Fish Passage Restoration Guidelines

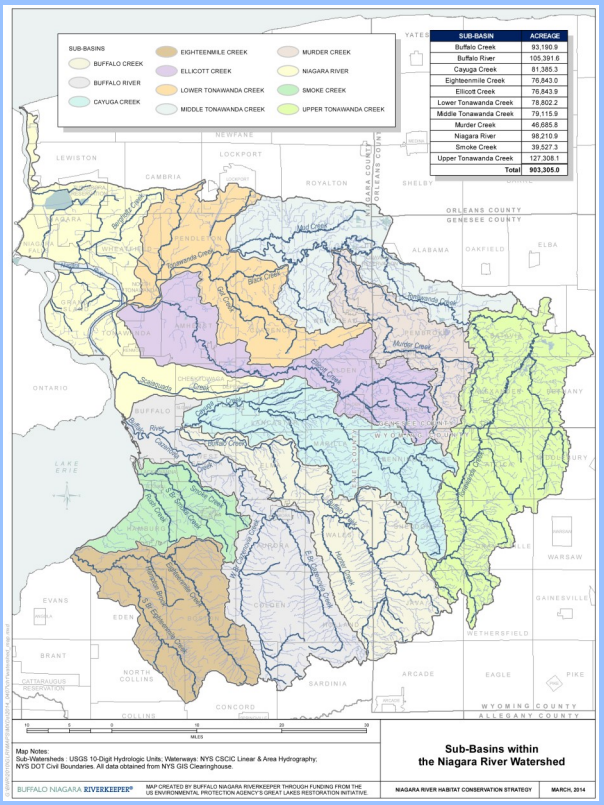
Reducing Barriers to Fish and Wildlife and Improving Stream Function in the Niagara River Watershed

BUFFALO NIAGARA RIVERKEEPER®

Introduction

Stream Barriers in the Niagara River Watershed

A watershed is a natural geographic divide where any fallen water will drain into a waterbody. The Niagara River Watershed, those areas of land that funnel water into the Niagara River, drains approximately 900,000 acres of land and spans four counties. As shown in Map 1, the Niagara River Watershed can be further divided into sub-watersheds in which funnel their water into the major tributary streams that empty into the Niagara River. These sub-watersheds are defined by a series of ridges that step down in elevation as you move from the headwaters in the southern portion of the Niagara River Watershed to the lake plain in the north.



SUB-BASIN	ACREAGE
Buffalo Creek	93,190.9
Buffalo River	105,391.6
Cayuga Creek	81,365.3
Eighteenmile Creek	76,843.0
Ellicott Creek	76,843.9
Lower Tonawanda Creek	78,802.2
Middle Tonawanda Creek	79,115.9
Murder Creek	46,685.8
Niagara River	98,210.9
Smoke Creek	39,527.3
Upper Tonawanda Creek	127,308.1
Total	903,305.0

Map 1- Niagara River Watershed

In 2014, Buffalo Niagara Riverkeeper completed the Niagara River Watershed Habitat Conservation Strategy (http://bnriverkeeper.org/habitatstrategy/), which identified conservation of headwaters as a key priority for improving the overall health of the watershed. Headwaters are the places far upstream where small tributaries originate from seeps and groundwater, feeding and supplying larger waterbodies downstream. Headwaters have a long-term influence on aquatic habitat both locally and downstream. Through this extensive watershed planning effort, two priority actions were identified to protect the continued viability of Niagara River headwaters: conservation and enhancement of upland forests, and removal of barriers such as dams and improperly installed stream crossings. The focus for this document is on the latter, but it should be noted that headwater forests play a vital role in preserving water quality, keeping stream temperatures cool, providing critical source materials such as leaf and woody debris, along with many other ecological benefits.

Statement of Purpose

This document is meant to inform and educate practitioners working in the headwaters of the Niagara River Watershed about current conditions and ongoing efforts to assess and improve stream connectivity. It is meant to serve as a guide to identify stream barriers and discuss how proper barrier installation techniques can benefit aquatic habitat. It also seeks to discuss other contributing factors to trout habitat degradation by discussing how stream class, and other environmental and anthropogenic factors impact brook trout populations within the watershed.

Streams are complex systems that are naturally in flux, but this change is being accelerated by land use practices and global climate change. Because these influences on a watershed's health are multivariate, and affect a wide variety of parameters, from water quality to fishery populations, this guide aims to address a manageable problem affecting a valuable aquatic species—namely stream barriers that preclude fish such as Brook Trout from navigating streams to spawn and reproduce.

