COMMUNITY PLANNING GUIDE

STREAM CROSSINGS

FLOOD RESILIENCY & ECOLOGICAL HEALTH

NORTH COUNTRY COUNCIL

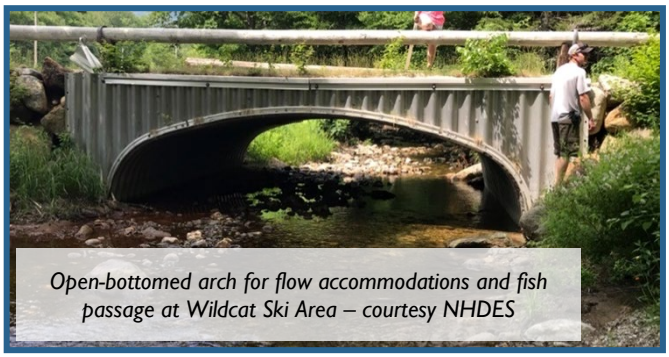
STREAM CROSSINGS

Stream crossings are structures (i.e., culverts, bridges, arches) that carry a road over a river, stream, wetland, or surface waterbody.

With over **20,000 crossings** within the state, they are critical to our road networks and infrastructure. Improperly designed and underperforming structures threaten infrastructure and property, public safety, aquatic habitat, and ecosystem connectivity.

Example of a poor & failing crossing in Rumney, NH 2019

Failed corrugated steel culvert – courtesy NHDES



Open-bottomed arch for flow accommodations and fish passage at Wildcat Ski Area – courtesy NHDES

CREATING HEALTHY STREAMS & RESILIENT COMMUNITIES

Understanding the importance of stream crossings can help stakeholders in decision-making to:

- Mitigate **flood impacts** to adjacent properties and ecosystems.
- Ensure **public safety** and **emergency service access** during natural hazard events.
- Protect **water quality** and **stream health** through crossing and streambank improvements.
- Reconnect **fish & wildlife habitat** for ecologically and culturally important species.
- Reduce the frequency & costs of **emergency repairs.**

Extreme precipitation events are increasing, finds a 2017 Dartmouth College study showing a **53% higher frequency** between 1996-2014 than between 1901-1995[1]. Resulting in **road damage** and **closures** in critical travel corridors creating emergency access issues and **financial impacts** on local communities and tourism-oriented businesses. **Environmental impacts** are often compounding and under-addressed. https://journals.ametsoc.org/doi/10.1175/JHM-D-16-0195.1

Performing crossing assessments that rank **vulnerability to flooding**, **aquatic organism passage** and **geomorphic compatibility** with the river environment provides information that will *allow for data-driven decisions in prioritizing stream-crossing replacement projects within towns, watersheds, or regions.*

Update 02-2023

DEFINING THE IMPACTS OF STREAM CROSSINGS

What are the causes and effects of "bad" stream crossings?

Wood, leaves, & other materials are likely to create clogs in undersized crossings. Not only creating a barrier to wildlife, but clog-prone crossings are also costly to maintain and are more likely to overtop. Clogs can build over time or occur suddenly in high flows.

Undersized and poorly aligned crossings constrict water flows and result in higher flow velocities through the pipe, restricting wildlife passage and increasing the likelihood of streambed scour and damaging downstream erosion.

Crossings should maintain the same continuity of flows and streambed substrate materials as upstream and downstream. Unnatural structure bottoms and high-placed structures make it difficult for aquatic wildlife to pass during low flows.

Undersized and poorly aligned crossings that don't follow the natural stream form or accommodate high water flows can result in bank erosion and habitat degradation upstream and downstream. The crossing can become unstable as the material is washed away, and pools that develop downstream can lead to perching.

An unnatural backup of water upstream, called ponding, due to clogging or being undersized and can lead to road and streambank erosion and a higher likelihood of flooding in seasonal or storm-related events. It also alters stream habitat, which may be undesirable.

The crossing outlet is elevated above the water's surface, creating a waterfall effect due to poor design or installation. This can also worsen erosion. Most aquatic wildlife cannot navigate perched culverts, cutting them off from upstream habitat that may have resources needed for survival and reproduction.

Making the investment in designing stream crossings that can accommodate wildlife and protect stream health will ultimately reduce the costs associated with flooding, erosion and structural damage in the long term.

The images above are sourced from the *ASCA Project, managed by NHDES and hosted on the NH SADES System.*

STREAM CROSSING ASSESSMENT DATA COMPATIBILITY

- Fully Compatible
- Mostly Compatible
- Partially Compatible
- Mostly Incompatible
- Fully Incompatible

