NORTH CAROLINA
Department of Transportation

Statewide Resilience Improvement Plan

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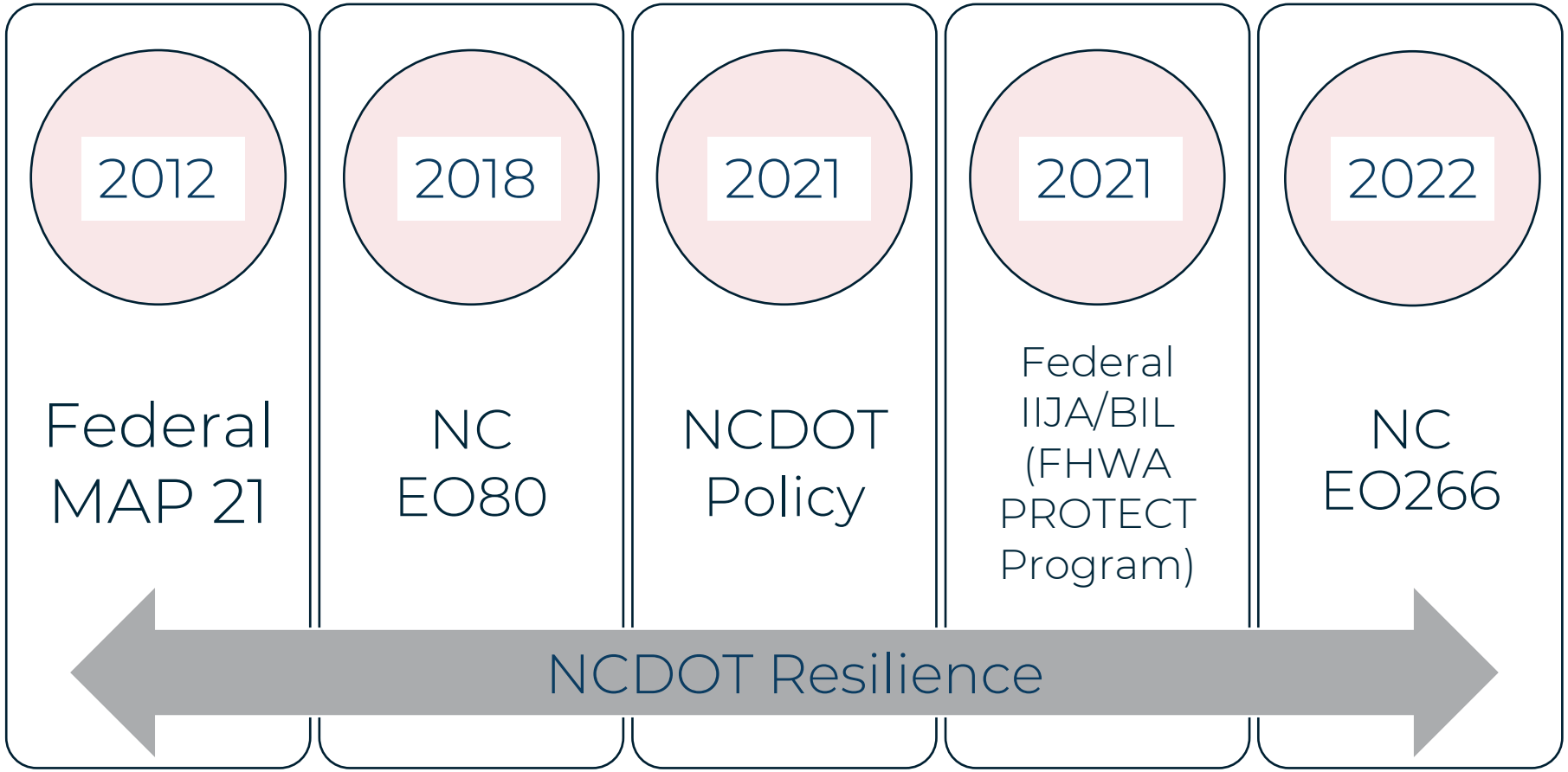
Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina

Federal, State and Agency Resilience Policies & Regulations



NCDOT RIP Development Purpose

- Advance NCDOT Resilience Program and initiatives
- Fulfill State and NCDOT Resilience Policies
- Meet the requirements for the cost share incentive of the FHWA PROTECT Program.
  - 7% resilience project discount if RIP is developed and project is identified in prioritization list
  - 3 % resilience project discount if RIP is incorporated into long range transportation plan

The NCDOT RIP was developed in alignment with the FHWA PROTECT program guidance and in support of Section 9 of the North Carolina Governor's Executive Order 80, NCDOT employed a GIS framework to assess NCDOT highway and rail assets exposed to flooding and landslides, integrated existing NCDOT criticality and resilience studies, and prioritized exposed assets for consideration for resilience-focused projects.

