Identification of Biologically Important Barriers in the Hudson River Estuary

FINAL REPORT

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1. **INTRODUCTION**

There are millions of potential stream barriers across NYS. The impact of dams and culverts on species and ecosystems is well documented (Forman, Sperling et al. 2003). Within aquatic systems, dams and culverts can significantly alter habitat for fish and wildlife directly through habitat loss or indirectly by altering ecosystem functions (Meixler et al. 2009). Ecosystem functions affected can include hydrologic processes like flooding and the transport of materials such as sediments, soil, large wood, and nutrients (Trombulak and Frissell 2000; Forman, Sperling et al. 2003; Meixler et al. 2010).

The shape, size, and composition of these structures can affect whether a dam or culvert is a barrier to fish passage or negatively impacting stream functions. For example, many dams in the Eastern U.S. are falling into disrepair, yet still creating barriers to fish passage; undersized and poorly-designed culverts are often the cause of debris build-up and flood damage. To be effective at passing water, organic materials, and fish, a culvert must be big enough to accommodate the highest flow events in a year and should be positioned to maintain the hydrologic connection during the lowest annual flows.

Recent advances in culvert and dam design have facilitated fish and wildlife movement as well as ecosystem processes (Beckmann, Clevenger et al. 2010). In New York State (NYS), ecological and engineering guidelines provide specifications for culvert designs that ensure natural movements of aquatic and terrestrial organisms and the ecosystem processes that maintain their habitats. For example, an optimal stream crossing structure should maintain natural flows, contain natural substrate, and accommodate mean annual flood events without flow constriction or increased velocity through structure (New York State Department of Transportation 2009).

Increasingly, the changing climate is putting additional pressure on existing dams and culverts. In much of the northeast, increased precipitation and extreme flooding have caused extensive damage to transportation infrastructure. In the wake of several severe storms and flooding events in NYS, the Governor commissioned a report to improve the strength and resilience of the state’s infrastructure. Specific recommendations from the Commission include the strengthening of culverts to protect against future storms and flooding and replacing metal pipe culverts with new designs in flood-prone areas.

An emerging strategy in the conservation of aquatic systems is the mitigation of barriers that affect aquatic connectivity in streams and rivers. This strategy can simultaneously abate threats to fish and wildlife, human safety, and ecosystem processes. For example, larger culverts and bridges that allow fish movement are also more likely to withstand more frequent flooding.

In the Hudson River Estuary watershed (HRE) alone, there are thousands of potential stream barriers. Because of the number of barriers and the cost to retrofit or replace them, it is imperative that we prioritize the most important places to work. This project is the first step toward identifying biologically important barriers for mitigation in the HRE study area (Fig. 1).
Aquatic Connectivity in the Hudson River Estuary

Figure 1. Hudson River Estuary Watershed

Project Objectives

This project combined a GIS prioritization framework with field assessment methods to identify and prioritize culverts and dams that are of biological importance in the Hudson River Estuary (HRE). The goal of this project was to identify a suite of barriers whose removal would provide a meaningful biological benefit in the HRE. To meet this goal, we accomplished the following objectives:

1. Prioritized biologically important aquatic barriers (dams and culverts) in the Hudson River Estuary watershed.
2. Evaluated barriers and assemble associated location, ownership, and impact data for each barrier.
3. Field verified the location and condition of each priority barrier.

2. METHODS

A. GIS PRIORITIZATION OF BIOLOGICALLY IMPORTANT AQUATIC BARRIERS

The prioritization methodology consisted of three analyses conducted in a geographic information system (GIS): 1) stream assessment, 2) fragmentation analysis, and 3) the selection of priority barriers. The stream assessment addressed biological criteria including species of greatest conservation need (SGCN) and stream condition to focus the suite of streams for priority barrier inventory. The fragmentation
analysis identified the most intact stream networks in the watershed. We calculated how many miles of stream existed 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 aquatic organisms. We combined information from the stream assessment and fragmentation analysis to select priority barriers---those located on ecologically important streams, were potentially significant fragmenting features, and contained SGCN important habitat. 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 USGS National Hydrography Dataset (NHD) High Resolution 1:24,000 (Fig. 2). The original NHDPlus was developed country wide at the 1:100,000 scale and was design to be a snapshot in time due to the extreme overhead of keeping it up to date. The high-resolution NHD was developed at 1:24,000/1:12,000 scale and is designed to be updated continually although it may never have all of the features of NHDPlus. We verified the directionality of the stream flow and removed any bifurcations so all streams could flow to the outlet.

Unit of analysis

The fundamental unit of analysis for the stream assessment was defined by the ComID (“common identifier”) field in the NHD Flowline feature class. ComIDs are unique identifiers for each NHD feature (i.e. streams, lakes, ponds) and delineate the smallest unit in the NHD hierarchy (Fig. 3). For the stream assessment it was necessary to remove artificial centerlines through lake and pond features. Features were eliminated if they met two conditions: (1) contained artificial path flow types, and (2) intersected lake/pond or sea/ocean features in the NHD Waterbody feature class. Hereafter, the term “streams” technically refers to ComID features. The ComID field was chosen as the unit of analysis because it is the finest scale of the NHD and can be combined with any other products derived using NHD data.
1) Stream Assessment

Objective: Prioritize streams across the Hudson River Estuary watershed using models for SGCN and stream condition as criteria

The objective of the stream assessment was to use ecological information to assign all streams in the Hudson River Estuary 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 condition criterion and attributed them to stream reaches; and (2) summed the cumulative scores across each condition criteria to create a composite score for each stream reach. Streams were then grouped into very good, good, fair, and poor classes.

Species Criteria

Species of Greatest Conservation Need (SGCN) habitat models were developed by the New York Natural Heritage Program (NYNHP) and applied by TNC (Important Area models) (Jaycox 2005; Howard 2006). These models were advantageous over species element occurrences because point locations represent an exact location a species was observed, not the habitat it needs to survive. 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 or significant 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.
Table 1. Species and condition criteria used in stream assessment model.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
<th>Source</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGCN Important Area models</td>
<td>Dynamic buffers for SGCN animals and their habitats (Jaycox et al. (2010)).</td>
<td>New York Natural Heritage Program</td>
<td>Polygon</td>
</tr>
<tr>
<td>ARA (Active River Areas)</td>
<td>River channels and riparian lands necessary to sustain physical and ecological riverine processes.</td>
<td>The Nature Conservancy</td>
<td>Polygon</td>
</tr>
<tr>
<td>Floodplain Complexes</td>
<td>Areas of large floodplain cores and corridors (&gt;150 acres and &gt;250 acres)</td>
<td>New York Natural Heritage Program</td>
<td>Polygon</td>
</tr>
<tr>
<td>Impervious Surface</td>
<td>Percent impervious surface by catchment</td>
<td>New York Natural Heritage Program</td>
<td>Polygon</td>
</tr>
<tr>
<td>Matrix Blocks</td>
<td>Priority unfragmented forest blocks as identified by TNC’s ecoregional planning process.</td>
<td>The Nature Conservancy</td>
<td>Line</td>
</tr>
<tr>
<td>Aquatic Ecoregional Portfolio</td>
<td>Priority river networks as identified by TNC’s ecoregional planning process.</td>
<td>The Nature Conservancy</td>
<td>Line</td>
</tr>
<tr>
<td>TNC Summary Report: Conservation Priorities</td>
<td>Synthesis of ten ecological assessments within the HRE</td>
<td>The Nature Conservancy</td>
<td>Polygon</td>
</tr>
</tbody>
</table>

Twelve Important Area models were utilized and included three new models developed specifically for the HRE project – brook trout, wood turtle, and Eastern box turtle. The full list of species that were included in Important Area models were: pond and riverine brook trout, wood turtle, eastern box turtle, riverine mussels (elktoc, eastern pondmussel, yellow lampmussel, alewife floater, eastern pearlshell), longtail salamander, northern red salamander, and diadromous fish (blueback herring, alewife, American shad, American eel). Appendix A contains detailed methodology of the Important Area model and justification.

**Stream Condition Criteria**

In addition to the species models, we considered six stream condition metrics for use in the stream assessment (Table 1). 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 priority barrier selection solely on species criteria. Briefly, the stream condition criteria were:
Active River Areas (ARA)

The active river area framework was developed by TNC and is a spatially explicit, holistic view of rivers that includes both the channels and the riparian lands necessary to accommodate the physical and ecological processes associated with river systems. The framework informs river conservation by providing an approach to account for the areas and processes that form, change and maintain a wide array of habitat types and conditions in and along rivers and streams, including: 1) material contribution areas (e.g. source areas for organic and inorganic materials); 2) meander belts; 3) floodplains; 4) terraces; and 5) riparian wetlands. These areas are defined primarily by the type and frequency of interaction with the river and have been mapped across the northeast U.S (Smith et al. 2008). Percent natural cover within the floodplain complexes was calculated using the National Land Cover Data (NLCD) from 2001. Natural cover types used to create cores include Deciduous Forest, Emergent Herbaceous Wetlands, Evergreen Forest, Mixed Forest, Shrub/Scrub, and Woody Wetlands. Undeveloped land cover used to create corridors include all of the above (natural land cover) as well as Open Water in tributaries or the riparian zone, Cultivated Crops, and Hay/Pasture. Table 2 contains the scoring framework for the ARA criterion.

Table 2. Active River Area stream assessment score.

<table>
<thead>
<tr>
<th>Percent natural cover within the Active River Area</th>
<th>Stream score</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 – 75%</td>
<td>4</td>
</tr>
<tr>
<td>75 – 50%</td>
<td>3</td>
</tr>
<tr>
<td>50 – 25%</td>
<td>2</td>
</tr>
<tr>
<td>25 – 0%</td>
<td>0</td>
</tr>
</tbody>
</table>

Floodplain Complexes

Floodplain complexes were developed by the NYNHP and updated by TNC for the HRE (Fanok et al. 2010, White et al. 2011). ARA spatial data were used to select floodplain cores (areas of natural cover greater than 150 acres and 250 acres along rivers) and combine them with floodplain corridors (natural and undeveloped cover patches of any size along a stream reach that contains a core or natural and undeveloped cover patches greater than 100 acres that are adjacent to a core). Percent natural cover within the floodplain complexes was calculated using the National Land Cover Data (NLCD) from 2001. Natural cover types used to create cores include Deciduous Forest, Emergent Herbaceous Wetlands, Evergreen Forest, Mixed Forest, Shrub/Scrub, and Woody Wetlands. Undeveloped land cover used to create corridors include all of the above (natural land cover) as well as Open Water in tributaries or the riparian zone, Cultivated Crops, and Hay/Pasture. Table 3 contains the scoring framework for the floodplain criterion.
Table 3. Floodplain Complexes stream assessment score.

<table>
<thead>
<tr>
<th>Percent natural cover within floodplain complexes</th>
<th>Stream score</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 – 75%</td>
<td>4</td>
</tr>
<tr>
<td>75 – 50%</td>
<td>4</td>
</tr>
<tr>
<td>50 – 25%</td>
<td>2</td>
</tr>
<tr>
<td>25 – 0%</td>
<td>1</td>
</tr>
</tbody>
</table>

Impervious Surface

The impervious surface metric was developed by the NYNHP and updated by TNC for the HRE using 2006 NLCD impervious surface layer (White et al. 2011). Impervious surfaces are those, like asphalt, concrete, and most roofs, that are impenetrable to water. Stream quality has been shown to decrease with increasing imperviousness in a watershed (Anderson and Olivero Sheldon 2011). The amount of impervious surface was calculated for each stream segment in the HRE by assessing impervious surface for each catchment, and then accumulating the percentage impervious from every stream source, downstream, to every terminus. Thus, every stream segment is attributed with the percentage of impervious surface in the lands immediately draining into this segment (the catchment) and the percentage of impervious surface for the entire basin draining to this stream segment. To depict the percentage impervious surface, we follow Anderson and Olivero Sheldon (2011) with the following thresholds: undisturbed areas as 0 < 0.5 % impervious, low impacted streams as 0.5 – 2% impervious, moderately impacted as >2 – 10%, and highly impacted as >= 10%. These thresholds were based on current research showing serious impacts to aquatic systems when impervious cover exceeds a threshold of 10%. In addition, studies show that declines in the number of stream taxa at a regional scale begin between 0.5 and 2% impervious and declines of 40- 45% at 2-3% impervious (Anderson and Olivero Sheldon 2011). Table 4 contains the scoring framework for the impervious surface criterion.

Table 4. Impervious surface stream assessment score.

<table>
<thead>
<tr>
<th>Percent impervious surface</th>
<th>Stream score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.5%</td>
<td>4</td>
</tr>
<tr>
<td>0.5 – 2%</td>
<td>3</td>
</tr>
<tr>
<td>2 – 10%</td>
<td>2</td>
</tr>
<tr>
<td>&gt;10%</td>
<td>0</td>
</tr>
</tbody>
</table>
Matrix Blocks

TNC and partners have conducted prioritizations of aquatic and terrestrial systems throughout North America as part of their ecoregional planning process. Terrestrial ecoregional portfolios identify large, continuous forest blocks that represent conservation priorities for forest conservation. We extracted matrix block features from the Lower New England/Northern Piedmont ecoregional portfolio and manually selected all stream features that fell within each matrix block from our hydrology layer. We then attributed a score of two to each stream within a matrix block and a score of zero to all non-matrix block streams.

Aquatic Ecoregional Priorities

TNC and partners have conducted prioritizations of aquatic and terrestrial systems throughout North America as part of their ecoregional planning process. Aquatic ecoregional portfolios identify significant and intact stream networks that represent the full diversity of biophysical settings within an ecoregion. We extracted river and stream features from the Lower New England/Northern Piedmont ecoregional aquatic portfolio and manually selected all coinciding stream features within our hydrology layer. We then attributed a score of four to each priority stream and a score of zero to all non-priority streams.

TNC Summary Report

A TNC report, Identifying conservation priorities in the Hudson River Estuary Watershed: Linking perspectives across multiple scales, compiled the results of ten separate studies in the HRE and developed a simple framework to identify common priorities (TNC 2005). This synthesis focused on intermediate-scale ecological assessments including published reports from government agencies, NGOs, and academic institutions. The priority features (e.g. stream segments) identified in each report were tabulated summed across all ten projects resulting in a single value that reflected the number of times a watershed captured a conservation priority. We divided this final ranking into four equally-distributed tiers and assigned scores for the stream condition assessment. Table 5 contains the scoring framework for the TNC summary report criterion.

Table 5. TNC summary report stream assessment score.

<table>
<thead>
<tr>
<th>Watershed tier (based on the number of reports that identified a watershed as being a priority for conservation)</th>
<th>Stream score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>4</td>
</tr>
<tr>
<td>Tier 2</td>
<td>3</td>
</tr>
<tr>
<td>Tier 3</td>
<td>3</td>
</tr>
<tr>
<td>Tier 4</td>
<td>2</td>
</tr>
</tbody>
</table>
2) Fragmentation Analysis

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

The Barrier Analysis 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 and culverts). 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. We systematically removed those points from our dataset 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 network length and 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 4 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 4, the dividing barrier would be attributed with the number of stream miles illustrated by the dashed reaches (Olivero and Jospe 2006).
3) **Priority Barrier Selection**

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

Priority barriers were selected by combining the results of the stream assessment and the fragmentation analysis. First, priority streams were selected based on a total summed score greater than the median (Table 6). Project partners including TNC, NYNHP, HREP, and DOT met in December 2011 to develop a final scoring framework. Barriers that intersected these high priority stream reaches were further refined based on network fragmentation criteria. Finally, a final set of barriers was derived by overlaying the SGCN models on the barriers. The final set of priority barriers all rated high for stream condition, contained SGCN Important Area models, and were in key locations for increasing connected stream miles.

4) **Evaluate barriers and assemble associated location, ownership, and impact data for each barrier.**

After the biologically important barriers were identified through the stream assessment framework, we examined each barrier on an orthophoto to verify it existed on the ground. As a result of this process, we determined the likelihood that each potential barrier actually existed. In lieu of removing potential barriers from the database, we simply ranked them unlikely to be present because we did not want to mistakenly eliminate an important biological barrier. It was very difficult to say definitively that a barrier did not exist from the orthophoto alone. For example, trees can commonly block culverts in a photo. Additionally, we assembled data including latitude and longitude and property ownership and contact information, when available. Several of the barrier points fell within the right-of-way of the real property data, therefore we created a 100m envelop around each point to select ownerships. This can result in multiple ownerships being attributed to each point.

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**Figure 4.** 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.”
Table 6. Scoring criteria for stream assessment prioritization. Each stream reach was attributed with a cumulative score.