Geomorphic Compatibility

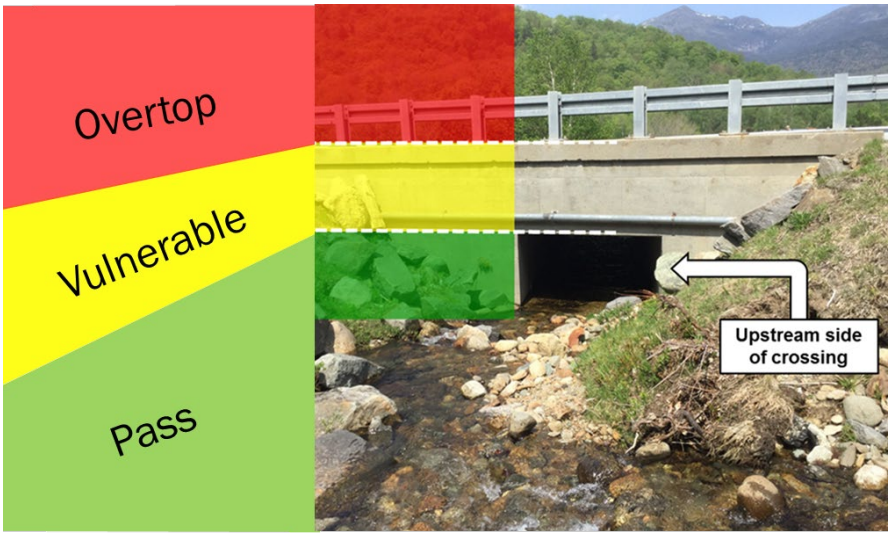
- The crossing's long-term compatibility with the natural form and sediment transport processes of the stream.

  How well is the structure designed, placed, and sized for the stream?
- What is evidence of incompatibility? Upstream sediment deposits, stream bed scour, bank erosion, failing bank armoring, the angle of the stream into the structure, improper culvert sloping, and a small ratio of structure width to stream channel width.

Flood Resiliency & Vulnerability

- How well can a crossing transport flows during a large storm event?

  What is the culvert's capacity to withstand peak discharge in 10-25-50-100-year floods?
- The vulnerability to overtopping (flooding over) of the road that can result in damage or public safety risk is modeled using calculated site drainage characteristics and land-cover data, along with the collected culvert and stream channel data.



- Full Passage
- Reduced Passage
- Passage Only for Adult Trout
- No Passage

Aquatic Organism Passage

- Whether fish & other aquatic species at different life stages can make it upstream of a crossing.

  Is there an outlet drop ("perching") , a downstream pool, clogs or other barriers, or is it too shallow or have high flow velocities that affect passage?
- ***Why Brook Trout?*** Their presence indicates good water quality and healthy streams, and they are a *species of conservation* need in NH in addition to being a staple for the outdoor recreation economy.

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STREAM CROSSING CONSIDERATIONS

DID YOU KNOW?


Wild Brook Trout

- Stream segments that become disconnected because of human-caused barriers can result in *local brook trout extinctions* within 2-6 generations (4-12 years) https://doi.org/10.1371/journal.pone.0001139.t001
- *Though upfront costs may be higher for a structure designed for better flow accommodations and wildlife, the annual costs become less expensive as the structure's lifespan increases.*

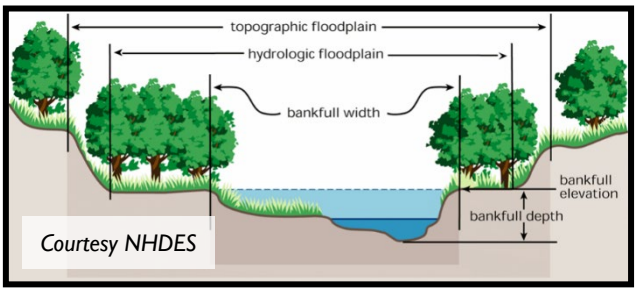

Crawford Notch 2017

Cost Benefit Study: compatible culvert upgrades can be **~38% less expensive** than in kind replacement and maintenance costs over 30 years, and creates additional economic value from ecosystem service restoration *https://www.mass.gov/files/documents/2016/08/wi/summary-of-der-economic-benefits-studies-all-phases.pdf*

Image Sources: (Left) Update: N.H. Sees Widespread Damage from Severe Wind, Rainstorm, NHPR, Oct 30, 2017, (Right) NCC

CULVERT DESIGN PRINCIPLES

BANKFULL WIDTH



- Culverts should span the bankfull width of streams (equivalent to the 1.5-year floodplain). Ideally, culverts should span over 1.2 times the bankfull width.
- Culverts that are smaller than bankfull width can cause pooling, erosion, structure damage, and can overtop, clog, and fail during flood events.

STREAM DEPTH, ANGLE & ORIENTATION


Perched Outlet limits passage Courtesy NHDES

- Culverts should match the vertical angle, elevation, and orientation of the stream channel. Where possible, culverts should match the stream's orientation as it crosses under the roadway. Streams should directly enter the culvert without relying on wingwalls or bank armoring to guide the stream.
- Culverts that do not match the stream angle or orientation may be at risk for erosion & sedimentation.

NATURAL STREAM CHANNEL BOTTOM

- When possible, culverts should be open-bottomed or embedded in natural stream channel material to promote natural sediment transport and aquatic organism passage.
- Concrete or steel-bottomed culverts can accelerate water flow, leading to erosion and limiting aquatic organism passage.

