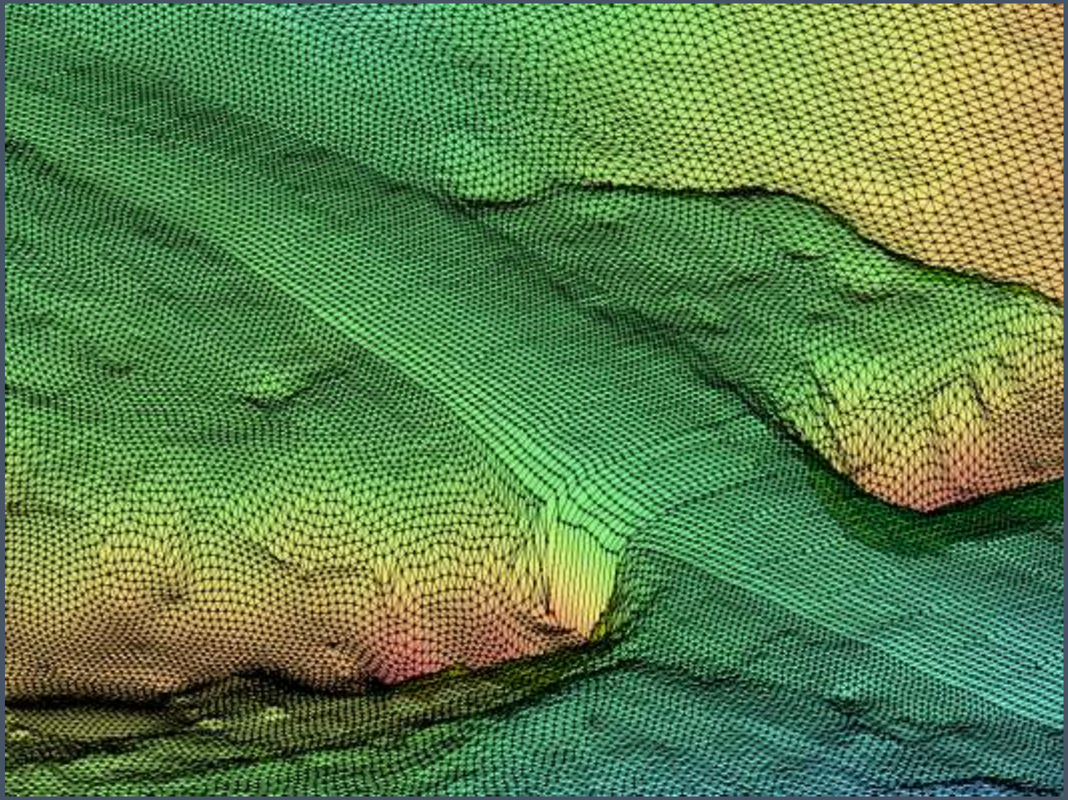
MODELING HYDRAULIC CAPACITY OF CULVERTS IN NEW HAMPSHIRE



Thomas P. Taggart, EIT
Assistant Flood Hazards Geoscientist
New Hampshire Geological Survey
New Hampshire Department of
Environmental Services

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Outline

- Quick overview of NH stream crossing efforts to date
- What methods do we use?
  - 1st order model based on algorithms pulled from FHWA's HY-8 Model
  - Exploring 2D modeling using two different models
- What are our steps going forward?
  - What screening parameters should be used for selecting culverts for 2D modeling?

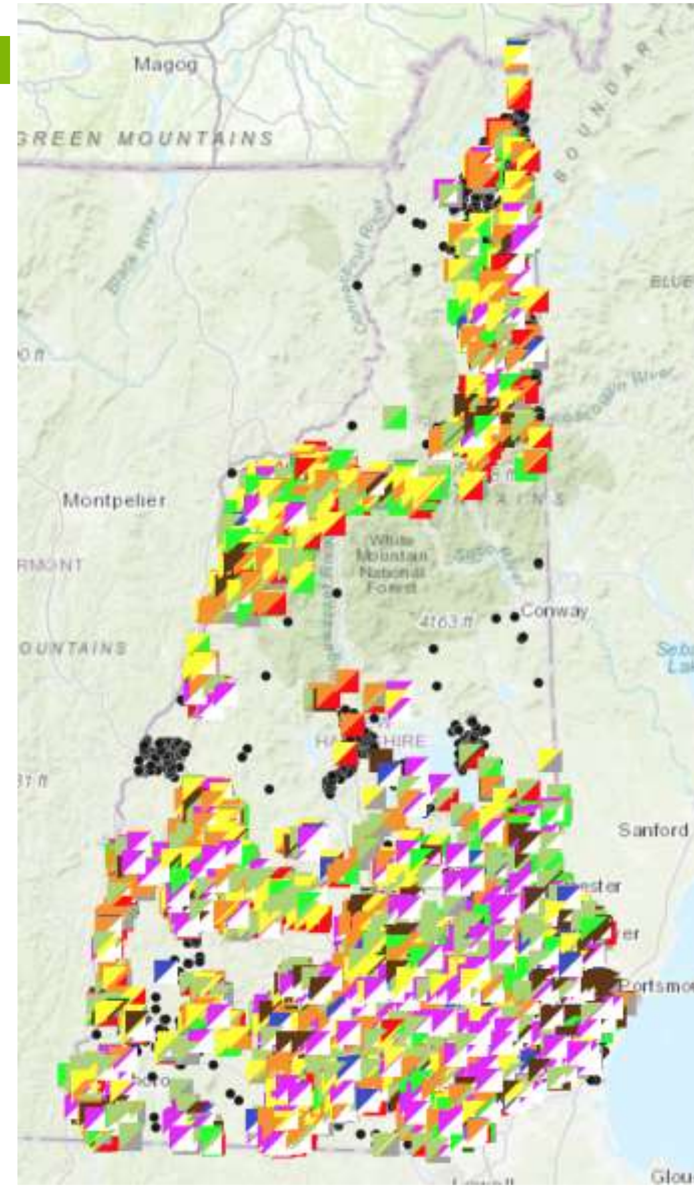
Where are we now?

