Tools for Transportation Resilience Planning in the Green Mountain State

ACEC/NHDOT 2016 Technical Exchange Conference, Concord, NH | April 7, 2016

Milone & MacBroom

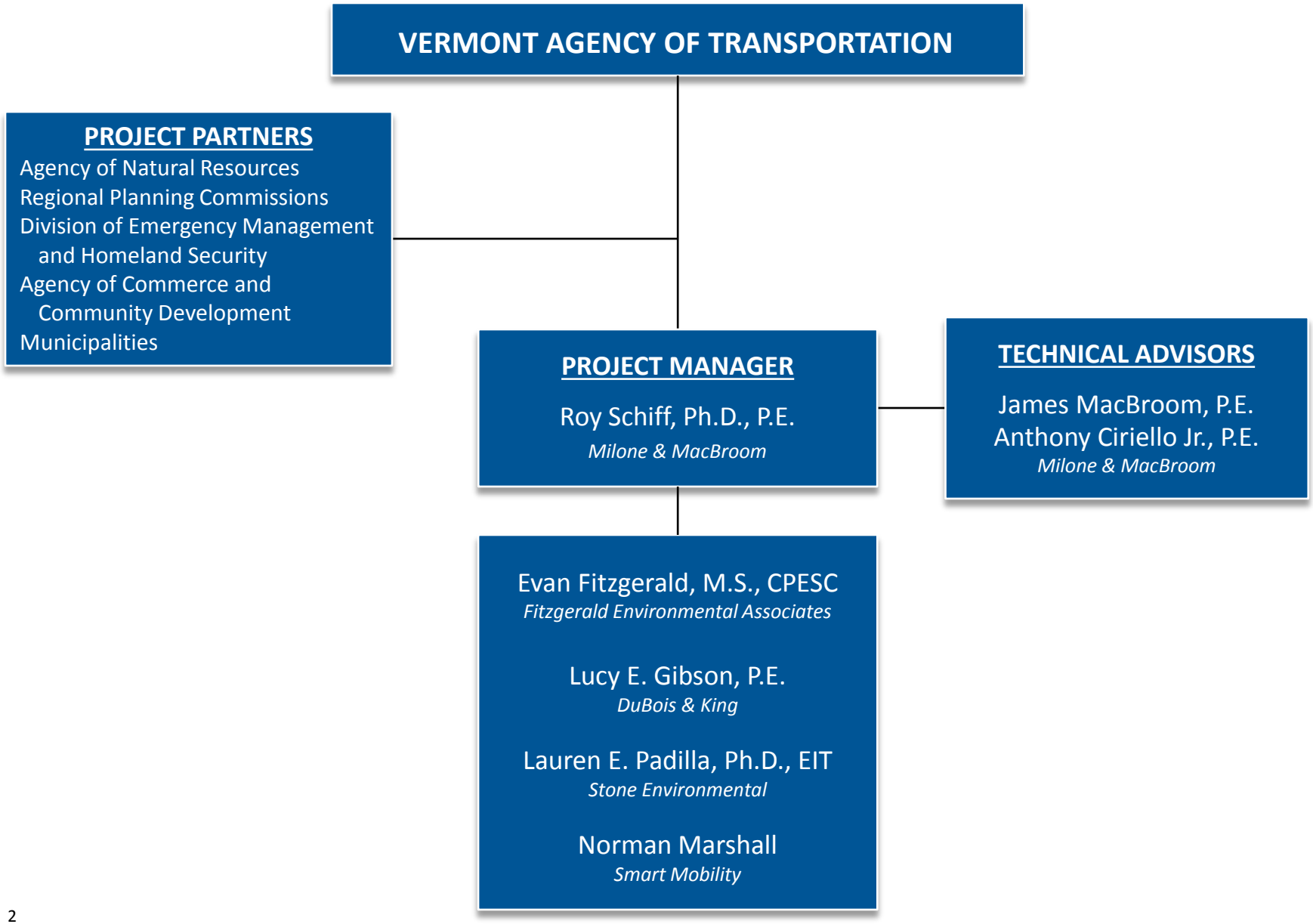
Fitzgerald Environmental Associates, LLC.
Applied Watershed Science & Ecology

DuBois & King Inc.