NATURAL FLOW CONDITIONS

- Crossings should seem invisible in the stream. A good crossing can maintain the same natural stream depths and flow velocities upstream, downstream, and within the structure.
- Downstream weirs, internal baffles, outlet cascades, and other retro-fitting practices can dissipate damaging flow velocities and increase passage for aquatic organisms.

STREAM CROSSING IMPROVEMENTS
KEY PLANNING CONCEPTS AND STRATEGIES

ASSESS & PRIORITIZE

- **Assessments**— Determine whether a stream crossing inventory has already been performed in your community. North Country Council is available to assist you in planning for any new assessments. Identify local partnership opportunities with organizations and institutions that can help in conducting the assessments and in managing the data and results.
  - To see if what information is available for your community, contact North Country Council or visit the NH Department of Environmental Services Aquatic Restoration Web Mapper, available at: bit.ly/2tXNoiq
- **Prioritization**—The results of stream crossing assessments can be used to assist with prioritizing culverts for replacement or improvement. Typically, culverts with poor condition, poor compatibility with the stream, and/or reduced aquatic organism passage are prioritized the highest. Cross-referencing local flood history information against the assessment data can help inform prioritization as well.

IMPLEMENT

- **Budget Improvement Costs**— Use the prioritization results to begin annual and multi-year municipal budgeting.
- **Research Best Management Practices (BMPs)**—When seeking to replace or retrofit a stream crossing, research BMPs to ensure what is required for crossing compatibility with the stream.
  - NH Department of Environmental Services provides technical and regulatory guidance on their *Streams and Stream Crossings* page. Visit: https://www.des.nh.gov/organization/divisions/water/wetlands/streams_crossings.htm
  - The University of New Hampshire has created a Stream Crossing Guideline (2009) that assists in the design considerations, construction, and permitting of stream crossings in New Hampshire. Visit: https://www.des.nh.gov/organization/divisions/water/wetlands/documents/nh-stream-crossings.pdf
- **Utilize Available Resources**—Assistance from state and non-governmental organizations, such as North Country Council, is available for planning and providing guidance regarding funding resources available for flood hazard mitigation and/or aquatic habitat improvements. North Country Council can also assist with multi-year capital improvements planning and budgeting that will allow funds for improvement efforts to be built up over time.
- **Consult with Experts**—Engineers, biologists, and agency staff can be consulted in order to design culverts that meet not only the permitting standards, but allow for adequate hydrological function, geomorphic compatibility with natural stream form, and in meeting resource conservation goals and ecological function.
- **Use Natural Bank Stabilization Techniques** - Various environmental grants are available to support riparian restoration efforts to promote bank stabilization, reduce sedimentation, and improve water quality. Hydro-seeding, riparian vegetation plantings, root wad and log jam installations, and soil wraps are some alternative techniques to rip-rap (a temporary technique which may actually increase downstream erosion) that can provide increased longevity and environmental benefits to bank stabilization projects.
- **Improve Swale & Ditch Maintenance** - Identify areas where drainage ditches are needed or are underperforming through a visual inspection. Infiltration ditches must be routinely cleared of debris and sedimentation in order to provide water quality improvements.
- **Install Green Stormwater Infrastructure** - Green infrastructure includes rain gardens, permeable pavement, bioswales, and other similar techniques to attenuate runoff and floodwaters from impervious surfaces, such as roads and parking lots, and decrease the flow burden on culverts.

PLANNING SUPPORT

Regional Resources	State Resources	Federal Resources
North Country Council • Culvert and road surface condition assessments. • Technical assistance for project development. • Assistance with master plans, capital improvements planning, grant/funding applications, and transportation planning.	**NH Department of Transportation** • Technical manuals & standards **NH Department of Environmental Services** • NH Stream Crossing Initiative • Stream crossing design & permitting guidance **NH Fish and Game Department** • Technical assistance • Performing crossing assessments and fish inventories.	**Federal Emergency Management Agency (FEMA)** • Hazard Mitigation Planning guidance. **Environmental Protection Agency (EPA)** • Best management practices. **Natural Resource Conservation Service (NRCS)** • Technical assistance. • Best management practices.

FUNDING SUPPORT

Local Funding Sources
• Annual budgeting & warrant articles • Multi-year capital improvements planning • Establish a Municipal Transportation Improvement Fund (see RSA 261:153, VI)
Statewide Funding Sources
• **NHDOT:** Statewide Ten Year Transportation Plan; State Aid Bridge Program, Culvert & Drainage Replacement Program • **NHDES:** Aquatic Resource Mitigation Fund
Federal Funding Sources
• **FEMA:** Hazard Mitigation Grant Program • **USFWS:** National Fish Passage Program • **NRCS**: Environmental Quality Incentive Program
Private & Non-Profit Funding Sources
• **NFWF:** New England Rivers and Forests Fund • **Eastern Brook Trout Joint Venture (EBTJV)**

Culvert assessments are one of many services North Country Council provides to communities to assist with resiliency planning.

North Country Council Regional Planning Commission produced this guide. The Council serves in an advisory role to 50 communities and 25 unincorporated areas in Carroll, Coos, and Grafton Counties.
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