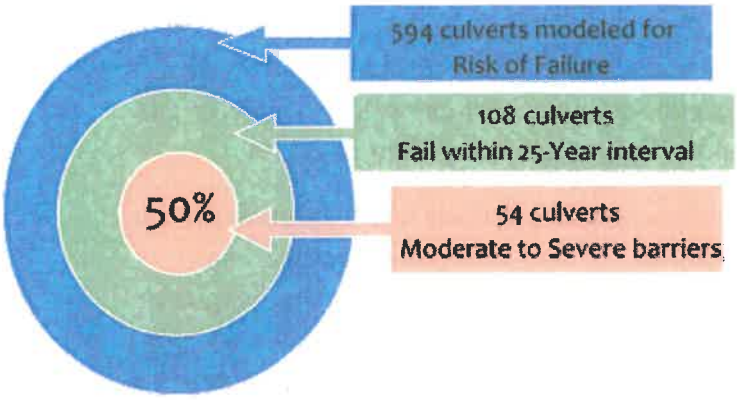
II. General Recommendations:

Wherever possible, build road-stream crossings that allow for natural stream function upstream, downstream and within the structure.



Proportion of culverts that fail in the 25-year flood interval and are considered moderate or worse barriers to fish and wildlife movement

There is significant overlap between flood risk and habitat barriers at non-bridge road-stream crossings; the results of HVA's regional study of the intersection of culvert barrier status and flood risk indicate that 56% of all culverts that fail in the 25-year flood interval or smaller are also considered moderate or worse barriers to fish and wildlife movement based on NAACC evaluation. A growing body of research indicates that design techniques that conserve stream shape and processes through a crossing structure accomplish multiple benefits- these structures reduce long-term maintenance costs, risk of failure during large floods, and restore stream habitat connectivity[1]. ***The Town of Dover should build road-stream crossings that conserve stream shape and process across the road elevation to the maximum extent possible with every replacement project, using the principles of Stream Simulation Design.***

Heavy rain from a thunderstorm, Town of Sharon. Photo source: Litchfield County Times

[1] Stream Simulation Working Group. (2008). *Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings*. San Dimas Technology and Development Center: U.S. Department of Agriculture, Forest Service.

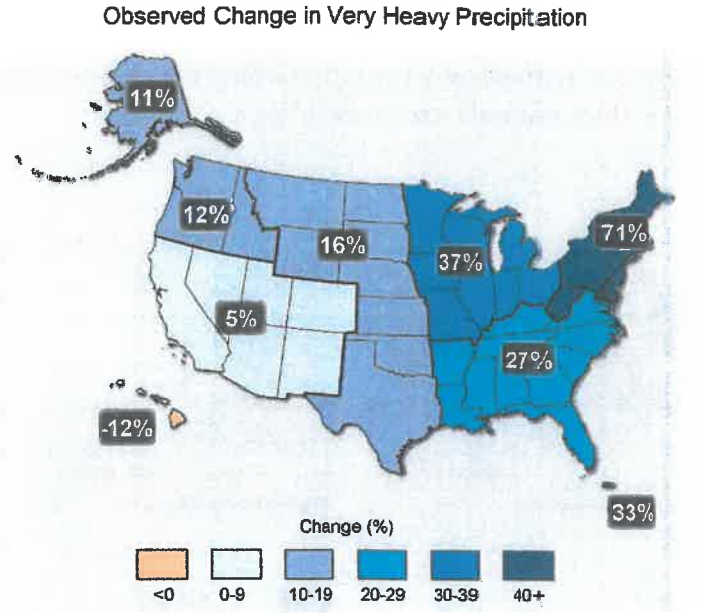
Gillespie, N., et al. (2014). Flood Effects on Road–Stream Crossing Infrastructure: Economic and Ecological Benefits of Stream Simulation Designs. Fisheries, 39(2), 62–76.

Levine, J. (2013). An Economic Analysis of Improved Road-Stream Crossings. Keene Valley, NY: The Nature Conservancy, Adirondack Chapter.

Massachusetts Division of Fish and Game, Division of Ecological Restoration. (2015). Economic & Community Benefits from Stream Barrier Removal Projects in Massachusetts.

Wherever possible, build road-stream crossings to pass the 100-year recurrence interval flood, based on the most up-to-date hydrologic information for the Northeast.

Climate change is increasing occurrences of intense rainfall and extreme precipitation events in northeastern U.S. towns, such as the Town of Dover[2]. Road-stream crossings are particularly susceptible to increased flood risk, especially if they were designed using outdated hydrologic information. Many structures in Dover were sized using design storms derived from National Weather Service Technical Paper 40 (TP-40)[3], which was released in 1961. The most recent NOAA Precipitation Atlas for the Northeastern United States (released in 2016)[4] shows a roughly 2-inch increase in the amount of rain expected during the 24-hour, 1% annual chance storm from TP-40. This trend is expected to continue as climate change progresses. ***Therefore, it is critical that the Town of Dover takes advantage of replacement projects to increase hydraulic capacity at road-stream crossings, using the best available hydrologic information.***



The map shows percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2012 for each region of the continental United States. The changes shown in this figure are calculated from the beginning and end points of the trends for 1958 to 2012. (Source: Melillo, J.M. et al., Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, as updated from Karl, T. R., et al. (2009): Global Climate Change Impacts in the United States. T.R. Karl, J.T. Melillo, and T.C. Peterson, Eds. Cambridge University Press.)