When assessing or designing a stream crossing, this guide will help to identify key factors that should be considered, however, a case by case approach is needed to achieve best results.

As part of this effort Buffalo Niagara Riverkeeper and the US Fish and Wildlife Service surveyed and mapped culverts within the Niagara River watershed, to fill data gaps in current knowledge of stream conditions, identify barriers within streams, and relate observations to actual Brook Trout habitat.

Stream Barriers

The Effects on Fish and Wildlife

As streams meander throughout the landscape, they are particularly vulnerable to fragmentation by dams and road networks. In the same way that roadways act as transportation corridors for humans, streams serve the same purpose for fish and wildlife. When movement is hindered, fish and wildlife are more susceptible to stressors.

Barriers to fish movement can result in the isolation of populations that weaken genetics, hindering the fish's ability to access appropriate food sources and spawning locations, and limiting the ability to find cold water refuge in warm summer months. Sedimentation and runoff from construction and land use changes near streams can also impact species success by affecting water quality, egg survival, and the aquatic insects that serve as an important food source.

In addition to fish species, a number of other aquatic animals are affected by barriers to movement within a stream corridor. This includes salamanders, turtles and other reptiles, hellbenders, and crayfish. One of the most vulnerable aquatic species is the freshwater mussel. Dispersal of these species rely on larvae that attach to host salamanders or fish. The long-term survival of these populations are dependent on the ability to easily move through stream systems.

Streams also serve the basic but important role of transporting water and sediment. When stream crossings are properly engineered and installed they do not disturb this hydrologic process. Poorly designed crossings can be both destructive to the environment, and costly. It should be noted that even though some stream crossings may not have been a barrier when installed, they could become one due to changing conditions (e.g. land-use changes and increased precipitation). Therefore, it is important to understand local conditions when determining a proper crossing installation and if and when it should be replaced.


Credit: GLFC

How are Stream Crossings Barriers to Fish?

- Unnatural channels with shallow or high flow cause fish to reach their **exhaustion rate.**
- **Water velocities** higher than 4 cubic feet per second (CFS) will begin to impede passage for some species.
- Without adequate **natural stream bed material** fish do not have refuge to rest and feed.
- On average, barriers higher than 16 inches (40cm) are above the **maximum jump height** of an adult Brook Trout.

