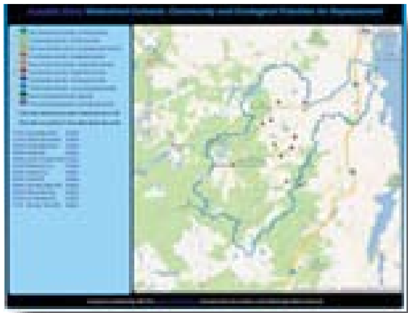
TECHNICAL REPORT NO. 73

Fish Passage and Connectivity in the Ausable Watershed using GIS Prioritization and Field Assessment Tools



December 2012

Final Report

Prepared by:
Corrie Miller, Project Manager, Ausable River Association
Michelle Brown, Dirk Bryant and Craig Cheeseman, The Nature Conservancy, Adirondack Chapter
Tim Mihuc, QA Manager, Lake Champlain Research Institute, SUNY Plattsburgh
Curt Gervich, Center for Earth and Environmental Science, SUNY Plattsburgh

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Project Code: *LS-2011-084*

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PREPARED FOR LAKE CHAMPLAIN BASIN PROGRAM

DECEMBER 2012

PREPARED FOR: Lake Champlain Basin Program

UNDER CONTRACT TO: New England Interstate Water Pollution Control Commission

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CO-PROJECT INVESTIGATORS:

Corrie Miller
Project Manager
Ausable River Association
1181 Haselton Rd, P.O. Box 8,
Wilmington, NY 12997
(518) 873-3752
corrie@ausableriver.org

Michelle Brown, Dirk Bryant and Craig Cheeseman
The Nature Conservancy, Adirondack Chapter
8 Nature Way, P.O. Box 65
Keene Valley, NY 12943
(518) 576-2082
michelle_brown@tnc.org, dbryant@tnc.org; ccheeseman@tnc.org

Tim Mihuc
QA Manager
Lake Champlain Research Institute
SUNY Plattsburgh
101 Broad Street
Plattsburgh, NY 12901
(518) 564-3039
mihuctb@plattsburgh.edu

Curt Gervich
Center for Earth and Environmental Science
SUNY Plattsburgh
101 Broad Street
Plattsburgh, NY 12901
(518) 564-4030
cgervich@gmail.com

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1. INTRODUCTION

Recent evidence suggests that fish passage at the sub-watershed level may be impaired in the Champlain Basin (Bates and Kim 2007). Road culverts, bridge structures, small dams and other human engineered infrastructure often place demands on small fishes that may exceed swimming burst speed and/or leaping abilities (Clarkin et al. 2005). Often road crossing structures have interfered with hydrological processes that normally serve to maintain upstream-downstream connections and could threaten local fish populations with extinction (Letcher et al. 2007). The Eastern Brook Trout Joint Venture lists stream fragmentation from road culverts as one of the top ten threats to wild brook trout across 17 states. Within New York, roads, dams, and culverts are identified as threats to biodiversity in up to 15 conservation action plans, including the Adirondack Mountains and Lake Champlain (ConPro. 2007). Accumulating evidence points to the need and opportunity to remedy these problems as culverts and bridges fail or are replaced during road upgrades.

This need for attention to road crossing infrastructure is magnified with consideration of climate change predictions for the Lake Champlain Basin. A recent The Nature Conservancy report, entitled *Climate Change in the Champlain Basin: what natural resource managers can expect and do* (Stager and Thill 2010) used Climate Wizard (a GIS planning tool) to downscale global circulation models in order to predict potential climate change impacts to the basin. Models anticipate more frequent severe storm events, a 15% increase in annual precipitation, and mean lake levels rising by up to two feet by the end of this century. This suggests record floods which occurred in 2011 could be 'the new norm' in the future. Already, climate records show that mean annual temperature in the North Country has warmed 1.5 degrees C and weather records from stations within the North Country region show an increase in large, high intensity rainstorms (Jenkins 2010).

One strategy identified as an important response to the potential impacts on streams from climate change involves removing barriers to aquatic species movement, so that native trout and other aquatic organisms in main-stem rivers can move unencumbered into colder tributaries as summer heat waves increase in frequency. Furthermore, the larger culverts and bridges that allow fish movement are also more likely to withstand more frequent flooding. Healthy tributary segments allow for wildlife adaptation and therefore the conservation of fish populations as well as improved resilience of human communities in the face of a changing climate.

The Ausable River Watershed

The Ausable River watershed is 512 square miles with 94 river miles and 70 tributaries (Figure 1). It is a NYS DEC "Blue Ribbon Trout Stream" and is a New York State Wild, Scenic, and Recreational River. The Ausable attracts roughly $3.7 million dollars from fishing tourism annually (NYS DEC, 2003), generated mainly from the West Branch fishery. The East Branch and Main Stem attract visitors but fishing allure has declined over the past 30 years (Marriner 1993). Impacts on the fishery from development and climate change have been noted in studies conducted by the Ausable River Association.

Temperature studies show that the main river is above what is tolerable for trout for between 20 to 30 days each summer and water quality studies show increases in pollutants carried by stormwater (Ausable River Association 2009). Passage to smaller, cooler, more pristine upland tributaries is imperative for conserving wild fish populations in the Ausable Watershed.

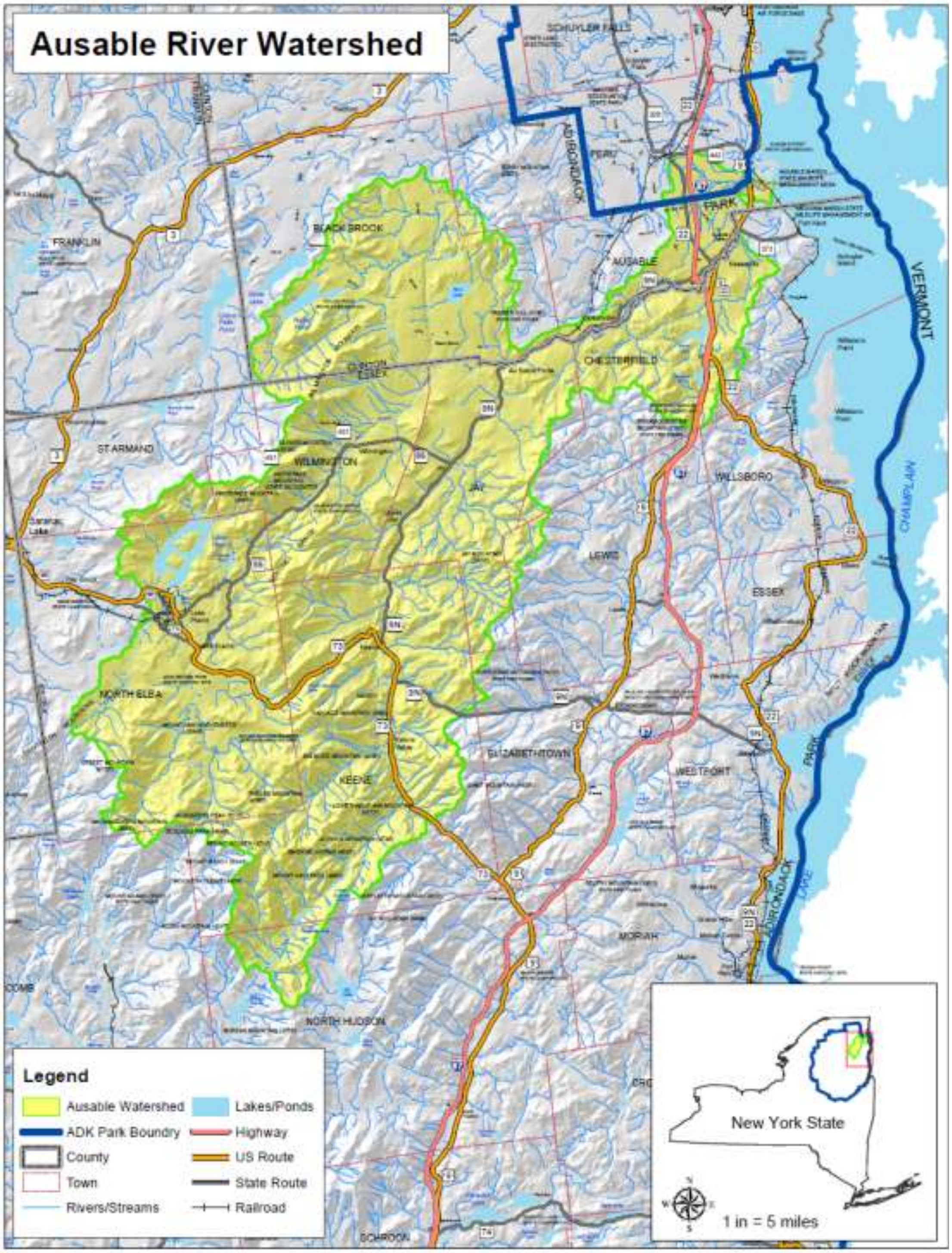


Figure 1. Ausable River Watershed, Essex and Clinton Counties, New York.

Project Objectives

This project brings together GIS and field assessment methods to identify and prioritize culverts that impair the upstream migration of trout in the Ausable Watershed. The stream and culvert prioritization methods were developed, executed and results were presented locally to municipal and county highway employees as well as to interested organizations and agencies. Data from state roads within the Ausable watershed has been incorporated into The New York Department of Transportation's (DOT) culvert database, used by that agency to plan for and design road improvement work.

The project was a collaborative effort between Adirondack Chapter of The Nature Conservancy (TNC), SUNY Plattsburgh's (SUNY) Lake Champlain Research Initiative (LCRI) and Center for Earth and Environmental Science, and the Ausable River Association (AsRA). This partnership represents the cross pollination of two tools which have been developed to asses habitat quality and connectivity on the New York side of the Champlain Basin. TNC, in partnership with NYS DOT, previously developed a remote assessment tool (hereafter referred to as the GIS AOP model) that ranks streams based on habitat availability for Species of Greatest Conservation Need, stream condition, and habitat fragmentation. The LCRI, in coordination with U.S. Fish and Wildlife, previously developed field based protocols to assess roadway stream crossings and identify and rank barriers to aquatic organisms in the Lake Champlain Basin. The union of these two tools has yielded a powerful and cost-effective method for transportation planners who wish to identify the most critical barriers for restoration or replacement.

