Transportation Asset Management Webinar Series

Webinar 82

Risk and Resilience in Asset Management

Sponsored by FHWA and AASHTO

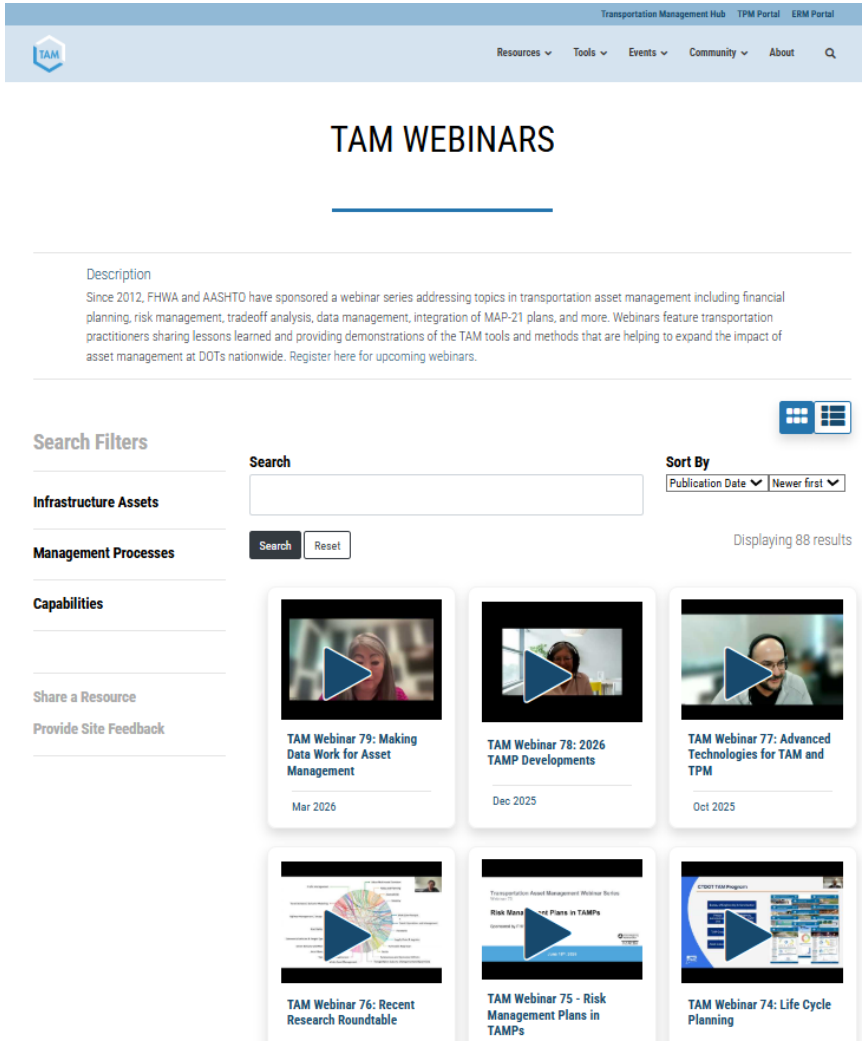
September 16, 2026

- CPBM Annual Meeting: San Diego, October 2–6, 2026
- Today's topic includes the Transportation Asset Risk and Resilience (TARR) Manual, NCHRP 23-32
- Voting member workshop: October 2, San Diego — travel support available
- New monthly CPBM newsletter — signup link in the chat
- amclaughlin@aashto.org

TAM

Welcome!

- Today is the **82nd** webinar in our bimonthly series, held on Wednesdays at 2:00 PM ET
- Webinars cover a variety of topics with a performance management focus
  - You will be able to find the materials from this webinar on the TAM Portal: https://www.tam-portal.com/event-directory/tam-webinars/
- We are always welcoming ideas for webinar topics and presentations!
- Use the webinar chat to submit questions for today's presenters and ideas for future webinars



Webinar Objectives

- **Explore** how agencies are addressing natural threat–asset pairs in their TAMPs and how these approaches align with the forthcoming TARR Manual
- **Identify** key challenges agencies face in assessing and managing asset risks, including data, risk assessment methods, prioritization, funding, and integration into asset management decisions
- **Consider** how the forthcoming TARR Manual can help agencies strengthen current practices and more effectively incorporate risk and resilience into TAM
- **And as always, share** practical lessons, experiences, and ideas that agencies can apply to advance risk-informed and resilient asset management

Webinar Agenda

2:00 **Welcome and Agenda Overview**
Anna McLaughlin, AASHTO
Hyun-A Park, Spy Pond Partners

2:15 **Transportation Asset Risk and Resilience (TARR) Manual**
William Johnson, Spy Pond Partners

2:30 **Panel of Subject Matter Experts**
Claire Martini, Colorado Department of Transportation
Habte Kassa, Georgia Department of Transportation
Christopher Berrens, Minnesota Department of Transportation

3:00 **Q&A Discussion and Wrap Up**
Hyun-A Park, Spy Pond Partners

Transportation Asset Risk and Resilience Manual

NCHRP 23-09 *Scoping Study to Develop the Basis for a Highway Standard to Conduct an All-Hazards Risk and Resilience Analysis*.

Completed 04/20/2022

NCHRP 23-32 *Transportation Asset Risk and Resilience*.

Expected Completion date 11/27/2026

TARRMANUAL.COM

Need for a Transportation Asset Risk and Resilience Manual

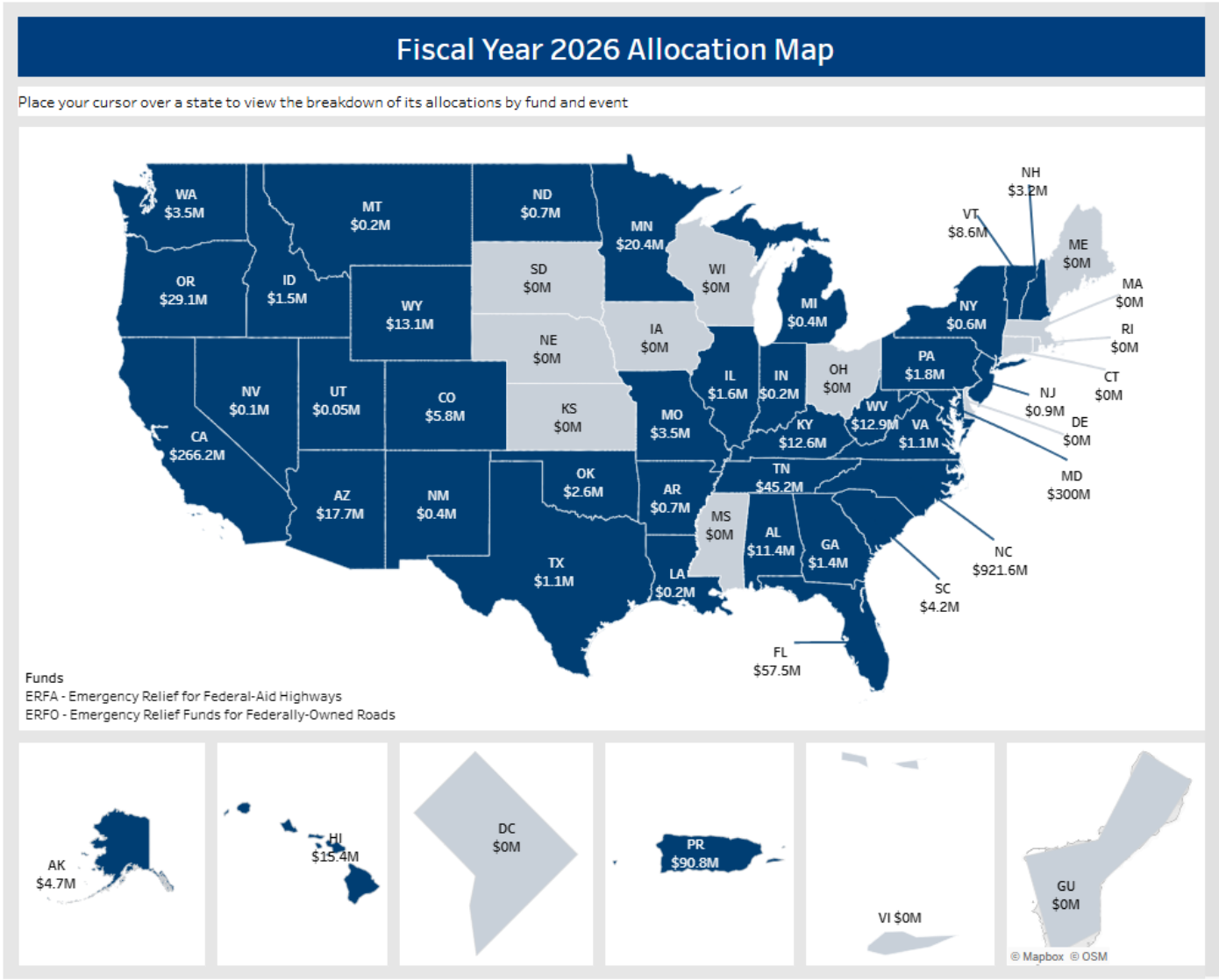
"In 2023, there were a record-breaking 28 individual confirmed U.S. billion-dollar weather and climate disasters (Climate Central 2024). These events resulted in an estimated **492 lives lost** and over $93 billion in damages. In 2024, there were 27 individual weather and climate disasters with at least $1 billion in damages, resulting in **586 direct or indirect fatalities** and an estimated total cost of $182.7 billion (NOAA 2025a)."