Stone Environmental

smart mobility

Team Organization



Project Team

Joe
Vermont Agency of Transportation

Roy
Milone & MacBroom

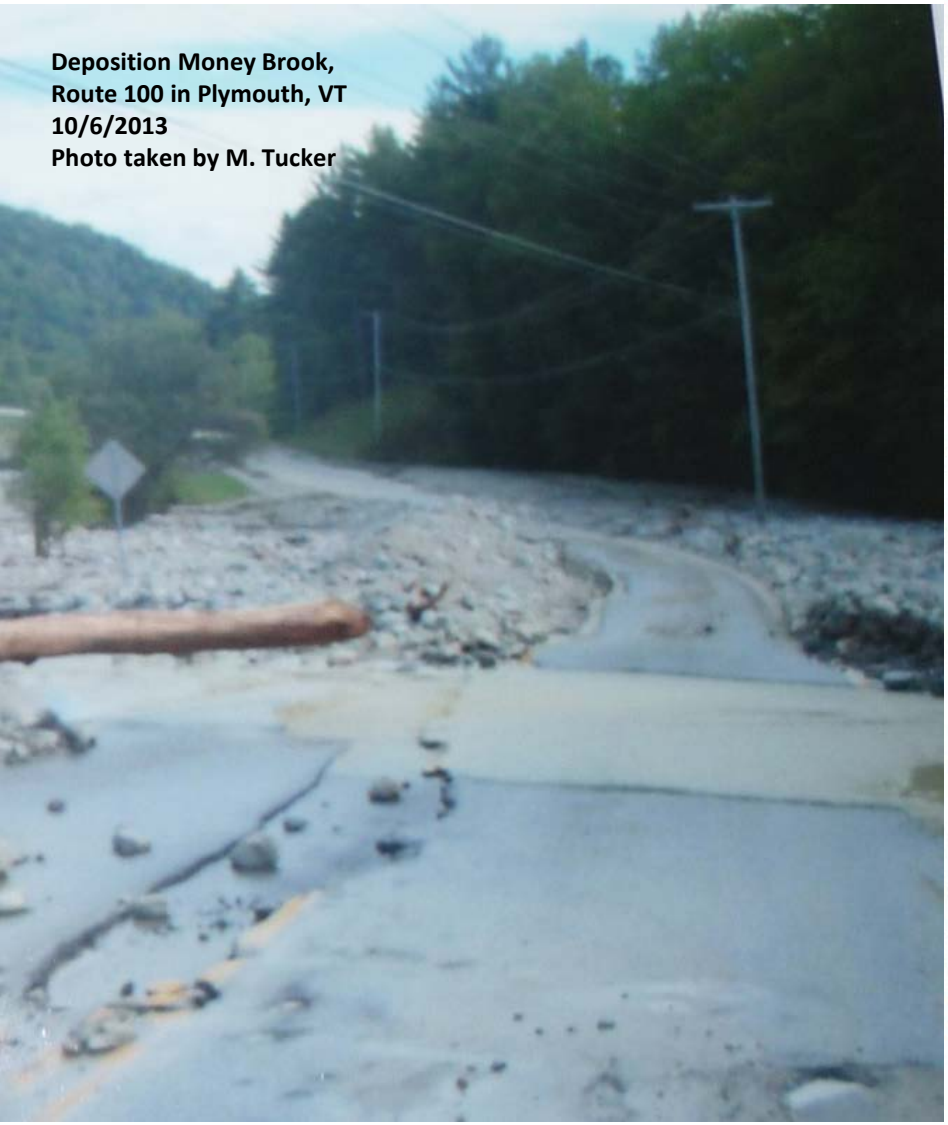
Evan
Fitzgerald Environmental

Norm
Smart Mobility

Lucy
Dubois & King

Lauren
Stone Environmental

Need for Transportation Resiliency



Resilience in Vermont Needs a Unique Approach

- **Relationship between Rivers and Roadways**
- **Flood recovery a major expense for Vermont**