Brook Trout

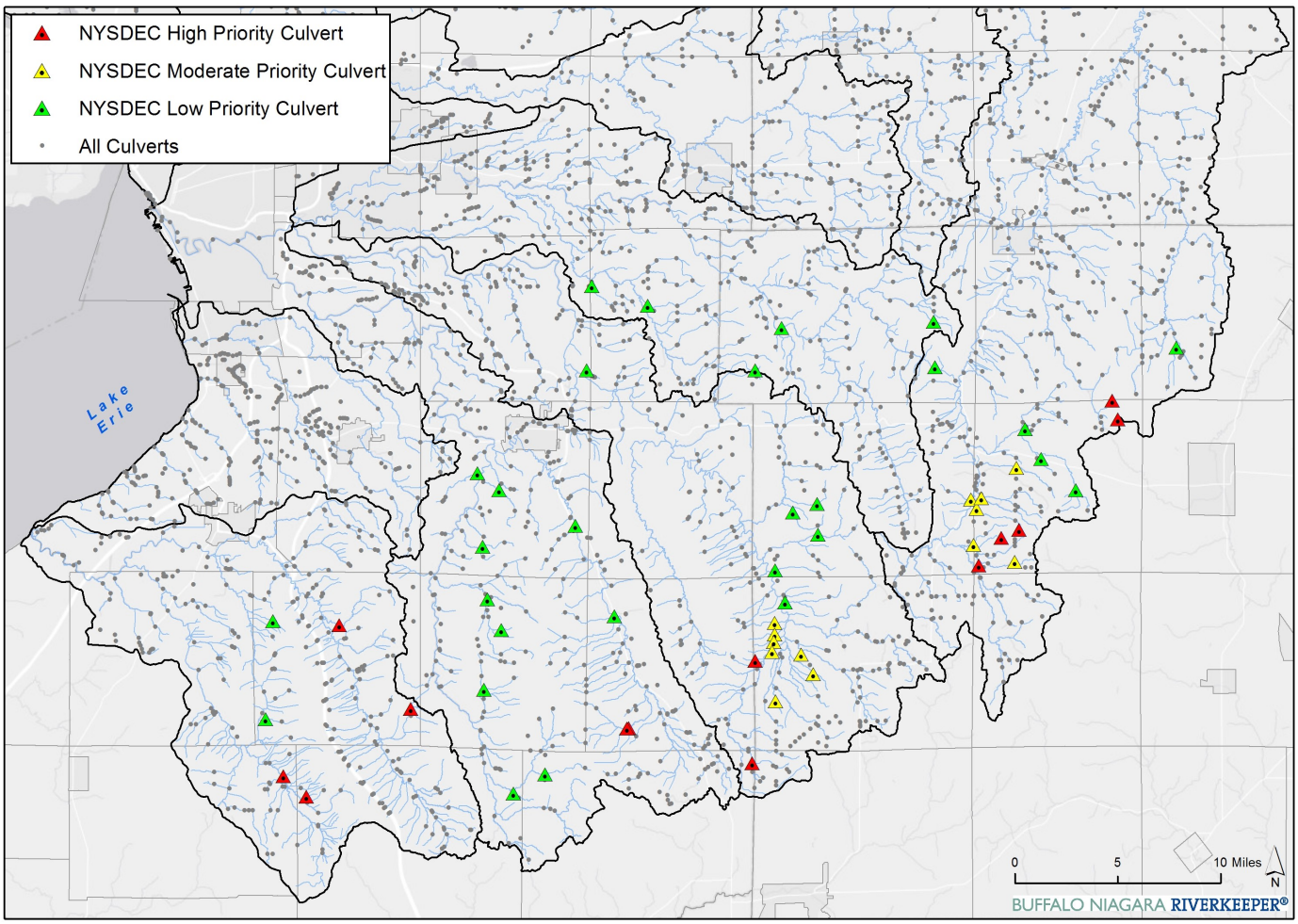
Brook Trout have been particularly vulnerable to stressors in the Niagara River Watershed as well as throughout the Northeast— they can in many ways act as the "canary in the coal mine" for aquatic health. Brook Trout play a vital role in the Niagara River headwater ecosystems as the primary dominant predator in the absence of non-native species such as Brown Trout or sunfish. Brook Trout eat a wide variety of prey, as a trout's diet consists of nearly any prey of a suitable size within a stream. In this way, trout keep the food web in balance, and their protection is extremely important to overall watershed health.


Credit: Scott Cornett, NYSDEC

Brook Trout rely on regular seasonal movements, documented at over a mile, in order to maintain viable populations. During spawning, fish will expend an extraordinary amount of energy in order to attempt to pass barriers, with 600 leaps observed at one culvert, of which only five were successful. Once fish have successfully passed the barrier, they are often faced with additional obstacles. For instance, velocity of water flowing through a culvert can exist beyond the swimming ability of a fish (as shown above), especially when the fish are near their exhaustion rate.

Ongoing Work

Efforts to date have determined priority barriers to address fish passage within the Niagara River Watershed. Close to 4,000 stream road crossings (culverts) exist throughout the watershed. Map 2 (below) shows all known stream road crossings, and ranks assessed culverts as high, moderate, or low priority. Those culverts in need of immediate replacement or modification, as they greatly restrict fish and wildlife movement within streams, are designated as high priority. While moderate and low priority culverts also represent barriers, they are considered less significant barriers to fish and wildlife movement. In some case, barriers that separated healthy Brook Trout population from Brown Trout were ranked moderate or low to avoid competition for resources.



Map 2 – Stream Road Crossings (culverts) in the Niagara River Watershed (Note: dams are not included in this data set)

In addition to outreach and education, restoring passability at these high priority culverts will be the next step. Further efforts to continue research and restoration work related to trout populations and habitat conservation are needed to better understand and improve conditions for these species in decline.

Funding for this, and other efforts to restore trout populations in the watershed was provided by the US Fish and Wildlife Service.

Common Problems with Stream Crossings

The following examples show problems commonly associated with stream crossings throughout the watershed. For more information please refer to the references at the end of this guide or visit http://bnriverkeeper.org/fishbarriers/

Perched Crossing

- Height barrier to fish and wildlife.
- Can result from improper installation or downstream bed erosion over time.
- Can cause deep scour pools or the stream undercutting the culvert.

Shallow Crossing

- Low flow and lack of natural bed material.
- Sufficient water depth is needed to move upstream.
- This can also lead to stagnant conditions that can degrade water quality.

Undersized Crossing

- Causes clogging and constricts flow.
- High velocities cause scouring downstream, degrading habitat and potentially undercutting the culvert.
- High velocity impedes movement.