Federal RIP Requirements

The Plan Shall…	
✓	Encompass immediate and long-range planning activities and resilience investments
✓	Demonstrate a systemic approach
✓	Consistent with state and local hazard mitigation plans
✓	Include a risk-based assessment of assets and systems
Shall as appropriate…	
✓	Describe ways to improve responses to the impacts of weather, natural disasters, and climate change
✓	Describe how the regulatory framework ensures resilience improvements
✓	Describe the benefits of nature-based solutions/green infrastructure
✓	Assess the resilience of community infrastructure
✓	Use a long-term planning process
May also…	
✓	Designate evacuation routes and strategies
✓	Plan for response to emergencies
✓	Describe the resilience improvement policies
✓	Include investment plans and priorities
✓	Use science and data

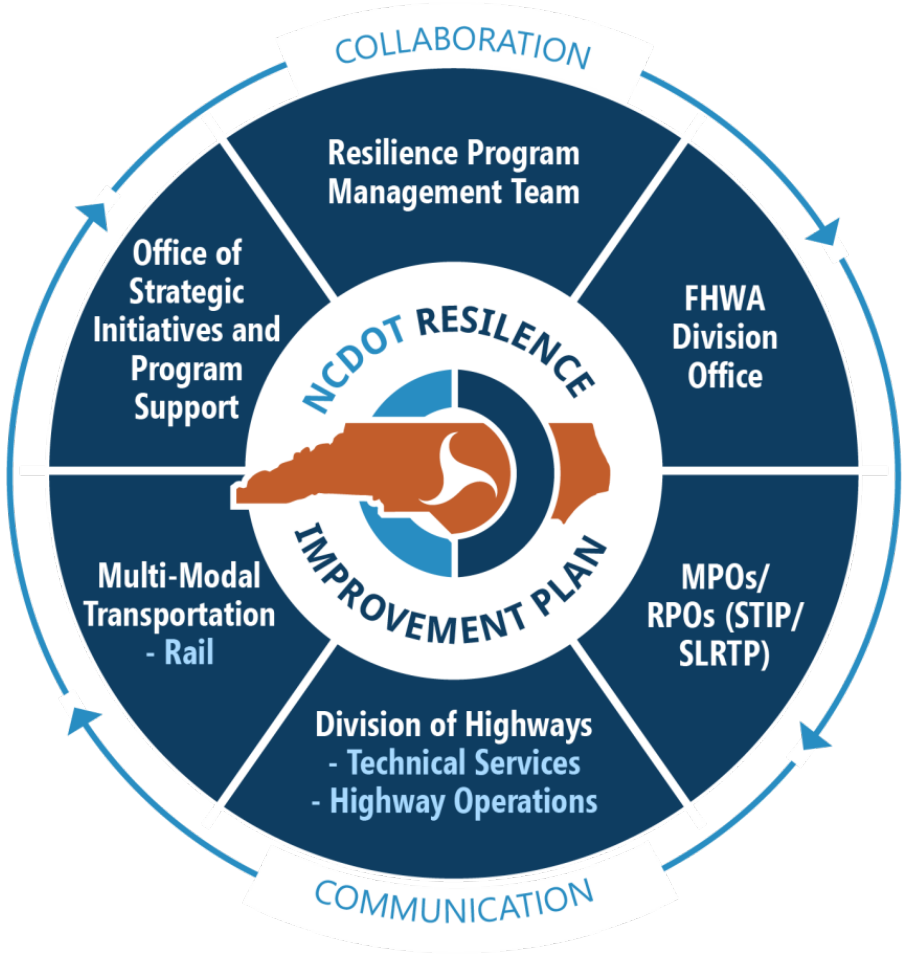
✓ *NCDOT RIP meets all requirements*

NCDOT RIP Development - Framework

- The RIP framework summarizes all the important steps followed to develop all the resilience models/processes included in the report

Collaboration & Communication for NCDOT RIP Development

- **Multiple NCDOT divisions/units**
  - Data sharing & tool development and implementation
  - Process and report development
  - Coordination with other plans: TAMP, LRTP, Statewide Freight Plan, etc.
  - Previous vulnerability pilots and resilience projects
- **Multiple external agencies**
  - MPOs and RPOs during development of STIPs and SLRTP
  - Coordination of state and local hazard mitigation plans
- **Through coordination with other plans**
- **NC FHWA Division Office**
  - Check RIP requirements
  - Resilience projects discussion
  - Grant application
  - NCDOT RIP process and approval



Review of Resilience-related Regulations and Initiatives

Relevant Codes, Standards, and Regulatory Framework
- EO80 and EO266
- NCDOT Resilience Policy F.35.010
- PROTECT Program and RIP Requirements

FHWA Guidance and Tools
- FHWA Assessing Criticality in Transportation Adaptation Planning

NCDOT Tools
- RIT and CRIS
- FIMAN-T and Bridge Watch
- T-SAPP
- GAM Rating System

NCDOT Vulnerability Studies
- I-95/I-40 (East) Flood Feasibility Study
- US-74 and US-70 Pilots

Research Projects
- NCHRP 15-61, Pilot Project, Climate Change Design
- NCHRP 20-44(23), Rainfall/Runoff Modeling for Resilient Design

NC/NCDOT Plans
- NC State and Local Hazard Mitigation Plans
- NC Statewide Multimodal Freight Plan
- NCDOT LRTP (NC Moves 2050) and TAMP
- NC Climate Risk Assessment and Resilience Plan (2020)
- NCDOT Climate Strategy Progress report (2022, 2023)
- NCDOT Resilience Strategy Report (2022)
- Emergency Response and Evacuation Plans