In this project, partners combined and enhanced the GIS AOP model developed by Adirondack TNC with field assessment methods developed by LCRI and SUNY Plattsburgh to identify and prioritize culverts and bridges that impair the upstream migration of trout in the Ausable Watershed.

The Ausable Watershed was an ideal location to test and refine this methodology. It is 512 square miles and contains 94 river miles and 70 tributaries. The ability to remotely identify key stream crossings prior to field assessment is powerfully practical at this scale. When refined and applied regionally, the product of this project will demonstrate a cost effective prioritization tool for transportation officials statewide.

Project objectives included:

(1) Use a GIS model to identify priority AOP barriers within the Ausable Watershed:

a) Incorporate salmonid data to refine the species habitat portion of the GIS AOP model.

b) Identify an initial list of priority barriers using the GIS AOP model to identify barriers in terms of conservation value, condition and 'connectivity gain'.

(2) Field assess 90-100 priority barrier culverts for aquatic organism passage and retrofit/replacement opportunity.

(3) Integrate field results into the GIS AOP model: further refine the predictive model to improve its ability to remotely assess priority barriers in other watersheds.

(4) Use participatory methods of planning and engagement, to present workshops, with key audiences. Present a workshop and webinar that documents and disseminates results in formats useful for guiding road maintenance planning work (integrate results with DOT's model, provide maps and database for county and town highway departments).

2. METHODS

To examine consistent bi-state prioritization and inventory methods in the Champlain Basin, the remote assessment tool used in this project will be applied to Vermont streams by the Vermont Chapter of TNC and partners supported by LCBP. Furthermore, the field assessment tool chosen here is the same one used in other tributaries of the New York Champlain Watershed. Together these two projects yield consistency of methodology across the entire Champlain Basin.

A. GIS ANALYSES

The methodology consisted of three analyses conducted in a geographic information system (GIS): 1) a stream assessment, 2) a fragmentation analysis, and 3) the identification of priority culverts. The stream assessment addressed biological criteria including species of greatest conservation need (SGCN), species habitat, salmonid presence, and stream condition to focus the suite of streams available for priority culvert selection. A priority culvert is a high priority for culvert replacement with a fish and wildlife-friendly design. The fragmentation analysis identified the most intact stream networks in the watershed. We calculated how many miles of stream exist between every dam and culvert in the analysis, and associated each barrier with the number of stream miles that would be gained if the barrier was passable by fish. We combined information from the stream assessment and fragmentation analysis to select priority culverts---those located on ecologically important streams and those which are potentially significant fragmenting features in the overall stream network. Each analysis resulted in standalone products in addition to cumulative products as described below.

Hydrology

The hydrology data set that was used for the analysis was the New York State 1:24000 Hydrography Network Coverages (hydronet) (Figure 2). These features are from the United States Geological Service (USGS) 1:24000 quadrangle maps and consist of a linear network coverage, surface water and a wetland coverage. We verified the directionality of the stream flow and removed any bifurcations so all streams could flow to the outlet.

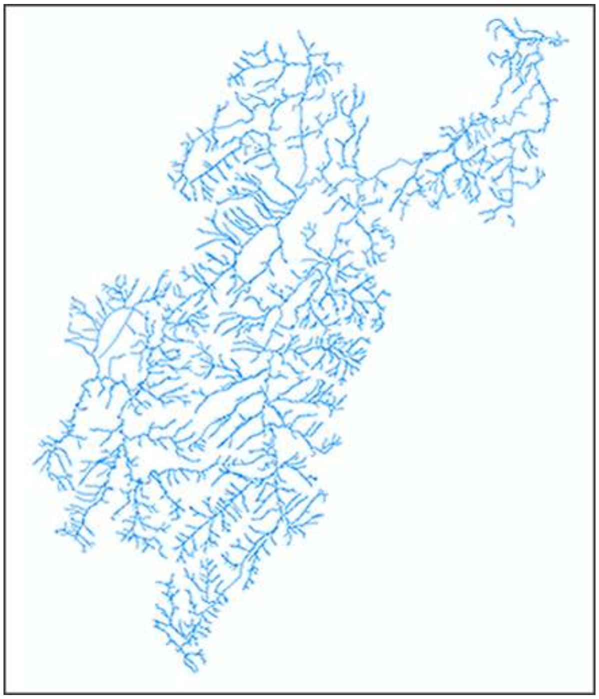


Figure 2. Stream hydrology clipped to the Ausable River watershed boundary.

1) Stream Assessment

Objective: Prioritize streams across the Ausable watershed using models for SGCN, their habitats, and stream condition as criteria

The objective of the stream assessment was to use ecological information to assign all streams in the Ausable watershed to priority classes. The stream assessment model was developed by combining multiple criteria of species and stream health in a GIS (Table 1). To assign streams to priority classes, we (1) developed scores for each criterion and attributed them to streams; (2) assigned weights to each criterion based on project goals; and (3) combined scores with weights to create a composite score for each stream. Streams were then grouped into very good, good, fair, and poor classes based on these scores.

Table 1. Species and condition criteria used in stream assessment model.

Criterion	Description	Source	Format
SGCN element occurrences[1]	Locations of species of greatest conservation need.	New York Natural Heritage Program	Polygon
SGCN Important Area models	Dynamic buffers for SGCN animals and their habitats (Jaycox et al. (2010)).	New York Natural Heritage Program	Polygon
Watershed Ecological Risk Index (ERI)	Watershed health/threat index created for statewide Hydrologic Unit Code (HUC) 11 watersheds. Based on methods of Mattson and Angermeier (2007).	The Nature Conservancy	Polygon
Riparian health model	Riparian health model based on land use/land cover within 30m buffer of stream reaches. Based on methods of Meixler et al. (2010).	The Nature Conservancy	Line
Aquatic ecoregional priorities	Priority river networks as identified by TNC's ecoregional planning process.	The Nature Conservancy	Line
Fish locations	Confirmed locations for select trout species	Department of Environmental Conservation (DEC)	Point
Predicted fish abundance	Predicted fish abundance per stream reach	USGS	Line
Designated trout stream	Designated NYS trout stream	DEC	Line

Species Criteria

Species data were collected by the New York Natural Heritage Program (NYNHP) and applied by TNC. The criteria consisted of SGCN locations on the ground and - because these observed locations are incomplete - their modeled habitat. Modeled habitats were identified through Important Area models, which are lands and waters that are predicted to support the continued presence and quality of known populations of rare animals. Important Areas include specific locations where animals have been observed, but go beyond these to also include:

- habitat that may be used by rare animals for breeding, nesting, feeding, roosting, or over-wintering.
- areas that support the natural ecological processes critical to maintaining the habitats of rare animal populations (Jaycox 2005; Jaycox, Shaw et al. 2010). For example, certain amphibian species utilize the margins of aquatic and terrestrial habitats. The Important Area models capture enough area to protect these critical habitats from degradation.

[1] An element occurrence (EO) is the basic conservation unit of NYNHP and is defined as an area of land and/or water where a species or ecological community is or was present and has practical conservation value.

Two Important Area models were developed in the Ausable watershed: 1) Boreal snaketail (Ophiogomphus colubrinus), and 2) Eastern pearlshell mussel (Margaritifera margaritifera). These two SGCN species are rare in NYS and need aquatic connectivity for population persistence.

The second species criterion we used were fisheries data from DEC. Confirmed locations for all salmonids (brook trout, brown trout, rainbow trout, Atlantic salmon) in the Champlain Basin were spatially mapped and incorporated into the prioritization model.

Stream Condition Criteria

In addition to the species criteria, we considered three stream condition metrics for use in the stream assessment. Conservation planners have long recognized the importance of utilizing ecosystem and species data in prioritization models (Groves 2003). We felt it was important to consider some system-level data and not to base the culvert selection solely on species criteria.

The first stream condition criterion examined general threats to each small watershed in the Ausable. This Ecological Risk Index summarized factors like percent development, road density, and different types of agriculture within each watershed (Mattson and Angermeier 2007). Each variable in the Ecological Risk Index is correlated with impacts to water quality and cumulatively serve as proxies for watershed health. The second stream condition criteria assessed riparian health. Natural land cover like forest is important in riparian areas for slowing nutrient and sediment runoff, regulating stream water temperature, and for providing important nutrients and coarse woody debris into stream systems (ELI 2008). This criterion provided an assessment of riparian system health based on the make-up of land cover adjacent to each stream (Meixler and Bain 2010). The final metric we utilized was whether a stream was of ecoregional importance. These streams were identified in a previous regional-scale conservation planning effort (TNC). A group of experts selected streams to be of regional importance if they met certain standards including size, representation of system type, and unfragmented stream lengths (Olivero and Anderson 2003).

2) Fragmentation Analysis

<u>Objective</u>: Evaluate the fragmenting effects of potential barriers including culverts, dams, and waterfalls

The Barrier Assessment Tool (BAT) was used to analyze the fragmenting effects of dams and culverts on streams. BAT is a GIS tool that was developed in support of the Northeast Aquatic Connectivity Project led by TNC (Hornby 2010). Starting with barriers and streams, BAT allows users to assess overall watershed connectivity, as well as the potential magnitude of each individual barrier's fragmenting effect.

Inputs

The primary input datasets for the fragmentation analysis were streams and barrier location points (dams, culverts, and waterfalls). Even though our primary interest was in culvert locations, it was necessary to include dams and waterfalls in the fragmentation analysis to have a more complete understanding of unfragmented stream networks in the Ausable watershed. Each barrier point needed to be connected to a stream (i.e., to adjust their positions to intersect, or lie directly on, the hydrology centerlines). The "snapping" process was unique to each type of barrier, as outlined in the following two sections.

Culverts

There was no comprehensive database of culvert locations in the watershed. Therefore, we created a predicted culverts layer in GIS by intersecting the hydrology layer with roads and railroads. This produced a point dataset representing all potential road-stream crossings. Two methods were then used to refine the dataset. In other words, not all stream/road crossings are culverts so we systematically removed those points from our dataset that were likely to be bridges or that occurred on isolated stream reaches not connected to a larger network.

Dams

The primary digital source of dam locations was the New York State Department of Environmental Conservation (DEC) Inventory of Dams dataset. This dataset contains approximate locations of publicly and privately owned dams in NYS extracted from the Division of Water's Dam Safety Section database. Due to the fact the spatial locations for the dams were extracted from the database and not related to NHD stream hydrology it was necessary to snap the dams to the proper stream.