Need for a Transportation Asset Risk and Resilience Manual

FY 2026 FHWA ER Allocations

- Federal-Aid Highways – $1.77 Billion
- Federally-Owned Roads – $97 Million

- **Total = $1.86 Billion**



Source: https://www.fhwa.dot.gov/programadmin/erelief/allocations.cfm

Manual Framework & Chapter Architecture

TRANSPORTATION ASSET RISK & RESILIENCE (TARR) • COMPREHENSIVE TAXONOMY

4 Sections · 26 Chapters

Phase I of Many

Section I
Ch 1–8

Foundational Chapters

ORIENTATION
Ch 1: Background & Purpose
Ch 2: Manual Application

FRAMEWORK CORE
Ch 3: Organization
Ch 4: Scoping
Ch 5: Assessment

DATA & MODELING
Ch 6: Resilience
Ch 7: Data Sources
Ch 8: Data in Modeling

Section II
Ch 9–17

Technical Chapters: Risk Assessment in Transportation

STRUCTURES
Ch 9: Scour · Bridge
Ch 10: Flood · Bridge
Ch 11: Storm Surge · Bridge
Ch 12: Riverine Flood · NBI Culverts

ROADWAY & DRAINAGE
Ch 13: Inland Flood · Pavement
Ch 14: Sea Level Rise · Pavement
Ch 15: Flood Erosion · Embankment

GEOTECH & WIND
Ch 16: Rockfall · Pavement
Ch 17: Wind · Mast Arm

Section III
Ch 18–20

Multi-Modal Application Quantitative Risk Assessment in Transportation

MARITIME
Ch 18: Marine · Bridge Strike

RAIL TRANSIT
Ch 19: Extreme Heat · Rail Track

AVIATION
Ch 20: Extreme Heat · Airport Departures

Section IV
Ch 21–26

Management of Risk & Resilience & Case Studies

Investment Decision Making
Ch 21: Measuring Asset Resilience
Ch 22: Management of Risk & Resilience

State DOT Case Studies
Ch 23: Arizona DOT (Scour-Bridge)
Ch 24: NC DOT (Post-Event Assessment)
Ch 25: Virginia DOT (Sea Level Rise)
Ch 26: Georgia DOT (Enterprise)

Risk and Resilience Defined

Risk - The potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and associated consequences (AASHTO 2017)

Resilience - "the ability to prepare and plan for, absorb, recover from, or more successfully adapt to adverse events" (AASHTO 2017)

C x V x T

Where:

C = Consequence ($)
V = Vulnerability (%)
T = Threat (%)

ROBUSTNESS

The ability to withstand disaster forces without significant degradation or loss of performance.

REDUNDANCY

The extent to which the systems can satisfy functional requirements if significant degradation or loss of functionality occurs.

RESOURCEFULNESS

The ability to diagnose and prioritize problems and to initiate solutions by identifying and mobilizing resources.

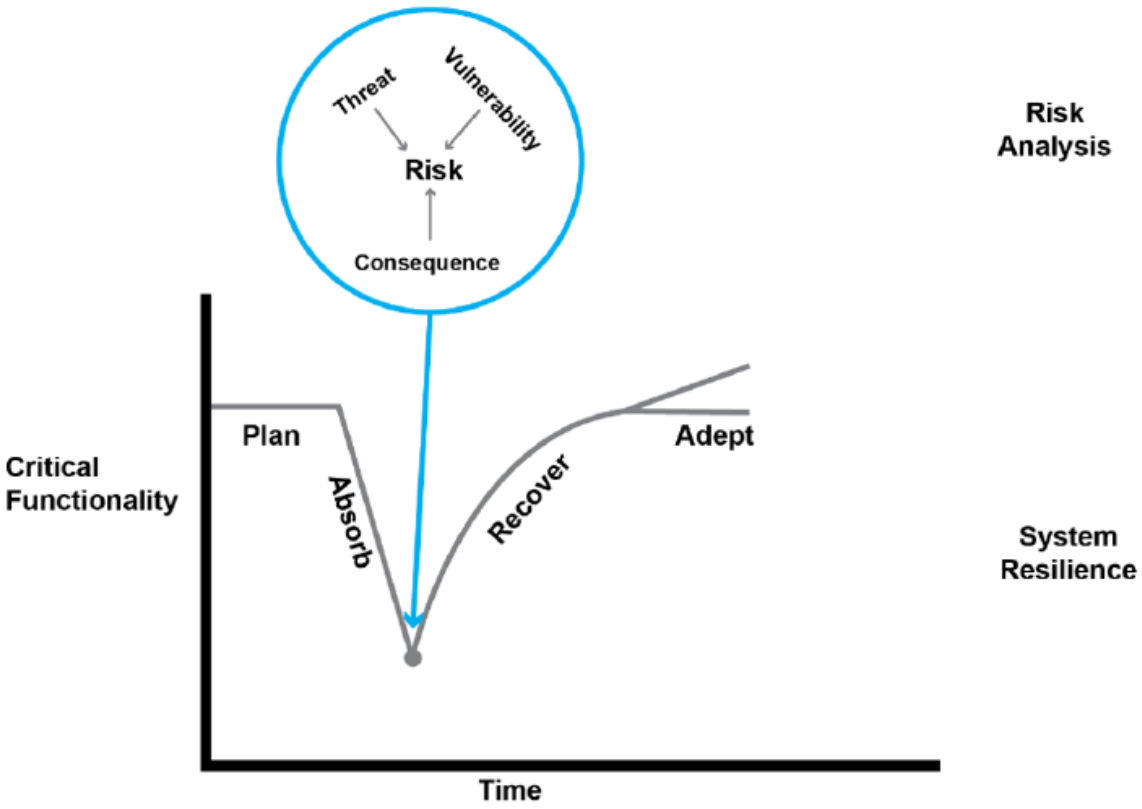
RAPIDITY

The capacity to restore functionality, contain losses, and avoiding disruptions.

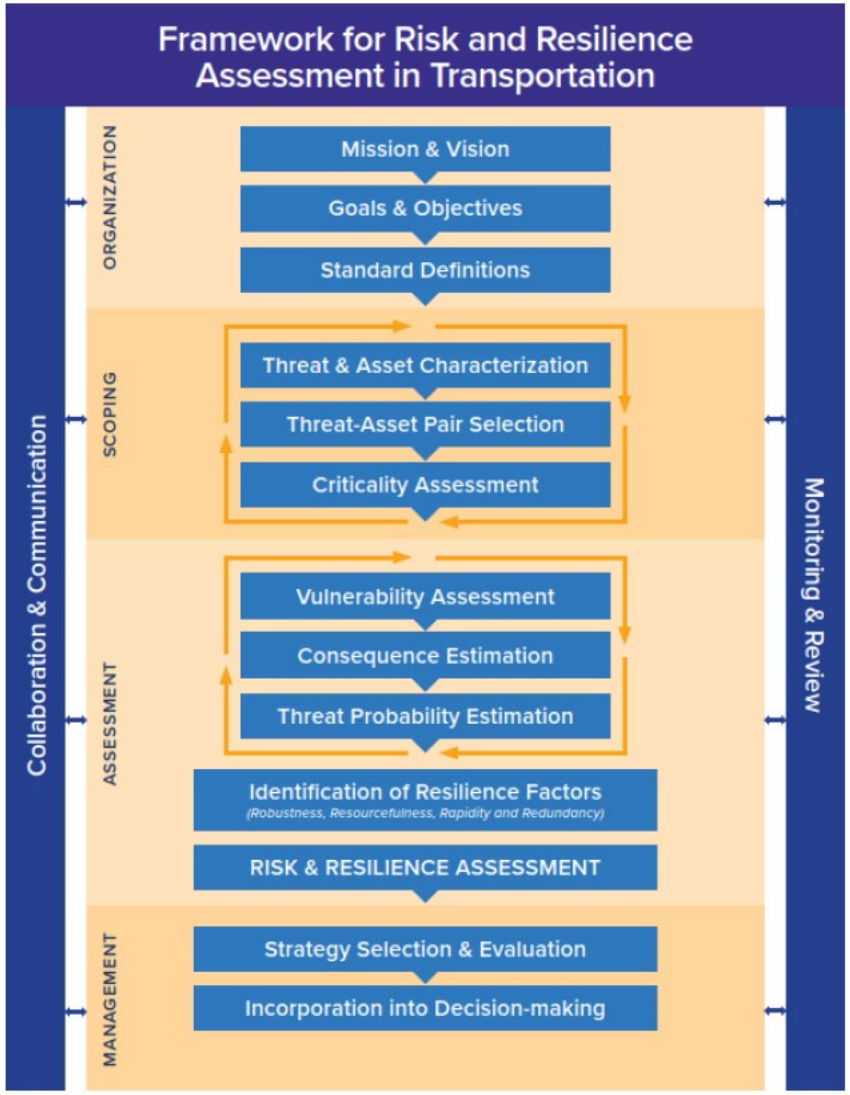
Source: https://www.fhwa.dot.gov/programadmin/erelief/allocations.cfm