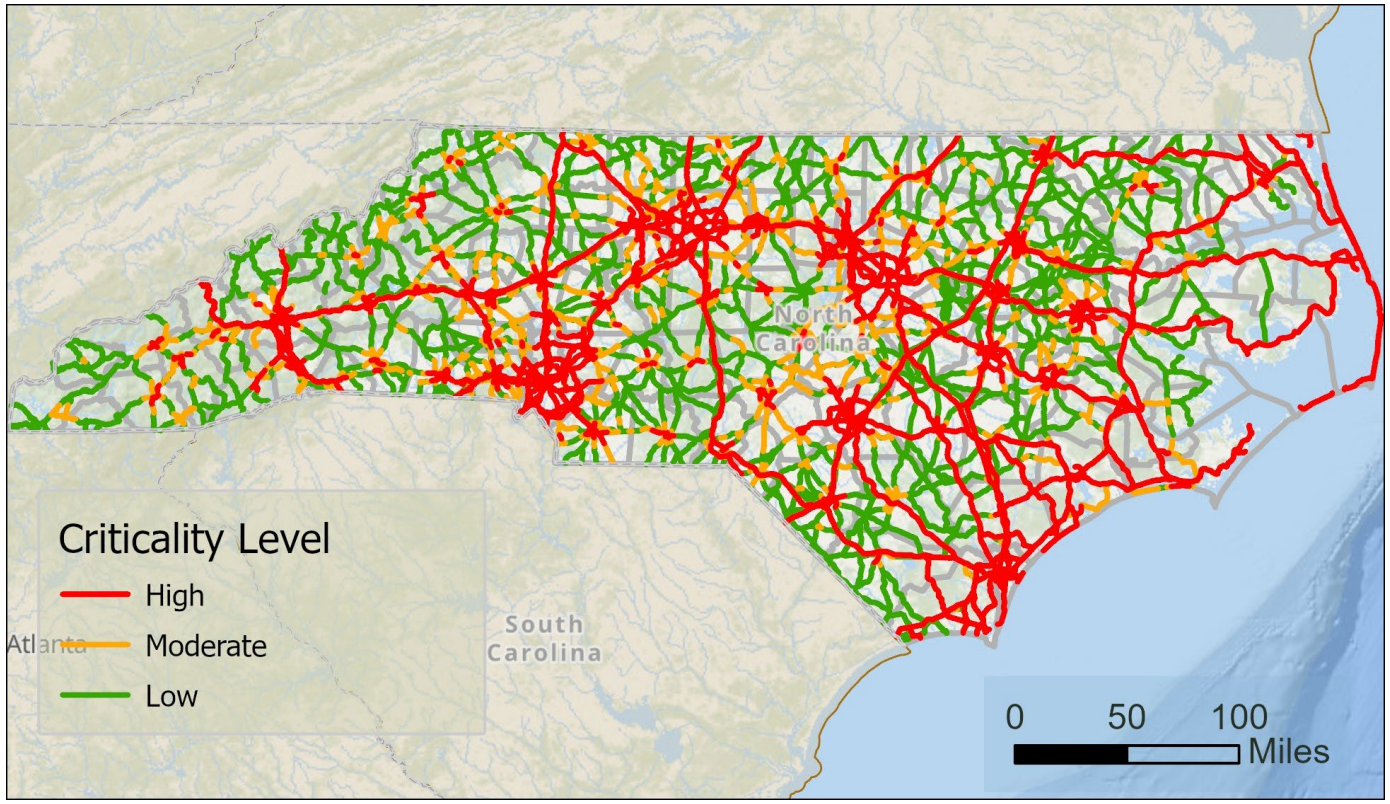
Resilience Projects
- Future I-87 Revitalization, Innovation, Safety, Economy (RISE) Project
- Nature-based solutions: NC 24 Living Shoreline Project
- Incorporation of Resilience into Design Guidelines
- Reducing Erosion Susceptibility Along Coastal Highways

NCDOT RIP Key Components

1. Development of Statewide Roadway and Railroad ***Criticality Models/Maps***
2. Development of a ***Resilience Maps***
   - Identification of vulnerable assets/areas
3. Development of score-based ***prioritization process and list and maps of potential areas for resilience improvements***
   - Asset Exposure to Hazards
   - Asset Sensitivity (condition)
   - Criticality
4. RIP ***report*** development collaboration and approval

1.Statewide Criticality Modeling: *Roadway*

- Methodology adapted from US-70 Study/FHWA
- Includes **primary roadways**:
  - (Interstates, Evacuation routes and NC and US routes)
- Three Composite Indices:
  - ***Usage and Operations*** *(truck traffic, redundancy)*
  - ***Socioeconomic*** *(tourism, jobs, TDI, proximity to military and transportation hubs)*
  - ***Health and Safety*** *(proximity to hospitals, shelters, utilities)*
- Addition of **Interstates** (current and future) plus **Evacuation routes** as HIGH criticality



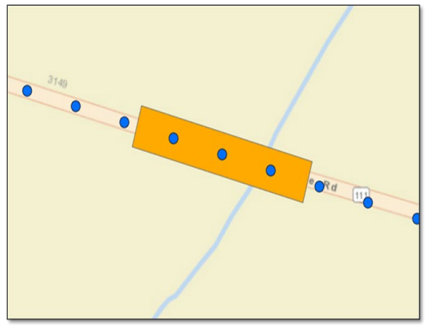
Hazards-Asset Pairs for Risk-based Vulnerability Assessment