- Have focused on:
  - Aquatic Organism Passage
  - Geomorphic Compatibility
  - Structure Condition

- Multi-stakeholder effort
  - Assessed 7000+ locations across the state - 9000 left!

- Current efforts focus on well understood issues, but…
  - How do we examine flooding concerns?
  - Is geomorphic compatibility enough? Not likely…

- Also when looking at hydraulic capacity, what do we focus on?
  - Continual small-scale flooding issues?
  - Potential for catastrophic failure?



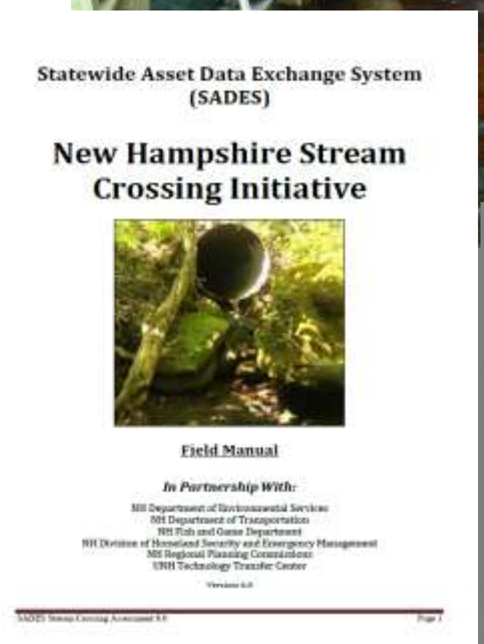
Hydraulic Capacity Analysis Methods

- Simplified Hydraulic Capacity Estimates
  - Streamworks – Trout Unlimited Model
    - 1st Order estimates of Hydraulic Capacity
    - Inputs:
      - Field: Local relative elevations, structure information
      - GIS: Topography, land cover, soils, wetlands/ponds, precip, streamflow
    - Basis: HY-8 (FHWA)

- 2D Modeling
  - Using HEC-RAS 2D, Aquaveo's SMS
    - Initial investigations of 2D flood models
    - Inputs:
      - Field: cross sections, structure information
      - GIS: LiDAR, land cover (Manning's N), streamflow