Risk and Resilience Framework

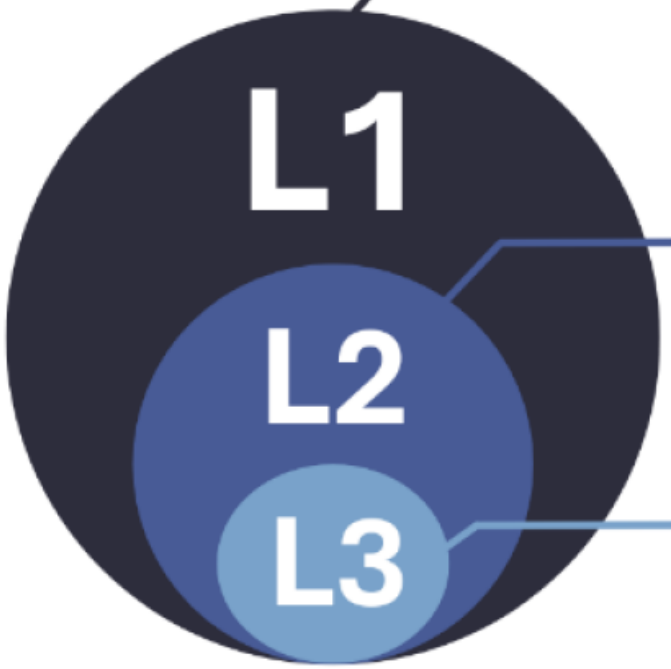
Relationship Between Risk and Resilience Analysis



Source: Linkov et al. 2014



Risk Modeling Levels of Analysis



LEVEL 1

Risk exposure methods most applicable when limited asset-specific or location-specific threat data is known. Initial screening models for narrowing the universe of assets that require more detailed analysis to understand annual risk. Reliance on existing threat mapping and asset location mapping. May include a consideration of asset criticality within overall system operations to identify for further assessment.

LEVEL 2

Models that are most applicable when information is available about the setting of the asset including watershed characteristics, NBI data, global design characteristics, etc. Risk assessment is conducted with semi-probabilistic methods.

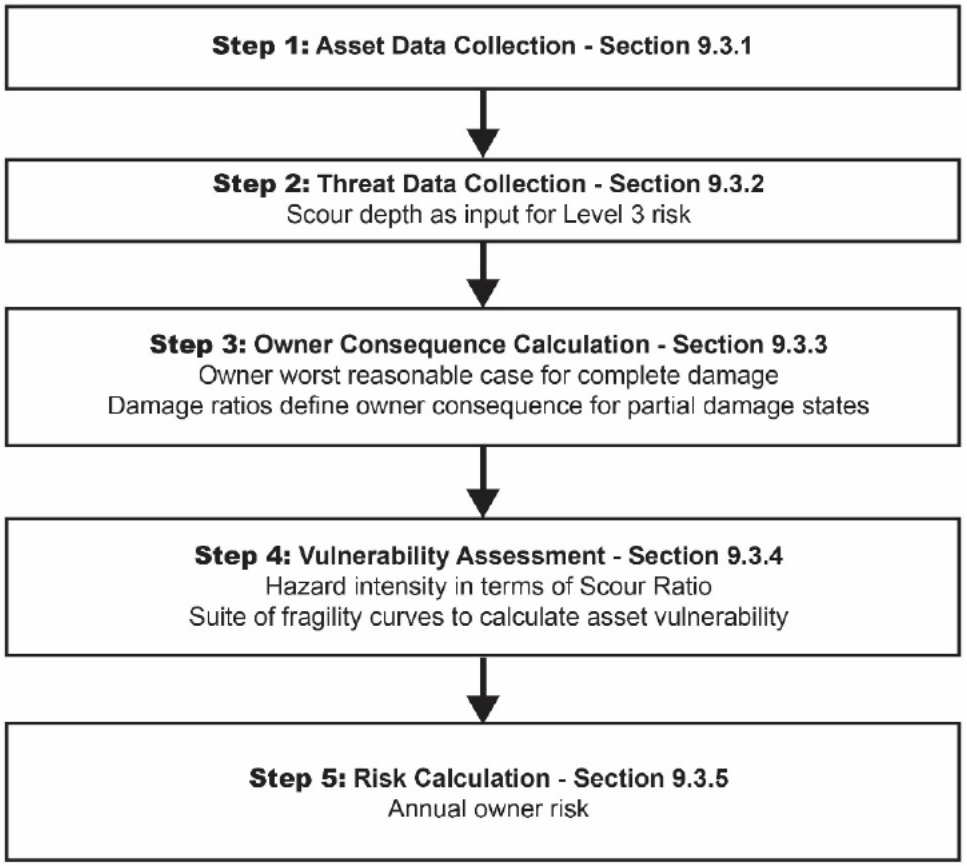
LEVEL 3

Models that include asset-specific and threat-specific information. Threat-Asset pairs that can be modeled in a fully quantitative manner (deterministic or probabilistic). Level 1 would assess the specific conditions of a given pavement asset or bridge asset under various threats using location-specific threat data (probabilistic or deterministic; stationary or non-stationary).

How the TARR Models Can Be Used

Assessment Procedure and Data

Example: Scour – Bridge

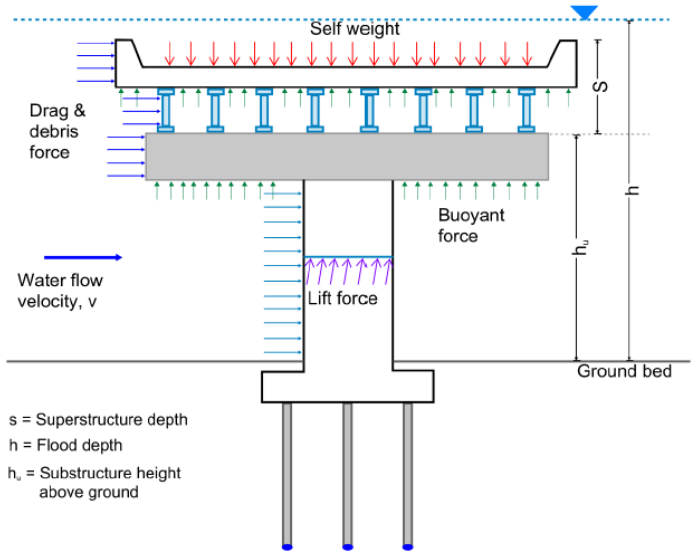


Model Steps	Data Sources/Resources Needed	Output
Step 1: Asset Data Collection	**All Levels:** ▪ NBI database ▪ Agency's asset management databases **Levels 2 and 3:** ▪ As-built plans ▪ Inspection records	Asset Data
Step 2: Threat Data Collection	**Level 1:** ▪ National H&H toolsets **Levels 2 and 3:** ▪ Agency H&H toolsets ▪ Detailed H&H assessments ▪ Expert knowledge ▪ SME: H&H	Threat Probability by Magnitude (*T*, %)
Step 3: Owner Consequence Assessment	**Levels 2 and 3:** ▪ FHWA bridge repair and full replacement costs ▪ NBI database ▪ Agency's maintenance records ▪ Economic impact studies ▪ Expert knowledge ▪ SME: Economic impact analysis	Consequences (*C*, $)
Step 4: Vulnerability Assessment	**Levels 2 and 3:** ▪ Analytical fragility) ▪ Scour depth ▪ SME: Bridge engineer ▪ SME: H&H	Vulnerability (*V*, %)
Step 5: Risk Assessment	**Levels 2 and 3:** ▪ Risk = C×V×T	Risk in monetary losses ($)