Deposition

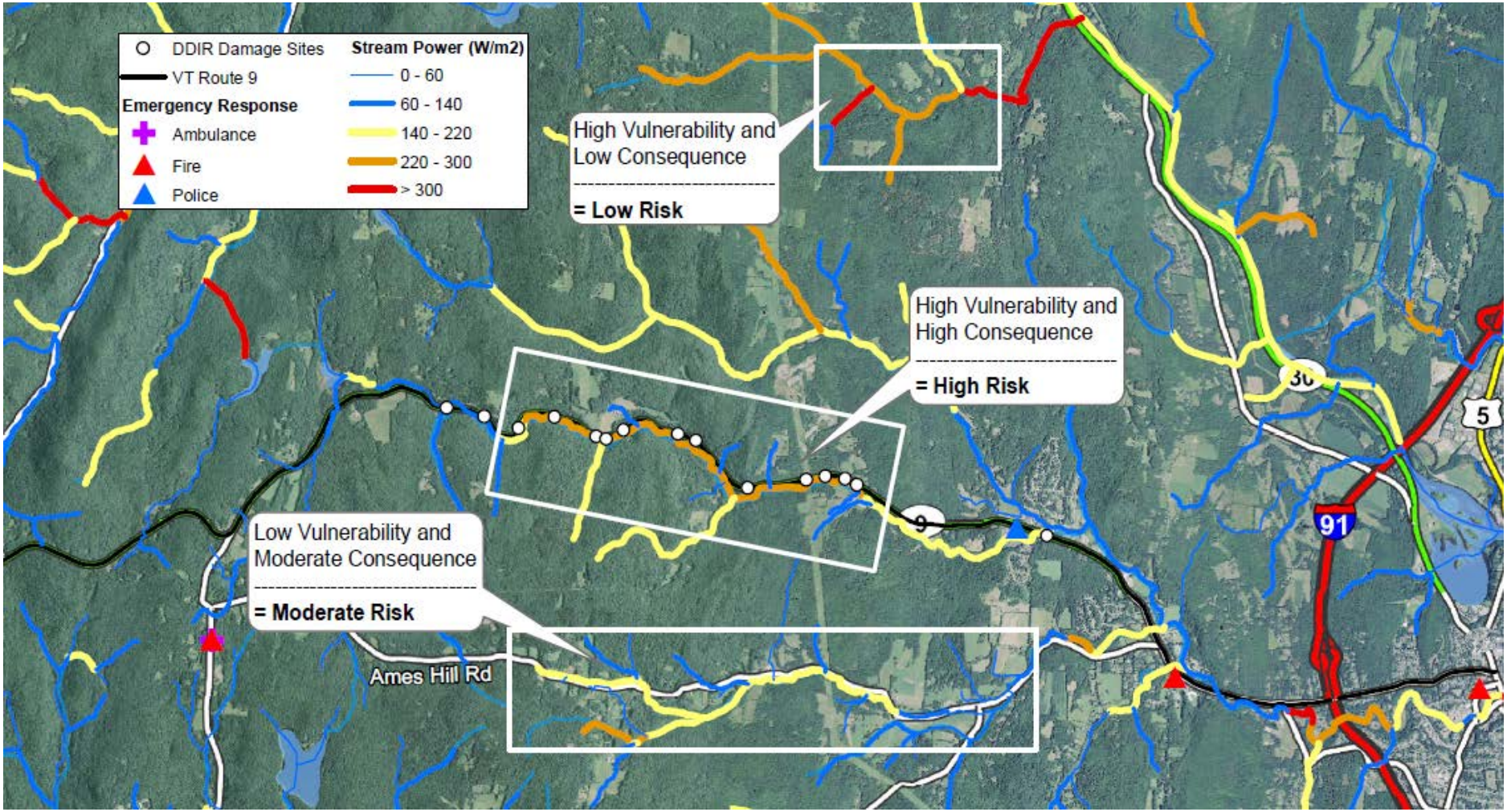
Route 4 - Killington

Erosion

Route 4 - Mendon

Goal: Develop Flood Risk Methods and Tools

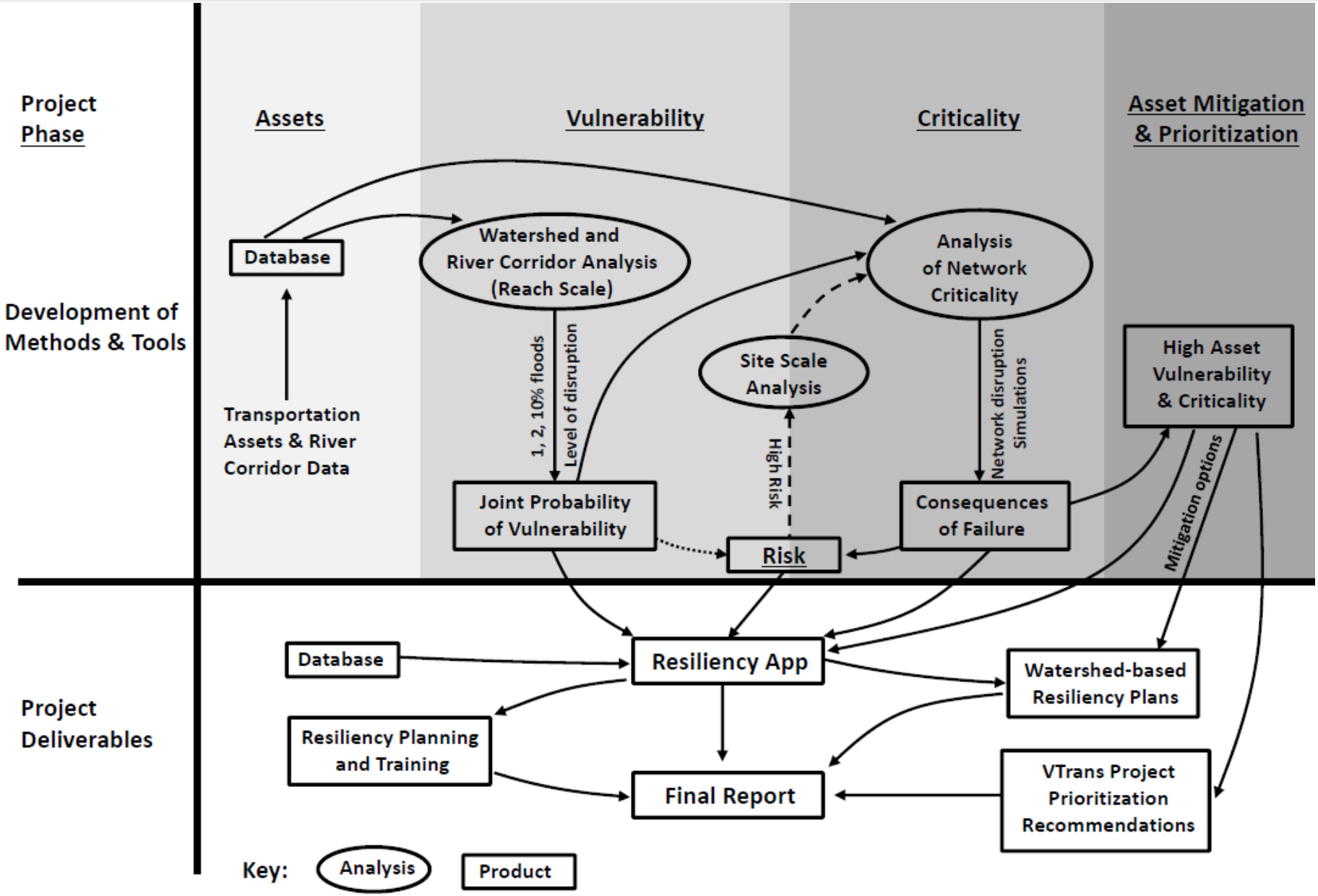
- **Systematically identify high risk road segments and crossing structures**
- **Incorporate vulnerability and risk into planning process**



Definitions

- **Vulnerability** – The extent that a transportation asset is exposed to a threat from inundation, erosion, or deposition.
- **Probability** – The likelihood that a threat will damage a transportation asset.
- **Consequence** – The effect of the disruption to mobility due to damage to a transportation asset.
- **Risk** – The combination of the probability of vulnerability and consequence of damage.

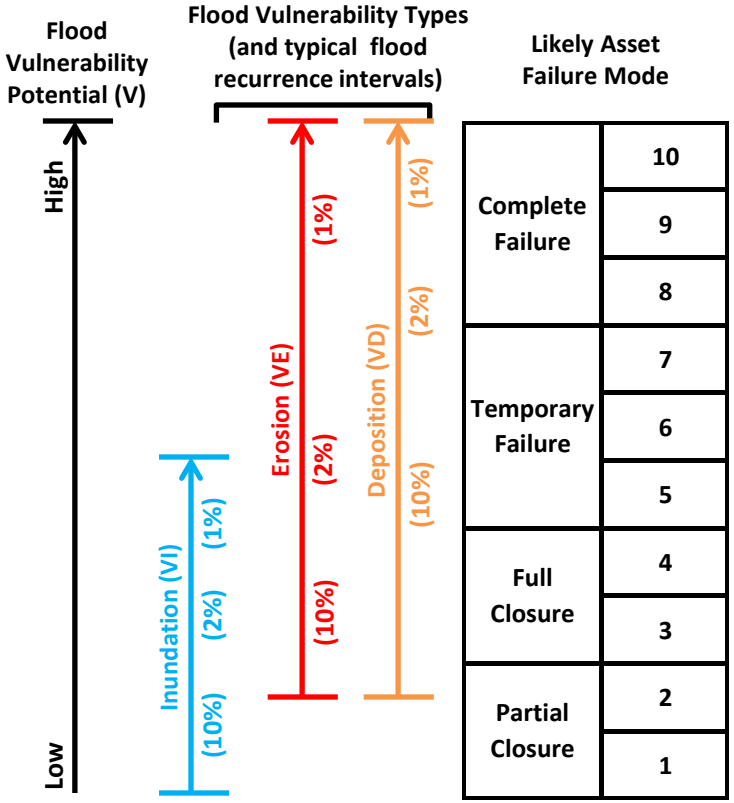
Work Flow & Deliverables



Vulnerability Assessment

$$\text{Vulnerability} = \sum_{I,E,D} V_{\text{ROAD SEGMENT}} = \sum_{I,E,D} (V_{\text{EMBANKMENT}} + V_{\text{BRIDGES}} + V_{\text{CULVERTS}})$$

where I = inundation, E = erosion and D = deposition



$VI_{\text{ROAD SEGMENT}} = VI_{\text{EMBANKMENT}} + VI_{\text{BRIDGES}} + VI_{\text{CULVERTS}}$

$VE_{\text{ROAD SEGMENT}} = VE_{\text{EMBANKMENT}} + VE_{\text{BRIDGES}} + VE_{\text{CULVERTS}}$

$VD_{\text{ROAD SEGMENT}} = VD_{\text{EMBANKMENT}} + VD_{\text{BRIDGES}} + VD_{\text{CULVERTS}}$

- VI = Predicted vulnerability due to inundation; Lane or road closures likely with potential for temporary failure.
- VE = Predicted vulnerability due to erosion; Closures possible, with temporary or complete failure likely.
- VD = Predicted vulnerability due to deposition; Closures possible, with temporary or complete failure likely.
- VX = $P(V_{score}, RI)$