Simplified Modeling

Collection of field parameters

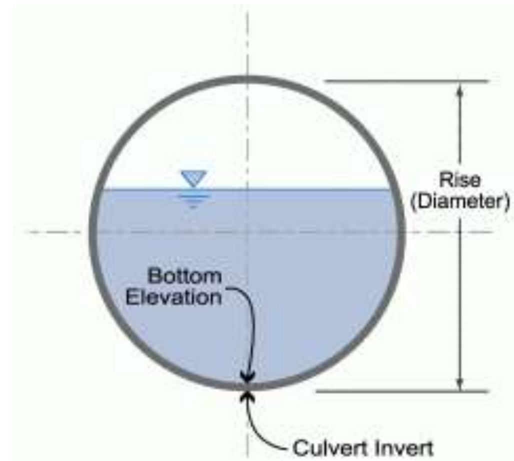


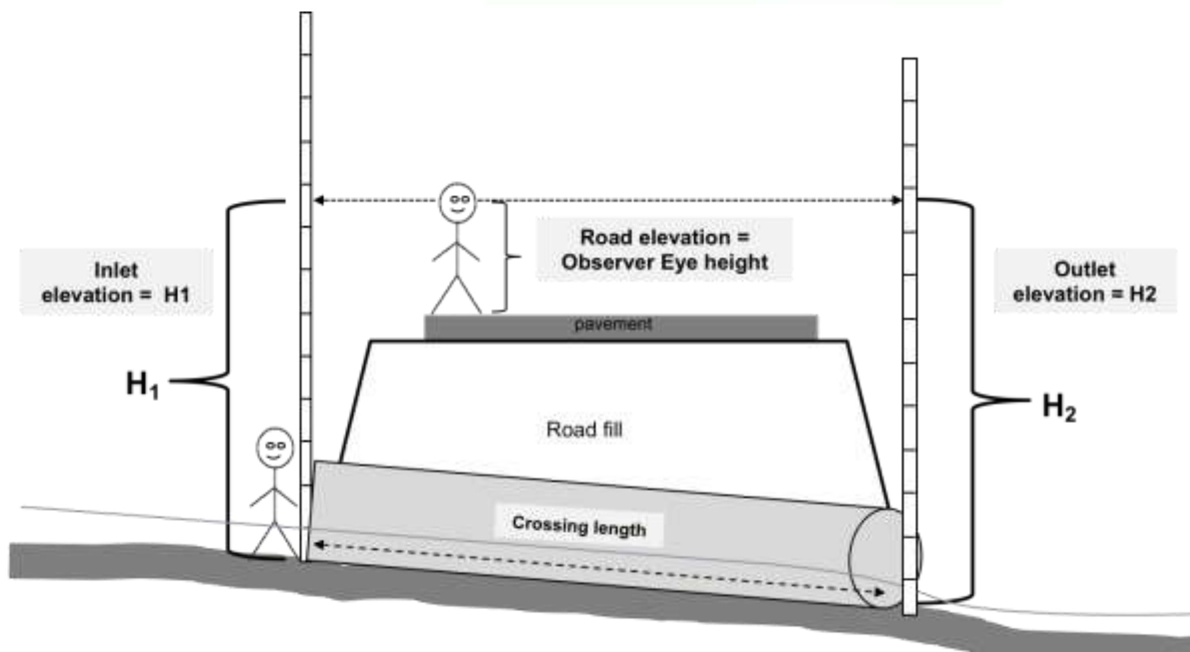
NH Stream Crossing Assessment Protocol

- Training each spring
- Environmental and Transportation data
  - Input for 3 screening tools used to rank culverts
- Electronic data collection

Streamworks – Trout Unlimited Model

- Crossing structural characteristics
  - Shape, material
  - Width, height and length
  - Condition – obstructed, deformed, rusted out
- Crossing elevations
  - Inlet Invert Elevation
  - Road Elevation
  - Outlet Invert Elevation



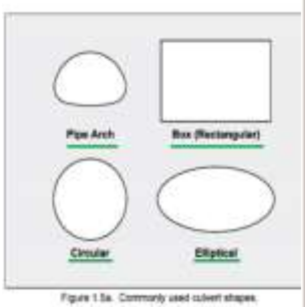


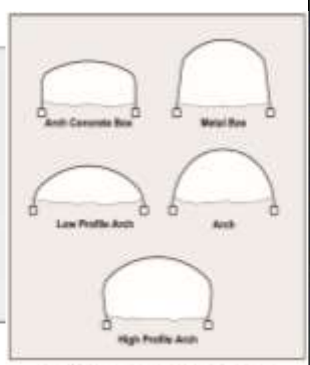
Streamworks – Trout Unlimited Model

- Brought into an excel-based, batch version of HY-8 equations
- Which set of equations from HY-8?
  - User translates shape, material, edge type into a culvert reference number - activates correct eqns.
- Combined with output from GIS processing
  - Drainage area, soils, precipitation, etc.
- Streamflow predictions from NH / StreamStats regression equations

Selecting the Culvert Type Reference Number

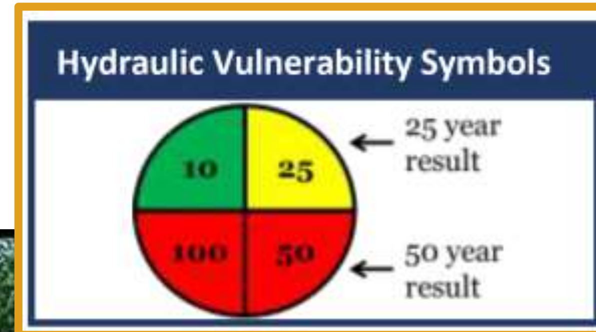
Culvert Shape	Pipe Material	End and Edge Type	Culvert Type Reference No.
Circular	CMP	Thin Projecting	1
		Mitered	2
		Square Headwall	3
		1:1 Beveled Edge	6
		1.5:1 Beveled Edge	7
	RCP	1:1 Beveled Edge	6
		1.5:1 Beveled Edge	7
		Groove Projecting	4
		Groove Headwall	5
		Square Projecting	8
		Square Headwall	9
		End Section	10
	PVC	RC Square Headwall	50
		1:1 Beveled Edge	51
		1.5:1 Beveled Edge	52
		Mitered	53
	HDPE	RC Square Headwall	54
		1:1 Beveled Edge	55
		1.5:1 Beveled Edge	56
		Thin Projecting	57
		Mitered	58
	Corr PE	CM Square Headwall	59
		1:1 Beveled Edge	60
		1.5:1 Beveled Edge	61
		Thin Projecting	62
		Mitered	63

