N.C. Department of Transportation
2022 Resilience Strategy Report

The 2021 hurricane season marked another above-average tropical season for the Atlantic Ocean. There were twenty-one named systems, seven of which became hurricanes. But North Carolina did not see a land-falling hurricane in 2021. In fact, no tropical storm system made direct landfall along our coast. Yet weather related destruction and disruption, including loss of life, still played a significant role.

Three tropical systems – Claudette, Elsa, and Fred – made their way across the state bringing gusty winds, heavy rainfall, and isolated tornadoes. Tropical depression Fred dropped over a foot of rain in August across areas of western North Carolina that had recently received several inches of rain. Significant flooding occurred, washing out multiple highway and railroad bridges and closing over a hundred roads, largely in Haywood, Transylvania, Henderson, Yancey, and Buncombe Counties. Six people lost their lives and millions of dollars in damage occurred with some communities still trying to fully recover. The North Carolina Department of Transportation (NCDOT) crews were able to open almost all the 100 plus roads that were closed within a week. Crews from central and eastern North Carolina helped crews in the west restore connectivity by refilling washouts, reconnecting bridges and stabilizing shoulders along damaged roads.

Eastern North Carolina also experienced significant storm damage in November not associated with a named storm event. The nor'easter brought prolonged heavy winds and ocean over wash forcing the closure of NC 12 for two days and disrupting ferry operations.

NCDOT's 2021 Resilience Strategy Report outlined the department's strategies to address the resilience of the state's transportation network. Many resilience related programs were already underway, but a concerted effort was made to collaborate and share information, to combine overlapping efforts, and to leverage existing data to achieve common goals. A year later tremendous progress has been made with a new department-wide policy in place under which all NCDOT is directed to make not only the state's transportation infrastructure, but all business practices more resilient to disruption.

Activity	Status	Completion Date
1.0. Cross-cutting		
1.1. Build agency awareness of resilience	Complete	Fall 2021
1.2. Build an agency resilience brand	Complete	Fall 2021
1.3. Explore funding opportunities	Ongoing	Continuous
1.4. Investigate resilience related criteria for use in determining funding opportunities at the state and federal level	Ongoing	FY2023
1.5. Research participation	Ongoing	Continuous
2.0. Planning		

2.1. Conduct multimodal vulnerability assessment on Strategic Transportation Corridor (STC)	Ongoing	Summer 2022
2.2. Incorporate resilience assessments in long range plans	Ongoing	Continuous
2.3. Incorporate resilience within Integrated Project Delivery (IPD)	Ongoing	Continuous
2.4. Address gaps in Aviation planning and standards - Investigate and pilot, protocols and strategic opportunities for using air transportation technologies to support transportation infrastructure resilience	Complete	Fall 2021
2.5. Address gaps in Ferry planning and standards - Assess the vulnerability of all the Ferry Division's infrastructure assets, including waterway channels, with respect to natural hazards	Ongoing	FY2025
2.6. Address gaps in Freight planning and standards - Investigate and pilot resilience-based guidelines, framework, protocols, strategic opportunities, and communications plan focused on redundancy, supply chain, data and risk analysis	Ongoing	FY2023
2.7. Address gaps in Ports planning and standards – Outline framework with strategic opportunities including design protocols	Complete	Fall 2021
2.8. Address gaps in Rail planning and standards - Incorporate resilience evaluations in multimodal plans and designs and with other federal and state agencies and regulatory parties as needed	Complete	Fall 2021
3.0. Design		
3.1. Investigate incorporating resilience into design guidance	Ongoing	Continuous
4.0. Operations		
4.1. Identify and pilot risk and resilience analysis and explore implications in Transportation Asset Management Plan updates	Complete	Fall 2021
5.0. Maintenance		
5.1. Explore retrofit and ongoing treatments to withstand future high impact events	Ongoing	Continuous
6.0. Construction		
6.1. Explore retrofit and ongoing treatments to withstand future high impact events	Ongoing	Continuous

Activity Progress

1.0. Cross-cutting

1.1. Build agency awareness of resilience **COMPLETE**

Through the formation of a Core Management Team, a multi-disciplinary Program Management Team, and an Executive Leadership Team, department wide goals and strategies were shared and aligned. A Department Resilience Policy was established. An internal SharePoint page was established with a *Resilience Registry* summarizing completed and ongoing work.

