li>• NIST meetings on Climate Change Resilience.</li> <li>• Need more coordination among all projects to identify the best value outcome for decision-making.</li> </ul>
Strengths	DelDOT Stakeholders
<ul style="list-style-type: none"> <li>• Access to maps that provide projections of sea level rise.</li> <li>• Retroreflectivity for signs and striping prepared for very low visibility.</li> </ul>	<ul style="list-style-type: none"> <li>• Mike Simmons, Transportation Solutions, <i>Project Development - South</i></li> <li>• Mark Tudor, Transportation Solutions, <i>Project Development - North</i></li> <li>• Barry Benton, <i>Transportation Solutions - Bridge</i></li> <li>• Mark Luszcz, <i>Transportation Solutions - Traffic</i></li> <li>• Marc Cote, <i>Planning - Subdivisions Planning</i></li> </ul>

## 4. Build Transportation Enhancements (Pathways, Trails, Roadscapes, etc.) to Accommodate Impacts of Climate Change

### Recommendation Summary

DeIDOT should incorporate accommodations in its Transportation Alternatives Program to provide resiliency for extreme heat, drought, heavy rainfall, or extreme cold and prolonged freezing. Current Transportation Alternatives projects strive for a minimum of maintenance and context sensitive design. Future designs should include noninvasive resilient plants and should deliberately minimize stormwater runoff impacts.



### Current Progress

- Current work for trails and pathways using DNREC’s flooding sliders for sea-level rise and hurricane GIS files.
- Identification of existing processes that help to address climate change impacts has started with internal meetings.
- Conducting review of the following resources: University of Delaware Institute for Public Administration (IPA) Toolkit for a Healthy Delaware; ASCE/Institute for Sustainable Infrastructure Envision rating system; FHWA INVEST system; and NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems. Review will be finalized in calendar year 2016.
- Standard Specification Section 908 already includes language barring use of invasive species plants in design.

### Next Steps

- Incorporate requirements for non-invasive plants and other approaches to minimize stormwater runoff.
- Evaluate current procedures and identify areas where additional elements could be considered that help to maintain or improve transportation system resilience.

### Challenges

- Limited funding for construction of transportation enhancements to accommodate impacts of climate change.
- Could have larger impacts on utilities depending on what is required. Some of these costs may be the responsibility of the state. Could also require additional right of way or easements.

### Other Considerations

- None

### Strengths

- Working with DNREC and University of Delaware.
- Extensive transportation enhancement program already exists, part of which is looking at alternative transportation methods.

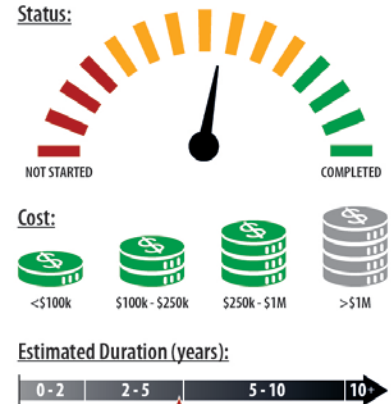
### DeIDOT Stakeholders

- Silvana Croope, *Planning - Decision & Data Support*
- Jeff Niezgoda, *Planning – Statewide and Regional Planning*

## 5. Identify and Assess Existing Chronic Flooding and Erosion Problems Caused by Sea Level Rise, Frequent Storms, Tidal Forces, Subsidence, and Aging Infrastructure

### Recommendation Summary

DeIDOT should coordinate with DNREC (Divisions of Fish and Wildlife, Watershed Stewardship, and Water) to identify and assess existing chronic flooding and erosion caused by sea level rise, frequent storms, tidal forces, subsidence, and aging infrastructure (e.g., water-control structures, levees, culverts, and roadside shoulder erosion).



### Current Progress

- DeIDOT has an extensive inventory and database of major infrastructure such as roadways and bridges. Database contains condition data and former inspection results that can be used to review and monitor conditions overtime.
- Current initiatives include the completed Phase-1 for adding flooding monitoring capabilities for roadways for 10 sites looking at water levels, discharge, and velocity for streams and tides. These sites will have an initial forecasting capability with alarms that are triggered when water exceeds roadway elevations.
- The Statewide Weather and Flooding Strategic Plan was completed in May 2016 and submitted to DeIDOT for review and final approval. This plan helps define what, where, and how many weather and flooding monitoring systems are still needed in the State for different coverage scenarios and suggests time for review of current plans.
- Continuity of Operations Plan is being developed.
- Much of the assessment to date has been project-specific rather than comprehensive; there has been a fair amount of discussion regarding dams.

### Next Steps

- For weather interoperability capabilities to work, need to integrate on flooding piece, consider portable capabilities and other capabilities that are not yet covered.
- Portable equipment could be deployed on trailer to collect data from locations that are not currently covered by existing monitoring sites. State Planning and Research funding will be allocated to purchase trailer.
- Explore NCHRP approach way to calculate cost impacts of climate change on transportation.
- Partner w/ Transportation Research Board (TRB) – National Cooperative Highway Research Program (NCHRP) “FloodCast” Project No. 20-59(53)
  - \$250k in current funding
  - \$4m in possible research funding
- Interagency climate change forum for transportation
- Infrastructure & Climate Network (ICNET) – letter of support to University of New Hampshire
- Flood monitoring will continue; data management will be complemented with work from operations and maintenance to planning and construction, closing the loop for the cycle of transportation infrastructure management.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

### Challenges

- Need to overcome Data silos that currently exist within DeIDOT.
- Challenges coordinating across divisions due to organizational / cultural issues.
- Financial constraints. Need to consider different approach to funding projects. Seek opportunities to collaborate with private sector and multiple agencies to decrease investment and maintenance levels.
- Most challenging piece is subsidence, must identify pinpoint problem areas better.

### Other Considerations

- Need to better leverage existing funding opportunities for voluntary programs.
- Utilize Machine Learning and Artificial Intelligence for asset review.
- Need to continue developing capabilities in the department. Some staff are further along the learning curve than others. Need more in the way of continuity and succession plans.
- Microsoft software systems do not support analytical requirements needed for robust climate change analysis. Need more comprehensive decision support systems.
- Need to discuss and reach agreement with FEMA for replacement value that impacts plans and disaster aid.
- Need to better understand how technology is advancing that can support/facilitate work in this area

### Strengths

- DeIDOT has policies in place that demand action. DeIDOT has a team in place to implement resilience and sustainability. Following up on 100 Resilient Cities, Delaware wants to be First Resilient State.
- Maximo System could be used as a tool to help identify where chronic flooding events occur.

### DeIDOT Stakeholders

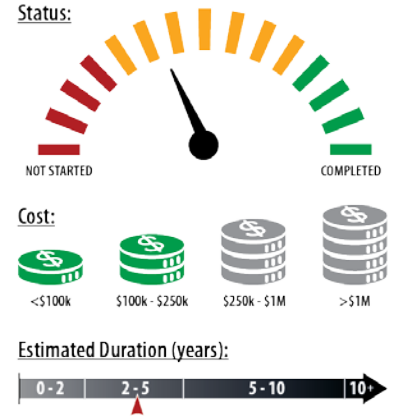
- Silvana Croope, *Planning - Decision & Data Support*
- Brian Urbanek, *Maintenance & Operations - Statewide Support Services*
- Gene Donaldson, *Transportation Solutions – TMC*
- Thomas (Bill) Brockenbrough, *Planning – Development Coordination*



## 6. Evaluate Materials Used to Reduce the Impacts of Stormwater Runoff

### Recommendation Summary

DeIDOT should evaluate and qualify materials used to treat roads to meet standards for environmental impacts to vegetation, rivers, streams, etc. As greater moisture events (heavy rainfall, snow) occur due to climate change, use of chemicals for snowmelt plays a part in the impact of stormwater on roadside vegetation, wildlife and fish, and other aquatic species. Development of new designs with stormwater management alternatives and use of low impact chemicals (or no chemicals at all) will reduce these impacts.



### Current Progress

- National Pollutant Discharge Elimination System (NPDES) permittees striving to reduce salt usage during snow and ice event in New Castle County (Phase 1) and Dover and Kent County (Phase 2). Maintenance & Operations has been reaching out to other states, participating in conferences such as AASHTO Extreme Events Symposium and Clear Roads, and participating in training through the University of Wisconsin learning about best practices new technologies to reduce salt use in winter operations. There is a combined effort for a research lab, modeling and topographic/geologic and hydrologic monitoring capabilities.

### Next Steps

- DeIDOT anticipates reducing use of sand to treat roadways in snow events to reduce total suspended solids (TSS).
- DNREC looking to include Sussex County municipalities within NPDES Phase 2 permit.

### Challenges

- Need to balance concerns regarding environmental impacts of products used to treat roadways during snow and ice events with public safety concerns of roadway users.

### Other Considerations

- Initiatives include the Sea Grant, green-infrastructure initiatives with DNREC and FHWA, University of New Hampshire, Infrastructure & Climate Network (ICNET) and more.

### Strengths

- DeIDOT has an established NPDES Team

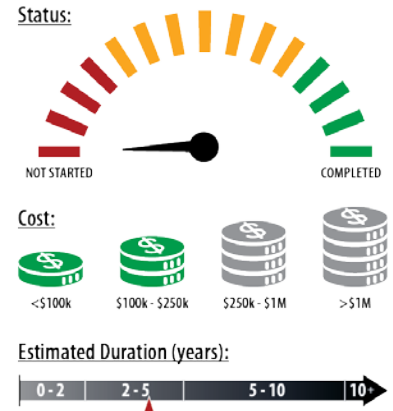
### DeIDOT Stakeholders

- Vince Davis, Transportation Solutions - *Stormwater*
- LaTonya Gilliam, Transportation Solutions – Engineering Support
- Andrew Whitman, Maintenance & Operations - *NPDES Program Manager*

## 7. Reevaluate Stormwater Management Approaches

### Recommendation Summary

DeIDOT should work with DNREC and the Office of State Planning Coordination to review the state’s strategy for stormwater management with an eye to improved resiliency. Special attention should be paid to striking the right balance between deliberately retaining stormwater in an effort to enhance groundwater recharge and accommodating efficient drainage. Currently, stormwater management designs focus on volume and location. Alternative designs for stormwater management and advanced techniques to capture runoff and pollutant discharge will be explored. If appropriate, changes should be made in our design standards and in our regulatory requirements for subdivisions.



### Current Progress

- In 2008, a Stormwater Management Task Force was created and tasked with developing a comprehensive implementation plan.
- DeIDOT approves their own plans to reduce stormwater discharge and runoff. Models are updated in a dynamic manner to reflect changes in environmental conditions over time (e.g., rain curves).

### Next Steps

- DeIDOT should consider engaging one of the Universities to research and develop alternative designs to stormwater management that consider advance techniques to capture runoff and pollutant discharge.

### Challenges

- Need to explore new parameters or different ways of using existing data and analysis.

### Other Considerations

- As sea level rises, invert sizing and capacity of swales will need to be reevaluated.

### Strengths

- Stormwater Pollution Prevention Management Plan for New Castle County

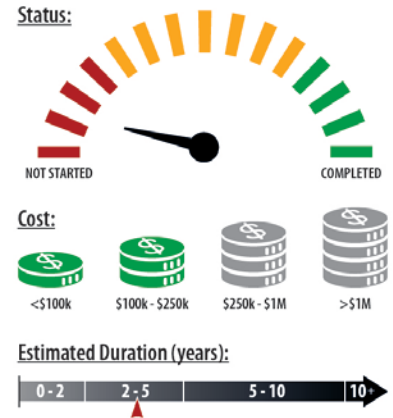
### DeIDOT Stakeholders

- Vince Davis, *Transportation Solutions - Stormwater*
- LaTonya Gilliam, *Transportation Solutions – Engineering Support*

## 8. Explore New Pavement Technology

### Recommendation Summary

DeIDOT should explore the deployment of new technologies in asphalt and concrete pavement composition to mitigate damage associated with climate change. Currently, asphalt pavements are impacted by prolonged heat and other environmental effects (water, salt, etc.). Alternative materials and substrates will be explored to prevent climate change-related failures and lengthen the lifecycle of paved surfaces to withstand extreme temperature changes and moisture impacts.



### Current Progress

- Increased usage of beneficial use materials such as Recycled Asphalt Pavement (RAP), Reclaimed Asphalt Shingles (RAS), and ground granulated blast furnace slag (GGBFS). Always reviewing new research and lessons learned from national and regional partners.

### Next Steps

- DeIDOT considers new pavement technology based on demonstration of successful use in other areas with similar climate.

### Challenges

- Need to consider material source locations. For example, a new pavement mix may require an aggregate found on west coast and may be too costly to transport across country to test/implement.

### Other Considerations

- This initiative needs joint collaboration by all divisions from DeIDOT. Different types of pavement may impact the types of vehicles using the system, and may also impact revenue and maintenance cost. There must be a holistic approach.
- DeIDOT is interested in incorporating other recycled materials with minimal detriment to performance.

### Strengths

- DeIDOT has its own research labs: soil & aggregate, asphalt, concrete, chemical labs. These labs allow for testing of new cement and asphalt binders that can be done in house.
- Good relationship with regional partners: Delaware State, University of Delaware.

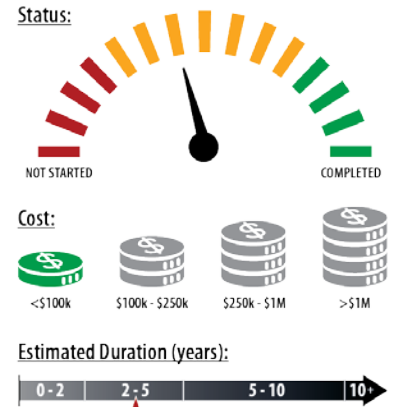
### DeIDOT Stakeholders

- Jennifer Pinkerton, Transportation Solutions - *Materials & Research*

## 9. Incorporate Climate Impacts into Cost-Effective Investments in Infrastructure

### Recommendation Summary

DelDOT should reevaluate the process by which projects are prioritized into the Capital Transportation Program to ensure that the process adequately reflects the strategies contained in currently adopted comprehensive land use plans. Currently, investments are made primarily for improving safety, accommodating greater traffic volumes, and maximizing the lifecycle value. As climate changes the variables for design (e.g., more right-of-way needed for a higher bridge), greater funding in the Capital Transportation Program will be needed to accommodate costs of longer and larger bridges (and subsequent increased maintenance costs). DelDOT will evaluate how best to include in the decision-making process the cost/benefit of building to accommodate potential vulnerabilities weighed against the financial means to build them.



### Current Progress

- DelDOT Planning/DTC utilizes the Pipeline Process, a prioritization process that solicits nomination for projects from the Council on Transportation and MPOs. The process reflects the goals and objectives found in “Shaping Delaware’s Future”, the Statewide Long Range Plan and the State Investment Strategies Map. This process is used to determine which projects will be funded in the Capital Transportation Program (CTP).

### Next Steps

- DelDOT is seeking to incorporate environmental impact criteria into Decision Lens, an online software tool that utilizes multiple criteria for prioritization and resource optimization.
- Develop workshops/information sessions for municipalities learn about incorporating cost-effective infrastructure enhancements for climate change resilience.

### Challenges

- Consideration of future needs and funding sources for maintenance of items such as newly constructed sidewalks.
- Infrastructure is outdated; need funding to reach current standards and to prepare for climate impacts.
- To include cost-effective specific infrastructure enhancements for climate resilience requires new approaches/paradigms that need to be supported by policy or complementary policy to avoid liability and/or competitiveness issues.

### Other Considerations

- Utilize the Municipal Street Aid Fund to encourage municipalities to consider climate impacts in infrastructure investments. Through the Municipal Street Aid Fund, the State Legislature appropriates a portion of the Delaware Transportation Trust Fund within the CTP to each of the 57 municipalities. The funds are to be used for the maintenance of municipal maintained streets as prescribed in Title 30, Ch. 51, Subchapter III of the Delaware Code. The distribution is based on two factors: Population (40%) and Mileage (60%).
- Changing criteria is responsibility of Counsel on Transportation.