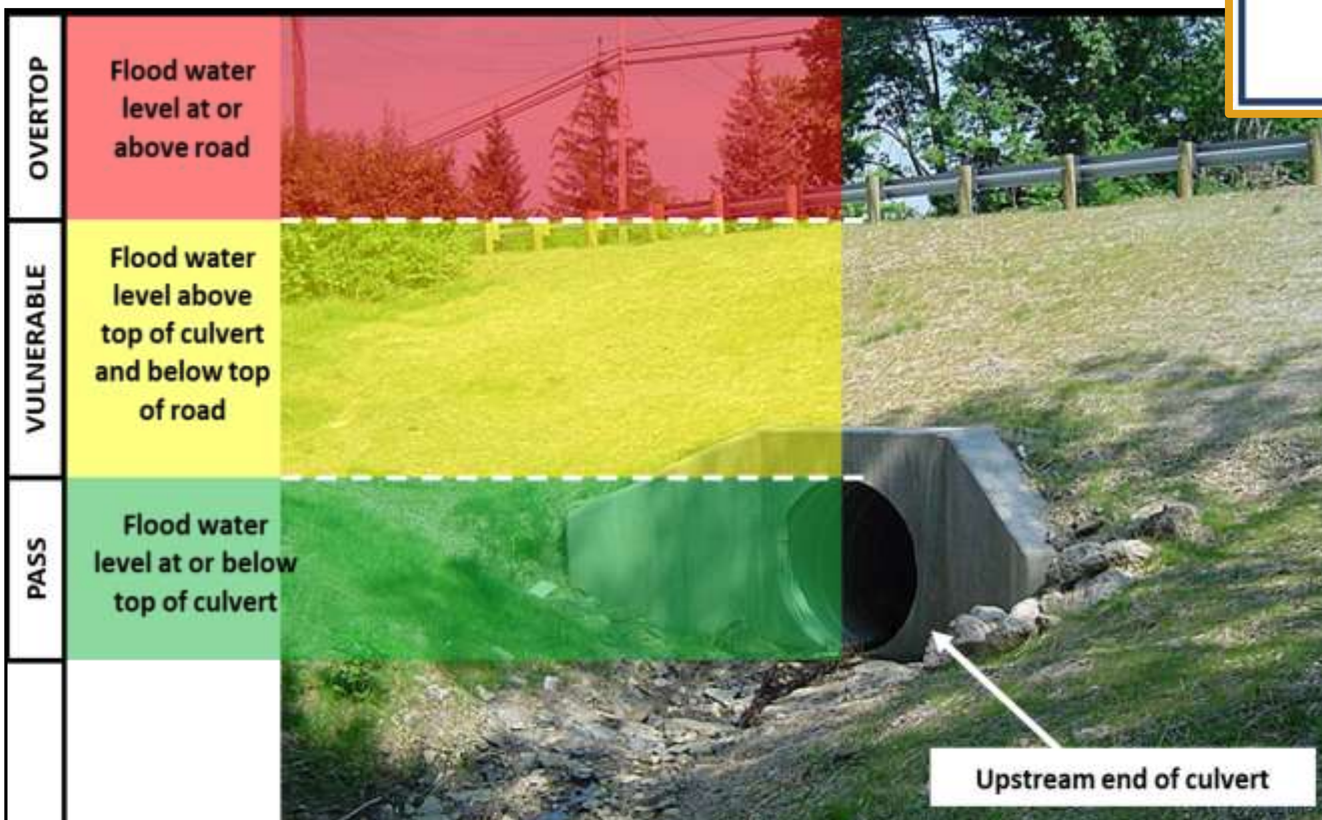




Visualizing and Communicating the Results

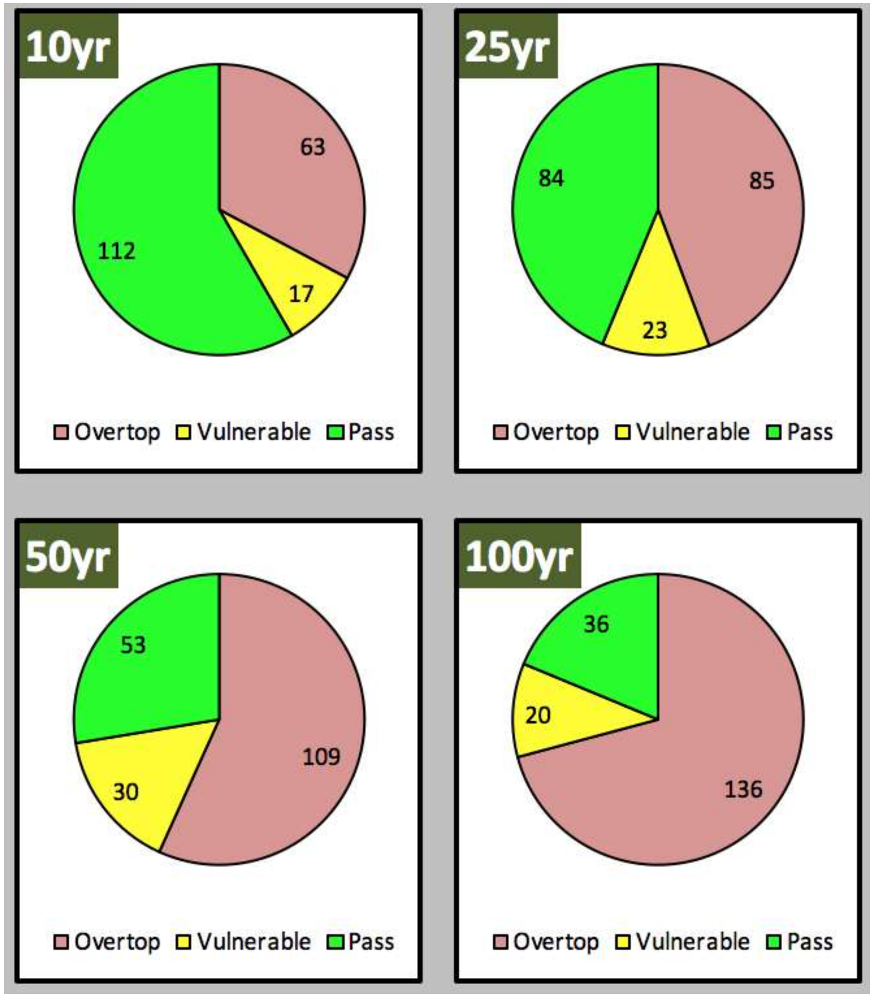
- **Hydraulic capacity model**
- **2, 10, 25, 50, 100 year flows**