Revised 3/30/2016

Transportation Failures

Failure Mode	Influence	Damage Distance	Vulnerability Type
Partial Closure	Single lane closure, reduced capacity with some allowable travel, <24 hours	100 feet or less	Inundation (Erosion and Deposition possible)
Full Closure	Multi-lane closure, detour required, 24 hours to several days	100s of feet	Inundation, Erosion, or Deposition
Temporary Failure	Partial destruction of facility. Several days to a 1 week for recovery.	100s to 1,000s of feet	Inundation, Erosion, or Deposition
Complete Failure	Complete destruction of facility. 1 week to months for recovery.	Varies	Erosion or Deposition

Vulnerability

Vulnerability

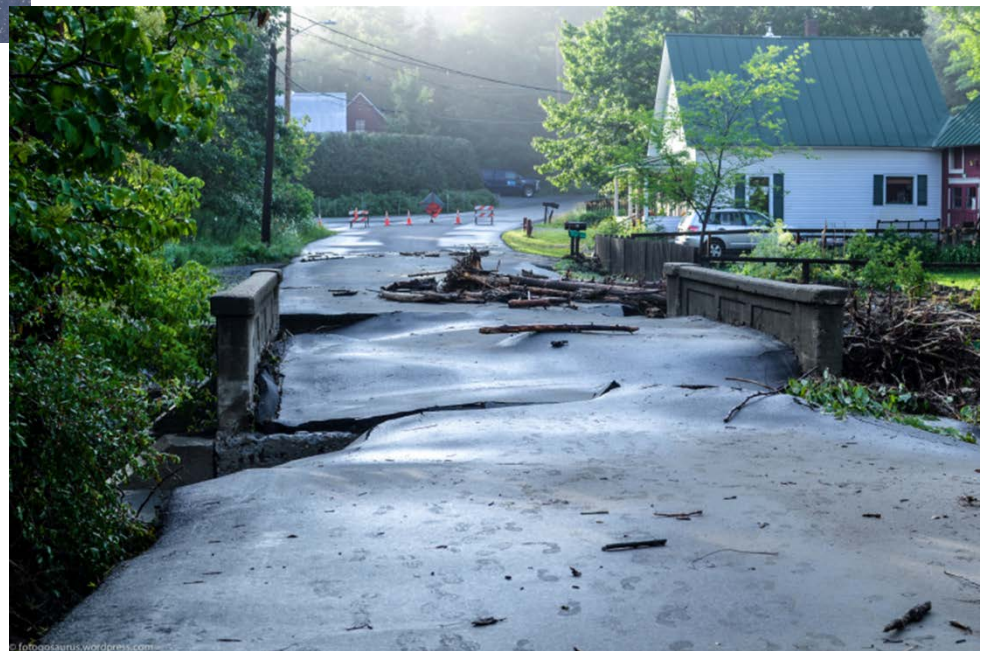
Mendon Brook
US 4 in Mendon, VT
9/1/2011
Photo taken by J. Louisos

Vulnerability

Winooski River
Cochran Road in Richmond, VT
8/29/2011
Photo taken by Shem Roose Photography

Vulnerability

Great Brook
Brook Road in Plainfield, VT
7/19/2015
Photo taken by B. Towbin



Great Brook
Brook Road in Plainfield, VT
7/20/2015
Photo taken by B. Towbin

Vulnerability

Great Brook
Brook Road in Plainfield, VT
5/26/2011
Photo taken by G. Springston

Great Brook
Brook Road in Plainfield, VT
5/27/2011
Photo taken by G. Springston

Vulnerability

Great Brook
Creamery Street in Plainfield, VT
5/27/2011
Photo taken by G. Springston

Great Brook
Brook Road in Plainfield, VT
7/20/2015
Photo taken by B. Towbin

Vulnerability

Inundation Vulnerability Screen – VTrans Methods and Tools for Transportation Resilience Planning

March 3, 2016

VULNERABILITY DUE TO INUNDATION	HIGH		MODERATE		LOW	

More detailed variables

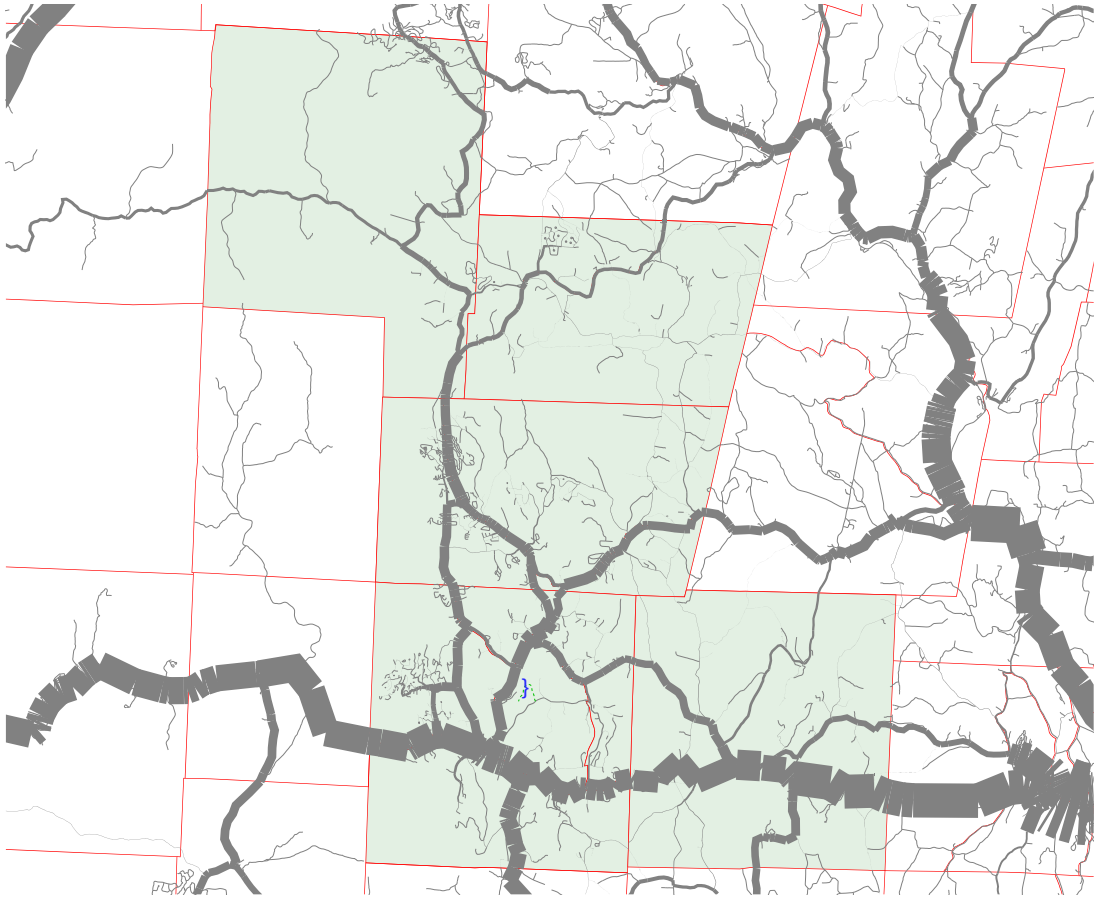
Documented Past Damages due to Inundation	Present				Absent	*Data Replacement*
River-Roadway Relief or Structure-Roadway Relief (feet)	< 5		5-10		> 10	None
Incision Ratio and Entrenchment Ratio	IR<1.2; ER>5	IR=1.2-1.4; ER>5	IR<1.4; ER=3-5	IR<1.4; ER<3	IR≥1.4; ER>3	IR≥1.4; ER<3
FEMA 100-Year Flood Depth Above Road (feet)	>2		0-2			0
Length of Road in FEMA 100-Year Floodplain (detailed study) (feet)	>200		50-200			0-50
Structure Hydraulic Capacity for Design Flow (Hw/D)	>1.2		1.0-1.2			<1.0