Outputs

The BAT produces a large amount of information concerning stream networks and barriers. We utilized absolute gain values as the main BAT outputs. Absolute gain values are calculated based on total functional stream network lengths. Any given barrier is associated with two stream networks; one upstream network and one downstream network. As Figure 3 illustrates, the removal of a dividing barrier results in the solid stream network "gaining" the dashed stream network. Each barrier is attributed with the increased mileage of the stream network that would be "gained" with their removal (or if they were passable). In the case of Figure 3, the dividing barrier would be attributed with the number of stream miles illustrated by the dashed reaches (Olivero and Jospe 2006).

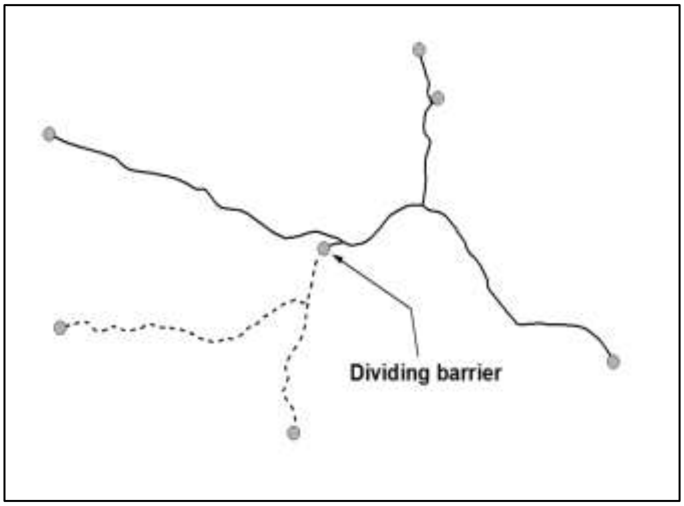


Figure 3. Barriers (gray points) serve as the dividing point between two networks (solid and dashed lines). The removal of a dividing barrier results in the solid stream network "gaining" the dashed stream network. This is termed "absolute gain."

3) Environmental Culvert Prioritization

Objective: Identify the most important culverts for focus to improve habitat and ecosystem function

Priority culverts were selected using the results from the stream assessment and the fragmentation analysis. Priority streams (that were developed during the stream assessment) were combined with the culverts that yielded the highest absolute gain values in the fragmentation analysis. All barriers on the mainstem were also selected as priority culverts as well as the first barrier on each tributary upstream of the mainstem. These culverts were selected based on their position in the watershed and subsequent importance for fish passage.

B. Field Assessments

Objective: Develop field protocols and methods to assess and prioritize fish passage impediments

Recently numerous State and Federal agencies have developed assessment methods and field protocols for determining fish passage impediments. We adapted an existing protocol from Vermont and applied it in New York watersheds in the Lake Champlain Basin (Bates and Kim 2007). A site scoring system, based on four simple to measure physical parameters (stream width, stream depth, water velocity and structure outlet drop), was created to prioritize individual culverts and bridges for replacement based on the impairment of fish passage. Priority culverts identified in GIS analyses were target locations for field assessments.

1) Fish Barrier Field Assessment

We implemented field assessment protocols based on the protocol used by Mihuc et al. (2008). The field assessments included in-structure and upstream reference site velocity measurements (taken with a Global Water FP 101 velocity meter), depth measurements, stream wetted channel width measurements, as well as the structure's outlet drop at the downstream end. Field assessment data sheets can be found in Appendix A. Other than outlet drop, culvert or bridge measurements (width and depth) were taken at the upstream entry to the structure. Upstream reference measurements were based on a set of three transects spaced 10 m apart that were located at least 25 m upstream from the structure in an un-channelized section of stream reach. Upstream reference measurements included wetted channel width, thalweg water depth and thalweg water velocity.

2) Fish Barrier Site Scores and Prioritization

Using the field data we utilized the four part scoring system from Mihuc et al. (2008) to prioritize road crossings into three categories: high, medium, and low priority for replacement based on impediments to fish movement. High priority sites were classified based on a combination of traits that prove unsuitable for fish passage. Each site was prioritized based on four criteria selected from the measured suite of physical variables that best represent the impacts of a crossing on fish passage. The scoring criteria for each variable are based on suitability for Brook Trout movement, adapted from Bates and Kim (2007). The four criteria represent the two most critical parameters often cited as impediments to fish movement at a crossing (outlet drop and in-structure water velocity) and two in-structure to upstream ratios that represent the potential impact of the structure on water depth and stream width. We modified the 2008 protocol for stream width for this study by using the wetted channel upstream width to in structure width ratio to determine the width ratio score

The scoring criteria used to assign points for each site were:

- Outlet drop [Measured drop at the road crossing structure outlet. Drop to water level in the stream below the structure.]
    - » greater than 4 inch drop for juveniles and greater than 8 inch drop for adults acts as a barrier to Brook Trout
- In-structure water velocity [Measured Velocity (m/s) in the structure at the upstream end.]
    - » greater than 2.6 ft/sec can impact Brook Trout movement
- Culvert (or bridge) stream channel width to reference site in-stream width ratio [This is the ratio of the stream width in the structure to mean width from the upstream reference site.]
    - » a stream in structure less than 80% of the reference width can impact Brook Trout movement

- Culvert (or bridge) structure to in-stream water depth [This is the ratio of the stream water depth in the road crossing structure to the mean thalweg depth from the upstream reference site.]
    - » a structure with water depth less than 75% of in-stream depth can impact fish movement

Figure 4 depicts the scoring system used for each of the criterion. Points are assigned based on potential impact of that criterion on fish passage with 0 points indicating no impact, 1 point for moderate impact and 2 points for high impact.

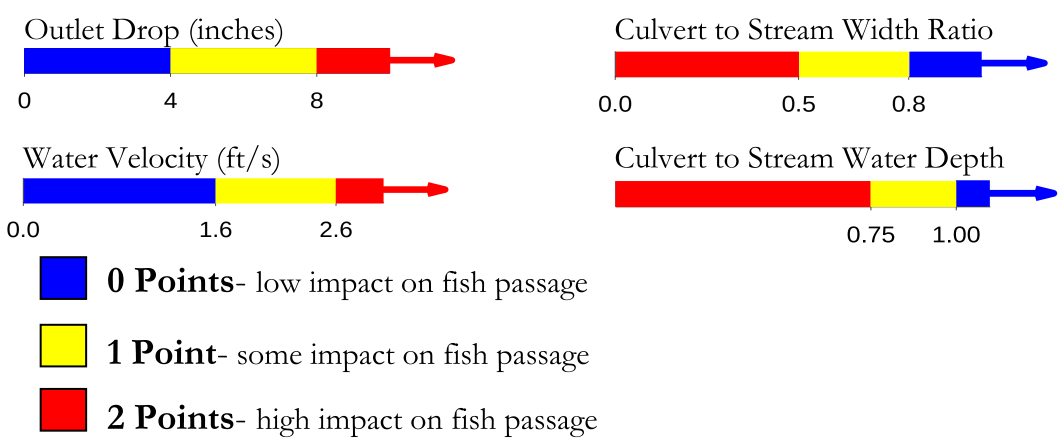


Figure 4. Scoring used for the four variables to assess fish passage at each road crossing structure (bridge or culvert).

To determine a site score the value of all four variables were summed. A "poor" score (5 – 8 points or any site which has greater than 8 inch outlet drop) indicates that the crossing is undersized or exhibits an un-passable outlet drop, most likely representing a severe impediment to fish movement. A "medium" score (3 – 4 points, with less than 8 inch outlet drop) indicates that the road crossing has some deficiencies, such as reduced width relative to the stream channel, but most likely allows fish passage. A "good" score (0 – 3 points, with less than 8 inch outlet drop) indicates that crossing is appropriately sized for the stream and allows fish to pass fluidly. Site scores were ranked to prioritize structure replacement and retro-fitting, with poor scoring culverts being highest priority.

C. Integration of Field Assessment into GIS Analyses

Objective: Integrate field results into the GIS AOP model: further refine the predictive model to improve its ability to remotely assess priority barriers in other watersheds

The results of the field data were incorporated into the GIS model to update the accuracy of the model and reflect what culverts were actually barriers to aquatic organism passage. Data from towns and Essex County (described below) were also included into the GIS and represent human priorities for safety and flooding concerns. These data provide a cursory look at feasibility given the current resources available for culvert upgrades and retrofits are largely local.

D. Participatory Planning and Engagement

Objective: Use participatory methods of planning and engagement, to present workshops, with key audiences. Present a workshop and webinar that documents and disseminates results in formats useful for guiding road maintenance planning work (integrate results with DOT's model, provide maps and database for county and town highway departments).

Tropical Storm Irene and ensuing environmental outcry for restoration efforts increased the tension in Ausable communities between so called "environmental" values and public safety values. This circumstance necessitated a more thoughtful outreach effort that highlights the connection between environmental benefits and public safety benefits.

Furthermore, Irene's damage in Ausable communities raised the profile of public infrastructure. With nearly $1.4 million in damage in the Towns of Jay and Keene alone due to culvert failure (Jessica Levine, personal communication, September 24, 2012) there was the opportunity for improved traction with regard to replacing existing culverts with appropriately sized culverts (for the benefit of aquatic organisms *and* handling increasing flood flows).

To build enduring relationships, better bridge environmental and public safety values, and capitalize on infrastructure focus in flooded communities we updated our original outreach strategy. We incorporated many one-on-one meetings with key road maintenance personnel and town supervisors in order to identify and incorporate local objectives into our data. During these meetings we were able to educate stakeholders about our project, about culvert impact on fish passage, and about fish-friendly culvert designs as well as learn about community priorities for replacement (based on public safety or maintenance issues), about decision-making processes regarding roads and culverts, and about budget-friendly culvert designs.

Concurrently, TNC engaged a Fellow who focused on an economic analysis of the long term costs of different kinds of culverts and possible models for funding culvert improvement. Her preliminary analysis was an important resource we to provided communities interested in engaging in a conversation about culvert improvement.

After building significant local traction in communities with this outreach strategy, we incorporated community priorities into our growing GIS database and initiated "results-sharing" workshops called for in Work Plan.

3. Results

A. GIS Analyses

The summarized results for each of the three analyses—the stream assessment, fragmentation analysis, and culvert prioritization—are presented below. Detailed information on specific stream attributes and barriers can be found in the accompanying spatial databases.