<table>
<thead>
<tr>
<th>ARA</th>
<th>Floodplains</th>
<th>Impervious Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 - 75% natural cover = 4</td>
<td>100 - 75% natural cover = 4</td>
<td>&lt;0.5 = 4</td>
</tr>
<tr>
<td>75 - 50 = 3</td>
<td>75 - 50 = 4</td>
<td>0.5 - 2 = 3</td>
</tr>
<tr>
<td>25 - 50 = 2</td>
<td>25 - 50 = 2</td>
<td>2 - 10 = 2</td>
</tr>
<tr>
<td>0 - 25 = 0</td>
<td>0 - 25 = 1</td>
<td>&gt;10 = 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Matrix Blocks</th>
<th>ER Portfolio*</th>
<th>TNC Summary Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>In = 2</td>
<td>Yes = 4</td>
<td>Tier 1 = 4</td>
</tr>
<tr>
<td>Out = 0</td>
<td>No = 0</td>
<td>Tier 2 = 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tier 3 = 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tier 4 = 2</td>
</tr>
</tbody>
</table>

*Considered with the TNC summary report results and only used the portfolio stream scores that were not included in the TNC Summary Report to avoid double counting.

B. FIELD ASSESSMENTS

Objective: Field verify the location and condition of each priority barrier.

1) Fish Barrier Field Assessment

After we had a list of priority potential berries to inventory, we developed a field protocol to evaluate whether the dams and culverts were actually barriers to aquatic organism passage. Recently numerous State and Federal agencies have developed assessment methods and field protocols for determining fish passage impediments (Bates and Kim 2007; Stream Continuity 2012). First, we adapted an existing protocols developed by the River and Stream Continuity Partnership in Massachusetts and NYS DEC field forms for the field methods (Stream Continuity 2012; NYS DEC 2006). The major adaptation we made to the protocol was to include a quick visual assessment upon arrival at the site. The purpose of the visual inspection was to determine whether the dam or culvert was an actual barrier. If the remotely-identified barrier was not an actual barrier in the field, it was not assessed using the full field protocol. This saved time and focused the field work where there were actual barriers (versus potential barriers) and was a main project goal for HREP. The visual inspection for a dam was based on condition and the visual inspection for a culvert was based on inlet and outlet drop and stream to culvert ratio. Appendix B contains the complete field methods, field names, and descriptions and is briefly summarized below.

A measuring tape was used for culvert wetted width, the length of stream through crossing, and, when possible, the stream wetted width and bankfull. A stadia rod was used for all other measurements. The inlet drop was considered present if the water from the streambed had to fall into the culvert or if the culvert was perched above the streambed. In the case of the water falling from the streambed into the culvert the standard field instructions were followed. If the culvert was perched at the inlet, the bottom of the culvert to the streambed was measured and labeled as a negative. When the outlet or inlet of a determined barrier could not be accessed but could be viewed, estimations were used in place of all
measurements that could not be accessed. If the crossing was not considered a barrier no measurements were taken. A dam was treated as an automatic barrier unless more than 50% of it was collapsed or it had been removed.

Pictures were taken at each site. For culverts pictures were taken in the following sequence: upstream habitat, inlet of culvert, downstream habitat, outlet of culvert. If deemed useful a picture was taken looking through the culvert as well. For dams and bridges, one to two pictures were taken of the structure and surrounding area. If no crossing existed or it was removed, no pictures were taken.

The field assessment was recorded using a custom developed ArcPad application installed on a Trimble GeoExplorer GEOXT. The data sheets contained a total of 81 possible fields for collection where 13 were for all barriers, 60 were specific to culverts and 8 specific to dams. Projects were set up by county to help field crew focus on one area at a time. The project contained point locations for each barrier plus multiple scale planimetric images for orientation. At the end of a field day, the GPS unit was synced to a laptop and then backed up via FTP to a remote location.

2) Fish Barrier Site Scores and Prioritization

We adapted a culvert site scoring system from SUNY Plattsburgh to rank the actual barrier culverts into restoration priorities relative to each other (Mihuc 2008). Two scores were derived to assess the degree to which each culvert was a barrier. The first score focused on longitudinal connectivity and focused on the biological need of juvenile brook trout. Outlet drop, inlet drop, and the comparison of stream to crossing slope were used as ranking criteria. The water velocity and depth of culvert to stream were used but as a comparison rather than a quantitative value (Table 7).

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Ranking</th>
<th>Point(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Drop (inches)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;-4; &lt;4</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>-4 to -2; 2 to 4</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>&gt;-2 to 2&lt;</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Outlet Drop (inches)</td>
<td></td>
<td></td>
</tr>
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<td>&lt;4</td>
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<td>2&lt;</td>
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<tr>
<td>Crossing vs. Stream Depth</td>
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<td>Shallower</td>
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<td>0</td>
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<td>Crossing vs. Stream Slope</td>
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<td>Flatter</td>
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<td>Steeper</td>
<td></td>
<td>1</td>
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<td>Comparable</td>
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<td>0</td>
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<tr>
<td>Water Velocity through Crossing</td>
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<tr>
<td>Faster</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Slower</td>
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<tr>
<td>Comparable</td>
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</tbody>
</table>
The second score focused on habitat impact (e.g. huge scour pools) that caused culverts to be barriers. Presence and relative size of the scour pool, the span description, crossing alignment, and a ratio of wetted width in culvert versus the stream were used to determine the degree to which each culvert was a barrier based on near-by habitat alterations (Table 8). We summed the points for each criterion and resulted with two scores per barrier, one for connectivity and one for habitat impact. The cumulative score represented the degree to which each culvert was a barrier.

**Table 8.** Criteria used to determine the relative severity of each culvert as a habitat barrier.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Ranking</th>
<th>Point(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing vs. Stream Wetted Width (Ratio)</td>
<td>0 to 0.34</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0.34 to 0.67</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&lt;0.67</td>
<td>0</td>
</tr>
<tr>
<td>Scour Pool</td>
<td>Large</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>Crossing vs. Stream Alignment</td>
<td>Skewed</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Aligned</td>
<td>0</td>
</tr>
<tr>
<td>Span Description</td>
<td>Severe Constriction</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Mild Constriction</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Spans Bank to Bank</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Spans Channel &amp; Banks</td>
<td>0</td>
</tr>
</tbody>
</table>

**C. INTEGRATION OF FIELD ASSESSMENT INTO GIS ANALYSES**

*Objective: Integrate field results into the GIS prioritization to further refine future important barrier selection*

After the completion of the field work, the status of the potential barriers was updated in the GIS database. In other words, when we calculated the fragmentation metrics originally, we assumed all dams and culverts were barriers. Now, we know many of them are not barriers. We manually incorporated the results of the field season into the barrier database and re-ran the Barrier Analysis Tool (BAT) and updated the resultant barrier statistics.

**3. RESULTS**

**A. GIS PRIORITIZATION OF BIOLOGICALLY IMPORTANT AQUATIC BARRIERS**

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

*Objective: Prioritize streams across the Hudson River Estuary watershed using models for SGCN and stream condition as criteria*

There were 9925 total stream miles in the Hudson River Estuary watershed. Over 28% of these were categorized as high priority streams (Table 9, Fig.5). Based on the scoring framework for attributing each stream reach, we grouped the stream reaches into quantiles. All stream reaches with Very Good or Good score were considered streams with high condition (above the median score of 7).

<table>
<thead>
<tr>
<th>Stream priority class</th>
<th>Length (miles)</th>
<th>% of total length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Good (green)</td>
<td>1580.77</td>
<td>15.92</td>
</tr>
<tr>
<td>Good (yellow)</td>
<td>2642.07</td>
<td>26.62</td>
</tr>
<tr>
<td>Fair (orange)</td>
<td>3891.65</td>
<td>39.21</td>
</tr>
<tr>
<td>Poor (red)</td>
<td>1810.05</td>
<td>18.23</td>
</tr>
</tbody>
</table>

*Figure 5. Stream prioritization in the Hudson River Estuary River watershed.*
Six stream criteria contributed to the final stream assessment ranking (Fig. 5). Figure 6 shows the results of each individual criterion and summary results.

<table>
<thead>
<tr>
<th>Active River Area</th>
<th>Count</th>
<th>Length (miles)</th>
<th>% of total length</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 - 75% natural cover = 4</td>
<td>14430</td>
<td>4612.1</td>
<td>46.5</td>
</tr>
<tr>
<td>75 - 50 = 3</td>
<td>5969</td>
<td>2384.7</td>
<td>24.0</td>
</tr>
<tr>
<td>25 - 50 = 2</td>
<td>4662</td>
<td>1612.8</td>
<td>16.2</td>
</tr>
<tr>
<td>0 – 25 = 0</td>
<td>6875</td>
<td>1315.4</td>
<td>13.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Floodplains</th>
<th>Count</th>
<th>Length (miles)</th>
<th>% of total length</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 - 75% natural cover = 4</td>
<td>558</td>
<td>171.6</td>
<td>1.7</td>
</tr>
<tr>
<td>75 - 50 = 3</td>
<td>642</td>
<td>220.9</td>
<td>2.2</td>
</tr>
<tr>
<td>25 - 50 = 2</td>
<td>35</td>
<td>17.2</td>
<td>0.2</td>
</tr>
<tr>
<td>0 – 25 = 1</td>
<td>601</td>
<td>129.2</td>
<td>1.3</td>
</tr>
<tr>
<td>NA = 0</td>
<td>30100</td>
<td>9386.2</td>
<td>94.6</td>
</tr>
</tbody>
</table>
Aquatic Connectivity in the Hudson River Estuary

<table>
<thead>
<tr>
<th>Impervious Surface</th>
<th>Count</th>
<th>Length (miles)</th>
<th>% of total length</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.5 = 4</td>
<td>18602</td>
<td>4913.6</td>
<td>49.5</td>
</tr>
<tr>
<td>0.5 - 2 = 3</td>
<td>5778</td>
<td>2390.0</td>
<td>24.1</td>
</tr>
<tr>
<td>2 - 10 = 2</td>
<td>5164</td>
<td>1824.0</td>
<td>18.4</td>
</tr>
<tr>
<td>&gt;10 = 0</td>
<td>2392</td>
<td>797.4</td>
<td>8.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Matrix Block</th>
<th>Count</th>
<th>Length (miles)</th>
<th>% of total length</th>
</tr>
</thead>
<tbody>
<tr>
<td>In = 2</td>
<td>1837</td>
<td>906.6</td>
<td>9.1</td>
</tr>
<tr>
<td>Out = 0</td>
<td>30099</td>
<td>9018.5</td>
<td>90.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ecoregional Portfolio</th>
<th>Count</th>
<th>Length (miles)</th>
<th>% of total length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes = 4</td>
<td>1171</td>
<td>470.0</td>
<td>4.7</td>
</tr>
<tr>
<td>No = 0</td>
<td>30765</td>
<td>9455.1</td>
<td>95.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TNC Summary Report</th>
<th>Count</th>
<th>Length (miles)</th>
<th>% of total length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank 1 = 4</td>
<td>644</td>
<td>287.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Rank 2,3 = 3</td>
<td>202</td>
<td>97.4</td>
<td>1.0</td>
</tr>
<tr>
<td>All other Ranks = 2</td>
<td>356</td>
<td>168.8</td>
<td>1.7</td>
</tr>
<tr>
<td>NA = 0</td>
<td>30734</td>
<td>9371.1</td>
<td>94.4</td>
</tr>
</tbody>
</table>

2) Fragmentation Analysis

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

There were 13057 total potential barriers analyzed in the Hudson River Estuary watershed (12053 culverts and 1004 dams). Each potential 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 (Fig. 7). BAT results varied greatly for culverts, ranging from a minimum of <0.0001 miles to a maximum of 52.85 miles, with a mean of 0.434 miles (Table 10)

We also used the sum length of each river network to focus on the longest unfragmented river networks. Sections again ranged from the very small of <0.0001 miles up to a maximum of 520 miles, with a mean of 0.75 miles (Fig. 7)

Table 10. Absolute gain statistics for both barrier types.

<table>
<thead>
<tr>
<th>Absolute gain values (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Culverts</td>
</tr>
<tr>
<td>Dams</td>
</tr>
</tbody>
</table>
Figure 7. Fragmentation analysis results. Total numbers of potential barriers (left) and unfragmented stream networks (right).

3) Priority Barrier Selection

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

The end goal was to have a set of priority barriers upon which to focus scarce inventory resources. An ecological priority barrier was identified from a suite of high quality streams, SGCN habitat, network length, and high potential for connectivity gain. Barriers that had relatively high gain (absolute gain values >= 750 m and a network length of > 2000 m) were classified as priority barriers. There were 363 barrier records identified as priorities (Fig. 8, Table 11).
Table 11. Derivation of important barrier identification.

<table>
<thead>
<tr>
<th>Prioritization Metric</th>
<th>Number of Possible Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total possible barriers</td>
<td>13,057</td>
</tr>
<tr>
<td>Total possible barriers on high condition streams</td>
<td>3,277</td>
</tr>
<tr>
<td>Total possible barriers with &gt; 2000m network length</td>
<td>1,677</td>
</tr>
<tr>
<td>Total possible barriers with &gt;=750m stream gain</td>
<td>924</td>
</tr>
<tr>
<td>Total possible barriers that intersect SGCN models</td>
<td>363</td>
</tr>
<tr>
<td>Possible barriers intersecting with SGCN’s that are culverts</td>
<td>283</td>
</tr>
<tr>
<td>Possible barriers intersecting with SGCN’s that are dams</td>
<td>80</td>
</tr>
</tbody>
</table>

Figure 8: Important biological potential barriers (n=363).
Because we could not evaluate 363 barriers in the field, we further prioritized by species richness and priority subwatershed to aid in field logistics (Fig. 9).

Figure 9. Initial Selection from Richness (n=193)

B. Field Assessments

Two-hundred and seven barriers were field assessed between June 4, 2012 and July 26, 2012. A summary of the field assessment site resulted in 92 actual barriers, 50 culverts that were passable, 44 bridges that were passable, and 16 barriers that scored high ecologically, but did not exist in the field (Figs. 10, 11, 12). Appendix C describes the prioritization and field data that are available in the GIS geodatabase.
Figure 10. Hudson River Estuary River Fish Passage site ratings at 207 road crossing sites.

Figure 11. Spatial distribution of all rated culverts across the Hudson River Estuary watershed.

<table>
<thead>
<tr>
<th>Category</th>
<th># of points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culvert, barrier</td>
<td>46</td>
</tr>
<tr>
<td>Dam, barrier</td>
<td>46</td>
</tr>
<tr>
<td>Culvert, not barrier</td>
<td>50</td>
</tr>
<tr>
<td>Bridge, not barrier</td>
<td>44</td>
</tr>
<tr>
<td>Dam, not barrier</td>
<td>5</td>
</tr>
<tr>
<td>Culvert, did not exist</td>
<td>6</td>
</tr>
<tr>
<td>Dam, did not exist</td>
<td>10</td>
</tr>
</tbody>
</table>
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. The first step was to remove the points that were found not to be barriers. Table 12 shows the change in statistics for two fields we used in our prioritization analysis after the incorporation of the field data.

Figure 12. Total number of barriers and non-barriers to aquatic organism passage.

C. Integration of Field Assessment into GIS Analyses

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. The first step was to remove the points that were found not to be barriers. Table 12 shows the change in statistics for two fields we used in our prioritization analysis after the incorporation of the field data.
Table 12. Statistical comparison of BAT outputs.

**Sum Length of Networks**

<table>
<thead>
<tr>
<th></th>
<th>Old</th>
<th>New</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>13132</td>
<td>12848</td>
<td>-2.16%</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.000148</td>
<td>0.005986</td>
<td>3944.59%</td>
</tr>
<tr>
<td>Maximum</td>
<td>838894.2</td>
<td>1137055</td>
<td>35.54%</td>
</tr>
<tr>
<td>Sum</td>
<td>15913337</td>
<td>15913337</td>
<td>0.00%</td>
</tr>
<tr>
<td>Mean</td>
<td>1211.798</td>
<td>1238.585</td>
<td>2.21%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>8631.581</td>
<td>Standard Deviation: 11546.08</td>
<td>33.77%</td>
</tr>
</tbody>
</table>

**BAT Abs Gain**

<table>
<thead>
<tr>
<th></th>
<th>Old</th>
<th>New</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>13057</td>
<td>12776</td>
<td>-2.15%</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.000152</td>
<td>0.000244</td>
<td>60.53%</td>
</tr>
<tr>
<td>Maximum</td>
<td>85115.29</td>
<td>299108.8</td>
<td>251.42%</td>
</tr>
<tr>
<td>Sum</td>
<td>9143785</td>
<td>8973126</td>
<td>-1.87%</td>
</tr>
<tr>
<td>Mean</td>
<td>700.2975</td>
<td>702.3423</td>
<td>0.29%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2360.241</td>
<td>Standard Deviation: 3811.092</td>
<td>61.47%</td>
</tr>
</tbody>
</table>

The most surprising statistic was the increase in absolute gain based on updated field data. While the number of barriers only decreased by 2.15% within the HRE watershed, the absolute gain maximum value increased by over 200%. This increase was verified to ensure it was not an error during processing. Figure 13 illustrates the updated database after 4 culverts were changed from potential barrier to non-barriers after field inventory. In other words, removing strategically placed barriers can have a huge amount of benefit to aquatic connectivity.

