‘Resilient Routes’
Flood-Resilient Roadway Accessibility for Secondary Roads

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Resiliency Planner - Kleinfelder
Lumber River Region in NC:
A Long History of Flooding

Five-county region in NC:
- Bladen
- Hoke
- Richmond
- Robeson
- Scotland
Project Background
Background

• Project stemmed from the 2022 RISE Program with the NC Office of Recovery and Resiliency (NCORR)
• It came of the necessity to protect NC communities from extreme weather events

Flooded section of NC Highway 70 on September 21, 2018, following Hurricane Florence. Image from NCDOT via climate.gov
Core Components

- **Climate Resiliency Planning**
  - Achieves success at a regional scale to avoid fragmented efforts across neighboring municipalities

- **Transportation Resilience**
  - Vital for enhancing connectivity and mobility during extreme weather events

- **Study of Ripple Effects**
  - Impacts to public safety, emergency management, traffic flow, and economic and community well-being throughout the larger area
‘Resilient Routes’ Project Elements

1. Inventory roads vulnerable to flooding
2. Develop a prioritization process
3. Develop conceptual strategies/recommendations for one route per county
4. Cost estimates
5. Identify funding sources
Project’s Focus Area

- US Highways
- NC Routes
- Secondary Roads

We are **not** looking at Interstates or non-system roads.
Prioritization of Flood Vulnerable Roadways
Workflow Summarized

Step 1 - Data Collection
- Transportation
- Hazards
- Critical Facilities
- Demographics

Step 2 - Analysis
- Set parameters
- Intersect datasets
- Set recurrence intervals

Step 3 - Scoring
- Identified 7 categories
- Developed weighted criteria
- Rank 1-5

Step 4 - Process Data
- Run automated processes in ArcGIS Pro
- Generate list of scored routes
Data Collection

- Transportation
- Current and projected flooding
- Historical flooding, inundation
- Local input
- Socioeconomic data
- Critical facilities
- Natural resources

Data sources: FEMA, NCDOT, NCEM, local knowledge, NCDPS, CEJST, FWS
Data Analysis

- Intersect datasets
- Set recurrence intervals
  - 25-year storm for Secondary Roads
  - 50-year storm for US Hwys and NC Routes
  - 100-year storm for evacuation routes
- Filters for 0.5 ft to 5+ ft deep
## Scoring Criteria & Metrics

<table>
<thead>
<tr>
<th>Questions</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which roads serve the most people?</td>
<td>Traffic Volume</td>
</tr>
<tr>
<td>Which critical facilities need to remain accessible to people?</td>
<td>Access to Critical Facilities</td>
</tr>
<tr>
<td>Is route located in an area with a high concentration of EJ populations?</td>
<td>Equity / EJ</td>
</tr>
<tr>
<td>Does the route have a history of flood impacts?</td>
<td>Flood History: Repeat Events &amp; Duration</td>
</tr>
<tr>
<td>Which routes need to remain open during an emergency?</td>
<td>Evacuation Route</td>
</tr>
<tr>
<td>Which routes connect to major employers?</td>
<td>Access to Job centers</td>
</tr>
</tbody>
</table>

*EJ* stands for Environmental Justice.
### Scoring Matrix

How to get the highest score in all categories:

<table>
<thead>
<tr>
<th>SCORE</th>
<th>TRAFFIC VOLUME</th>
<th>ACCESS TO CRITICAL FACILITIES</th>
<th>EQUITY / EJ</th>
<th>FLOOD HISTORY: REPEAT EVENTS</th>
<th>FLOOD HISTORY: DURATION</th>
<th>EVACUATION ROUTE</th>
<th>JOB CENTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>AADT – first tier</td>
<td>Multiple facilities are on (or within ½ mi.) of route</td>
<td>Route lies within a High Vulnerability census tract (CEJST tool)</td>
<td>Route is in/near a: a) community’s known flood spot and b) prior washout area (buffer)</td>
<td>Route closed for: more than a week</td>
<td>Yes</td>
<td>Route leads to multiple major employer(s) on (or within ½ mi.) of route</td>
</tr>
</tbody>
</table>

**WEIGHT**

<table>
<thead>
<tr>
<th>TRAFFIC VOLUME</th>
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<th>JOB CENTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x</td>
<td>3x</td>
<td>1x</td>
<td>3x</td>
<td>1x</td>
<td>1x</td>
<td>2x</td>
</tr>
</tbody>
</table>
ArcGIS Network Analyst

- Determine roadway criticality
  - Analyze factors such as traffic volume, road conditions, and connectivity to help identify key routes for transportation resilience

- Determine roadway access
  - Analyze factors such as proximity to transportation networks, land use patterns and infrastructure
Unique Aspects
Unique Aspects of Project

- Focused Stakeholder involvement – EMs
- Qualitative and quantitative data
- GIS tools (i.e., Network Analyst)
- Metrics for ‘Flood History’ category – Flood Hot Spots and Duration
- NCDOT Partnership for data collection
- Weighting reflects stakeholder/client’s priorities
- Assessment of secondary routes

In Robeson County, sections of I-95 at the Lumber River remain under water in the wake of Hurricane Florence
Maps of Local Floodprone Areas

Converted stakeholder feedback (qualitative information) into quantitative data for analysis.
Converted Images into a Digitized Layer
NCDOT Collaboration

Data-sharing with NCDOT: washouts, TIMS data for flood duration

Washout Data - Map, Clean & Characterize

- Matthew: 728 -> 667
- Florence: 489 -> 464
- 2020 Storms: 193 -> 182

1313 - Confirmed location and pipe size
Weighting Criteria

When everything is a priority...

Disadvantaged Census Tracts (CEJST Tool)
What’s the priority?

- Stakeholders decide weighted criteria
Lessons Learned
Lessons Learned

- Data discrepancies
  - Outliers have an impact – AADT
  - Data gaps - TIMS, road segments
- Reliance on flood modeling data
- Focused stakeholder engagement was beneficial
- Align efforts with the State’s (e.g., the STIP)
Next Steps for the Region
Roadway Adaptation Strategies

1. Design and Engineering Solutions
2. Nature-Based Solutions
3. Policy-Based Solutions
   a. Operations & Maintenance
   b. Outreach & Collaboration
   c. Data, Planning, & Policy
Conceptual Recommendations

Wetland storage

Road Raising
Conceptual Recommendations

Flood Gauge Installation

Culvert Enhancements
Thank You!

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