1) Stream Assessment

<u>Objective</u>: Prioritize streams across the Ausable watershed using models for SGCN, their habitats, and stream condition as criteria

There were 1102 total stream miles in the Ausable watershed. Over 28% of these were categorized as high priority streams (Table 2, Figure 5). Based on the scoring framework for attributing each stream reach, we grouped the stream reaches into quartiles. Species data and condition criteria (watershed health, riparian health, and ecoregional priorities) accounted for the selection of the high priority streams. In general, the poor condition class streams were not associated with SGCN, had poor watershed and/or riparian health, and were not ecoregional priorities.

Table 2. Summary of stream assessment results.

Stream priority class	Length (miles)	% of total length
Very Good (green)	267.95	24.32
Good (yellow)	309.67	28.11
Fair (orange)	268.76	24.39
Poor (red)	255.41	23.18

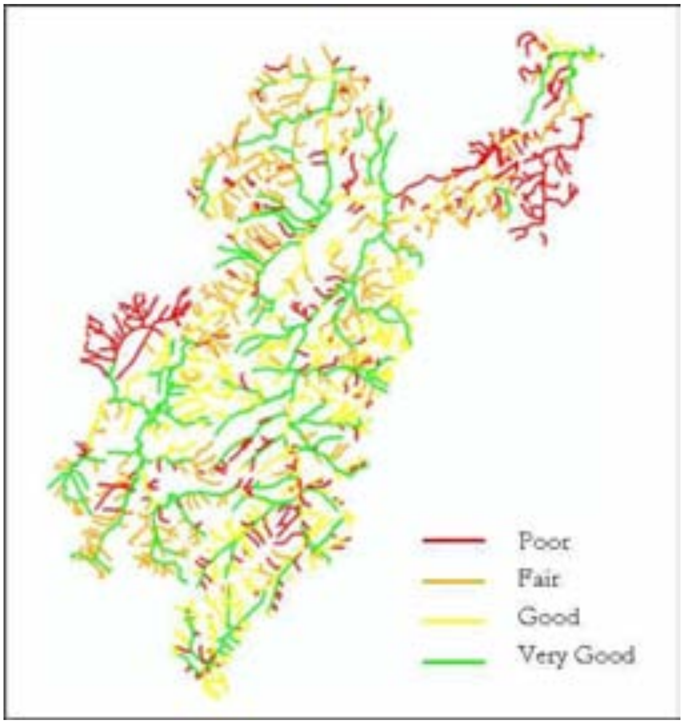


Figure 5. Stream prioritization in the Ausable River watershed.

2) Fragmentation Analysis

Objective: Evaluate the fragmenting effects of potential barriers including culverts, dams, and waterfalls

There were 574 total barriers analyzed in the Ausable watershed (537 culverts, 20 dams, and 17 waterfalls). Each barrier had a calculated "gain" in stream miles that resulted from the BAT analysis. This gain represents the amount of stream miles that would become connected if the barrier was passable (Figure 2). BAT results varied greatly for culverts, ranging from a minimum of 0.0006 miles to a maximum of 36.18 miles, with a mean of 0.989 miles.

3) Environmental Culvert Prioritization

Objective: Identify the most important culverts for focus to improve habitat and ecosystem function

The end goal was to have a set of priority culverts upon which to focus scarce resources for fish and wildlife- friendly culvert design. An ecological priority barrier was identified from a suite of high quality streams and high potential for connectivity gain (Stream Assessment and Fragmentation Analysis described above). We also included all barriers on the main stem and the first upstream barrier on each tributary of the main stem as priority barriers after review of the GIS model with biologists from USFWS and SUNY Plattsburgh. Barriers on the mainstem and the first barriers on each tributary flowing into the mainstem are fundamental connectivity barriers for fish seeking refugia upstream. Barriers that had relatively high gain were classified as priority barriers (absolute gain values > 0.33 miles). There were 207 barrier records identified as priorities (Figure 6).

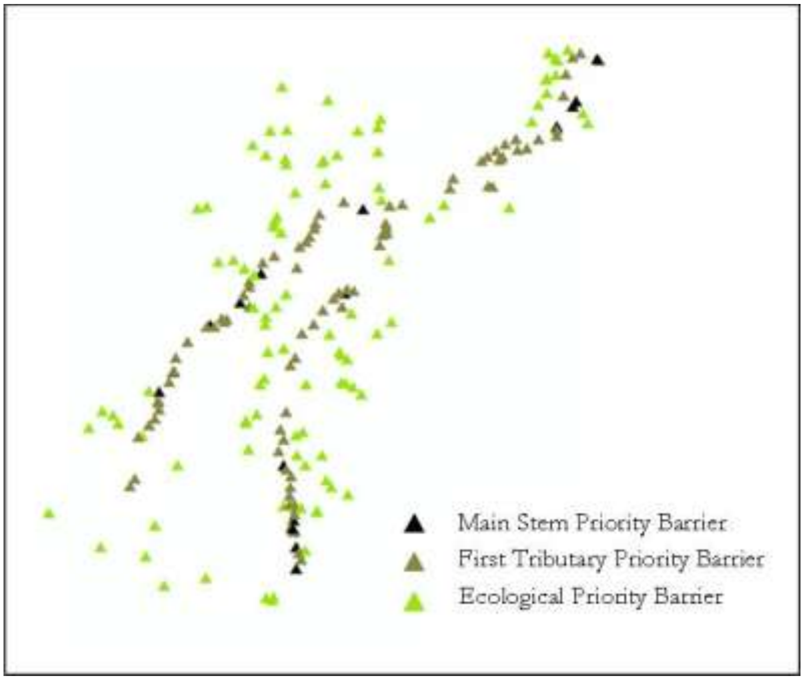


Figure 6. Priority barriers. n=207

B. Field Assessments

173 culvert sites were field assessed between June 1, 2011 and August 28, 2012. Appendix B describes the field headings for the resulting GIS geodatabase which is entitled "Ausable_Final.gdb" (feature class "Ausable_Field") and available for download at: http://nyanc-alt.org/GIS/Ausable/Download/AusableGISData.zip.

A summary of the field assessment site scores for fish passage illustrates that approximately half (81 sites) of all sites assessed received a "good" rating for fish passage (Figure 7). Approximately one third (56 sites) rated "poor" for fish passage suggesting that culvert replacement or retrofit at those sites should be considered a priority. The remaining 36 culverts rated "medium." Figure 8 shows rating distribution across the Ausable watershed.

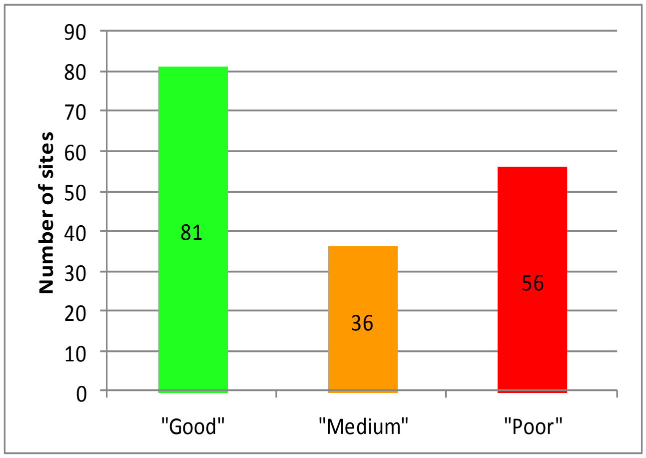


Figure 7. Ausable River Fish Passage site ratings at 173 road crossing sites. "Poor" is > 5 points on the 8 point scoring system and/or a failed outlet drop, "Medium" is 4-5 points with a passable outlet, and "Good" category is fewer than 4 points with a passable outlet.

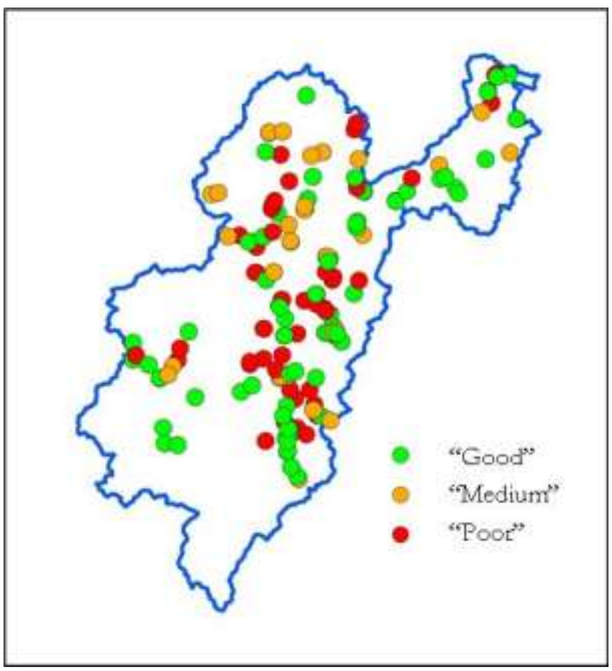


Figure 8. Spatial distribution of "good," "medium," and "poor" rated culverts across the Ausable watershed.

An outlet drop greater than 8 inches results in an automatic "poor" rating of a crossing site for fish passage regardless of other scoring. Among the "poor" rated sites 19 of 56 failed primarily due to an outlet drop > 8 inches. Of these 19 sites 17 would have received a "medium" score while 2 would have received a "good" score based on point totals alone. The result is 19 sites categorized as "poor" (33%) that otherwise would be rated suitable for fish passage. This suggests that if the outlet drop can be addressed at these otherwise "medium" and "good" sites, there may be no need for entire replacement of the culvert.

The remainder of the "poor" rated sites (37 sites) received > 5 points (including failed outlet drop for 30 of 37), suggesting those sites have a combination of inadequate width, depth, velocity and/or outlet drop which is likely impacting movement through the culvert. These sites are among the highest priority candidates for future culvert replacement.

The number of total sites that received 2 pts for each criteria (the maximum score possible) appears in Figure 9. Stream depth and width ratios, which compared in structure to upstream reference data, were responsible for the majority of high (2 pt) scores across the study sites. 88 and 90 sites respectively failed the scoring criteria for width ratio and depth ratio while only 25 failed the velocity score.