**Figure 13.** Green dots represent field inventoried potential barriers that are passable to fish. Now, by removing one dam, NY-209-5141, the absolute gain will increase from 44km to 299km.
Products

An interactive Google Map was created to communicate results to stakeholders (http://nyanc-alt.org/gis/HRE/). The tool highlights the Hudson River Estuary watershed and each biologically important barrier. A user can look at several categories of barriers (e.g., culverts that were not passable by aquatic organisms). Figure 14 is a screen capture that illustrates all the culverts in the Hudson River Estuary watershed that were inventoried and determined to be 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 15).

![Google Map of Hudson River Estuary watershed culvert inventory results](image)

**Figure 14.** Screen capture of Google map of Hudson River Estuary watershed culvert inventory results showing community priority culverts and major fish passage barriers in red.
Figure 15. Google map showing detailed data that is available through the online tool.
## Final products resulting from project

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRE_Final.gdb</td>
<td>Geodatabase containing all outputs from prioritization process, network analysis, real property ownership and SGCN models.</td>
</tr>
<tr>
<td>BAT_Final.gdb</td>
<td>Re-run of barrier analysis after the non-barriers were removed. Includes new network output, network statistics and barrier statistics.</td>
</tr>
<tr>
<td>Blueprint_Diadomous.gdb</td>
<td>Cumulative diadromous fish layer supplied by Natural Heritage Program and used for the richness calculation to prioritize the 363 selected barriers.</td>
</tr>
<tr>
<td>HRE_Culverts_ImportantAreas.gdb</td>
<td>SGCN Important Area models supplied by Natural Heritage Program</td>
</tr>
<tr>
<td>Layer Files</td>
<td>Layer files for ARA, Floodplain, Impervious surface, Geology, Gradient, Matrix Block, Size Class, Selected Barriers and Surveyed Culverts to be used to display data in GIS.</td>
</tr>
<tr>
<td>HRE Web Interface</td>
<td>Google Map interface to display all selected culverts and their results. Gives users ability to obtain all information about a barrier that was created or obtained from a survey. URL: <a href="http://nyanc-alt.org/gis/hre/">http://nyanc-alt.org/gis/hre/</a></td>
</tr>
</tbody>
</table>

### EXTRAS

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRE_Grids.gdb</td>
<td>Input grids for ARA, Floodplain, DEM, and Impervious surface</td>
</tr>
<tr>
<td>BAT_v13.zip</td>
<td>Barrier Assessment Tool (BAT) for ArcGIS 10.1</td>
</tr>
<tr>
<td>ElevationProcessing.py</td>
<td>Python script used to create catchments needed to complete accumulation statistics for size class and Impervious surface. Catchments also used to calculate geology, gradient and temperature.</td>
</tr>
<tr>
<td>GDBSchema.XML</td>
<td>XML schema file of proper field types and structure to run ElevationProcessing.py.</td>
</tr>
<tr>
<td>NY_Dams_NEAFWA092011.zip</td>
<td>NYS Dam dataset comprised of Dams from NYS but cleaned up and processed by Eastern Resource office of The Nature Conservancy for the NEAFWA project.</td>
</tr>
</tbody>
</table>
4. DISCUSSION

Over 13,000 potential barriers exist in HRE streams and rivers. Resources are far too limited to comprehensively inventory all of them, especially when mitigating barriers through retrofits and replacements is the ultimate goal. GIS modeling allowed us to direct limited field inventory to the most important biological locations. This project created the first biologically important barriers dataset for mitigation in the HRE study area. The mitigation of any of these barriers would help meet ecological goals in the HRE and as demonstrated above, focused removal of certain barriers can have huge positive effects on aquatic connectivity. A few considerations:

- The stream prioritization framework determined where the field inventory was focused. SGCN habitat models and stream condition criteria drove the identification of biologically important barriers. Because of these decisions, much of the inventory was focused on smaller streams upstream from main tributaries. This does not mean there are not additional important biologically barriers in the HRE. This does mean that our results are specific to the framework documented here.
- There are likely more barriers in the watershed than have been mapped. This is a result of the resolution of the data.
- Several of the potential barriers visited were bridges. These could not be discerned from orthophotos, but in the future additional assumptions could be made based on stream size to reduce the number of bridges visited. Bridges are likely not to be barriers.
- We developed a framework for determining culvert restoration priorities utilizing connectivity and habitat impact scores. This could be used to focus scarce adaptation money.
- There are several different sources of money focused on retrofitting and replacing barriers. Diversifying funding sources could lead to more adaptation money (e.g. fish passage funding and climate resilience funding).
- Field assessment – several culverts were inventoried that were not ecological priorities because of proximity to other field sites. In some cases this is time well spent (e.g. when a barrier is not mapped, but is on the same stream reach as an important mapped barrier), but do not waste too much time on non-ecological priorities.
- Field assessment – several culvert sites included more than one culvert. The database should allow for this possibility.
- Field assessment – Eighty fields is a lot. Consider reducing the number of variables collected in the field and limiting them based on their importance for determining retrofit, replacement, or restoration priorities.
- We hoped to identify remote (GIS) criteria (e.g. stream size, gradient) that could be used in the future to predict when a potential barrier would actually be a barrier. We were unable to do this for several reasons. First, we decided to focus on sites that at a quick glance were deemed to be likely barriers. This skewed the number of resultant barriers and non-barriers. Second, the results of the prioritization model were focused on smaller catchments, which limited the range of each criterion that was recorded. In other words, a lot of our sites were similar to each other. Third, it
may not be possible to remotely identify passable versus non-passable barriers given the scale of the GIS variables. Similar efforts in MA have resulted in little information on predictive variables besides stream size matters (Jackson, pers. comm.).

The most significant outcomes from this project in the Hudson River Estuary are: 1) identification of a suite of high priority barriers for replacement, 2) a flexible database that can serve as the basis of barrier inventory data and is compatible with regional databases, 3) repeatable prioritization and inventory methods that can be replicated and updated, 4) user-friendly products (e.g. Google Map), and 5) a foundation upon which to attract adaptation and mitigation money.
5. REFERENCES


6. APPENDICES

New York Natural Heritage Program SGCN Important Area Methods

Field Assessment Methods and Datasheets

GIS Database Metadata
Species and Methodology for HR Culverts

Methodology_Ref: I.A.1. Basic Riverine

Species

Alasmidonta varicosa, Anodonta implicata, Lampsilis cariosa, Ligumia nasuta, Notropis amoenus.

Steps

1 - Select all EOs with IA_Model = 01ERIV_G01,01HRIV_G01. Select shapefiles: "01ERIV_G01_fish" and "01HRIV_G01_fish" from the following path: W:\Projects\HRE_Culverts\GIS_data\non_tracked_IA_Model_Ready.

2 - Add a 10 meter buffer to point features (non-EO).

3 - Run the riverine community IA model on these polygons. (Note: the upstream component of this methodology was clipped at 3 km.)

4 - Aggregate all adjacent polygons, dissolve internal boundaries, and eliminate all ‘donut holes’.

Justifications: 1, 4.

Methodology_Ref: I.A.3. Stream/River Salamanders

Species

Pseudotriton ruber.

Steps

1 - Select EOs with IA_Model= 01ERIV_SAL or shapefile(s) containing "01ERIV_SAL" at W:\Projects\HRE_Culverts\GIS_data\non_tracked_IA_Model_Ready.

2 - Add a 10 meter buffer to point features (non-EO) to account for locational uncertainty.

3 - Buffer the occurrence boundary by 30 meters (known movement distance- not maximum).

4 - Buffer these boundaries by 340 meters. (Explanation: 290 meter buffer for amphibians and 50 meter terrestrial buffer added to protect from edge effects).

5 - Clip at Class 1 and 2 roads.

6 - Select all ponds and lakes that intersect the buffered area from Step 4.

7 - Clip out the following CCAP LU/LC : High Intensity Developed (2).

8 - Aggregate all adjacent polygons, dissolve internal boundaries, and eliminate all ‘donut holes’.

9 - Delete disjunct polygons.

Justifications: 6, 47.

Methodology_Ref: I.A.7. Salvelinus fontinalis (Brook Trout)

Species

Salvelinus fontinalis.

Monday, December 12, 2011
Steps

1 - Select all records containing the following: "01ERIV_ABT" and "01ERIV_WBT" at W:\Projects\HRE_Culverts\GIS_data\non_tracked_IA_Model_Ready

2 - Select the stream systems for each point based on the drainage catchment.

3 - Run the riverine community IA model on these polygons. (Note: the upstream component of this methodology was clipped at 3 km.)

4 - Remove the Hudson River, if it is included, from the model results. (The lower Hudson River is not suitable habitat for Brook Trout (Fred Henson, personal communications).)

5 - Aggregate all adjacent polygons, dissolve internal boundaries, and eliminate all ‘donut holes’.

Justifications: 48.

Methodology_Ref: I.B.1. Basic Lacustrine 1

Species

Ligumia nasuta, Salvelinus fontinalis.

Steps

1 - Select all EOS with IA_Model = 01ELAC_G01, 01HLAC_G01. Also select shapefiles containing "01ELAC_ABT" and "01ELAC_WBT" from Projects\HRE_Culverts\GIS_data\non_tracked_IA_Model_Ready.

2 - For non-EO points- select the nearest lacustrine waterbody within 50 meters. Omit any points that are not within this distance.

3 - Capture the wetlands within 100 meters of these occurrences (open water ponds/lakes and associated palustrine communities) and digitize the surrounding wetland boundary using a combination of NWI, State Regulated, and land use/land cover wetlands.

4 - Run the palustrine wetland community IA model on these polygons.

5 - Aggregate all adjacent polygons, dissolve internal boundaries, and eliminate all ‘donut holes’.

Justifications: 1, 2, 42, 48.

Methodology_Ref: I.C.3. Eurycea longicauda (Longtail Salamander)

Palustrine

Species

Eurycea longicauda.

Steps

1 - Select all EOs with IA_Model = 01EPAL_LTS

2 - Buffer the occurrence boundary by 30 meters (known movement distance- not maximum).

3 - Capture the contiguous wetlands (palustrine communities from NWI, land use/land cover, and state regulated) that intersect these occurrences.
4 - Buffer these wetlands by 340 meters. (290 meter buffer for amphibians and 50 meter terrestrial buffer added to protect from edge effects). Explanation: Amphibian buffer suggested by Semlitsch and Bodie (2003). “We propose the stratification should include three terrestrial zones adjacent to core aquatic wetland habitats: (1) a first terrestrial zone immediately adjacent to the aquatic habitat, which is restricted from use and designed to buffer the core aquatic habitat and protect water resources; (2) starting again from the wetland edge and overlapping with the first zone, a second terrestrial zone that encompasses the core terrestrial habitat defined by semiaquatic focal-group use (e.g., amphibians 159-290 m); and (3) a third zone, outside the second zone, that serves to buffer the core terrestrial habitat from edge effects from surrounding land use (e.g., 50 m; Murcia 1995).” As this “buffer” is designed to protect upland habitat as well as the wetland for amphibians in general, and is greater than the NYNHP palustrine buffer, it seems appropriate to use this instead of the palustrine buffer in order to protect all areas that may be potentially used by the salamanders.

5 - Aggregate all adjacent polygons, dissolve internal boundaries, and eliminate all ‘donut holes’.

Justifications: 7 .

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Methodology_Ref:  I.E.6. Wood Turtle

Species
Glyptemys insculpta.

Steps

1- Select layer containing "01ETRV_WDT".
2 - Apply a 10 meter buffer to account for locational uncertainty.
3 - Capture contiguous streams 500 meters upstream and 500 meters downstream, including tributaries, from the buffered point (Step 2).
4 - Apply a 300 meter buffer to Step 2 results. (Wood Turtle are typically found within 300 meters of a stream.)
5 - Apply Ecology Terrestrial IA buffers.
6 - Clip out the following 2005 CCAP LU/LC: High Intensity Developed (2), Open Spaces Developed (5), and Bareland (20). Clip out the Hudson River and any ponds or lakes.
7 - Aggregate all adjacent polygons, dissolve internal boundaries, and eliminate all ‘donut holes’.
8 - Remove disjunct polygons.

Justifications: 51.

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Methodology_Ref:  I.E.7. Diadromous Fishes

Species
Alosa aestivalis, Alosa pseudoharengus, Alosa sapidissima, Anguilla rostrata.

Steps

1 - Select the shapefile named 01ERES_DIF.
2 - Select all open waters downstream of the locations.

3 - Apply the Riverine Community Model to streams and rivers except for the Hudson River. (OMIT for HRE Culverts - time constraints. Instead, add 163 meter buffer from Community methodology.)

4 - Apply the Estuarine Community Model for “non-woody tidal community” to the Hudson River.

5 - Apply a 5 kilometer buffer that only includes marine waters that are contiguous with the results from Step 4. OMIT for HRE Culverts- time contraints. Instead, clip to HRE Boundary provided by ANC.)

6 - Aggregate all adjacent polygons, dissolve internal boundaries, and eliminate all ‘donut holes’ that are not associated with development.

Justifications: 39 , 49.

Methodology_Ref: I.G.12. Terrapene carolina (Eastern Box Turtle)

Species
Terrapene carolina

Steps

1- Select all points layer= 01ETER_BOT_Box_Turtle.shp.
2- Add a 10 meter buffer to point features to account for locational uncertainty.
3- Apply a 1000 meter buffer.
4- Clip the results from Step 2 at Class 1-3 roads.
5 - Clip out the following LU/LC: 2 (High Intensity Developed), 3 (Medium Developed), 6 (Cultivated Lands), 21 (Water), 22 (Palustrine Aquatic Bed), 23 (Estuarine Aquatic Bed).
6 - Aggregate all adjacent polygons, dissolve internal boundaries, and eliminate all ‘donut holes’ that are not associated with development.
7 - Remove disjunct polygons.

Justifications: 50.
Justifications

1  \- Mollusks

Notes:

Freshwater mussels are susceptible to habitat loss and degradation due to a variety of factors. These factors include, but are not limited to, water temperature changes that result from human-induced activities, siltation, scouring, industrial and agricultural contaminants, and barriers between populations. Mussels included in this project are dependent upon several host fish species, which may also require stable water quality or lack of barriers (especially for anadromous host fishes). In order to preserve water quality and identify areas important to freshwater mussels, it makes sense to define the watershed that each occurrence falls within. Once defined, all waters upstream of the mussel occurrence should be delineated and appropriately buffered to protect these waters from potentially negative impacts that could impact a mussel occurrence farther downstream (e.g., siltation, contaminant loads, etc.). However, a buffer of this type presents challenges as the areas depicted become so large that they are often impractical for conservation planning efforts. Therefore, a buffer distance of 3 km will be applied to the NYNHP EO boundary in order to capture the EO and the associated section of stream that is likely to be important to the species being buffered. Freshwater mussels that sometimes have occurrences in lakes, like Ligumia nasuta, should be adequately protected by applying a lacustrine (palustrine) community buffer to the lake and associated wetland boundary.

Citations:


4  \- Freshwater Fishes

Notes:

Fish are susceptible to habitat loss and degradation due to a variety of factors. These factors include, but are not limited to, water temperature changes that result from human-induced activities, siltation, scouring, industrial and agricultural contaminants, and barriers to movement and between populations. In order to preserve water quality and identify areas important to fish, it makes sense to define the watershed that each occurrence falls within. Once defined, all waters upstream of the fish should be delineated and appropriately buffered to protect these waters from potentially negative impacts that could impact a fish occurrence farther downstream (e.g., siltation, contaminant loads, etc.). However, a buffer of this type presents challenges as the areas depicted become so large that they are often impractical for conservation planning efforts. Therefore, a buffer distance of 3 km will be applied to the original location in order to capture the known habitat and the associated section of stream that is likely to be important to the species being buffered. Fish that have occurrences in lakes should be adequately protected by applying a lacustrine (palustrine) community buffer to the lake and associated wetland boundary. Note: Comely Shiner is not actively tracked by NYNHP. We obtained point locations only. Data were not reviewed at the same level as Element Occurrences.
7  • Eurycea longicauda (Longtail Salamander) - Palustrine

Notes:

Longtail Salamanders generally occur at the margins of streams and wetlands (e.g., marsh). Typically, they remain within 20-30 meters of these aquatic habitats (Semlitsch and Bodie 2003). We suggest capturing the continuous wetland area that intersects the salamander EOs and protecting this wetland area with the amphibian buffer suggested by Semlitsch and Bodie (2003) to adequately protect the core wetland. The following is the amphibian buffer suggested by Semlitsch and Bodie (2003): “We propose the stratification should include three terrestrial zones adjacent to core aquatic wetland habitats: (1) a first terrestrial zone immediately adjacent to the aquatic habitat, which is restricted from use and designed to buffer the core aquatic habitat and protect water resources; (2) starting again from the wetland edge and overlapping with the first zone, a second terrestrial zone that encompasses the core terrestrial habitat defined by semi-aquatic focal-group use (e.g., amphibians 159-290 m); and (3) a third zone, outside the second zone, that serves to buffer the core terrestrial habitat from edge effects from surrounding land use (e.g., 50 m; Murcia 1995).” As this “buffer” is designed to protect upland habitat as well as the wetland for amphibians in general, and is greater than the NYNHP palustrine buffer, it seems appropriate to use this instead of the palustrine buffer in order to protect all areas that may be potentially used by the salamanders.