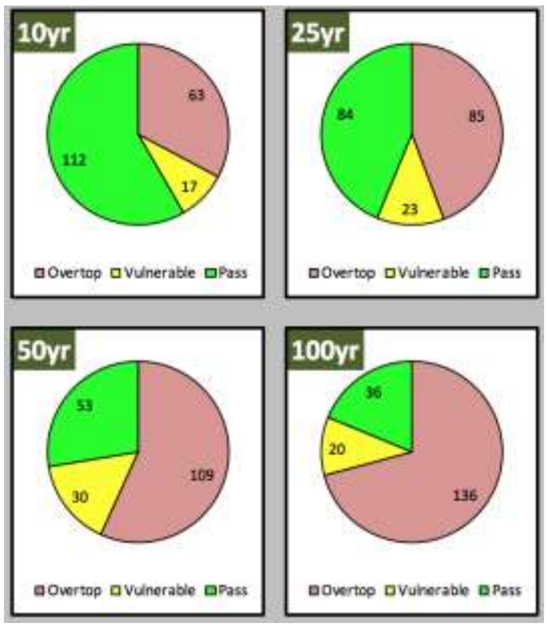
Results so far…..

- Several watersheds analyzed (over 1000 culverts)
- What trends are we seeing?
  - Large percentages of culverts are predicted to overtop at frequent storms (2, 10, 25)
  - Vast majority predicted to overtop 100yr+ storms

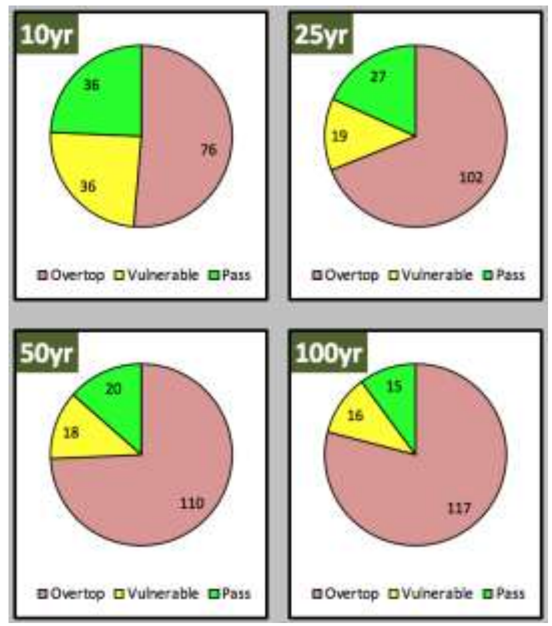


Results so far…

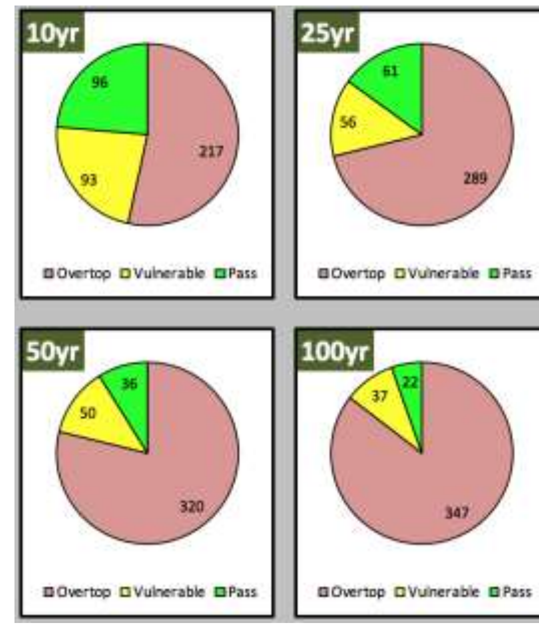
Less Steep → **More Steep**



Salmon Falls Watershed, ME–NH Border



Warner River Watershed, Central Western NH



Ammonoosuc River Watershed, Eastern-Northern White Mountains NH

- How do we properly interpret these results?
  - Our partner agencies will testify, that this overestimates failure rates…..

Simplified model….

- Limitations abound
  - Ignorant of network effects
    - Undersized upstream culverts providing storage?
    - Can a static model truly represent a dynamic system?
  - Simplified assumptions regarding runoff generation
    - Do the StreamStats regression equations adequately address
      - urban stormwater effects?
      - Initial moisture conditions?
      - Culvert conditions, obstructions

Upstream culverts providing flood storage and moderating peak flows?