- *Roadway segments and NBI structures limited to primary roads.*

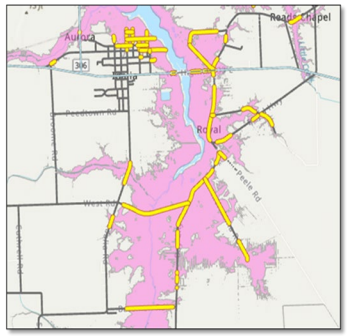
ASSETS	HAZARDS		
	Riverine & Coastal Flooding	Geotechnical	SLR plus Storm Surge
Roadway	✓	✓	✓
NBI Structures (bridges/culverts)	✓	✓	✓
Rail Lines	✓	✓	✓

Vulnerability Assessment: EXPOSURE

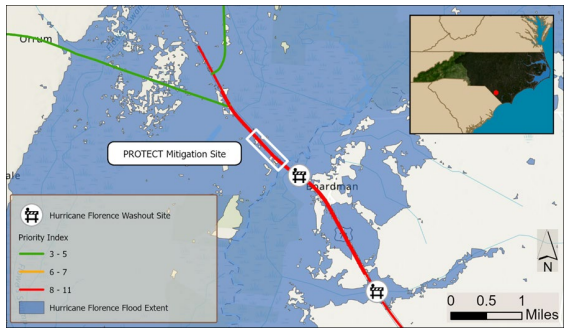
- NCDOT GIS tools used to generate threat maps and exposure areas and magnitudes
  - RIT (riverine and coastal flooding)
  - CRIS (SLR plus storm surge)
  - GAM Rating (geotechnical hazards)
  - Past Events (limited data)
- GIS tools used to intersect assets and STIPs with hazards
- Development of asset EXPOSURE scoring (Low, Moderate, High)



Bridge Rectangle Intersecting with 500-Year RIT points (US 111 over Black Swam Creek)



CRIS Data 6-ft SLR + Storm Surge



Roadway Washout section from hurricane Florence

Inland Flood Exposure Scoring Table

Flood Recurrence Interval	Flood Overtopping Depth			
	<=0.5	>0.5-2 ft	>2 ft – 5ft	> 5ft
10-yr	L	H	H	H
25-yr	L	H	H	H
50-yr	L	M	H	H
100-yr	L	M	M	H
500-yr	L	L	M	M

Coastal Flood Exposure Scoring Table

Road Elevation		
> 16ft	7ft – 16ft	< 6ft
L	M	H

GAM Exposure Scoring Table

GAM Rating		
<= 1,000	>1,000 - <1,500	>1,500
L	M	H

Vulnerability Assessment: SENSITIVITY

Based on asset condition state:

- *Roadway – Based on International Roughness Index (IRI)*
- *Bridges/Culverts – Based on National Bridge Inventory (NBI) data*
- *Rail – Assigned default score of "3" ("Good").*

International Roughness Index – Sensitivity for Pavement

IRI		
< 95 inch/mile (good)	95-170 inch/mile (fair)	>170 inch/mile (poor)
L	M	H

Bridge Condition Scoring for Bridges with Known Foundations

Scour Condition (NBI 113)	Substructure Condition (NBI 60)		
	7-9	5-6	0-4
4-T	L	M	H
0-3	M	H	H

Culvert condition based on NBI Item 62

Culvert Condition (NBI 62)		
7-9	5-6	0-4
L	M	H

Bridge Condition Scoring for Bridges with Unknown Foundations

Channel Protection (NBI 61)	Substructure Condition (NBI 60*)										
	0	1	2	3	4	5	6	7	8	9	N
0 Failure	0	0	0	0	0	0	0	0	0	0	0
1 Failure	0	1	1	1	1	1	1	1	1	1	N
2 Near Collapse	0	1	2	2	2	2	2	2	2	2	N
3 Channel Migration	0	1	2	2	3	4	4	4	4	4	N
4 Undetermined Bank	0	1	2	3	4	4	5	5	6	6	N
5 Eroded Bank	0	1	2	3	4	5	5	6	7	7	N
6 Bed Movement	0	1	2	3	4	5	6	6	7	7	N
7 Minor Drift	0	1	2	3	4	6	6	7	7	8	N
8 Stable Condition	0	1	2	3	4	6	7	7	8	8	N
9 No Deficiencies	0	1	2	3	4	7	7	8	8	9	N
N Not Over Water	0	1	N	N	N	N	N	N	N	N	N

*Codes for Substructure Condition are: 0 failed; 1 bridge closed – imminent failure; 2 critical scour; 3 serious scour; 4 advanced scour; 5 minor scour; 6 minor deterioration; 7 good condition; 8 very good condition; 9 excellent condition; N not applicable.