TAM Data and Risk and Resilience

Example: Flood – Bridge

Flood Induced Loading for Bridges



Source: Ibrahim and Banerjee 2024

Asset Data Collection

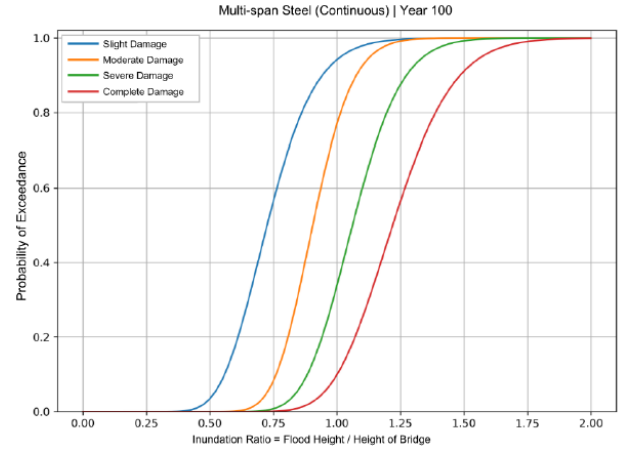
SN	SNBI Item ID	Corresponding NBI Item Code	Description	Data Use	Data Source
1	B.ID.01	8	Bridge number	Identification	
2	B.L.05	16	Latitude	Location	
3	B.L.06	17	Longitude	Location	
4	B.SP.01	43	Span configuration designation	Fragility curve selection	
5	B.SP.02	45/46	Number of spans	Fragility curve selection	
6	B.SP.04	43A/44A	Span material	Fragility curve selection	
7	B.SP.05	43/44	Span continuity	Fragility curve selection	
9	B.SB.04	N/A; to be obtained from as-built plans	Substructure type	Fragility curve selection	
10	B.G.16	N/A; can be obtained from 49 and 52	Calculated deck area	Owner Consequence calculation	
11	B.H.01	26	Functional classification	Level 1 and Level 2 risk assessment	
12	B.IE.11	N/A	Inspection note	Any additional information	
13	B.C.03	60	Substructure condition rating	Fragility curve selection	
14	B.C.09	61	Channel condition rating	Level 1 and Level 2 risk assessment	
15	B.C.10	N/A	Channel protection condition rating	Level 1 and Level 2 risk assessment	
16	B.AP.02	71	Overtopping likelihood	Level 1 and Level 2 risk assessment	
17	B.W.01	27	Year built	Fragility curve selection	SNBI/ NBI
18	N/A	N/A	Low Chord Elevation	Calculate vulnerability	As-built plans

ID = identification
N/A = not applicable
SN = serial number

Form of Fragility Function

$$Inundation\ Ratio = \frac{Flood\ Height}{Height\ of\ Bridge}$$

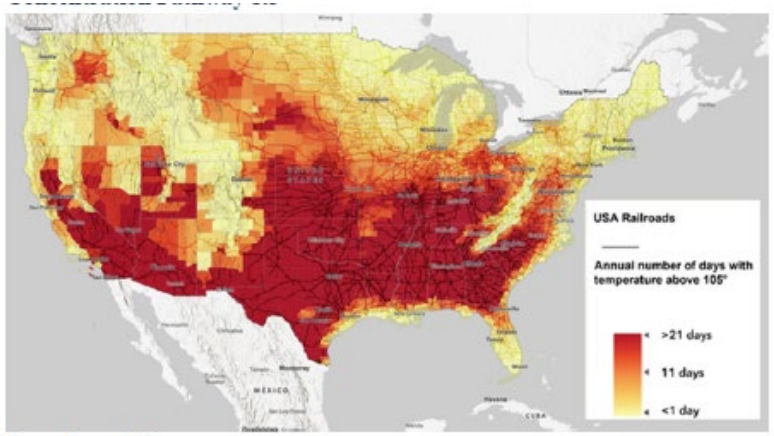
Fragility Curve



Multi-Modal Applications

Example: Extreme Heat – Rail Track

Heat Map of Temperature Above 105°F using Representative Concentration Pathway 8.5



Source: Lavery 2022

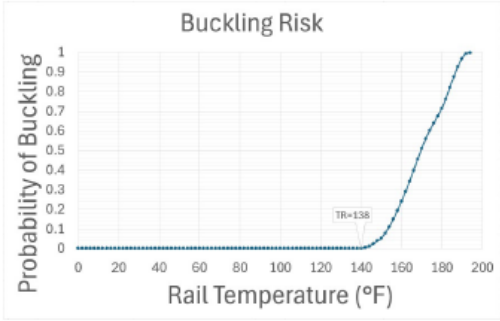
Future Projections of Average Annual Temperature Days, Medium Emissions (RCP 4.5)

Parameter	2024-2055 (~2050) Average	2024-2055 (~2050) 95% Confidential Interval	2075-2085 (~2080) Average	2075-2085 (~2080) 95% Confidential Interval
Average Annual Days at 81 °F	106	103 to 109	109	101 to 117
Average Annual Days at 90 °F	65	61 to 69	74	69 to 70
Average Annual Days at 111 °F	2	1 to 2	3	2 to 3

Source: Obtained from NOAA Climate Data Online Search Tool (2026) and NOAA CMIP6 2025 (LLNL 2026)

CWR-SAFE Software Risk Module

Values Extracted from CWR Software Results for Curve Segments



Rail Temperature, Tr curve (°F)	Probability of Buckling, Pb curve
138	0.0000
140	0.0009
142	0.0051
144	0.0119
146	0.0228
148	0.0392
150	0.0528
152	0.0798
154	0.1126
156	0.1503
158	0.1932
160	0.2414
162	0.2896
164	0.3424
166	0.3981
168	0.4545
170	0.5094
172	0.5594
174	0.6019
176	0.6391
178	0.6749
180	0.7138
182	0.7615
184	0.8207
186	0.8760
188	0.9269
190	0.9682
192	0.9931
194	0.9966

Source: Obtained from CRW SAFE Software Risk Module

Next Steps

NCHRP 23-32 *Transportation Asset Risk and Resilience*.

- Panel Comments Due September 14
- Expected Completion date 11/27/2026

AASHTO CPMB Meeting

- Full Day Workshop on the TARR Manual

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Risk and Resilience in Asset Management

Claire Martini, Risk and Resilience Program Manager

Organizational Structure

Asset Management Program

Coordinates with FHWA, the Department's asset-program managers, CDOT Regions, and other agencies to manage the 12 asset classes. The program meets federal requirements for asset management (e.g., TAMP development), and coordinates budget setting and treatment-list development for the four-year program for the asset classes.

Performance Management Program

Collects performance data for various CDOT programs and meets National Performance Measure reporting requirements (including PMI, PM2, and PM3 measures/ targets). The program also develops CDOT's state-required *Performance Plan*, which contains the Department's annual strategic goals and reports on annual performance against PD 14.0 targets.

Risk and Resilience Program

Develops tools and processes to analyze and enhance resilience considerations in support of federal and state requirements, and leads the implementation of PD 1905.0 for CDOT.

Economic Analysis Program

Develops asset valuations and economic forecasts in support of asset management. The program also performs cost/benefit analysis for federal grant opportunities, and maintains and develops tools for economic analysis and project selection and prioritization.

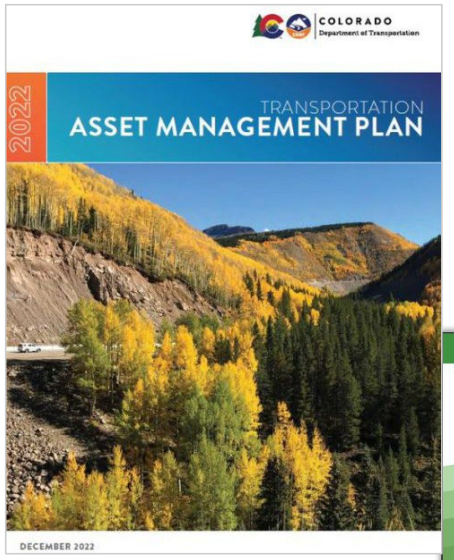
Risk and Resilience in Asset Management

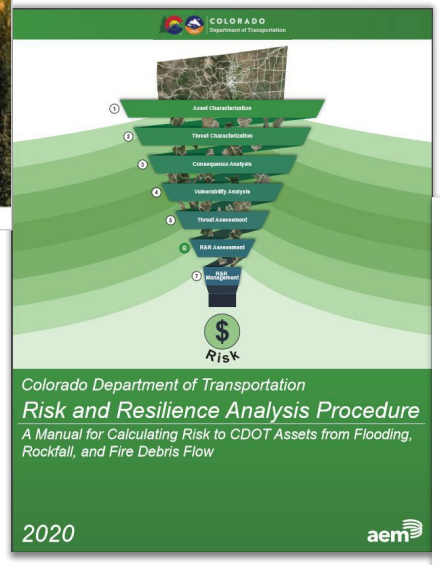
1. Managing risk across various levels: Enterprise (strategic), Program, and Project/Activity levels.

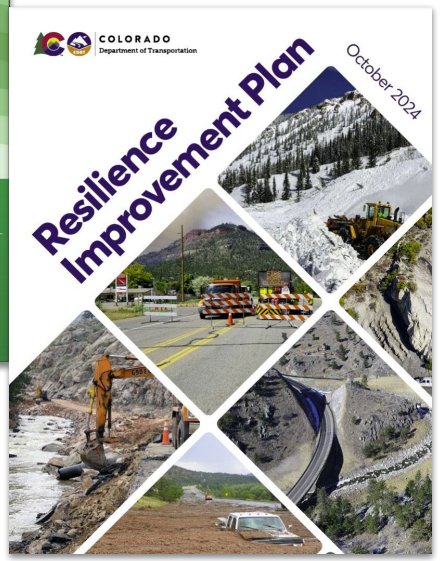
2. Defining the risk process: Developing the risk register to establish risk-management priorities.