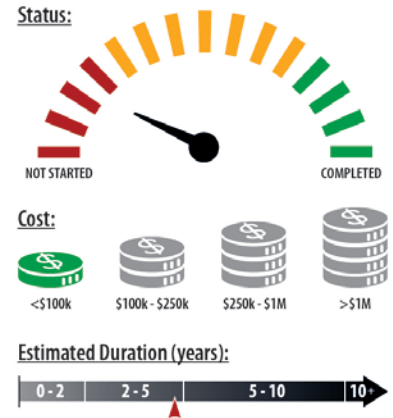
## 9. Incorporate Climate Impacts into Cost-Effective Investments in Infrastructure

Strengths	DeIDOT Stakeholders
<ul style="list-style-type: none"><li>• Ability to communicate and guide all 57 municipalities.</li><li>• Workshops/Information sessions can be organized at county level.</li></ul>	<ul style="list-style-type: none"><li>• John Sisson, <i>Delaware Transit Corporation</i></li><li>• Karen Brittingham, <i>Planning – Statewide and Regional Planning</i></li><li>• Stephanie Johnson, <i>Planning - Decision &amp; Data Support</i></li><li>• Drew Boyce, <i>Planning</i></li></ul>

## 10. Evaluate Obtaining Insurance to Assist in Recovery from Catastrophic Events

### Recommendation Summary

DeIDOT should work with the Office of Management and Budget (OMB) and the Insurance Coverage Office to assess the effectiveness of obtaining some sort of insurance that could help provide the funds necessary to recover from catastrophic and prolonged loss of major elements (roadways, bridges, and equipment) within the transportation system. Because the state self-insures, DeIDOT is concerned that a catastrophic event involving either Delaware’s roadways or DeIDOT equipment and the revenue generated by opening the state to interstate commerce will put the state finances at risk, particularly if there was a significant loss of economic activity during this time.



### Current Progress

- DeIDOT is self-insured, but has insurance in place to protect revenue stream (e.g., tolling facilities).
- In contact with financial advisors to see how insurance may apply to catastrophic systemic damage; preliminary research suggests some level of insurance may be needed for catastrophic events, resilience/sustainability.

### Next Steps

- Plan to contact NJ Transit and City of San Francisco to determine insurance lessons learned.
- Develop a Transportation Risk Map, which will identify the vulnerabilities in Delaware and work towards having a climate-resilient and sustainable transportation infrastructure system.
- Develop strategies for disaster risk reduction that can help determine level of investment necessary as well as where the investments should occur.

### Challenges

- Not ready to make a commitment to this approach until better understanding of benefits and cost.
- Risk Assessment requires knowing the risk. While traditional approaches to probable events exist, catastrophic events impacting transportation infrastructure to identify critical thresholds and types of events that can cause failure and permanent loss of productivity haven’t been identified.

### Other Considerations

- Perpetual insurance
- I-495 emergency bridge closure example – able to leverage federal emergency funds (\$50 million line of credit)
- In an emergency, utility repairs may be reimbursable by DeIDOT
- If a disaster occurs in a short period of time without insurance, it could result in loss of FEMA funds

### Strengths

- Finance office is knowledgeable of risk assessment and different insurance products available.
- Opportunity to learn from other states that are beginning to insure against catastrophic risks.
- Transit has insurance through DTC.

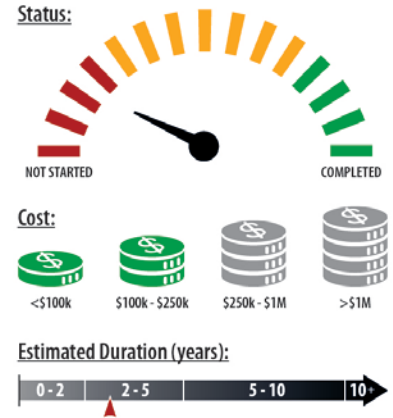
### DeIDOT Stakeholders

- Lanie Thornton, *Finance -- Director Transportation Solutions -*
- Silvana Croope, *Planning - Decision & Data Support*

## 11. Evaluate and Adjust Worker Safety Guidelines

### Recommendation Summary

DeIDOT should evaluate, and as necessary, adjust guidelines addressing worker safety and train workers to identify risks of exposure to high heat, extreme temperatures, and impacts to roadway and project site conditions. Currently, DeIDOT monitors extreme events and adjusts work schedules accordingly. DeIDOT should review and adjust its safety guidelines to accommodate for higher temperatures, impaired air quality, and extreme site conditions. It should encourage its contractors to do the same for its workers.



### Current Progress

- Susan Love and Jennifer DeMooy of DNREC Division of Energy & Climate hosted meeting for worker safety titled “Workforce Safety Pilot Project” where flexible work schedules were discussed. This pilot project is ongoing and DeIDOT is an active participant.
- DeIDOT provides safety breakfast training to the M&O area yards and include topics such as “Cold & Hot Weather”, “First Aid/ CPR/ AED”, and “Working Near Water”.

### Next Steps

- Determine the impacts of extreme events on Worker Safety, and develop appropriate Worker Safety guidelines. [For example, if sustained winds are measured at 40 mph or more, then workers may be taken off the road.]

### Challenges

- Collective bargaining agreement makes it difficult to change work hours.
- Shortage of management resources to take on both additional projects and training.

### Other Considerations

- DNREC Division of Energy & Climate can advise on adjusting worker safety guidelines.
- What do other DOT’s do in warmer climates? Additional research necessary.

### Strengths

- Good relationships with contractors, which will facilitate information exchange on worker conditions in extreme events.

### DeIDOT Stakeholders

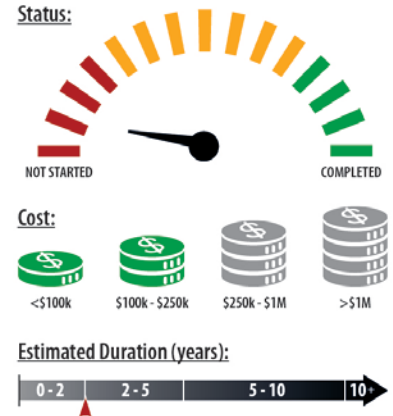
- Brian Urbanek, *Maintenance & Operations - Statewide Support Services*



## 12. Provide Training to Improve Worker Knowledge

### Recommendation Summary

DeIDOT should train workers utilizing materials for roadway maintenance to apply more resilient materials in responsible ways. Contractors currently do not undergo DeIDOT training programs on state-of-the-art materials science or application. DeIDOT should develop a best practice training program for approved construction firms.



### Current Progress

- None

### Next Steps

- Develop training requirements for using the identified materials and processes in roadway maintenance.

### Challenges

- Currently there are no worker training programs specific to state-of-the-art practices in roadway material application or maintenance.
- Shortage of management resources to take on the additional projects and training.

### Other Considerations

- As DeIDOT develops new materials, require contractors to get trained by vendors.
- The National Highway Institute (NHI) offers instructor-led training courses in state-of-the-art material applications. For example, they currently offer a course entitled “Asphalt Pavement In-Place Recycling Techniques”. This course includes two web-based training modules and two days of instructor led classroom-based training.
- Surface Transportation Workforce Development, Training, and Education – States may use funds apportioned for the National Highway Performance, Surface Transportation, Highway Safety Improvement Program, and Congestion Mitigation and Air Quality Improvement Program for surface transportation workforce development, training and education.

### Strengths

- Good relationship and communication with contractors that can be leveraged for pilot projects and knowledge sharing.

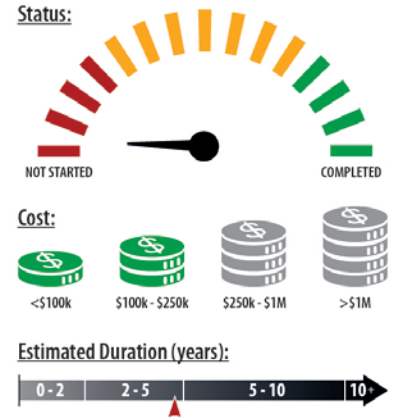
### DeIDOT Stakeholders

- Jim Pappas, *Transportation Solutions - Performance Management*
- Jennifer Pinkerton, *Transportation Solutions - Materials & Research*

### 13. Evaluate Driving Restrictions For Air Quality Events

#### Recommendation Summary

In conjunction with the Governor’s Office, DNREC, and DHSS, DeIDOT should evaluate the costs, benefits, and feasibility of “reduced driving days” when atmospheric conditions are such that air quality is a significant health risk. Currently, air quality is assessed and advisory warnings are issued for certain segments of the population (aged, young, those with health conditions). As the temperatures begin to increase over historical averages, ever-greater numbers of citizens may be impacted. The state should develop policies for addressing advisory and required compliance for public safety to a greater number of people who previously would not have been impacted.



#### Current Progress

- None

#### Next Steps

- Research should be conducted to evaluate the cost/benefits of reduced driving days.

#### Challenges

- It may be difficult to implement driving restrictions on the citizens of Delaware. How will the restrictions be enforced?

#### Other Considerations

- Delaware should research examples of driving restriction in response to air quality. There are several cities around the world that have implemented such policies including London, Paris, Berlin, and Mexico City.

#### Strengths

- Technology at state level can support telecommuting.

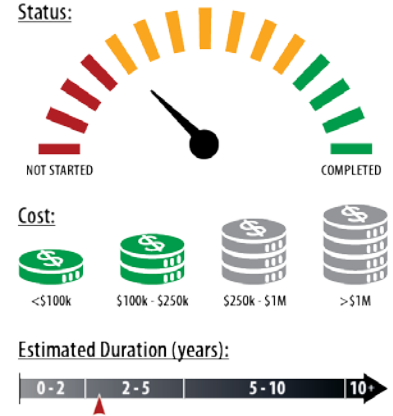
#### DeIDOT Stakeholders

- Brian Urbanek, *Maintenance & Operations - Statewide Support Services*
- Mike DuRoss, *Planning - Regional System Planning*

## 14. Develop Revised Maintenance Schedule in Response to Air Quality

### Recommendation Summary

DeIDOT should develop revised maintenance schedules in response to air quality and climate conditions. During poor air quality days, less mowing and reduced work during the day will reduce the state’s pollution footprint. Electrification of vehicle work areas should be considered for needed idling to maintain air conditioning in vehicles. Decisions to reduce workdays will be balanced against higher costs, nuisance issues (e.g., work at night), and lengthening of projects.



### Current Progress

- M&O District able to skip a mowing cycle if the weather is dry and grass isn’t growing
- M&O doesn’t mow on red ozone days.

### Next Steps

- Consider other maintenance operations this recommendation may apply to (e.g. street sweeping).

### Challenges

- Need float in schedule to adjust operations (e.g., reducing workdays).
- Changes to work schedules may need to be negotiated as part of collective bargaining agreement for Maintenance & Operations employees.
- Nighttime work poses a safety hazard for certain maintenance activities.

### Other Considerations

- A significant portion of pollution from idling construction vehicles: pickups, backhoes.
- Synchro generating air quality modeling.
- Purchasing electric vehicles may be justified due to use in maintenance activities and work schedule.

### Strengths

- Ability to revise maintenance schedule to reflect seasonal or weather-related changes: “When the grass ain’t growing, it don’t need mowing”.

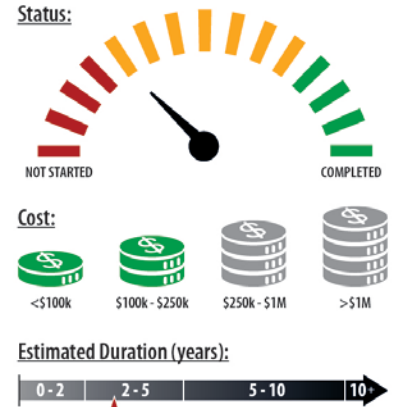
### DeIDOT Stakeholders

- Brian Urbanek, *Maintenance & Operations - Statewide Support Services*

## 15. Adjust Emergency Response Strategies to Provide Transit as Necessary Without Endangering Drivers or Passengers

### Recommendation Summary

DeIDOT should build into its emergency response strategies to provide transit as necessary without endangering drivers or passengers. DeIDOT currently weighs its transit deployment based on extreme weather events. As the intensity of these events grows, alternative deployment strategies should be considered. For instance, vehicles will be redistributed to more localized service routes based on density to avoid impassable roads to reach passengers in need. Also, transit vehicles will be taken out of service if imminent danger is posed to drivers and potential passengers. DeIDOT will provide more maintenance and alternative vehicle types with longer life spans, and accommodate worker conditions as temperatures increase. In addition, both DeIDOT and Delaware Transit Fleet vehicles will have location options for storage at higher elevations at times of flooding. Lastly, more shelters for passengers to protect them from the elements (rain, cold, and heat) will be evaluated.



### Current Progress

- DTC provides alternative transit service, under the direction of the TMC during state of emergency.
- Paratransit service available for dialysis patients.
- After Sandy, DTC reviewed lessons learned from the emergency response.
- DTC has participated in DEMA emergency response exercises, and is working with DEMA on revised emergency evacuation procedures.
- DTC utilizes higher-ground locations for storage of buses in the event of flood conditions.

### Next Steps

- DeIDOT should discuss making climate change resilience a higher priority when planning transit projects or infrastructure enhancements (such as bus shelters).
- Review work being finalized with the TMC's updates on evacuation routes and add flooding analysis to help build resilience to the system that is also inclusive of capacity constraints.

### Challenges

- Currently, DTC has many ongoing projects. This can make it difficult to initiate new projects that incorporate climate change resilience.
- Scarcity of resources given timeframe for changes.
- Areas where bus shelters are located must be accessible and safe for pedestrians.

### Other Considerations

- During emergencies or severe weather events, DTC Operators will not drive into imminent danger. DTC operators will operate in confines of safe services. National Guard could operate buses in more dangerous areas.

### Strengths

- DTC has established lines of communication and coordination with DEMA and TMC.
- DTC is already familiar with the use of social media as well as traditional communications to alert the public of emergency operations and to disseminate information.

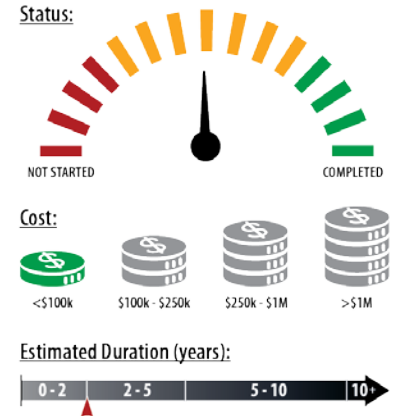
### DeIDOT Stakeholders

- Rich Paprcka, *Delaware Transit Corporation*
- Jim Pappas, *Transportation Solutions - Performance Management*
- Brian Urbanek, *Maintenance & Operations - Statewide Support Services*
- Silvana Croope, *Planning - Decision & Data Support*

## 16. Reevaluate Emergency Response Protocols

### Recommendation Summary

DelDOT and Homeland Security will reevaluate current long-term strategies for response to significant catastrophic events and current short-term evacuation policies, and detour/evacuation route management and implementation. Currently, the Transportation Management Center (TMC), in conjunction with DEMA, provides coordination of emergency events ranging from 72 hours to two weeks in duration. If a catastrophic emergency hits Delaware, DelDOT and Homeland Security will assist in the long-term recovery process. It is recommended that a full-scale emergency response exercise occur with participation from all state departments and programs.



### Current Progress

- The DelDOT TMC has conducted tabletop, functional, and full-scale exercises on various topics including detour plan implementation, active shooter, radiological drills, and Computer-Aided-Dispatch (CAD)- to= CAD integration with Delaware State Police (DSP).
- The DelDOT TMC is developing a Transportation Homeland Security Plan.
- DelDOT is participating in a Workforce Safety pilot project.

### Next Steps

- DelDOT to integrate National Incident Management System (NIMS) best practices and Incident Command System (ICS) forms and strategies.
- DelDOT to work with Department of Safety and Homeland Security (DSHS) to develop resilience and sustainability strategies for long-term recovery from catastrophic events.

### Challenges

- There is a shortage of management resources for the TMC to take on the additional projects and training.

### Other Considerations

- Integration of Homeland Security reviews into the capital planning review process.

### Strengths

- Robust wireline and wireless telecommunication system allows for strong coordination among agencies.
- Dedicated Transportation Homeland Security Planner.
- Routinely conduct After Action Reviews (AARs).