Citations:


47  • Pseudotriton ruber ruber (Northern Red Salamander)

Notes:

Little is known about Northern Red Salamander movement patterns or territory sizes. They migrate from streams and seeps to terrestrial habitats in early April in New York (AmphibiaWeb 2011). According to Petranka (1998), red salamanders rarely disperse more than 30 meters from hibernacula sites in New York. Buffer recommendations from Semlitsch et al. (2003) should capture the important areas for these salamanders. Note: This species is not actively tracked by NYNHP. We obtained point locations only and added a 10 meter buffer to account for locational uncertainty. Data were not reviewed at the same level as Element Occurrences.

Citations:


Metropolitan Conservation Alliance. 2007. Metropolitan Conservation Alliance Fieldwork Database (MCA_Data_070807.mdb).


48  -  Salvelinus fontinalis (Brook Trout)

Notes:

Brook Trout inhabit clear, cool, well-oxygenated waters (e.g., creeks and small-medium rivers), and lakes. They prefer water temperatures that range from 14-16°C, and they rarely thrive in water over 20°C for extended periods of time (NatureServe 2010). They can tolerate pH as low as 5 (Trout Unlimited 2011), and they prefer dissolved oxygen levels that are greater than or equal to 6.0mg/l (Osmond et al. 1995). (Note: In the future, it may be desirable to incorporate water temperature, pH, and dissolved oxygen levels into the IA models. There were time constraints that inhibited reviewing possible datasets.) Movement distances can be as high as 65-100 km (NatureServe 2010). The Lower Hudson River is not suitable habitat for Brook Trout. In order to preserve water quality and identify areas important to Brook Trout, it makes sense to define the watershed that each occurrence falls within. Once defined, all waters upstream of the Brook Trout occurrence should be delineated and appropriately buffered to protect these waters from potentially negative impacts that could impact populations farther downstream (e.g., siltation, contaminant loads, etc.). However, a buffer of this type presents challenges as the areas depicted become so large that they are often impractical for conservation planning efforts. Therefore, a buffer distance of 3 km will be applied to the original location in order to capture the known habitat and the associated section of stream that is likely to be important to the species being buffered. Brook Trout that inhabit lakes should be adequately protected by applying a lacustrine (palustrine) community buffer to the lake and associated wetland boundary. Notes: (1) This species is not actively tracked by NYNHP. We obtained point locations only. Data were not reviewed at the same level as Element Occurrences. (2) Heritage strains of Brook Trout have not been well documented by extensive genetic studies. Streams in the HRE Culverts study area have been heavily stocked over several decades. It's assumed there are few, if any, Heritage strain populations in the area. Heritage strains are known from the Adirondacks and a few locations on Long Island (Fred Hanson (NYSDEC), personal communications).

Citations:


49  Diadromous Fishes

Notes:

This model includes freshwater, estuarine, and marine components to cover all habitats occupied by diadromous fish stages of life within New York State jurisdiction. The freshwater/estuarine component uses the Ecology methodology for estuarine and riverine habitats. These models should capture important areas for diadromous fishes. The marine component is captured by adding a 5 km marine water buffer to the freshwater/estuarine results. (Note: These fishes are typically found in deep marine habitat during at least one life stage. It is likely that the majority of marine habitat that is used by the various species covered in this model is not represented in the final results.) Fish are susceptible to habitat loss and degradation due to a variety of factors. These factors include, but are not limited to, water temperature changes that result from human-induced activities, siltation, scouring, industrial and agricultural contaminants, and barriers to movement and between populations. In order to preserve water quality and identify areas important to fish, it makes sense to define the watershed that each occurrence falls within. Once defined, all waters upstream of the fish should be delineated and appropriately buffered to protect these waters from potentially negative impacts that could impact a fish occurrence farther downstream (e.g., siltation, contaminant loads, etc.). However, a buffer of this type presents challenges as the areas depicted become so large that they are often impractical for conservation planning efforts. Therefore, a buffer distance of 3 km will be applied to the original location in order to capture the known habitat and the associated section of stream that is likely to be important to the species being buffered. Notes: The species in this model are not actively tracked by NYNHP. We obtained point locations only. Data were not reviewed at the same level as Element Occurrences.

Citations:


50  Terrapene carolina (Eastern Box Turtle)

Notes:

Eastern Box Turtle movement patterns from Massachusetts and New York studies were used to determine the buffer in this Important Area. In Massachusetts, the Natural Heritage Atlas described using a 991 m buffer for Eastern Box Turtle that was based on radio telemetry studies in the state (Natural Heritage & Endangered Species Program 2008). In New York, a Hudson River Valley study found movement distances that were a minimum of 76.55 m, maximum of 1551.98 m, and an average of 460.79 m (McGowan et al. 2009). NatureServe (2010) recommends an inferred extent of 0.5 km. While NatureServe's estimate is close to the average from the New York study, most of the movement distances were greater than 500 m and Massachusetts used a greater distance. For the purposes of this model, a 1000 m buffer was applied to the known locations because the longer distances traveled in Hudson River Valley was closer to that distance. Using a 1000 m buffer should capture most of the Important Areas for this species. Notes: (1) This species is not actively tracked by NYNHP. We obtained point locations only and added a 10 meter buffer to account for locational uncertainty. Data were not reviewed at the same level as Element Occurrences. (2) Class 1 and Class 2 roads likely cause a higher mortality rate than other road classes. However, it's difficult to determine how much of a barrier these roads are without visiting each site. We decided to "ignore" roads as a barrier for this model. When reviewing the Eastern Box Turtle Important Area near busy roads, it's important to consider the possibility that few, if any, turtles may be able to cross some of the roads.

Citations:


Metropolitan Conservation Alliance. 2007. Metropolitan Conservation Alliance Fieldwork Database (MCA_Data_070807.mdb).


Wood Turtles generally inhabit wooded areas that are within 150-300 meters of permanent streams. They have also been found in cultivated fields, woodland bogs, and marshy pastures that are close to wooded areas with streams. Hibernacula are the bottoms or banks of streams (NatureServe 2010). A study at a Hudson Valley site in New York found that the maximum distance a radio-tracked Wood Turtle moved was 1134.89 meters and the minimum distance was 94.20 meters. The average distance the radio-tracked turtles moved was 471.52 meters (McGowan et al. 2009). The Important Area captures the movement of the turtles by selecting the nearest stretches of streams 500 meters upstream and 500 meters downstream of the known locations and then applying a 300 meter buffer to the stream. (Some Wood Turtle locations were not near streams in the hydrography layer. These locations did not go through the whole model and therefore have only the locational uncertainty buffer.) Notes: (1) This species is not actively tracked by NYNHP. We obtained point locations only and added a 10 meter buffer to account for locational uncertainty. Data were not reviewed at the same level as Element Occurrences. (2) Class 1 and Class 2 roads likely cause a higher mortality rate than other road classes. However, it's difficult to determine how much of a barrier these roads are without visiting each site. We decided to "ignore" roads as a barrier for this model. When reviewing the Wood Turtle Important Area near busy roads, it's important to consider the possibility that few, if any, turtles may be able to cross some of the roads.

Citations:


Metropolitan Conservation Alliance. 2007. Metropolitan Conservation Alliance Fieldwork Database (MCA_Data_070807.mdb).


Field Assessment Datasheets
River and Stream Continuity Project

DRAFT
Instruction Guide for the 5/14/12 Field Data Form: Road–Stream Crossing Inventory

Developed by the
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OVERVIEW

The River and Stream Continuity Project is a program that trains volunteers and technicians to inventory river and stream road crossings (culverts, bridges, etc.). This information will be used to help determine if crossings are barriers to fish and wildlife movement, and cause habitat fragmentation. Barriers that are identified can then be prioritized for remediation.

These instructions provide additional explanations for the questions on the Road–Stream Crossing Inventory Field Data Form. Remember that the data form is for the entire river or stream crossing, which might include multiple culverts or multiple cell bridges. With the exception of dimensions, answer each question for the crossing as a whole. It is not necessary that every cell of a multiple cell bridge crossing span the channel. Look instead to determine whether, for example, the combination of cells collectively spans the stream channel.

It can be difficult to determine how best to evaluate multiple culvert/cell crossings. Please use the following as a guide for these inherently confusing situations.

1. When the multiple culverts/cells are similar in material, size and elevation use the best case for answering questions on page one of the crossing form. For example if a crossing has two similar sized culverts and where only one of the culverts contains substrate that is comparable to that found in the natural stream channel and the other does not, then answer “comparable” to question #12 (Crossing substrate).

2. When the culverts/cells are significantly different in either material, size, elevation or other characteristics then focus the review on the structure that carries most of the stream flow.

3. When the culverts/cells are significantly different but no single structure carries the majority of the stream flow then focus the review on the “best case” structure considering the full range of characteristics on the data form. If it is not clear which structure is the “best case” structure then consult with the survey coordinator.

Please be sure to answer every question.

SHADE BOXES

The Survey Coordinator will provide the necessary information for these boxes. These include “Coordinator,” “Crossing ID#,” Stream/River,” “Road,” “Town” and “Flow condition” as well as information related to entering and reviewing data in the Crossings Database. Do not enter data in these boxes.

Survey teams in the field they may encounter unmapped crossings or be unclear as to whether or not the crossing they are assessing is one of the crossings depicted on the map. A crossing may exist on the map that does not exist in the field (in this case the “No crossing” option should be checked on line 3 of the field data form). Survey teams also may encounter unmapped crossings because either the road or the stream was unmapped or due to errors in the GIS analysis that generated the crossings. In some cases the crossing on the map may just be a little off.

When an unmapped crossing is encountered in the field survey teams should write “Unmapped crossing #___” (providing a unique number for each unmapped crossing) at the top of the field data form. Later the Survey Coordinator will forward the record to the National Coordinators for assignment of a crossing code.
**BASIC INFORMATION**

**GPS Coordinates (lat/long)** – Use of a GPS (Global Positioning System) unit is required.

- Map Datum: It is best to use datum WGS84 but NAD 83 (North American Datum 1983) or NAD 83 Conus are acceptable as well.
- Location Format: Use projection Latitude-Longitude decimal-degrees (hddd.ddddd or dd.ddd) with 6 decimals if possible.
- If coordinates are collected in decimal degrees then check the “Decimal degrees” check box and enter coordinates in the spaces provided.
- If coordinates are collected in degrees, minutes and seconds then check the “Degrees, minutes, seconds” check box and enter coordinates in the spaces provided.
- Make sure that you are standing on the road above the culvert when taking the GPS point.

**Date** – Date that the crossing was evaluated.

**Location** – Provide enough information about the exact location of the crossing so that another person using your data sheet will be confident that they are at the same crossing that you evaluated. For example “between telephone poles # 162 and 163” or “right across from the Depot Restaurant.”

**Observer** – Your name.

**Photo IDs** – If you took digital photos record the ID numbers from your camera. Enter “none” if you did not take photos.

Digital photographs are an extremely useful tool to use in assessing potential barriers to aquatic organism passage. When taking photos, be sure to use the date/time stamp to code each photo if possible, and record the ID number from the camera of each photo in the appropriate blank on the form. It is important to set the camera to record in low to medium resolution so that the photos do not take up too much space when downloaded for storage. Ideally, to minimize storage space required, but still allow a reasonable image, each photo would be between 100 and 500 kilobytes in size when downloaded.

You can take and submit to the survey coordinator as many photographs as it takes to thoroughly document the site. Only two photographs from each site can be uploaded to the database. Please ensure that you have one good photo of the inlet taken from upstream of the crossing and another of the outlet taken from downstream of the crossing.

A simple way to know which photos were taken at a particular site is to use a black marker to write the date, crossing ID # and inlet/outlet on a dry-erase board or an 8 ½”X11” paper (waterproof if available). The white board should be strategically placed in the photo to make it legible and to not block key features of the crossings. This will make the photo readily identifiable with the appropriate crossing # and will denote whether the image is of the outlet or inlet of the structure. Some people have noted that white dry-erase boards and white paper reflect so much light that they are often “washed out” in the photos and the codes written on the board impossible to read. Use of a small blackboard and chalk may be preferable depending on light conditions.
ROAD / RAILWAY CHARACTERISTICS

Road surface - Check “Paved,” “Unpaved” or “Railroad.”

Road type – Check the most appropriate box for the type of road at the crossing location.

1-Lane road – Check this option for one-lane roads and smaller, including cart paths, bike baths, trails, and abandoned rail beds. If the road is greater than 18 feet wide it should be considered a 2-lane road.

2-Lane road – Use this option for typical roads – with or without shoulders/breakdown lanes – that have two travel lanes. Include in this category unpaved roads that are of comparable width to paved, two-lane roads.

Multilane road – This category includes roadways with three or more travel lanes but not divided highways.

Divided highway – Include any divided highway with a total of four or more travel lanes (e.g. two lanes eastbound + two lanes westbound). Any multi-lane (>2 lanes) roadway with a median, vegetated island, Jersey barriers, or guardrails should be considered a divided highway. When travel lanes are separated by a median you can get two crossings (e.g. one for eastbound and one for west bound traffic). Where you have a divided highway but no median you often get a single crossing. In both cases, the road type should be “divided highway.”

Railroad – Use this category for rail beds with railroad tracks regardless of how many sets of tracks may be involved. Use “1-Lane road” for abandoned rail beds and rail trails.

Buried Stream – Use this category for a segment of stream that has been buried within a pipe extending well beyond the road crossing itself.

CROSSING / STREAM CHARACTERISTICS – Assess the following for the entire crossing

Crossing type – If a crossing exists at an assessment location check the most appropriate choice among “Ford,” “Bridge,” “Open bottom arch,” “Single culvert” and “Multiple culverts” to identify the crossing type (for additional information see descriptions in the glossary). For an open-bottom box culvert check “Bridge.” If there is no crossing at the assessment location check either “Removed” if there was once a bridge there that had since been removed or “No crossing” if it appears that there was never a crossing at that location. If you choose the “No crossing” option then it is not necessary for you to fill out the remainder of the data form.

Condition of crossing – Check the appropriate box: “New,” “Excellent,” “Fair” or “Poor.”

Does the stream at the crossing support fish? – Check “Yes” if you see fish or believe that the stream segment at the crossing supports fish. Also check “Yes” if you think that the stream both above and below the crossing supports fish. Check “Not likely” if you think that it is almost certain that the stream segment does not support fish (including fish just passing through). Otherwise check “Don’t know.”

Is the stream flowing? – Check “Yes” if stream is flowing in the channel upstream and downstream of the crossing. To answer “yes” water in the channel must be moving (even if very slow) and consistent. Puddled areas separated by dry land and rocks does not constitute flow.

Crossing span: Natural streams are variable in width. In selecting the appropriate category consider the average conditions in the natural stream channel outside the influence of the crossing itself.
Bankfull is amount of water that just fills the stream channel and where additional water would result in a rapid widening of the stream or overflow into the floodplain. Indicators of bankfull width include:

- **Abrupt transition from bank to floodplain.** The change from a vertical bank to a horizontal surface is the best identifier of the floodplain and bankfull stage, especially in low-gradient meandering streams.
- **Top of point bars.** The point bar consists of channel material deposited on the inside of meander bends. Set the top elevation of point bars as the lowest possible bankfull stage.
- **Bank undercuts.** Maximum heights of bank undercuts are useful indicators in steep channels lacking floodplains.
- **Changes in bank material.** Changes in soil particle size may indicate the operation of different processes. Changes in slope may also be associated with a change in particle size.
- **Change in vegetation.** Look for the low limit of perennial vegetation on the bank, or a sharp break in the density or type of vegetation.

Check the appropriate description from the list below.

**Severe constriction:** The crossing is half as wide, or narrower, than the bankfull width of the natural stream.

**Mild constriction:** The crossing is narrower than bankfull width in the natural channel upstream and downstream of the crossing but not enough to qualify as a severe constriction.

**Spans bank to bank:** Choose this option if the crossing spans the bankfull width of the channel, but does not include the banks of the stream.

**Spans channel and banks:** Choose this option if the crossing structure spans the bankfull channel width and one or more of the banks with sufficient headroom to allow dry passage for some wildlife.

**Tailwater scour pool:** These are pools created downstream as a result of high flows exiting the crossing. Use as a reference natural pools occurring in a portion of the stream that is outside the influence of the crossing structure and not otherwise altered. A scour pool is considered to exist when its size (a combination of length, width and depth) is larger than pools found in the natural stream. Check “Large” if the width or depth of the pool is twice that of pools in the natural stream channel or more. Otherwise, check either “Small” if a smaller pool exists or “None” if there is no scour pool.

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Crossing alignment matches stream? – Assess crossing alignment at the structure inlet. Use as reference a line connecting the center of the channel where it enters the structure and the center of the channel as it exits the structure. If within 30 feet upstream of the structure the channel deviates from this line by 45 degrees or more check “No (skewed).” If the channel deviates by less than 45 degrees check “Yes (flow aligned).”
CULVERT/BRIDGE CELL CHARACTERISTICS – Assess the following for each structure that makes up the crossing

Structure embedded?: An embedded culvert is a culvert that is installed in such a way that the bottom of the structure is below the stream bed and there is substrate in the culvert. Indicate on the data form whether or not the culvert is embedded and the degree that the culvert is embedded.