Misaligned High Gradient Crossing

- Can erode the stream bank or bed and misdirect flow.
- A slope grater than 3% is considered a high gradient stream. A culvert 50 feet long with 2.5 feet of drop has a 5% gradient.

Stream Crossing Guidelines

Road crossings can provide passage for species of a certain size, or under certain flow conditions; however, it is important that all work completed within a stream take into consideration all native species and their habitat needs throughout varying conditions in order to address the negative impacts associated with stream fragmentation. Culverts should be installed to mimic the natural flow and substrate of the stream. Ensuring that the following guidelines are met will both accommodate wildlife and protect stream health.

- **Embeddedness:** Bridges or open archers are preferred over culverts. Where culverts do exist, they should be embedded, or sunken into the stream, at least 25% of the pipe diameter.
- **Sizing:** The width of a stream crossing should be at least 1.2 times the width of the stream's ordinary high water level.
- **Substrate:** The substrate should match the natural substrate that exists both upstream and downstream of the crossing, and be able to withstand flood events.
- **Erosion Control:** Throughout construction, stabilizing soil in order to prevent erosion and sediment from entering the stream is important to maintain good water quality. This will also reduce long-term costs.

Cost Savings: Installing stream crossings to meet these guidelines will help to reduce long-term costs associated with maintenance, repairs, and replacements for crossings that become clogged, washed out, or cause scour, erosion, and/or flooding.

A Well Designed Crossing

- Large size suitable for handling flood flows
- Open-arch design considered optimum under most conditions
- Openness ratio greater than 0.5m, suitable for most settings
- Greater than 1.2x stream width maintains dry banks for wildlife passage
- Water depth and velocity match conditions upstream and downstream
- Natural substrates create good conditions for stream-dwelling animals