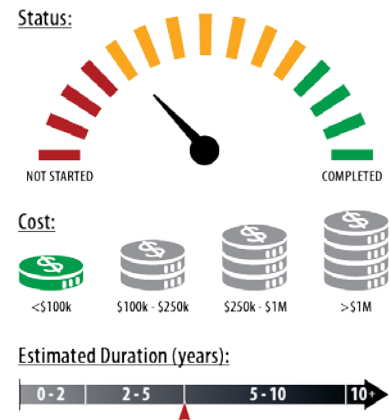
### Key Stakeholders

- Gene Donaldson, *Transportation Solutions - TMC*
- LaTonya Gilliam, *Transportation Solutions – Engineering Support*

## 17. Support Local Governments with Land Use Assessment Tools

### Recommendation Summary

DeIDOT will continue to work with the Office of State Planning, the municipalities, and the counties on the development of geospatial mapping and infrastructure assessment tools to help inform the municipalities and counties about the potential impacts of climate change and assist in developing strategies for enhanced resilience. Currently, comprehensive land use plans vary with respect to their treatment of resilience and do not account for greater rainfall, sea level rise, or dynamic events such as storm surge, drought, increased summer temperatures, etc. Adaptation of comprehensive plans to address these vulnerabilities will allow governments to do more to protect the long-term health and safety of residents.



### Current Progress

- DeIDOT has supported the development of the University of Delaware Institute for Public Administration toolkit for community development that included an approach to resilience.
- DeIDOT Planning is working with the National Institute of Standards and Technology (NIST) Guide to Community Resilience and the American Society of Civil Engineers (ASCE) / Institute for Sustainable Infrastructure (ISI) ENVISION System for Sustainability on initiatives that can help with project development, complete streets and smart cities.

### Next Steps

- Updating Long Range Transportation Plan.
- Planning to incorporate climate change / resilience language into the Development Coordination Manual.
- DeIDOT to develop outreach programs for using geospatial and infrastructure assessment tools in the identification of climate change vulnerabilities.

### Challenges

- Land use agencies will need to be informed about the effects of climate change.
- Specific action items and funding are needed to properly address current task. Internal DeIDOT staff have been working on initiatives in this area but not specific to climate change, resilience, or sustainability.

### Other Considerations

- DeIDOT routinely provides input to different land use agencies on proposed plans; however climate change resilience has not been included in this input. Currently, it is up to each land use agency to determine how much they want to incorporate climate change into their planning. DeIDOT should explore different approaches to provide guidance and recommendations for inclusion of climate change considerations in land use plans.
- DeIDOT may be able to tell local governments “If you choose to develop in these areas we will not provide/maintain access impacted by extreme events”.
- Working on mobility element of comprehensive plan.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

### Strengths

- DeIDOT is in a position to influence land use agencies.

### DeIDOT Stakeholders

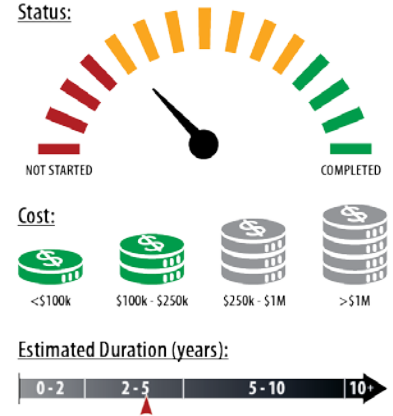
- Marc Cote, *Planning - Development Coordination*
- Silvana Croope, *Planning - Decision & Data Support*
- Thomas (Bill) Brockenbrough, *Planning – Development Coordination*



## 18. Evaluate Low-Emission Vehicle Deployment

### Recommendation Summary

DelDOT should purchase and deploy lower emission light-duty vehicles equal to 10% of its fleet by 2020. Currently, DelDOT does not purchase lower emission/no-emission vehicles due to the high cost, maintenance requirements, and state bidding rules. DelDOT will re-evaluate the purchase of these vehicles and will coordinate efforts with the Office of Management and Budget. Until government provides a catalyst for the purchase of the vehicles, the cost will not decrease for the market in general. DelDOT will perform a life cycle cost analysis to determine the financial benefit of various types of alternative vehicles. This analysis does not preclude the adoption of the vehicles, but rather will inform what types of vehicles may be more cost-effective and evaluate the economic benefits in stimulating the market for these types of vehicles.



### Current Progress

- Demoed propane powered truck by Roush, did not get anticipated mileage; looking at using electric and propane powered vehicles.
- DelDOT fleet managers participate in the Delaware Clean Cities, a group who advocates for deployment of alternative fueled vehicles.
- Federal Transit Administration (FTA) LoNo program – The LoNo program provides funding for transit agencies for capital acquisition and leases of zero emission and low-emission transit buses. This also includes acquisition, construction, and leasing of required supporting facilities such as recharging, refueling and maintenance facilities.
- DTC has received grant to purchase 20 propane vehicles and add fueling stations.
- DTC has won a \$2 million grant from the federal government to purchase six electric buses.

### Next Steps

- Conduct an economic analysis for electric and alternative-fuel vehicles, including maintenance and infrastructure (e.g., charging and fueling stations).
- Explore partnerships with governmental and non-governmental organizations that can promote infrastructure developments for lower emission vehicles.

### Challenges

- Challenges include availability of fuel stations and fuel range.
- Ford no longer producing light duty hybrid/electric trucks.
- Identify where/which projects and strategies can offer double benefit for mitigation and adaptation

### Other Considerations

- Electric fueling stations at DelDOT facilities would be one way to promote this opportunity by allowing employees to charge electric vehicles at work.
- Autonomous vehicles should improve efficiency.
- If all traffic signals were re-timed in the state, congestion and emissions would be reduced.
- DTC is researching the use of hydrogen buses at UD.

### Strengths

- Delaware is a small state therefore electric vehicles travelling within the state will be able to reach their destination on one charge.

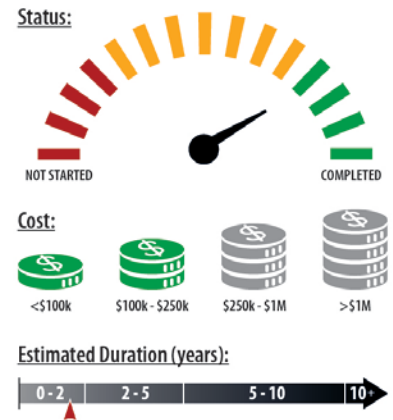
### DelDOT Stakeholders

- Anne Brown, *Maintenance & Operations – Business Management*
- John Sisson, *Delaware Transit Corporation*

## 19. Evaluate Alternative Energy Technology In Facilities

### Recommendation Summary

DeIDOT will consider the deployment of more alternative energy technologies, namely energy efficiency and wind and solar technology, in its administrative and operational buildings. Currently, only one facility has solar installed. DeIDOT will evaluate these programs for all new and renovated facilities for life cycle cost/benefit.



### Current Progress

- Solar Project – In 2011, Ameresco proposed energy efficient solutions for DeIDOT facilities. The estimated payback period for the solar installation was about 100 years. Because of this, the project did not move forward.
- Energy Use Tracking – DeIDOT is tracking energy use data in DeIDOT facilities through Energy Star to track the energy savings from energy efficient solutions.
- Following the Executive Order 18 for Energy Conservation and Efficiency, DeIDOT aspires to meet Leadership in Energy and Environmental Design (LEED) Silver Certification requirements for design of new facilities. Upgrading lights, roofs, windows, and Heating Ventilation Air Conditioning systems to improve energy efficiency.
- Some DeIDOT locations utilize waste oil heaters.
- DTC is building new transit station in Newark and Claymont using LEED Silver concepts; will include bike stations and American with Disabilities Act (ADA) improvements.

### Next Steps

- Engage consultant to research and evaluate alternative energy opportunities at DeIDOT facilities, including technology advances and funding.
- Revisit installing solar for DeIDOT buildings.

### Challenges

- Current cost of alternative energy solutions relative to costs of fossil fuels and other traditional energy sources.
- Straight cost-benefit analysis will make it difficult to justify alternative energy solutions; need to find ways to incorporate external benefits in evaluation.

### Other Considerations

- There may be an opportunity for a Public-Private Partnership (P3) to help fund solar project.
- Delaware Technical Community College has installed solar panels in the parking lot that also provide shade.

### Strengths

- Forward-thinking DeIDOT leadership is already evaluating alternative energy technologies.

### DeIDOT Stakeholders

- Brian Urbanek, *Maintenance & Operations* - Statewide Support Services
- Eric Cimo, *Transportation Solutions* - Utilities

## Appendix B. Reference Material

1. *Climate Framework for Delaware*, Cabinet Committee on Climate and Resilience; December 31, 2015.
2. *Executive Order 41*, Executive Department for State of Delaware; September 12, 2013.
3. *New Mowing Guidance*, Delaware Department of Transportation Division of Maintenance and Operations; April 7, 2014.
4. *A Data Strategy for Hazus for Delaware: Moving into Implementation*, Edward Strauss, Delaware Emergency Management Agency, Silvana V Croope, Delaware Department of Transportation; December 8, 2015.
5. *Roadside Vegetation Establishment and Management Manual*, Susan Barton, University of Delaware, Rick Darke, Rick Darke LLC, Gary Schwetz, Delaware Center for Horticulture; April 2009.
6. Delaware Database for Funding Resilient Communities, University of Delaware Institute for Public Administration, <http://www.completecommunitiesde.org/planning/ddfrc/>; accessed: June 3, 2016.
7. *Hazus and Climate Change – A Historical Construct*, Silvana V Croope, Delaware Department of Transportation; August 5, 2014.
8. *Delaware Climate Change Impact Assessment*, Delaware Department of Natural Resources and Environmental Control Division of Energy and Climate; February 2014.
9. *The Effects of Driving Restrictions on Air Quality: Theory and Empirical Evidence*, C.-Y. Cynthia Lin Lawell et al.; 2011.
10. *New Castle County/DelDOT Phase I Permit Fact Sheet*, Delaware Department of Natural Resources & Environmental Control Division of Water; 2013.
11. *Recycled Materials and New Pavement Technologies*, Delaware Department of Transportation Design Teams; September 1, 2009.
12. *DelDOT Project Prioritization Criteria*, Delaware Department of Transportation; undated.
13. Title 30. State Taxes, Part IV. Commodity Taxes, Chapter 51. Motor Fuel Tax, Subchapter III. State Aid to Municipalities for Streets, Delaware Code Online.
14. *Executive Order 18: Leading by Example – Towards a Clean Energy Economy & Sustainability Natural Environment*, Office of the Governor; February 17, 2010.
15. Newark Train Station to be Improved with \$10 million Federal Grant, University of Delaware; June 22, 2012.
16. *National Climate Change Assessment*, National Climate Assessment and Development Advisory Committee (NCADAC), Draft Report, January 11, 2013.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

17. *National Infrastructure Protection Plan 2013 – Partnering for Critical Infrastructure Security and Resilience*, US Department of Homeland Security, 2013.
18. *NIPP 2013 Supplemental Tool: Incorporating Resilience into Critical Infrastructure Projects*, US Department of Homeland Security, 2013.
19. *FloodCast: A Framework for Enhanced Flood Event Decision Making for Transportation Resilience*, NCHRP Project No. 20-59(53) [Active].
20. *National Infrastructure Protection Plan 2009 – Partnering to Enhance Protection and Resiliency*, US Department of Homeland Security, 2009.
21. *Understanding Transportation Resilience: A 2016-2018 Roadmap*, American Association of State Highway and Transportation Officials; January 2017.
22. *Transportation Systems Resilience: Effective Measures and Research Needs*, National Science Foundation, National Workshop on Resilience Research; October 22, 2015.
23. *Transportation System Resilience, Extreme Weather and Climate Change – Final Report*, US Department of Transportation, Volpe National Transportation Systems Center; September 2014.
24. *US Department of Transportation Climate Adaptation Plan 2014 – Ensuring Transportation Infrastructure and System Resilience*, USDOT; 2014.
25. *Adding Resilience to the Freight System in Statewide and Metropolitan Transportation Plans: Developing a Conceptual Approach*, David S. Ortiz, Liisa Ecola, and Henry H. Willis, prepared for AASHTO, June 2009.
26. *Infrastructure Resiliency: A Risk-Based Framework*, USDOT, Volpe National Transportation System, 2013.
27. *Low or No Emission Vehicle Deployment Program (LoNo Program) Webinar*, Federal Transit Administration; March 27<sup>th</sup>, 2014.

## Appendix C. DeIDOT Interviewees

In April and May of 2016, 24 interviews were conducted with DeIDOT personnel in researching the progress of activities concerning the Climate Change Recommendations from the Climate Framework for Delaware. Below is a list of the interviewees along with their Position and Divisions within DeIDOT. This list represents the title of the interviewee at the time the interviews were conducted. As such, this list reflects the Positions and Divisions as of May 2016.

**Table 9: DeIDOT Interviewees**

<b>Name</b>	<b>Position</b>	<b>Division</b>
<b>Barry Benton</b>	<i>Assistant Director, Bridge</i>	<i>Transportation Solutions</i>
<b>Karen Brittingham</b>	<i>Planner</i>	<i>Planning</i>
<b>Anne Brown</b>	<i>Chief of Administration, Business Management</i>	<i>Maintenance &amp; Operations</i>
<b>Eric Cimo</b>	<i>Utilities Engineer</i>	<i>Transportation Solutions</i>
<b>Mark Cote</b>	<i>Assistant Director, Development Coordination</i>	<i>Planning</i>
<b>Silvana Croope</b>	<i>Resilience, Climate Change and Sustainability Strategist</i>	<i>Planning</i>
<b>Hugh Curran</b>	<i>(Former) Director</i>	<i>Finance</i>
<b>Vince Davis</b>	<i>Stormwater Engineer</i>	<i>Transportation Solutions</i>
<b>Gene Donaldson</b>	<i>Operations Manager</i>	<i>Transportation Management Center</i>
<b>Mike DuRoss</b>	<i>Planning Supervisor</i>	<i>Planning</i>
<b>Bobbie Geier</b>	<i>(Former) Assistant Director, Regional System Planning</i>	<i>Planning</i>
<b>Bernie Gilbert</b>	<i>GIS Transportation Planner</i>	<i>Planning</i>
<b>LaTonya Gilliam</b>	<i>Environmental Stewardship Engineer</i>	<i>Transportation Solutions</i>
<b>Monroe Hite</b>	<i>ROW Engineering</i>	<i>Transportation Solutions</i>
<b>Connie Holland</b>	<i>Director</i>	<i>Office of State Planning Coordination</i>
<b>Stephanie Johnson</b>	<i>Assistant Director, Decision &amp; Data Support</i>	<i>Planning</i>
<b>Mark Luszcz</b>	<i>Assistant Director, Traffic</i>	<i>Transportation Solutions</i>
<b>Dorothy L. Morris</b>	<i>Principle Planner</i>	<i>Office of State Planning Coordination</i>
<b>Jeff Niezgoda</b>	<i>Assistant Director, Local Systems Improvement</i>	<i>Planning</i>
<b>Jim Pappas</b>	<i>Assistant Director, Performance Management</i>	<i>Transportation Solutions</i>
<b>Rich Paprcka</b>	<i>Chief, Operations Officer</i>	<i>Delaware Transit Corporation</i>

**Strategic Implementation Plan for Climate Change,  
Sustainability & Resilience for Transportation**

<b>Name</b>	<b>Position</b>	<b>Division</b>
<b>Jennifer Pinkerton</b>	<i>Chief Materials &amp; Research Engineer</i>	<i>Transportation Solutions</i>
<b>Mike Simmons</b>	<i>Assistant Director, Project Development, South</i>	<i>Transportation Solutions</i>
<b>John Sisson</b>	<i>Chief Executive Officer</i>	<i>Delaware Transit Corporation</i>
<b>Brett Taylor</b>	<i>(Former) Director</i>	<i>Office of the Secretary</i>
<b>Mark Tudor</b>	<i>Assistant Director, Project Development, North</i>	<i>Transportation Solutions</i>
<b>Brian Urbanek</b>	<i>Assistant Director, Statewide Support Services</i>	<i>Maintenance &amp; Operations</i>

## Appendix D. Alternative Prioritization of Climate Framework Recommendations Using Modified Decision Lens Process

In 1998, a prioritization process for DeIDOT projects was adopted by the Council on Transportation. This process compared projects of similar type and funding and was pre-allocated into project types. This process worked well when funding was abundant; however, as funding became limited, it became more important to compare projects across project types. Over time it became increasingly difficult to fit federal, state, and DeIDOT goals into the 1998 prioritization process. In 2015, the Council on Transportation adopted a new prioritization process.