Channel Protection (NBI 61)	
	0
0 Failure	0
1 Failure	0
2 Near Collapse	0
3 Channel Migration	0
4 Undetermined Bank	0
5 Eroded Bank	0
6 Bed Movement	0
7 Minor Drift	0
8 Stable Condition	0
9 No Deficiencies	0
N Not Over Water	0

*Codes for Substructure Conditic
critical scour; 3 serious scour; 4 a

Scour Vulnerability		
7-9	5-6	0-4
L	M	H

3. Resilience Prioritization Process and Use

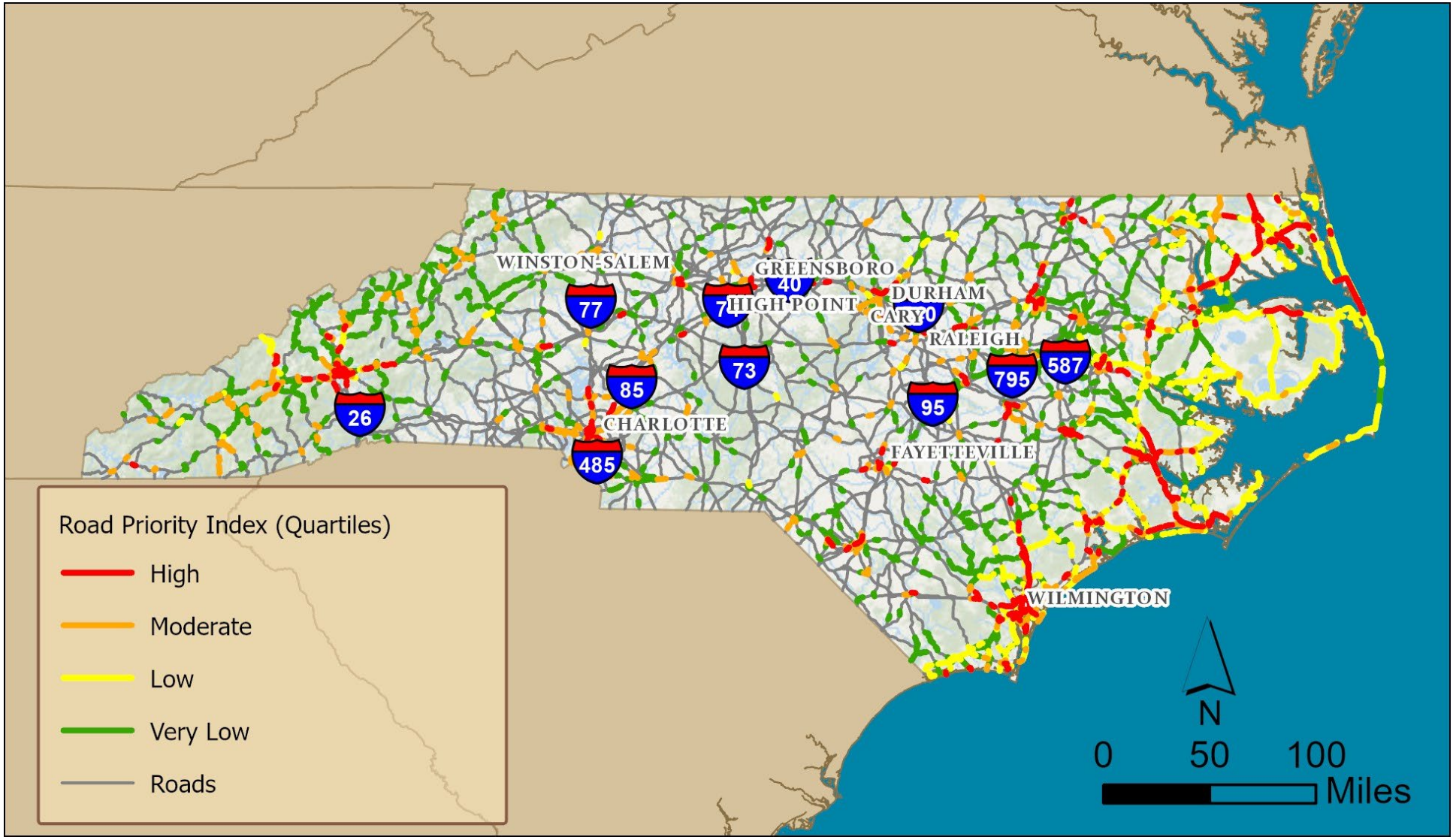
- Score-based Prioritization Process based on = Exposure + Sensitivity + Criticality
- Scoring distribution was based on the following table below:
  - Each asset exposed to each threat was ran by this process

Criticality Level			Exposure Level (For each threat)			Sensitivity			Total Points
L (1 pt)	M (2 pt)	H (3 pt)	L (1 pt)	M (2 pt)	H (3 pt)	L (1 pt)	M (2 pt)	H (3 pt)	Total points range (3 –12)