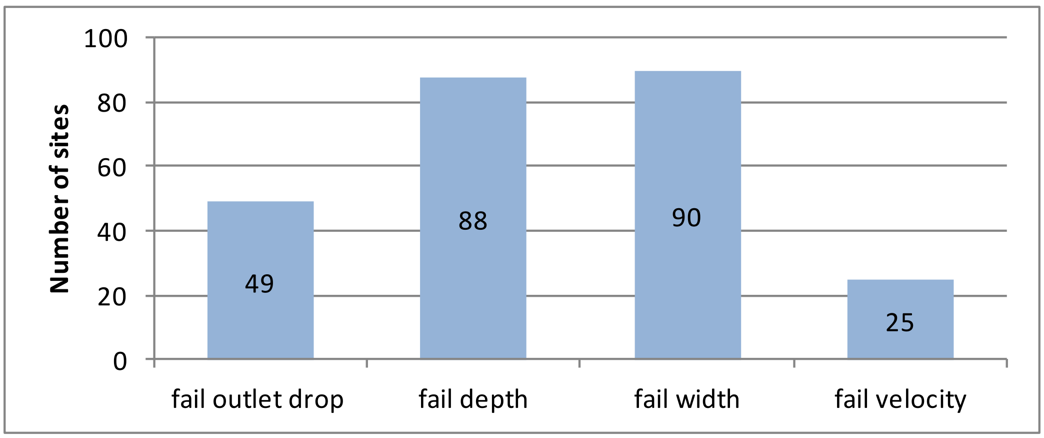


Figure 9. Number of Ausable River sites with the highest score (2 pts = failed score) in each of the four score categories.

"Poor" rated sites and those with failing outlet drops primarily occurred where small tributaries interfaced with small roads; only 7 of 56 "poor" sites were on State Roads. This suggests that culverts on town/county roads should be a priority in field assessments in other watersheds over larger highways and bridge sites. Culverts tend to score poorly because often a culvert is undersized and fill is used for the remainder of the road crossing, thereby reducing the stream flow that the crossing can accommodate. In general bridge sites scored much better for fish passage, mainly due to sufficient width engineered during bridge construction to accommodate stream flow. Also, because bridges do not have a bottom in contact with the stream, they present fewer issues with outlet drop.

Approximately 35 sites visited during the field work (in addition to the 173 that were scored) could not be scored because there was no road crossing at the site, or ponding conditions prevented useful assessment.

C. Integration of Field Assessment into GIS Analyses

Data from the inventoried culverts were used to update the GIS database. The final database contains the ecological criteria for each stream/road crossing (n=630) and the field data for each inventoried culvert (n=173). The amount of upstream habitat available for fish (absolute gain) was updated based on the fish passage field assessment. Appendix B contains the metadata for the resulting GIS geodatabase which is entitled "Ausable_Final.gdb" (feature class "Ausable_Barrier") and available for download at: http://nyanc-alt.org/GIS/Ausable/Download/AusableGISData.zip.

D. Participatory Planning and Engagement

1) Community Priorities

In the spring, summer and fall of 2012, we engaged town and county officials and DPW personnel as stakeholders in the project. We conducted meetings with 5 of 7 town highway department superintendents (Black Brook, Jay, Keene, North Elba, and Wilmington) and 1 county highway department director (Essex) to share information about our project and learn about their local culvert priorities. In some cases there were also trips into the field and multiple follow up conversations or meetings.

Data from the interviews with towns and counties were digitized and mapped (Figure 10) and incorporated into GIS database (Appendix B). This resulted in three distinct groups of priority culverts: 1) ecological priorities, 2) town priorities, and 3) county priorities. Several culverts emerged as being ecologically important as well as significant for human safety and flooding (n=34). Of these, 20 culverts were rated "poor" or "medium" for fish passage after inventory (Figure 11).

Each of the priority culvert groups (ecological, town, and county) are distinctly represented in the associated GIS database. Each culvert is attributed with the priority culvert group, fish passage ranking (if inventoried), ecological criteria, and fragmentation metrics. Appendix B illustrates the data associated with each culvert in the Ausable watershed.

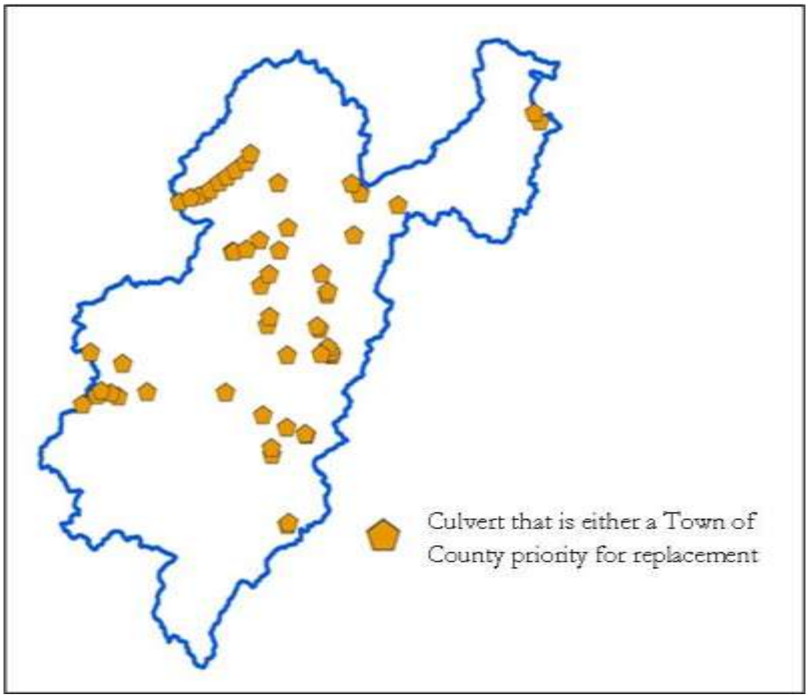


Figure 10. Ausable Watershed Town and County Culvert Replacement Priorities. n=118

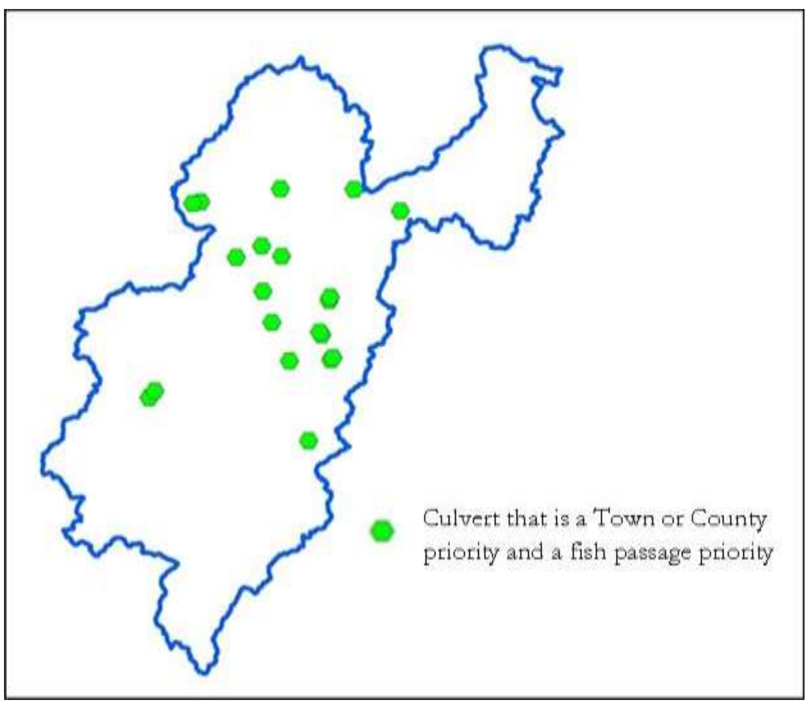


Figure 11. Culverts that are both a community priority (Town of County identified them for needed replacement) and a fish passage priority ("medium" or "poor" rating). n=20

2) Community Education and Use

After engaging municipal leaders in the data collection aspect of the project, we returned to them and presented our results.

Resources

An interactive Google Map was created to communicate results to towns, counties, and other stakeholders (e.g. USFWS) (http://nyanc-alt.org/gis/ausable/). The tool highlights the Ausable watershed and each stream/road crossing. A user can look at several categories of culverts like community priorities and ecological priorities. For example, Figure 12 is a screen capture that illustrates all the culverts in the Ausable watershed that were identified as community priorities and are major barriers to fish passage. Each culvert can also be viewed in detail highlighting data like amount of habitat upstream from each culvert, fish passage rating, and its location on a Google aerial image (Figure 13).

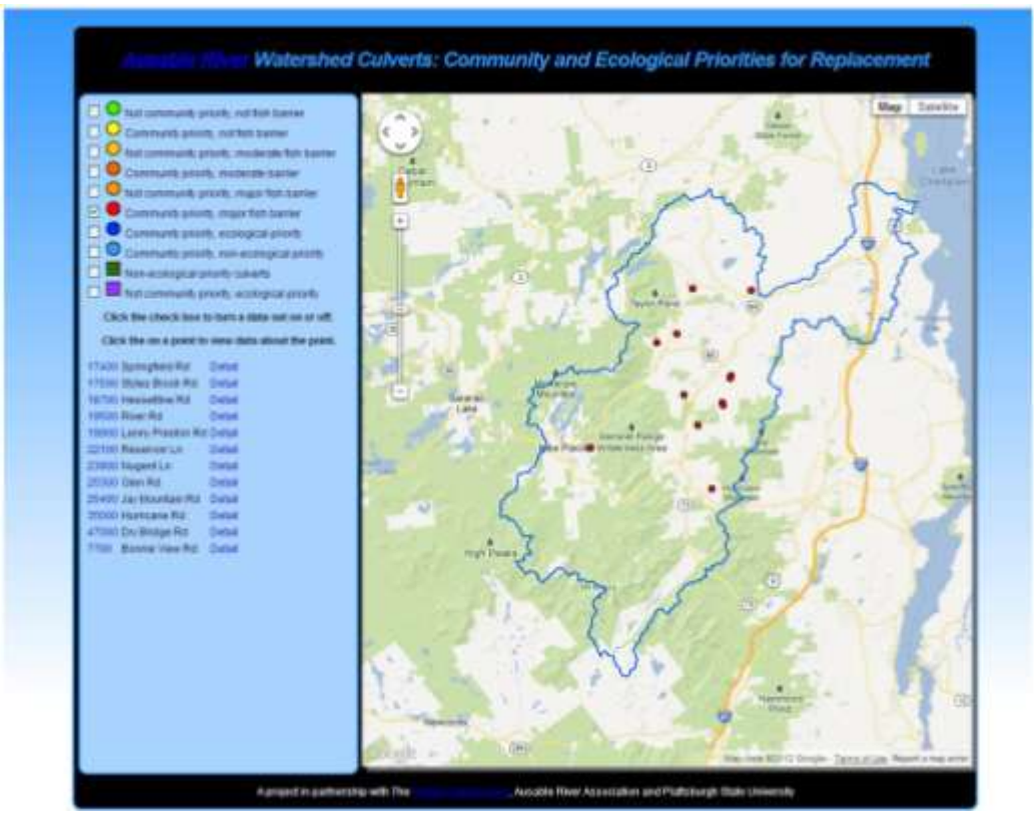


Figure 12. Screen capture of Google map of Ausable watershed culvert inventory results showing community priority culverts and major fish passage barriers in red.