Less detailed variables (to replace more detailed variables when they do not exist)

Valley Slope	<0.5		0.5-1.5			>1.5
Approximate FEMA (Zone A) or SSURGO-Derived Floodplains	Present					Absent
Length of Road in Approximate FEMA or SSURGO Floodplains (feet)	>200		50-200			0-50
Structure Width vs. Bankfull Channel Width	<25%	25-50%	50-75%		>75%	≥100%

VULNERABILITY DUE TO INUNDATION	HIGH		MODERATE		LOW	

Transportation Modeling of Criticality



North Branch Deerfield

Vermont Statewide Travel Model (TransCAD)

Explore Network Criticality (TransCAD)

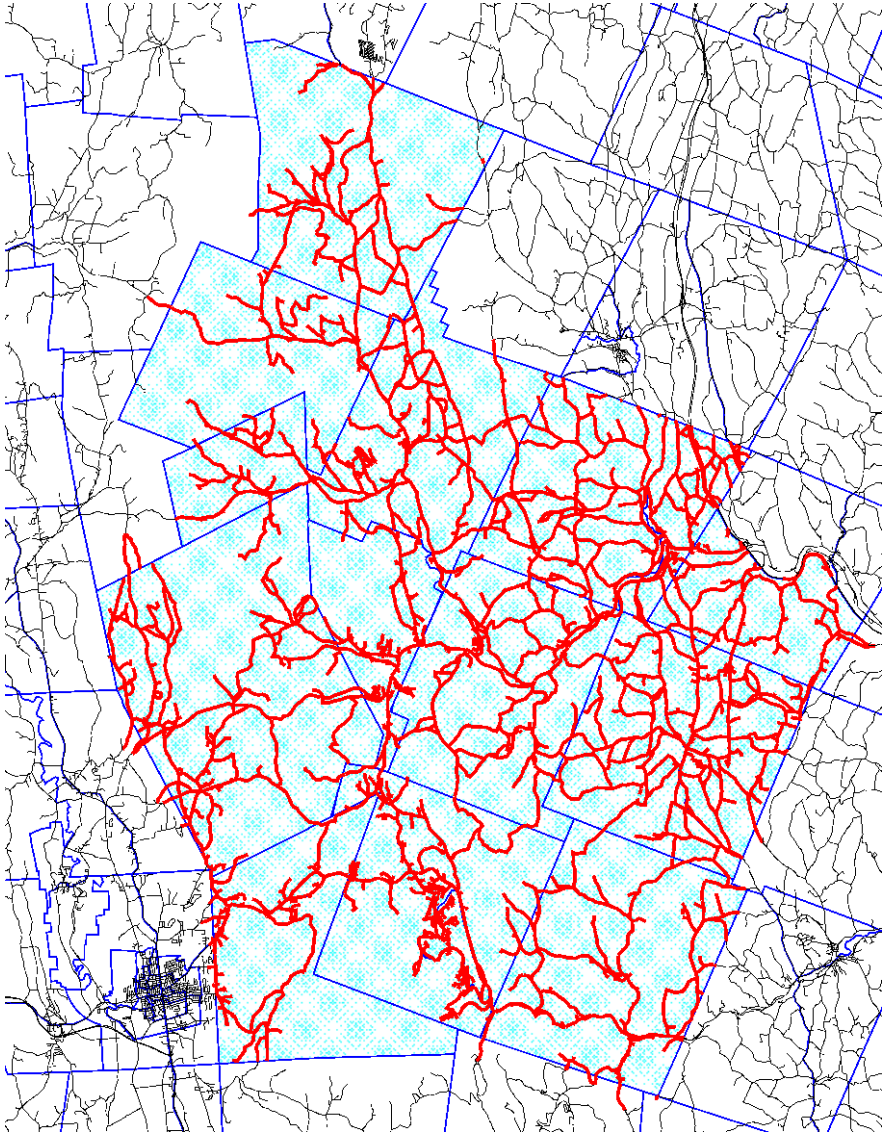
- Add local roads
- Add E-911 buildings
- Input probability of vulnerability
- Output failure consequences to identify risk