NCDOT was selected to participate in the initial phase of a pilot course *Addressing Climate Resilience in Highway Project Development*. Developed through a partnership between the National Highway Institute (NHI) and the Federal Highway Administration (FHWA), the course consists of a series of online modules followed by a 2 ½ day in-person class. Only the online portion could be completed in 2021. The in-person class will be held late March 2022. Feedback from NCDOT personnel will help shape the final course content.

1.2. Build an agency resilience brand **COMPLETE**

NCDOT embarked on a series of activities. The Core Management Team has given multiple presentations and participated in conferences to share information and data with local governments, non-governmental organizations (NGOs), and other state and federal agencies. We have a website available to the public found at: https://www.ncdot.gov/initiatives-policies/Transportation/transportation-resilience/Pages/default.aspx.

1.3 Explore funding opportunities **ONGOING**

During 2021, NCDOT cooperated with and supported state and local government partners on multiple BRIC and Resilient Coastal Communities grant applications. While NCDOT did not have any specific resilience allocations in the 2021 state budget, several cabinet agencies (NCDEQ, NCEM, NCDMS, and others) received funding mandates covering that will require NCDOT collaboration and will benefit from NCDOT data and technical input.

NCDOT is actively exploring funding opportunities in the Infrastructure and Investment Jobs Act of 2021 (IIJA).

1.4 Investigate resilience related criteria for use in determining funding opportunities at the state and federal level **ONGOING**

NCDOT will use the results of completed flood inundation studies as well as the upcoming results of pilot vulnerability assessments to identify and develop projects that will make the state's transportation infrastructure more resilient to extreme weather events. The criteria that define these projects will be highlighted to maximize state and federal funding resources.

1.5 Research participation **COMPLETE/ONGOING**

NCHRP 15-61 Pilot Project – Climate Change Design

NCHRP 20-44(23) Rainfall/Runoff Modeling for Resilient Design

NCDOT Active Research Projects include: Future Precipitation for Resilient Design; Predicting Roadway Washouts; Improving Resilience of Transportation Infrastructure; Geo-FRIT: A Web-based Geospatial Analytics Tool for Quantifying Freight Risk and Resilience in Transportation.

2.0. Planning

2.1. Conduct multimodal vulnerability assessment on Strategic Transportation Corridor (STC) **ONGOING**

NCDOT is conducting vulnerability assessments on two strategic transportation corridors, U.S. 70 and U.S. 74.

U.S. 74 study area extends from I-485 in Matthews to the port in Wilmington and includes a 10-mile buffer on either side of the corridor, using City Simulator model developed by Atkins. To understand the potential vulnerabilities that will be exposed by continued growth along with future weather challenges, a holistic assessment of the transportation corridor and its various interacting systems is required. This assessment will include people, economy, weather, and infrastructure. This assessment is taking a stakeholder-inclusive approach by including several NCDOT units, N.C. state agencies, federal partners, metropolitan planning organizations, and rural planning organizations. The objective of this pilot study is to determine goals and objectives for future U.S. 74 resiliency, identify and define any vulnerabilities of the U.S. 74 corridor to future extreme weather events - including large storms, hurricanes, and heat waves - and to develop and stress-test mitigation and adaptation scenarios against future conditions and quantify benefits relative to goals and objectives.

U.S. 70/ Future I-42 study extends from Wake/Johnston County line to MCOLF Atlantic Air Force Base. This study assesses the vulnerability of routes to airports, ports, and the NCRR rail line adjacent to the corridor. As part of the data collection effort, NCDOT is coordinating with FHWA and other state agencies. All sections of U.S. 70 will be assessed, with a focus on vulnerable areas where storm surge and floods impact U.S. 70. This study will assess infrastructure vulnerability and risk using FHWA's Vulnerability Assessment Scoring Tool (VAST), stakeholder engagement, and other agency expertise/resources. VAST is an Excel based tool that uses data and stakeholder input to create an indicator-based vulnerability assessment of transportation assets. As a part of this assessment, a gap analysis will be performed to identify missing data needed to perform a better assessment.