Figure 13. Google map showing detailed data that is available through the online tool.

Presentations

To date, we have presented methods and results of this Ausable River Watershed study on four formal occasions.

Lake Champlain Basin Program Flood Workshop #2

On May 4, 2012 we presented at the second of three workshops hosted by LCBP following the historic floods of 2011. Local, state, provincial officials, legislators, federal partners, NGOs, and university scientists participated in a workgroup discussion of jurisdictional and community responses to the flood events, and the policies or conditions that drove those responses. The intention of the workshop series was to inform an LCBP report for policy makers and the public to increase flood resilience in the three jurisdictions of Quebec, Vermont, and New York. Information, including presentation slides, available at: http://www.lcbp.org/flood_resilience.htm.

ClimAid and Your Community

On September 25, 2012 at the Wild Center in Tupper Lake, New York, we worked with Town of Jay and Keene Supervisors to present at a workshop to audience of approximately 20 municipal leaders and community planners across the Adirondacks, 4 DOT personnel, and 3 NYSERDA personnel. The supervisors shared a reflection of "lessons learned in Irene." We presented our culvert project as a case study of a way to prioritize and begin making positive change towards climate resilience within Adirondack communities. Information, including presentation slides, available at: http://www.adkcap.org/projects/municipalities-and-climate-change.

Resulting press:

Press Republican, October 15, 2012
http://pressrepublican.com/0100_news/x674146448/Officials-share-extreme-weather-concerns-experiences

Essex County Highway Association

On November 12, 2012, at the Board of Supervisors Room in County Office complex in Elizabethtown, New York, we presented project methods and results to 25 Essex County and Town highway employees. They were interested in the project and a good conversation about future endeavors ensued over lunch afterwards.

Figure 13. Presentation to Essex County Highway Association in Elizabethtown, NY.

Adirondack Park Agency, Public Awareness and Communications Committee of the Board

On November 15, 2012, at the APA conference room in Ray Brook, New York, we were invited to repeat the ClimAid presentation to the APA Board's Public Awareness and Communications Committee and their open public audience. The Board was particularly interested in this project as demonstrating a way to prioritize climate resilience efforts. A meeting agenda can be found at: http://apa.ny.gov/Mailing/2012/11/FullAgency/Agency-20121015-TM-O-NovemberAgenda.pdf.

A video recording of the presentation (time 03:42:30) is available at: http://nysapa.granicus.com/MediaPlayer.php?view_id=2&clip_id=318.

Resulting press:

Adirondack Daily Enterprise, November 21, 2012
http://adirondackdailyenterprise.com/page/content.detail/id/534133/More-severe-weather-expected-with-Adirondack-climate-warming.html?nav=5008

Adirondack Explorer, Jan./Feb. 2013
http://www.adirondackexplorer.org/stories/2012/12/21/park-perspectives-culverts-as-a-common-cause/

Future Funding Opportunities

In September 2012, we submitted information about top four priority culverts to US Fish and Wildlife Service for consideration for 2013 and 2014 Fish Passage funding (Appendix C).

4. Discussion

With too few resources for planning and successful implementation and too many culverts to possibly survey, efficiency is critical. GIS modeling allowed us to refine the field work to only ecologically important stream crossings. By collecting field data and community information, we were able to further refine implementation work to highest priority culverts for ecological and social values.

As discussed, we found that the majority of ecologically important culverts impassable to fish were on County or Town roads. This reinforced the value of our project's focus on outreach and education to local town and county officials and employees. Engaging supervisors, highway superintendents and road crews early in the process (as a source of valuable data) proved to also be helpful in garnering interest. In so doing, local officials could see that their information was important and critical to a successful project. Furthermore, this project helped the Ausable River Association strengthen relationships with the community, and specifically with highway staff who play an important role in the river's health and can affect it positively or negatively.

The project has set a foundation for climate change dialogue in the Ausable communities. Communities feel overwhelmed by competing ecological, public safety, and climate change interests; this project has highlighted the areas of overlap where progress can be made that benefits all.

The most significant outcomes from this project in the Ausable are: 1) identification of a suite of high priority culverts for replacement and 2) a growing partnership (municipal leaders, non-profit groups, scientists, local planners, etc…) with the expertise and awareness to begin affecting change, replacing culverts and building ecological and community resilience to climate change.

This study highlights that the integration of GIS modeling, field assessments, and community engagement is an effective strategy to improve natural community and human community resilience. The refined model can be replicated across the Champlain Basin and beyond.

5. REFERENCES

Ausable River Association. (2009) Ausable River Watershed Management Strategy. http://ausableriver.org/pdf/AusableWMPStrategy.pdf.

Bates, K.K. and R. Kim. 2007. Guidelines for the design of stream/road crossings for passage of aquatic organisms in Vermont. VT Fish and Wildlife report, March 2007.

Clarkin, K., A. Connor, M.J. Furniss, B. Gubernick, M Love, K. Moynan, S. WilsonMusser. 2005. NATIONAL INVENTORY AND ASSESSMENT PROCEDURE—For Identifying Barriers to Aquatic Organism Passage at Road-Stream Crossings. United States Department of Agriculture Forest Service, National Technology and Development Program 7700—Transportation Mgmt. November 2005

ConPro. (2007). Conservation Projects Database. The Nature Conservancy. http://conservationtools.tnc.org/conpro/.

Environmental Law Institute. 2008. Planner's Guide to Wetland Buffers for Local Governments. ELI Project No. 0627-01. Washington, D.C.

Groves, C. R. (2003). Drafting a Conservation Blueprint: A practitioner's guide to planning forbiodiversity. Washington, DC, Island Press.

Hornby, D. (2010). Barrier Analysis Tool (BAT) User Guide, Geodata Institute of the University of Southampton.

Jaycox, J. (2005). Important areas for rare animals. Albany, NY, New York Natural Heritage Program.

Jaycox, J., H. Shaw, et al. (2010). Important Areas: Model methodology for New York State aquatic animal Species of Greatest Conservation Need. Albany,NY, New York Natural Heritage Program.

Jenkins, J., 2010, Climate Change in the Adirondacks, Comstock Publishing Associates, Ithaca, NY, 183 p.

Letcher, B.H., K. H. Nislow, J. A. Coombs, M. J. O'Donnell, T. Dubreuil1. 2007. Population Response to Habitat Fragmentation in a Stream-Dwelling Brook Trout Population. Plosone (Nov. 2007), issue 11, p 1-11.

Mattson, K. and P. Angermeier (2007). "Integrating Human Impacts and Ecological Integrity into a Risk-Based Protocol for Conservation Planning." Environmental Management 39(1): 125-138.

Marriner, Paul (1993). River Journal: Ausable River, Frank Amato Publications, Portland, Oregon, 47 p.

Meixler, M. S. and M. T. Bain (2010). "Landscape scale assessment of stream channel and riparianhabitat restoration needs." Landscape and Ecological Engineering 220: 2782-2791.

Mihuc,T.B., E. Allen, E.A. Romanowicz, M. Malchoff. Lake Champlain Basin Fish Passage Initiative 2008- Final report. USFW Service.

Olivero, A. P. and M. A. Anderson (2003). Planning Methods for Ecoregional Targets: Freshwater Ecosystems and Networks. Boston, MA, The Nature Conservancy, Eastern Conservation Science Office.

Olivero, A. P. and A. Jospe (2006). Fragmentation analysis in the Connecticut River watershed. Draft. Boston, MA, The Nature Conservancy, Eastern Conservation Science Office.

Powell, R.O., S.J. Miller, B.E. Westergard, C.I. Mulvihill, B. P. Baldigo, A.S. Gallagher and R.R. Starr, 2004, Guidelines for Surveying Bankfull Channel Geometry and Developing Regional Hydraulic-Geometry Relations for Streams in New York State, U.S. Geological Survey Open-File Report 03-92, U.S. Geological Survey: Troy, NY, 17 p.

Stager, C. and M. Thill. (2010). *Climate Change in the Lake Champlain Basin: What natural resource managers can expect and do.* Keene Valley, NY and Montpelier, VT: The Nature Conservancy.

6. Appendices

A. Field Assessment Data Sheet

Date: ______________ Site ID: ______________

Bridge & Culvert - Geomorphic & Habitat Parameters

Structure Type: **Bridge or Arch / Culvert** Field Map # _____

Stream Name		Site Identification		Town	
Observer(s) / Organization(s)		Time In		Date	
		Time Out		GPS Datum	
Road Name				UTM, North, m	
Mileage Marker				UTM, East, m	
Road Type	**Highway Paved Gravel Trail Railroad**			High Flow Stage	**yes no**
Number of Culverts/Bridges		Structure Material	**Concrete** **Aluminum/iron (corrugated/smooth)** **Steel (corrugated/smooth)** **Plastic (corrugated/smooth)** **Stone** **Timber** **Tank** **Other:** ______________	Overflow pipe(s) Present	**yes no**
Structure Length	(m)			Azimuth Compass Direction: Down Stream	
Structure Height	(m.)				
Structure Width	(m)			Azimuth Compass Direction: Road	
Stream Width In Structure (min)	(m)	**Uniform Wetted Width Under Structure**	**Yes No**	Standing Waves Under Structure	**Yes No**
Water Velocity In structure	(m/s)	**Outlet Drop Height**	(m)	**Water Depth In Structure (min)**	(m)

Geomorphic and Fish Passage Data

General

Floodplain filled by roadway approaches: **entirely partially not significant**

Structure located at a significant break in valley slope: **yes no unsure**

Structure slope as compared with the channel slope is: **higher lower same**

Upstream **Water Velocity:** _______ (m/s)

Is structure opening partially obstructed by (circle all that apply): **wood debris sediment deformation none**

Steep riffle present immediately upstream of structure: **yes no**

If channel avulses, stream will: **cross road follow road unsure**

Estimated distance avulsion would follow road: _________ (m)