The criteria used in the current prioritization process are based on several factors: DeIDOT's Mission Statement, Vision, and Goals; provisions from Title 29 Chapter 84 § 8419 of the Delaware Code; provisions from the Federal Authorization Bill Map-21; and remnants of the 1998 prioritization process. The current criteria were weighed based on stakeholder survey data comparing the criteria. These stakeholders included DeIDOT personnel and Subject Matter Experts (SMEs) in transportation planning and policymaking.

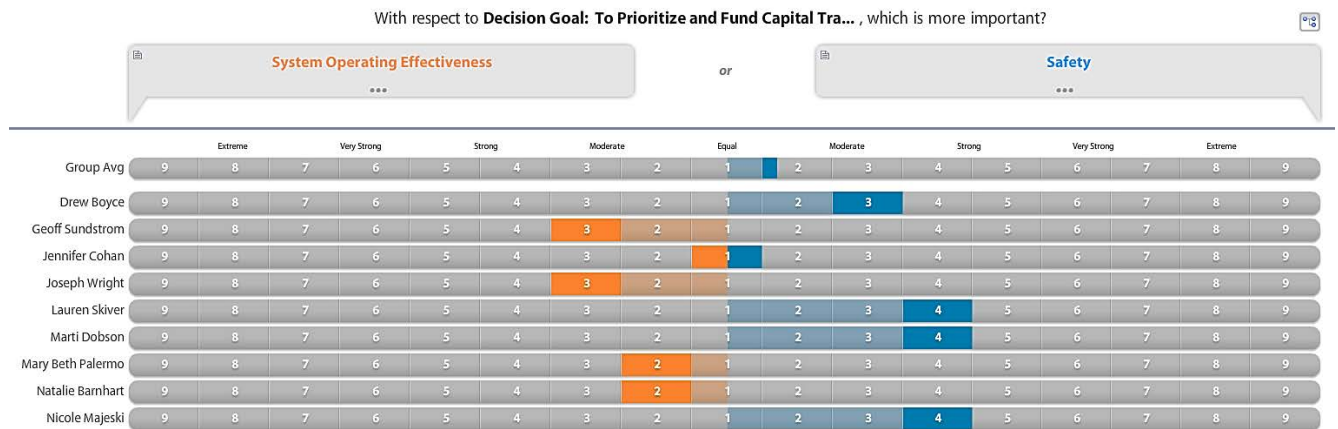


Figure 2: The Decision Lens Process

Stakeholders compare the importance of System Operating Effectiveness to Safety with respect to Prioritizing and Funding Capital Transportation Projects for Statewide CTP.<sup>31</sup>

Input from regional planning organizations in the Decision Lens process also affects how projects are prioritized. The criteria used in the current prioritization process are detailed in the next section.<sup>32</sup>

<sup>31</sup> DeIDOT Prioritization Process: Winter Workshop, Delaware Department of Transportation, February 17, 2015.

<sup>32</sup> DeIDOT Prioritization Process: Winter Workshop, Delaware Department of Transportation, February 17, 2015.



## D.1 Current DeIDOT Project Prioritization Criteria Summary<sup>33</sup>

1. **Safety [33.0%]** – The ability of the transportation system to allow people and goods to move freely, without harm.

This criterion is used to assess the extent to which the Project addresses, maintains, and improves safety.<sup>34</sup>

- a. Identified in a Safety Program [80%] – This criterion is used to assess the extent to which the Project has been identified as a project in the Hazard Elimination Program (HEP) or the High Risk Rural Roads Program (HRRRP).
- b. Addresses strategies in the State Highway Safety Program (SHSP) [20%] – This criterion is used to assess the extent to which the Project addresses specific strategies in the Delaware Strategic Highway Safety Plan; reducing the frequency and severity of roadway departure crashes, improving safety of intersections and making walking and street crossing safer.

2. **System Operating Effectiveness [24.8%]** – The ability of the transportation system to efficiently move people, goods and services without excessive delay or inconvenience.

This criterion is used to assess the extent to which the Project meets operating objectives as described in the State Strategy and in regional or local community plans.<sup>35</sup>

- a. Existing Level of Service (LOS) [50%]
- b. Identified as a congested corridor in the MPO Congestion and Management Analysis [50%]

3. **Multi-Modal Mobility, Flexibility/Access [15.6%]** – The ability of a project to provide efficient movement of people and goods between destinations by motor vehicle, pedestrian, bicycle and transit modes (including land side access to airports and marine terminals.)

This criterion is used to assess the extent to which the project addresses transportation choices and allows additional connectivity to the existing system.<sup>36</sup>

- |                            |      |
|----------------------------|------|
| a. Significant Improvement | 100% |
| b. Moderate Improvement    | 50%  |
| c. No Improvement          | 0%   |
| d. Detrimental             | 0%   |

4. **Revenue Generation/Economic Development/Jobs & Commerce [7.9%]** – The ability of a project to facilitate or support business development and employment.

This criterion is used to assess the extent to which the Project has the potential to generate revenue or will support economic development and benefit commerce.<sup>37</sup>

- |   |     |
|---|-----|
| a. Located in a Transportation Improvement District (TID) | 33% |
| b. Degree of Non-State/Non-Federal Contribution           | 33% |
| c. Located in Designated Freight Corridor                 | 33% |

<sup>33</sup> Adapted from “DeIDOT Project Prioritization Criteria Summary”, Delaware Department of Transportation, 2015.

<sup>34</sup> Critical ratio value or program data provided by DeIDOT Traffic Section.

<sup>35</sup> Score value is determined by existing state data.

<sup>36</sup> Improvement level is defined within rating scale.

<sup>37</sup> Locations or Contributions are determined by existing State data.

- 5. Impact on the Public/Social Disruption/Economic Justice [7.2%]** – The assessment of the project on the transportation system as it relates to existing communities and population centers.

This criterion is used to assess the extent to which the Project supports investment in existing communities and provides community enhancements such as sidewalks, safe routes to school.<sup>38</sup>

a. Positive Impact	100%
b. No Impact	25%
c. Negative Impact	0%

- 6. Environmental Impact/Stewardship [6.5%]** – The effect of the transportation system on energy use and the natural environment.

This criterion is used to assess the extent to which the Project mitigates the threat or damage to the environment, including Air Quality.<sup>39</sup>

a. Positive Impact	100%
b. No Impact	50%
c. Minor Negative Impact	20%
d. Major Negative Impact	0%

- 7. System Preservation [5.0%]** – Fix It First/State of Good Repair addresses the improvement of the physical condition of existing transportation assets.

This criterion will assess the extent to which the Project contributes towards system preservation and is addressed through an existing preservation program.<sup>40</sup>

- a. Yes
- b. No

Criteria that directly relate to Climate Change Resilience and Sustainability only account for about 34% of total project prioritization score. This includes Environmental Impact/ Stewardship [6.4%], Multi-Modal Mobility/Flexibility/Access [15.6%], Impact on the Public/ Social Disruption/ Economic Justice [7.2%], and System Preservation [5%]. Safety, Revenue Generation/Economic Development/Jobs & Commerce, and System Operating Effectiveness make up more than 50% of the project prioritization score [33%, 7.9%, and 24.8% respectively]; however, these criteria do not apply to the recommendations from the Climate Framework. Therefore, it is necessary to develop new criteria that are more applicable to the Climate Change Recommendations.

Below are new prioritization criteria that incorporate the “Efforts and Outcomes” section from The Climate Framework for Delaware. There are three key strategies in the Efforts and Outcomes section: Using the best available science to understand current and future impacts of climate change, reducing greenhouse gas emissions (climate mitigation), and increasing Delaware's resiliency to climate change (climate adaptation). The three key strategies were adapted into the four new criteria used for the revised prioritization. The new proposed criteria are summarized below.

<sup>38</sup> Impact level is defined within rating scale.

<sup>39</sup> Impact level is defined within rating scale.

<sup>40</sup> Improvements/Impacts are identified through State data.

## D.2 Summary of Proposed Criteria Based on Climate Framework for Delaware

1. **Understanding Climate Change Impacts [25%]** – Understanding Climate Change Impacts is a foundation of sound decision-making. The state of Delaware has conducted comprehensive assessments of the impacts to Delaware of sea level rise, and changes in temperature and precipitation.
  - a. Does the recommendation involve a climate impact assessment? [50%]
  - b. Does the recommendation involve an asset assessment? [50%]
2. **Policy and Guidelines [25%]** – Implementing policy and establishing guidelines for pollution mitigation should be a key objective of DelDOT. EO41 established a goal of 30% GHG mitigation by 2030. Policies and guidelines should be in place for each division to meet this goal. Research into sustainable technology and methods should also be pursued to support mitigation initiatives.
  - a. Does the recommendation promote mitigation of greenhouse gases? [35%]
  - b. Does the recommendation incorporate methods guidelines or policies to reduce the effect of stormwater runoff? [35%]
  - c. Does the recommendation support research or the use of sustainable technology and materials? [30%]
3. **Resilience to Climate Change (Climate Adaptation) and System Recovery [25%]** – This criterion gives priority to recommendations that
  - a. Does the recommendation enhance the state infrastructure's resilience to climate change impacts and its ability to recover from catastrophic events? [40%]
  - b. Does the recommendation involve activities that support land use planning for flood avoidance? [30%]
  - c. To what extent does the recommendation minimize the impact on the welfare and ability to cover, recover, reconstruct, and minimize consumption losses? [15%]
  - d. To what extent does the recommendation minimize the impact on the welfare and ability to cover, recover, reconstruct, and minimize consumption losses? [15%]
4. **Safety and Emergency Response [25%]** – This criterion ranks the recommendations based on the extent to which the safety of DelDOT employees and the public is considered. Moreover, the criterion concerns the development and coordination of emergency response protocols and methods.
  - a. Does the recommendation improve workforce health and safety? [40%]
  - b. Does the recommendation involve activities to protect or improve public health and safety? [40%]
  - c. Does the recommendation involve updating emergency planning and coordination? [20%]

### D.3 Alternative Method of Prioritization

An alternative method for prioritizing projects is presented here that incorporates both the current process and the proposed new prioritization criteria based on the Climate Framework Efforts and Outcomes. Here, the weighted proposed new criteria were 40% and the current criteria 60%.

**Table 10: Revised Prioritization for Climate Change Resilience and Sustainability**

Criteria	Weight
<b>Climate Change Criteria</b>	<b>40%</b>
<b>1. Understanding Climate Change Impacts</b>	<b>25%</b>
A. Climate Impact Assessment	[Extensive = 1, Moderate = 0.5, None = 0] - 50%
B. Asset Assessment	[Extensive = 1, Moderate = 0.5, None = 0] - 50%
	<b>Score = A * 0.5 + B * 0.5</b>
<b>2. Policy and Guidelines</b>	<b>25%</b>
A. Reducing GHG Emissions	[Strong = 1, Moderate = 0.5, None = 0] - 35%
B. Reducing Stormwater Runoff	[Strong = 1, Moderate = 0.5, None = 0] - 35%
C. Sustainable Technology and Materials Research	[Strong = 1, Moderate = 0.5, None = 0] - 30%
	<b>Score = A * 0.35 + B * 0.35 + C * 0.3</b>
<b>3. Resilience to Climate Change (Climate Adaptation) and System Recovery</b>	<b>25%</b>
A. Infrastructure Resilience and Recovery	[Strong = 1, Moderate = 0.5, None = 0] - 40%
B. Land Use Planning for Flood Avoidance	[Strong = 1, Moderate = 0.5, None = 0] - 30%
C. Financial Resilience	[Strong = 1, Moderate = 0.5, None = 0] - 15%
D. Economic Resilience	[Strong = 1, Moderate = 0.5, None = 0] - 15%
	<b>Score = A * 0.4 + B * 0.3 + C * 0.15 + D * 0.15</b>
<b>4. Safety and Emergency Response</b>	<b>25%</b>
A. Workforce Health and Safety	[High = 1, Medium = 0.5, Low = 0.25, None = 0] - 40%
B. Public Health and Safety	[High = 1, Medium = 0.5, Low = 0.25, None = 0] - 40%
C. Emergency Planning and Coordination	[High = 1, Medium = 0.5, Low = 0.25, None = 0] - 20%
	<b>Score = A * 0.4 + B * 0.4 + C * 0.2</b>
	<b>Climate Change Criteria Score = (1 * 0.25 + 2 * 0.25 + 3 * 0.25 + 4 * 0.25) * 0.4</b>
<b>Decision Lens Criteria</b>	<b>60%</b>

Strategic Implementation Plan for Climate Change,  
Sustainability & Resilience for Transportation

Criteria	Weight
<b>1. Safety</b>	<b>33%</b>
A. Identified in a Safety Program	[0; 0.1 - 10 (y=.0808x + 0.2)] - 80%
B. Addresses Strategies in the Strategic Highway Safety Plan	[0 or 1] - 20%
	Score = A * 0.8 + B * 0.2
<b>2. System Operating Effectiveness</b>	<b>24.8%</b>
A. Existing Level of Service	[LOS: A = 0, B = 0, C = 0.25, D = 0.5, E = 0.8, F = 1, N/A = 0] - 50%
B. Congestion Management	[No Cong. = 0, Local Cong. = 0.75, Cong. Corridor = 1] - 50%
	Score = A * 0.5 + B * 0.5
<b>3. Multi-Modal Mobility/Flexibility/Access</b>	<b>15.6%</b>
	[Significant = 1, Moderate = 0.5, None/Detriment = 0] - 100%
	Score = above
<b>4. Revenue Generation/Economic Development/Jobs &amp; Commerce</b>	<b>7.9%</b>
A. Identified in a Transportation Improvement District (TID)	[ Y = 1, N = 0] - 33%
B. Cost Sharing Support	[Refer to scale in guide] - 33%
C. Freight Corridor	[Primary = 1, Secondary = 0.75, Not = 0] - 33%
	Score = A * 0.33 + B * 0.33 + C * 0.33
<b>5. Impact on the Public/Social Disruption/Economic Justice</b>	<b>7.2%</b>
	[Positive = 1, None = 0.25, Detriment = 0] - 100%
	Score = above
<b>6. Environmental Impact/Stewardship</b>	<b>6.5%</b>
	[Positive = 1, None = 0.5, Minor Negative = 0.2, Major negative = 0] - 100%
	Score = above
<b>7. System Preservation</b>	<b>5%</b>
	[Y=1, N=0] - 100%
	Score = above
Decision Lens Criteria = (1 * 0.33 + 2 * 0.248 + 3 * 0.156 + 4 * 0.079 + 5 * 0.072 + 6 * 0.065 + 7 * 0.05) * 0.6	
Total Score = Climate Change Criteria Score + Decision Lens Criteria Score	

It is critical to the successful implementation of climate change resilience and sustainability into DeIDOT projects that new criteria be introduced into the Decision Lens process. Moreover, the

proposed method of implementing new climate change criteria, the weight of each criterion, and how they are to be scored, should be further discussed and refined.

#### **D.4 Analytical Hierarchy Process for Group Decision Making**

In the current Decision Lens prioritization process, the Analytical Hierarchy Process (AHP), a compensatory type of decision-making method to evaluate multiple criteria, is used to prioritize projects in the CTP. AHP is widely used for group decision making in government, business, healthcare, and education. Decision makers using AHP decompose their decision problem into a hierarchy of simpler sub problems that can be evaluated independently. This allows decisions to be broken down into qualitative and quantitative attributes that can be used to evaluate each criterion. AHP is a compensatory type because it allows positive attributes to compensate for the negative attributes. For example, Rec. #10 asks DeIDOT to work with the Office of Management and Budget to evaluate obtaining insurance to assist in recovery from catastrophic events. This recommendation does not reduce the greenhouse gas effect or improve stormwater drainage to assist in flood resilience; however, it is an important aspect of financial resilience that will allow DeIDOT to recover in the case of significant loss of economic activity.

The decision makers participating in the Decision Lens process consist of the Council on Transportation, and stakeholders from the various divisions of DeIDOT, MPO's, and relevant agencies who will be impacted by DeIDOT projects. Due to the many stakeholders involved in a transportation project implementation, the Decision Lens process is subject to uncertainty. Uncertainty is an incomplete understanding that occurs due to a lack of information.<sup>41</sup> Uncertainty within the context of project prioritization represents the knowledge gap between what the final order of priority for projects is using Decision Lens and the actual order in which projects are initiated. These gaps in information stem from both internal and external influences such as inaccurate data, a small sample size of stakeholders, stakeholder preference, and mistakes in processing or modelling data. Depending on which stakeholder is asked to evaluate a project, there will be varying answers because of different areas of expertise, experience level, and perspective depending on their position and objectives. To obtain a better sense of how the projects should be prioritized, an AHP should include responses from as many of the relevant stakeholders as is practical.