2.2. Incorporate resilience assessments in long range plans **Continuous**

The Fixing America's Surface Transportation (FAST) Act, signed into law in December 2015, requires agencies to take resiliency into consideration during the transportation planning process. Following passage of the FAST Act, the Federal Highway Administration and the Federal Transit Administration updated the metropolitan and statewide transportation planning regulations to reflect these new requirements. The transportation planning rule includes the following:

- A new planning factor states and metropolitan planning organizations (MPOs) to consider and implement improving the resiliency and reliability of the transportation system (23 CFR 450.206(a)(9) and 23 CFR 450.306(b)(9)).
- A recommendation for MPOs to consult with agencies and officials responsible for natural disaster risk reduction when developing a metropolitan transportation plan and the transportation improvement program (23 CFR 450.316(b)).

- A requirement that the metropolitan transportation plan assess capital investment and other strategies that reduce the vulnerability of the existing transportation infrastructure to natural disasters (23 CFR 450.324(g)(7)).

NCDOT plans to share the flood inundation tools it has developed to help the MPOs and Regional Planning Organizations with this process.

2.3. Incorporate resilience within Integrated Project Delivery (IPD) ONGOING

The current objective for incorporating resilience within IPD is to develop an inventory of products and map resiliency outputs for NCDOT system-wide planning, project prioritization and programming, and individual project planning and development. To facilitate this objective there will be a survey conducted to better understand how our business units and partners are using NCDOT products and information and how they could better use it in the future. The overall goal of IPD is to help all projects move effectively from planning to construction and a crucial part of that is having resiliency information available where relevant in the process and to ensure the information is easily accessible.

Risk assessment criteria and benefit cost analysis are some of the factors that are being considered in the U.S. 74 and U.S. 70 pilot vulnerability studies. The results of these studies will help determine how these factors can be utilized by specific Project Development Networks (PDN) within the IPD. Current resilience projects in planning and design phases (I-6064 and HB-0001) are also providing examples of how and when resilience should be considered within IPD.

2.4. Address gaps in Aviation planning and standards COMPLETE

NCDOT Aviation works with NCDOT units to test and deploy manned and unmanned aircraft to monitor and assess transportation infrastructure. In 2021, we began testing the level and quality of data we can collect with drones for airport inspection and condition reporting, which will enable rapid data collection pre- and post-events to determine storm impacts more accurately. In 2022, we will conduct a one-year test of repairs to Jackson County Airport, where major failures impacted the runway. The airport has executed a contract to repair the runway through substantial earthwork. Our drone team will fly the site monthly and provide 3D modeling to identify problems and monitor repairs to provide data if a failure occurs in the future. This builds on NCDOT's use of drones to assess rockslides in the west, monitor erosion control along the coastline and support the state's hurricane response. Since 2018, NCDOT Aviation has mobilized a statewide drone response to support state and federal emergency responders. Drones allow rapid monitoring of transportation infrastructure and support for traffic rerouting. We are also partnering with drone companies to test delivery of emergency supplies to Ocracoke Island in the event it is cut off following a hurricane.

2.5. Address gaps in Ferry planning and standards - Assess the vulnerability of all the Ferry Division's infrastructure assets, including waterway channels, with respect to natural hazards ONGOING

NCDOT is currently considering the 2023-046 Natural Hazards Vulnerability Assessment of North Carolina Department of Transportation Ferry Division Assets research proposal to address resilience gaps in Ferry planning.

2.6. Address gaps in Freight planning and standards - Investigate and pilot resilience-based guidelines, framework, protocols, strategic opportunities, and communications plan focused on redundancy, supply chain, data and risk analysis **ONGOING**

Research project 2022-18 in cooperation with UNC-C. Geo-FRIT: A Web-based Geospatial Analytics Tool for Quantifying Freight Risk and Resilience in Transportation. Completion date June 2023.