Angle of stream flow approaching structure: **sharp bend mild bend naturally straight channelized straight**

Downstream **Water Velocity:** _______ (m/s)

Structure outlet invert: **at grade cascade free fall**

Pool present immediately downstream of structure: **yes no** Pool depth at point of stream flow entry: _________ (0.0 m)

Maximum pool depth: _________ (0.0 m or >1 m)

Downstream bank heights are substantially higher than upstream bank heights: **yes no**

Stepped Footers: **yes no**

Stream Geomorphic Assessment Field Sheet- SUNY Plattsburgh
May, 2012 - 1 -

Date: ______________ Site ID: ______________

	Upstream 1	2	3	Average	Downstream 1	2	3	Average
Width (m)								
Depth (m)								
Velocity (m/s)								
Bankfull width (m)								

Geomorphic and Fish Passage Data	UPSTREAM		DOWNSTREAM		IN STRUCTURE
Dominant bed material at structure	1 2 3 4 5 UK bedrock present: yes no		1 2 3 4 5 UK bedrock present: yes no		1 2 3 4 5 UK bedrock present: yes no
Sediment deposit types	none delta side stair stepped point mid-channel		none delta side stair stepped point mid-channel		none delta side stair stepped point mid-channel
Elevation of sediment deposits is greater than or equal to ½ bankfull elevation:	yes no		yes no		yes no
(left/right bank determined facing downstream)	LEFT	RIGHT	LEFT	RIGHT	
Bank erosion (**H**igh, **M**edium, **L**ow, **N**one)					**Bed Material Codes** **1**-bedrock **2**-boulder **3**-cobble **4**-gravel **5**-sand **UK**-unknown
Hard bank armoring (Indicate for each bank) **I**ntact, **F**ailing, **N**one, **U**nknown					
Streambed scour causing undermining around/under structure (circle all that are present)	none abutments footers wing walls		none abutments footers wing walls		
Dam near structure Distance from structure to dam	yes no distance: ________ ft.		yes no distance: ________ ft.		
Wildlife Data					**Vegetation Type Codes** **C**-coniferous forest **D**-deciduous forest **M**-mixed forest **S**-shrub/sapling **H**-herbaceous/grass **B**-bare **R**-road embankment
(left/right bank determined facing downstream)	LEFT	RIGHT	LEFT	RIGHT	
Dominant vegetation type					
Does a band of shrub/forest vegetation that is at least 50' wide start within 25' of structure and extend 500' or more up/downstream?	yes no	yes no	yes no	yes no	

Wildlife sign and species observed near (up/downstream) and inside structure (circle none or list species and sign types)	Outside Structure		Inside Structure	
	species	species	species	species
Image Numbers:				

Stream Geomorphic Assessment Field Sheet- SUNY Plattsburgh
May, 2012 - 2 -

Date: ________________ Site ID: ______________

Photo Log

Roll and Frame Number or File Name	Photo View (See Abbreviations)	Comments

Abbreviations:

Left and right designations assume one is looking downstream

LBUS	left bank upstream	RBUS	right bank upstream	LBDS	left bank downstream
RBDS	right bank downstream	USFS	upstream from structure	DSTS	downstream toward structure
USTS	upstream toward structure	DSFS	downstream from structure		
LBF	left bankfull	RBF	right bankfull	LEW	left edge of water
LBFH	left bankfull high	RBFH	right bankfull high	REW	right edge of water
LBFM	left bankfull middle	RBFM	right bankfull middle	LTOB	left top bank
LBFL	left bankfull low	RBFL	right bankfull low	RTOB	right top bank
TOR	top of riffle	BOR	bottom of riffle	R	rebar
TOP	top of pool	BOP	bottom of pool	TP	turning point
LFP	left flood prone area	CIF	culvert inflow	WS	waster surface
RFP	right flood prone area	COF	culvert outflow		
RM	reference mark	PBM	permanent benchmark		
RP	reference point	BM#	benchmark w/ number		
TH	thalweg				

Stream Geomorphic Assessment Field Sheet- SUNY Plattsburgh
May, 2012 - 3 -

B. GIS Database Metadata

Geodatabase name Ausable_BAT.gdb

Stream connectivity metrics derived from Barrier Assessment Tool. The following tables describe the GIS feature classes created during the modeling process.

Dataset: Barriers_Ausable_Snapped

Description: Point data set of all barriers snapped to the hydrologic layer used for the BAT processing as well as ecological prioritization. Dam data was collected from NYS GIS clearinghouse and uses the DamID supplied in their data set. RRCulverts and Culverts were generated by creating points where roads and rivers intersected. Waterfall data points came from a regional Nature Conservancy dataset.

Field List:

Field Name	Description
DamID	NYS Dam ID
CulvertID	Unique ID for generated culverts
RRCulvertI	Unique ID for railroad culvert
WaterfallI	Unique ID for Waterfall
BarrierID	Unique ID for all barriers
batSnapped	Was the barrier snapped to the network
batLineID	The intersecting polyline ID
batRegion	Region value
batSnapDis	The distance moved to snap the point to the network
batDisAlng	The distance along the polyline the samp point is (as ratio)
batDis2Mth	The distance from network mouth to snampped point
MainStem	Barrier located on the Main stem of the Ausable River
FirstTribB	Barrier located first on a trib off the main stem
Pri_Select	Barrier a priority based on ecological prioritization

Dataset: FunctionalRiverNetwork_Stats

Description: Statistics table for FunctionalRiverNetwork

Field List:

Field Name	Description
batNetID	The unique ID given to the functional network
batSumLen	The total length for each functional network

Dataset: BarrierData

Description: BarrierData is the base table created by a BAT model run and is updated by the processing tools.

Field List:

Field Name	Description
BarrierID	Unique ID for Barrier
batFuncUS	The available upstream (functional) network that is not blocked by barriers or river source
batCountUS	The number of barriers upstream of a barrier
batLenUS	The total available length of river upstream of each barier
batFuncDS	The available downstream (functional) network that is not blocked by barriers or river source
batDis2Mth	The distance from network mouth
batCountDS	The number of barriers downstream of a barrier
batTotUSDS	The total length of upstream and downstream functional network
batAbs	Absolute gain obtained by removing barrier (meters)
batRel	Relative gain obtained by removing barrier
batDSDnsty	Downstream barrier density
batUSDnsty	Upstream barrier density

batUSNetID	The upstream functional network ID for the barrier
batDSNetID	The downstream functional network ID for the barrier
batAbsMi	Absolute gain obtained by removing barrier (miles)

Dataset: FunctionalRiverNetwork

Description: Network split at barrier locations. Original hydrologic source 1:24,000 Hydrography Digital Line Graph (DLG) data for New York State. DLG data created by NYS-DEC DOW, and US Geological Survey - National Mapping Division.

Field List:

Field Name	Description
REGION	subwatershed id for BAT processing
Fnode	From node in network
Tnode	To node in network
batFn	The from node ID for this network generated by BAT
batTn	The to node ID for this network generated by BAT
batNetID	The unique ID given to the functional network
ComID	Unique ID fror each segment from original dataset
MainStem	Section is part of Ausable Main Stem
Shape_Length	Auto-created field for the length of each segment in meters

Geodatabase name Ausable_Final.gdb

This geodatabase contains two feature classes. One is the final prioritization metrics for all barriers (Ausable_Barriers) which includes the final categorization for ecological, town and county priorities. The second is the field data collected by Plattsburgh State University.

Dataset: Ausable_Barriers

Description: Final GIS layer containing all connectivity metrics, ecological rating and final PSU ranking for barriers in the Ausable Watershed. A total of 630 points are included. Not all barriers contain all data fields. Culverts found by PSU field survey that were not in original connectivity model do not have metrics for connectivity or ecological assessment.

Field List:

Field Name	Description
BarrierID	Unique ID for Barrier
CulvertID	Unique ID for generated culverts
DamID	NYS Dam ID
RRCulvertI	Unique ID for railroad culvert
WaterfallI	Unique ID for Waterfall
PSUID	ID for PSU Surveyed Barriers
Rating	Site rank from PSU field calculation
FirstTribB	Barrier located first on a trib off the main stem
MainStem	Section is part of Ausable Main Stem
Pri_Select	Barrier a priority based on ecological prioritization
batLineID	The intersecting polyline ID
batDisAlng	The distance along the polyline the snap point is (as ratio)
batRegion	Subwatershed id for BAT processing
batDis2Mth	The distance from network mouth to snapped point
batFuncUS	The available upstream (functional) network that is not blocked by barriers or river source
batCountUS	The number of barriers upstream of a barrier
batFuncDS	The available downstream (functional) network that is not blocked by barriers or river source
batLenUS	The total available length of river upstream of each barier
batCountDS	The number of barriers downstream of a barrier
batAbs	Absolute gain obtained by removing barrier (meters)

batTotUSDS	The total length of upstream and downstream functional network
batDSDnsty	Downstream barrier density
batRel	Relative gain obtained by removing barrier
batUSDnsty	Upstream barrier density
batDSNetID	The downstream functional network ID for the barrier
batUSNetID	The upstream functional network ID for the barrier
UTM_E	UTM NAD83 Zone18N Easting Coordinate
UTM_N	UTM NAD83 Zone18N Northing Coordinate
CountyPri	Barrier is a priority for a County. Name of County shown.
TownPri	Barrier is a priority for a Town. Name of Town shown.
CountyName	County Name of Barrier location.
StreetName	Street name of Barrier location.
RoadJurisdiction	Jurisdiction of Road. Town, County, State, Private, City
TownName	Town Name of Barrier location.
StreamName	Stream name of Barrie location.
ComID	Unique ID for each segment from original hydro dataset
EO_Pri1	Element Occurrences from New York Heritage Program with aquatic priority of 1 (mussel)
EO_Pri2	Element Occurrences from New York Heritage Program with aquatic priority of 2 (dragon fly)
Model_Pri1	This field contains a number of SGCN dynamic buffer models developed by the New York Natural Heritage Program. If a model was attributed to the stream segment containing the barrier it was given a value of 1.
Model_Pri2	This field contains a number of SGCN dynamic buffer models developed by the New York Natural Heritage Program. If a model was attributed to the stream segment containing the barrier it was given a value of 1.