- If the culvert is not buried and generally lacks substrate, then check “Not embedded”.
- If the culvert is partially buried and contains substrate for half or more of its length, check “Partially embedded.”
- If the culvert is buried for its entire length, check “Fully embedded”.
- If the structure has no bottom (bridge, open bottom arch, etc.) or is a ford then check “No bottom.”
**Structure substrate:** Record whether the substrate in the crossing is “Inappropriate,” “Contrasting,” “Comparable,” or absent (“None”).

- If the culvert is not fully embedded check “None.” If a culvert is only partially embedded then the substrate should be considered “none.”
  - Check “None (smooth)” if the structure bottom lacks corrugations or other roughened conditions
  - Check “None (rough/corrugated)” if the structure bottom is corrugated (e.g. metal or plastic pipe), contains some substrate (but not enough to be considered fully embedded) or is otherwise roughened.

- Large riprap and broken slabs of concrete are examples of substrates that are “Inappropriate” for river and stream continuity.

- Check “Contrasting” if the substrate is not wholly inappropriate, but contrasts with the substrate in the natural stream channel. For example, if the crossing’s predominant substrate is boulders and large cobble on a stream where the natural stream bottom is predominantly mud/muck.

- Check “Comparable” if the substrate in the crossing is similar to that found in the natural stream channel.

**Internal features:** Check the appropriate box(es) if any of the following features are present within the crossing structure. If no such features are present check “none.”

- Slip lined – Slip lining is when a small liner pipe is inserted into a larger culvert and sealed in place as a way of repairing a crossing without having to replace the structure.

- Baffles/sills – These are low structures that run roughly perpendicular to the flow of water to either reduce velocity or trap/hold sediment. Typically a series of baffles or sills are used within a structure.

- Weirs – Are substantial structures that typically run perpendicular to the flow to back water up (increase depth), reduce velocity or confine low flows to create a channel. One or more weirs might be present within a structure.

- Support structures – Include any internal supports that intercept or interfere with the flow of water.

**Physical barriers to fish and wildlife passage:** This includes any durable structure that physically blocks fish or wildlife movement. Do not include temporary barriers such as debris or sediment accumulations that are not likely to persist for a number of years. If physical barriers exist at a crossing indicate whether the barrier effect is:

- “Severe” (essentially blocking all fish and wildlife passage),
- “Moderate” (blocking passage for some species or individuals but not others) or
- “Minor” (blocking passage for only a few species or individuals or for only a small proportion of the year) and describe them on the data form.

- Otherwise check “None.”

**Is there a clear line of sight through the structure?** – Look through the structure if you can see clear through the structure to the other side and check “yes.” Otherwise check “no.”

**Does the structure provide dry passage suitable for use by terrestrial wildlife?** – Check “yes” if at the time of the assessment the structure provides dry passage with sufficient headroom for semi-aquatic and terrestrial wildlife (e.g. along banks or within the stream channel). Otherwise check
“no.” If “yes” is checked then also record the maximum structure height in the portion of the structure that offers dry passage.

Comments – Add anything you feel may not have been included, but is important for describing the crossing.

Water depth matches stream? – To evaluate water depth use as a reference a portion of the natural stream channel that is outside the influence of the crossing structure and not otherwise altered. Depth is considered comparable if water depths in the crossing are similar to the depths upstream and downstream in the natural stream channel. Comparable means that the depth in the crossing falls within the range of depths naturally occurring in that reach of the stream and for comparable distances. For example a crossing that has water depths that are similar to those found in deeper pool sections of the stream but that extend for longer distances along the stream than do the pools would not be considered comparable. After evaluating the crossing relative to the natural stream check the most appropriate option among “Yes (comparable),” “No (deeper),” “No (shallower)” or “Dry.”

Water velocity matches stream? – To evaluate water velocity use as a reference a portion of the natural stream channel that is outside the influence of the crossing structure and not otherwise altered. Velocity is considered comparable if water velocities in the crossing are similar to the velocities in the nature stream channel upstream and downstream of the crossing. Comparable means that the velocities in the crossing fall within the range of velocities naturally occurring in that reach of the stream and for comparable distances. For example a crossing that has water velocities that are similar to those found in riffle sections of the stream but that extend for longer distances along the stream than do the ripples would not be considered comparable. After evaluating the crossing relative to the natural stream check the most appropriate option among “Yes (comparable),” “No (slower),” “No (faster)” or “Dry.”

Crossing Slope matches stream? – To evaluate crossing slope use as a reference a portion of the natural stream channel that is outside the influence of the crossing structure and not otherwise altered. Slope is considered comparable if the crossing slope is similar to the slopes found in the nature stream channel upstream and downstream of the crossing. Comparable means that the crossing slope falls within the range of slopes naturally occurring in that reach of the stream and for comparable distances. For example a crossing that has a slope that is similar to that found in short, high-gradient sections of the stream but that extend for longer distances than found in the natural stream would not be considered comparable. After evaluating the crossing relative to the natural stream check the most appropriate option among “Yes (comparable),” “No (flatter)” or “No (steeper).”

Length of stream through crossing (ft.) Measure the crossing from inlet to outlet by walking through the structure if it is large enough and safe to do so. If walking through culvert is not possible, then hold measuring tape at inlet and let current carry it to the outlet where someone else catches it and measure the length. Another option is to estimate length by measuring distance from inlet to outlet on the road above the structure.

Upstream/Downstream Crossing Type – Choose the most appropriate choice from #1-9 or Ford that describes the type of crossing. Record crossing type separately for upstream and downstream portions of the structure. If you have a partially embedded culvert you will have a different culvert type at one end (e.g. round culvert) compared to the other (e.g. embedded round culvert) and will need to record different dimensions.

1. Open Bottom Arch will look like a pipe culvert on the top half, but you will not see a bottom half. Instead for the bottom, it has metal footings that are sunk into concrete below the stream channel. For recording dimensions a stone arch bridge should be considered an open bottom arch.
2. Bridge with abutments will have sides at right angles, but no bottom structure.

3. Bridge with side slopes will have angled sides, and no bottom structure.

4. Bridge with side slopes and abutments will have both sloping sides as well as sides at right angles to give the bridge height over the stream.

5. Round Culvert will be a circular pipe. If the culvert typically contains a significant amount of water then choose “Round Culvert Embedded or with Persistent Water” instead.

6. Elliptical Culvert will have a wider, squashed look than a round pipe culvert. If the culvert typically contains a significant amount of water then choose “Elliptical Culvert Embedded or with Persistent Water” instead.

7. Box Culvert will usually be made of concrete.

8. Round Culvert Embedded or with Persistent Water Use this option for a round culvert where the bottom has been buried below the stream channel or for a round culvert that typically contains significant amounts of water, even if not truly embedded.

9. Elliptical Culvert Embedded or with Persistent Water Also known as a “pipe arch” use this option for an elliptical culvert where the bottom has been buried below the stream channel or for an elliptical culvert that typically contains significant amounts of water, even if not truly embedded.

Ford is a shallow water crossing directly across the streambed, often with logs, stone, or gravel to protect or stabilize the bottom. These are rare, and are mostly found on roads that are not frequently used.

Upstream /Downstream dimensions (ft.) Provide the measurements shown in the appropriate diagram for the crossing type. (If measurements cannot be taken, please estimate and write EST. after estimated measurement.)

A. Measure interior width of crossing at its widest point above the water line at the time of the assessment.

B. Measure height from underside of crossing to:
   - Water surface or top of bank whichever is higher for bridges, open-bottom arches, and embedded culverts
   - Water surface for box culverts and culverts with persistent water
   - Structure bottom for non-embedded culverts lacking persistent flow

C. Measure width of actual stream channel (wetted width) through crossing structure if natural bottom exists (i.e. bridges or embedded culverts).

D. Measure height of vertical abutments from underside of bridge to where sides start sloping. If the opening of the culvert is completely submerged under water then check “Submerged.”

Inlet/Outlet Water Depth: Measure (if possible/safe) or estimate the water depth at the deepest point where the stream enters and exits the structure (at edge of structure).

Inlet drop: Where water level drops suddenly at the crossing inlet, causing changes in water speed and turbulence. In addition to the higher velocities and turbulence, these jumps can be physical barriers to fish and other aquatic animals when they are swimming upstream and are unable to swim out of the culvert. Only measure if it is safe to access the pipe, otherwise estimate the drop and check the appropriate box. Measure or estimate the distance that water has to drop to enter the culvert (e.g. from the top of the water in the stream just above the inlet to the top of the water
in the culvert at the inlet) and record the measurement (in inches). If there is no inlet drop then check “None.”

Outlet Drop: An outlet drop occurs when water drops off or cascades down from the outlet, usually into a receiving pool. This may be due to the original design/construction or subsequent erosion of material at the downstream end of crossing. Outlet drops create barriers to the upstream movement of fish and other aquatic animals that are unable to jump up over the drop. Only measure if it is safe to access the pipe, otherwise estimate the two drop characteristics. Record the measurements (in inches) and check the appropriate boxes (measured or estimated).

a. **Culvert bottom to water surface** – Measure or estimate the distance from the bottom of the culvert to the water surface in the first pool large enough to provide resting habitat for fish swimming upstream. If there is no outlet drop then check “None.”

b. **Culvert bottom to stream bed** – Measure or estimate the distance from the bottom of the culvert to the bottom of the channel in the stream bed directly below the outlet. If there is no outlet drop then check “None.”

c. If there is an outlet drop, check “Cascade” if the water tumbles over rocks, logs, or other debris; or “Freefall”, if the water falls directly into the pool below. Use “Freefall onto cascade” for a combination of characteristics (see illustrations below). If there is no outlet drop then check “No drop.” If the structure is backwatered (see below) check “No drop.”
Armored Streambed at Outlet: This includes concrete aprons, plastic aprons, riprap or other structures added to the streambed at the crossing outlet to facilitate flow and prevent erosion. This does not include wing walls, retaining walls, or armored stream banks. Indicate on the data form whether tailwater armoring at the outlet of the crossing is “extensive”, “not extensive” or absent (“none”). Armoring is considered extensive if it covers the entire width of the channel at the outlet and extends downstream for a length equal to or greater than half the bankfull width of the natural stream.

Multiple Culvert or Bridge Cell Crossings

When inventorying multiple culverts or bridge cells, label left culvert/cell #1 and go in increasing order from left to right from downstream end (outlet) looking upstream. Record data for culvert/cell #1 on pages 1 and 2 of the data sheet. Use page #3 for additional culverts or cells.

Culvert or Bridge Cell #: Record the culvert/cell number.

Record Data: Follow the same instructions as above to complete data on page #3.
Glossary

→ **Bankfull Width** – Bankfull is amount of water that just fills the stream channel and where additional water would result in a rapid widening of the stream or overflow into the floodplain. Indicators of Bankfull width include:
  
  ▪ **Abrupt transition from bank to floodplain.** The change from a vertical bank to a horizontal surface is the best identifier of the floodplain and Bankfull stage, especially in low-gradient meandering streams.
  
  ▪ **Top of pointbars.** The pointbar consists of channel material deposited on the inside of meander bends. Set the top elevation of pointbars as the lowest possible Bankfull stage.
  
  ▪ **Bank undercuts.** Maximum heights of bank undercuts are useful indicators in steep channels lacking floodplains.
  
  ▪ **Changes in bank material.** Changes in soil particle size may indicate the operation of different processes. Changes in slope may also be associated with a change in particle size.
  
  ▪ **Change in vegetation.** Look for the low limit of perennial vegetation on the bank, or a sharp break in the density or type of vegetation.

→ **Bridge** – A crossing structure typically consisting of abutments and a deck spanning the stream.

→ **Culvert** – Round, elliptical or rectangular structures that are fully enclosed (contain a bottom) designed primarily for channeling water beneath a road, railroad or highway.

→ **Embedded Culvert** – A culvert that is installed in such a way that the bottom of the structure is below the stream bed and there is substrate in the culvert.

→ **Ford** – Modified or unmodified portions of a stream or river where vehicle drive through rather than over the streambed. Vented fords provide culverts to pass water during low flows while higher flows pass over the ford.

→ **Inlet drop** – Where water level drops suddenly at an inlet, causing changes in water speed and turbulence. In addition to the higher velocities and turbulence, these jumps can be physical barriers to fish and other aquatic animals when they are swimming upstream and are unable to swim out of the culvert.

→ **Open Bottom Arch** – An arched crossing structure that spans all or part of the stream bed, typically constructed on buried footings and without a bottom.

→ **Open Bottom Box Culvert** – A pre-cast box culvert with no bottom that spans all or part of the stream bed. Difficult to distinguish from a bridge.

→ **Openness ratio** – Equals cross-sectional area of the structure divided by crossing length when measured in meters. For a box culvert, openness = (height x width)/ length.

→ **Outlet drop** – An outlet drop occurs when water drops off or cascades down from the outlet, usually into a receiving pool. This may be due to the original culvert placement or erosion of material at the downstream end of culvert. Outlet drops are barriers to fish and other aquatic animals that can’t jump to get up into the culvert.
→ **Physical barriers to fish and wildlife passage** – Any structure that physically blocks fish or wildlife movement as well as structures that would cause a culvert to become blocked. Beaver dams, debris jams, fences, sediment filling culvert, weirs, baffles, aprons, and gabions are examples of structures that might be or cause physical barriers. Weirs are short dams or fences in the stream that constrict water flow or fish movements. Baffles are structures within culverts that direct, constrict, or slow down water flow. Gabions are rectangular wire mesh baskets filled with rock that are used as retaining walls and erosion control structures.

→ **Pipe Arch** – A pipe that has been factory deformed from a circular shape such that the width (or span) is larger than the vertical dimension (or rise), and forms a continuous circumference pipe that is not bottomless.

→ **Tailwater armoring** – Concrete aprons, plastic aprons, riprap or other structures added to culvert outlets to facilitate flow and prevent erosion.

→ **Tailwater scour pool** – A pool created downstream from high flows exiting the culvert. The pool is wider than the stream channel and banks are eroded.
GIS DATABASE METADATA

Geodatabase name HRE_Final.gdb

This geodatabase contains the GIS analysis for the Hudson River Estuary looking at priority barriers that intersect with SGCN's. The analysis included network and barrier statistics generated by The Nature Conservancy's BAT (Barrier Analysis Tool) as well as ecological prioritization utilizing species models from The Natural Heritage program and Aquatic Blueprint work by both TNC and Heritage. The list below gives a brief description of each data layer. For full metadata please refer to the individual feature class.

Datasets included in this Geodatabase:

- **BarrierData** - Barrier statistical outputs from BAT
- **Catchments** - individual watersheds for each ComID
- **FunctionalRiverNetwork** - Split river network output from BAT
- **FunctionalRiverNetwork_Stats** - River statistical outputs from BAT
- **HRE_Boundary** - Outer boundary of study area.
- **HRE_Dendrite** - River network used as input for BAT. Based on NHD High Resolution. Includes embedded blueprint data.
- **HRE_Field** - 2012 field season collecting barrier data on 207 sites.
- **HRE_Impoundments** - Barrier inputs used in the BAT processing. Culverts generated by road river intersections. Barriers from NYS dam database.
- **HRE_QC** - Quality Control sites for 2012 field season.
- **HRE_Rating** - Table to link final ratings to UniqueID value
- **HRE_Roads** - NYS simplified streets layer clipped to study boundary.
- **HRE_Selection_All** - All 363 originally selected sites based on network and prioritization assessment.
- **HRE_Selection_NotSurveyed** - The 170 from the original 363 that were not surveyed during the 2012 field season.
- **HRE_Web** - Combined data with final categorization used for Google Map interface.
- **Parcels_"County Name"** - These feature classes contain the landownership information for the 363 initially selected. Not all of Columbia county and Rockland was available.
**Dataset:** BarrierData

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

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BarrierID</td>
<td>Unique ID for Barrier</td>
</tr>
<tr>
<td>batFuncUS</td>
<td>The available upstream (functional) network that is not blocked by barriers or river source</td>
</tr>
<tr>
<td>batCountUS</td>
<td>The number of barriers upstream of a barrier</td>
</tr>
<tr>
<td>batLenUS</td>
<td>The total available length of river upstream of each barrier</td>
</tr>
<tr>
<td>batFuncDS</td>
<td>The available downstream (functional) network that is not blocked by barriers or river source</td>
</tr>
<tr>
<td>batDis2Mth</td>
<td>The distance from network mouth</td>
</tr>
<tr>
<td>batCountDS</td>
<td>The number of barriers downstream of a barrier</td>
</tr>
<tr>
<td>batTotUSDS</td>
<td>The total length of upstream and downstream functional network</td>
</tr>
<tr>
<td>batAbs</td>
<td>Absolute gain obtained by removing barrier (meters)</td>
</tr>
<tr>
<td>batRel</td>
<td>Relative gain obtained by removing barrier</td>
</tr>
<tr>
<td>batDSDnsty</td>
<td>Downstream barrier density</td>
</tr>
<tr>
<td>batUSDnsty</td>
<td>Upstream barrier density</td>
</tr>
<tr>
<td>batUSNetID</td>
<td>The upstream functional network ID for the barrier</td>
</tr>
<tr>
<td>batDSNetID</td>
<td>The downstream functional network ID for the barrier</td>
</tr>
</tbody>
</table>
**Dataset:** Catchments

**Description:** Catchments dataset is the individual sub-watershed polygon created for each individual ComID in the NHD High Resolution dataset. Used for calculations creating size class, geology, temperature, slope and impervious surface.