This project is a comprehensive study on the risk and resiliency profiles of North Carolina public roads, specifically primary and secondary freight routes, with the objective of establishing a geospatial analytics platform for transportation data integration and modeling. The platform, identified as “Geo-FRIT", provides a web-based geospatial analytics tool for quantifying freight risk and resilience in transportation. Geo-FRIT will allow for data collection and sharing among NCDOT divisions, and routing analytics as well as advanced modeling of disaster data for risk-based freight routing through spatial simulation-driven scenario analysis. This project can enhance freight management and safety via web-based data access, integration, and automation, which also promotes transportation resiliency. NCDOT can benefit substantially from state-of-the-art geospatial technologies that allow for the automated fusion and dissemination of digital data associated with risk-based freight rerouting. Moreover, the integrated platform can help researchers in modeling transportation resiliency and risks during various disasters. The Geo-FRIT tool provides solid support for risk-based freight routing analysis that can lead to significant labor and operational cost savings for NCDOT and enhance highway safety, emergency management, community transportation planning, and public health.

2.7. Address gaps in Ports planning and standards – Outline framework with strategic opportunities including design protocols **COMPLETE**

The initiatives intended to address resilience gaps within the North Carolina Ports Authority include: the activation of a new, fully automated terminal gate; the introduction of multi-agency security related to Disaster Recovery management and simulations in the Port community to support incidents related to weather, TSI, active shooter, and bomb threats; the installation of new generators at the Port of Morehead; cybersecurity improvements to address cybersecurity gaps; the implementation of an off-site Eastern Data Center data back-up system for all Port data systems; and Port of Wilmington Data Center resiliency upgrades with new HVAC and backup power with auto-transfer switch along with 2nd Head End back-up location on the Port.

2.8. Address gaps in Rail planning and standards - Incorporate resilience evaluations in multimodal plans and designs and with other federal and state agencies and regulatory parties as needed **COMPLETE**

The Rail Division completed a flood inundation analysis of statewide rail STCs that is ready to be posted through NCDOT’s GIS platform. The analysis maps the elevation of rail lines and their vulnerability to the 10-, 25-, 50-, & 100-year flood events. Planning based on the results of this analysis will be ongoing.

Rail lines are also being assessed as part of the ongoing pilot vulnerability assessments on U.S. 74 and U.S. 70.

3.0. Design

3.1. Investigate incorporating resilience into design guidance **ONGOING**

Resilient design considerations are being implemented into projects. Examples include project numberI-6064, which includes road elevation, bridge elevation and hydraulic opening, and drilled holes in a concrete median to facilitate faster roadway water runoff. Another example is the HB-0001 Alligator River Bridge replacement that is considering resilient construction materials with a design life through 2100 requiring projected sea level rise (SLR) and storm activity to be considered. The SLR analysis for Wilmington, Beaufort, and Manteo areas are for future design and planning support.

4.0. Operations

4.1. Identify and pilot risk and resilience analysis and explore implications in Transportation Asset Management Plan updates **COMPLETE**

Transportation Asset Management Program has established georeferenced statewide inventory and condition assessment database that is available to the public. As projects are completed, the database will be updated quarterly. The database can be found at https://ncdot.maps.arcgis.com/home/index.html.

5.0. Maintenance

5.1. Explore retrofit and ongoing treatments to withstand future high impact events **ONGOING**

Options, other than raising infrastructure, are being explored to adapt to and recover quickly from storm disruptions. Geogrid embankment reinforcement designed to protect roadway embankment in the event of overtopping is being incorporated into the B-4636 project in Sampson County. The M-0540A project is addressing the protection of the NC 24 causeway near Swansboro using living shorelines, which offer an alternative to embankment hardening with rock and provide a solution that will adapt to rising sea levels.

6.0. Construction

6.1. Explore retrofit and ongoing treatments to withstand future high impact events **ONGOING**

The HB-0001 Alligator River Bridge replacement is an investigation of the use of carbon fiber reinforced concrete for bridge construction.

SB 356 – Session Law 2019-251
Disaster Relief Funds Section 1.7

In addition to any other funds appropriated during the 2019-2020 fiscal year, there is appropriated from the General Fund to the Department of Transportation the sum of thirty-six million dollars ($36,000,000) to be used as follows:

(1) $30,000,000 for current and future activities related to recovery from Hurricane Dorian such as debris removal and repair of highway infrastructure damage.

To date, NCDOT has expended about $24 Million on damages associated with Hurricane Dorian. The Hurricane Dorian Financial Recovery process has not yet entered the close out process for FEMA reimbursement. Once the project is closed, state funds are then applied to the unreimbursed balance. NCDOT will utilize the $30 Million Dorian funds for any unreimbursed balances.