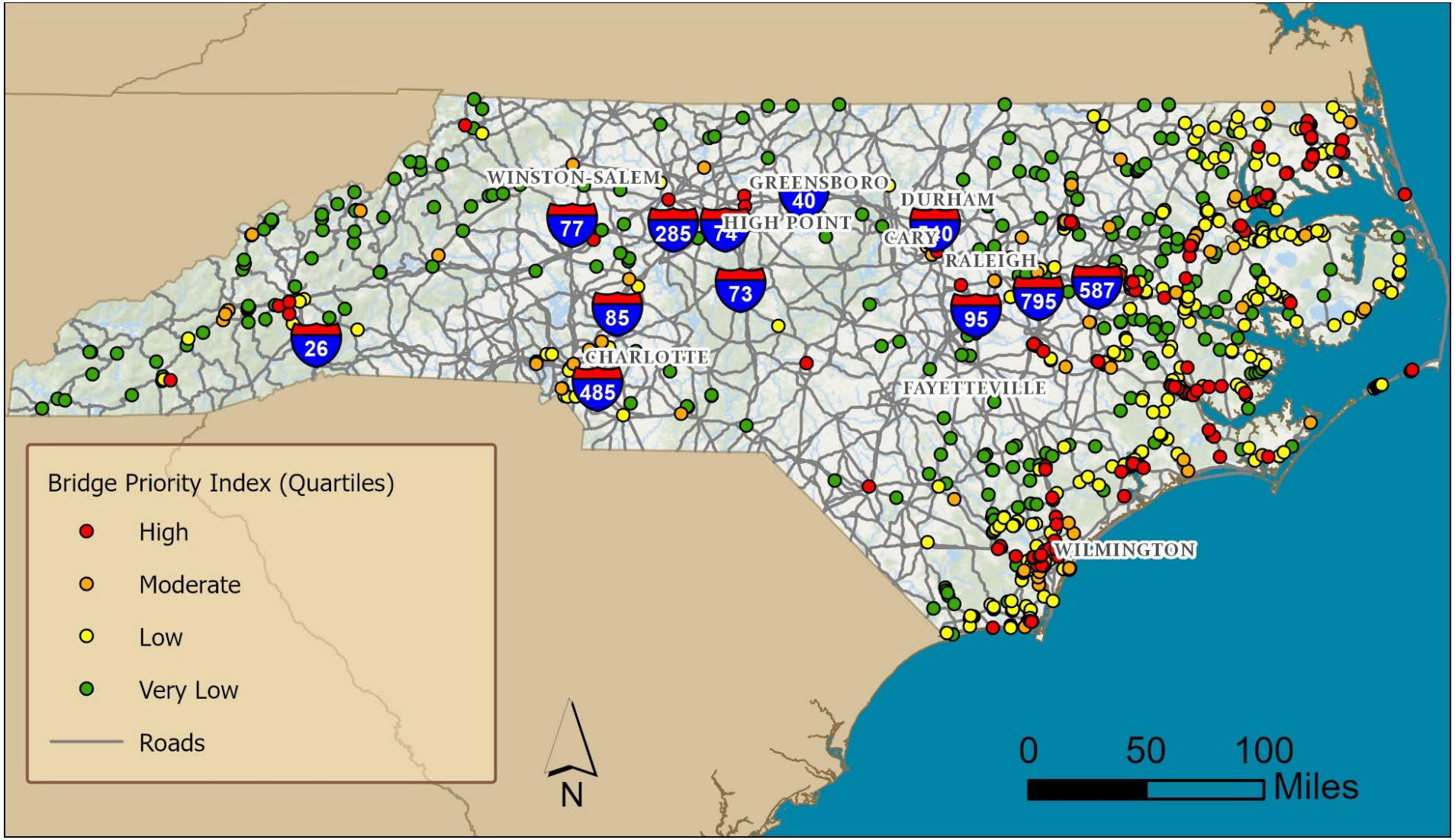
- A spreadsheet with all vulnerable assets/areas scored through the prioritization process was developed

The asset resilience prioritization list will help NCDOT to rank and select assets and potential resilience projects based on priority and other related criteria

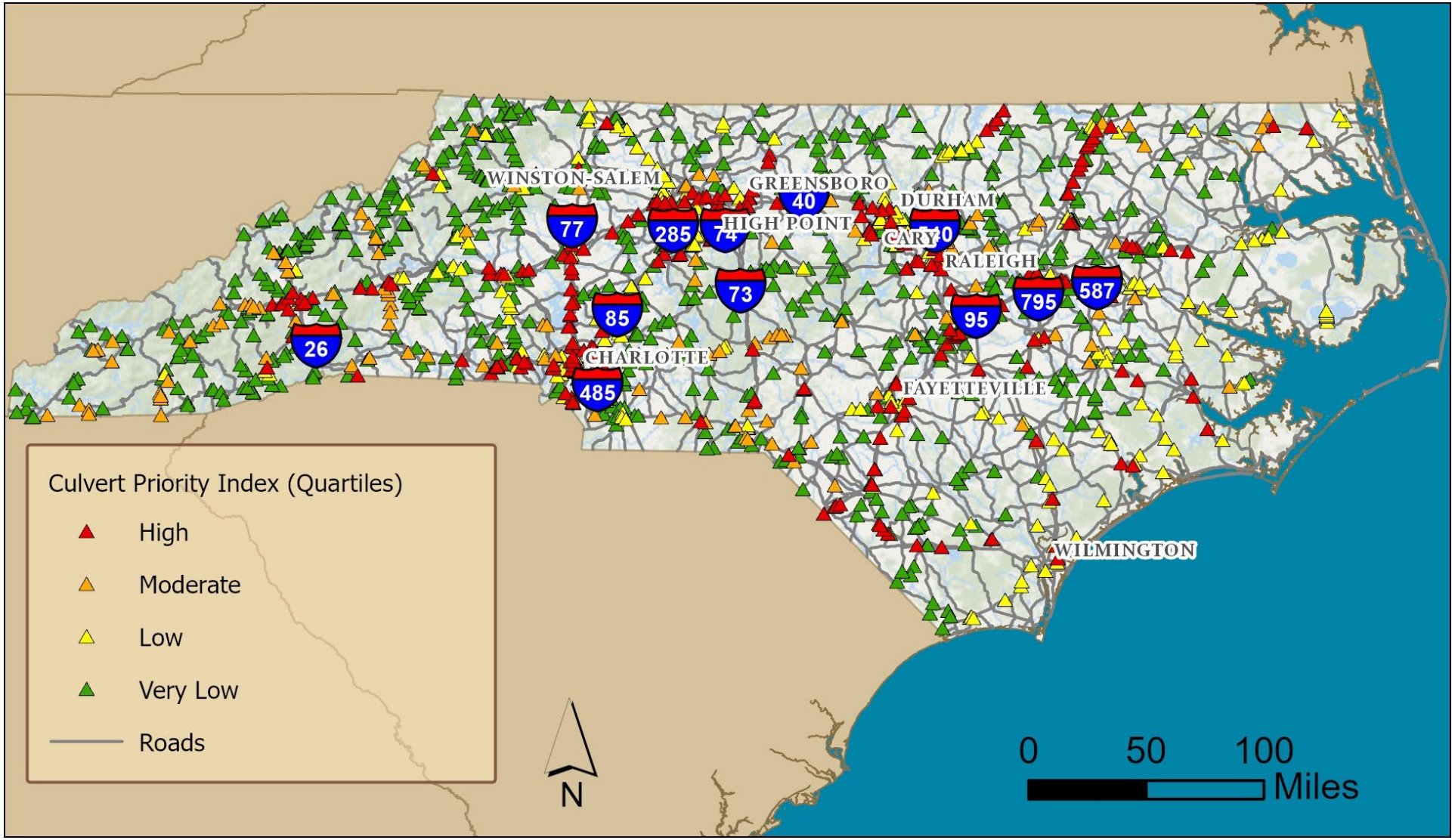
Final Prioritization Score Map- Roadways