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
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<tbody>
<tr>
<td>ID</td>
<td>Unique generated ID</td>
</tr>
<tr>
<td>grid_code</td>
<td>COMID value for each generated catchment</td>
</tr>
<tr>
<td>Area</td>
<td>Area in acres</td>
</tr>
<tr>
<td>Shape_length</td>
<td>Perimeter in meters</td>
</tr>
<tr>
<td>Shape_Area</td>
<td>Area in square meters</td>
</tr>
<tr>
<td>sqmeter</td>
<td>Area in square meters</td>
</tr>
</tbody>
</table>
Dataset: FunctionalRiverNetwork


Field List:

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>REGION</td>
<td>subwatershed id for BAT processing</td>
</tr>
<tr>
<td>Fnode</td>
<td>From node in network</td>
</tr>
<tr>
<td>Tnode</td>
<td>To node in network</td>
</tr>
<tr>
<td>batFn</td>
<td>The from node ID for this network generated by BAT</td>
</tr>
<tr>
<td>batTn</td>
<td>The to node ID for this network generated by BAT</td>
</tr>
<tr>
<td>batNetID</td>
<td>The unique ID given to the functional network</td>
</tr>
<tr>
<td>ComID</td>
<td>Unique ID for each segment from original dataset</td>
</tr>
<tr>
<td>Shape_Length</td>
<td>Auto-created field for the length of each segment in meters</td>
</tr>
</tbody>
</table>

Dataset: FunctionalRiverNetwork_Stats

Description: Statistics table for FunctionalRiverNetwork

Field List:

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<tr>
<th>Field Name</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>batNetID</td>
<td>The unique ID given to the functional network</td>
</tr>
<tr>
<td>batSumLen</td>
<td>The total length for each functional network</td>
</tr>
</tbody>
</table>

Dataset: HRE_Boundary

Description: Outer boundary of Study area. Generated by merging HUC8 watershed.
Dataset: HRE_Dendrite

Description: Summery from USGS Metadata: The NHD is a national framework for assigning reach addresses to water-related entities, such as industrial discharges, drinking water supplies, fish habitat areas, wild and scenic rivers. Reach addresses establish the locations of these entities relative to one another within the NHD surface water drainage network, much like addresses on streets. Once linked to the NHD by their reach addresses, the upstream/downstream relationships of these water-related entities--and any associated information about them--can be analyzed using software tools ranging from spreadsheets to geographic information systems (GIS). GIS can also be used to combine NHD-based network analysis with other data layers, such as soils, land use and population, to help understand and display their respective effects upon one another. Furthermore, because the NHD provides a nationally consistent framework for addressing and analysis, water-related information linked to reach addresses by one organization (national, state, local) can be shared with other organizations and easily integrated into many different types of applications to the benefit of all.

Field List:

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>OBJECTID</td>
<td>Geodatabase generated ID</td>
</tr>
<tr>
<td>ComID</td>
<td>Unique ID for each river section</td>
</tr>
<tr>
<td>Permanent_Identifier</td>
<td>Same as ComID</td>
</tr>
<tr>
<td>FDate</td>
<td>Feature Date</td>
</tr>
<tr>
<td>Resolution</td>
<td>USGS Field</td>
</tr>
<tr>
<td>GNIS_ID</td>
<td>Unique ID for Geographic name</td>
</tr>
<tr>
<td>GNIS_Name</td>
<td>Geographic Name</td>
</tr>
<tr>
<td>LengthKM</td>
<td>Length of segment in KM</td>
</tr>
<tr>
<td>ReachCode</td>
<td>Code for all segments that make up a reach</td>
</tr>
<tr>
<td>FlowDir</td>
<td>Direction of flow. All have been modified to correct direction to outlet.</td>
</tr>
<tr>
<td>WBAreaComID</td>
<td>ComID of Water body that a artificial path flows through.</td>
</tr>
<tr>
<td>WBArea_Permanent_Identifier</td>
<td>ComID of Water body that a artificial path flows through.</td>
</tr>
<tr>
<td>FType</td>
<td>Feature Type</td>
</tr>
</tbody>
</table>
FCode

Feature Type Code

Enabled

USGS Field

SourceHUC

Watershed HUC value that contains the segment

comments

USGS Field

Edits

Field added to track edits during BAT preparation

Bifurc

Field added to track bifurcations

CtchSqMi

Catchment size for each segment in square miles

NESZCL

Northeast Size Class code

D_NESZCL

Northeast Size Class description

NESLPCL

Northeast Slope code

D_NESLPCL

Northeast Slope description

NEGEOCL

Northeast Geology code

D_NEGEOCL

Northeast Geology description

NETEMPCL

Northeast Temperature code

D_NETEMPCL

Northeast Temperature description

CLNEFL7634

Combined classification code

D_CL7634

Combined classification description

MTX_BLOCK_NAME

Matrix Block Name

MTX_BLOCK_ID

Matrix Block Number

ECOREG

Ecoregional location

TIER

Tier of Matrix Block

Catchment_Area

Size of catchment in square meters

Impervious_Area

Amount of impervious surface within catchment

Catchment_Accumulation

Accumulated catchment area
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impervious_Accumulation</td>
<td>Accumulated impervious surface</td>
</tr>
<tr>
<td>Percent_Impervious</td>
<td>Percentage of impervious surface in accumulated catchment</td>
</tr>
<tr>
<td>Catchment_perc_Imperv</td>
<td>Percentage Impervious within Catchment</td>
</tr>
<tr>
<td>ARA</td>
<td>Active River Area</td>
</tr>
<tr>
<td>ARA_PERCENT_NAT_COVER</td>
<td>Percent Natural Cover in ARA</td>
</tr>
<tr>
<td>ARA_DESC_SHORT</td>
<td>ARA description short form</td>
</tr>
<tr>
<td>ARA_DESC_LONG</td>
<td>ARA description long version</td>
</tr>
<tr>
<td>ARA_ALLOCATION</td>
<td>The size class of the river from which this ARA area is likely flooded/interacts with</td>
</tr>
<tr>
<td>ARA_SIZE2UP</td>
<td>Only the ARA for size 2 and larger rivers</td>
</tr>
<tr>
<td>ARA_INBASEZONE</td>
<td>ARA Riparian Base Zone has been mapped using cost distance modeling. We expect the meander belts, riparian wetlands, ~100 year floodplains, and lower terraces to be primarily within the ARA Riparian Base Zone, however these features could not be separately distinguished in the regional scale model. An additional ARA Riparian Material Contribution Zone was delineated to extend three 30m cells (90-125m total) on either side of input water cells for those streams and rivers that do not have the ARA Riparian Base Zones covering this area already.</td>
</tr>
<tr>
<td>ARA_ALLO_NUM</td>
<td>Numeric size class of the river from which this ARA area is likely flooded/interacts with, e.g. 20 for small river, 31 for medium tributary, 32 for medium mainstem, 40 for large river, 50 for great river</td>
</tr>
<tr>
<td>ARA_FLOODPLAINID</td>
<td>ID value for floodplain polygon</td>
</tr>
<tr>
<td>ARA_NAME_COMPLEX</td>
<td>Name of floodplain complex</td>
</tr>
<tr>
<td>ARA_ACRES</td>
<td>Size of complex in Acres</td>
</tr>
<tr>
<td>EDU</td>
<td>Ecological drainage unit</td>
</tr>
<tr>
<td>EDU_PERCENT_NAT_COVER</td>
<td>Percentage of natural cover within EDU</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>IA_DiadFish</td>
<td>Important area model Diadromous Fish</td>
</tr>
<tr>
<td>IA_BoxTurtle</td>
<td>Important area model Box Turtle</td>
</tr>
<tr>
<td>IA_Lac_BrookT</td>
<td>Important area model Lacustrine Brook Trout All</td>
</tr>
<tr>
<td>IA_Lac_BrookT_W</td>
<td>Important area model Lacustrine Brook Trout Wild</td>
</tr>
<tr>
<td>IA_PondMussel</td>
<td>Important area model Eastern Pondmussel</td>
</tr>
<tr>
<td>IA_NR_Sal</td>
<td>Important area model Northern Red Salamander</td>
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<tr>
<td>IA_Pal_LT_Sal</td>
<td>Important area model Palustrine Longtail Salamander</td>
</tr>
<tr>
<td>IA_Riv_BrookT</td>
<td>Important area model Riverine Brook Trout All</td>
</tr>
<tr>
<td>IA_Riv_BrookT_W</td>
<td>Important area model Riverine Brook Trout Wild</td>
</tr>
<tr>
<td>IA_Comely_Shiner</td>
<td>Important area model Riverine Comely Shiner</td>
</tr>
<tr>
<td>IA_Comely_Shiner_H</td>
<td>Important area model Riverine Comely Shiner Historical</td>
</tr>
<tr>
<td>IA_Riv_Mussel</td>
<td>Important area model Riverine Mussels</td>
</tr>
<tr>
<td>IA_Riv_Mussel_H</td>
<td>Important area model Riverine Mussels Historical</td>
</tr>
<tr>
<td>IA_Wood_Turtle</td>
<td>Important area model Wood Turtle</td>
</tr>
<tr>
<td>River_System_Rank</td>
<td>River System Rank</td>
</tr>
<tr>
<td>River_System_Name</td>
<td>River System Name</td>
</tr>
<tr>
<td>Portfolio_Rivers</td>
<td>Is River a Portfolio River</td>
</tr>
<tr>
<td>ARA_Rating</td>
<td>TNC rating for ARA 0-4</td>
</tr>
<tr>
<td>FloodPlain_Rating</td>
<td>TNC rating for Floodplain 0-4</td>
</tr>
</tbody>
</table>

**ARA_Rating**

100 - 75% natural cover = 4
75 - 50 = 3
25 - 50 = 2
0 - 25 = 0

**FloodPlain_Rating**

100 - 75% natural cover = 4
75 - 50 = 4
25 - 50 = 2
0 - 25 = 1

TNC rating for Impervious Surface 0-4

<0.5 = 4
0.5 - 2 = 3
2 - 10 = 2

**ImpervSurf_Rating**

>10 = 0

TNC Matrix Block Rating 0 or 2

In = 2

**MatrixBlock_Rating**

Out = 0

TNC Ecoregional River Portfolio Rating 0 or 4

Yes = 4

No = 0

Consider with the TNC summary report results and only use the portfolio streams that are not included in the TNC Summary Report (so there is no double counting).

**ERPortfolio_Rating**

TNC Summary Report - TNC System Rank Rating 0 - 4

Based on new rank:

Rank 1 = 4

Rank 2, 3 = 3

**TNCHRE_Rating**

everything else = 2

**Condition_Rating**

Total Added Condition rating

**Dataset:** HRE_Field

**Description:** The HRE_Field feature class was generated from the 2012 field season. These data were collected with a Trimble GeoXT 2008 series using an custom ArcPad application for data entry. The description below gives the field structure and descriptions for the data collected at each location.
<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
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<tbody>
<tr>
<td>ID</td>
<td>Autonumber ID</td>
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<tr>
<td>FieldID</td>
<td>Barrier ID as entered in the field</td>
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<tr>
<td>UniqueID</td>
<td>Barrier ID corrected to match original data</td>
</tr>
<tr>
<td>FlowDesc</td>
<td>Description of the Flow of stream</td>
</tr>
<tr>
<td>FlowID</td>
<td>Code for Flow</td>
</tr>
<tr>
<td>SURDATE</td>
<td>Date of Survey visit</td>
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<td>RdSurfID</td>
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<td>Crossing Type description</td>
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<td>Crossing Type code</td>
</tr>
<tr>
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</tr>
<tr>
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<td>Condition of Crossing ID value</td>
</tr>
<tr>
<td>CrossCondition</td>
<td>Condition of Crossing description</td>
</tr>
<tr>
<td>CrossSupportFish</td>
<td>Will crossing support fish?</td>
</tr>
<tr>
<td>StreamFlowing</td>
<td>Is stream flowing?</td>
</tr>
<tr>
<td>StructureHeight</td>
<td>Structure Height at low water</td>
</tr>
<tr>
<td>StructureHeightM</td>
<td>Was height a measurement or estimate</td>
</tr>
<tr>
<td>CrossSubstrateID</td>
<td>Crossign substrate ID</td>
</tr>
<tr>
<td>CrossSubstrate</td>
<td>Crossing substrate description</td>
</tr>
<tr>
<td>PhyBarrier2WL</td>
<td>Physical Barrier to Wildlife</td>
</tr>
<tr>
<td>PhyBarrier2Fish</td>
<td>Physical Barrier to Fish</td>
</tr>
<tr>
<td>PhyBarrierDesc</td>
<td>Physical Barrier description</td>
</tr>
<tr>
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</tr>
<tr>
<td>InletDrop</td>
<td>Inlet drop in feet</td>
</tr>
<tr>
<td>InletDropM</td>
<td>Measured or estimated</td>
</tr>
<tr>
<td>USCrossingTypeID</td>
<td>Upstream Crossing type code</td>
</tr>
<tr>
<td>USCrossingType</td>
<td>Upstream Crossing Type description</td>
</tr>
<tr>
<td>UPDIMA</td>
<td>Upstream dimensions ft</td>
</tr>
<tr>
<td>UPDIMB</td>
<td>Upstream dimensions ft</td>
</tr>
<tr>
<td>UPDIMC</td>
<td>Upstream dimensions ft</td>
</tr>
<tr>
<td>UPDIMD</td>
<td>Upstream dimensions ft</td>
</tr>
<tr>
<td>UPCrossSubmerged</td>
<td>Upstream crossing submerged?</td>
</tr>
<tr>
<td>SWWUP1</td>
<td>Upstream wetted width 1 ft</td>
</tr>
<tr>
<td>SWWUP2</td>
<td>Upstream wetted width 2 ft</td>
</tr>
<tr>
<td>SWWUP3</td>
<td>Upstream wetted width 3 ft</td>
</tr>
<tr>
<td>SBFUP1</td>
<td>Upstream bankfull 1 ft</td>
</tr>
<tr>
<td>SBFUP2</td>
<td>Upstream bankfull 2 ft</td>
</tr>
<tr>
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<td>Upstream bankfull 3 ft</td>
</tr>
<tr>
<td>SDUP1</td>
<td>Upstream depth 1 ft</td>
</tr>
<tr>
<td>SDUP2</td>
<td>Upstream depth 2 ft</td>
</tr>
<tr>
<td>SDUP3</td>
<td>Upstream depth 3 ft</td>
</tr>
<tr>
<td>ZOIUP</td>
<td>Zone of influence upstream</td>
</tr>
<tr>
<td>USScourPool</td>
<td>Upstream Scour pool - None, Small, Large</td>
</tr>
<tr>
<td>OutDropSurface</td>
<td>Outlet drop to water surface - feet</td>
</tr>
<tr>
<td>OutDropSurfaceM</td>
<td>Measured or estimated</td>
</tr>
<tr>
<td>OutDropSBed</td>
<td>Outlet drop - culvert bottom to stream bed - feet</td>
</tr>
<tr>
<td>Field</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>OutDropSBedM</td>
<td>Measured or estimated</td>
</tr>
<tr>
<td>OutletDropID</td>
<td>Outlet type ID</td>
</tr>
<tr>
<td>OutletDrop</td>
<td>Type of outlet drop</td>
</tr>
<tr>
<td>ArmoredSBedOutlet</td>
<td>Armored streambed at outlet</td>
</tr>
<tr>
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<td>Crossing embedded code</td>
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<td>Crossing embedded description</td>
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<td>Downstream crossing type code</td>
</tr>
<tr>
<td>DSCrossingType</td>
<td>Downstream crossing type description</td>
</tr>
<tr>
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<td>Downstream dimensions ft</td>
</tr>
<tr>
<td>DNDIMB</td>
<td>Downstream dimensions ft</td>
</tr>
<tr>
<td>DNDIMC</td>
<td>Downstream dimensions ft</td>
</tr>
<tr>
<td>DNDIMD</td>
<td>Downstream dimensions ft</td>
</tr>
<tr>
<td>DSCrossSubmerged</td>
<td>Downstream crossing submerged?</td>
</tr>
<tr>
<td>SWWDWN1</td>
<td>Downstream wetted width 1 ft</td>
</tr>
<tr>
<td>SWWDWN2</td>
<td>Downstream wetted width 2 ft</td>
</tr>
<tr>
<td>SWWDWN3</td>
<td>Downstream wetted width 3 ft</td>
</tr>
<tr>
<td>SBFDWN1</td>
<td>Downstream bankfull 1 ft</td>
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<td>SBFDWN2</td>
<td>Downstream bankfull 2 ft</td>
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<tr>
<td>SBFDWN3</td>
<td>Downstream bankfull 3 ft</td>
</tr>
<tr>
<td>SDDWN1</td>
<td>Downstream depth 1 ft</td>
</tr>
<tr>
<td>SDDWN2</td>
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</tr>
<tr>
<td>SDDWN3</td>
<td>Downstream depth 3 ft</td>
</tr>
<tr>
<td>ZOIDWN</td>
<td>Zone of influence downstream</td>
</tr>
<tr>
<td>DSScourPool</td>
<td>Downstream Scour pool - None, Small, Large</td>
</tr>
</tbody>
</table>
PPoolDepth  Plunge Pool Depth
NoPool     Plunge Pool No Pool
PPoolWidth Plunge Pool Width
DepthInCulvertUS Depth in culvert upstream ft
DepthInCulvertDS Depth in culvert downstream ft
WettedWidthCulvert Wetted Width in Culvert ft
StreamLnthCrossing Length of stream through crossing - feet
CrossingSpanID  Crossing span ID
CrossingSpan    Crossing span description
DepthMatchStreamID Crossing span - water depth matches stream code
DepthMatchStream  Crossing span - water depth matches stream description
VelocityMatchStreamID Crossing span - velocity matches stream code
VelocityMatchStream  Crossing span - velocity matches stream description
SlopeMatchStreamID Crossing span - slope matches stream code
SlopeMatchStream   Crossing span - slope matches stream description
AlignMatchStreamID Crossing span - crossing alignment matches stream code
AlignMatchStream   Crossing span - crossing alignment matches stream description
CrossingComments  Crossing span Comments
DamTypeID        Dam type ID
DamType          Dam type description
DamMaterialID    Dam Material ID
DamMaterial      Dam Material description
DamConditionID   Dam Condition ID
DamCondition     Dam Condition description
<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DamHeight</td>
<td>Dam height feet</td>
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<tr>
<td>DamLength</td>
<td>Dam length feet</td>
</tr>
<tr>
<td>DamFishStructure</td>
<td>Is there existing fish structure</td>
</tr>
<tr>
<td>DZOI</td>
<td>Dam zone of influence feet</td>
</tr>
<tr>
<td>DamComments</td>
<td>Dam comments</td>
</tr>
</tbody>
</table>

Connectivity score derived for each culvert based on connectivity and the degree to which aquatic organisms can pass through each culvert (using juvenile brook trout life history).