---

<sup>41</sup> *Exposure factors handbook: 2011 edition (final)*, U.S. Environmental Protection Agency, 2011.

## Appendix E. Sample Progress Report Forms

Tabled Format – Tabled report for multiple recommendations

### CLIMATE CHANGE RECOMMENDATION QUARTERLY PROGRESS REPORT

Point of Contact \_\_\_\_\_ Division \_\_\_\_\_ Date \_\_\_\_\_

Rec #	Recent Progress	Planned Activities	Constraints/Issues

Figure 3: Tabled Quarterly Progress Report

This format is useful for shorter reports and is organized for updates on multiple recommendations. This format could be used for quick notes on updates that can be expanded upon later in a different format.



Open-Ended Format – Full-page report for each recommendation

CLIMATE CHANGE RECOMMENDATION QUARTERLY PROGRESS REPORT

Rec # \_\_\_\_\_

Point of Contact \_\_\_\_\_ Division \_\_\_\_\_ Date \_\_\_\_\_

Recent Progress

---

---

---

---

---

---

---

---

Planned Activities

---

---

---

---

---

---

---

---

Constraints/Issues

---

---

---

---

---

---

---

---

Figure 4: Open-Ended Quarterly Progress Report

This alternative format for the quarterly progress report is open-ended allowing for a more detailed account of the progress, planned activities, and any constraints on progress for the recommendation.

## Appendix F. INVEST Case Study

### F.1 DeIDOT - Using INVEST to Measure Sustainability for the DeIDOT Pavement and Rehabilitation Program<sup>42</sup>

**Lead Agency:** Delaware Department of Transportation (DeIDOT)

**INVEST Modules:** Operations and Maintenance

**SOURCE:** USDOT, Federal Highway Administration, INVEST Case Studies, [www.sustainablehighways.org](http://www.sustainablehighways.org)

DeIDOT used the INVEST Operations and Maintenance (OM) module to score its Pavement and Rehabilitation Program and other OM activities. Even though DeIDOT has actively employed sustainable practices (such as the use of recycled materials) for over 20 years, the agency had never quantified these efforts prior to INVEST. By using INVEST, DeIDOT was able to measure the sustainability achievement of its Pavement and Rehabilitation Program and identify areas for improvement across many aspects of project delivery. Some of the INVEST OM criteria addressed DeIDOT or statewide initiatives not specifically associated with the Pavement and Rehabilitation Program, which focuses specifically on pavement preservation. In those cases, DeIDOT gathered information from the other relevant program areas to complete the evaluation.

#### Scoring

To do the scoring, DeIDOT brought together several subject matter experts within the agency, including representatives from the following sections: Planning, Traffic Safety, Business Management, Maintenance and Operations, and Engineering Support. With the combined input from the subject matter experts, DeIDOT calculated a score of 146 out of 210 possible points, as displayed in the chart below, which equates to the platinum level in INVEST.

#### Highlights from Specific Criteria:

Sustainability highlights from the OM INVEST evaluation included:

- **OM-7 Pavement Management System and OM-8 Bridge Management System.** DeIDOT scored very highly on these criteria because the agency has extensive pavement and bridge management systems that track performance and condition across the State. DeIDOT uses the data to inform and prioritize maintenance actions. The summary information is also available to the general public via a dashboard on the DeIDOT website at [www.deldot.gov](http://www.deldot.gov).
- **OM-4 Recycle and Reuse.** DeIDOT did not score as highly on this criterion, even though the agency has employed these practices for decades. This is because the agency does not yet have a formal mandate or target for construction material recycling. Despite the lack of a formal target, DeIDOT has incorporated recycled materials, including recycled asphalt pavement, recycled asphalt shingles, recycled concrete aggregate, tire-derived aggregate, crumb rubber, cellulose fibers, and plastic from bottles for over 20 years in highway construction. DeIDOT also has used industrial byproducts, such as ground granulated blast furnace slag, silica fume, and fly ash in the Portland cement concrete used for projects. In the past decade, DeIDOT has also used in-place roadway reclamation and recycling operations for maintaining roadways. The

<sup>42</sup> <https://www.sustainablehighways.org/779/37/deldot-using-invest-to-measure-sustainability-for-the-deldot-pavement-and-rehabilitation-program.html>

process keeps pavements in place for pulverizing, stabilizing, and reshaping while minimizing the construction footprint of the work. The reclaimed and recycled pavement provides a stable construction platform for the overlay of structural pavement materials. DeIDOT will investigate opportunities to formalize the commitment to recycling and reuse through agency targets.

**Table 11: Result of DeIDOT Operation and Maintenance INVEST Evaluation**

Criterion	Points Scored	Maximum Points Possible
OM-01 Internal Sustainability Plan	8	15
OM-02 Electrical Energy Efficiency and Use	5	15
OM-03 Vehicle Fuel Efficiency and Use	11	15
OM-04 Recycle and Reuse	6	15
OM-05 Safety Management	13	15
OM-06 Environmental Commitments Tracking System	13	15
OM-07 Pavement Management System	15	15
OM-08 Bridge Management System	15	15
OM-09 Maintenance Management System	7	15
OM-10 Highway Infrastructure Preservation and Maintenance	10	15
OM-11 Traffic Control Infrastructure Maintenance	2	15
OM-12 Road Weather Management Program	15	15
OM-13 Transportation Management and Operations	13	15
OM-14 Work Zone Traffic Control	13	15
<b>TOTAL POINTS</b>	<b>146</b>	<b>210</b>

**Lessons Learned through INVEST Evaluation:**

DeIDOT identified many areas where it was performing well with respect to sustainability, but the agency also identified some potential future improvements, such as the following:

- **OM-01 Internal Sustainability Plan.** While senior leadership within the State is committed to sustainability, there are opportunities to improve tracking and monitoring in some areas. For example, although DeIDOT recycles materials, the agency has not yet tried to measure the extent and impact of recycling.

## Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

- **OM-02 Electrical Energy Efficiency and Use.** DeIDOT (and the State overall) has targets for reducing energy consumption and increasing renewable energy use statewide. DeIDOT can use the results of this module to advance those goals while balancing the economic impacts.
- **OM-03 Vehicle Fuel Efficiency and Use.** The State has set goals to reduce fossil fuel use and DeIDOT has used alternative fuels for their fleet. However, DeIDOT plans to increase the use of alternative fuels in fleet vehicles where available and economically practical.
- **OM-04 Recycle and Reuse.** Based on this criterion, DeIDOT has identified an opportunity to establish recycling and/or reuse targets for construction materials and/or industrial byproducts. DeIDOT already implements recycling and reuse, but has not yet set targets.
- **OM-11 Traffic Control Infrastructure Maintenance.** DeIDOT policy requires traffic control plans. However, they are project specific, do not include performance metrics, and do not explicitly reference sustainability. DeIDOT plans to review this area and consider improvements based on the INVEST evaluation.

### Key Outcomes of Using INVEST:

The INVEST OM scoring module helped DeIDOT to identify several opportunities to enhance the agency's sustainability efforts. Now DeIDOT plans to further assess and pursue these improvements. DeIDOT also plans to conduct subsequent evaluations of its programs with the INVEST System Planning and Project Development modules. The outlook is promising based on senior leadership's commitment to sustainability both within DeIDOT and across the State.

## Appendix G. Strategic Planning Workshop Climate Change, Sustainability & Resilience for Transportation

### G.1 Strategic Planning Workshop Summary

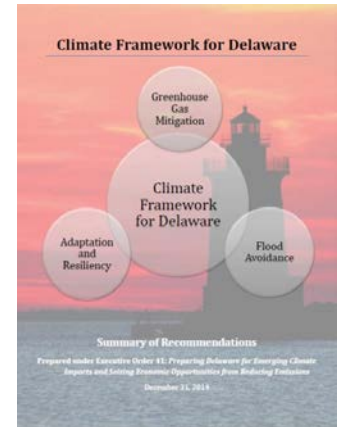
**PROJECT:** Delaware Department of Transportation (DelDOT)  
Strategic Planning for Climate Change, Sustainability  
& Resilience for Transportation

**PURPOSE:** Strategic Planning Workshop

**DATE/TIME:** July 28, 2016; 9:00am to 12:15pm

**LOCATION:** DelDOT Administration Building, Smyrna-Clayton Room

**ATTENDEES:** Mark Alexander, DelDOT M&O ([mark.alexander@state.de.us](mailto:mark.alexander@state.de.us))  
Barry Benton, DelDOT Bridge ([barry.benton@state.de.us](mailto:barry.benton@state.de.us))  
Darren Black, Jacobs ([darren.black@jacobs.com](mailto:darren.black@jacobs.com))  
Anne Brown, DelDOT M&O ([anne.brown@state.de.us](mailto:anne.brown@state.de.us))  
Eric Cimo, DelDOT Utilities ([eric.cimo@state.de.us](mailto:eric.cimo@state.de.us))  
Mark Coté, DelDOT Planning ([mark.cote@state.de.us](mailto:mark.cote@state.de.us))  
Silvana V Croope, DelDOT Planning ([silvana.croope@state.de.us](mailto:silvana.croope@state.de.us))  
Vince Davis, DelDOT ES2M ([vince.davis@state.de.us](mailto:vince.davis@state.de.us))  
Gene Donaldson, DelDOT TMC ([gene.donaldson@state.de.us](mailto:gene.donaldson@state.de.us))  
Bernie Gilbert, DelDOT Planning ([bernie.gilbert@state.de.us](mailto:bernie.gilbert@state.de.us))  
Thomas Hastings, Jacobs ([thomas.hastings@state.de.us](mailto:thomas.hastings@state.de.us))  
Mark Luszcz, DelDOT Traffic ([mark.luszcz@state.de.us](mailto:mark.luszcz@state.de.us))  
Kevin Needham, Jacobs ([kevin.needham@jacobs.com](mailto:kevin.needham@jacobs.com))  
Jim Pappas, DelDOT OPM ([jim.pappas@state.de.us](mailto:jim.pappas@state.de.us))  
Jennifer Pinkerton, DelDOT Materials & Research ([jennifer.pinkerton@state.de.us](mailto:jennifer.pinkerton@state.de.us))  
John Sisson, DTC ([john.sisson@state.de.us](mailto:john.sisson@state.de.us))  
Mark Tudor, DelDOT PD North ([mark.tudor@state.de.us](mailto:mark.tudor@state.de.us))  
Brian Urbanek, DelDOT M&O ([brian.urbanek@state.de.us](mailto:brian.urbanek@state.de.us))  
Kathy Wilson, DTC ([kathy.wilson@state.de.us](mailto:kathy.wilson@state.de.us))



## 1. Overview

- a. On Wednesday July 27<sup>th</sup>, a group of 15 DeIDOT employees representing various divisions across the organization participated in a Strategic Planning Workshop on Climate Change, Sustainability & Resilience for Transportation that was facilitated by Jim Pappas, Brian Urbanek, Silvana Croope and consultants from Jacobs Engineering. A key focus of the workshop were the 19 'Climate Framework' recommendations that DeIDOT has been tasked with accomplishing in order to address both the causes and consequences of climate change per Governor Markell's Executive Order 41 (EO41).

Jim Pappas began the workshop with an overview of EO 41, highlighting the focus areas – adaptation, flood avoidance, and mitigation – as well as the progress that has been accomplished to date. Brian Urbanek followed Jim's presentation by providing an overview of how climate change, and DeIDOT efforts to mitigate the causes of climate change, may impact maintenance and operations. His presentation focused on implications for workforce safety, facilities, and operations, including for example, mowing operations, snow and ice removal, and emergency operations.

After Brian and Jim's presentations, the Jacobs team reviewed each Fact Sheet that was developed for each of DeIDOT's 19 Climate Framework recommendations. The Fact Sheets include the recommendation summary, current progress, next steps, DeIDOT stakeholders, strengths, challenges, and other considerations related to each recommendation.

After reviewing, discussing and revising the Fact Sheets per input from the workshop participants, Silvana Croope ended with workshop with a presentation that looked beyond climate change and expanded the discussion to include resilience and sustainability of the transportation system. Silvana's presentation focused on incorporating sustainability and resilience into the strategic planning process. She gave a brief overview of integrating sustainability and resilience into operations and planning. Her presentation stressed the importance of utilizing data such as flood monitoring sites, debris removal information, ITS monitoring systems for risk assessment, resilience, and sustainability planning.

## 2. Strategic Planning Process/Workshop Objectives

- a. Kevin Needham from Jacobs provided an overview of the strategic planning process that we are utilizing to develop the Strategic Implementation Plan for Climate Change, Resilience & Sustainability for Transportation.
- b. The Strategic Planning Process involved background research, stakeholder interviews, preparing fact sheets, and organizing a workshop. After the workshop, we will expand our focus to include sustainability and resilience and develop the Strategic Implementation Plan.
- c. The objectives for the workshop were to update the stakeholders on EO41, review the fact sheets, prioritize the Climate Framework recommendations, and build support for the Strategic Planning Process. Due to time limitations, we were unable to prioritize the Climate Framework recommendations.

## 3. Update on Executive Order 41

- a. Jim Pappas gave a presentation on Executive Order 41, which prepares Delaware for emerging climate impacts and seizing economic opportunities for reducing emissions. All state agencies have recommendations for climate change impacts resilience.

- b. The Cabinet Committee on Climate and Resiliency (CCoCAR) was created through Executive Order 41 and set a mitigation target of 30% greenhouse gas reduction from a 2008 baseline by 2030.
- c. Jim showed the DE Flood Risk Adaptation Map, which depicted the 1% annual chance floodplain with 3 feet of sea level rise. Mark Luszcz, asked if this mapping tool could be added to gateway.

#### **4. Climate Framework Impacts on Maintenance & Operations**

- a. Brian Urbanek presented on Implications of Climate Impacts for maintenance and operations.
- b. The presentation highlighted how workforce safety, facility operations, emergency response, mowing, snow & ice removal are all affected by climate change
- c. Brian is participating in the “Climate-Ready Workforce Pilot Project” which identifies risk to workers, reviews existing resources, and develops policies, training, and best practices.
- d. Maintenance and Operations has also kept track of energy use through Energy Star; a 14% reduction from 2008 to 2014.

#### **5. Review of Climate Framework Fact Sheets**

- a. The consultant team consisting of Kevin Needham, Darren Black, and Thomas Hastings from Jacobs, presented the Climate Framework Fact Sheets that highlighted progress, next steps, and challenges for each Climate Framework recommendation.
- b. Vince Davis emphasized the importance of starting with a good model in order to get valid results in reference to modeling impacts of severe weather events.
- c. In reference to integrating climate resiliency into project development and design Gene Donaldson asked “What is the design standard?” Silvana Croope replied that there are acceptable levels of disruption that we should expect when designing but we should design so that the structure or infrastructure can recover more efficiently.
- d. Silvana mentioned that she attends meetings with NIST who are helping state agencies plan for climate resilience.
- e. In reference to reevaluating emergency response protocols, Gene made it clear to the group that evacuations occur before flooding. Once flooding starts residents are told to stay where they are, and if need be they will be rescued.

#### **6. Incorporation of Sustainability & resilience in Strategic Planning Process**

- a. Silvana presented on the building blocks of incorporating sustainability and resilience into the strategic planning process:
  - i. Integrating Operations and Planning
  - ii. Risk-based (Asset) Management
  - iii. Climate Change
  - iv. Resilience
  - v. Sustainability
- b. The presentation showed that not only will operations and maintenance, planning, land-use, environmental permitting, energy and other resources be affected by climate change impacts but also by integrating sustainability into these processes, the State can become more resilient.



- c. Resilience must be assessed before events to understand a system's adaptive ability to restore itself to its former condition. After an event, a system must provide an acceptable level of service and ensure continuous system operations.
- d. There are 10 flood-monitoring sites throughout Delaware, seven of which are in Sussex County.
- e. Silvana pointed out that the rate of sea level rise is estimated to be 2.51 to 3.75 mm/yr (~ 0.1 to 0.15 in. /yr).
- f. Sustainability can only be achieved by considering the environment society and the economy. That is the framework on which sustainable planning and design must be built.

