OCTOBER 2019

IMPLEMENTING A TIDAL STREAM CROSSING PROTOCOL IN MASSACHUSETTS

TECHNICAL REPORT

Prepared by: Kaitlyn Shaw

IPSWICH RIVER WATERSHED ASSOCIATION

TEAMS INVOLVED

This project was a collaboration between the Ipswich River Watershed, as project manager and Scott Jackson of the North Atlantic Aquatic Connectivity Collaborative (NAACC) and UMASS Amherst as technical project lead.

Funding for this project was provided by the Massachusetts Environmental Trust. To preserve the environmental education, conservation or public awareness efforts funded by the Trust in your community is easy: choose one of three environmental plates, the Right Whale & Roseate Terns, the Leaping Brook Trout, or the Blackstone Valley Mill when you purchase a new car or renew your registration with the Registry of Motor Vehicles. The first-time cost of your specialty plate is $90. There is a renewal fee of $90 every two years. Visit your local Registry of Motor Vehicles or order a plate online at www.mass.gov/rmv or log onto www.mass.gov/eea/met where you can learn more about the Trust, the programs it supports, and the specialty license plate offerings.

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INTRODUCTION

As long linear aquatic ecosystems, streams and rivers are exceptionally vulnerable to fragmentation. Recently much attention has been focused on the role of road-stream crossings (bridges and culverts) on the movement of aquatic organisms and semi-aquatic wildlife. These crossings include non-tidal crossings located throughout a watershed as well as tidal crossings in the coastal zone and estuarine portions of river systems. Aquatic organism passage through road-stream crossings on tidal streams is of critical importance for not only fish and other organisms that live in coastal marshes and estuaries, but also for diadromous fish, such as American shad and rainbow smelt, that must pass through the tidal portions of streams to reach important habitat further upstream. As these are the first structures encountered by returning diadromous fish, their potential to impact migratory pathways to freshwater spawning and rearing habitat is of particular concern.

For over a decade, the Massachusetts River and Stream Continuity Project assessed road-stream crossings for aquatic passability using a protocol developed by the University of Massachusetts. UMass and representatives from other agencies and organizations engaged in crossing assessments, came together to create a unified protocol to be used throughout the Northeastern U.S. This protocol, and an effort to coordinate and support crossings assessments throughout the region, was launched in June 2015 as the North Atlantic Aquatic Connectivity Collaborative (NAACC).

From 2017-2018 UMass and IRWA developed and field-tested a rapid assessment field protocol for aquatic organism passage on tidal streams that can be integrated into the larger NAACC initiative. The process involved assembling information on the organisms and issues that should be addressed by such a protocol, the convening of an expert technical advisory committee to provide input and critical review of the materials developed as part of the project, development of a draft field assessment protocol and scoring system for road-stream crossings on tidal streams, and field testing the protocol to ensure that it was practical to implement in the field. Once the protocol was finalized, training opportunities were provided regionally.

GOALS & OUTCOMES

GOAL 1

Operationalize new tidal crossing protocol for the state

OUTCOMES

- Final Field Data Form
- Aquatic Passability Scoring System
- Instruction Manual for Tidal Crossing Assessment Protocol
- Powerpoint presentation for use by trainers
- Instructions for how to become trained in the Tidal Protocol
- Summary of supplemental resources and datasets

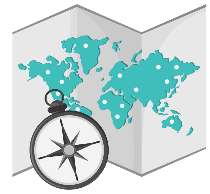
GOAL 2

Apply tidal crossing protocol to tidal region of the PIE-Rivers watersheds

OUTCOMES

- Over 100 tidal crossings were evaluated and 83 crossings were uploaded to the NAACC tidal crossing database
- Data and images from the Tidal Crossing surveys were incorporated into the MassBays Healthy Estuaries Grant: Great Marsh Barriers Mitigation- A comprehensive program to mitigate aquatic barriers in the Great Marsh Area of Critical Environmental Concern region

PROJECT APPROACH



Refine Barrier Maps/ Project Management → Database Implementation

Develop Training Materials/ NAACC Website → Integrate existing data/ Train Obervers

Field Survey Development/ Field Surveys → Training Workshop/ Webinars/ Field Training

PROJECT BENEFITS

- **Tool to identify problem structures and support decision making and long-term planning.**
- **Inventory and scoring results for all tidal and non-tidal crossings available in one place.**
- **Enhanced ability to prioritize sites, then initiate and complete on-the-ground restoration projects in the PIE-Rivers watersheds.**
- **A network of practioners around the coastal portion of the State ready to apply the tool to other watersheds.**
- **Enhanced information-sharing between stakeholders.**

GOAL 1: OPERATIONALIZE NEW TIDAL CROSSING PROTOCOL FOR THE STATE

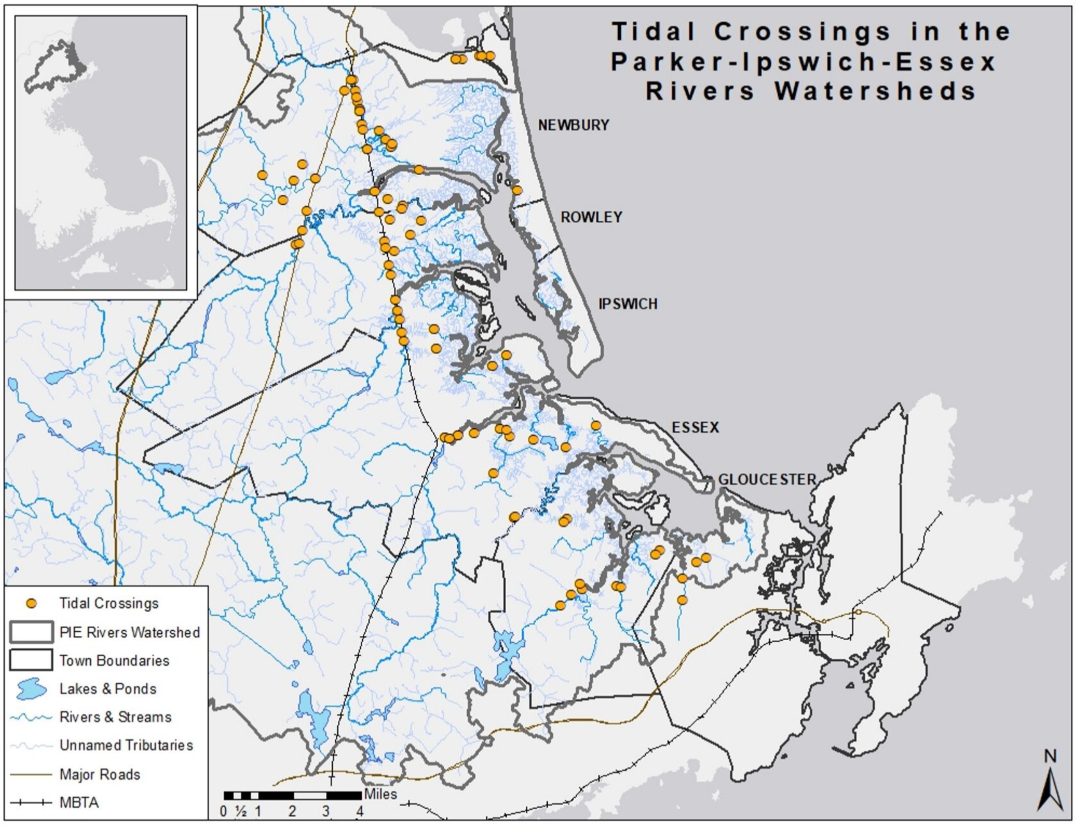
The NAACC trains observers to collect and upload data on non-tidal stream crossing structures to assess Aquatic Organism Passage (AOP). As part of this project, a tidal crossings assessment protocol was developed and fully integrated into the NAACC system. The NAACC database was modified to accept and score data from assessments using this protocol. An electronic data form was created and deployed. In addition, online and printed training materials were developed and finalized. A certification program and training workshops were hosted to establish a network of coordinators and observers capable of implementing the protocol throughout the coastal zone of Massachusetts.

To access Training Workshop materials, additional resources and instructions on how to get certified in the Tidal Crossing Protocol, visit https://www.pie-rivers.org/restoration/new-tidal-crossing-protocols/

OUTCOMES
(in Appendix)

- Instruction Manual for Tidal Crossing Assessment Protocol
- Final Tidal Crossing Field Data Form
- Aquatic Passability Scoring System
- Stream Continuity Resources (available online)

GOAL 2: APPLY TIDAL CROSSING PROTOCOL TO TIDAL REGION OF THE PIE-RIVERS WATERSHEDS



Over 100 tidal crossings were evaluated over the course of this project. 83 tidal crossings were surveyed and scored within the coastal zone of the PIE-Rivers watersheds using the new tidal crossing protocol. The survey results are incorporated into the online NAACC database and can now be used to update our regional prioritization of structures that are potential aquatic barriers. This effort provides a watershed-scale example of implementing the tidal protocol which can now be used as a model for other watershed groups working throughout the Massachusetts coastal zone.

These results can be used to help guide and advance restoration planning in the region. For more information visit, https://www.pierivers.org/restoration/new-tidal-crossing-protocols/

OUTCOMES

- Interactive webmap (online)
- NAACC Database (online)
  - Instructions on how to access data with NAACC database (appendix)
- PIE-Rivers Watersheds Tidal Crossing excel data file (available upon request)

TRAINING WORKSHOPS

Three training events took place as part of this project. The first was a workshop at the Massachusetts Association of Conservation Commissions (MACC) Conference. This workshop generated interest in the Tidal Protocol and resulted in a list of interested individuals for subsequent training opportunities. The next training was an in-person event attended by practitioners from municipal government, non-profit organizations and consulting agencies. This event included a field training component, where participants were able to visit Tidal Crossing sites and learn how to properly collect the required data.

A webinar was provided to train participants remotely. Field training opportunities were also made available to participants.

OUTCOMES

- Three Training Events (1 Workshop, 1 In-person training, 1 Webinar)
- Field Training Opportunitites
- Tidal Crossing Protocol PowerPoint Presentation
- Summary of supplemental resources and datasets

SPECIAL THANKS

Marie-Francoise Hatte, North Atlantic Aquatic Connectivity Collaborative
Bob English, Daystar Computing
Kristen Thiebeault, Ipswich River Watershed Association Technician
Lauren Fitzgerald, Ipswich River Watershed Association Super-Volunteer
Jacob Lehan, Division of Ecological Restoration

APPENDIX

Instruction Manual for Tidal Crossing Assessment Protocol

Final Tidal Crossing Field Data Form

Aquatic Passability Scoring System

Instructions on how to become trained in the Tidal Crossing Protocol

Instructions on how to access data with NAACC Database

NAACC Tidal Stream Crossing Instruction Manual for Aquatic Passability Assessments

North Atlantic Aquatic Connectivity Collaborative

Version 1.0 – August 23, 2019

(for Data Form dated 8/23/2019)

CONTACT

Scott Jackson
Department of Environmental Conservation
Holdsworth Hall
University of Massachusetts
Amherst, MA 01003
(413) 545-4743; sjackson@umass.edu

For more information, go to: **www.streamcontinuity.org/naacc**

ACKNOWLEDGEMENTS

This protocol was developed by a team of people from UMass Amherst, including Allison Roy, Adrian Jordaan, and Melissa Ocana. Sarah Becker conducted a literature review and compiled information used in the development of this protocol. Field testing was conducted by Bia Dias and Ashleigh Novak, with assistance from Brian Kelder and Kaitlyn Shaw of the Ipswich River Watershed Association. Additional field testing was done by Julia Devers of the U.S. Fish and Wildlife Service.

Many thanks go to the Technical Advisory Committee for this project: Brian Kelder, Peter Steckler, Eric Hutchins, Kristin Ferry, Marcin Whitman, Ted Castro-Santos, Pad Smith, Rob Vincent, Julie Devers, Kevin Lucey, Ellen Mecray, Megan Tyrrell, and James Rassman.

The development of this instruction guide and the survey protocol it explains would not have been possible without the effort of many people involved with the NAACC. Thanks especially to the North Atlantic Landscape Conservation Cooperative (NALCC) and Massachusetts Environmental Trust for funding this work. Megan Tyrrell served as our contact person for the NALCC and provided much useful information and advice.

Since the terrestrial passage protocol uses some of the same metrics as the NAACC's non-tidal aquatic passage assessment protocol, some of the content from that instruction guide, titled, "NAACC Stream Crossing Instruction Manual for Aquatic Passability Assessments in Non-tidal Stream and Rivers," is reused here. Thanks to my coauthor of the non-tidal aquatic passage guide, Alex Abbott, for his earlier work on that document.

Scott Jackson

Suggested Citation

Jackson, S.D. 2019. NAACC Tidal Stream Crossing Instruction Manual for Aquatic Passability Assessments. North Atlantic Aquatic Connectivity Collaborative (NAACC), University of Massachusetts Amherst. August 23, 2019. 34 pp.

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OVERVIEW

This document provides guidance for completing the North Atlantic Aquatic Connectivity (NAACC) Tidal Stream Crossing Assessment Data Form.

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from universities, conservation organizations, and state and federal natural resource and transportation departments focused on improving aquatic connectivity across a thirteen-state region, from Maine to Virginia. The NAACC has developed common protocols for assessing road-stream crossings (culverts and bridges) and developed a regional database for these field data. The information collected will identify high priority bridges and culverts for upgrade and replacement. The NAACC will support planning and decision-making by providing information about where restoration projects are likely to bring the greatest improvements in aquatic connectivity.

In 2015, the NAACC released a protocol for assessment aquatic connectivity for non-tidal streams. The Tidal Stream Crossing Assessment protocol was developed in 2019 as a complement to the non-tidal protocol. It is particularly challenging to assess aquatic passability for tidal streams because daily fluctuations in water levels and flow characteristics mean that, for some streams, barrier effects may vary greatly throughout a single day. Conditions that would be impassable at low tide might be fine at high tide.

The Tidal Stream Crossing Assessment Protocol is a rapid assessment methodology designed to provide a rough assessment of the barrier effects of culverts and bridges on aquatic organism passage. Although data are collected that can be used to evaluate the effects of stream crossings on tidal hydrology, this is not an objective of this protocol. The protocol addresses aquatic connectivity for three types of rivers/streams: 1) salt marsh creeks where the ebb and flow of ocean water dominates the hydrology, 2) salt/brackish flow-through streams with hydrology derived from a mix of salt and freshwater sources, and 3) freshwater tidal rivers/streams. Here are some key aspects of the protocol.

- Data collection is confined to a single visit at low tide. For tidal freshwater systems, data collection will occur at low tide, during typical low-flow conditions (seasonal);
- Data collection will be the same for all three tidal stream/river types: salt marsh creeks, salt/brackish flow-through streams, and freshwater tidal streams;
- Scoring for each of the tidal stream/river types will differ in the variables used and how they are used;
- Some data may not be used for scoring but could prove useful for specific (e.g. species-specific) applications;
- Some data may not be used for scoring aquatic passability but could be useful for assessing likeliness of replacement (condition), risk of failure (condition, alignment), terrestrial passability (dry passage) or cost of replacement (road fill height, presence of utilities).

The survey field data form is to be used for an entire road-stream crossing, which may include single or multiple culverts or multiple cell bridges. The first page of the field data form is for collecting general information and data related to the crossing as a whole. The second page is for data on the first (or only) structure at the crossing. Subsequent pages should be used to add data for additional culverts or bridge cells, if any. It can be difficult to determine how best to evaluate multiple culvert/cell crossings. Please remember that it is essential to gather all of the data required for each structure (pipe or bridge cell) for accurate assessment of the entire crossing.

Please be sure to complete every possible element of the field data form.

SURVEY PLANNING

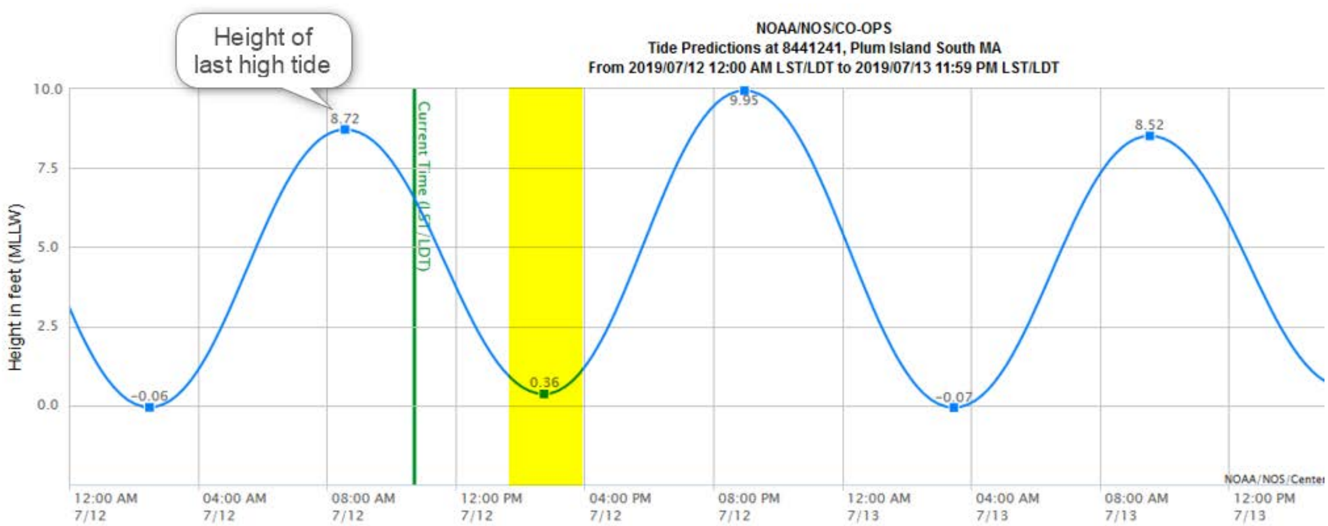
GENERAL PLANNING

Any effort to survey stream crossings should be based on a plan that includes answers to the following key questions:

1. ***Who is primarily responsible for managing the surveys?***
   Each NAACC state or region will have a coordinator who helps decide on priority areas for survey and how to manage the data once surveys are completed. This coordinator will also plan for, oversee, and collect data from the surveys. Contact the University of Massachusetts Amherst (contact@naacc.org) for more information, or refer to the NAACC website to locate a coordinator in your region: www.streamcontinuity.org/naacc.