Attributes that contributed to the score were:
1) inlet drop, 2) outlet drop, 3) crossing vs. stream depth, 4) crossing vs. stream slope, and 5) water velocity in crossing vs. stream.

BarrierCalculation1

Habitat impact score derived for each culvert based on the degree to which habitat and hydrology were limiting factors for connectivity.

Attributes that contributed to the score were:
1) crossing vs. stream wetted width, 2) scour pool size,
3) crossing vs. stream alignment, 4) span description

BarrierCalculation2

Cumulative score (connectivity score plus impact score) for each culvert. Can be used to assess the relative degree to which each culvert is a barrier and as a prioritization tool for retrofit and replacement.

Final_Rank

UTMEasting

UTM East coordinate value

UTMNorth

UTM North coordinate value

**Dataset:** HRE_Impoundments

**Description:** HRE impoundment snapped contains points for both Dam impoundments and culverts. As there is no culvert database for NYS we have generated points at all road/river intersections as a starting point. We then subtracted all know bridges from the NYS bridge database. We then intersected the dam data set to remove any overlapping culvert/dam intersections.

**Field List:**
### Field List:

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CulvertID</td>
<td>Unique ID for generated culvert</td>
</tr>
<tr>
<td>DamID</td>
<td>Unique ID for Dam</td>
</tr>
<tr>
<td>UniqueID</td>
<td>Unique ID for all barriers</td>
</tr>
<tr>
<td>batSnapped</td>
<td>Y or N if BAT snapped the barrier to a line</td>
</tr>
<tr>
<td>batLineID</td>
<td>ComID that barrier was snapped to</td>
</tr>
<tr>
<td>batRegion</td>
<td>HUC region code for BAT processing</td>
</tr>
<tr>
<td>batSnapDis</td>
<td>Distance in M barrier was moved to snap to line</td>
</tr>
<tr>
<td>batDisAlng</td>
<td>Distance (as ratio) along polyline length the point is at</td>
</tr>
<tr>
<td>batDis2Mth</td>
<td>Distance to Mouth of Watershed - M</td>
</tr>
<tr>
<td>batSrcID</td>
<td>ID created by BAT during processing</td>
</tr>
</tbody>
</table>

**Dataset:** HRE_QC

**Description:** The HRE_QC feature class was generated from the 2012 field season. These data were collected with a Trimble GeoXT 2008 series using a custom ArcPad application for data entry. The description below gives the field structure and descriptions for the data collected at each location. These are the 21 Quality Control sites to verify accuracy of the original field collection.

**Field List:**
<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Autonumber ID</td>
</tr>
<tr>
<td>FieldID</td>
<td>Barrier ID as entered in the field</td>
</tr>
<tr>
<td>UniqueID</td>
<td>Barrier ID corrected to match original data</td>
</tr>
<tr>
<td>FlowDesc</td>
<td>Description of the Flow of stream</td>
</tr>
<tr>
<td>FlowID</td>
<td>Code for Flow</td>
</tr>
<tr>
<td>SURDATE</td>
<td>Date of Survey visit</td>
</tr>
<tr>
<td>OBSERVER</td>
<td>Name of Field</td>
</tr>
<tr>
<td>RdSurfID</td>
<td>Road Surface description</td>
</tr>
<tr>
<td>RdSurf</td>
<td>Road surface code</td>
</tr>
<tr>
<td>CrossTypeID</td>
<td>Crossing Type description</td>
</tr>
<tr>
<td>CrossType</td>
<td>Crossing Type code</td>
</tr>
<tr>
<td>CrossNumber</td>
<td>Number of Crossings</td>
</tr>
<tr>
<td>CrossCondID</td>
<td>Condition of Crossing ID value</td>
</tr>
<tr>
<td>CrossCondition</td>
<td>Condition of Crossing description</td>
</tr>
<tr>
<td>CrossSupportFish</td>
<td>Will crossing support fish?</td>
</tr>
<tr>
<td>StreamFlowing</td>
<td>Is stream flowing?</td>
</tr>
<tr>
<td>StructureHeight</td>
<td>Structure Height at low water</td>
</tr>
<tr>
<td>StructureHeightM</td>
<td>Was height a measurement or estimate</td>
</tr>
<tr>
<td>CrossSubstrateID</td>
<td>Crossing substrate ID</td>
</tr>
<tr>
<td>CrossSubstrate</td>
<td>Crossing substrate description</td>
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<tr>
<td>PhyBarrier2WL</td>
<td>Physical Barrier to Wildlife</td>
</tr>
<tr>
<td>PhyBarrier2Fish</td>
<td>Physical Barrier to Fish</td>
</tr>
<tr>
<td>PhyBarrierDesc</td>
<td>Physical Barrier description</td>
</tr>
</tbody>
</table>
InletDrop: Inlet drop in feet
InletDropM: Measured or estimated
USCrossingTypeID: Upstream Crossing type code
USCrossingType: Upstream Crossing Type description
UPDIMA: Upstream dimensions ft
UPDIMB: Upstream dimensions ft
UPDIMC: Upstream dimensions ft
UPDIMD: Upstream dimensions ft
UPCrossSubmerged: Upstream crossing submerged?
SWWUP1: Upstream wetted width 1 ft
SWWUP2: Upstream wetted width 2 ft
SWWUP3: Upstream wetted width 3 ft
SBFUP1: Upstream bankfull 1 ft
SBFUP2: Upstream bankfull 2 ft
SBFUP3: Upstream bankfull 3 ft
SDUP1: Upstream depth 1 ft
SDUP2: Upstream depth 2 ft
SDUP3: Upstream depth 3 ft
ZOIUP: Zone of influence upstream
USScourPool: Upstream Scour pool - None, Small, Large
OutDropSurface: Outlet drop to water surface - feet
OutDropSurfaceM: Measured or estimated
OutDropSBed: Outlet drop - culvert bottom to stream bed - feet
OutDropSBedM: Measured or estimated
<table>
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<th>Variable</th>
<th>Description</th>
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</tr>
<tr>
<td>OutletDrop</td>
<td>Type of outlet drop</td>
</tr>
<tr>
<td>ArmoredSBedOutlet</td>
<td>Armored streambed at outlet</td>
</tr>
<tr>
<td>CrossEmbedID</td>
<td>Crossing embedded code</td>
</tr>
<tr>
<td>CrossEmbedded</td>
<td>Crossing embedded description</td>
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<td>Downstream crossing type code</td>
</tr>
<tr>
<td>DSCrossingType</td>
<td>Downstream crossing type description</td>
</tr>
<tr>
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<td>Downstream dimensions ft</td>
</tr>
<tr>
<td>DNDIMB</td>
<td>Downstream dimensions ft</td>
</tr>
<tr>
<td>DNDIMC</td>
<td>Downstream dimensions ft</td>
</tr>
<tr>
<td>DNDIMD</td>
<td>Downstream dimensions ft</td>
</tr>
<tr>
<td>DSCrossSubmerged</td>
<td>Downstream crossing submerged?</td>
</tr>
<tr>
<td>SWWDWN1</td>
<td>Downstream wetted width 1 ft</td>
</tr>
<tr>
<td>SWWDWN2</td>
<td>Downstream wetted width 2 ft</td>
</tr>
<tr>
<td>SWWDWN3</td>
<td>Downstream wetted width 3 ft</td>
</tr>
<tr>
<td>SBFDWN1</td>
<td>Downstream bankfull 1 ft</td>
</tr>
<tr>
<td>SBFDWN2</td>
<td>Downstream bankfull 2 ft</td>
</tr>
<tr>
<td>SBFDWN3</td>
<td>Downstream bankfull 3 ft</td>
</tr>
<tr>
<td>SDDWN1</td>
<td>Downstream depth 1 ft</td>
</tr>
<tr>
<td>SDDWN2</td>
<td>Downstream depth 2 ft</td>
</tr>
<tr>
<td>SDDWN3</td>
<td>Downstream depth 3 ft</td>
</tr>
<tr>
<td>ZOIDWN</td>
<td>Zone of influence downstream</td>
</tr>
<tr>
<td>DSScourPool</td>
<td>Downstream Scour pool - None, Small, Large</td>
</tr>
<tr>
<td>PPoolDepth</td>
<td>Plunge Pool Depth</td>
</tr>
<tr>
<td><strong>NoPool</strong></td>
<td>Plunge Poll No Pool</td>
</tr>
<tr>
<td><strong>PPoolWidth</strong></td>
<td>Plunge Pool Width</td>
</tr>
<tr>
<td><strong>DepthInCulvertUS</strong></td>
<td>Depth in culvert upstream ft</td>
</tr>
<tr>
<td><strong>DepthInCulvertDS</strong></td>
<td>Depth in culvert downstream ft</td>
</tr>
<tr>
<td><strong>WettedWidthCulvert</strong></td>
<td>Wetted Width in Culvert ft</td>
</tr>
<tr>
<td><strong>StreamLnthCrossing</strong></td>
<td>Length of stream through crossing - feet</td>
</tr>
<tr>
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<td>Crossing span ID</td>
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<tr>
<td><strong>CrossingSpan</strong></td>
<td>Crossing span description</td>
</tr>
<tr>
<td><strong>DepthMatchStreamID</strong></td>
<td>Crossing span - water depth matches stream code</td>
</tr>
<tr>
<td><strong>DepthMatchStream</strong></td>
<td>Crossing span - water depth matches stream description</td>
</tr>
<tr>
<td><strong>VelocityMatchStreamID</strong></td>
<td>Crossing span - velocity matches stream code</td>
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<tr>
<td><strong>VelocityMatchStream</strong></td>
<td>Crossing span - velocity matches stream description</td>
</tr>
<tr>
<td><strong>SlopeMatchStreamID</strong></td>
<td>Crossing span - slope matches stream code</td>
</tr>
<tr>
<td><strong>SlopeMatchStream</strong></td>
<td>Crossing span - slope matches stream description</td>
</tr>
<tr>
<td><strong>AlignMatchStreamID</strong></td>
<td>Crossing span - crossing alignment matches stream code</td>
</tr>
<tr>
<td><strong>AlignMatchStream</strong></td>
<td>Crossing span - crossing alignment matches stream description</td>
</tr>
<tr>
<td><strong>CrossingComments</strong></td>
<td>Crossing span Comments</td>
</tr>
<tr>
<td><strong>DamTypeID</strong></td>
<td>Dam type ID</td>
</tr>
<tr>
<td><strong>DamType</strong></td>
<td>Dam type description</td>
</tr>
<tr>
<td><strong>DamMaterialID</strong></td>
<td>Dam Material ID</td>
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<td><strong>DamMaterial</strong></td>
<td>Dam Material description</td>
</tr>
<tr>
<td><strong>DamConditionID</strong></td>
<td>Dam Condition ID</td>
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<tr>
<td><strong>DamCondition</strong></td>
<td>Dam Condition description</td>
</tr>
<tr>
<td><strong>DamHeight</strong></td>
<td>Dam height feet</td>
</tr>
<tr>
<td><strong>DamLength</strong></td>
<td>Dam length feet</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td><strong>DamFishStructure</strong></td>
<td>Is there existing fish structure</td>
</tr>
<tr>
<td><strong>DZOI</strong></td>
<td>Dam zone of influence feet</td>
</tr>
<tr>
<td><strong>DamComments</strong></td>
<td>Dam comments</td>
</tr>
</tbody>
</table>

Connectivity score derived for each culvert based on connectivity and the degree to which aquatic organisms can pass through each culvert (using juvenile brook trout life history). Attributes that contributed to the score were: 1) inlet drop, 2) outlet drop, 3) crossing vs. stream depth, 4) crossing vs. stream slope, and 5) water velocity in crossing vs. stream.

**BarrierCalculation1**

Habitat impact score derived for each culvert based on the degree to which habitat and hydrology were limiting factors for connectivity. Attributes that contributed to the score were: 1) crossing vs. stream wetted width, 2) scour pool size, 3) crossing vs. stream alignment, 4) span description

**BarrierCalculation2**

Cumulative score (connectivity score plus impact score) for each culvert. Can be used to assess the relative degree to which each culvert is a barrier and as a prioritization tool for retrofit and replacement.

**Final_Rank**

UTMEasting

UTM East coordinate value

UTMNorth

UTM North coordinate value
**Dataset:** HRE_Rating

**Description:** This table can be linked to any layer with the UniqueID field to show final ratings or legend values used on the web.

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UniqueID</td>
<td>The unique ID given to the barrier</td>
</tr>
<tr>
<td>LegendID</td>
<td>The ID used to display legend on Web version and Layer File</td>
</tr>
<tr>
<td>Rating</td>
<td>Final Rating for Report</td>
</tr>
</tbody>
</table>

**Dataset:** HRE_Roads

**Description:** Supplied by Office of Cyber Security: A vector street layer suitable for use in a GIS. The file has been dissolved on the fields: Full Street Name, Sheild, HWY_NUM, FCC, ACC and Jurisdiction. All generic street names (i.e. Driveway, Ramp, etc.) have been changed to null. The file has been intersected against the CensusMCD_2000 file adding the fields County_Name and MCD_Name.
**Dataset:** HRE_Selection_All

**Description:** This feature class contains the 363 barriers chosen from the network and ecological prioritization framework. We then added the Diadromous Blueprint data to create a richness calculation to prioritize to our final 200 for field analysis.