2D Modeling Efforts

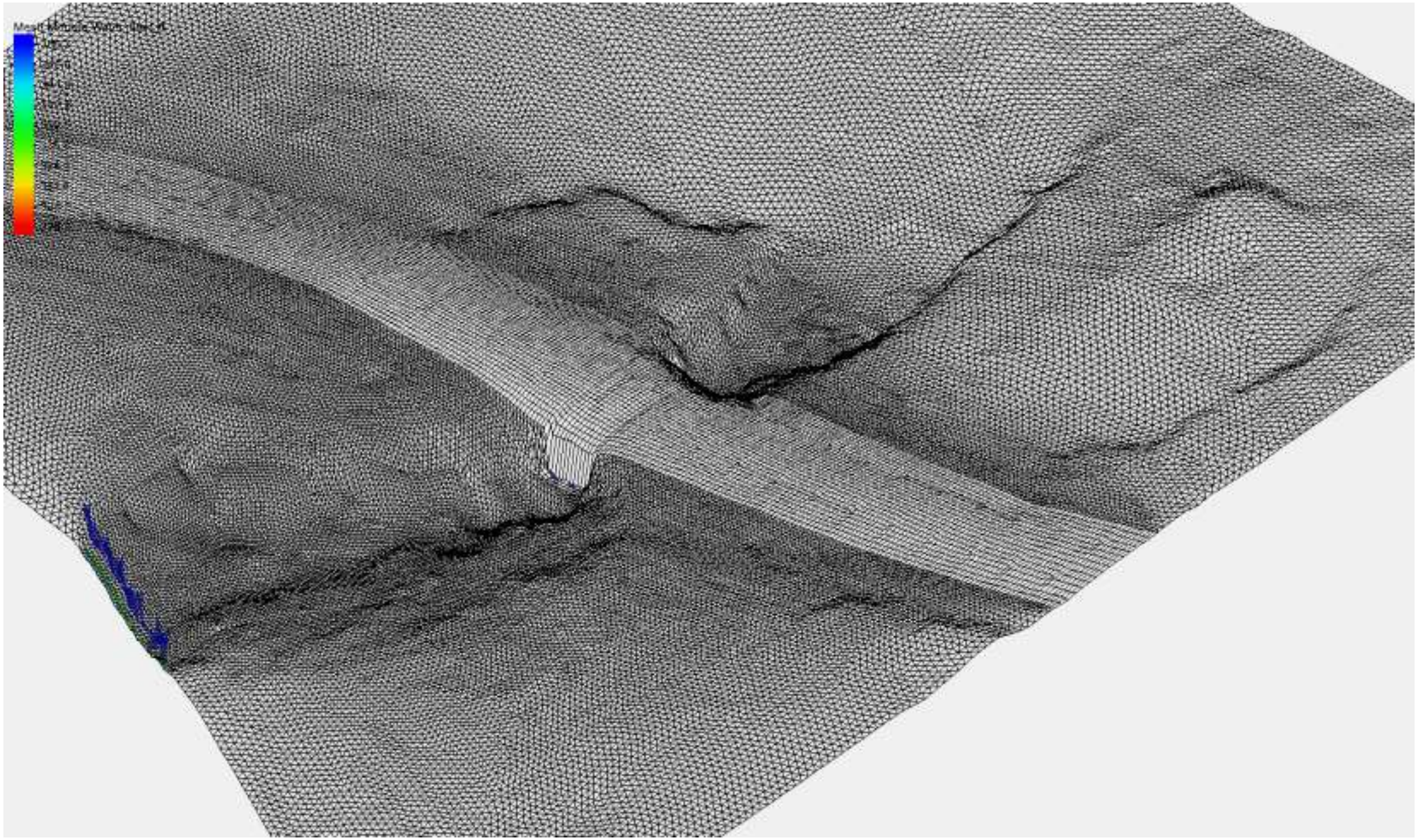
- Two parallel but ultimately different analyses
  - Culverts as culverts
    - Simple analysis of capacity – looking for overtopping at different flows
  - Culverts as dams
    - Assuming obstructions or deformations creates large volume buildup

- Both efforts follow similar data collection
  - Cross sections are gathered for 100-200 ft upstream/downstream
  - Merged with LiDAR data
  - Model domains and parameters are set
  - For each predicted peak flows (2, 10, 25, 50, 100 yr)