Final Prioritization Score Map- Bridges



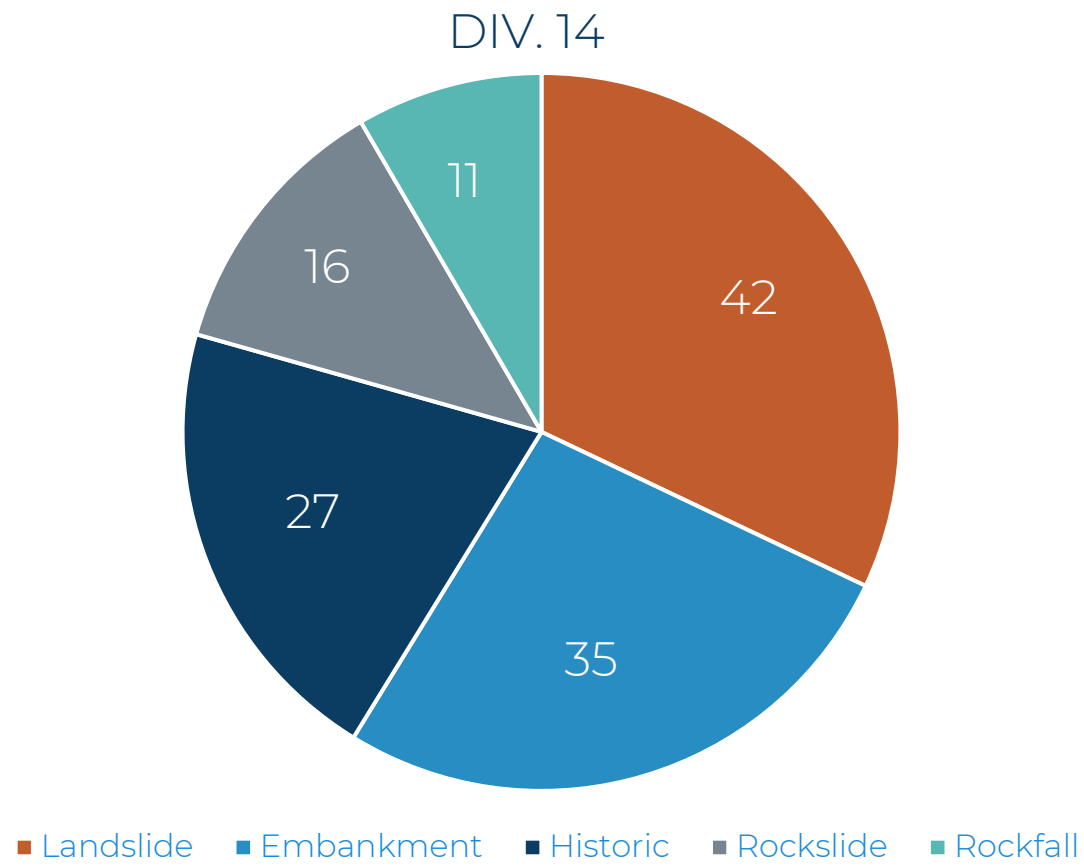
Final Prioritization Score Map- Culverts