Resiliency App

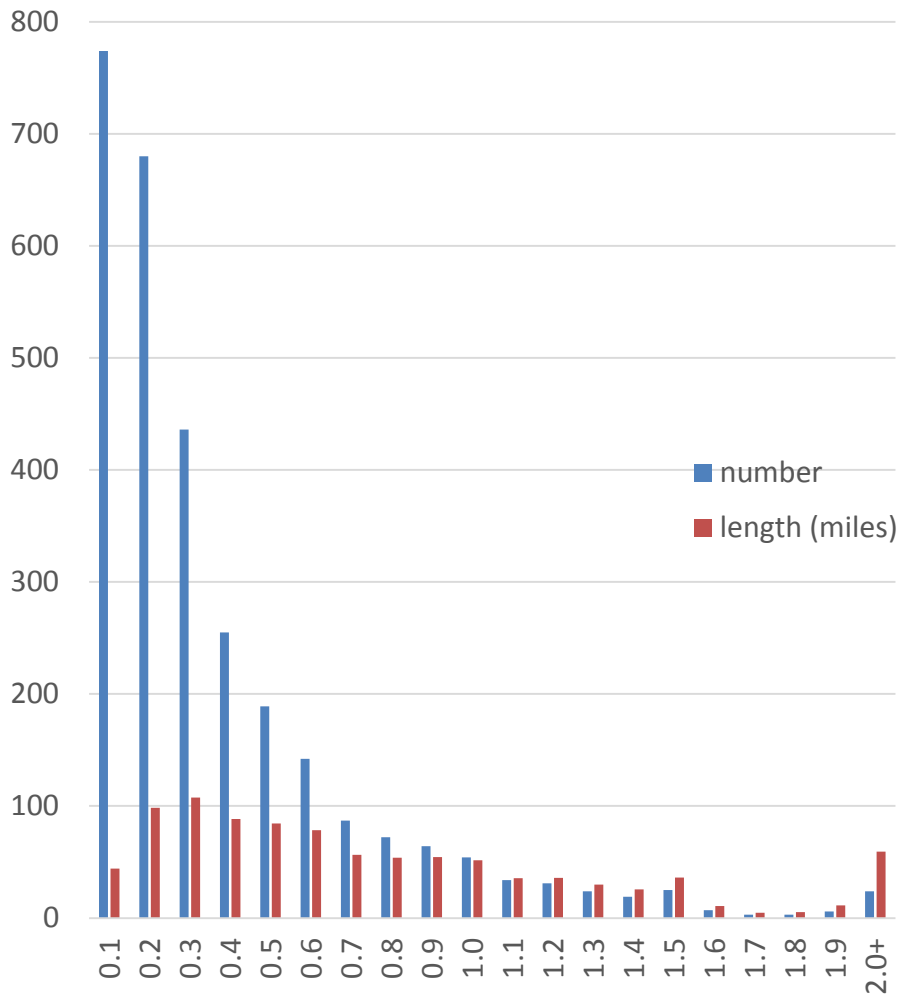
Road Segment Statistics

Layer	Number of Road Segments
2010 Statewide Model	5,500
TransRoad	75,000
TransRoad less Class 4, private roads, trails, & misc.	53,000
TransRoad usable segments plus centroid connectors	54,000
2015 TransRoad Statewide Model	21,000

Study Watersheds: Upper White River

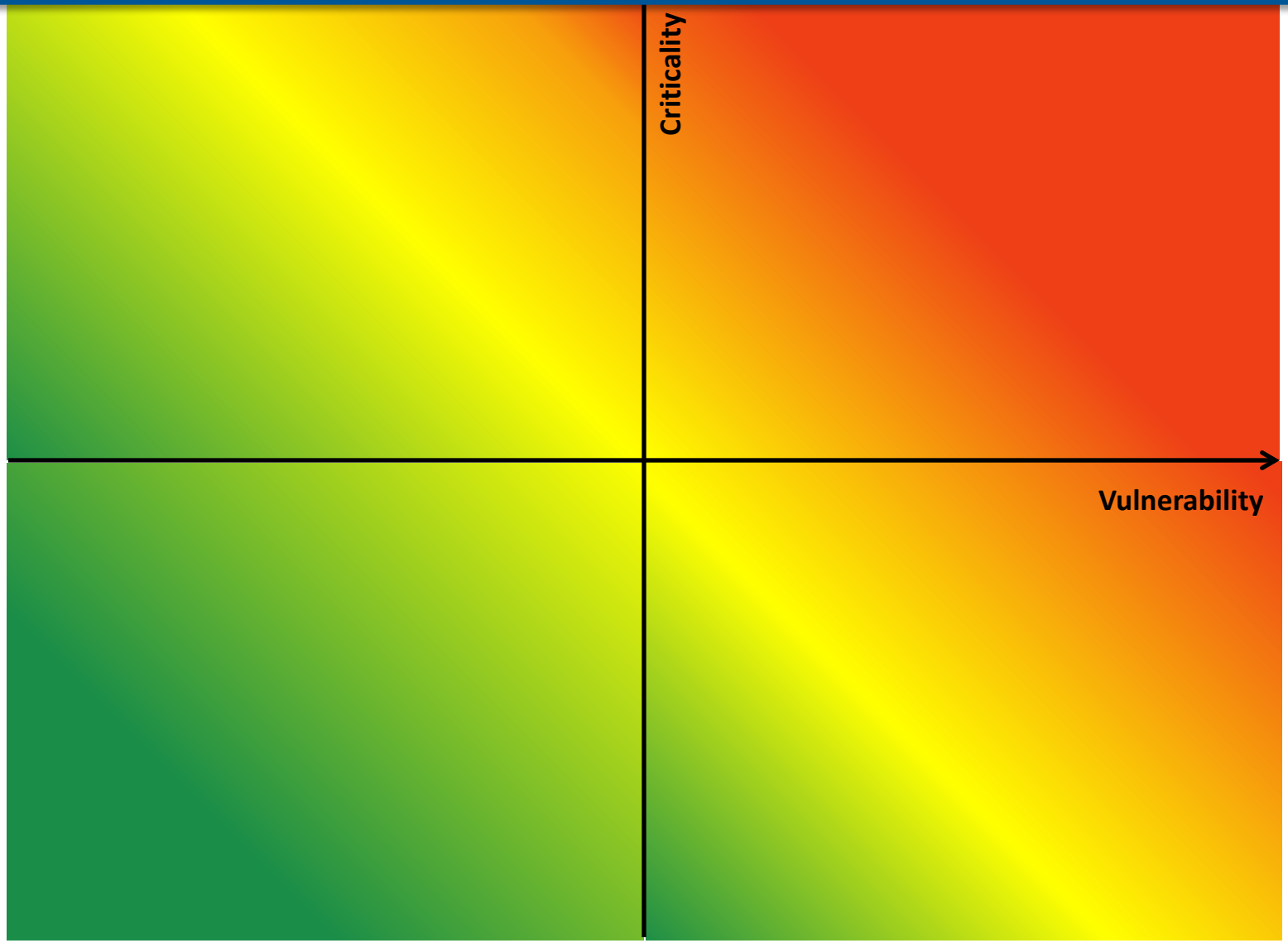


Study Watersheds: Upper White River



2938 road segments (includes Class 4 & private roads)