2. ***How will surveyors be trained?***
   Training should be arranged through your regional or state coordinator, and includes both classroom and field survey practice. Online training will be available soon and posted on www.streamcontinuity.org/naacc. The most important elements of training are becoming familiar with this instruction manual and gaining practice through survey of a variety of crossings with an experienced surveyor. To be certified to assess crossings on tidal streams you must 1) be certified as a lead observer for the non-tidal aquatic assessment protocol, 2) complete either in-person or online tidal protocol training, and pass the quiz in the online training module, and 3) attend a half-day tidal field training workshop.

3. ***When should surveys be done?***
   Surveys should be conducted during low tide (or just before or after low tide) when conditions allow for reasonable evaluation of water depths, substrate and other characteristics of tidal crossings. For tidal freshwater crossings, assessment should be conducted at low tide and during low-flow periods, particularly summer and early fall.



Tide chart showing a reasonable time period before and after low tide (in yellow) when tidal crossing assessments should be done

4. ***How should we decide where to survey?***
   Consult with your regional coordinator to decide whether surveys will be conducted in one or more watersheds, towns, or counties. Plan to have maps to help you navigate to sites you plan to survey, either

copies of existing maps such as the DeLorme Atlas and Gazeteer, or more sophisticated maps from a geographic information system (GIS).

For each state in the NAACC region, United States Geological Survey (USGS) HUC-12 subwatersheds have been prioritized for field surveys by the NAACC project team. These subwatersheds were prioritized based on several objectives including brook trout, diadromous fish, and the potential vulnerability of culverts to failure. These prioritized results can be a useful starting place for identifying areas to survey. In addition, there may be locally important watersheds or habitats in your state or region that may help guide the location of surveys. To see the NAACC priority subwatersheds in your area, visit the web map at http://arcg.is/1F2rPJu. This web map also depicts road-stream crossings symbolized by their estimated restoration potential which can help focus survey efforts within a subwatershed.

5. ***Which sites will be surveyed?***
Work with your state or regional coordinator to decide whether all crossings, or only certain types or sizes of streams will be considered. Some crossing surveys focus primarily on designated *perennial* streams containing most aquatic habitats, while other survey projects include all *ephemeral* and *intermittent* streams. In other cases, certain places in the watershed or town may be identified as highest priority for surveys, based on ecological or other criteria.

6. ***How will we keep track of the sites visited?***
You should maintain records, possibly as notations on paper maps, or in a table listing each planned survey site, showing which sites have been surveyed and when. Organize your survey forms by date, and be sure each survey form is complete. Once data have been entered to the NAACC database, you will be able to see all surveyed sites through online maps to verify that you have completed all planned crossing surveys.

7. ***How can we access crossings on major highways, railroads and private land?***
Depending on the scope of your surveys, you should have easy access to stream crossings on most public roads, though it is important to be aware of the right-of-way to avoid inadvertently trespassing on private land. Access to interstate highways and railroads is generally much more limited. For cases with limited access to crossings, you are responsible for contacting the appropriate owner or manager of those crossings to request access to conduct surveys. Similarly, for crossings on private roads, you should make concerted efforts to notify private landowners to request permission to conduct surveys on their lands. It may help to work with a local land trust, town or county governments, or state resource agencies to gain access from these landowners, as they often have similar needs for conducting habitat surveys or other resource assessments. In some survey efforts, when allowed by specific laws in effect in those jurisdictions, it has been considered permissible to survey crossings on private roads, particularly if good faith efforts to notify landowners have been undertaken first, or so long as crossings are not on posted or gated roads.

8. ***How can we be sure our data will lead to crossing improvements?***
For your data to be useful in setting stream restoration priorities, we encourage you to collect data as completely and accurately as possible and ensure that the data are entered properly into the database. Finally, be sure that all data, including survey forms and site photographs, whether collected digitally or on paper, are transmitted to your state or regional coordinator for archiving.

SAFETY[1]

Streams can be hazardous places, so take care to sensibly evaluate risks before you begin a survey at each stream crossing. While these efforts to record data about crossings are important, they are not nearly as important as your safety and well-being. Working around roads can be dangerous, so be sure to wear highly visible clothing, preferably safety vests in bright colors with reflective material; some vests have the additional

[1] Adapted with permission from New Hampshire's Tidal Crossing Assessment Protocol (Steckler et al., 2017).

bonus of containing many pockets to hold gear. Take care when parking and exiting your vehicle, and when crossing busy roads.

These surveys are best undertaken by teams of two or three people. This will facilitate taking measurements, making decisions in challenging situations, and recording data.

Take measurements seriously and carefully, but make estimates if necessary for your safety. Avoid wading into streams – even small ones – at high flows and entering pools of unknown depths, and take care scaling steep and rocky embankments. There are usually ways to effectively estimate some dimensions without risk. For example, an accurate laser rangefinder is a safe way to measure longer distances when conditions are unsafe, such as measuring culvert lengths through them instead of across busy roads.

Below is a summary of some of the known safety risks and precautions that should be taken.

- When using a telescoping leveling rod be aware of overhead utility lines and take care not to operate in any way that potentially puts the rod in contact with overhead utilities.
- Follow wader safety guidelines, including:
  - Wear a personal flotation device.
  - Move slowly to stay in control and minimize falling; expect slippery conditions.
  - Beware of mucky substrate that you may sink into, uneven footing, poor visibility into the water, and variable water currents.
  - Use the leveling rod as your third point of support. Always maintain two points of contact as you move. In deeper areas, test depths with the leveling rod to make sure you don't overtop the waders.
  - Use a wading belt when wearing chest waders—if you fall over it keeps water from flowing into the legs and boots of the waders, allowing for easier escape from the river.
  - Walk forward, not backward. Find stable footing around rocks and boulders rather than stepping on slippery high points.
  - Use common sense- do not wade into an area that is clearly too deep or where water velocities are too fast.
  - Use caution when entering a stream crossing structure. Be alert for hazards on the ceiling, uneven footing, rip-rap, and increased flow velocities in the structure. Never enter a structure without another person watching for your safety.
- Marine clay, which is inevitable and abundant in tidal habitats, is extremely slippery. Slippery conditions exist within the stream, along the stream banks, on the salt marsh, and along the road fill slope. Use caution when moving around and through these slippery conditions.
- Many salt marshes are lined with historic ditches, some fairly small and some deep and wide. Ditches can be grown over and present a hidden tripping or falling hazard. If you can't easily step over a ditch, or navigate across the ditch easily, walk around the ditch or to a point where you can easily step over. Take care when pushing off and landing, as ditch edges can be slippery, slough off, and be hidden under droopy tall grasses.
- Be prepared for biting insects. Consider wearing long sleeved clothes and using insect repellent. Check closely for ticks after each field day.
- Coastal roadsides and upland salt marsh edges are often covered with poison ivy. Take care to identify poison ivy and avoid contacting it, especially if you are allergic.
- Many tidal crossing sites are exposed, with limited shading and relief from the sun. Be prepared with sunscreen, ample water, sunglasses and a hat.

AVOIDING THE SPREAD OF INVASIVE SPECIES

Stream crossing inventory work may place NAACC observers in situations where they inadvertently contribute to the spread of aquatic invasive species (AIS), particularly when they cross watershed boundaries. AIS are harmful non-native plants, animals, and microorganisms living in some aquatic habitats that damage ecosystems or threaten commercial, agricultural, and recreational activities. The following best management practices are recommended for NAACC observers to prevent the spread of AIS between drainage basins.

Survey planning:

- Complete surveys of HUC12 watersheds one at a time. Staying within a HUC12 rather than changing sub-basins can help stop the spread of invasive species.
- Whenever possible, start surveying stream crossing sites at the upstream end of a HUC12 watershed and progress downstream over the course of the day. Invasive species are naturally moved downstream by streamflow but do not easily move upstream on their own. By progressing from upstream to downstream in surveys, observers can avoid helping move invasive species to upstream locations.
- Do not use waders with felt soles.
- In waters known to contain invasive species, try to avoid entering the stream to take measurements. This may not be possible at many sites but could be at some.

Between site surveys:

- Before leaving a survey site, clean, drain, and dry (or treat) equipment. Clean equipment by inspecting it for attached mud, plants, and debris. Remove and dispose of anything found. Scrub equipment with a stiff brush and rinse with water. Drain any standing water in waders and other equipment.
- Keep a plastic drum filled with bleach or quaternary ammonia solution (which is less harmful on gear than bleach) in the back of the vehicle and put the wading boots in the drum while driving to the next site.
- When survey schedules or logistics prevent cleaning and drying/treating of equipment, a set of duplicate wading boots are recommended when observers change watershed boundaries during a single day. Observers should change into dry boots before surveying crossings in new watersheds and cycle the previous pair to be clean and dry for the following day.

At the end of the day, or when moving between HUC12 watersheds, use one of these options:

- Dry equipment completely for at least 48 hours. Preferable ways to dry equipment include direct sunlight, a heated garage, or a boot drying device such as a PEET Dryer device.
- Soak or spray equipment with a mild bleach solution (1 Tbsp bleach per gallon of water) for 10 minutes. The bleach solution must be mixed daily to maintain its effectiveness after 24 hours.
- Visit a “wader wash” station, if available.
- Freeze equipment for 6-8 hours.

EQUIPMENT

To collect data on stream crossing structures, you will need several essential pieces of equipment for measuring and recording, and some other items to keep you healthy and safe:

- ✓ **NAACC Tidal Stream Crossing Instruction Manual for Aquatic Passability Assessments** (this document)
- ✓ **Tidal Stream Crossing Survey Data Forms**: Best printed on waterproof paper. Bring along more than you expect to use. Even digital surveys (using the tidal assessment ODM) should include these in case a digital

device becomes inoperable.

- ✓ **Clipboard**, **Pencils & Erasers**
- ✓ **Stream Crossing Maps**: For planning sites to survey, and for recording sites assessed, a *DeLorme Atlas and Gazeteer* or similarly accurate and updated set of maps with topography is helpful for navigation.
- ✓ **Measuring Implements** in feet and tenths (decimal feet rather than inches)
  - o **Reel Tape:** For measuring structure lengths and channel widths; 100 feet.
  - o **Pocket Tape:** Best in 6 foot "Pocket Rod" version with no spring to rust.
  - o **Stadia Rod:** Telescoping, 13 feet long to measure structure dimensions such as water depth.
- ✓ **Rangefinder** (optional): To safely take measurements without crossing structures, busy roadways or streams; should be accurate to within one foot for adequate data accuracy.
- ✓ **Safety Vests:** Brightly colored, reflective vests, preferably with lots of pockets to hold equipment, but most importantly to be seen on the road.
- ✓ **Waders or Hip Boots:** To stay dry, insulate from cold water, minimize abrasions, and allow access to tailwater pools and deeper streams**.**
- ✓ **Personal Flotation Device:** For streams with deep water or soft substrates.
- ✓ **Flashlight:** To be able to see features inside long dark structures.
- ✓ **Sun Protection:** Hat, sunglasses, and sunscreen as needed.
- ✓ **Insect Repellent**: To protect from annoying or dangerous bites.
- ✓ **First Aid Kit:** To deal with any minor injuries, cuts, scrapes, etc.
- ✓ **Cell Phone:** In case of emergency, to coordinate surveys, or to ask questions of coordinators.
- ✓ **GPS Receiver**: Set GPS to collect data in WGS84 datum, with Latitude and Longitude in decimal degrees.
- ✓ **Digital Camera**: Best if waterproof and shockproof, with sufficient battery power for a full day of surveying, and capable of storing approximately 100 low to moderate resolution images (approximately 100 - 500 kilobyte stored size, generally less than 1 million pixels–1 megapixel). Include batteries or battery charger, and download cable. A backup memory chip can be very useful to have on hand.
- ✓ **Refractometer for Measuring Salinity** (optional)

UNMAPPED SITES AND NONEXISTENT CROSSINGS

Survey teams may encounter unmapped crossings, or it may be unclear whether a crossing they have found in the field is on their map because its location does not match the map. In most cases, the surveyed crossing should be within 100-200 feet of the planned crossing. Survey teams also may encounter unmapped crossings because either the road was not mapped, as in the case of a road built to serve a new housing development, or because of an error in the road or stream data.

If there is no planned crossing near the site you are assessing, you need to assign a temporary *Crossing Code* to that crossing. A *Crossing Code* is composed of the prefix "xy" followed by the latitude and longitude of the site, with decimal degree latitude and longitude values as seven-digit numbers. For instance, a crossing located at 42.32914 degrees north and -72.67522 degrees west, will have the resulting *xy code* = "xy42329147267522", followed by the notation: "NEW XY" to indicate that this crossing site must be added to the map.

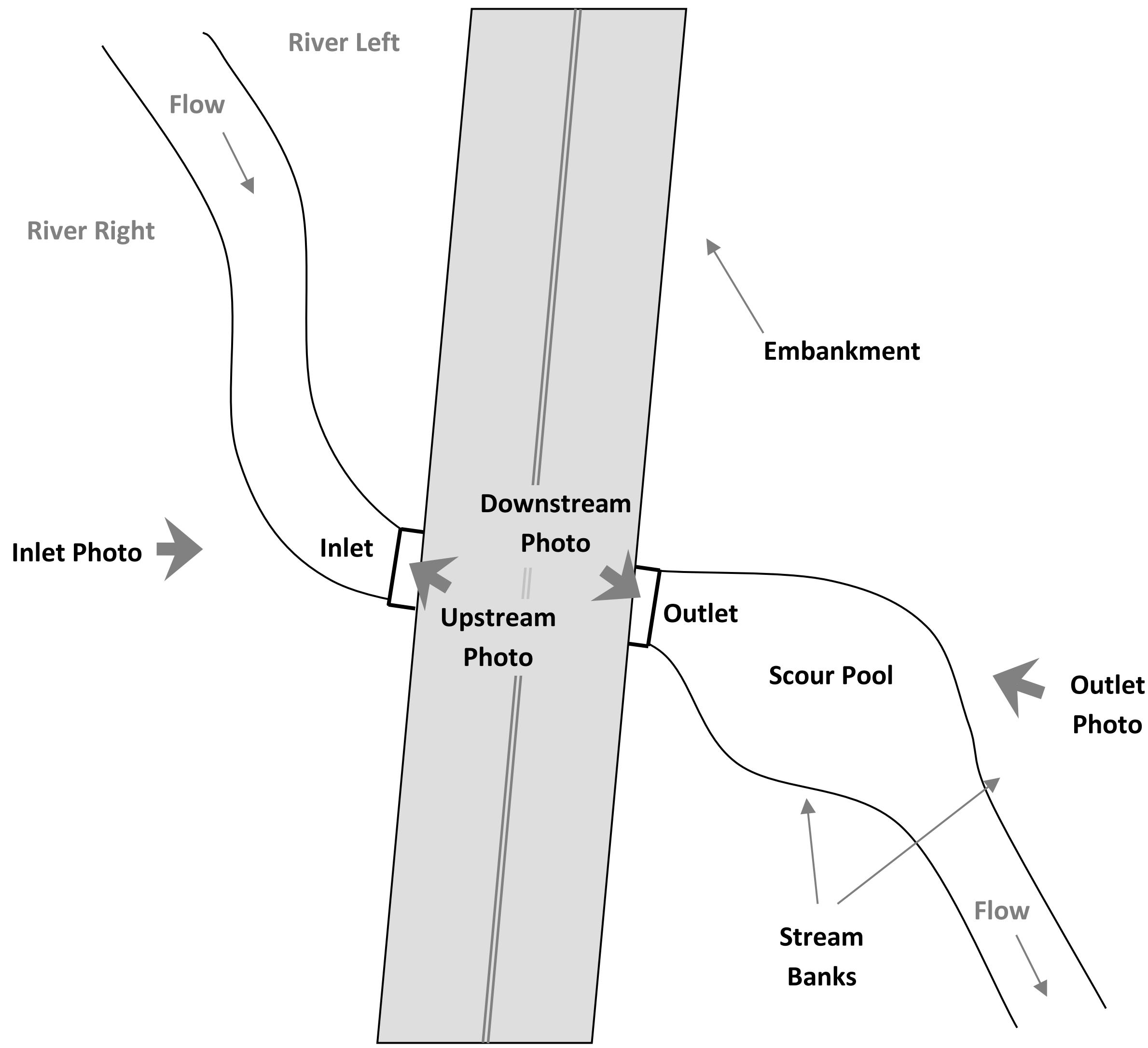
Conversely, a crossing may exist on the map but not in the field. If you try to navigate to a site and are certain that there is no crossing in the vicinity, you should select the "No Crossing" option for *Crossing Type* on the field data form. Some crossings may not actually exist due to errors in generating the crossing points. Another possibility is that there may have been a road crossing there at one time, but the crossing has been removed, but may still need to be surveyed to note passage problems. For these sites, you will select the "Removed Crossing" option. Similarly, sometimes an entire stream reach has been moved, particularly underground, in which case you will select the "Buried Stream" *Crossing Type*.

In all cases where a survey crew either cannot locate a mapped crossing or intends to add a new unmapped crossing, it is essential to check the location carefully to minimize navigation and data collection errors.

COMPLETING THE SURVEY DATA FORM

SITE IDENTIFICATION

While each crossing will be different from others in its details, many common features will be assessed, measured, or otherwise observed during all surveys. The diagram below contains the basic terminology for key stream crossing features in a simplified overhead view.



Undisturbed Stream Reference Reaches

When conducting crossing surveys, elements of this data form require you to understand key characteristics of an undisturbed, “natural” section of the stream (called a *reference reach*) near where the crossing is located. These characteristics include the stream’s approximate slope and the type of substrate that predominates there. You may need to go a distance upstream or downstream from the crossing that is between 10 and 20 times the width of the stream to get away from the influence of the crossing. This means for a 10-foot wide stream, you will need to go between 100 and 200 feet upstream or downstream from the crossing to find an undisturbed reach. The distance will be much larger for larger streams. Note that sometimes you will be unable to locate such a reference reach, either because upstream and downstream reaches are too disturbed or modified, or because access is limited, such as by *No Trespassing* signs.