Source: Massachusetts Riverway Program, 2005

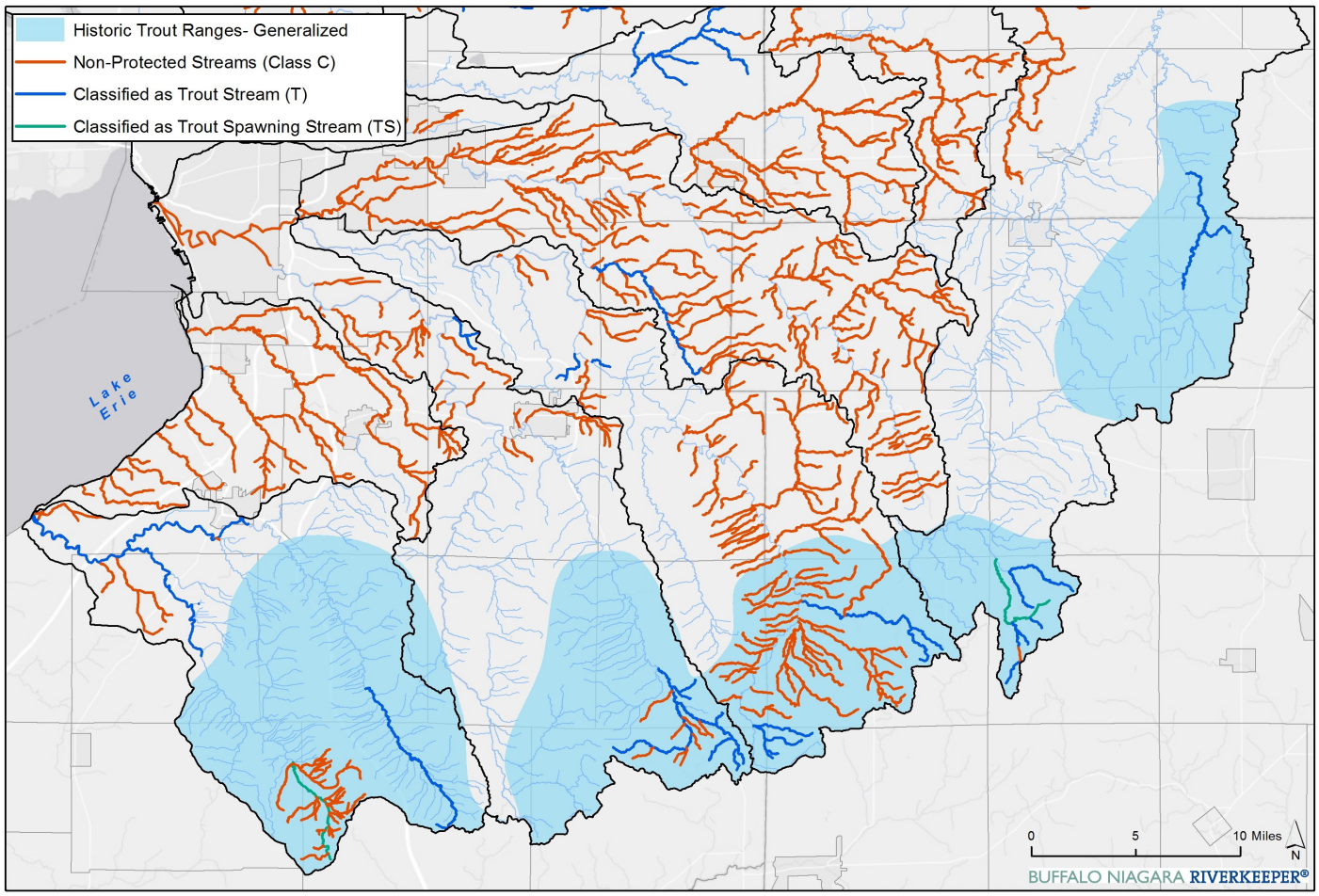
Stream Classifications

All waters within the state are assigned a designation based upon usage: AA, A, B, C, D. Additional standards are applied for streams thought to support trout populations (T), or trout spawning (TS). Special permits are required for any activity occurring within a stream designated as T or TS; however, these designations have been found inconsistent with the currently known locations of trout populations.

Streams supporting trout populations will have cool, clear water with a cobble substrate. The generalized area depicted below gives a good idea of where resident trout populations exist in the watershed. Special requirements apply to waters containing trout in order to protect and support these fisheries resources. If you think you are working in stream that contains trout populations, please contact your local DEC permitting agent.

Region 9 Permits
Erie, Niagara & Wyoming Counties
NYSDEC
270 Michigan Ave.
Buffalo, NY 14203-2915
www.dec.ny.gov/about/39381.html

Regional Permit Administrator
David Denk
Email: dep.r9@dec.ny.gov
Office: 716-851-7165
Fax: 716-851-7168



Map 3 – Generalized Range of Trout and Stream Classification in the Niagara River Watershed (Note: this does not include seasonal spawning or stocking)

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Methods & Resources

Stream crossing data was collected using the NAACC (North Atlantic Aquatic Connectivity Collaborative) Stream Crossing Survey Data Form. Survey data was upload to the NAACC regional database that has over 5000 stream crossing across a thirteen-state region. To assess this database, download the form, or for training modules for assessing road-stream crossings please visit their website at https://streamcontinuity.org/resources/index.htm

A modified version of the Data Form that is a fillable pdf can be found on the Buffalo Niagara Riverkeeper website at http://bnriverkeeper.org/fishbarriers/

Stream crossing data was modeled using the US Forest Service FishXing model for all culverts that were assessed and deemed high priority. This modeling software allows the user to evaluate a stream crossings as a barrier based on species capabilities as well the hydrologic parameters of the crossing. To download the model, as well a tutorials of how to use it please visit their website at http://www.stream.fs.fed.us/fishxing/

Resources

- Eastern Brook Trout Joint Venture. 2006. Eastern Brook Trout : Status and threats. Prepared by Trout Unlimited, Arlington, VA, for EBTJV36 pp.
- NYS Department of Environmental Conservation. 2011. Stream Crossings. http://www.dec.ny.gov/docs/permits_ej_operations_pdf/streamcrossing.pdf.
- Singler, A. and B. Graber. 2005. Massachusetts Stream Crossings Handbook. Massachusetts Riverways Program, Massachusetts Department of Fish and Game
- University of Massachusetts Amherst. 2004. River and Stream Continuity Project. www.streamcontinuity.org

For additional resource please visit Buffalo Niagara Riverkeeper website http://bnriverkeeper.org/fishbarriers/

Project Partners

United States Fish and Wildlife Service

New York State Department of Environmental Conservation

Erie County Soil and Water Conservation District

Buffalo Niagara RIVERKEEPER® is a community based organization dedicated to protecting the quality and quantity of water, while connecting people to water.
We do this by cleaning up pollution from our waterways, restoring fish and wildlife habitat, and enhancing public access through greenways that expand parks and open space.

Buffalo Niagara RIVERKEEPER® is a member of the global WATERKEEPER® ALLIANCE.

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