Next Steps

Types of Landslides in Division 14

131 failures recorded

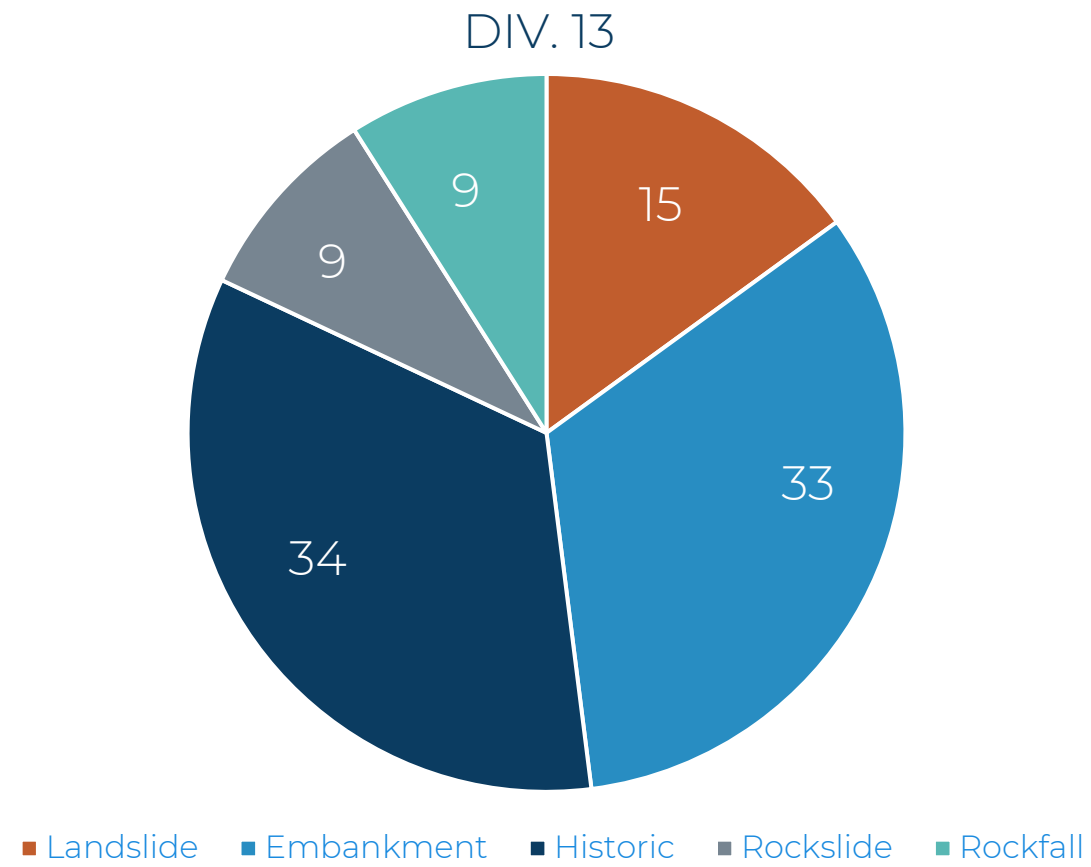


Failure Type in Division 14

- Landslide – 42
  - Movement of a mass of rock, debris, or earth down a slope
- Embankment – 35
  - Failure of built slopes
- Rockslide – 16
  - A usually rapid downward movement of rock fragments that slide over an inclined surface (avalanche of rock)
- Rockfall – 11
  - Rock that has fallen freely from a cliff face
- Historic – 27
  - Slopes that failed during construction, but have since been stabilized

Types of Landslides in Division 13

100 failures recorded



Failure Type in Division 13

- Landslide – 15
  - Movement of a mass of rock, debris, or earth down a slope
- Embankment – 33
  - Failure of built slopes
- Rockslide – 9
  - A usually rapid downward movement of rock fragments that slide over an inclined surface (avalanche of rock)
- Rockfall – 9
  - Rock that has fallen freely from a cliff face
- Historic – 34
  - Slopes that failed during construction, but have since been stabilized

ASSET MANAGEMENT - SLOPES

Date:		***Field Geologist:***		***Division:***	
County No.:		***Latitude:***		***Northing:***	
County Name:		***Longitude:***		***Easting:***	
Route No.:		***Common Name:***			
1. Route Type:					
2. Detour Factor:			*A. Type of Detour:*		
			B. Detour Length:		
3. Failure Type & Volume			*Type:*	*Volume (yd^3)*	
			Rockfall		
			Rockslide		
			Landslide		
			Embankment		
4. Average Vehicle Risk (AVR)					
$AVR = \frac{\frac{[AADT * Slope\ Length\ (miles)]}{24}}{Speed\ Limit\ (mph)}$			AADT =	Average Annual Daily Traffic	
			Slope Length (miles) =		
			Speed Limit (mph) =		
			AVR:	Traffic Info Needed	

Base Score

Level of Service

Length of Detour (in miles)

Impact by failure type

Risk and Travel Disruption

5. Roadway Impedence:		
6. Pavement Damage:		
7. Secondary Roadway Impact:		
8. Failure Frequency:		
9. Precipitation Amount (Effect anticipated in 24 hrs):	*Type:*	*Precipitation (in):*
	Rockfall	
	Rockslide	
	Landslide	
	Embankment	
10. Maintenance Required:		
11. Groundwater (Seepage):	*Type:*	*Seepage Presence:*
	Rockfall	
	Rockslide	
	Landslide	
	Embankment	
12. Previous Remediation:		
13. Total Score:		Please fill

Amount of Roadway Blocked

Surficial Pavement Damage

Repair Time

Frequency of Previous Failures

Rainfall Intensity Sensitivity

Annual Maintenance Frequency

Groundwater Saturation

Amount of Repair

Federal Discretionary Grants and Resiliency

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