Riparian_Health_Score	This field contains streams attributed with riparian health information and grouped into health categories (e.g., poor, excellent) which were converted to vales from 0-1. The riparian health model was developed by ANC. Source hydrology is based on the 1:100,000-scale National Hydrography Dataset.
ERI	This field contains Hydrologic Unit Code (HUC) 10 watersheds attributed with information describing the frequency and severity of a variety of human-induced threats. Based on these threats, watersheds are attributed with composite risk classes. The ERI was developed by ANC. Values range from 0-1.
Stream_Pri	This feature class contains TNC ecoregional stream priorities in New York. Various ecoregional layers were compiled into a comprehensive layer by the Adirondack Nature Conservancy.
ATLS	USGS predicted fish abundance from Great Lakes Regional Aquatic GAP analysis. Atlantic Salmon. Values: Very High=1, High=0.5, Medium=0.25, Low=0
BROK	USGS predicted fish abundance from Great Lakes Regional Aquatic GAP analysis. Brook Trout. Values: Very High=1, High=0.5, Medium=0.25, Low=0
BTRT	USGS predicted fish abundance from Great Lakes Regional Aquatic GAP analysis. Brown Trout. Values: Very High=1, High=0.5, Medium=0.25, Low=0
RAIN	USGS predicted fish abundance from Great Lakes Regional Aquatic GAP analysis. Rainbow Trout. Values: Very High=1, High=0.5, Medium=0.25, Low=0
WSUK	USGS predicted fish abundance from Great Lakes Regional Aquatic GAP analysis. White Sucker. Values: Very High=1, High=0.5, Medium=0.25, Low=0
R_Trout	NYS DEC fish location data for Rainbow Trout. Present=1 Absent=0
Salmon	NYS DEC fish location data for Salmon. Present=1 Absent=0
Bk_Trout	NYS DEC fish location data for Brook Trout. Present=1 Absent=0
Br_Trout	NYS DEC fish location data for Brown Trout. Present=1 Absent=0

TEMP_CAT_N	This field contains TNC ecoregional temperature classifications developed by TNC's Eastern Resource Division based on 1:100,000-scale National Hydrography Dataset. Values range from Hot=0, Warm=0.5, Cold=1.
CT_Stream	NYS DEC classification C for water supporting fisheries suitable for non-contact activities and support Trout population and possibly trout spawning.
Calculation	Total Condition rating summing all metrics. Range 0-32
Lat	Latitude of barrier in decimal degrees.
Lng	Longitude of barrier in decimal degrees.
Category	Descriptive categories for town and county priority culverts.
CatID	ID for Category
Notes	Comments about barrier from field and office staff.

Dataset: Ausable_Field

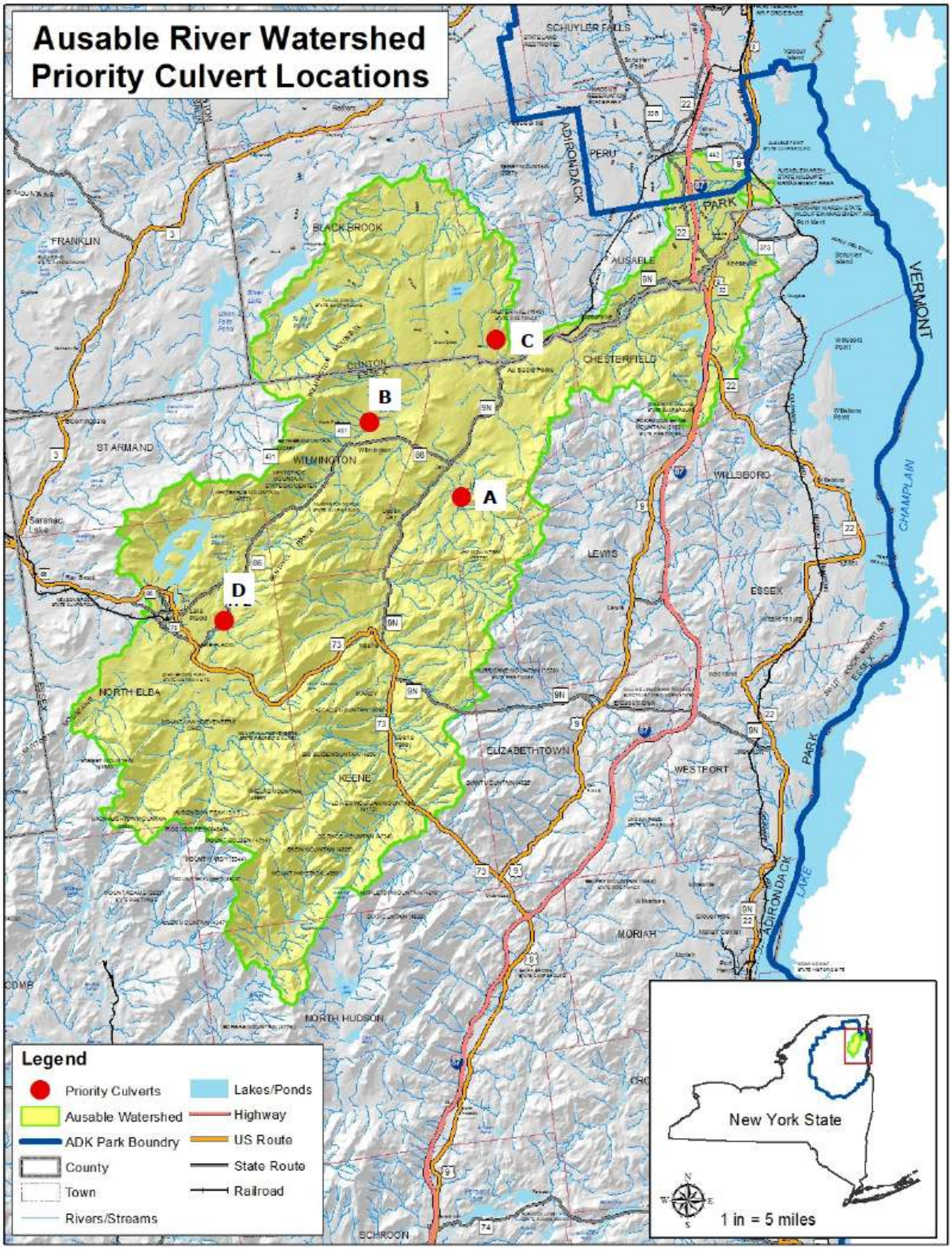
Description: GIS dataset of Plattsburgh State University collected field data for culvert ranking.

Field List:

Field Name	Description
SiteID	PSU site ID
TNCID	TNC barrier ID
Site_Rank	site rank - Poor = 6-8 pts Med- 4-5 pts Good <4 pts
StreamName	Name of stream where barrier is located
Ratio_WDIS_TWD	This is the ratio of the stream water depth in the road crossing structure to the mean thalweg depth from the upstream reference site
Ratio_ISSW_USW	This is the ratio of the stream width in the structure to mean width from the upstream reference site.
OutletDrop_m	Measured drop at the road crossing structure outlet. Drop

	to water level in the stream below the structure.
AVG_Velo	Merasured Velocity (m/s) in the structure at the upstream end.
Ratio_WDIS_TWD_Score	Ratio WDIS (water depth in structure) vs Thalweg water depth
Ratio_ISSW_USW_score	Ratio in-structure stream width/US stream width
Outlet_Drop_Score	OutletDrop (m)
AVG_Velo_Score	Ave. Vel. In Structure (m/s)
Site_summery_score	Summery score of variables
Sample_Year	Year of sampling
Notes	Field comments

C. US Fish & Wildlife Priorities for Fish Passage Funding 2013/2014



Culvert Field Data

Culvert ID	Culvert Length (m)	Culvert Height (m)	Culvert Width (m)	Number of Culverts	Water Velocity Immediately US	Water Velocity Immediately DS	Water Velocity In Structure (m/s)
A	9.5	0.92	0.92	2	0.34	0.45	0.87
B	12.5	0.80	0.78	1	0.00	0.00	0.00
C	No data	No data	No data	1	No data	No data	No data
D	15.45	1.80	1.80	2	0.84	0.73	0.99

Geographic Information

Culvert ID	UTM Northing	UTM Easting	Town	County	Road Jurisdiction	Road Name	Stream Name
A	4911995	602216	Jay	Essex	Town Road	Nugent Rd	Trib of Rocky Branch
B	4917390	595424	Wilmington	Essex	Town Road	Lenny Preston Rd	Trib of West Branch Ausable
C	4922994	604677	Black Brook	Clinton	Town Road	Dry Bridge Rd	Palmer Brook
D	4902924.5	584844	North Elba	Essex	County Road	River Rd	Roaring Brook

Culvert Field Data						
Culvert ID	Water Depth in Stucture (m)	Stream Width In Structure (m)	Avg Stream Width US Structure (m)	Outlet Drop Height (m)	Avg Bankful Width US (m)	Avg Bankful Width DS (m)
A	0.10	0.48	2.50	0.25	4.10	5.17
B	0.07	0.73	0.73	0.23	1.40	1.90
C	0.04	4.17	4.88	0.46	5.65	No data
D	0.16	1.10	5.03	0.06	No data	No data

GIS Data			
Culvert ID	Miles of Stream Gained Upstream*	Downstream Notes	NYS Classified Trout Stream
A	3.9	The total stream network length would be nearly 22 miles.	Yes
B	1.6 – 5.2 (range due to unknown passability of upstream barriers)	This would connect to the West Branch.	Yes
C	4.8	Several culverts downstream from here to the East Branch are passable. One culvert downstream is unknown in terms of passability. If passable, a total of 1.5 miles will be connected to the East Branch.	Yes
D	9.9	This would connect to the West Branch.	Yes

* This is an approximate distance measured in a GIS. The number represents the known miles of stream that will be accessible by fish if the culvert is passable. The number of miles gained could be limited by additional barriers upstream or the end of the mapped stream (in the headwaters).

Culvert ID	Notes
A	Flooded during Irene. Recently channelized. Highway supervisor would like to see box culvert.
B	Culvert washed out in Irene, but FEMA required culvert of same size and replaced.
C	Box culvert was replaced 14 years ago as FEMA project and is perched due to erosion. A lot of rock eroded in Irene and DEC worked with town to fill and hold soil. Since this work earlier in 2012, much of fill has already washed away. We think careful and planned modification of channel can create fish passage without culvert replacement. Size of culvert seems fine.
D	Stream supports two SGCN state-rare dragonflies: boreal and brook snaketail. Essex County Superintendent of Public Works said this is a high priority replacement culvert that was widened many years ago and has structural issues at the extension joint.