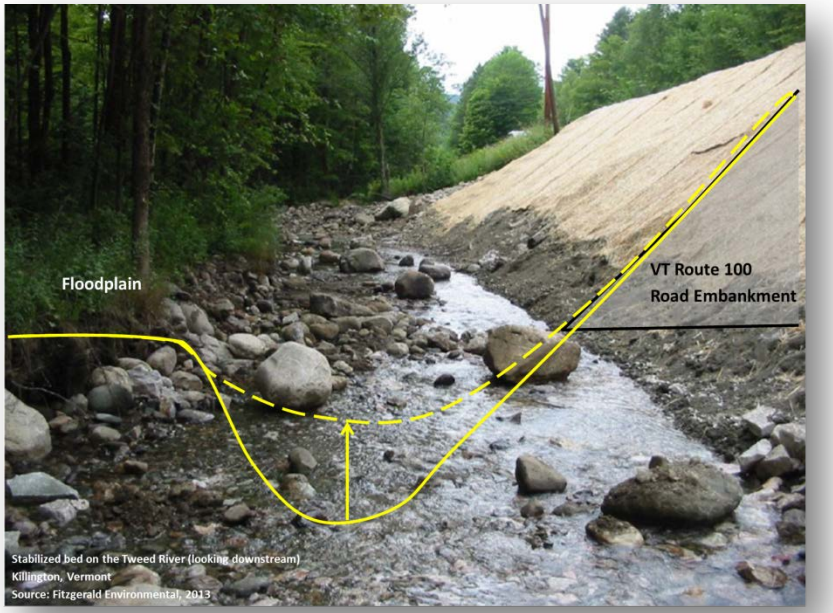
Risk Assessment



Mitigation Planning

Develop Mitigation Options

- Infrastructure Improvements (Revised alternatives analysis and design standards)
- River Management
- Alternative Routes
- Roadway Relocation
- Conservation
- Land Use Regulation



Transportation Flood Resilience App

Why have an App?

- Centralizes data for all users
  - Ensures everyone has latest version
- No commercial software requirements for users
  - Nothing to install or license
- Maximizes accessibility
- Simplifies complex data queries to answer technical questions for users/stakeholders
- Provides efficiencies over desktop GIS
  - Makes connections between datasets that would otherwise be cumbersome
- Structures/guides workflow to help users better understand the full risk picture

Transportation Flood Resilience App

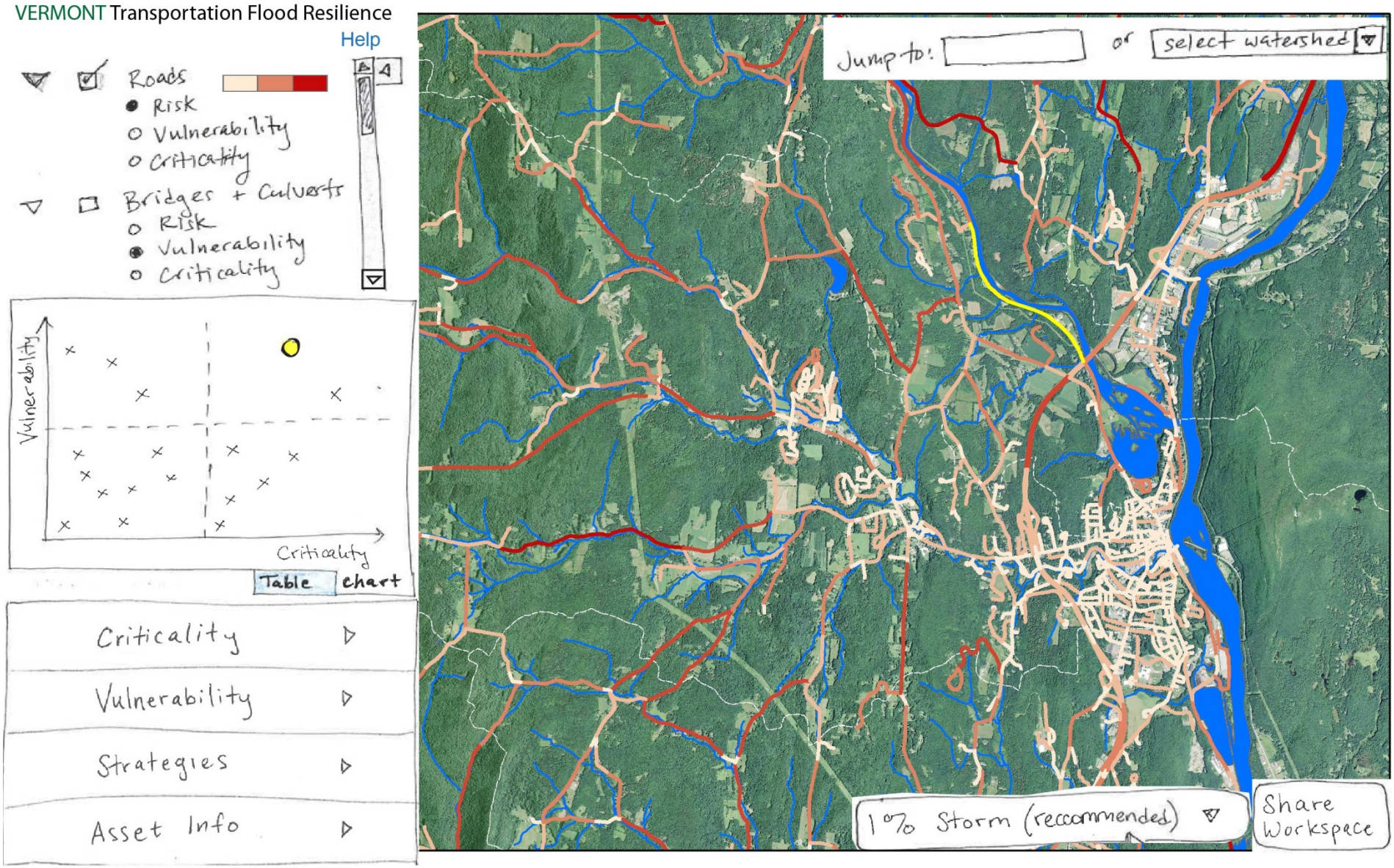
Primary Users

- VTrans (Strategic Planner, Bridge Engineer, Asset Manager, Hydraulic Engineer)
- VTDEC (River Management Engineer, Floodplain Manager, River Scientist)
- RPC (Regional Planner, Transportation Planner, staff)
- VTDEMHS (Hazard Mitigation Planner, Hazard Mitigation Grant Program Project Coordinator, Emergency Operation Center Watchstander)