Crossing Data

Complete this section for the entire crossing and the date when you completed the assessment. Choose only one option for the fields with checkboxes in the General Information section.

Crossing Code: This is the 18-character “xy code” assigned to each planned survey crossing on survey maps. Be very careful to record the correct numbers, as they represent the precise latitude and longitude of the planned crossing, which can be compared with the actual location you record as GPS Coordinates below.

Local ID: Optional field for a program’s own coding systems. Does NOT replace the Crossing Code.

Date Observed: Date that the crossing was evaluated, following the form *MM/DD/YYYY*.

Start Time: The time that you began your assessment (include am or pm).

End Time: The time you completed your assessment (include am or pm).

Lead Observer: The name of the survey team leader responsible for the quality of the data collected.

Town/County: The town or county in which the assessed crossing is located according to the map.

Stream/River: The name of the stream or river taken from the map, or if not named on the map, the name as known locally, or otherwise list as *Unnamed*.

Road: The name of the road taken from the map or from a road sign. Numbered roads should be listed as “Route #”, where # is the route number, with multiple numbers separated by “/” when routes overlap at the crossing (e.g., “Route 1/95”). For driveways, trails, or railroads lacking known names, enter *Unnamed*.

Road Type: Choose only one option:

Multilane: > 2 lanes, including divided highways (assumed paved)

1 or 2 Lane Paved: public or private roads

Unpaved: public or private roads

Driveway: serving only one or two houses or businesses (paved or unpaved)

Trail: primarily unpaved, or for all-terrain vehicles only, but includes paved recreational paths; include rail road beds without tracks

Railroad: with tracks, whether or not currently used

GPS Coordinates: Latitude and Longitude in decimal degrees to five decimal places. Use of a GPS (Global Positioning System) receiver is required, but your smart phone or tablet computer may include this capability.

Map Datum: It is best to use *WGS84* datum.

Location Format: Use Latitude-Longitude decimal-degrees (often in GPS menu as “hddd.ddddd”).

You should stand above the stream centerline, and ideally on the road centerline, when taking the GPS point, but use your judgment and beware of traffic.

Location Description: If there is any doubt about whether someone could find this crossing again, provide enough information about the exact location of the crossing so that others with your data sheet would be confident that they are at the same crossing that you evaluated. For example, the description might include “between houses at 162 and 164 Smith Road,” “across from the Depot Restaurant,” or “driveway north of Smith Road off Route 193.” This information could also include additional location information, such as a site identification number used by road owners or managers.

Crossing Type: If a crossing is found at the planned location, choose the one most appropriate option.

Bridge: A bridge has a deck supported by abutments (or stream banks). It may have more than one cell or section separated by one or more piers, in which case enter the number of cells to Number of Culverts/Bridge Cells. Enter data for any additional cells in Structure 2 Data, Structure 3 Data, etc.

Culvert: A culvert consists of a structure buried under some amount of fill. If it is a single culvert, you need only complete the first page of the data form.

Multiple Culvert: If there is more than one culvert, you must indicate that in Number of Culverts/Bridge Cells on the line below. Data must be entered in sections for additional structures starting on the second page (Structure 2 Data, Structure 3 Data, etc.). Count ALL structures, regardless of their size.

Ford: A ford is a shallow, open stream crossing, in which vehicles pass through the water. Fords may be armored to decrease erosion, and may include pipes to allow flow through the ford (vented ford).

If a planned crossing cannot be found or surveyed, the site will fit one of the following types:

No Crossing: There is no crossing where anticipated, usually because of incorrect road or stream location on maps. No further data is required. (Be sure you are in the correct location.)

Removed Crossing: A crossing apparently existed previously at the site but has been removed, so the stream now flows through the site with no provision for vehicles to cross over it. Continue to complete the survey form to the extent possible. Include information in Crossing Comments to explain your observations. For instance, indicate if an old culvert pipe is seen at the site, or if removal of the previous crossing structure left the stream with problems for aquatic organism passage.

Buried Stream: The planned crossing site does not include an inlet and/or outlet, likely because a stream previously in this location has been rerouted, probably underground. In this case, survey is not possible, and no further data is required.

Inaccessible: Survey is not possible because roads or trails to the crossing are not accessible. This may be due to private property posting, gates, poor condition, or other factors. Record in Crossing Comments why the site is inaccessible. No further data is required.

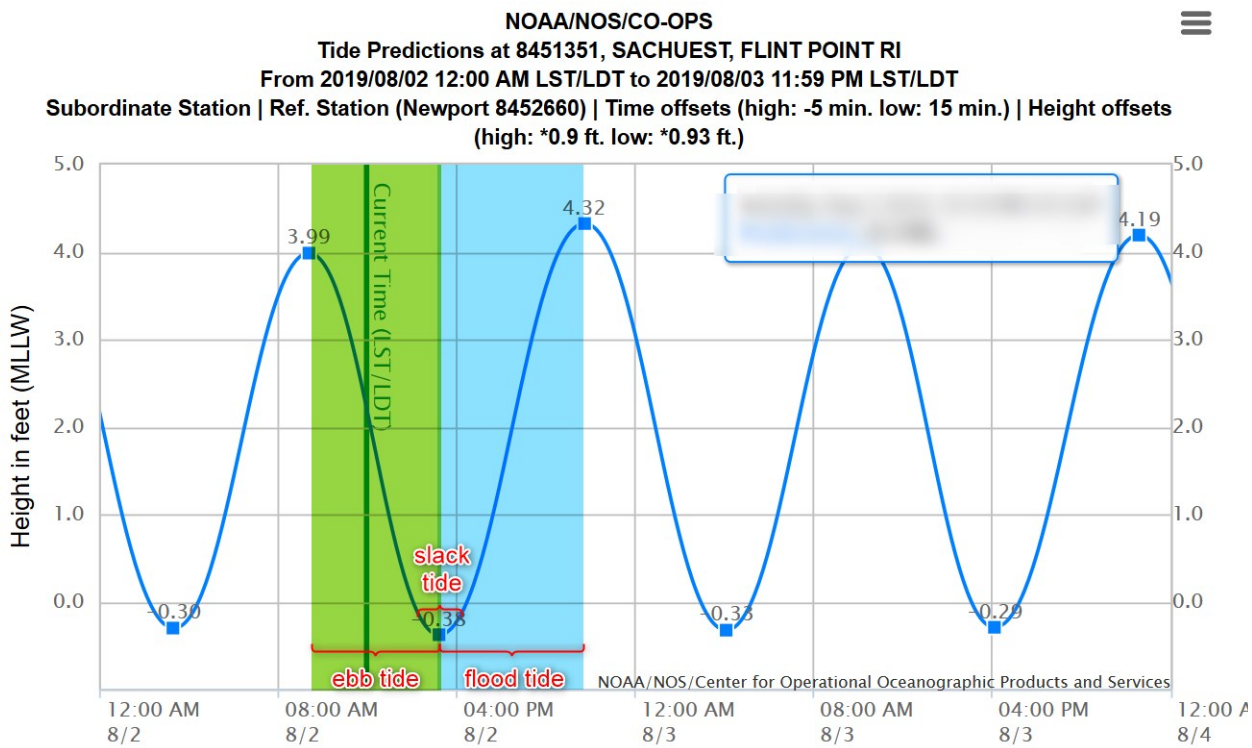
Partially inaccessible: Use this option when you can access a crossing well enough to collect some but not all required data. This is most likely to occur when you cannot access either the inlet or outlet side of a crossing and cannot reasonably estimate the dimensions or assess things like inlet perch, outlet perch, water depth or depth at high tide.

No upstream channel: This option is for places where water crosses a road through a culvert but no road-stream crossing occurs because there is no channel up-gradient of the road. This can occur at the very headwaters of a stream or where a road crosses a wetland that lacks a stream channel (at least on the up-gradient side).

Bridge Adequate: Coordinators have the option of using this classification for large bridges for which it is obvious that they present no barrier to aquatic organism passage. Observers may collect and enter data for these crossings but these data are not required.

Number of Culverts/Bridge Cells: For all Bridges with multiple sections or cells, and for all multiple culverts, you must enter the number of those cells or culvert structures here.

Tide Stage: Indicate whether your assessment occurred at low slack tide (no flow), low ebb tide (outgoing tide), low flood tide (incoming tide), or choose "unknown" if you are unsure. Assessments should only be conducted during low tide. However, if you assess a crossing at some other point in the tide cycle, select "other" and indicate when in the cycle you completed the assessment.



Tide chart showing portions of the tide cycle that are ebb tide (green) and flood tide (blue). Slack tide occurs at periods in the cycle between ebb and flood tides when there is no tidal flow.

Tide Prediction: Record the nearest estimated time of low tide for the site based on an appropriate tide chart, and record the tide chart station. Remember that the times and heights listed in a tide chart are for a specific location, usually near the shore; so, depending on how far you are inland, these estimates may differ from what you find at a particular crossing.

Flow Condition: Check the appropriate box to indicate how much water is flowing in the stream due to freshwater inputs (not tides). Normally, the value selected for the first perennial crossing of the day will hold for all perennial sites in the area during that day, unless a rainfall event changes the situation. Be aware however, that in the small watersheds of typical coastal streams, water levels can rise substantially due to rain events in the 24-hour period preceding your visit. Choose only one option.

Dewatered: No water is flowing in the natural stream channel; this option is typical of extreme droughts for perennial streams, or frequent conditions for intermittent or ephemeral streams.

Unusually-Low: Choose this option if unusually dry conditions create flow conditions that are unusually low, even for the driest times of a normal year.

Typical-Low: This is the most commonly used and expected value for surveys conducted during summer low flows, particularly on perennial streams. Water level in the stream will typically be below the level of non-aquatic vegetation, exposing portions of stream banks and bottom.

Moderate: This value is selected when recent rains have raised water levels at or above the level of herbaceous (non-woody) stream bank vegetation.

High: This value is selected only rarely, when flows are very high relative to stream banks, making crossing surveys very difficult or impossible, normally due to very recent, or ongoing major rain events. Avoid surveying crossings under high flows as data will not reflect more frequent flow conditions.

Stream Type: Choose the option that best describes the tidal river or stream at the crossing.

Salt Marsh Creek: Generally small creeks within salt marshes where water flows in and out with the tides with little or no freshwater inputs other than groundwater.

Salt/brackish flow-through stream: A freshwater stream flowing through a coastal area, mixing with saltwater and resulting in salt or brackish conditions.

Freshwater tidal: Rivers and streams with little or no ocean-derived salinity but where water levels are still influenced by daily tides.

The flow-through stream shown on the aerial photo has a freshwater source, as can be seen by the dammed-up pond upstream. The salt marsh creek is contained entirely within the salt marsh and has no surface freshwater source.

Salinity (optional): Record water salinity at the crossing in parts per thousands (ppt).

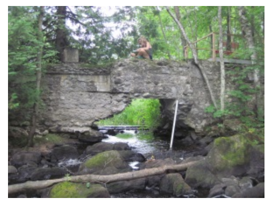
Crossing Condition: Check one box that best summarizes the condition of the crossing, based on your observations of the overall state or quality of the crossing, including all structures, particularly the largest or those carrying most of the flow. We are primarily trying to identify crossings in immediate danger of failing or in imminent need of replacement, as well as those that have been very recently installed. Focus primarily on the condition of structure materials.

New: This value is assigned only to a crossing that has been installed very recently. Look for unblemished structures with new riprap and/or vegetative bank stabilization.

OK: This is the value given to the vast majority of crossings. Many crossings have deficiencies such as surface rust, dents, dings, or cracks which do not indicate risk of failure.

Poor: This value is intended for structures where the material appears to be failing, such as metal culverts with rot (not just surface rust), or concrete, stone or wooden structures that are already collapsing, or in danger of immediate failure (see images below as examples).



Failing: Use this option for extreme cases when the crossing is no longer functional due to the poor condition of its structure(s).

Unknown: This value applies to all sites where the condition of the crossing cannot be assessed, such as when submerged.

Visible utilities: Record any utilities at the site that might complicate any effort to replace the crossing. Detailed information (e.g. type of utility or company name) can be included in the Notes/Comments section.

Overhead wires: electrical, telephone or cable wires.

Water/sewer pipes: visible pipes carrying drinking water, storm water or waste water either in or on the substrate, suspended within the structure(s), or otherwise associated with the crossing.

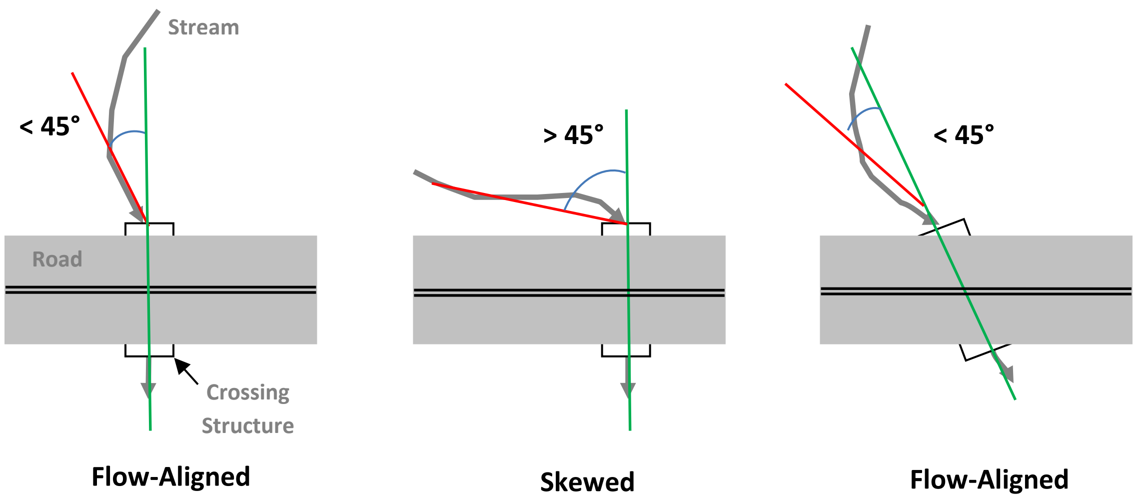
Gas line: pipes for natural gas (often not visible at the surface and only indicated by markers).

Other: include any other type of utility installation not covered above in the Crossing Notes/Comments section.

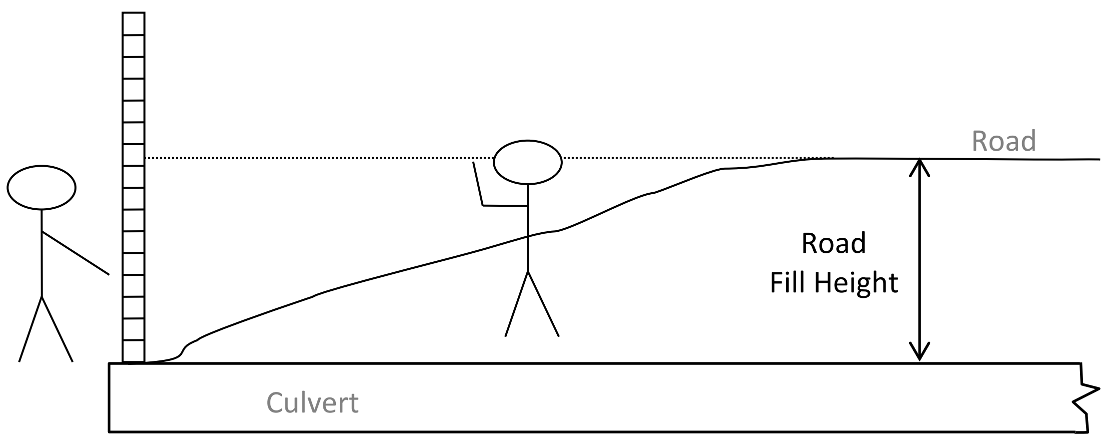
Alignment: Indicates the alignment of the crossing structure(s) relative to the stream at the inlet(s). Compare the crossing centerline (green lines below) to a centerline of the stream where it enters the crossing (red lines below).

Flow-Aligned: The stream approaches the crossing at less than a 45 degree angle from the centerline.

Skewed: The stream approaches the crossing structure(s) at an angle greater than 45 degrees from the centerline. Note that for some crossings the centerline is not perpendicular to the road.



Road Fill Height: Within 1 foot, measure the height of fill material between the top of the crossing structure(s) and the road surface. This is best measured with two people when the road surface or fill height is above a surveyor's height, with one person holding a stadia rod, and the other sighting the elevation of the road surface from the side (see diagram below). For multiple culverts with differing amounts of fill over them, provide an average fill height.



Road Flooded at High Tide: Base on indicators of high water at the site such as water stains (preferred) on nearby structures or vegetation, or wrack lines, indicate whether the road is likely to be flooded at high tide.

Pool and Channel Widths: _Measurements can be made in the field; however, it is generally recommended that you take these measurements from aerial photographs (e.g. Google Earth) as a safer alternative._

Downstream Channel Width: Average width (in decimal feet) of the natural channel (unaffected by the crossing). This is a measure of the active stream channel width at bankfull flow, the point at which water completely fills the stream channel and where additional water would overflow into the floodplain or marsh. When possible, use an average of measurements taken at three locations down-gradient of the crossing.