3. Considering risk and resilience as part of life-cycle planning and life-cycle cost analysis.

- Consideration of extreme weather and resilience in life-cycle and risk analysis, per 23 USC 119(e)(4)(D).
- Identification and treatment of twice-damaged assets (as required under 23 CFR 667).







Prioritized Natural Hazards on CDOT's Enterprise-Level Risk Register

Enterprise Threats	Risk Statement	Risk Score	Risk Management Strategy
Flood	There is a risk that flooding occurs leading to asset/route damage that causes mobility and safety impacts as well as increased asset management cost.	68 (T)5*(C)4.5*(V)3	Treat by implementing design standards; following agency continuity of operations plan; maintaining incident command center management structure; maintaining an Office of Emergency Management (OEM). Use tools and processes developed under the resilience program to identify high risk assets and corridors for focused analysis.
Post-Fire Debris Flow	There is a risk that post-fire debris flow occurs leading to asset/route damage that causes mobility and safety impacts as well as increased asset management cost.	48 (T)4*(C)3*(V)4	Treat by maintaining and office of OEM. Maintenance landscaping, erosion control, jersey barriers, and other practices.
Geohazards	There is a risk of geotechnical failure that causes mobility and safety impacts as well as increased asset management cost.	33 (T)5*(C)3.3*(V)2	Treat by implementing the geohazards management program and robust geohazards management plan.
Fire	There is a risk that fire occurs, leading to asset/route damage that causes mobility and safety impacts as well as increased asset management cost.	14 (T)4*(C)1.2*(V)3	Tolerate in the case of wildfires; and treat by tunnel fire-suppression systems and bridge-design standards, etc. Use tools and processes developed under the resilience program to identify high risk assets and corridors for focused analysis.
Snow (Avalanche)	There is a risk of avalanche occurring that causes mobility and safety impacts as well as increased asset management cost.	11 (T)4*(C)2.7*(V)1	Treat by maintaining a Winter Operations Program. Use tools and processes developed under the resilience program to identify high-risk assets and corridors for focused analysis.

Relevant Threat-Asset Pairs

TARR Manual	Both	CDOT's R&R Manual
Riverine Flood Erosion - Roadway Embankment Inland Flooding - Pavement Wind - Mast Arm Extreme Heat - Rail Track Extreme Heat - Airport Departures	Scour - Bridge Flood - Bridge Riverine Flooding - NBI Culverts Rockfall - Pavement	Flood - Culvert (any size) Flood - Bridge Approach Rockfall - Bridge Debris Flow - Culvert (Post-Fire component) Debris Flow - Roadway (Post-Fire component) *Wildfire - Roadway* *Avalanche - Roadway*

Challenges and Opportunities in Managing Asset Risks

- Advancing project development at the nexus of asset condition and resilience.
- Pursuing data that can be used to improve long-term asset durability. In particular, future natural hazard vulnerability data, including extreme weather data.
- Building resilience into the asset management model. Developing resilient treatment recommendations.

Potential Approaches to Incorporate Dynamic Data into Threat-Asset Modeling

Threat	Asset(s)	Method	Non-Stationary Data
Rockfall	Roadway Prism Bridge	Change Factors Threat Likelihood Change	Precipitation Temperature
		Decay Factors	Freeze-Thaw/ Permafrost Thaw
Flood	Roadway Prism Bridge Bridge Approaches	Change Factors Threat Likelihood Change Continuous Simulation	Precipitation Temperature Snowpack/Snow Water Equivalent (SWE)
Wildfire	Roadway Prism Culvert Bridge	Change Factors Threat Likelihood Change	Precipitation Temperature Fuel Moisture Relative Humidity Solar Radiation

Adding "Step 0" to Quantitative Risk & Resilience Assessment Methodology

Step 0: Future Data

- Non-Stationarity, Change Factors
- Decay Rates
- Probabilistic Modeling

Step 1: Threat Data Collection

- Threat Data Source
- Threat Likelihood (Baseline + Future-Adjusted)

Step 2: Asset Data Collection

- Asset Data Needs
- Existing (Baseline) Condition
- Proposed Conditions (for Resilience)

Step 3: Owner Consequence Calculation

- Owner Worst Reasonable Case (WRC) for Threat-Asset Pair
- Asset Unit Cost Estimation
- *Total Owner Consequence*

Step 4: User Consequence Calculation

- User WRC for Threat-Asset Pair
- Vehicle Operating Cost (VOC) and Loss of Wages (LW)
- Detour Estimation (Extra Travel Length, Time)
- *Total User Consequence*

Step 5: Vulnerability Assessment

- Threat-Asset Pair Vulnerability

Step 6: Risk Assessment

- Annual Owner Risk Calculation
- Annual User Risk Calculation
- *Total Annual Risk*

Step 7: Resilience Management

- Risk tolerance
- Decision-making and investment strategy

TARR Manual Opportunities for DOT Use

- Application of non-stationarity to risk and resilience assessment
- Out-of-the-box methodology for new threat-asset pairs
- Advancing understanding and quantification of asset performance (fragility curves)
- Levels of analysis
- Resilience Management" guidance

Exhibit 22-1. Opportunities to Incorporate Risk and Resilience into Decision-Making within Transportation Agencies

Decision Points	Typical Questions	Application of the TARR Manual	Extension of Results
Screening and Asset Management	Where are the most important concentrations of risk?	The manual supports the identification of assets, corridors, or threats requiring further review	Supplement conditions-based decision-making with threat, vulnerability, criticality, and consequence information. Risk should be considered alongside condition, preservation needs, safety, mobility, and life-cycle costs

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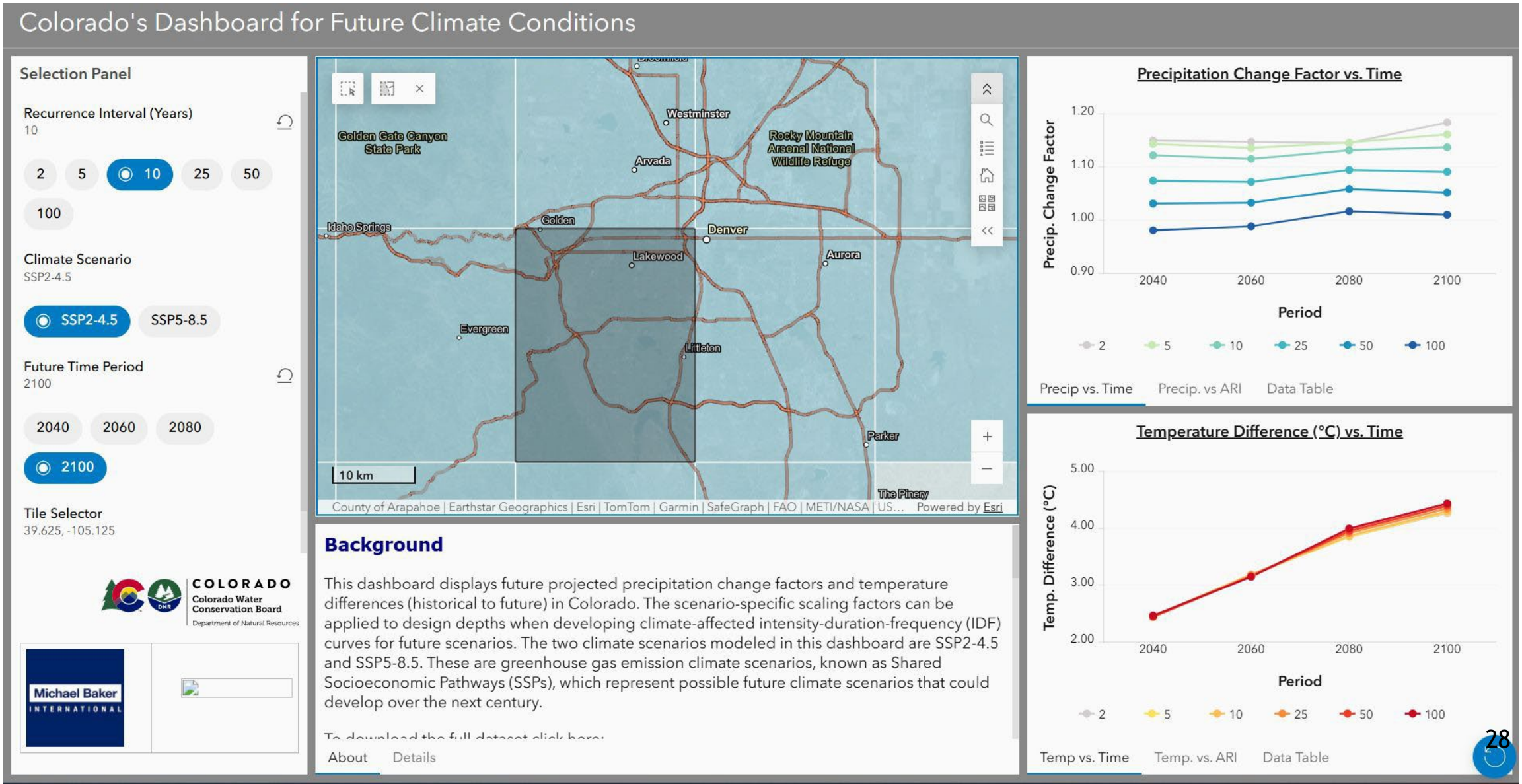
Thank You!