2D Modeling Efforts

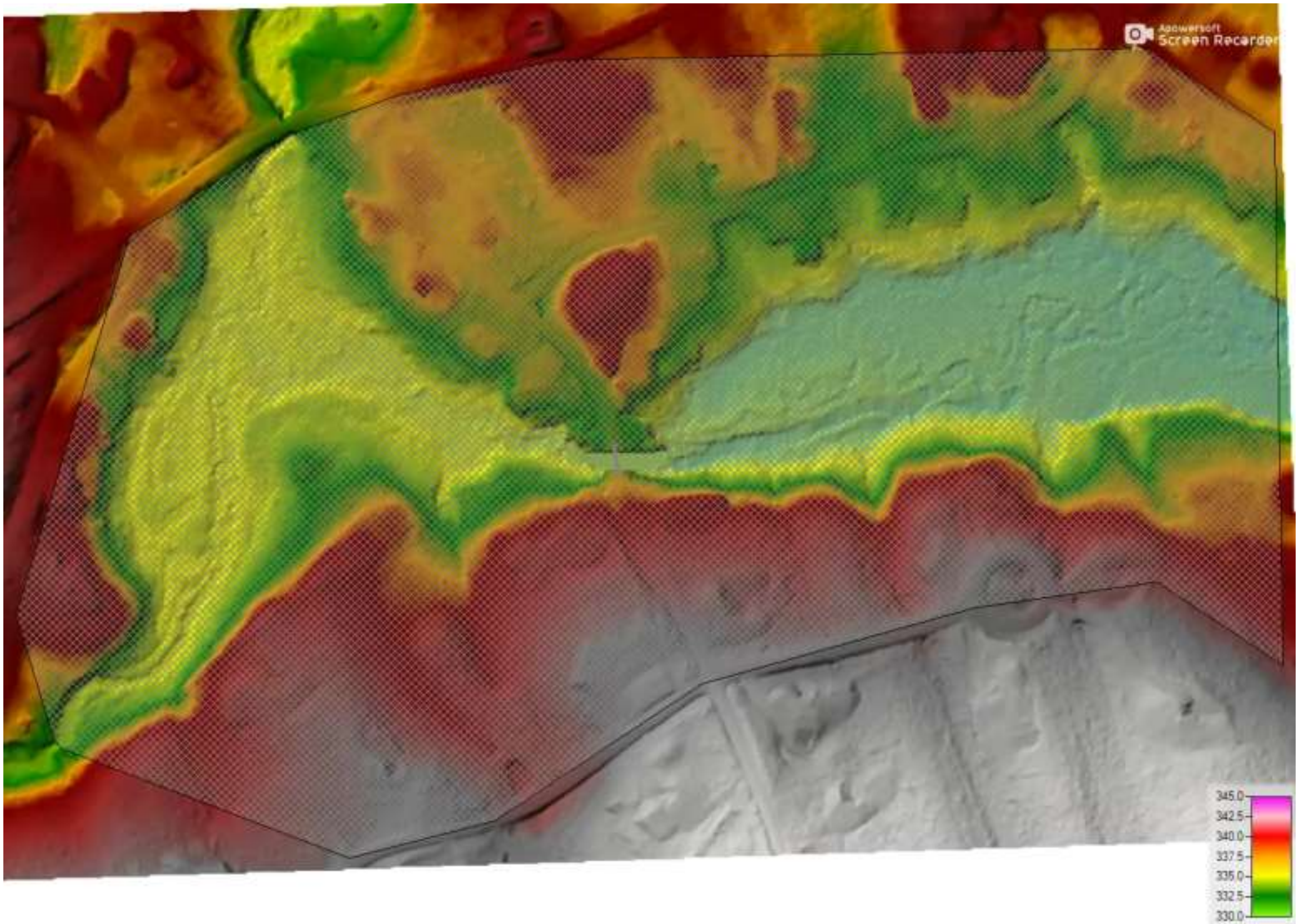
Culverts as Culverts

Being run in Aquaveo's SMS



2D Modeling Efforts

Culverts as Dams
Being run in 2D HEC-RAS (5.0.3)

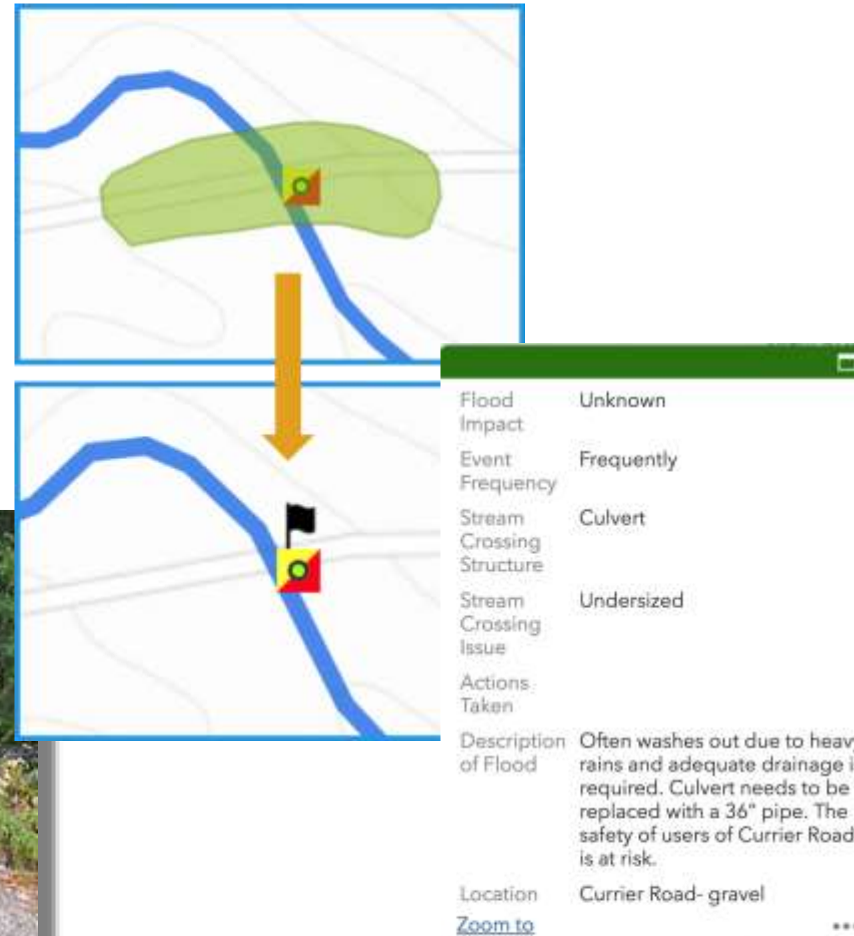


Next Steps….