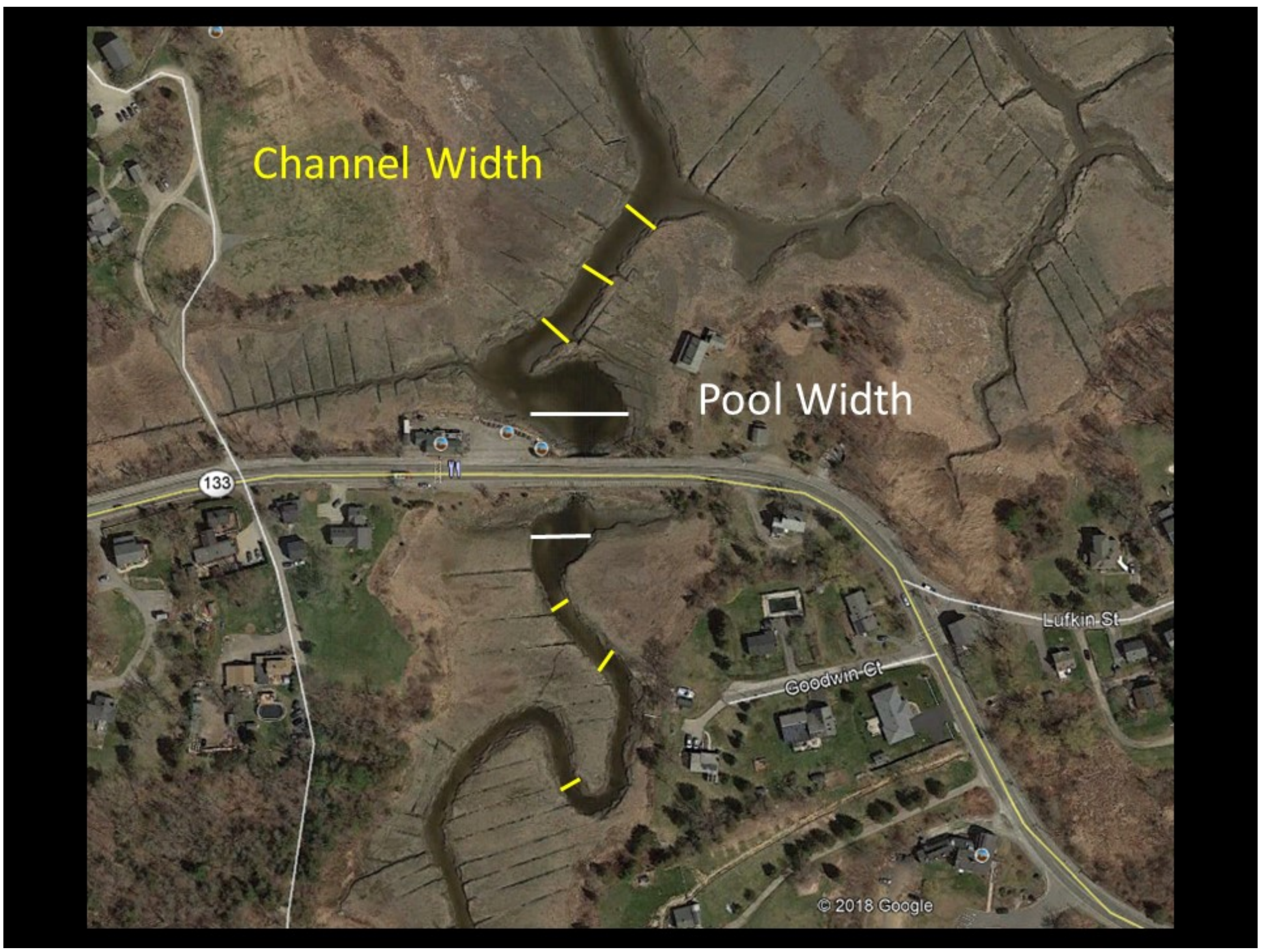
Downstream Pool Width: Maximum width of the scour pool (in decimal feet) directly down-gradient of the crossing. If no scour pool is present then record the pool width as the same as the channel width.

Downstream Tidal Range: Based on indicators of high water at the site such as water stains (preferred) on nearby structures or vegetation, or wrack lines, estimate the difference between low tide and high tide elevations (in decimal feet) at the downstream end of the crossing.

Upstream Channel Width: Average width (in decimal feet) of the natural channel (unaffected by the crossing). This is a measure of the active stream channel width at bankfull flow, the point at which water completely fills the stream channel and where additional water would overflow into the floodplain or marsh. When possible, use an average of measurements taken at three locations up-gradient of the crossing.

Upstream Pool Width: Maximum width of the scour pool (in decimal feet) directly up-gradient of the crossing. If no scour pool is present then record the pool width as the same as the channel width.

Upstream Tidal Range: Based on indicators of high water at the site such as water stains (preferred) on nearby structures or vegetation, or wrack lines, estimate the difference between low tide and high tide elevations (in decimal feet) at the upstream end of the crossing.



Vegetation Above/Below: Considering vegetative structure (trees, shrubs, herbaceous plants) and species composition, compare the vegetative communities above and below the crossing and choose the most appropriate characterization below. Transitions from salt water to freshwater plants are particularly significant.

Comparable: vegetative structure and species composition are not noticeably different

Slightly different: differences in vegetative structure and species composition are evident, but small

Moderately different: differences in vegetative structure and species composition are obvious and substantial, but similarities remain

Very different: vegetative structure and species composition are so different that different vegetative communities occur above and below the crossing. This typically occurs where there is a salt marsh below and a freshwater wetland above the crossing.

Unknown: Choose this option if it is impossible to assess vegetation above and/or below the crossing, due to time of year or lack of a vantage point for observations.

Photo IDs: All surveys should include a minimum of four digital photos of the following: crossing inlet, crossing outlet, stream channel upstream of crossing, and stream channel downstream of crossing. These photos are immensely useful in setting priorities for restoration. It is essential that all photos be associated with the correct crossing. If you take photos with a digital camera (and sometimes when using a smart phone or tablet computer), you should record the photo numbers assigned by the camera on the survey form in the space for each photo perspective. To record the correct photo numbers from any camera, each person taking photos must be familiar with the numbering system of the camera used. Record the ID number of each photo in the blanks on the data form.

While you may take multiple photos at a site in order to choose the best ones later, you must record on the data form the ID numbers of all photos taken at the site. It can be very helpful to have one or more additional photos, especially when important characteristics are not captured on the four required photos. For instance, if there is extreme erosion at the site, or if other aspects of the crossing make it a likely barrier to connectivity, it is useful to capture these with one or two additional photos.

A simple way to know which photos were taken at a particular site is to use a black marker on a white dry-erase board to record the date and Crossing Code, and to have the first photo at the crossing show this white board displaying the date and Crossing Code. The white board should be strategically placed in the photo so that it is legible and does not block key features of the crossings. This will make the photo readily identifiable with the appropriate crossing. 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, making the codes written on the board impossible to read; use of a small blackboard and chalk may be preferable depending on light conditions.

Another option for keeping track of photos is to make the first photo at each site an image of the field data sheet with the xycode and location information. All other photos of that crossing should immediately follow the photo of data form (with the xycode). It is important to remember to photograph the data form first, before you take any other photos for each crossing. Otherwise, you risk mixing up photos from different crossings.

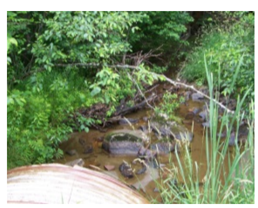
Here are several additional tips for taking useful photos:

- Always include more than just the structure or stream area you are photographing; it is better to capture more context. Remember that with digital photos, we can zoom in to see detail.
- Including a stadia rod in photos of the inlet and outlet can be valuable to verify some measurements, and as a general reference for scale.
- When available, use a date/time stamp to code each photo.
- Set your camera to record in low to medium resolution so that the photos do not take up too much

space on the memory card and when downloaded for storage. To minimize storage space but still allow a reasonable quality image, each photo should be between 100 and 500 kilobytes in size when downloaded. This often equates to a camera resolution setting of "1 Megapixel."

- Review photos at the site to discard bad photos and to be sure all perspectives are well represented.
- If you haven't used the camera before, practice to be sure you know how to take photos in dark or mixed light situations, as these often exist when surveying stream crossings.

The following are some examples of useful photos:

	Site 1	**Site2**	**Site 3**
Inlet			
Outlet			
Upstream			
Downstream			

Crossing Comments: Use this area for brief comments about any aspect of the overall crossing survey that warrants additional information. Do not use this box for comments about particular structures; comment boxes for each structure are provided elsewhere on the form.

STRUCTURE DATA

<u>Choose only one option</u> for structure data fields, **except** when identifying Tide Gates and Other Barriers.

When there are multiple culverts and/or bridge cells, number them from left to right, while looking downstream toward the culvert inlet. The left-most structure is Structure 1, and structure numbers increase to the right. See examples below. When entering data via the ODM or data entry screen make sure that you enter the structures in the same order in which they are numbered.

At the top of each Structure page, record the number of the structure being assessed and the total number of structures making up the crossing. For example, if you are assessing culvert #2 at a crossing with three culverts, record it as "*Structure <u>2</u> of <u>3</u>*."

The structure **inlet** is the opening that is upstream, up-gradient or at the farthest inland end of the structure. The **outlet** is downstream, down-gradient or at the most seaward end of the structure.

For each structure, collect the following information.

Tide Gate Type: Tide gates can be assumed to impede at least some aquatic passage. Choose the most appropriate option from among the following.

No Tide Gate: Choose this option if no tide gate is associated with the structure.

Stop Logs: A tide gate that uses boards or logs to control the movement of water or adjust water elevations up-gradient of the crossing

Flap Gate: A tide gate on hinges that opens just enough to allow water to flow downstream but passively closes (due to water pressure) to prevent water flowing upstream with incoming tides; most are top-hinged, but there are also side-hinged and bottom-hinged flap gates.

Sluice Gate: A tide gate or other water management device that opens by sliding up from the bottom via hand crank or power mechanism to regulate the amount of water flowing upstream or downstream

Self-regulating Tide Gate: Self-regulating tide gates are fixed with floats or some other mechanism that allows unregulated flow at times, but restricts high flows to prevent upstream flooding.

Other (describe): Choose this option for tide gates that don't match any of the descriptions above and describe the type of tide gate in the Structure Notes/Comments section.

Tide Gate Barrier Severity: Tide gates are often severe barriers to aquatic organism passage. Self-regulating tide gates may provide better opportunities for passage, but the other types of gates are likely to provide significant passage only when jammed open or broken. Evaluate the severity of the barrier presented by tide gates by considering the number of individual organism likely to pass through the gate, as well as the proportion of species capable of moving upstream through the gate. Choose only one option.

No Tide Gate: Choose this option it there is no tide gate associated with the structure.

Minor: The tide gate is self-regulating or broken enough to provide mostly unaffected passage for most species.

Moderate: The tide gate is a substantial barrier but self-regulating or broken enough to provide some passage for some species.

Severe: The tide gate restricts upstream movement for most species, although some passage by a small number of individuals is still possible.

No Aquatic Passage: The tide gate prevents any upstream movement of aquatic organisms.

Inlet/Outlet Material: Record here the material on the inside of the structure (not aprons, headwalls, or wingwalls) that is most in contact with the stream. If the interior of the structure is made of two or more materials, such as a metal culvert that has been lined along its entire bottom with concrete, select both metal and concrete. For metal and plastic pipes, indicate whether the structure is smooth or corrugated. Choose all options that apply.

Concrete: culverts and bridges made of concrete

Stone: masonry culverts and bridges

Wood: usually bridges, but occasionally culverts may be made of wood

Metal-smooth: aluminum, steel, alloy or case iron, with a smooth internal surface (no corrugations)

Metal-corrugated: aluminum, steel, or alloy with a corrugated internal surface

Plastic-smooth: plastic pipe with a smooth internal surface; be aware that some plastic pipes that appear corrugated on the outside actually have smooth internal surfaces.

Plastic-corrugated: plastic pipe with a corrugated internal surface

Other: any other material not listed above; describe the material in the Structure Notes/Comments section.

Inlet/Outlet Shape: Refer to the diagrams on the last page of the field data form, and record here the structure number that best matches the shape of the structure opening observed at the inlet of the culvert. This is usually simple, but when a shape seems unusual, you should carefully choose the most reasonable option from among the seven available. We collect this information to be able to find the “open area” inside the structure above any water or substrate, so the shape is vital to accurately calculate area. Choose only one option.

1 - Round Culvert: This is a circular pipe. It may or may not have substrate inside, even though the diagram on the field form shows a layer of substrate. It may be compressed slightly in one dimension, and should be considered round unless it is truly squashed so that it reflects a type 2 shape below.




2 - Pipe Arch/Elliptical Culvert: This is essentially a squashed round culvert, where the lower portion is flatter, and the upper portion is a semicircular arch, or as on the right below, more of a pure ellipse. It may or may not have substrate inside (the diagram on the field form shows a layer of substrate).




3 - Open Bottom Arch Bridge/Culvert: This structure will often look like a round culvert on the top half, but it will not have a bottom. There will be some sort of footings to stabilize it, either buried metal or concrete footings, or concrete footings that rise some height above the channel bottom. There will be natural substrate throughout the structure. To distinguish between an embedded Pipe Arch Culvert and an Open Bottom Arch, note that the sides of the Pipe Arch curve inward in their lower section, while the sides of the Open Bottom Arch will run straight downward into the streambed substrate or to a vertical footing. Beware of confusion between an Open Bottom Arch and an embedded Round Culvert; Open Bottom Arches tend to be larger than most Round Culverts. This shape could also be selected for certain bridges that have a similar arched shape and are not well represented by other bridge types (Types 5, 6, 7, below).




4 - Box Culvert: These structures are usually made of concrete or stone, but sometimes of corrugated metal with a slightly arched top. Typically, they have a top, two sides, and a bottom.

A box culvert <u>without</u> a bottom, called a bottomless box culvert, should be classified as a *Box/Bridge with Abutments* (#6, below). If you cannot tell if the structure has a bottom, classify it as a *Box/Bridge with Abutments* (#6). The images below show *Box Culverts* (#4).




5 - Bridge with Side Slopes: This is a bridge with angled banks up to the bottom of the road deck. This type will have no obvious abutments, though they may be buried in the road fill.

6 - Box/Bridge with Abutments: This is a bridge or bottomless box culvert with vertical sides.

7 - Bridge with Side Slopes and Abutments: This is a bridge with sloping banks and vertical abutments (typically short) that support the bridge deck. (Arrows below show the abutments.)

Ford: A ford is a shallow, open stream crossing that may have a minimal structure to stabilize where vehicles drive across the stream bottom. The arrows below indicate the length of a ford, to be measured as Dimension *L*, described below.

Removed: Select this option when the structure is no longer present (the crossing type should be "Removed crossing").

Unknown: Select when a structure's shape is unidentifiable for any reason. Typically, the inlet shape may be unidentifiable because it is submerged or completely blocked with debris.

Clogged/Collapsed/Submerged: Select this option if the structure opening is either full of debris, collapsed, or completely underwater (not usually all three), making measurements impossible. This may be found in places where beavers or debris have plugged a structure inlet so completely that water has backed up and covered the structure opening, or where a crossing has collapsed to the point that it cannot be measured at its inlet/outlet. **Chose this option only if you are unable to collect data on outlet dimensions.**

Inlet/Outlet Dimensions: Four measurements should be taken at both the inlet and outlet inside all structures. An additional measurement is required for a *Bridge with Side Slopes and Abutments* (#7 structure). These are shown on the diagrams on the last page of the field data form.

Dimension A, ***Structure Width:*** To the nearest tenth of a foot, measure the full width of the structure inlet/outlet according to the location of the horizontal arrows labeled ***A*** in the diagrams. Take this measurement **inside** the structure.

Dimension B, ***Structure Height***: To the nearest tenth of a foot, measure the height of the structure inlet/outlet according to the location of the vertical arrows labeled ***B*** in the diagrams. Take this measurement **inside** the structure. This may be the full height of a culvert pipe if there is no substrate inside, or if there is substrate, it will be the height from the top surface of the substrate up to the inside top of the structure. We measure dimensions, in part, to calculate openness. Openness is the opposite of how confining a structure might feel to an aquatic or semi-aquatic organism. Therefore, if there is something inside the structure (such as a large water pipe) that effectively reduces the openness of the crossing, you should measure structure height (B) from the substrate (or structure base if no substrate) to the bottom of the obstruction (see example in the photo below).

Dimension C, ***Substrate/Water Width***: To the nearest tenth of a foot, measure the width of **either** the substrate layer in the bottom of the structure, or the water surface, whichever is wider, according to the general location indicated by the arrows labeled ***C*** in the diagrams. Take this measurement **inside** the structure at the inlet/outlet. Some rules of thumb for Dimension C are below:

- When there is no substrate in a structure, measure the width of the water surface.

- When there is no water in a structure, but there is substrate, measure the width of substrate.
- When there is no substrate or water in a structure, C = 0.

*Dimension D, **Water Depth***: To the nearest tenth of a foot (except when < 0.1 foot, to the nearest *hundredth* of a foot), measure the average depth of water in the structure at the inlet/outlet according to the location of the vertical arrows labeled ***D*** in the diagrams. This measurement must be taken **inside** the structure. When there are many different water depths due to a very uneven structure bottom, take several measurements and record the average.

Dimension E, **Abutment Height**: This measurement is only taken when surveying a *Bridge with Side Slopes and Abutments* (#7 structure**)**. To the nearest foot, measure the height of the vertical abutments from the top of the side slopes up to the bottom of the bridge deck structure.

High Tide Water Depth: Using high water indicators, estimate the average depth at the inlet/outlet of water (in decimal feet) in the structure at the most recent high tide.

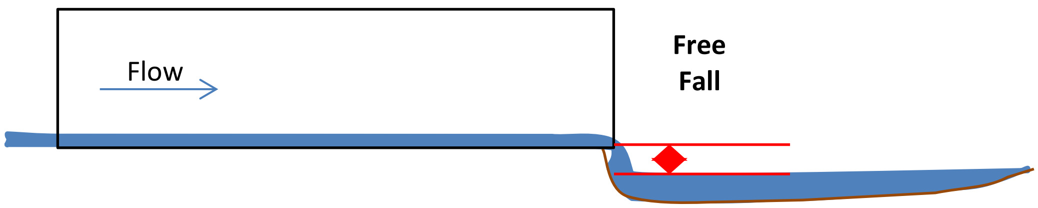
Spring Tide Water Depth: Using high water indicators, estimate the average depth at the inlet/outlet of water (in decimal feet) in the structure at high spring tide. Spring tide is a tide cycle during, just before, or just after a new or full moon, where there is the greatest difference each month between high and low tide.