Contact Claire Martini, Risk and Resilience Program Manager

- Email: claire.martini@state.co.us
- Phone: 720-450-7057

Step 0: Flood-Roadway Example



Flood-Roadway Example

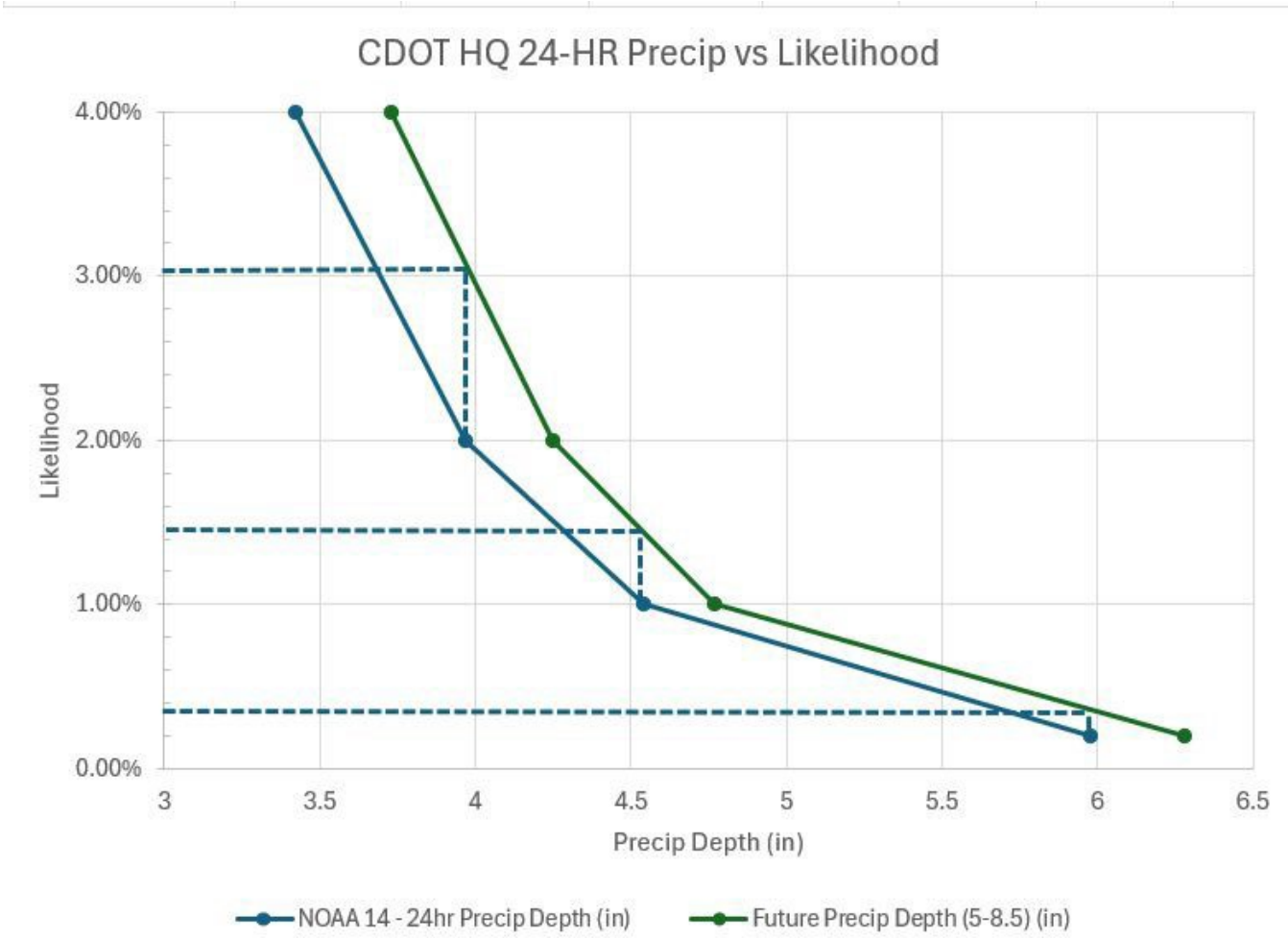
Approach: Fix (i.e., make constant) both the consequence and vulnerability by adjusting the likelihood to properly reflect future risk conditions.

Risk Score = C x V x T

C = Consequences and considerations

V = Vulnerability of CDOT to risk event; the probability that estimated consequences will be realized

T = Threat likelihood (probability) event will occur



Flood-Roadway Example

Preview of updated R&R Assessment Tool:

Threat-Asset:

	Flood-Roadway Information	Existing (No Action)	Proposed (Mitigated)
Flood Threat ID (River):	Unnamed	Divded Roadway	Divded Roadway
Road ID:	I-70 EB MP195.8-197.0	100-Year Overtopping	100-Year Overtopping
Road Classification:	Interstate	500-Year Overtopping	500-Year Overtopping
CDOT Region:		Asphalt Road Material	Asphalt Road Material
		2100 Climate Change Time Period	2100 Climate Change Time Period
		(Notes)	(Notes)

	Ex. (No Action)	Pr. (Mitigated)
Owner Risk:	$377,888	$166,272
User Risk:	$176,646	$58,882
Total Annual Risk:	$554,534	$225,154
ARC:	$19,280,800	$8,480,800
Cost of Mitigation		$2,505,000
Life Span of Mitigation		100

Adjust mitigation

	Pr. (Mitigated)
Owner Benefit:	$211,616
User Benefit:	$117,764
Total Benefit:	$329,380
ARC Delta	$2,505,000
Mitigation Annual Cost	$86,011

Owner BCR	2.46
User BCR	1.37
Total BCR	3.83

Step 0 Non-Stationarity:

Future Time Period Analyzed: 2100 — Match Asset Lifespan or select "No Step 0 Consideration" and proceed to Step 1

Threat Recurrence Interval	Starting Annual Threat Likelihood	Annual Threat Likelihood for Analysis
5 Year	20.00%	
10 Year	10.00%	24.48%
25 Year	4.00%	11.28%
50 Year	2.00%	5.75%
100 Year	1.00%	2.58%
500 Year	0.20%	0.63%

Threat Recurrence Interval	NOAA Precip Depth*	SSP2-4.5 Climate Scenario Precip Change Factor**	SSP5-8.5 Climate Scenario Change Factor**	SSP2-4.5 Climate Scenario Future Likelihood	SSP5-8.5 Climate Scenario Future Likelihood
5 -Year	1.63 (inches)	1.16	1.28		
10 -Year	1.92 (inches)	1.15	1.25	19.13%	24.48%
25 -Year	2.36 (inches)	1.13	1.21	8.01%	11.28%
50 -Year	2.72 (inches)	1.11	1.18	3.68%	5.75%
100 -Year	3.11 (inches)	1.10	1.15	1.78%	2.58%
500 -Year	4.12 (inches)			0.50%	0.63%

*Data Source: NOAA Atlas 14 Vol 8 Ver 2: https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=co

**Data Source: CWCB Climate Change Dashboard: https://coloradohazardmapping.com/climate2

Step 1 Threat Data:

Threat Recurrence Interval	Annual Threat Likelihood Analysis
10 Year	24.48%

Flood-Roadway Example

Preview of updated R&R Assessment Tool:

Threat-Asset:

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User Benefit:	$117,764
Total Benefit:	$329,380
ARC Delta	$2,505,000
Mitigation Annual Cost	$86,011

Owner BCR	2.46
User BCR	1.37
Total BCR	3.83

Step 0 Non-Stationarity:

Future Time Period Analyzed: 2100

Match Asset Lifespan or select "No Step 0 Consideration" and proceed to Step 1

Threat Recurrence Interval	Starting Annual Threat Likelihood	Annual Threat Likelihood for Analysis
5 Year	20.00%	
10 Year	10.00%	24.48%
25 Year	4.00%	11.28%
50 Year	2.00%	5.75%
100 Year	1.00%	2.58%
500 Year	0.20%	0.63%

Threat Recurrence Interval	NOAA Precip Depth*	SSP2-4.5 Climate Scenario Precip Change Factor**	SSP5-8.5 Climate Scenario Change Factor**	SSP2-4.5 Climate Scenario Future Likelihood	SSP5-8.5 Climate Scenario Future Likelihood
5 -Year	1.63 (inches)	1.16	1.28		
10 -Year	1.92 (inches)	1.15	1.25	19.13%	24.48%
25 -Year	2.36 (inches)	1.13	1.21	8.01%	11.28%
50 -Year	2.72 (inches)	1.11	1.18	3.68%	5.75%
100 -Year	3.11 (inches)	1.10	1.15	1.78%	2.58%
500 -Year	4.12 (inches)			0.50%	0.63%