- Continue Modeling
  - Model more culverts using the Streamworks-TU model
    - In talks about improvements to address upstream network effects
  - Identify culverts that could cause high-risk failures, catastrophic events
    - culverts with large cover depths (storage volumes), near population centers
  - Continue and refine 2D model development
    - Field collected cross sections (time intensive) versus channel definition from hydraulic geometry curves

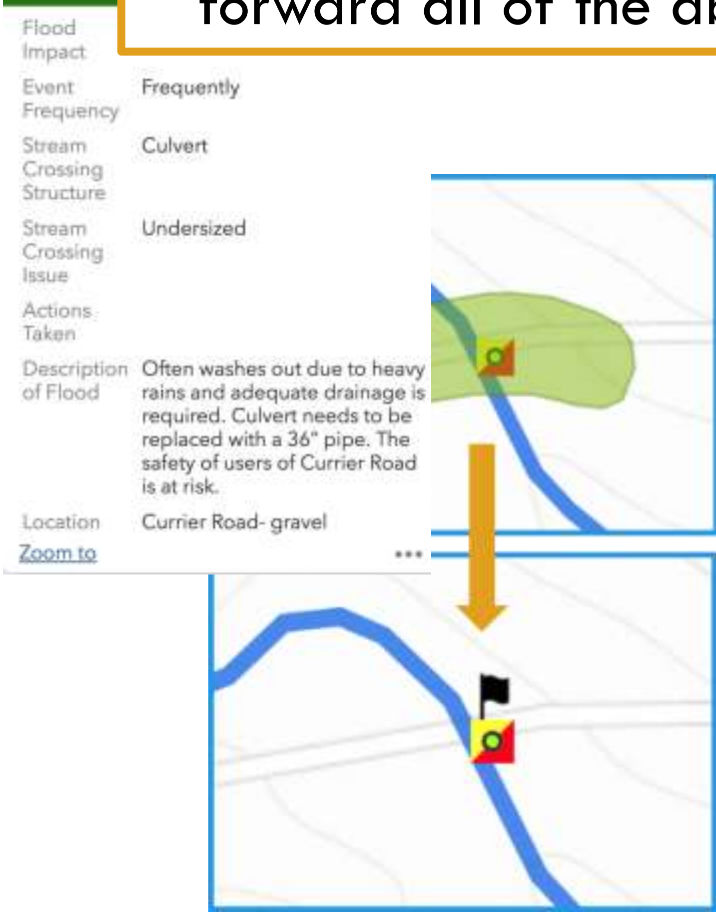
Next Steps….

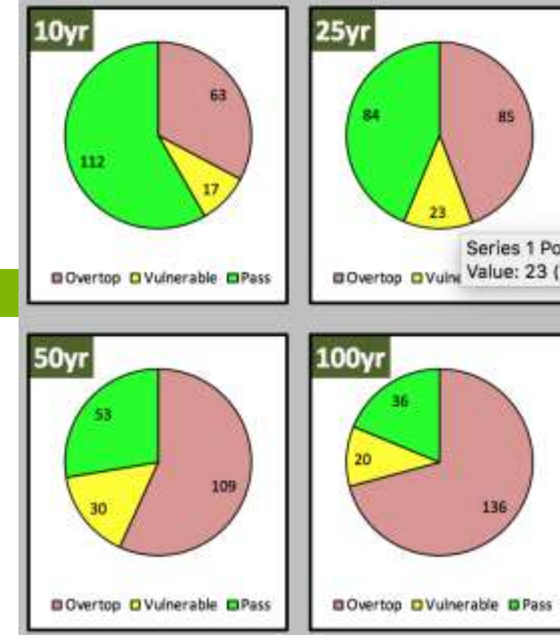
- Incorporate historical, first hand knowledge
  - Development of a statewide flood hazards geodatabase



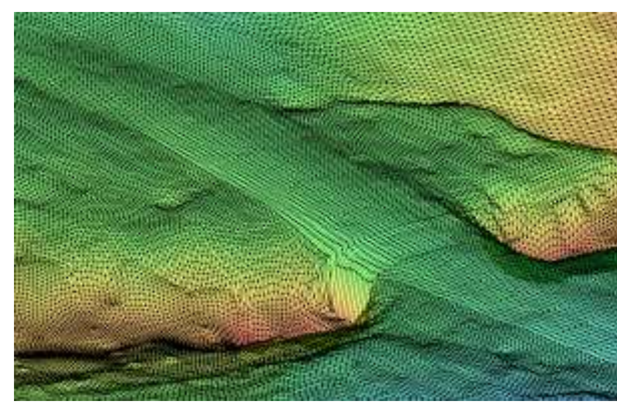
Where we hope to go…

Is this be the best path forward all of the above?





Cross Effort Comparisons



Thank You!

New Hampshire Stream Crossing Initiative

Lead by:

NH Department of Environmental Services

- Geological Survey
- Wetlands Bureau

Co-Leads and Partners:

NH Department of Transportation

NH Fish and Game Department

NH Division of Homeland Security and Emergency Management

MISSION

Inventory stream crossings throughout the state to inform data-driven decisions on culvert replacement and stream restoration

- Multi-agency effort to document transportation and environmental concerns
  - Combined protocol
  - Individual agency responsibilities clear on specific missions and expertise
- Field assessments are coordinated
  - Minimize duplication of effort
- Consistent messaging to the public on data outputs and scoring