Note: High spring tides are identified by the highest mark or wrack line. High tides are identified by the most recent mark or wrack line. Some crossing surveys are inevitably going to take place right after a high spring tide, in which case the high tide line is the same as the high spring tide line.

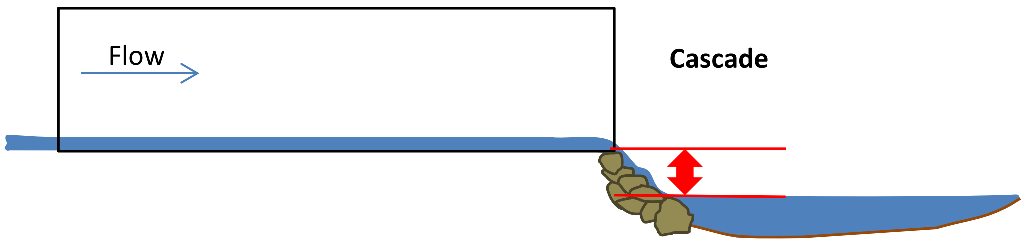
Inlet/Outlet perch: A perched outlet occurs when the invert (inside bottom) of the structure is suspended (perched) above the water level in the pool or channel below. Measure the perch (in decimal feet) from the invert to the water surface in the receiving pool or channel (if there is no pool). This is easiest to measure for free falls. However, a perched inlet/outlet may occur where the water either cascades down from the structure or free falls onto a cascade (see illustrations below). When cascades are involved make sure to measure distance to the surface of the water in the pool at the end of the cascade.

If you observe a perched outlet at low tide, measure the distance (in decimal feet) from the invert to the water surface in the pool or channel below the crossing. Then estimate, based on high water indicators, what the distance is from the invert to the water surface at high tide. If no perch is observed (for low tide) or estimated (for high tide), record the distance as zero.

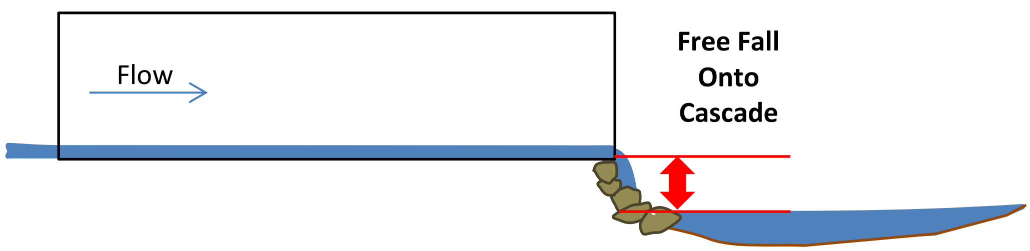
Free Fall: The inlet/outlet of the structure is above the stream bottom such that **water drops vertically** when flowing out of the structure.



Cascade: The inlet/outlet of the structure is raised above the stream bottom such that water flows very steeply downward across rock or other hard material when flowing from the structure. Think of this as series of small waterfalls sloping away from the structure at the inlet/outlet.



Free Fall Onto Cascade: The inlet/outlet of the structure is raised above the stream bottom such that water drops vertically onto a steep area of rock or other hard material, then flows very steeply downward until it reaches the stream.



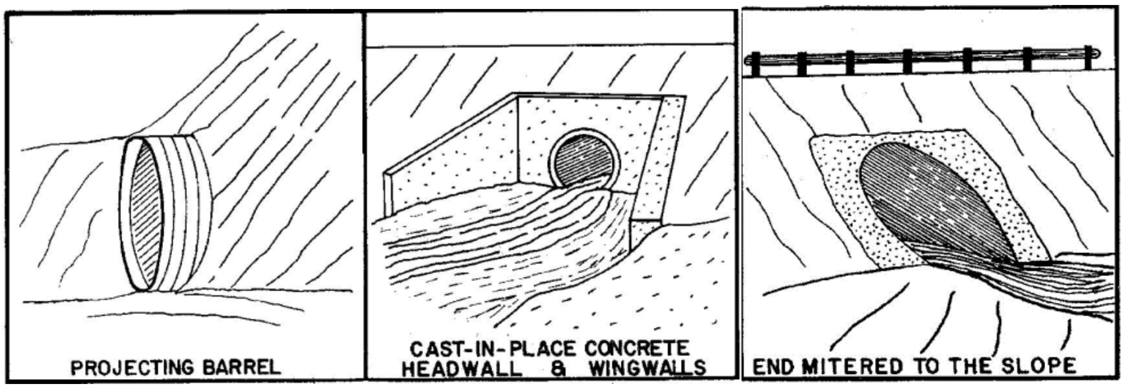
Inlet/Outlet Armoring: Select from the options to indicate the presence and extent of material placed outside the inlet/outlet for the purpose of diffusing flow and minimizing scour. The most common form of armoring is a layer of riprap (angular rock) placed outside the inlet/outlet. A few pieces of rock that may have fallen into the stream near the structure's inlet/outlet **do not** constitute armoring. Armoring of the road embankment and stream banks should not be confused with armoring of the stream bottom. Choose only one option.

None: This situation represents the majority of crossing structures. You may observe rocks that have fallen from the embankment or that are natural to the stream. Most cascades do not constitute armoring unless specifically put in place to minimize scour.

Not Extensive: There is of a layer of material covering the channel for a length upstream or downstream that is <u>less than 50% of the channel width</u>, placed purposefully outside the inlet/outlet specifically to minimize the effects of scour.

Extensive: Select this option only if you observe an extensive layer of material covering the channel for a length upstream or downstream that is <u>more than 50% of the channel width</u>, which was put in place specifically to minimize scour.

Inlet Type: <u>Choose only one option</u> for the style of a culvert inlet, which affects how water flows into the crossing, particularly at higher flows. The drawings here are meant as general guides, but refer to the photos below for more specific images of each type.



Projecting: The inlet of the culvert projects out from (is not flush with) the road embankment.




Mitered to Slope: The inlet is angled to fit **flush with the slope of the road embankment**. Note that many mitered culverts project out from the embankment, and should be recorded as *Projecting*.




Flush: The inlet is flush with the embankment, but not mitered.

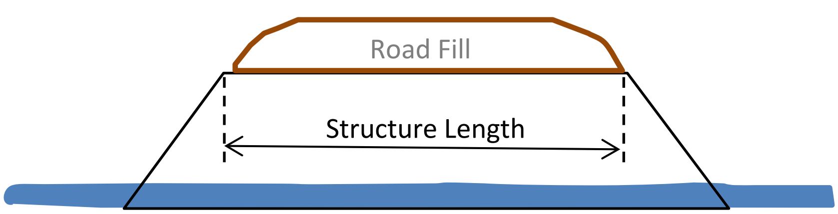
Headwall: The inlet is set flush in a vertical wall, often composed of concrete or stone.

Wingwalls: The inlet is set within angled walls meant to funnel water flow. These walls can be composed of the same material as the culvert, or different material. It is relatively rare to see wingwalls without a headwall.

Headwall & Wingwalls: The inlet is set flush in a vertical wall, and has angled walls to funnel flow.

Other: There may be some other inlet characteristics that do not match any of the above types and which may limit flow into the culvert (but are not *Physical Barriers*), in which case select *Other*, and describe inlet type in the Structure Notes/Comments section.

Structure Length, *Dimension L*: To the nearest foot, measure the length of the structure at its top (top of the inlet to top of the outlet).



Relative Water Depth: Average water depth in the structure divided by the average water depth in the natural channel downstream of the crossing. No actual measurement of the water depth in the natural channel is required. Rather, you can visually estimate water depth in the channel from the creek banks. Record as: <0.10, 0.10-0.24, 0.25-0.49, 0.50-0.74, 0.75-0.99, or ≥ 1.0.

Structure Substrate Type: Choose only one option from the table below to indicate the most common or dominant substrate type inside the structure. If you are certain that the structure contains substrate, but cannot assess the type, select *Unknown*. If there is no substrate in the structure, select *None*.

Substrate Type	Feet	Approximate Relative Size
Muck/Silt	< 0.002	Finer than salt
Sand	0.002 – 0.01	Salt to peppercorn
Gravel	0.01 – 0.2	Peppercorn to tennis ball
Cobble	0.2 – 0.8	Tennis ball to basketball
Boulder	> 0.8	Bigger than a basketball
Bedrock	Unmeasurable	Unknown - buried

Structure Substrate Matches Stream*:* Choose only one option based on a comparison of the substrate (e.g., rock, gravel, sand) inside the structure and the substrate in the natural, undisturbed stream channel.

None: Select this option when there is very little (e.g., a thin layer of silt or a few pieces of rock) or no substrate inside the structure.

Comparable: The substrate inside the structure is similar in size to the substrate in the natural stream channel.

Contrasting: The substrate inside the structure is different in size from the substrate in the natural channel.

Not Appropriate: The substrate inside the structure is very different in size (usually much larger) than the substrate in the natural stream channel. Imagine turtles that typically move along a sandy stream trying to traverse an area of large cobbles, angular riprap or boulders (rarely observed).

Unknown: There is no way to observe if there is substrate inside the structure or what type it is. Select this option when deep, fast, or dark water or other factors do not allow direct observation.

Structure Substrate Coverage: Choose one option, based on the extent of the substrate inside the crossing structure as a ***continuous*** layer across the entire bottom of the structure from bank to bank (side to side).

None: Substrate covers < 25% of the length of the structure, or there is no substrate inside the structure at all.

25-50%: Substrate covers *at least* 25% but not more than 50% of the length of the structure.

50-75%: Substrate covers *at least* 50% but not more than 75% of the length of the structure.

75-99%: Substrate covers *at least* 75% but not the entire length of the structure.

100%: Substrate forms a ***continuous*** layer throughout the ***entire*** structure.

Unknown: It is not possible to directly observe whether substrate forms a continuous layer on the structure bottom.

Structure Slope: To evaluate structure slope use as a reference a portion of the natural stream channel that is outside the influence of the crossing and not otherwise altered. Slope is considered comparable if the structure slope is similar to the slopes found in the nature stream channel upstream and downstream of the crossing. Comparable means that the structure slope falls within the range of slopes naturally occurring in that reach of the stream and for comparable distances. For example, a structure that has a slope that is similar to that found in short, high-gradient sections of the stream but that extends for longer distances than found in the natural stream would not be considered comparable. After evaluating the structure relative to the natural stream check the most appropriate option.

Comparable: no apparent difference or difficult to determine

Substantially Flatter: the structure slope is obviously and substantially flatter than the slope of the natural channel

Substantially Steeper: the structure slope is obviously and substantially steeper than the slope of the natural channel

Other Barriers: Select any of these barrier types in or associated with the structure you are surveying, but do not include here information already captured in **Inlet and Outlet perches** and **Tide Gate Type/Severity.** Note here additional barriers, including those associated with blockages or Internal Structures. If a barrier feature affects more than one structure at a crossing (e.g., a beaver dam), include it for all affected structures. Refer to the photos below for examples of physical barriers.

Note that some structures have a combination of physical barriers. Check all that apply.

None: There are no physical barriers associated with this structure aside from any already noted in **Inlet and Outlet Perches and Tide Gate Type**.

Sediment blockage: Rock, or sediment blocks the flow of water into or through the structure. This can consist of sand, gravel, or rock. Do not check this option if you observe only very small amounts of debris that are likely to be washed away during the next rain event. Also, do not confuse sediment inside a structure that constitutes an appropriate streambed with an accumulation that limits flow or passage of organisms.




Debris: Woody debris or synthetic material blocks the flow of water into or through the structure. This can consist of wood or other vegetation, trash, or other large materials. Do not check this option if you observe only very small amounts of debris that are likely to be washed away during the next rain event.



Fencing: The structure has some sort of fencing, often at the inlet to deter beavers. Depending on the mesh size of that fencing, it may directly block the movement of aquatic and terrestrial organisms, and it may become clogged with debris. If also blocked with debris, be sure to check *Debris* as a **Physical Barrier** type as well.




Pipes: Exposed pipes in the bottom of the structure or low hanging pipes within the structure that block aquatic passage.

Deformation: The structure is deformed in such a way that it significantly limits flow or inhibits the passage of aquatic organisms. This does not include minor dents and slightly misshapen structures.




*Free Fall***:** In addition to its **Inlet or Outlet Perches**, which may include a *Free Fall*, the structure has one or more **additional** vertical drops associated with it. These may include a dam at the inlet, a vertical drop over bedrock inside the structure, or some other feature likely to inhibit passage of aquatic organisms. Note that a *Free Fall* inside a structure is often more limiting than similar size drops found in an undisturbed natural reach of the same stream which occur where there may be multiple paths for organisms to follow. A *Free Fall* can exist because of a debris blockage, so both physical barriers would be recorded.




Other: There may be different situations that do not fit clearly into one of the above categories, but may still represent significant physical barriers to aquatic organism passage. Use this option to capture such situations, and add information about the barrier in Structure Notes/Comments section. Below are examples of some unusual physical barriers which may not fit under Physical Barrier categories listed above.

If there is no water in this structure even though water is flowing in the stream, count this as a physical barrier under "*Other*." Note that if you recorded *Dewatered* for crossing Flow Condition, you should not consider the dry conditions in the structure as a physical barrier; we expect a dry structure at a dry crossing. This barrier type helps to identify passage problems associated with overflow or secondary crossing structures.

These are examples of structures with a combination of physical barriers. When multiple relevant barrier types are present then check all that apply.





Other Barrier Severity: Choose only one option for each surveyed structure, and rank the severity based on an assessment of *the cumulative effect of all physical barriers affecting that structure* according to the table that follows. Do not consider information already captured in **Inlet and Outlet Perch** and **Tide Gate**. Decide on an overall severity for each structure by considering all the different physical barriers present. If any barrier affects more than one structure at a crossing, it should be included in the severity rating for each structure affected. Refer to the table below for guidance in choosing the **Severity** rating.

If, in your opinion, the physical barriers affecting the structure (apart from inlet and outlet perches and tide gates) are likely to prevent any upstream aquatic organism passage, choose "No aquatic passage."

Other Barrier	Severity	Severity Definition
None	*None*	No physical barriers exist - **apart from** Inlet & Outlet Perches, and tide gates
Sediment/Rock *silt, sand, gravel, rock*	*None*	None
	Minor	< 10% of the open area of the structure is blocked
	Moderate	10% - 50% of open area blocked
	Severe	> 50% of open area of structure blocked
Debris *Logs, branches, leaves*	*None*	None
	Minor	< 10% of the open area of the structure is blocked
	Moderate	10% - 50% of open area blocked
	Severe	> 50% of open area of structure blocked
Fencing *Wire, metal grating, wood*	*None*	No fencing exists in any part of the structure
	Minor	Widely spaced wires or grating with > 0.5 foot (6 inch) gaps
	Moderate	Wires or grating with 0.2 - 0.5 foot (~ 2-6 inches) spacing
	Severe	Wires or grating with < 0.2 foot (~ 2 inch) spacing
Pipes Exposed or low hanging pipes or other, similar infrastructure	*None*	No pipes or pipes not obstructing passage
	Minor	Exposed pipes in the bottom of the structure or low hanging pipes within the structure have a small effect on aquatic passage
	Moderate	Exposed pipes in the bottom of the structure or low hanging pipes within the structure block passage for some species or for a portion of the year
	Severe	Exposed pipes in the bottom of the structure or low hanging pipes within the structure block passage for many species for a large portion of the year
Free Fall *Vertical or near-vertical drop*	*None*	No vertical drop exists - **apart from** Inlet or Outlet Perch
	Minor	0.1 - 0.3 foot vertical drop - **apart from** Inlet or Outlet Perch
	Moderate	0.3 - 0.5 foot vertical drop - **apart from** Inlet or Outlet Perch
	Severe	> 0.5 foot vertical drop - **apart from** Inlet or Outlet Perch
Other Including structures that are dry even when water is flowing in the stream	*Minor*	Use best judgment based on above standards
	Moderate	Use best judgment based on above standards
	Severe	Use best judgment based on above standards

Dry Passage for Terrestrial Wildlife Through Structure? Consider this question two different ways, depending on whether water is flowing through the structure. *If there is water flowing in the structure*: Is there a continuous dry stream bank through at least one side of the structure at low tide, that allows the safe movement of terrestrial or semi-aquatic animals, and does this dry pathway connect to the stream banks upstream and downstream of the structure? *If there is no water flowing in the structure at the time of your assessment*: then there is continuous dry passage through the structure. Choose only one option.

Yes: A continuous bank connects upstream, through the structure, and downstream, or there is otherwise continuous dry passage through the structure.

No: There is no dry passage, the dry passage is not continuous, or the dry passage through the structure does not connect with stream banks upstream or downstream.

Unknown: It is not possible to determine if continuous dry passage exists through this structure.

Height above Dry Passage: If there is dry passage through the structure, measure the average height from the dry stream bank to the top of the structure directly above (i.e., the clearance) to the nearest tenth of a foot. If both stream banks are dry and connected, record the higher measurement. If the structure has no water flow, measure the average height above the bottom of the structure or dry streambed to the top of the structure.

Structure Comments: Use this area to briefly comment on any aspects of the structure needing additional information. Enter comments about the overall crossing in the **Crossing Comments** box.