*Data Source: NOAA Atlas 14 Vol 8 Ver 2: https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=co

**Data Source: CWCB Climate Change Dashboard: https://coloradohazardmapping.com/climate2

Step 1 Threat Data:

Threat Recurrence Interval	Annual Threat Likelihood Analysis
10 Year	24.48%

Flood-Roadway Example

Preview of updated R&R Assessment Tool:

Threat-Asset:

	Flood-Roadway Information	Existing (No Action)	Proposed (Mitigated)
Flood Threat ID (River):	Unnamed	Divded Roadway	Divded Roadway
Road ID:	I-70 EB MP195.8-197.0	100-Year Overtopping	100-Year Overtopping
Road Classification:	Interstate	500-Year Overtopping	500-Year Overtopping
CDOT Region:		Asphalt Road Material	Asphalt Road Material
		2100 Climate Change Time Period	2100 Climate Change Time Period
		(Notes)	(Notes)

	Ex. (No Action)	Pr. (Mitigated)
Owner Risk:	$377,888	$166,272
User Risk:	$176,646	$58,882
Total Annual Risk:	$554,534	$225,154
ARC:	$19,280,800	$8,480,800
Cost of Mitigation		$2,505,000
Life Span of Mitigation		100

Adjust mitigation

	Pr. (Mitigated)
Owner Benefit:	$211,616
User Benefit:	$117,764
Total Benefit:	$329,380
ARC Delta	$2,505,000
Mitigation Annual Cost	$86,011

Owner BCR	2.46
User BCR	1.37
Total BCR	3.83

Step 0 Non-Stationarity:

Future Time Period Analyzed: 2100 — Match Asset Lifespan or select "No Step 0 Consideration" and proceed to Step 1

Threat Recurrence Interval	Starting Annual Threat Likelihood	Annual Threat Likelihood for Analysis
5 Year	20.00%	
10 Year	10.00%	**24.48%**
25 Year	4.00%	**11.28%**
50 Year	2.00%	**5.75%**
100 Year	1.00%	**2.58%**
500 Year	0.20%	**0.63%**

Threat Recurrence Interval	NOAA Precip Depth*	SSP2-4.5 Climate Scenario Precip Change Factor**	SSP5-8.5 Climate Scenario Change Factor**	SSP2-4.5 Climate Scenario Future Likelihood	SSP5-8.5 Climate Scenario Future Likelihood
5 -Year	1.63 (inches)	1.16	1.28		
10 -Year	1.92 (inches)	1.15	1.25	19.13%	24.48%
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500 -Year	4.12 (inches)			0.50%	0.63%

*Data Source: NOAA Atlas 14 Vol 8 Ver 2: https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=co

**Data Source: CWCB Climate Change Dashboard: https://coloradohazardmapping.com/climate2

Step 1 Threat Data:

Threat Recurrence Interval	Annual Threat Likelihood Analysis
10 Year	24.48%

GDOT TAM Risk and Resilience

Habte Kassa

September 16, 2026

1. Key Natural Hazard Risks Affecting Georgia Transportation Assets

Extreme rainfall is one of Georgia's most significant climate threats, directly affecting both pavement performance and bridge operations.

Threat	Asset	Resiliency Strategy
Intense rainfall	Pavements	• Utilizes Open Graded Friction Course (OGFC) on interstate pavements to improve drainage and safety • Utilizes Pavement Management System (PMS) – See next page
Flooding/storm events	Bridges	• Utilizes BridgeWatch monitoring system and inspection data

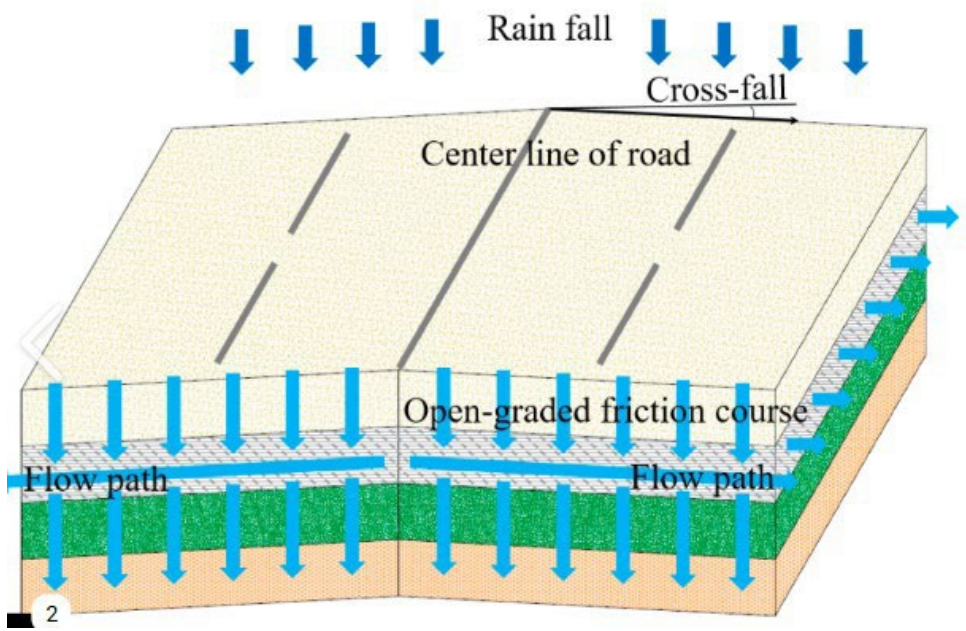


Illustration of Rainfall Flow Path on Open Graded Friction Course (OGFC) Surface

1.1 GDOT Pavement Management: Managing Asset Risk

How the pavement management program addresses data, risk assessment, prioritization, funding, and organizational challenges

1. Data & Condition

- Statewide automated pavement data collection supports consistent condition measures.
- OCI and pavement distress data are integrated into dTIMS and the Resurfacing Database.
- QA/QC, LRS reconciliation, and field review help address data gaps and anomalies.

2. Risk Assessment

- dTIMS evaluates deterioration, treatment timing, and life-cycle impacts.
- Pavement condition is combined with roadway importance, traffic, and network objectives.
- Forecasting identifies where current conditions create future system risk.

3. Prioritization

- Projects are prioritized through condition, treatment strategy, cost, and network needs.
- The Wishlist / Project Picking process connects pavement needs to programmed work.
- Interstate, NHS, and other critical routes receive additional management attention.

4. Funding Constraints

- Funding levels are tested against long-term pavement needs and performance targets.
- Scenario analysis demonstrates the consequences of different investment levels.
- Preservation is used strategically to extend pavement life when reconstruction cannot be funded.

5. Organizational Coordination

- Maintenance, Planning, OMAT, OTD, and Districts share responsibility for asset decisions.
- Pavement evaluations inform project development and STIP programming.
- TAMP performance measures provide a common statewide framework.