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CulvertID</td>
<td>Unique ID for generated culvert</td>
</tr>
<tr>
<td>DamID</td>
<td>Unique ID for Dam</td>
</tr>
<tr>
<td>UniqueID</td>
<td>Unique ID for all barriers</td>
</tr>
<tr>
<td>batLineID</td>
<td>ComID that barrier was snapped to</td>
</tr>
<tr>
<td>VNotes</td>
<td>Notes from visual look at each barrier with air photo</td>
</tr>
<tr>
<td>COUNTY_ID</td>
<td>ID for County barrier located within</td>
</tr>
<tr>
<td>COUNTY</td>
<td>County name where barrier is located</td>
</tr>
<tr>
<td>batSnapped</td>
<td>Y or N if BAT snapped the barrier to a line</td>
</tr>
<tr>
<td>batRegion</td>
<td>HUC region code for BAT processing</td>
</tr>
<tr>
<td>batSnapDis</td>
<td>Distance in M barrier was moved to snap to line</td>
</tr>
<tr>
<td>batDisAlng</td>
<td>Distance (as ratio) along polyline length the point is at</td>
</tr>
<tr>
<td>batDis2Mth</td>
<td>The distance from network mouth</td>
</tr>
<tr>
<td>batFuncUS</td>
<td>The available upstream (functional) network that is not blocked by barriers or river source</td>
</tr>
<tr>
<td>batCountUS</td>
<td>The number of barriers upstream of a barrier</td>
</tr>
<tr>
<td>batLenUS</td>
<td>The total available length of river upstream of each barrier</td>
</tr>
<tr>
<td>batFuncDS</td>
<td>The available downstream (functional) network that is not blocked by barriers or river source</td>
</tr>
<tr>
<td>batCountDS</td>
<td>The number of barriers downstream of a barrier</td>
</tr>
</tbody>
</table>
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
DiadFish: Important area model DiadromousFish
EBoxTurtle: Important area model Box Turtle
LacBrookTA: Important area model Lacustrine Brook Trout All
LacBrookTW: Important area model Lacustrine Brook Trout Wild
LacEPondMu: Important area model Eastern Pondmussel
NRedSal: Important area model Northern Red Salamander
PalLTSal: Important area model Palustrine Longtail Salamander
RivBrookTA: Important area model Riverine Brook Trout All
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RivComelyS: Important area model Riverine Comely Shiner
RivComel_1: Important area model Riverine Comely Shiner Historical
RivMuss: Important area model Riverine Mussels
RivMussHis: Important area model Riverine Mussels Historical
WoodTurtle: Important area model Wood Turtle
Alewife: Blueprint Diadromous cumulative model for Alewife
AmericanEe: Blueprint Diadromous cumulative model for American Eel
AmericanSh: Blueprint Diadromous cumulative model for American Shad
<table>
<thead>
<tr>
<th>Species</th>
<th>Blueprint Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AtlanticSa</td>
<td>Blueprint Diadromous cumulative model for Atlantic Salmon</td>
</tr>
<tr>
<td>AtlanticSt</td>
<td>Blueprint Diadromous cumulative model for Atlantic Sturgeon</td>
</tr>
<tr>
<td>AtlanticTo</td>
<td>Blueprint Diadromous cumulative model for Atlantic Tomcod</td>
</tr>
<tr>
<td>BluebackHe</td>
<td>Blueprint Diadromous cumulative model for Blueback Herring</td>
</tr>
<tr>
<td>BrookTrout</td>
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<tr>
<td>ChinookSal</td>
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<tr>
<td>CohoSalmon</td>
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</tr>
<tr>
<td>RainbowSme</td>
<td>Blueprint Diadromous cumulative model for Rainbow Smelt</td>
</tr>
<tr>
<td>SeaLamprey</td>
<td>Blueprint Diadromous cumulative model for Sea Lamprey</td>
</tr>
<tr>
<td>StripedBas</td>
<td>Blueprint Diadromous cumulative model for Striped Bass</td>
</tr>
<tr>
<td>ShortnoseS</td>
<td>Blueprint Diadromous cumulative model for Shrotnose Sturgeon</td>
</tr>
</tbody>
</table>

**Richness**
Cumulative value of all Important Area species and Blueprint Diadromous Fish

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HighPriority</td>
<td>0 for No, 1 for Yes</td>
</tr>
<tr>
<td>InitialiseSelect</td>
<td>0 for No, 1 for Yes</td>
</tr>
<tr>
<td>ComID</td>
<td>Unique ID for each river section</td>
</tr>
<tr>
<td>Lat</td>
<td>Latitude location in decimal degrees</td>
</tr>
<tr>
<td>Long</td>
<td>Longitude location in decimal degrees</td>
</tr>
</tbody>
</table>
**Dataset:** HRE_Selection_NotSurveyed

**Description:** This feature class contains the 170 barriers that were found to be priorities in the initial network and ecological prioritization but were not field surveyed during the 2012 field season.

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CulvertID</td>
<td>Unique ID for generated culvert</td>
</tr>
<tr>
<td>DamID</td>
<td>Unique ID for Dam</td>
</tr>
<tr>
<td>UniqueID</td>
<td>Unique ID for all barriers</td>
</tr>
<tr>
<td>batLineID</td>
<td>ComID that barrier was snapped to</td>
</tr>
<tr>
<td>VNotes</td>
<td>Notes from visual look at each barrier with air photo</td>
</tr>
<tr>
<td>COUNTY_ID</td>
<td>ID for County barrier located within</td>
</tr>
<tr>
<td>COUNTY</td>
<td>County name where barrier is located</td>
</tr>
<tr>
<td>batSnapped</td>
<td>Y or N if BAT snapped the barrier to a line</td>
</tr>
<tr>
<td>batRegion</td>
<td>HUC region code for BAT processing</td>
</tr>
<tr>
<td>batSnapDis</td>
<td>Distance in M barrier was moved to snap to line</td>
</tr>
<tr>
<td>batDisAlng</td>
<td>Distance (as ratio) along polyline length the point is at</td>
</tr>
<tr>
<td>batDis2Mth</td>
<td>The distance from network mouth</td>
</tr>
<tr>
<td>batFuncUS</td>
<td>The available upstream (functional) network that is not blocked by barriers or river source</td>
</tr>
<tr>
<td>batCountUS</td>
<td>The number of barriers upstream of a barrier</td>
</tr>
<tr>
<td>batLenUS</td>
<td>The total available length of river upstream of each barrier</td>
</tr>
<tr>
<td>batFuncDS</td>
<td>The available downstream (functional) network that is not blocked by barriers or river source</td>
</tr>
<tr>
<td>batCountDS</td>
<td>The number of barriers downstream of a barrier</td>
</tr>
<tr>
<td>batTotUSDS</td>
<td>The total length of upstream and downstream functional network</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>batAbs</td>
<td>Absolute gain obtained by removing barrier (meters)</td>
</tr>
<tr>
<td>batRel</td>
<td>Relative gain obtained by removing barrier</td>
</tr>
<tr>
<td>batDSDnsty</td>
<td>Downstream barrier density</td>
</tr>
<tr>
<td>batUSDnsty</td>
<td>Upstream barrier density</td>
</tr>
<tr>
<td>batUSNetID</td>
<td>The upstream functional network ID for the barrier</td>
</tr>
<tr>
<td>batDSNetID</td>
<td>The downstream functional network ID for the barrier</td>
</tr>
<tr>
<td>DiadFish</td>
<td>Important area model DiadromousFish</td>
</tr>
<tr>
<td>EBoxTurtle</td>
<td>Important area model Box Turtle</td>
</tr>
<tr>
<td>LacBrookTA</td>
<td>Important area model Lacustrine Brook Trout All</td>
</tr>
<tr>
<td>LacBrookTW</td>
<td>Important area model Lacustrine Brook Trout Wild</td>
</tr>
<tr>
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<td>NRedSal</td>
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<td>PalLTSal</td>
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<td>RivBrookTA</td>
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<tr>
<td>RivComelyS</td>
<td>Important area model Riverine Comely Shiner</td>
</tr>
<tr>
<td>RivComel_1</td>
<td>Important area model Riverine Comely Shiner Historical</td>
</tr>
<tr>
<td>RivMuss</td>
<td>Important area model Riverine Mussels</td>
</tr>
<tr>
<td>RivMussHis</td>
<td>Important area model Riverine Mussels Historical</td>
</tr>
<tr>
<td>WoodTurtle</td>
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<tr>
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Richness  Cumulative value of all Important Area species and Blueprint Diadromous Fish
HighPriority  0 for No, 1 for Yes
Initialselect  0 for No, 1 for Yes
ComID  Unique ID for each river section
Lat  Latitude location in decimal degrees
Long  Longitude location in decimal degrees
Dataset: HRE_Web

Description: HRE_Web is a combination of the initial selection dataset, field data, BAT and dendrite data. This has been categorized to 8 values described in the description section. All other field definitions can be found in their corresponding data sets.

Field List:

<table>
<thead>
<tr>
<th>LegendID</th>
<th>Legend Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat1</td>
<td>Culvert, fish barrier</td>
</tr>
<tr>
<td>Cat2</td>
<td>Dam, fish barrier</td>
</tr>
<tr>
<td>Cat3</td>
<td>Culvert, not fish barrier</td>
</tr>
<tr>
<td>Cat4</td>
<td>Bridge, not fish barrier</td>
</tr>
<tr>
<td>Cat5</td>
<td>Dam, not fish barrier</td>
</tr>
<tr>
<td>Cat6</td>
<td>Not Surveyed</td>
</tr>
<tr>
<td>Cat7</td>
<td>Culvert, Did not Exist</td>
</tr>
<tr>
<td>Cat8</td>
<td>Dam, did not exist</td>
</tr>
</tbody>
</table>
Dataset: HUC12

Description: USGS derived 12 digit watershed.

Dataset: HUC8

Description: USGS derived 8 digit watershed.

Dataset: Parcels_"County Name"

Description: These feature classes contain the landownership information for the 363 initially selected. Not all of Columbia county and Rockland was available.

Geodatabase name BAT_Final.gdb

This geodatabase contains the final run of the BAT (barrier assessment tool) post field work. Non barriers were removed after field work from the 363 priority barriers designated during the initial prioritization process. All other data may be linked to this dataset via the ComID for hydrology and UniquieID for barriers. Datasets included in this Geodatabase:

BarrierData - Barrier statistical outputs from BAT

FunctionalRiverNetwork - Split river network output from BAT

FunctionalRiverNetwork_Stats - River statistical outputs from BAT

HRE_Dendrite - River network used as input for BAT. Based on NHD High Resolution

HRE_Impoundments_Snapped - Barrier inputs used in the BAT processing. Culverts generated by road river intersections. Barriers from NYS dam database.
**Dataset:** BarrierData

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

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BarrierID</td>
<td>Unique ID for Barrier</td>
</tr>
<tr>
<td>batFuncUS</td>
<td>The available upstream (functional) network that is not blocked by barriers or river source</td>
</tr>
<tr>
<td>batCountUS</td>
<td>The number of barriers upstream of a barrier</td>
</tr>
<tr>
<td>batLenUS</td>
<td>The total available length of river upstream of each barrier</td>
</tr>
<tr>
<td>batFuncDS</td>
<td>The available downstream (functional) network that is not blocked by barriers or river source</td>
</tr>
<tr>
<td>batDis2Mth</td>
<td>The distance from network mouth</td>
</tr>
<tr>
<td>batCountDS</td>
<td>The number of barriers downstream of a barrier</td>
</tr>
<tr>
<td>batTotUSDS</td>
<td>The total length of upstream and downstream functional network</td>
</tr>
<tr>
<td>batAbs</td>
<td>Absolute gain obtained by removing barrier (meters)</td>
</tr>
<tr>
<td>batRel</td>
<td>Relative gain obtained by removing barrier</td>
</tr>
<tr>
<td>batDSDnsty</td>
<td>Downstream barrier density</td>
</tr>
<tr>
<td>batUSDnsty</td>
<td>Upstream barrier density</td>
</tr>
<tr>
<td>batUSNetID</td>
<td>The upstream functional network ID for the barrier</td>
</tr>
<tr>
<td>batDSNetID</td>
<td>The downstream functional network ID for the barrier</td>
</tr>
</tbody>
</table>
**Dataset:** FunctionalRiverNetwork

**Description:** Network split at barrier locations. Original hydrologic source 1:24,000 National Hydrography Data (NHD) High Resolution created by US Geological Survey - National Mapping Division.

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBJECTID</td>
<td>Geodatabase generated ID</td>
</tr>
<tr>
<td>ComID</td>
<td>Unique ID for each river section</td>
</tr>
<tr>
<td>Permanent_Identifier</td>
<td>Same as ComID</td>
</tr>
<tr>
<td>FDate</td>
<td>Feature Date</td>
</tr>
<tr>
<td>Resolution</td>
<td>USGS Field</td>
</tr>
<tr>
<td>GNIS_ID</td>
<td>Unique ID for Geographic name</td>
</tr>
<tr>
<td>GNIS_Name</td>
<td>Geographic Name</td>
</tr>
<tr>
<td>LengthKM</td>
<td>Length of segment in KM</td>
</tr>
<tr>
<td>ReachCode</td>
<td>Code for all segments that make up a reach</td>
</tr>
<tr>
<td>FlowDir</td>
<td>Direction of flow. All have been modified to correct direction to outlet.</td>
</tr>
<tr>
<td>WBAreaComID</td>
<td>ComID of Water body that a artificial path flows through.</td>
</tr>
<tr>
<td>WBArea_Permanent_Identifier</td>
<td>ComID of Water body that a artificial path flows through.</td>
</tr>
<tr>
<td>FType</td>
<td>Feature Type</td>
</tr>
<tr>
<td>FCode</td>
<td>Feature Type Code</td>
</tr>
<tr>
<td>Enabled</td>
<td>USGS Field</td>
</tr>
<tr>
<td>Region</td>
<td>BAT requires regionalization for processing. Code for Region.</td>
</tr>
<tr>
<td>Reg</td>
<td>Watershed HUC value that contains the segment</td>
</tr>
<tr>
<td>Fnode</td>
<td>From node</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Tnode</td>
<td>To node</td>
</tr>
<tr>
<td>batDis2Mth</td>
<td>Distance to Mouth of Watershed - M</td>
</tr>
<tr>
<td>batUSLen</td>
<td>Upstream length - M</td>
</tr>
<tr>
<td>batSrcID</td>
<td>ID created by BAT during processing</td>
</tr>
<tr>
<td>batFn</td>
<td>Bat generated from node</td>
</tr>
<tr>
<td>batTnode</td>
<td>Bat generated to node</td>
</tr>
<tr>
<td>batNetID</td>
<td>Bat generated network ID</td>
</tr>
<tr>
<td>Shape_Length</td>
<td>Length of segment in M</td>
</tr>
</tbody>
</table>
**Dataset:** FunctionalRiverNetwork_Stats

**Description:** Statistics table for FunctionalRiverNetwork

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>batNetID</td>
<td>The unique ID given to the functional network</td>
</tr>
<tr>
<td>batSumLen</td>
<td>The total length for each functional network</td>
</tr>
</tbody>
</table>
**Dataset:** HRE_Dendrite

**Description:** Summery from USGS Metadata: The NHD is a national framework for assigning reach addresses to water-related entities, such as industrial discharges, drinking water supplies, fish habitat areas, wild and scenic rivers. Reach addresses establish the locations of these entities relative to one another within the NHD surface water drainage network, much like addresses on streets. Once linked to the NHD by their reach addresses, the upstream/downstream relationships of these water-related entities—and any associated information about them—can be analyzed using software tools ranging from spreadsheets to geographic information systems (GIS). GIS can also be used to combine NHD-based network analysis with other data layers, such as soils, land use and population, to help understand and display their respective effects upon one another. Furthermore, because the NHD provides a nationally consistent framework for addressing and analysis, water-related information linked to reach addresses by one organization (national, state, local) can be shared with other organizations and easily integrated into many different types of applications to the benefit of all.

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBJECTID</td>
<td>Geodatabase generated ID</td>
</tr>
<tr>
<td>ComID</td>
<td>Unique ID for each river section</td>
</tr>
<tr>
<td>Permanent_Identifier</td>
<td>Same as ComID</td>
</tr>
<tr>
<td>FDate</td>
<td>Feature Date</td>
</tr>
<tr>
<td>Resolution</td>
<td>USGS Field</td>
</tr>
<tr>
<td>GNIS_ID</td>
<td>Unique ID for Geographic name</td>
</tr>
<tr>
<td>GNIS_Name</td>
<td>Geographic Name</td>
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<tr>
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<td>Length of segment in KM</td>
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<tr>
<td>ReachCode</td>
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<tr>
<td>FlowDir</td>
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<td>Field</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>FType</td>
<td>Feature Type</td>
</tr>
<tr>
<td>FCode</td>
<td>Feature Type Code</td>
</tr>
<tr>
<td>Enabled</td>
<td>USGS Field</td>
</tr>
<tr>
<td>Region</td>
<td>BAT requires regionalization for processing. Code for Region.</td>
</tr>
<tr>
<td>Reg</td>
<td>Watershed HUC value that contains the segment</td>
</tr>
<tr>
<td>Fnode</td>
<td>From node</td>
</tr>
<tr>
<td>Tnode</td>
<td>To node</td>
</tr>
<tr>
<td>Shape_Length</td>
<td>Length of segment in M</td>
</tr>
</tbody>
</table>
**Dataset:** HRE_Impoundments_Snapped

**Description:** HRE impoundment snapped contains points for both Dam impoundments and culverts. As there is no culvert database for NYS we have generated points at all road/river intersections as a starting point. We then subtracted all know bridges from the NYS bridge database. We then intersected the dam data set to remove any overlapping culvert/dam intersections.

**Field List:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CulvertID</td>
<td>Unique ID for generated culvert</td>
</tr>
<tr>
<td>DamID</td>
<td>Unique ID for Dam</td>
</tr>
<tr>
<td>UniqueID</td>
<td>Unique ID for all barriers</td>
</tr>
<tr>
<td>batSnapped</td>
<td>Y or N if BAT snapped the barrier to a line</td>
</tr>
<tr>
<td>batLineID</td>
<td>ComID that barrier was snapped to</td>
</tr>
<tr>
<td>batRegion</td>
<td>HUC region code for BAT processing</td>
</tr>
<tr>
<td>batSnapDis</td>
<td>Distance in M barrier was moved to snap to line</td>
</tr>
<tr>
<td>batDisAlng</td>
<td>Distance (as ratio) along polyline length the point is at</td>
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