**7. Next Steps**

- a. Kevin Needham discussed what the next steps were, following the workshop. The consultant team would gather notes from the review of the Climate Framework recommendation fact sheets and update the fact sheets to be incorporated into the Strategic Implementation Plan. Any additional opportunities for input or questions will be followed up by email or call.

## **Appendix H. Workshop Presentations by Silvana Croope, Brian Urbanek, and Jim Pappas**



# DeIDOT Strategic Planning Workshop

## Climate Change, Sustainability & Resilience for Transportation

July 27, 2016



## Agenda

- Welcome/Introductions
- Strategic Planning Process
- Workshop Objectives
- Update on EO41
- Implications for Maintenance & Operations
- Review Climate Framework Fact Sheets
  - High Level Overview
  - Address Gaps
  - Comments from Workshop Participants
  - Prioritize Recommendation (Priority 1/2/3)
- Break
- Review Climate Framework Fact Sheets (cont.)
- Incorporation of Sustainability & Resilience in Strategic Planning Process
- Next Steps
- Closing Remarks

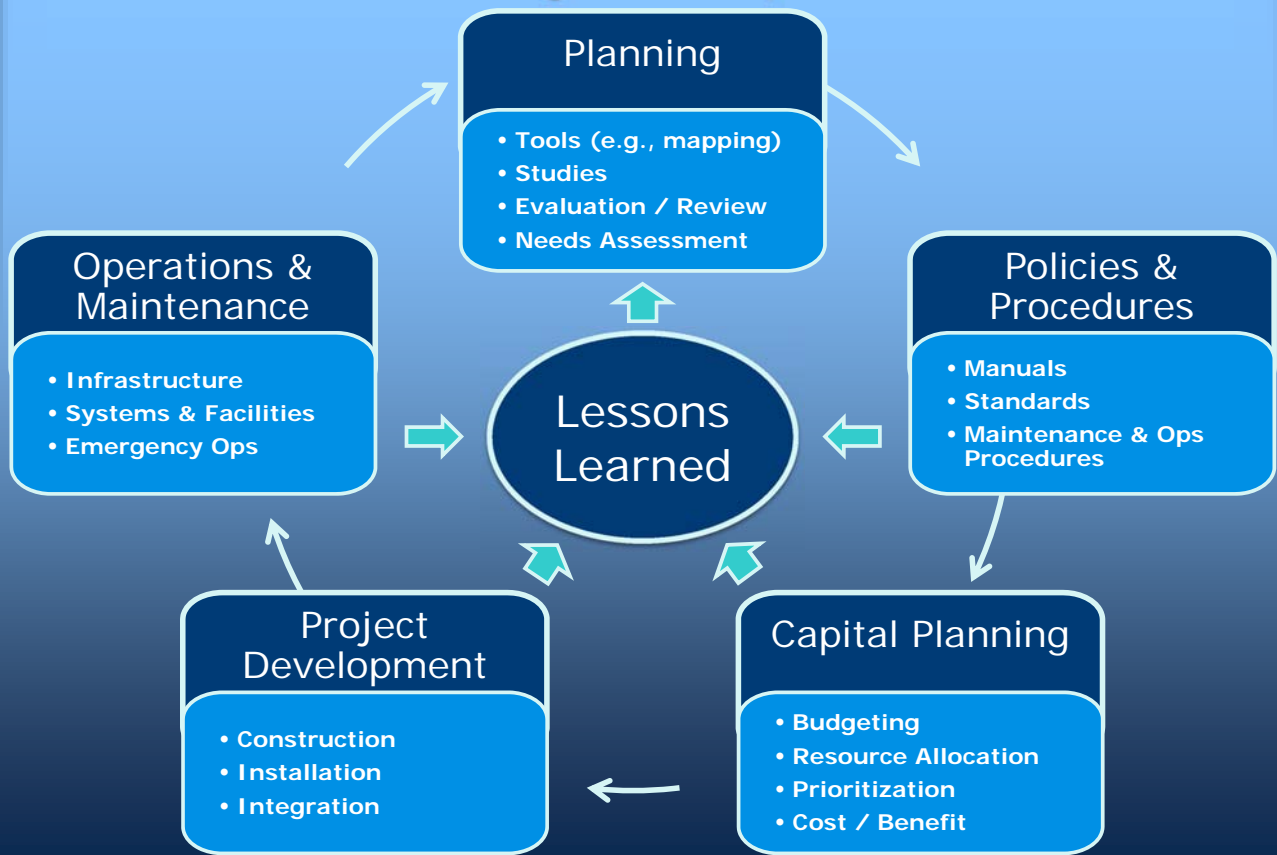
# Strategic Planning Process

- Background Research
- Conduct Stakeholder Interviews
- Prepare Climate Framework Fact Sheets
- Convene Stakeholder Workshop
- Expand Focus to Include Sustainability & Resilience
- Develop Strategic Implementation Plan for Climate Change, Sustainability & Resilience for Transportation

# Workshop Objectives

- Provide Update on EO41
- Review Fact Sheets
  - Highlight Gaps & Collaborate on Solutions
  - Prioritize DeIDOT Climate Framework Recommendations
- Build Support for Strategic Planning Process

# From Planning to Implementation



## UPDATE ON EXECUTIVE ORDER 41

# Executive Order 41 Update

## Climate Framework Strategic Planning Workshop

July 27, 2016

Jim Pappas  
Office of Performance Management



## Executive Order 41

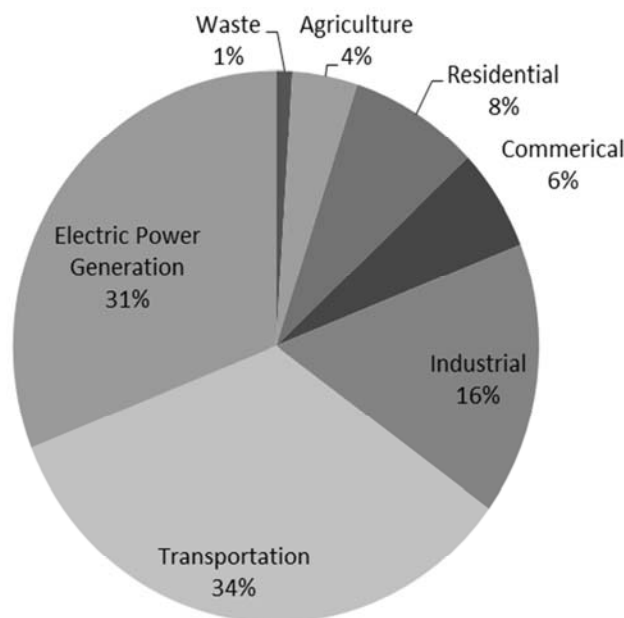
- *Preparing Delaware for Emerging Climate Impacts and Seizing Economic Opportunities for Reducing Emissions*
- Signed September 12, 2013
- All state agencies are subject to the provisions of EO 41 for both construction projects and long-range planning
- Directs agencies to address both the causes and consequences of climate change



## Executive Order 41 (cont)

- Creates Cabinet Committee on Climate and Resiliency (CCoCAR)
- Directs the state to set a mitigation goal
- Requires State Agencies to plan and design projects for flooding and sea level rise
- Requires State Agencies to prepare adaptation recommendations

## Delaware's Greenhouse Gas Emissions Portfolio (2010)



Source: Delaware 2010 Greenhouse Gas Inventory, Division of Air Quality, 2014



# EO 41 – Workgroups

- **Adaptation**
  - Develop agency specific, actionable recommendations for improving Delaware's preparedness and resilience to climate impacts.
- **Flood Avoidance**
  - Established to develop flood avoidance and design guidance to incorporate measures for adapting to increased flood heights and sea level rise.

# EO 41 – Workgroups (cont.)

- **Mitigation**
  - Examine GHG emissions, regulations, programs, and policies that influence GHG emissions, use best data available to establish a GHG mitigation target, and develop an implementation plan to guide Delaware toward its goal
    - **Recommended mitigation target of 30% greenhouse gas reduction from a 2008 baseline by 2030**

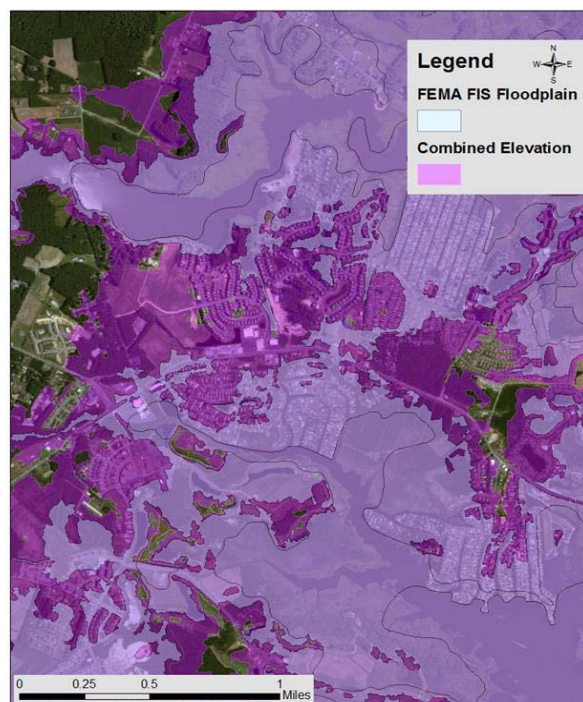
# Significant Progress

- Climate Framework for DE published on December 31, 2014
- Contains 166 recommendations
- Includes 30% GHG reduction goal



# Mapping Tools – DE Flood Risk Adaption Map

- Future looking
- Developed for state agency use
- Depicts the 1% annual chance floodplain with 3 feet of sea level rise
  - Many caveats and limitations
- Use for planning and assessment



# Interagency Pilot Projects

- Kick start work on climate adaptation measures to address cross-cutting issues
  - Asset Management
  - Workforce Safety
- Funding available
- Multiagency participation requested

## Still to do ...

- Finalize, approve and use
- Flood avoidance guidelines
- Strategies for reducing GHG
- Formalize GHG reduction target of 30%
- Then implementation plan
- More implementation of EO 41 recommendations

**Thank you for your time  
and attention**

Jim Pappas  
302.760.2379  
[james.pappas@state.de.us](mailto:james.pappas@state.de.us)



*“Don’t follow the rules. If everybody followed the rules, nothing would change, and without change there is no progress.”* Sir Richard Branson

CLIMATE CHANGE IMPACTS ON  
MAINTENANCE & OPERATIONS



# Implications for Maintenance & Operations

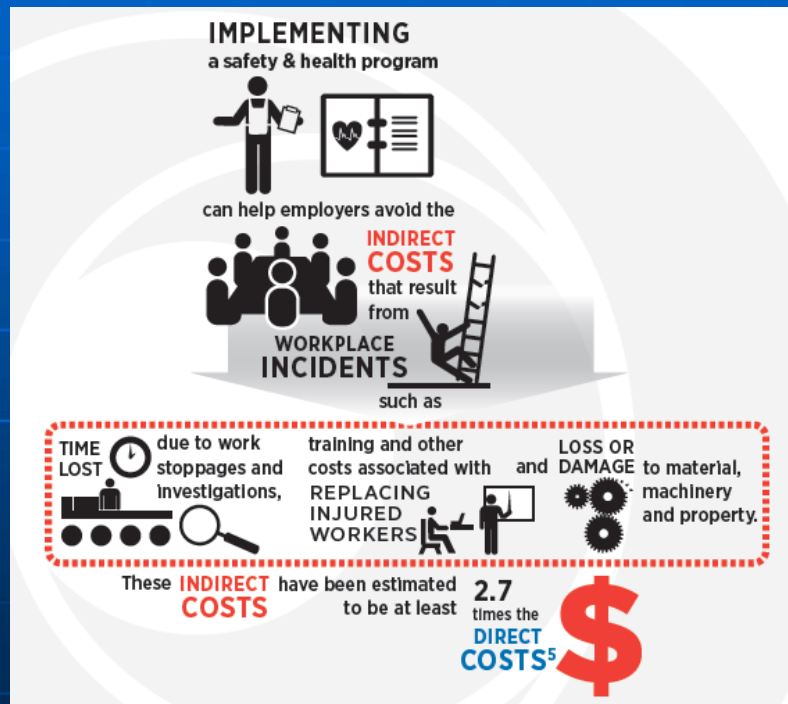
- Workforce Safety
- Facilities
- Operations
  - Emergency response
  - Mowing
  - Snow & ice removal

## Workforce Safety

- Participating in the Climate-Ready Workforce Pilot Project
  - Cross-cutting theme shared by multiple agencies
    - DeIDOT, DNREC, DHSS, DOS, OMB, DSHS
  - Identify risks
  - Review existing resources
  - Develop Policies, Training, and Best Practices

# Workforce Safety

- Pilot Project Goal
  - The main goal of safety and health programs is to **prevent workplace injuries, illnesses, and deaths**, as well as the suffering & financial hardship these events can cause for workers, their families and employers. [OSHA]



# Workforce Safety

- Existing Resources
  - Personnel
    - **Risk Management Safety Officers**, Traffic Safety Officers, Human Resources
  - Reference Material
    - Performance Plans, Safety Manual, Collective Bargaining Agreement (CBA), Occupational Safety Website
  - Training
    - New Employee Orientation (NEO), Cold and Hot Weather, First Aid/CPR/AED, Working Near Water

# Facilities

- Participating in the Asset Management Pilot Project
- Following Executive Order 18 for Design of Capital Facility Projects to Meet LEED Silver Certified
  - Building envelope, HVAC/Geothermal systems, lighting, etc.
- Tracking Energy Use Through Energy Star

# Facilities

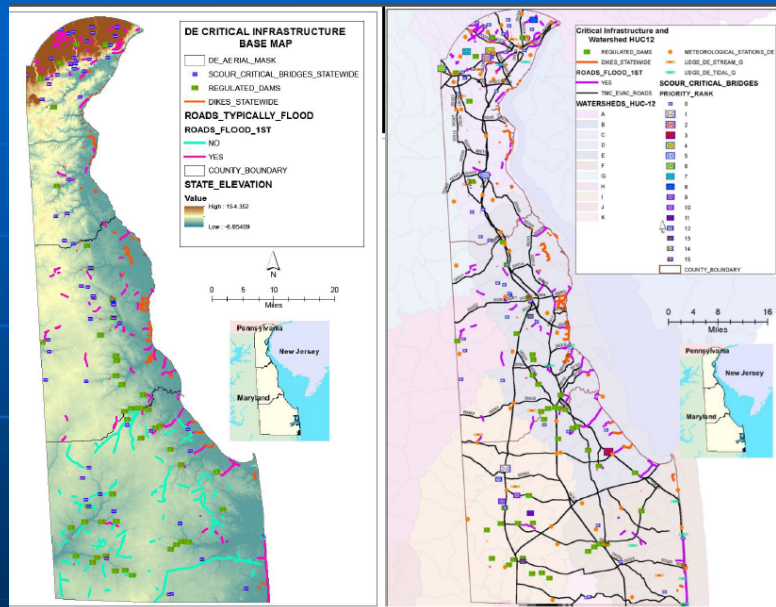


- Energy Audits Performed On Some Existing Facilities
  - Recommendations for projects
  - Return on Investment
- DNREC Developing RFP for Resilience and Sustainability Assessment of Facilities



# Operations

- Emergency Response
  - Developed Flood Map
  - Utilize Road Weather Information System (RWIS)



# Operations

- Modify Mowing Operations Based on Ozone / Air Quality Alerts
  - Currently do not adjust employee schedules for weather
  - Collective bargaining agreements with unions may restrict modifications of operations



# Snow & Ice Removal

- Safety considerations
  - Movement of emergency responders
  - Public safety – accidents, mobility
  - Safety of snowfighters
- Performance
  - Define levels of service & achieve them
- Cost Effectiveness
- **Environmental protection**



# Snow & Ice Removal

- Environmental considerations
  - Controlling runoff from roadway operations
    - Streams, groundwater, vegetation, habitat
    - Bridges, pavement, appurtenances
  - Storage of abrasives & chemicals
  - Minimizing air quality impacts
  - Innovation, experimentation & evolution
    - Abrasives versus chemicals versus mixes
    - Alternatives to traditional rock salt