(2) $2,000,000 for the Living Shoreline projects.
60% Plans Complete. Permit Application submitted 12/20. Anticipated Let Fall 2022.

(3) $2,000,000 to expand the Flood Inundation Mapping Alert Network for Transportation.
38 monitored sites added to initial 6 in 2021. 15 more sites in progress. 2,310 miles of roadway monitored. FIMAN-T (storm surge) covers 22 coastal counties and 1,700+ miles of roadway

(4) $2,000,000 for a Flood Risk and Vulnerability Assessment on the Strategic Highway Corridor System.

- I-95/I-40 Flood Resilience Study complete

- Statewide Roadway Inundation Analysis complete. Upload to NCDOT GIS platform early 2022

- Rail STCs Inundation analysis complete. Upload to NCDOT GIS platform early 2022

- Coastal Roadway Inundation Tool complete.

- US-70 vulnerability assessment pilot from Raleigh to Morehead scoped and started. Anticipated completion Summer 2022

- US-74 vulnerability assessment pilot from Charlotte to Wilmington scoped and started. Anticipated completion Spring 2022

-Future Precipitation for Resilient Design Applied Research – Future rainfall distributions for modeling.

Session Law 251 Expenditure and Status 11/30/2021

TIP	Description	Funded	Expenditures	Unexpended Balance	Commitments	Unencumbered
M-0540A	Living Shoreline Project	$2,000,000	$470,923	$1,529,076	$260,559	$128,517
M-0540B	Expansion of the Flood Inundation Mapping Alert Network for Transportation [and BridgeWatch]	$2,000,000	$977,740	$1,022,259	$893,648	$128,611
M-0540C	Development of a Flood Risk and Vulnerability Assessment for the Strategic Transportation Corridors	$2,000,000	$509,704	$1,490,295	$914,455	$200,000*

Notes: COVID and financial constraints delayed projects by 6 Months
M-0540A has allowed the State to acquire matching federal grant funding totaling $1.9MM
M-0540B/M-0540C technologies assisted in winning BUILD and INFRA grants totaling $47MM
* Future precipitation research in western NC pending

Looking Ahead

During 2021, NCDOT scoped, planned, and began multiple activities and projects to directly address the resilience of the state's transportation infrastructure. Many of these efforts are still ongoing and will form a foundation for future efforts moving forward. In 2022, two overarching goals will guide NCDOT's resilience activities: The first will be to align the program with priority actions of the USDOT Climate Action Plan; and the second will be to look for resilience related opportunities and resources available in the Infrastructure Investment and Jobs Act of 2021 (IIJA).

The USDOT 2021 Climate Action Plan builds upon previous Climate Action Plans prepared in 2012 and 2014. The 2012 Action Plan focused on the climate change's impacts to USDOT's critical mission activities—safety, state of good repair, and federally owned building's environmental sustainability. The 2014 Climate Adaptation Plan provided updates on USDOT's accomplishments to date and Fiscal Year (FY) 2013 and FY2014 commitments. The 2021 Climate Action Plan focuses on actions to revitalize efforts to bolster adaption and increase resilience. This plan identified five key priority adaptation actions. NCDOT will be focusing on 3 of these actions: 1) incorporating resilience into NCDOT grant and loan applications, 2) enhance resilience throughout the project planning and development process, and 3) improve climate education and research on resilience. Integrate resilience into grant funding applications when applying for federal funds.

NCDOT will look to use the results of its vulnerability assessments to identify project that will qualify for funding under various sections of the IIJA. NCDOT will also collaborate, coordinate, and share data with state and local partners to maximize opportunities statewide.

Other specific resilience activities planned for 2022 include:

- Continuing to pilot and assess risk and vulnerability studies: Future I-87 corridor in eastern NC and I-40 and I-26 in the west;
- Incorporating resilience planning into the Statewide Multimodal Freight Plan;
- Continuing incorporating risk and resilience considerations into the Transportation Asset Management Plan; and
- Continuing building and improving storm operation tools (FIMAN-T, FIMAN-T Surge, and BridgeWatch).