Always consider potential downstream impacts when right-sizing road-stream crossings

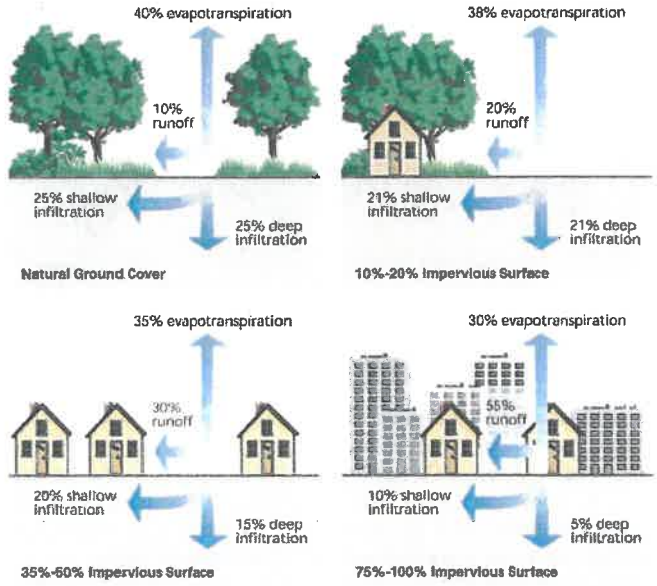
While increasing hydraulic capacity is critical to reducing maintenance costs and flood risk at individual structures, care must be taken to minimize risk to downstream property and infrastructure when doing so. Many undersized structures in road elevations currently serve as de-facto flood storage dams, reducing downstream flood peaks. Note that this is not a good

[2] Spierre, Susan G, and Cameron Wake. (2010). Trends in Extreme Precipitation Events for the Northeastern United States 1948-2007. *Carbon Solutions New England.*
New York State Department of Environmental Conservation. (2015). Observed and Projected Climate Change in New York State: An Overview. https://doi.org/10.7930/J0Z31WJ2

[3] Hershfield, David M. (May 1961). *Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from I to 100 Years*. Washington D.C.: Engineering Division, Soil Conservation Science, U.S. Department of Agriculture.

[4] Perica, Sanja, Sandra Pavlovic, Michael St Laurent, Carl Trypaluk, Dale Unruh, Deborah Martin, and Orlan Wilhite. (2015). *Precipitation-Frequency Atlas of the United States: Volume 10 Version 2.0: Northeastern States.* Silver Spring, Maryland: National Oceanic and Atmospheric Administration.

reason to leave undersized structures in place- road elevations are not designed to the same standards as dams, and failures can be catastrophic. *The Town of Dover should consider road-stream replacements holistically, with the appropriate amount of analysis to understand potential risk to downstream property and infrastructure.* In some cases, it may be necessary to increase hydraulically capacity starting at a downstream structure in a series and work upstream, or replace multiple structures at once.



Changes in proportion of rainfall that becomes runoff in different IC scenarios (Source: Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG))

Consider restoring and protecting natural hydrology upstream of undersized structures through Green Infrastructure/Low Impact Development practices

Impervious surfaces like roofs, roads and parking lots cause runoff to enter the stream channel much faster than undeveloped landscapes, which generally allow water to soak into the ground. This often results in higher peak flows downstream of developed areas, which in turn put more strain on hydraulically inadequate structures. Green Infrastructure practices that capture and infiltrate stormwater runoff before it reaches the stream channel can help reduce flood risk and maintenance costs at structures downstream of developed areas. These practices can also restore and protect water quality. *The Town of Dover should identify hydraulically inadequate structures downstream of areas with existing high concentrations of impervious cover and areas targeted for development, and consider the adoption of Green Infrastructure/LID practices in areas where impervious cover is contributing to higher peak flows.*

Use this document to track ongoing maintenance, replacement projects, and other factors that may change priorities

This document, particularly the Road-Stream Crossing Inventory section, should be updated periodically to reflect changing stream and structure conditions as well as ongoing maintenance and replacement projects. This is important for internal record-keeping and continuity of knowledge between staff, but is also extremely helpful for securing financing for replacement projects. For example, FEMA Hazard Mitigation Assistance through competitive grants or in the wake of the flood for projects like upsizing a road-stream crossing generally require a Cost-

Benefit Analysis; having comprehensive records of information such as required maintenance and associated costs, road closures during floods, and photographic documentation flood damage can be advantageous in this process. *The Town of Dover should use this plan as a framework for keeping track of important information related to road-stream crossing management.*