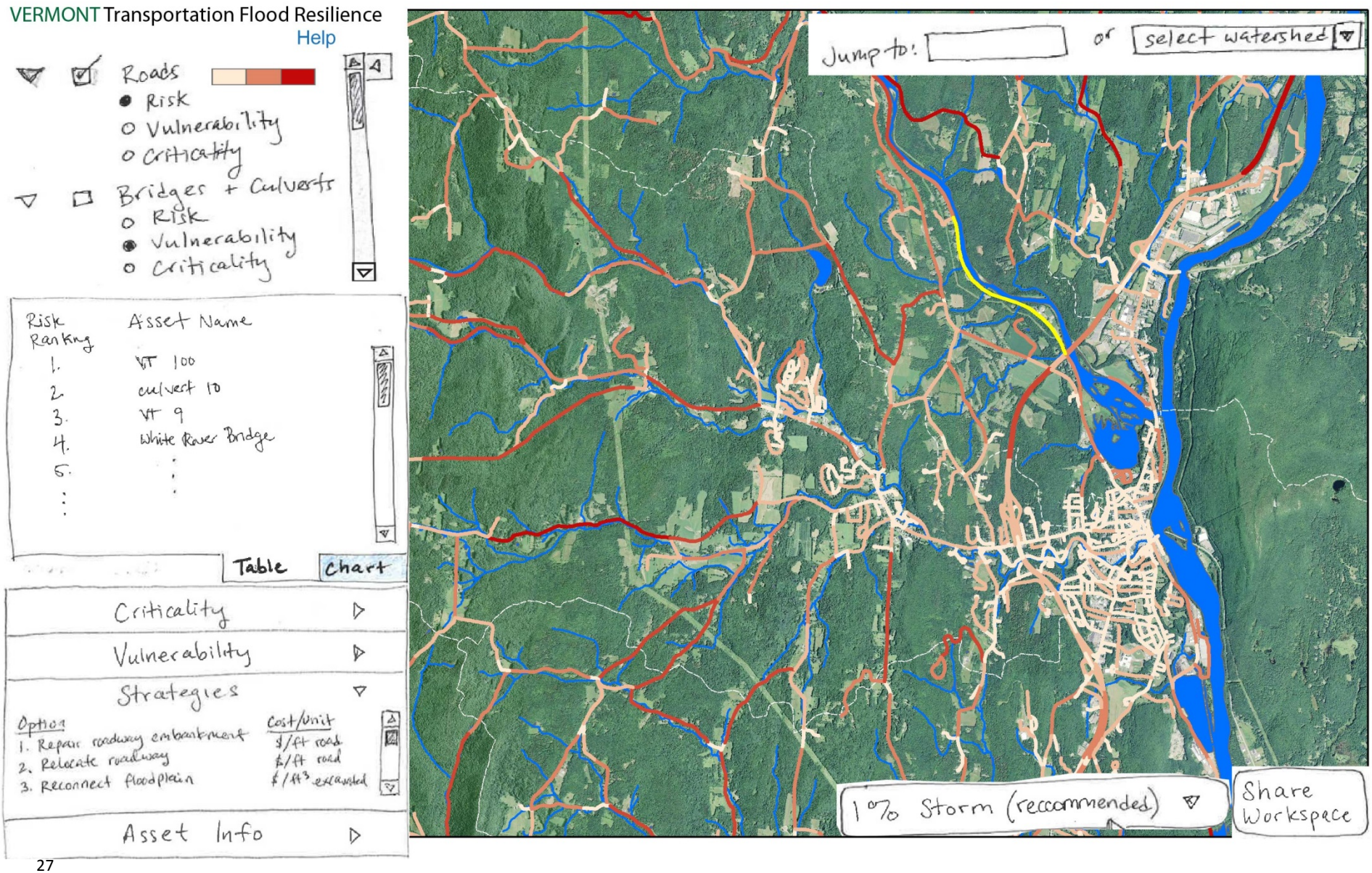
Co-beneficiary Users

- VTrans (District Manager, District Tech, Project Manager)
- VTACCD (Economic Development Specialist , Community Planner)
- Municipal Official (State Support Function 1, Planner, emergency management, Road Foreman)
- VTDEMHS (Emergency Operation Center GIS Analyst)
- Researcher (Academia, Agency, NGO, Private)
- Consultant (Planner, Engineer)

Transportation Flood Resilience App

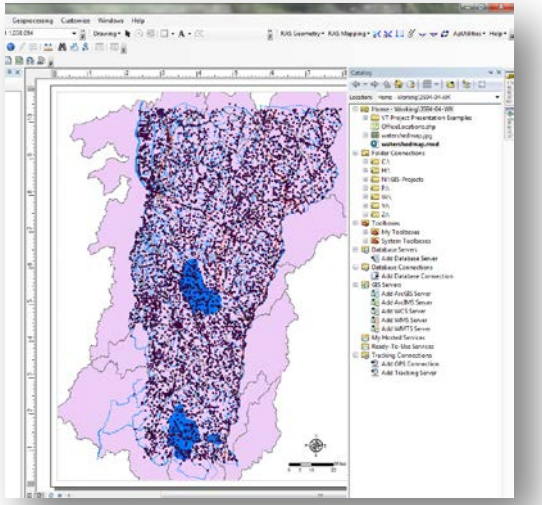


Transportation Flood Resilience App



Database Development & Management

- **Microsoft SQL Server geospatial database**
- **Container for source and derived datasets**
  - watershed attributes
  - road segment/river reach data
  - site analysis
- **Backend for the App**
- **Generalized schema for extension to additional watersheds**
- **Eventually administered by VTrans**
- **Will provide procedures, tools and training to VTrans to update/add data**



Thank you.

Joe Segale - joe.segale@vermont.gov

Roy Schiff - roys@miloneandmacbroom.com

Lauren Padilla - lpadilla@stone-env.com

Evan Fitzgerald – evan@fitzgeraldenvironmental.com

Norm Marshall – nmarshall@smartmobility.com

Lucy Gibson – lgibson@dubois-king.com





ACEC/NHDOT 2016 Technical Exchange Conference, Concord, NH | April 7, 2016

MILONE & MACBROOM

Fitzgerald Environmental Associates, LLC.
Applied Watershed Science & Ecology

DuBois & King Inc.

STONE ENVIRONMENTAL

smart mobility