# Recommendations Summary Table

Category	#	Recommendation	Planning & Evaluation	Policies & Procedures	Capital Planning/ Resource Allocation	Project Development	Operations & Maintenance	Cost	Status	Estimated Duration
To incorporate climate change into asset management	1	Development of geospatial data sets	●	●	●			\$250k – \$1,000k	In Progress (50% complete)	2 - 5 years
	2	Conduct a comprehensive analysis of the state's roadways risk and assets	●					\$250k – \$1,000k	In Progress (50% complete)	2 - 5 years
	3	Integrate climate resiliency into project development, traffic, bridge, and highway design		●	●			> \$1,000k	In Progress (less than 50% complete)	10+ years
	4	Build transportation enhancements to accommodate impacts of climate change.				●	●	\$250k – \$1,000k	In Progress (less than 50% complete)	5 years
	5	Identify and assess existing chronic flooding and erosion problems that affect transportation infrastructure.	●					\$250k – \$1,000k	In Progress (50% complete)	4-6 years
	6	Evaluate materials used to reduce the impacts of stormwater runoff		●	●			\$100k – \$250k	In Progress (less than 50% complete)	4-6 years
	7	Reevaluate stormwater management approaches	●	●				\$100k – \$250k	In Progress (just begun)	2-5 years
	8	Explore new pavement technology	●	●				\$100k – \$250k	Not Started	2-5 years
	9	Incorporate climate impacts into cost-effective investment in infrastructure.		●	●			< \$100k	In Progress (less than 50% complete)	0-2 years
	10	Evaluate whether to obtaining insurance to assist in recovery from catastrophic events.	●					> \$1,000k	In Progress (just begun)	4-6 years

# Recommendations Summary Table

Category	#	Recommendation	Planning & Evaluation	Policies & Procedures	Capital Planning/ Resource Allocation	Project Development	Operations & Maintenance	Cost	Status	Estimated Duration
To ensure workforce and public health and safety	11	Evaluate and adjust worker safety guidelines	●	●				\$100k - \$250k	In Progress (just begun)	2-5 years
	12	Provide training to improve worker knowledge					●	\$100k - \$250k	Not Started	1-3 years
	13	Evaluate driving restrictions for air quality events	●					\$100k - \$250k	Not Started	4-6 years
	14	Develop revised maintenance schedules in response to air quality		●				\$100k - \$250k	In Progress (less than 50% complete)	0-2 years
	15	Adjust transit service in emergencies		●			●	\$100k - \$250k	In Progress (less than 50% complete)	2-5 years
	16	Reevaluate emergency response protocols	●	●				< \$100k	In Progress (50% complete)	0-2 years
To support climate resiliency in local communities	17	Support local governments with land use assessment tools	●					< \$100k	In Progress (less than 50% complete)	2-5 years
To identify and support policy initiatives that reduce greenhouse gas emissions (climate mitigation)	18	Evaluate low-emission vehicle deployment			●		●	\$250k - 1,000k	In Progress (less than 50% complete)	2-5 years
	19	Evaluate alternative energy technology in facilities			●	●		\$100k - \$250k	In Progress (substantially complete)	1-3 years



# INCORPORATING SUSTAINABILITY & RESILIENCE IN STRATEGIC PLANNING PROCESS

Strategic Planning Workshop  
Climate Change, Sustainability  
& Resilience for Transportation

## INCORPORATING SUSTAINABILITY & RESILIENCE IN STRATEGIC PLANNING PROCESS

# Building Blocks

- ◉ Integrating Operations/Planning, and more ...
- ◉ Risk-based (Asset) Management
- ◉ Climate Change
- ◉ Resilience
- ◉ Sustainability

## Integration of Operations, Planning and more ...

### Operations

- Critical and priority locations (traffic flow)
- 24 – 7 – 365 ITS monitoring systems (data collection)
- Transportation Weather and Flooding Monitoring System
- Response
- Power
- Telecommunications

### Planning

- Strategic planning
- Policies, governance
- Data analyses
- Budget (contingency funding)
- Research
- Technology innovation and impacts
- Resilience, risk, uncertainties, sustainability
- Communication

Land-Use

Environmental  
Permitting

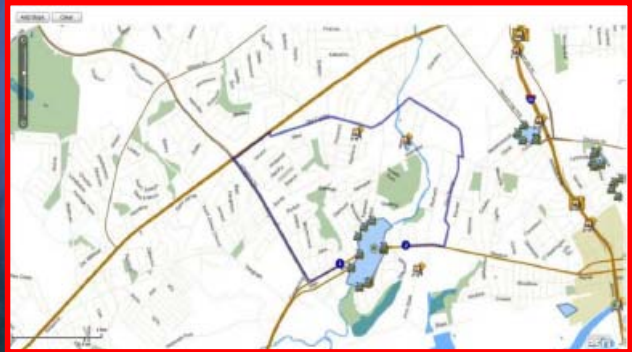
Users and  
Private  
Sector

Energy and  
other  
resources

**SR-1 Closure  
Detour**



- Damage assessment (deterioration <http://tinyurl.com/tran-shug>)
- Debris removal



**Resilience – engineering**

Before event (diagnosis)

System fulfillment of resilience characteristics:

adaptive ability to restore itself to former conditions

**Resilience – network**

After events

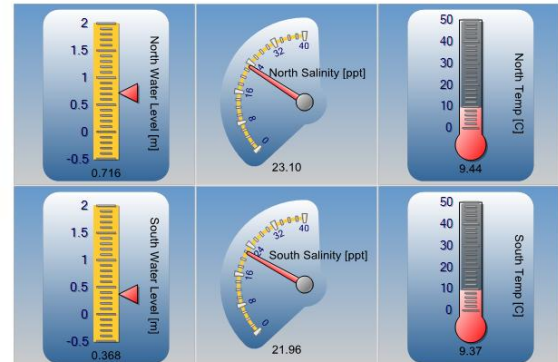
- provide/maintain an acceptable level of service manage CI problems, develop protection strategies, ensure continuous system operation (uncertain future)



You are here: US Fish & Wildlife Service / Coastal Delaware NWR Complex / Prime Hook NWR / Prime Hook Rd

Name: Prime Hook Rd  
Description:

Last read: 04/23/2013 09:45 AM



Parameter: North Water Level [m]  
Start Date: 10/28/2012 End Date: 10/31/2012 Submit



Figure 13 - Prime Hook National Wildlife Refuge Marsh & Water Monitoring Network and Flooding Threshold

Source: Delaware Department of Transportation, Transportation Management Center, 4/2/2013  
<http://eops.dot.state.de.us/eops/app/secure/resources/Home>



CLOSE

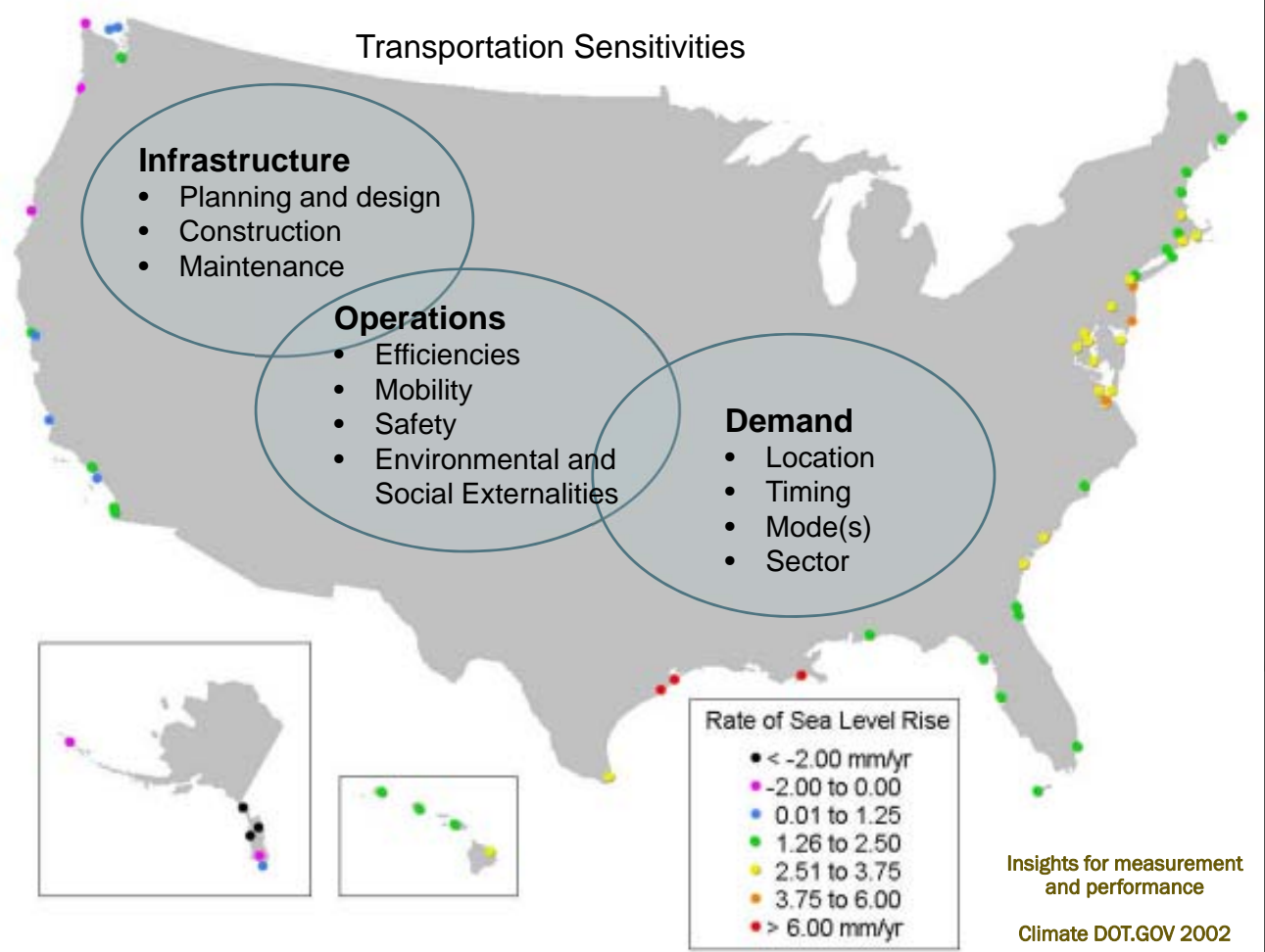
MAP LAYERS	
DART Bus Stops	i
Traffic Flow	i
Travel Times	i
Traffic Cameras	i
Advisories	i
Roadway Weather	i
Water Over Roadways	i
<b>Water Level</b>	<b>i</b>
Snow Accumulations	i
Snow Plow Tracking	i
Restrictions	i
Variable Message Signs	i
Variable Speed Limits	i
Railroad Crossings	i
Woodland Ferry	i
Red Light Enforcement	i



- 10 flooding monitoring sites (2016)
- Statewide Monitoring Coverage Strategic Plan (2016)
- ...

<http://www.deldot.gov/map/#>

### Transportation Sensitivities





# Why Does FHWA Care About Climate Change Adaptation?



- **Need to protect integrity of transportation investments, safety**
  - Infrastructure has long design life (decades)
  - Infrastructure needs to handle new conditions as climate changes
  - Adaptation is ensuring that we plan our infrastructure for the future
- **FHWA Goal: Systematic consideration of climate change vulnerability and risk in transportation decision making, at system and project level**



Rob Hyman - FHWA, Office of Natural Environment - Delaware 11/2/2011

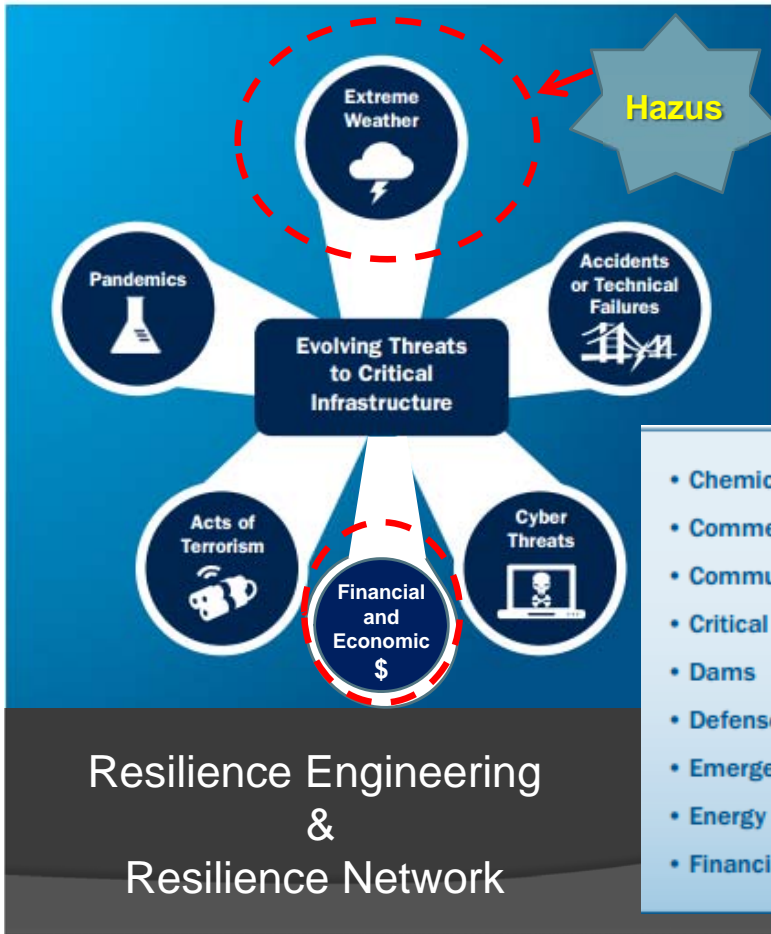


## Risk Assessment and Resilience of Systems

<i><b>Risk</b></i>	<i><b>Resilience</b></i>
<ul style="list-style-type: none"> <li>- Impacts</li> <li>- <b>Hazus (frequent &amp; stronger storms: WIND, FLOOD)</b></li> <li>- Insight for mitigation</li> </ul>	<ul style="list-style-type: none"> <li>- Preparedness</li> <li>- Mitigation</li> <li>- Actions, plans, projects (resilience engineering/hardening, resilience network/adaptation, resilience planning/urban engineering)</li> </ul>

- System capacity to absorb disturbance and reorganize
- Principles: redundancy, robustness, rapidity, resourcefulness
- Systems designs vulnerability (damage from hazardous events) & increasing adaptive capacity of systems

Figure 2 – Evolving Threats to Critical Infrastructure



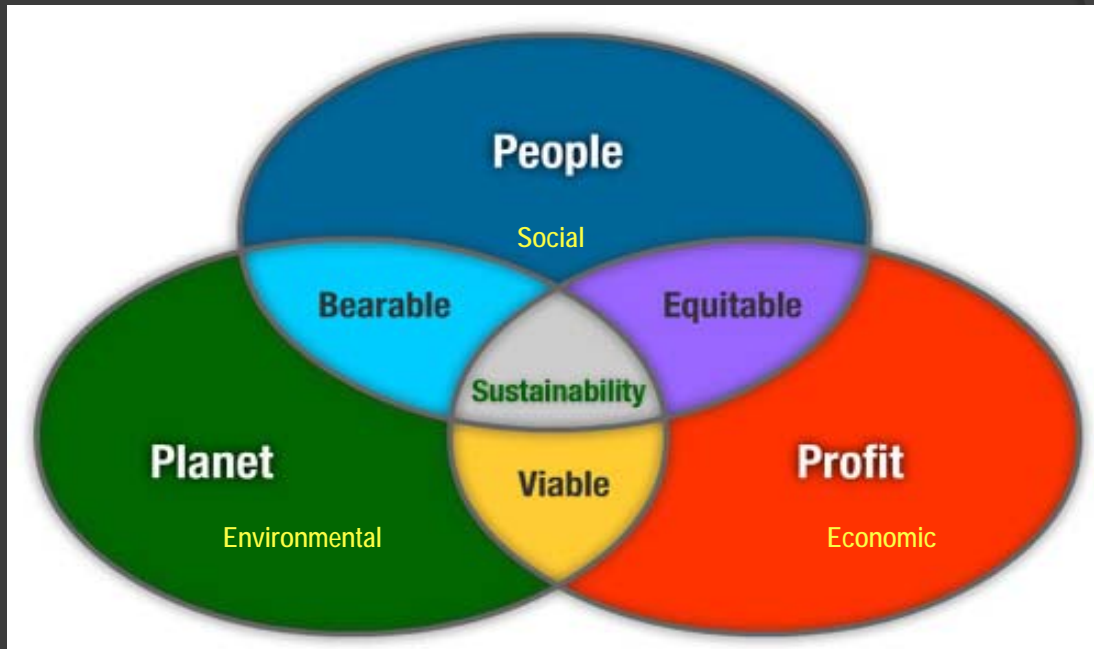
**NIPP – National Infrastructure Protection Plan**