AQUATIC CONNECTIVITY

Tidal Stream Crossing Survey

DATA FORM

DATABASE ENTRY BY ____ ENTRY DATE ____

DATA ENTRY REVIEWED BY ____ REVIEW DATE ____

CROSSING DATA

Crossing Code ____ **Local ID** (Optional) ____

Date Observed (00/00/0000) ____ **Start Time** ____ **End Time** ____ **Lead Observer** ____

Town/County ____ **Stream/River** ____

Road ____ **Type** ☐ MULTILANE ☐ PAVED ☐ UNPAVED ☐ DRIVEWAY ☐ TRAIL ☐ RAILROAD

GPS Coordinates (Decimal degrees) ☐☐.☐☐☐☐☐ °N Latitude — ☐☐.☐☐☐☐☐ °W Longitude

Location Description

Crossing Type ☐ BRIDGE ☐ CULVERT ☐ MULTIPLE CULVERT ☐ FORD ☐ NO CROSSING ☐ REMOVED CROSSING ☐ BURIED STREAM ☐ INACCESSIBLE ☐ PARTIALLY INACCESSIBLE ☐ NO UPSTREAM CHANNEL ☐ BRIDGE ADEQUATE

Number of Culverts/Bridge Cells

Tide Stage ☐ LOW SLACK TIDE ☐ LOW EBB TIDE ☐ LOW FLOOD TIDE ☐ UNKNOWN ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Tide Prediction Time of nearest low tide ____ Tide chart ____

Flow Conditions ☐ DEWATERED ☐ UNUSUALLY LOW ☐ TYPICAL LOW FLOW ☐ MODERATE FLOW ☐ HIGH FLOW

Stream Type ☐ SALT MARSH CREEK ☐ SALT/BRACKISH FLOW-THROUGH STREAM ☐ FRESHWATER TIDAL

Salinity (Optional) ____ **ppt**

Crossing Condition ☐ NEW ☐ OK ☐ POOR ☐ FAILING ☐ UNKNOWN

Visible Utilities ☐ NONE ☐ OVERHEAD WIRES ☐ WATER/SEWER PIPE ☐ GAS LINE ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Alignment ☐ FLOW ALIGNED ☐ SKEWED (>45°)

☐ **Road Fill Height (ft.)** (Top of culvert to road surface; bridge = 0) ____ **Road Flooded at High Tide** ☐ YES ☐ NO

Downstream Channel Width (ft.) ____ Pool Width (ft.) ____ Tidal Range (ft.) ____

Upstream Channel Width (ft.) ____ Pool Width (ft.) ____ Tidal Range (ft.) ____

Vegetation Above/Below ☐ COMPARABLE ☐ SLIGHTLY DIFFERENT ☐ MODERATELY DIFFERENT ☐ VERY DIFFERENT ☐ UNKNOWN

Photo File #s Outlet ____ Downstream ____ Inlet ____ Upstream ____

Other ____

Crossing Notes/Comments ____

082319

STRUCTURE 1

OUTLET

Tide Gate Type ☐ NO TIDE GATE ☐ STOP LOGS ☐ FLAP GATE ☐ SLUICE GATE ☐ SELF-REGULATING
☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Tide Gate Barrier Severity ☐ NO TIDE GATE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Outlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED)
☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Outlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________
E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Outlet Perch (ft.) **Low Tide**________ **High Tide**________ **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

INLET

Inlet Type ☐ PROJECTING ☐ MITERED TO SLOPE ☐ FLUSH (NOT MITERED) ☐ HEADWALL ☐ WING WALL(S) ☐ HEADWALL & WING WALL(S)
☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED)
☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Inlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________
E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Inlet Perch (ft.) **Low Tide**________ **High Tide**________ **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

ADDITIONAL CONDITIONS

Structure Length (Overall length from inlet to outlet in ft.)________

Relative Water Depth ☐ <0.10 ☐ 0.10-0.24 ☐ 0.25-0.49 ☐ 0.50-0.74 ☐ 0.75-0.99 ☐ ≥1.0

Structure Substrate Type (Pick one) ☐ NONE ☐ MUCK/SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE (e.g. RIP RAP) ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25%-50% ☐ 50%-75% ☐ 75%-99% ☐ 100% ☐ UNKNOWN

Structure Slope (Relative to Channel) ☐ COMPARABLE ☐ SUBSTANTIALLY FLATTER ☐ SUBSTANTIALLY STEEPER

Other Barrier Type ☐ NONE ☐ SEDIMENT BLOCKAGE ☐ DEBRIS ☐ FENCING ☐ PIPES ☐ DEFORMATION ☐ FREE FALL
☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Other Barrier Severity ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Dry Passage for Terrestrial Wildlife ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage (ft.)** ________

Structure Notes/Comments________

082319

STRUCTURE 2

OUTLET

Tide Gate Type ☐ NO TIDE GATE ☐ STOP LOGS ☐ FLAP GATE ☐ SLUICE GATE ☐ SELF-REGULATING
☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Tide Gate Barrier Severity ☐ NO TIDE GATE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Outlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED)
☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Outlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________
E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Outlet Perch (ft.) **Low Tide**________ **High Tide**________ **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

INLET

Inlet Type ☐ PROJECTING ☐ MITERED TO SLOPE ☐ FLUSH (NOT MITERED) ☐ HEADWALL ☐ WING WALL(S) ☐ HEADWALL & WING WALL(S)
☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED)
☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Inlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________
E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Inlet Perch (ft.) **Low Tide**________ **High Tide**________ **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

ADDITIONAL CONDITIONS

Structure Length (Overall length from inlet to outlet in ft.)________

Relative Water Depth ☐ <0.10 ☐ 0.10-0.24 ☐ 0.25-0.49 ☐ 0.50-0.74 ☐ 0.75-0.99 ☐ ≥1.0

Structure Substrate Type (Pick one) ☐ NONE ☐ MUCK/SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE (e.g. RIP RAP) ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25%-50% ☐ 50%-75% ☐ 75%-99% ☐ 100% ☐ UNKNOWN

Structure Slope (Relative to Channel) ☐ COMPARABLE ☐ SUBSTANTIALLY FLATTER ☐ SUBSTANTIALLY STEEPER

Other Barrier Type ☐ NONE ☐ SEDIMENT BLOCKAGE ☐ DEBRIS ☐ FENCING ☐ PIPES ☐ DEFORMATION ☐ FREE FALL
☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Other Barrier Severity ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Dry Passage for Terrestrial Wildlife ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage (ft.)** ________

Structure Notes/Comments________

082319

STRUCTURE 3

OUTLET

Tide Gate Type ☐ NO TIDE GATE ☐ STOP LOGS ☐ FLAP GATE ☐ SLUICE GATE ☐ SELF-REGULATING ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Tide Gate Barrier Severity ☐ NO TIDE GATE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Outlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Outlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________

E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Outlet Perch (ft.) **Low Tide**________ **High Tide**________ **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

INLET

Inlet Type ☐ PROJECTING ☐ MITERED TO SLOPE ☐ FLUSH (NOT MITERED) ☐ HEADWALL ☐ WING WALL(S) ☐ HEADWALL & WING WALL(S) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Inlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________

E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Inlet Perch (ft.) **Low Tide**________ **High Tide**________ **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

ADDITIONAL CONDITIONS

Structure Length (Overall length from inlet to outlet in ft.)________

Relative Water Depth ☐ <0.10 ☐ 0.10-0.24 ☐ 0.25-0.49 ☐ 0.50-0.74 ☐ 0.75-0.99 ☐ ≥1.0

Structure Substrate Type (Pick one) ☐ NONE ☐ MUCK/SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE (e.g. RIP RAP) ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25%-50% ☐ 50%-75% ☐ 75%-99% ☐ 100% ☐ UNKNOWN

Structure Slope (Relative to Channel) ☐ COMPARABLE ☐ SUBSTANTIALLY FLATTER ☐ SUBSTANTIALLY STEEPER

Other Barrier Type ☐ NONE ☐ SEDIMENT BLOCKAGE ☐ DEBRIS ☐ FENCING ☐ PIPES ☐ DEFORMATION ☐ FREE FALL ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Other Barrier Severity ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Dry Passage for Terrestrial Wildlife ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage (ft.)** ________

Structure Notes/Comments________

082319

STRUCTURE 4

OUTLET

Tide Gate Type ☐ NO TIDE GATE ☐ STOP LOGS ☐ FLAP GATE ☐ SLUICE GATE ☐ SELF-REGULATING ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Tide Gate Barrier Severity ☐ NO TIDE GATE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Outlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Outlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________

E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Outlet Perch (ft.) **Low Tide**________ **High Tide**________ **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

INLET

Inlet Type ☐ PROJECTING ☐ MITERED TO SLOPE ☐ FLUSH (NOT MITERED) ☐ HEADWALL ☐ WING WALL(S) ☐ HEADWALL & WING WALL(S) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Inlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________

E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Inlet Perch (ft.) **Low Tide**________ **High Tide**________ **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

ADDITIONAL CONDITIONS

Structure Length (Overall length from inlet to outlet in ft.)________

Relative Water Depth ☐ <0.10 ☐ 0.10-0.24 ☐ 0.25-0.49 ☐ 0.50-0.74 ☐ 0.75-0.99 ☐ ≥1.0

Structure Substrate Type (Pick one) ☐ NONE ☐ MUCK/SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE (e.g. RIP RAP) ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25%-50% ☐ 50%-75% ☐ 75%-99% ☐ 100% ☐ UNKNOWN

Structure Slope (Relative to Channel) ☐ COMPARABLE ☐ SUBSTANTIALLY FLATTER ☐ SUBSTANTIALLY STEEPER

Other Barrier Type ☐ NONE ☐ SEDIMENT BLOCKAGE ☐ DEBRIS ☐ FENCING ☐ PIPES ☐ DEFORMATION ☐ FREE FALL ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Other Barrier Severity ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Dry Passage for Terrestrial Wildlife ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage (ft.)**________

Structure Notes/Comments________

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STRUCTURE 5

OUTLET

Tide Gate Type ☐ NO TIDE GATE ☐ STOP LOGS ☐ FLAP GATE ☐ SLUICE GATE ☐ SELF-REGULATING ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Tide Gate Barrier Severity ☐ NO TIDE GATE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Outlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Outlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________
E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Outlet Perch (ft.) **Low Tide**________ **High Tide**________ **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

INLET

Inlet Type ☐ PROJECTING ☐ MITERED TO SLOPE ☐ FLUSH (NOT MITERED) ☐ HEADWALL ☐ WING WALL(S) ☐ HEADWALL & WING WALL(S) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Inlet Dimensions (ft.) **A. Width**________ **B. Height**________ **C. Substrate/Water Width**________ **D. Water Depth**________
E. Abutment Height (Type 7 bridges only)________ **High Tide Water Depth**________ **Spring Tide Water Depth**________

Inlet Perch (ft.) **Low Tide**________ **High Tide**________ **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

ADDITIONAL CONDITIONS

Structure Length (Overall length from inlet to outlet in ft.)________

Relative Water Depth ☐ <0.10 ☐ 0.10-0.24 ☐ 0.25-0.49 ☐ 0.50-0.74 ☐ 0.75-0.99 ☐ ≥1.0

Structure Substrate Type (Pick one) ☐ NONE ☐ MUCK/SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE (e.g. RIP RAP) ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25%-50% ☐ 50%-75% ☐ 75%-99% ☐ 100% ☐ UNKNOWN

Structure Slope (Relative to Channel) ☐ COMPARABLE ☐ SUBSTANTIALLY FLATTER ☐ SUBSTANTIALLY STEEPER

Other Barrier Type ☐ NONE ☐ SEDIMENT BLOCKAGE ☐ DEBRIS ☐ FENCING ☐ PIPES ☐ DEFORMATION ☐ FREE FALL ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Other Barrier Severity ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Dry Passage for Terrestrial Wildlife ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage (ft.)**________

Structure Notes/Comments________

082319

STRUCTURE 6

OUTLET

Tide Gate Type ☐ NO TIDE GATE ☐ STOP LOGS ☐ FLAP GATE ☐ SLUICE GATE ☐ SELF-REGULATING ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Tide Gate Barrier Severity ☐ NO TIDE GATE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Outlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Outlet Dimensions (ft.) **A. Width**______ **B. Height**______ **C. Substrate/Water Width**______ **D. Water Depth**______
E. Abutment Height (Type 7 bridges only)______ **High Tide Water Depth**______ **Spring Tide Water Depth**______

Outlet Perch (ft.) **Low Tide**______ **High Tide**______ **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

INLET

Inlet Type ☐ PROJECTING ☐ MITERED TO SLOPE ☐ FLUSH (NOT MITERED) ☐ HEADWALL ☐ WING WALL(S) ☐ HEADWALL & WING WALL(S) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Inlet Dimensions (ft.) **A. Width**______ **B. Height**______ **C. Substrate/Water Width**______ **D. Water Depth**______
E. Abutment Height (Type 7 bridges only)______ **High Tide Water Depth**______ **Spring Tide Water Depth**______

Inlet Perch (ft.) **Low Tide**______ **High Tide**______ **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

ADDITIONAL CONDITIONS

Structure Length (Overall length from inlet to outlet in ft.)______

Relative Water Depth ☐ <0.10 ☐ 0.10-0.24 ☐ 0.25-0.49 ☐ 0.50-0.74 ☐ 0.75-0.99 ☐ ≥1.0

Structure Substrate Type (Pick one) ☐ NONE ☐ MUCK/SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE (e.g. RIP RAP) ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25%-50% ☐ 50%-75% ☐ 75%-99% ☐ 100% ☐ UNKNOWN

Structure Slope (Relative to Channel) ☐ COMPARABLE ☐ SUBSTANTIALLY FLATTER ☐ SUBSTANTIALLY STEEPER

Other Barrier Type ☐ NONE ☐ SEDIMENT BLOCKAGE ☐ DEBRIS ☐ FENCING ☐ PIPES ☐ DEFORMATION ☐ FREE FALL ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Other Barrier Severity ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Dry Passage for Terrestrial Wildlife ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage (ft.)** ______

Structure Notes/Comments______

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STRUCTURE 7

OUTLET

Tide Gate Type ☐ NO TIDE GATE ☐ STOP LOGS ☐ FLAP GATE ☐ SLUICE GATE ☐ SELF-REGULATING ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Tide Gate Barrier Severity ☐ NO TIDE GATE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Outlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Outlet Dimensions (ft.) **A. Width**_____ **B. Height**_____ **C. Substrate/Water Width**_____ **D. Water Depth**_____

E. Abutment Height (Type 7 bridges only)_____ **High Tide Water Depth**_____ **Spring Tide Water Depth**_____

Outlet Perch (ft.) **Low Tide**_____ **High Tide**_____ **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

INLET

Inlet Type ☐ PROJECTING ☐ MITERED TO SLOPE ☐ FLUSH (NOT MITERED) ☐ HEADWALL ☐ WING WALL(S) ☐ HEADWALL & WING WALL(S) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Materials (Select all options that apply) ☐ CONCRETE ☐ STONE ☐ WOOD ☐ METAL (SMOOTH) ☐ METAL (CORRUGATED) ☐ PLASTIC (SMOOTH) ☐ PLASTIC (CORRUGATED) ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ REMOVED ☐ UNKNOWN ☐ CLOGGED/COLLAPSED/SUBMERGED

Inlet Dimensions (ft.) **A. Width**_____ **B. Height**_____ **C. Substrate/Water Width**_____ **D. Water Depth**_____

E. Abutment Height (Type 7 bridges only)_____ **High Tide Water Depth**_____ **Spring Tide Water Depth**_____

Inlet Perch (ft.) **Low Tide**_____ **High Tide**_____ **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

ADDITIONAL CONDITIONS

Structure Length (Overall length from inlet to outlet in ft.)_____

Relative Water Depth ☐ <0.10 ☐ 0.10-0.24 ☐ 0.25-0.49 ☐ 0.50-0.74 ☐ 0.75-0.99 ☐ ≥1.0

Structure Substrate Type (Pick one) ☐ NONE ☐ MUCK/SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE (e.g. RIP RAP) ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25%-50% ☐ 50%-75% ☐ 75%-99% ☐ 100% ☐ UNKNOWN

Structure Slope (Relative to Channel) ☐ COMPARABLE ☐ SUBSTANTIALLY FLATTER ☐ SUBSTANTIALLY STEEPER

Other Barrier Type ☐ NONE ☐ SEDIMENT BLOCKAGE ☐ DEBRIS ☐ FENCING ☐ PIPES ☐ DEFORMATION ☐ FREE FALL ☐ OTHER (DESCRIBE IN COMMENTS SECTION)

Other Barrier Severity ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE ☐ NO AQUATIC PASSAGE

Dry Passage for Terrestrial Wildlife ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage (ft.)** _____

Structure Notes/Comments_____

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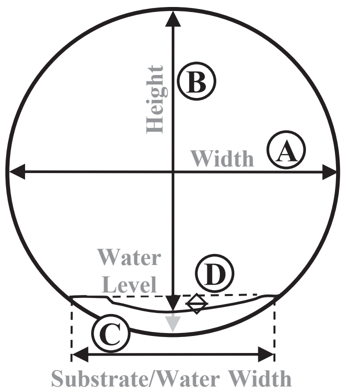
Structure Shape & Dimensions

1) Select the Structure Shape number from the diagrams below and record it on the form for Inlet and Outlet Shape.
2) Record on the form in the approriate blanks dimensions **A**, **B**, **C** and **D** as shown in the diagrams;
   C captures the width of water or substrate, whichever is wider; for dry culverts without substrate, C = 0.
   D is the depth of water -- be sure to measure inside the structure; for dry culverts, D = 0.
3) Record Structure Length (**L**). (Record abutment height (**E**) only for Type 7 Structures.)
4) For multiple culverts, also record the Inlet and Outlet shape and dimensions for each additional culvert.

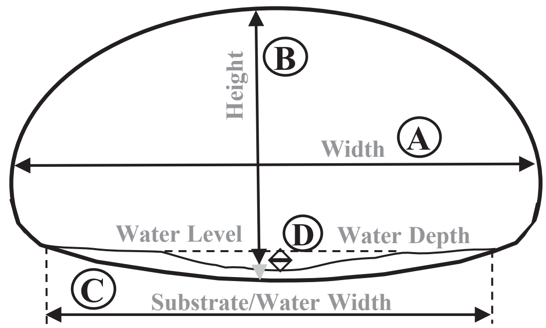
NOTE: Culverts 1, 2 & 4 may or may not have substrate in them, so height measurements (B) are taken from the level of the "stream bed", whether that bed is composed of substrate or just the inside bottom surface of a culvert (grey arrows below show measuring to bottom, black arrows show measuring to substrate).