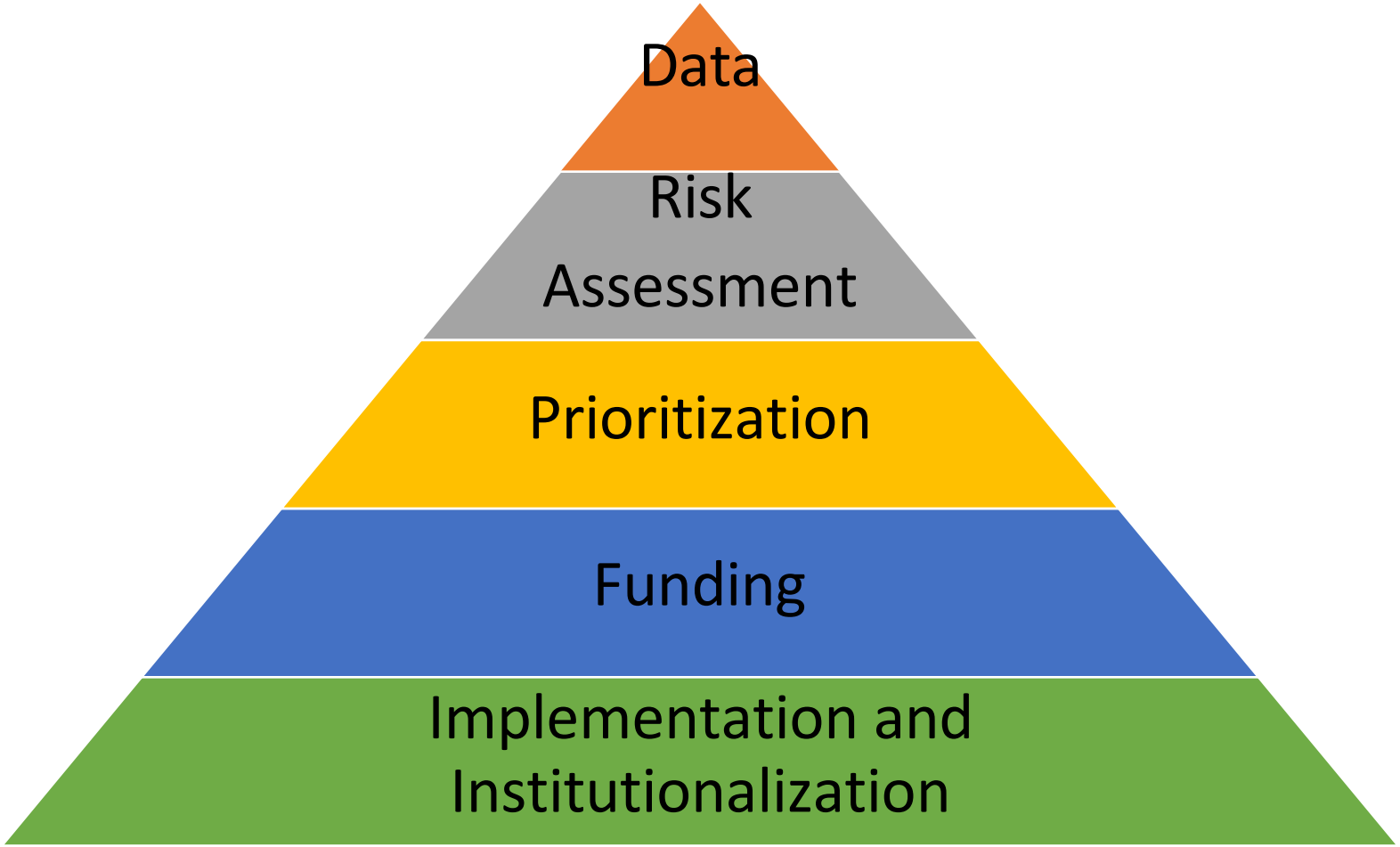
6. Resilience & Uncertainty

- Forecasting accounts for changing pavement condition, traffic, costs, and network growth.
- Concrete pavement and high-risk locations require longer-term strategies.
- Remaining challenge: better quantify uncertainty, climate/resilience impacts, and consequence of failure.

Core approach: measure → assess risk → optimize treatments → program projects → monitor performance

2. Challenges in Integrating Risk and Resilience into Asset Management

The greatest challenge is moving from reactive event response to proactive, data-driven resilience planning.



3. How the TARR Manual Could Advance GDOT's Resilience Practices

The TARR Manual presents an opportunity to establish a consistent, scalable framework for integrating resilience into transportation asset management.

GDOT has already integrated resilience into bridge monitoring and pavement management practices. The TARR Manual could help expand these efforts by providing a more consistent **framework for risk assessment, prioritization, and resilience-based investment decisions** across asset classes.

Habte Kasa, Assistant Planning Administrator

Habte Kasa, Assistant Planning Administrator

Email: Hkassa@dot.ga.gov
Phone:404-631-1797

Asset Needs	$ VERY LARGE (Billions)
Asset Planned Spending	$ LARGE (Billions)
Gap	$ HUGE (Billons)

DEPARTMENT OF TRANSPORTATION

Asset Performance Management and Target Setting

Performance Trend and Target Examples

Current Asset Performance Targets

Are integral for identifying statewide funding needs.

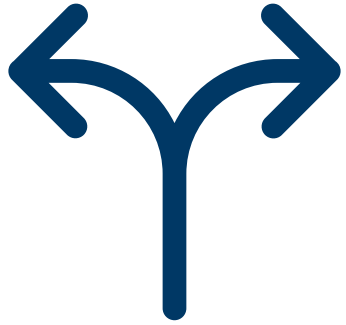
However,…

Feel out of reach with current financial reality.

Don’t directly consider risk variation across asset class or asset location.

Performance Targets and Decisions

Provide direction when making decisions



Asset tiers, detour lengths, AADT, alignment with safety & resilience

DEPARTMENT OF TRANSPORTATION

Cross-asset Risk and Resilience in TAMP

Previous TAMP Cross-asset Risk Assessment Process

Agency Level

Risk Management Priorities	Score
Aging Infrastructure	1
Data Management + Quality	2
Funding	3
Infrastructure Resilience	4
Multimodal Safety	5
Competing Stakeholder Expectations	6
Continuity Of Operations	7
Response to Disruptive Transportation Technologies	8

+

Work Group

Risk reduction	Score
Reduction to No Risk	0
High → Medium	1
Medium → Low	2
High → High	3
Medium → Medium	4
Low → Low	5

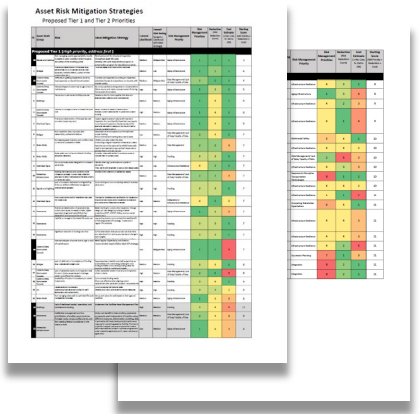
+

Work Group

Cost estimate	Score
No cost	1
$ = Less than $50K	2
$$ = $50K to $250K	3
$$$ = about $500K	4
$$$$ = $1M to $2M	5

=

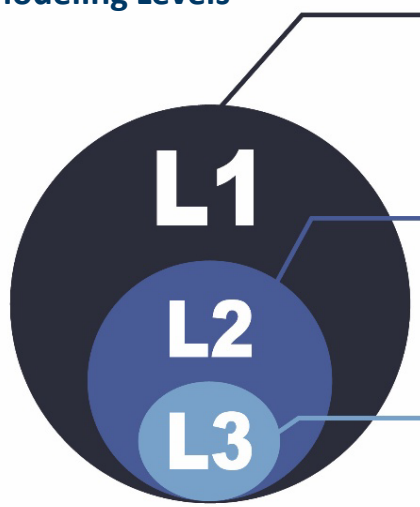
Prioritized Risk Mitigation Strategies



MnDOT Alignment with TARR
Chapter 12 Riverine Flooding-NBI Culverts

Introduction Summary
For the purposes of this chapter, culvert failure is defined as the loss of the structure's ability to perform its intended function as a result of structural collapse, significant erosion, or inadequate hydraulic capacity, such that full replacement of the asset is required.

Modeling Levels



LEVEL 1

Coarsest scale of risk assessment applied when data are limited, using existing threat maps (e.g. FEMA FIS), inspection reports and SNBI data to identify potential culvert and roadway overtopping and damage, narrowing inventory to assets needing further analysis.

LEVEL 2

Intermediate scale of risk assessment that uses limited hydraulic modeling (e.g., HDS-5 HY-8), geomorphologic data, and inspection reports to overtopping and damage potential refining the inventory to identify culverts requiring potential improvements.

LEVEL 3

Advance scaled of risk assessment with more sophisticated hydraulic modeling (e.g., HEC-RAS) and detailed geomorphologic analysis as well as agency and industry design standards and methods for culvert design.

Vulnerability Assessment Flow Chart

Vulnerability Components	Assess Baseline Vulnerability by Assessing Hydraulic Vulnerability* (V_H)	Determine Geomorphic Vulnerability Multiplier (V_G)	Determine Structural Vulnerability Multiplier (V_S)	Calculate Culvert Vulnerability (V)
Use	Exhibit 12-9 Hydraulic Vulnerability	Exhibit 12-11 Geomorphic Vulnerability	Exhibit 12-12 Structural Vulnerability	Equation 12-1

Result

Hydraulic Vulnerability	Baseline Vulnerability
VL	0.01
L	0.10
M	0.25
H	0.50
VH	0.75

Geomorphic Vulnerability	Baseline Multiplier
L	1.0
M	1.3
H	1.5

Structural Vulnerability	Baseline Multiplier
L	1.0
M	1.2
H	1.4

$$V = \min(0.99, V_H \times V_G \times V_S)$$

Culvert failure due to flooding can occur through the following multiple mechanisms and failure modes:

- Headwater elevation relative to the culvert and embankment fill is a primary influence;
- Erosion of roadway embankment material leading to pavement damage or washout;
- Scour/erosion at the inlet, outlet, or along the culvert barrel;
- Reduced conveyance capacity may result from debris accumulation or sediment deposition;
- Hydraulic surcharge loading and seepage through the embankment can compromise embankment integrity;
- Loss of structural support due to undermining, piping, or internal erosion; or
- Hydrostatic or uplifting pressure fluctuations induce strain, cracking, joint failures, or deformation.

Save the Date!

- To learn more about the Subcommittee on Asset Management, access the series archive, and explore asset management resources, visit the TAM Portal: https://www.tam-portal.com/
- Join us for an upcoming webinar and subcommittee meeting!
  - **TPM Webinar 33**
    - October 21st, 2026: Freight Performance
  - **TAM Webinar 83**
    - November 18th, 2026: Recent Research Roundtable
- **Thank you!!**