Climate Change =

↑ Extreme weather  
+  
↑ Stronger Storms

- Chemical
- Commercial Facilities
- Communications
- Critical Manufacturing
- Dams
- Defense Industrial Base
- Emergency Services
- Energy
- Financial Services
- Food and Agriculture
- Government Facilities
- Healthcare and Public Health
- Information Technology
- Nuclear Reactors, Materials, and Waste
- **Transportation Systems**
- Water and Wastewater Systems

**Sustainability Assessment Framework based on Triple Bottom Line – TBL or 3BL**



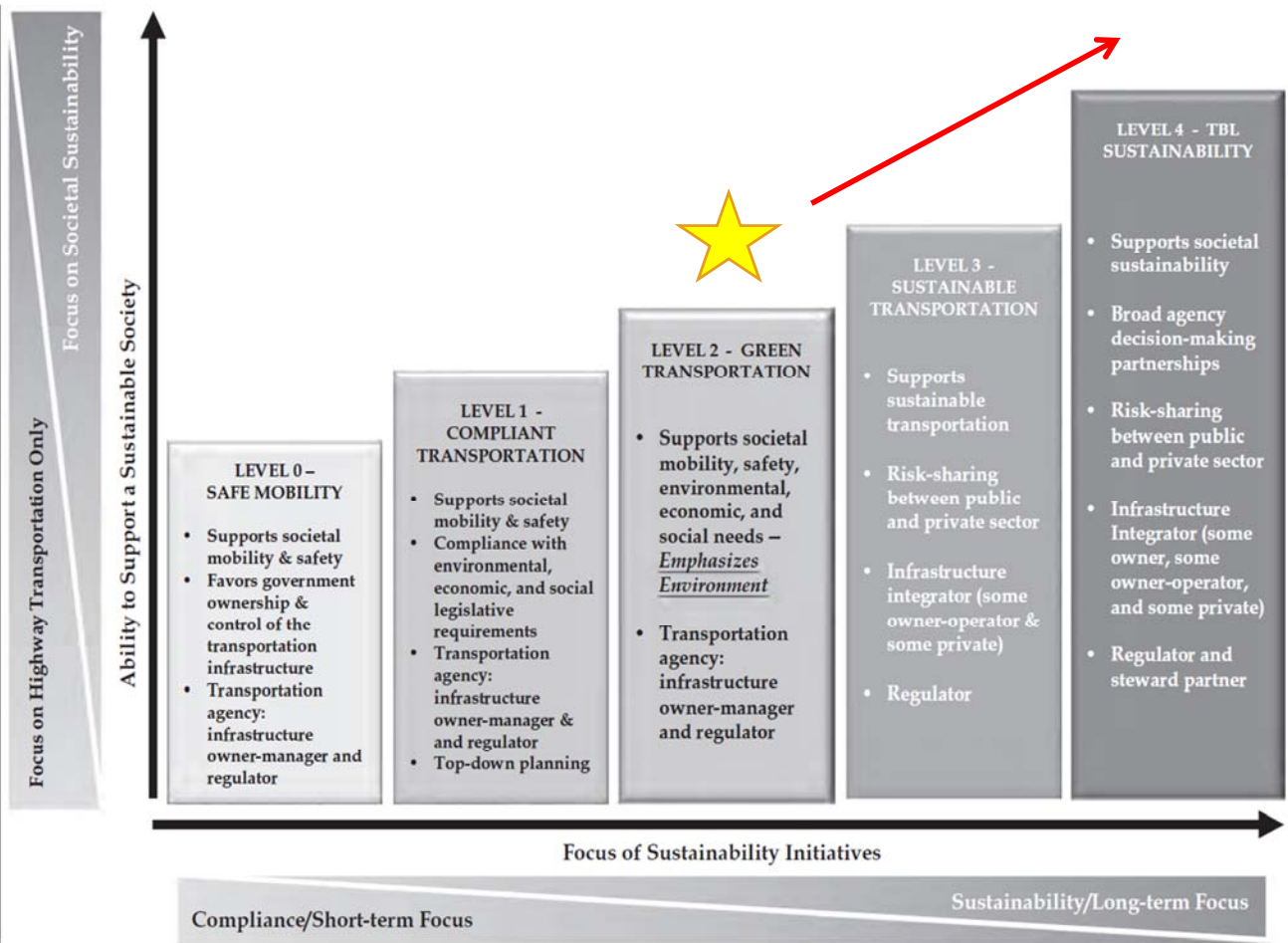
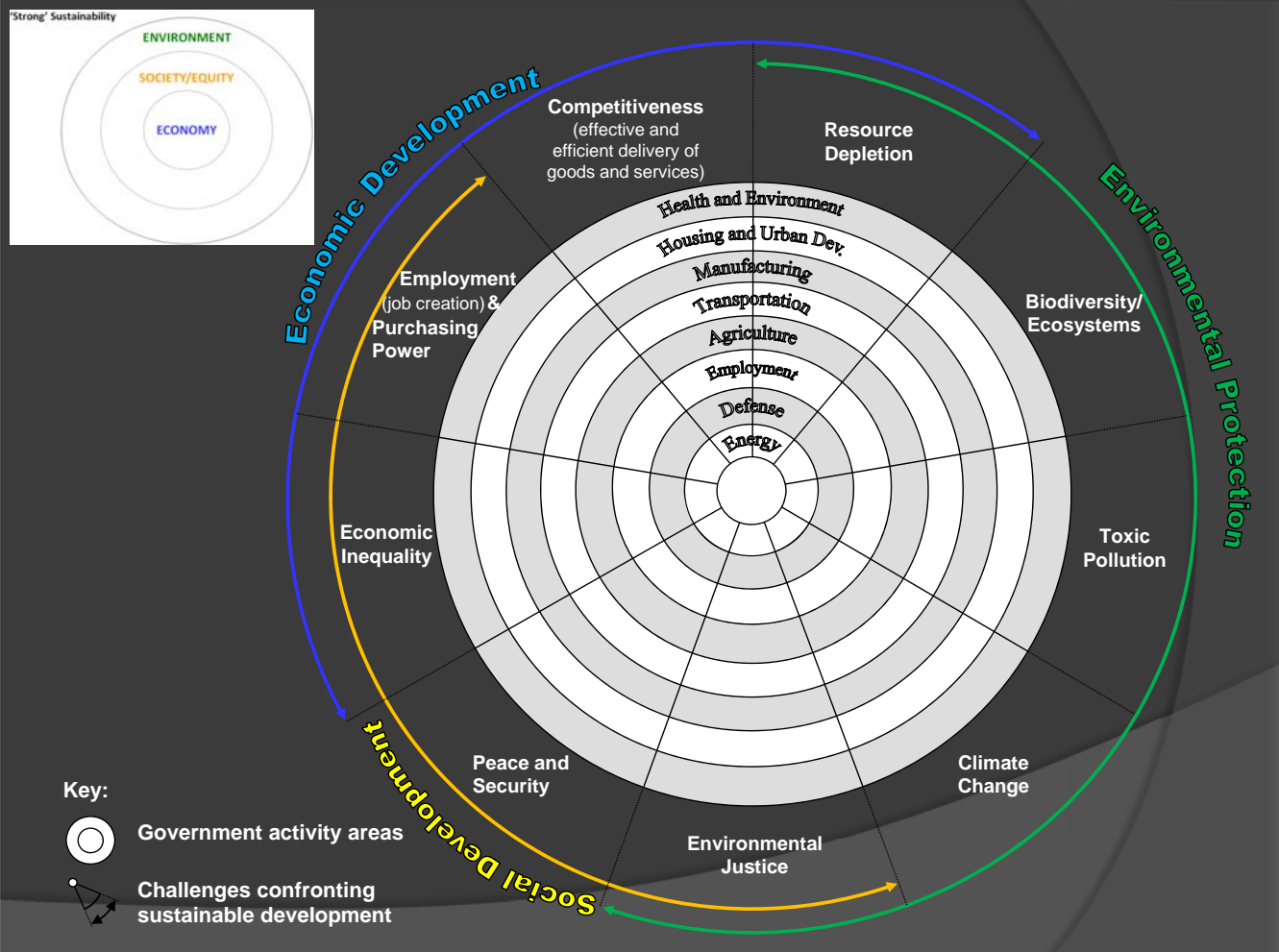


Figure 1. Past, present, and future transportation policy systems.

Source: NCHRP Report 750 (2014)



**Table 1.** Central attributes of sustainable transportation performance measures

- Accessibility
- Health and safety
- Cost effectiveness
- Impacts on competitiveness and generation of wealth
- Consumption of natural capital
- Production of pollutants (local and global)

Kennedy, Miller et al. (2005) *The Four Pillars of Sustainable Urban Transportation*. *Transport Reviews*.

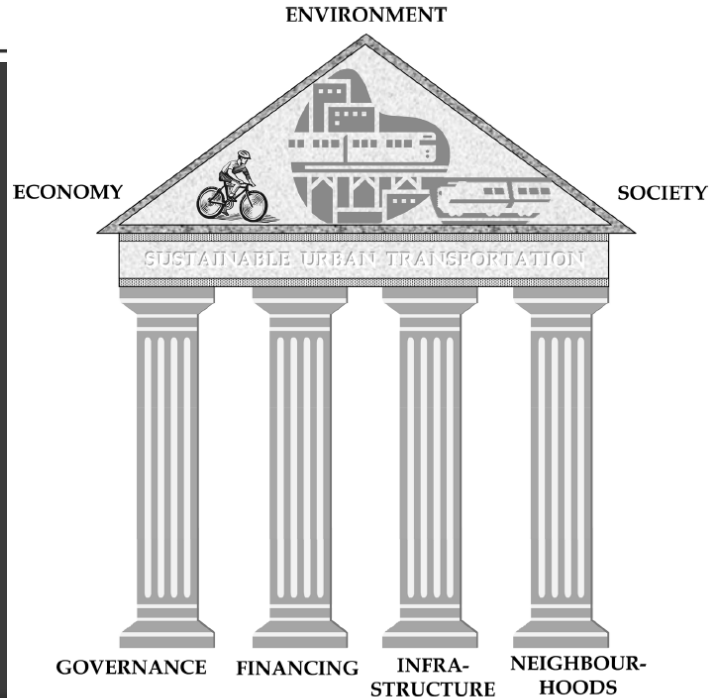


Figure 1. The four pillars of sustainable urban transportation (for further detail, see the text)

# ASCE Policy Statement 418

The civil engineering profession recognizes the reality of limited natural resources, the desire for sustainable practices ..., and the need for social equity in the consumption of resources.

## CREDIT LIST

Source: ISI, Envision, <http://www.sustainableinfrastructure.org/>



### 1 PURPOSE

- QL1.1 Improve Community Quality of Life
- QL1.2 Stimulate Sustainable Growth & Development
- QL1.3 Develop Local Skills & Capabilities

### 2 WELLBEING

- QL2.1 Enhance Public Health & Safety
- QL2.2 Minimize Noise and Vibration
- QL2.3 Minimize Light Pollution
- QL2.4 Improve Community Mobility & Access
- QL2.5 Encourage Alternative Modes of Transportation
- QL2.6 Improve Accessibility, Safety, & Wayfinding

### 3 COMMUNITY

- QL3.1 Preserve Historic & Cultural Resources
- QL3.2 Preserve Views & Local Character
- QL3.3 Enhance Public Space
- QL0.0 Innovate or Exceed Credit Requirements

### 1 COLLABORATION

- LD1.1 Provide Effective Leadership & Commitment
- LD1.2 Establish A Sustainability Management System
- LD1.3 Foster Collaboration & Teamwork
- LD1.4 Provide for Stakeholder Involvement

### 2 MANAGEMENT

- LD2.1 Pursue By-Product Synergy Opportunities
- LD2.2 Improve Infrastructure Integration

### 3 PLANNING

- LD3.1 Plan For Long-Term Monitoring & Maintenance
- LD3.2 Address Conflicting Regulations & Policies
- LD3.3 Extend Useful Life
- LD0.0 Innovate or Exceed Credit Requirements

### 1 MATERIALS

- RA1.1 Reduce Net Embodied Energy
- RA1.2 Support Sustainable Procurement Practices
- RA1.3 Use Recycled Materials
- RA1.4 Use Regional Materials
- RA1.5 Divert Waste From Landfills
- RA1.6 Reduce Excavated Materials Taken Off Site
- RA1.7 Provide For Deconstruction & Recycling

### 2 ENERGY

- RA2.1 Reduce Energy Consumption
- RA2.2 Use Renewable Energy
- RA2.3 Commission & Monitor Energy Systems

### 3 WATER

- RA3.1 Protect Fresh Water Availability
- RA3.2 Reduce Potable Water Consumption
- RA3.3 Monitor Water Systems
- RA0.0 Innovate or Exceed Credit Requirements

### 1 SITING

- NW1.1 Preserve Prime Habitat
- NW1.2 Protect Wetlands & Surface Water
- NW1.3 Preserve Prime Farmland
- NW1.4 Avoid Adverse Geology
- NW1.5 Preserve Floodplain Functions
- NW1.6 Avoid Unsuitable Development on Steep Slopes
- NW1.7 Preserve Greenfields

### 2 LAND+WATER

- NW2.1 Manage Stormwater
- NW2.2 Reduce Pesticide & Fertilizer Impacts
- NW2.3 Prevent Surface & Groundwater Contamination

### 3 BIODIVERSITY

- NW3.1 Preserve Species Biodiversity
- NW3.2 Control Invasive Species
- NW3.3 Restore Disturbed Soils
- NW3.4 Maintain Wetland & Surface Water Functions
- NW0.0 Innovate or Exceed Credit Requirements

### 1 EMISSIONS

- CR1.1 Reduce Greenhouse Gas Emissions
- CR1.2 Reduce Air Pollutant Emissions

### 2 RESILIENCE

- CR2.1 Assess Climate Threat
- CR2.2 Avoid Traps & Vulnerabilities
- CR2.3 Prepare For Long-Term Adaptability
- CR2.4 Prepare For Short-Term Hazards
- CR2.5 Manage Heat Island Effects
- CR0.0 Innovate or Exceed Credit Requirements



# Enterprise Risk Management

## Old Paradigm

- Historically focused
- Ad hoc activity
- Accounting, treasury and internal audit
- Fragmentation (Silo Approach)
- Financial risk
- Inspect, detect, react
- Focus on people

## New Paradigm

- Strategic
- Continuous activity
- All of management
- Focused and coordinated (Holistic)
- Business risks
- Anticipate, prevent, monitor
- Focus on processes and people

The Economist Intelligence Unit, *Managing Business Risk*, p. 10

Hurricane Sandy – IRIB – Sussex County  
2 to 3 feet of sand across DE1



# Next Steps

- Action Items from Workshop
- Additional Opportunities for Input from DeIDOT Stakeholders
- Begin Development of Strategic Implementation Plan

# SIP Report Outline

## Executive Summary

### 1. Introduction

- 1.1. Project Goals and Objectives
- 1.2. Project Stakeholders
- 1.3. Research Methodology
  - 1.3.1. Literature Review
  - 1.3.2. Stakeholder Interviews
  - 1.3.3. SWOT Analysis (Strengths, Weaknesses, Opportunities & Threats)
  - 1.3.4. Strategic Planning Workshop

### 2. Climate Framework Recommendations for DeIDOT – Status Assessment

- 2.1. Recommendations to Incorporate Climate Change into Asset Management
- 2.2. Recommendations to Ensure Workforce and Public Health and Safety
- 2.3. Recommendations to Support Climate Resilience in Local Communities
- 2.4. Recommendations to Identify and Support Policy Initiatives that Reduce Greenhouse Gas Emissions (climate mitigation)

### 3. Climate Framework Strategic Implementation Plan

- 3.1. Prioritization of Climate Framework Recommendations for DeIDOT
- 3.2. Key Projects, Activities and Policy Changes
- 3.3. Implementation Timelines
- 3.4. Implementation Costs and Funding
- 3.5. Resilience and Sustainability Considerations
- 3.6. Monitoring and Reporting
- 3.7. Summary and Next Steps

# Closing Remarks

Thank you all for participating!