1



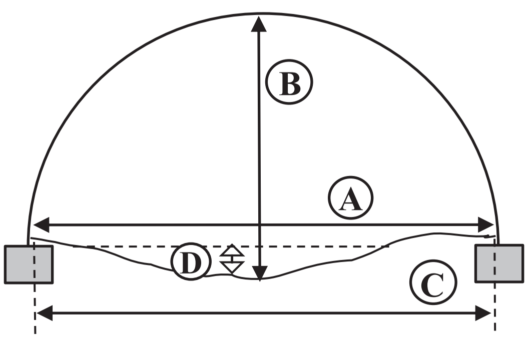
Round Culvert

2



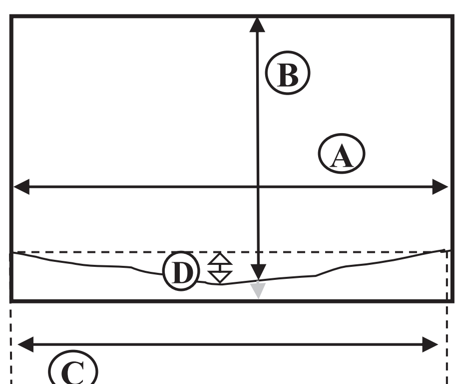
Pipe Arch/Elliptical Culvert

3



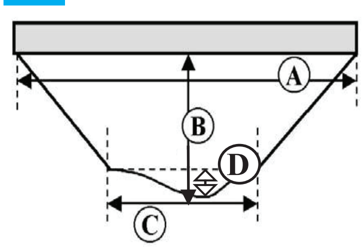
Open Bottom Arch Bridge/Culvert

4



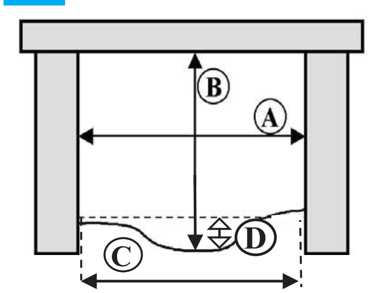
Box Culvert

5



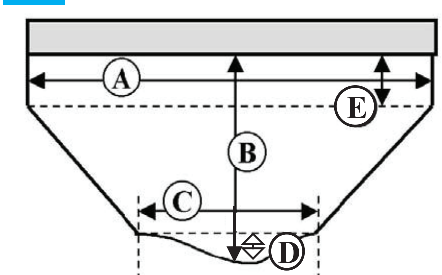
Bridge with Side Slopes

6



Box/Bridge with Abutments

7



Bridge with Abutments and Side Slopes

082319

North Atlantic Aquatic Connectivity Collaborative (NAACC)

Aquatic Passability Scoring Systems for Tidal Stream Crossings

March 19, 2019

The aquatic passability assessment protocol and scoring systems were developed to complement an existing protocol developed for road-stream crossings on non-tidal streams. It is particularly challenging to assess aquatic passability for tidal streams because daily fluctuations in water levels and flow characteristics mean that, for some streams, barrier effects may vary greatly throughout a single day. Conditions that would be impassable at low tide might be fine at high tide.

The Technical Advisory Committee that guided the development of the tidal stream crossing assessment protocol and scoring system weighed the costs and benefits of basing assessments on a single visit vs. multiple visits (e.g. to assess conditions at multiple points in the tide cycle). The consensus of the group was that a protocol based on a single visit would be more likely to be used, and used more widely than a multiple-visit protocol. Thus, the metrics used in these scoring systems utilize data that can be reasonably gathered during a single visit at low tide. Some variables are estimates of conditions at high tide, based on water staining in and around the crossing structures observable at low tide.

There are two scoring systems in use for tidal stream crossings: 1) a coarse screen that assigns each crossing to one of three classifications (no passage, reduced passage, full passage) and 2) a numeric scoring system that scores crossings on a continuous scale ranging from 0 (no passage) to 1 (full passage).

Coarse Screen

The Tidal Crossings Coarse Screen is a means for identifying those crossings that provide full passage for aquatic organisms and those that essentially provide no aquatic organism passage (AOP). All others fall into the category “Reduced AOP.” Crossings that are classified as “Full AOP” are assumed to provide passage for a wide range of species throughout the year (e.g. during periods of low and high flows). Those classified as “No AOP” are assumed to provide little or no passage for aquatic species at any point in the year.

Metric	Flow Condition	Crossing Classification **Good AOP** *If all are true*	**Moderate AOP** *If not RED or Orange and any are true*	**Poor AOP** *If not RED and any are true*	**No AOP** *If any are true*
Constriction ratio		≥ 1.5	≤ 1.5		
Tidal constriction		≥ 1.0	≤ 1.0		
Water depth	High tide	≥ 1.0	0.4 – 0.99	< 0.4	
Inlet perch	Low tide	0 ft.	≤ 1.0 ft.		
Inlet perch	High tide	0 ft.	0 ft.	0 < x < 2.5 ft.	> 2.5 ft.
Outlet perch	Low tide	0 ft.	< 0.25 ft.		
Outlet perch	High tide	0 ft.	0 ft.	0 < x < 2.5 ft.	> 2.5 ft.
Tide gate barrier severity		No tide gate	Minor or moderate	Severe	No aquatic passage
Other physical barrier severity		No barrier	Minor or moderate	Severe	No aquatic passage

Numeric Scoring System

The Tidal Crossings Numeric Score is a continuous range of scores from 0 (no passage) to 1 (full passage). Passability is a function of three elements that are difficult to measure but that make up the conceptual basis for the numeric scoring system: 1) proportion of species able to pass, 2) proportion of individuals able to pass (includes variability in size and life stage), and 3) proportion of the year that the crossing is passable.

The numeric scoring algorithm is based on the opinions of experts who decided both the relative importance of all the available predictors of passability as well as a way to score each predictor. Scoring involves five steps:

(1) generating a component score for each predictor variable,
(2) selecting which of the predictor variables to include in the scoring algorithm for each type of tidal stream,
(3) combining the selected predictor variables with a weighted average to generate a composite score for the crossing,
(4) determining predictor variables that will be considered limiting, and
(5) assigning a final score based on the minimum from among the composite score and each of the component scores for limiting variables.

The numeric scoring system uses many variables and most variables have only a limited effect on the overall passability score. Some variables, such as outlet drop and physical barriers, directly relate to passability. Others are indirect indicators of conditions at other points in the tide cycle or other seasons of the year. For example, the presence of scour pools or armoring suggests that high flows may be present at mid-tide or during periods of high freshwater discharge.

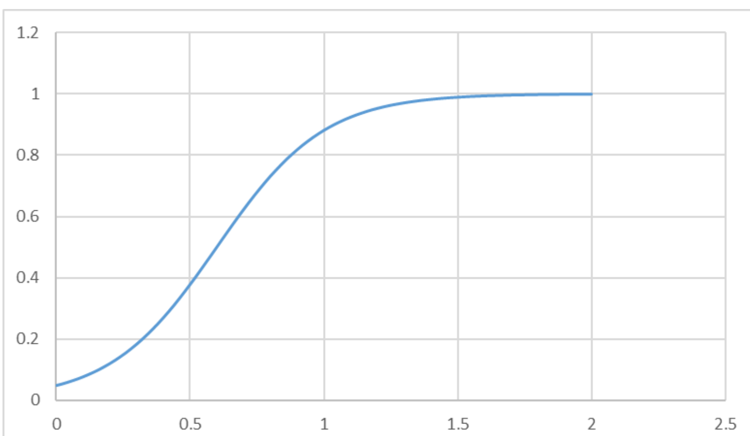
It is recognized that with so many variables, there will be a significant amount of correlation among them. The Technical Advisory Committee took this into account when assigning weights to the metrics for computing composite scores. We believe that redundancies in the metrics help to ensure that mistakes made in assessing individual metrics will not radically alter the final passability scores.

Three metrics are considered "limiting variables" and do have the potential to significantly affect the final passability score. These variables (outlet drop at high tide, tide gate severity, and other physical barrier severity) are considered so important for determining passabiltity that if any one of them has a component score lower than the composite score

This numeric scoring approach aims to identify an ideal crossing (one that scores 1.0 for each of the selected variables) so that, for crossings that lack a fatal flaw (e.g. tide gate that presents a severe barrier or blocks all aquatic passage) a weighted average of component scores will serve to quantify how much each crossing deviates from the ideal. The selection of limiting variables serves to identify fatal flaws that should result in low overall scores even if the composite score is not too bad.

Step 1: Following are the component scoring systems for each of the predictor variables (metrics). These are variables that were identified by the Technical Advisory Committee as having some direct or indirect relationship with aquatic passability.

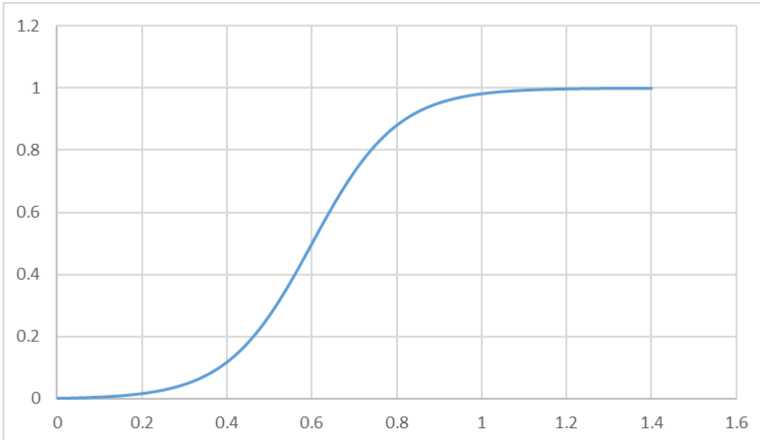
1. Constriction ratio: combined structure width divided by channel width (an indirect indicator of tidal restriction and potential velocity problems; tidal restrictions may indicate potential for biochemical barriers, such as salinity, dissolved oxygen, temperature, or pH)



$$Y = \frac{1}{1 + e^{(-5.0\,(X-0.6))}}$$

Constriction ratio (continuous)	Score
0.3	0.18
0.6	0.50
1.0	0.88
1.5	0.99

2. Tidal constriction: upstream tidal range divided by downstream tidal range (an indicator of tidal restriction, which may also indicate potential biochemical barriers, such as salinity, dissolved oxygen, temperature, or pH).



$$Y = \frac{1}{1 + e^{(-10.0\,(X-0.6))}}$$

Tidal Constriction (continuous)	Score
0.25	0.03
0.50	0.27
0.75	0.82
1.00	0.98

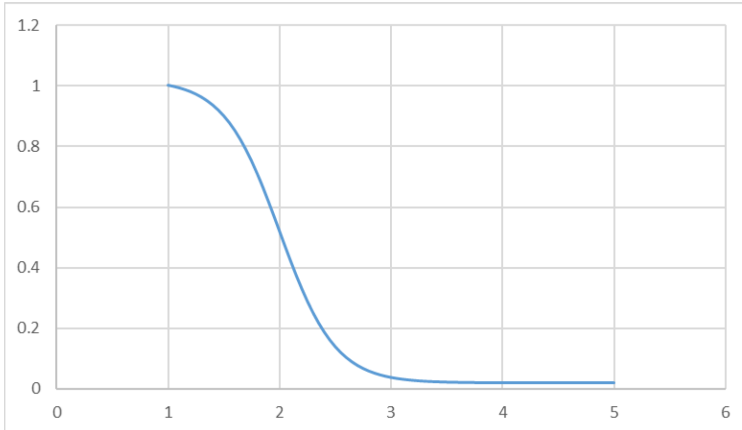
3. Vegetation change: upstream vs. downstream (an indirect indicator of tidal restriction, which may also indicate potential biochemical barriers, such as salinity, dissolved oxygen, temperature, or pH)

Vegetation change (categorical)	Score
Comparable	1.0
Slightly different	0.8
Moderately different	0.4
Very different	0.0
Unknown	No score

4. Ratio of high tide water depth in the structure relative to water depth in the downstream channel (water depth influences which species or what size organisms are able to pass through the structure)

High Tide Water Depth (categorical)	Score
< 0.10	0.0
0.10 – 0.24	0.2
0.25 – 0.49	0.4
0.50 – 0.74	0.6
0.75 – 0.99	0.8
≥ 1.0	1.0

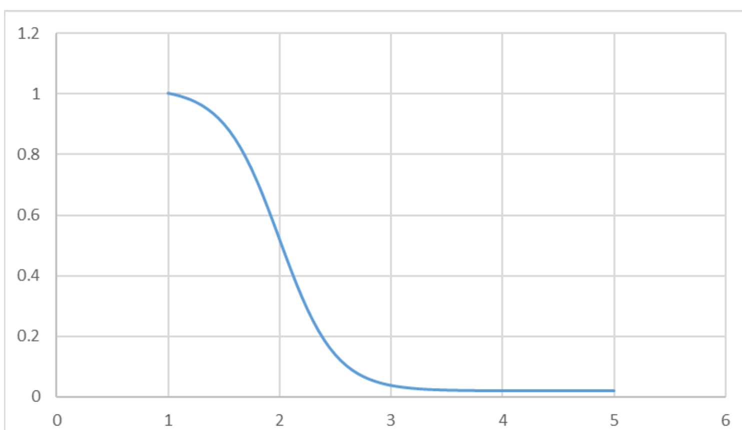
5. <u>Downstream scour: downstream pool width divided by downstream channel width (an indirect indicator of potential velocity problems)</u>



$$Y = \frac{1}{1 + e^{(4.0\,(X-2.0))}}$$

Downstream scour (continuous)	Score
1.0	1.00
2.0	0.50
2.5	0.14
3.0	0.04
4.0	0.02

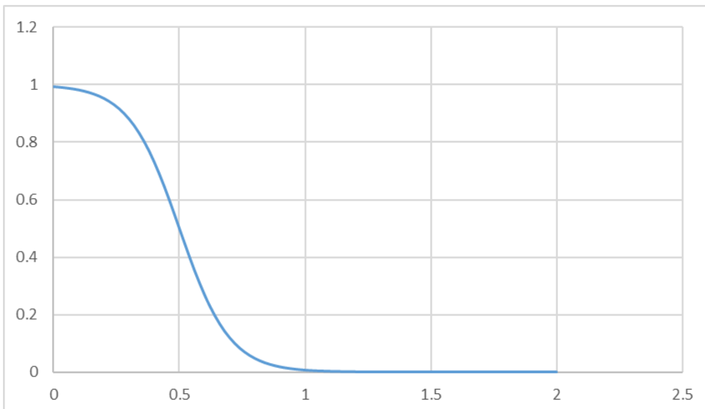
6. <u>Upstream scour</u>: upstream pool width divided by upstream channel width (an indirect indicator of potential velocity problems)



$$Y = \frac{1}{1 + e^{(4.0\,(X-2.0))}}$$

Upstream scour (continuous)	Score
1.0	1.00
2.0	0.50
2.5	0.14
3.0	0.04
4.0	0.02

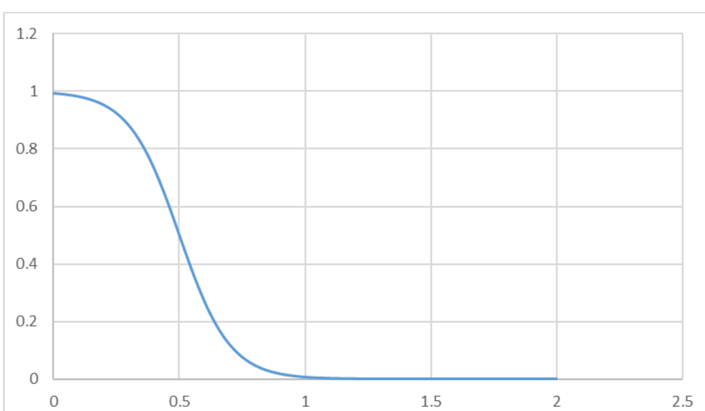
7. Inlet perch at low tide relative to tidal range (such a perch would likely prevent downstream movement at low tide)



$$Y = \frac{1}{1 + e^{(10.0\,(X-0.5))}}$$

Low tide inlet perch (continuous)	Score
0.00	0.99
0.25	0.92
0.50	0.50
0.75	0.07
1.00	0.01

8. Outlet perch at low tide relative to tidal range (an outlet perch at low tide would create a barrier to upstream passage at or around slack tide, a time when water velocities would be low)



$$Y = \frac{1}{1 + e^{(10.0\ (X - 0.5))}}$$

Low tide outlet perch (continuous)	Score
0.00	0.99
0.25	0.92
0.50	0.50
0.75	0.07
1.00	0.01

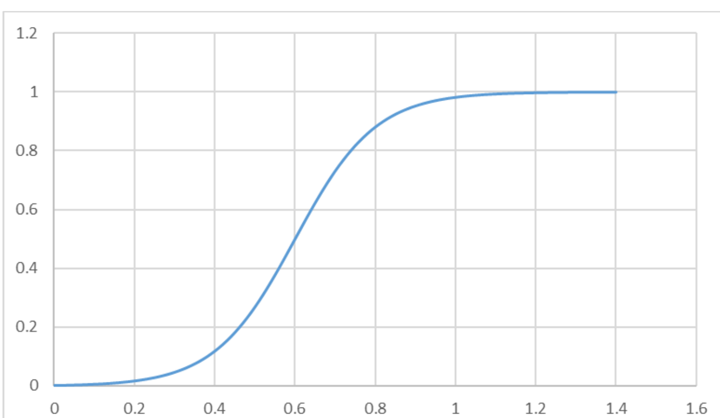
9. Inlet armoring (an indirect indicator of potential velocity problems at higher flows; armoring is often used to prevent scour due to high velocity flows)

Inlet armoring (categorical)	Score
None	1.0
Not extensive	0.5
Extensive	0.0

10. Outlet armoring (an indirect indicator of potential velocity problems at higher flows; armoring is often used to prevent scour due to high velocity flows)

Outlet armoring (categorical)	Score
None	1.0
Not extensive	0.5
Extensive	0.0

11. Crossing openness: cross-sectional area of the structure opening at low tide, divided by structure length (some organisms can be affected by darkness or how confining a structure feels when openness is low)



$$Y = \frac{1}{1 + e^{(-10.0\ (X - 0.6))}}$$

Openness (continuous)	Score
0.3	0.05
0.6	0.50
0.9	0.95
1.0	0.98

12. Substrate comparability (for benthic organisms)

Substrate comparability (categorical)	Score
Comparable	1.0
Contrasting	0.5
Not appropriate	0.0
None	0.0
Unknown	No score

13. Substrate coverage (for benthic organisms and as an indirect indicator of potential velocity problems)

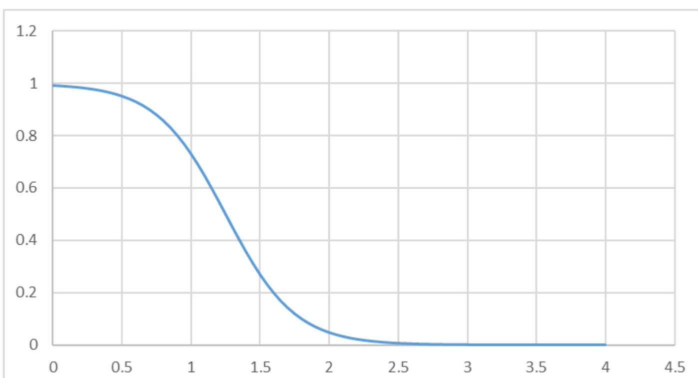
Substrate coverage (categorical)	Score
100 %	1.0
75-99 %	0.8
50-75 %	0.5
25-50 %	0.2
None	0.0
Unknown	No score

Steps 2 & 3: Selecting and Weighting Variables. For each of the tidal crossing types, the table below identifies variables for inclusion in the scoring system and how they are weighted to create a composite score. The weights are based on best professional judgement and assigned by members of the Technical Advisory Committee. Weights from individual Advisory Committee members were averaged and are listed to two decimal places, not because we have confidence in values to that level of precision, but to avoid additional errors/uncertainty in the scoring model due to rounding.

Variable	Salt marsh creek	Salt/brackish flow-through river/stream	Freshwater tidal river/stream
Constriction ratio	11.84	14.93	18.18
Tidal constriction	19.58	20.04	10.49
Vegetation change: upstream vs. downstream	14.32	8.07	4.90
Water depth at high tide	2.41	2.55	2.45
Downstream scour	5.84	6.22	6.64
Upstream scour	5.84	6.22	4.90
Inlet perch at low tide	3.51	5.45	5.94
Outlet perch at low tide	9.81	10.95	11.19
Inlet armoring	4.01	1.47	3.15
Outlet armoring	3.53	1.11	4.20
Crossing openness	9.97	9.51	16.08
Substrate comparability	4.88	7.31	5.94
Substrate coverage	4.47	6.18	5.94
Total	**100**	**100**	**100**

Step 4: Limiting Variables. A limiting variable is one that is so important that its score should take precedence if it is lower than the composite score (weighted average). Limiting variable were identified by consensus of the Technical Advisory Committee. All three tidal crossing types have the same three limiting variables.

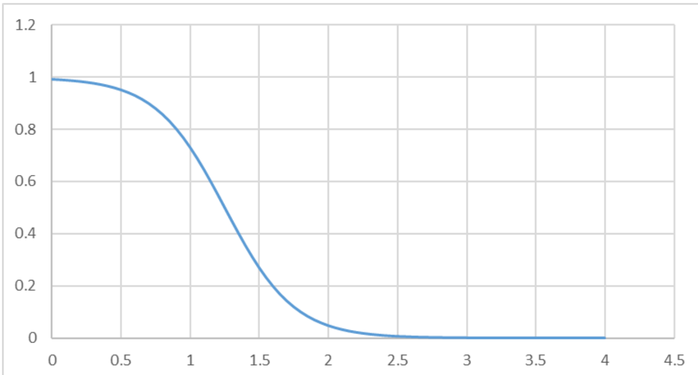
14. Inlet perch at high tide (an inlet perch at high tide would be expected to prevent downstream movement throughout the tide cycle)



$$Y = \frac{1}{1 + e^{(4.0\,(X - 1.25))}}$$

High tide inlet perch (continuous)	Score
0.50 ft.	0.95
1.00 ft.	0.73
1.25 ft.	0.50
2.00 ft.	0.05
2.50 ft.	0.01

15. Outlet perch at high tide (an outlet perch at high tide indicates that the structure is a barrier throughout the tide cycle)



$$Y = \frac{1}{1 + e^{(4.0\,(X-1.25))}}$$

High tide outlet perch (continuous)	Score
0.50 ft.	0.95
1.00 ft.	0.73
1.25 ft.	0.50
2.00 ft.	0.05
2.50 ft.	0.01

16. Tide gate barrier severity (tide gates often present significant physical barriers, blocking upstream movement of aquatic organisms). Coordinator review and approval/revision is required for tide gate severity.

Tide gates (categorical)	Score
No tide gate	1.0
Minor	0.8
Moderate	0.5
Severe	0.2
No aquatic passage	0.0

17. Other physical barrier severity (other physical barriers can block upstream and/or downstream movement of aquatic organisms)

Physical barriers (categorical)	Score
No physical barrier	1.0
Minor	0.8
Moderate	0.5
Severe	0.2
No aquatic passage	0.0

Step 5: Final Passability Score. The final passability score for all three tidal crossing types is the lowest among the component scores for limiting variables and the composite score.

Final Score = Min[composite score, inlet perch at high tide score, outlet perch at high tide score, tide gate barrier severity score, other physical barrier severity score]

Appendix A: Comparison Tidal Scoring Systems with the Aquatic Passability Scoring Systems for Non-tidal Stream Crossings

Non-tidal Aquatic Organism Passage Coarse Screen

Metric	Flow Condition	Crossing Classification Full AOP	Reduced AOP	No AOP
		If all are true	*If any are true*	*If any are true*
Inlet Grade		At Stream Grade	Inlet Drop or Perched	
Outlet Grade		At Stream Grade		Cascade, Free Fall onto Cascade
Outlet Drop to Water Surface		= 0		≥ 1 ft
Outlet Drop to Water Surface/ Outlet Drop to Stream Bottom				> 0.5
Inlet or Outlet Water Depth	Typical-Low	> 0.3 ft		< 0.3 ft w/Outlet Drop to Water Surface > 0
	Moderate	> 0.4 ft		< 0.4 ft w/Outlet Drop to Water Surface > 0
Structure Substrate Matches Stream		Comparable or Contrasting		
Structure Substrate Coverage		100%	< 100%	
Physical Barrier Severity		None	Minor or Moderate	Severe

Tidal Aquatic Organism Passage Coarse Screen

Metric	Flow Condition	Crossing Classification Good AOP	Moderate AOP	Poor AOP	No AOP
		If all are true	*If not RED or Orange and any are true*	*If not RED and any are true*	*If any are true*
Constriction ratio		≥ 1.5	≤ 1.5		
Tidal constriction		≥ 1.0	≤ 1.0		
Water depth	High tide	≥ 1.0	0.4 – 0.99	< 0.4	
Inlet perch	Low tide	0 ft.	≤ 1.0 ft.		
Inlet perch	High tide	0 ft.	0 ft.	0 < x < 2.5 ft.	> 2.5 ft.
Outlet perch	Low tide	0 ft.	< 0.25 ft.		
Outlet perch	High tide	0 ft.	0 ft.	0 < x < 2.5 ft.	> 2.5 ft.
Tide gate barrier severity		No tide gate	Minor or moderate	Severe	No aquatic passage
Other physical barrier severity		No barrier	Minor or moderate	Severe	No aquatic passage

Variables included in numeric scoring models, and their weights, for three classes of tidal crossings and for crossings on non-tidal streams.

Variable	Salt marsh creek	Salt/brackish flow-through river/stream	Freshwater tidal river/stream	Non-tidal streams
Constriction ratio	11.84	14.93	18.18	9.00
Tidal constriction	19.58	20.04	10.49	
Vegetation change: upstream vs. downstream	14.32	8.07	4.90	
Water depth at high tide	2.41	2.55	2.45	
Water depth (non-tidal)				8.20
Downstream scour	5.84	6.22	6.64	7.10
Upstream scour	5.84	6.22	4.90	
Inlet perch at low tide	3.51	5.45	5.94	
Inlet perch (non-tidal)				8.80
Outlet perch at low tide	9.81	10.95	11.19	
Outlet drop (non-tidal)				16.10
Other physical barrier severity				13.50
Inlet armoring	4.01	1.47	3.15	
Outlet armoring	3.53	1.11	4.20	3.70
Crossing height				4.50
Crossing openness	9.97	9.51	16.08	5.20
Substrate comparability	4.88	7.31	5.94	7.00
Substrate coverage	4.47	6.18	5.94	5.70
Water velocity				8.00
Internal structures				3.20
Total	**100**	**100**	**100**	**100**

Non-tidal Crossings Limiting Variables

- Outlet drop
- Other physical barrier severity (optional; coordinator’s choice)

Tidal Crossings Limiting Variables

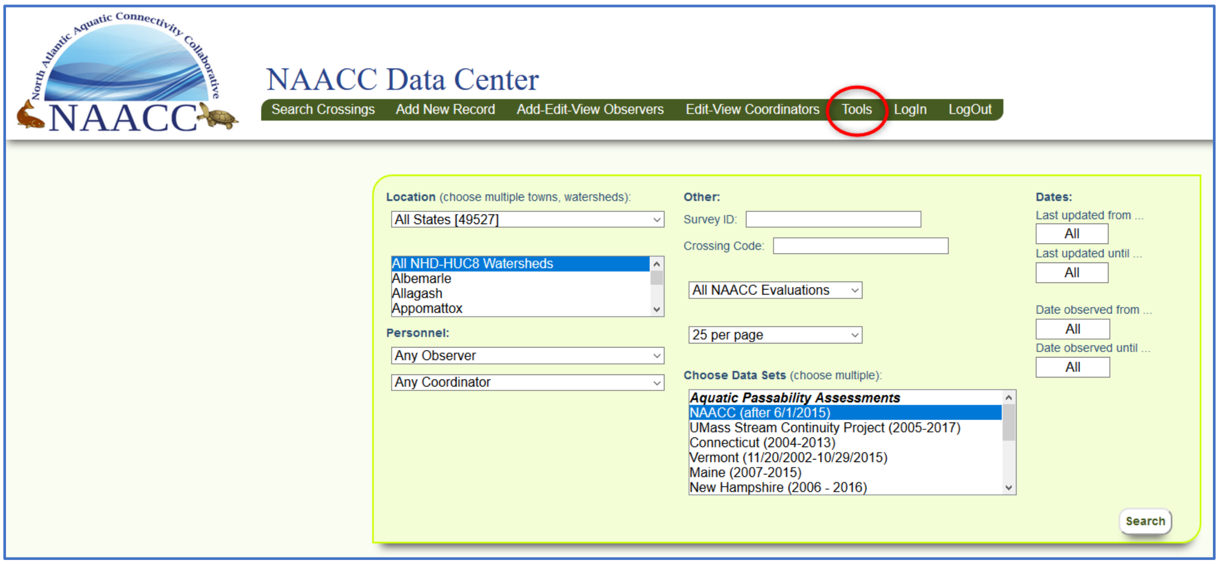
- Inlet perch at high tide
- Outlet perch at high tide
- Tide gate severity
- Other physical barrier severity

How to get NAACC certification for Tidal Streams Crossings Assessments

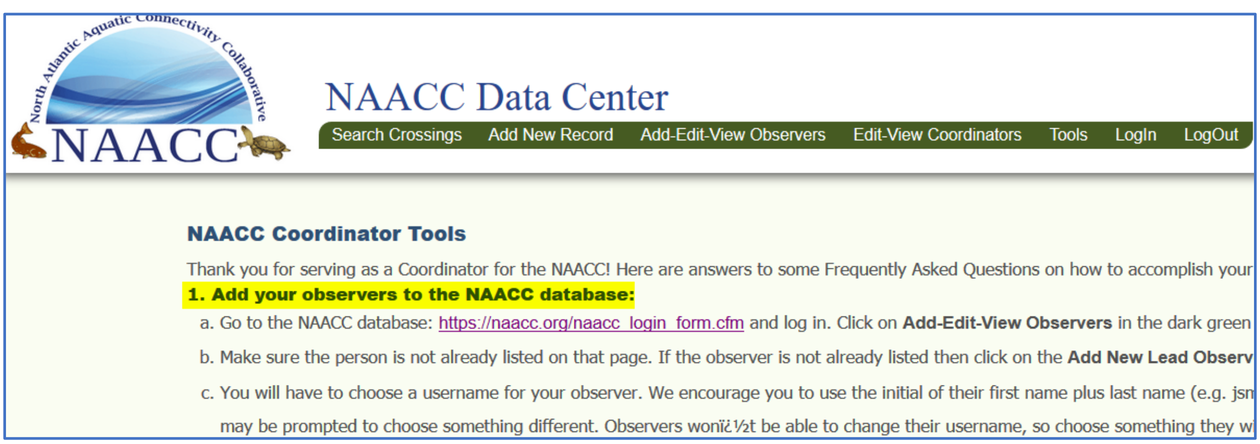
To get certified for tidal assessments, observers must first be certified in the Non-Tidal Streams Crossing Assessment Protocol. Then they must complete Tidal Aquatic Connectivity Protocol training (online or in-person) and pass the Tidal protocol quiz. Finally they must attend a Tidal Aquatic Connectivity Field Training workshop.

Here are the steps for coordinators:

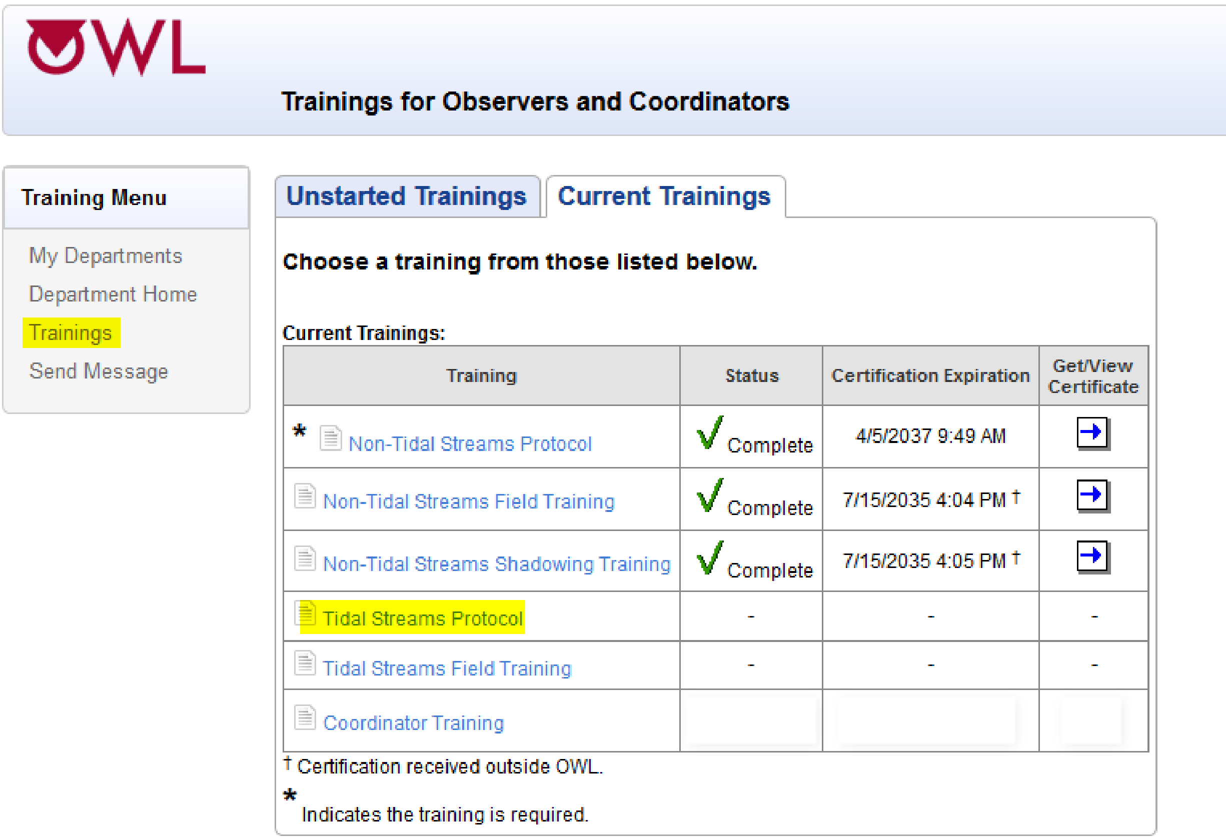
1) Log in to the database (naacc.org).
   Click on Tools in green navigation bar at top



2) Do step 1 to add new observers to the database and give them instructions on taking the non-tidal protocol.



3) Once Observers have completed the Non-Tidal training (protocol, field training, and shadowing requirement) they can proceed to take the Tidal protocol:



OWL

Trainings for Observers and Coordinators

Training Menu

- My Departments
- Department Home
- Trainings
- Send Message

Unstarted Trainings | Current Trainings

Choose a training from those listed below.

Current Trainings:

Training	Status	Certification Expiration	Get/View Certificate
* Non-Tidal Streams Protocol	Complete	4/5/2037 9:49 AM	
Non-Tidal Streams Field Training	Complete	7/15/2035 4:04 PM †	
Non-Tidal Streams Shadowing Training	Complete	7/15/2035 4:05 PM †	
Tidal Streams Protocol	-	-	-
Tidal Streams Field Training	-	-	-
Coordinator Training			

† Certification received outside OWL.

* Indicates the training is required.

4) When an observer has completed the Field Training, do step 2. No Shadowing is required for Tidal assessments, so fill out the form as soon as the observer has done the Field Training.

NAACC Data Center

Search Crossings | Add New Record | Add-Edit-View Observers | Edit-View Coordinators | Tools | LogIn | LogOut

NAACC Coordinator Tools

Thank you for serving as a Coordinator for the NAACC! Here are answers to some Frequently Asked Questions on how to accomplish your Coord

1. Add your observers to the NAACC database:

a. Go to the NAACC database: https://naacc.org/naacc_login_form.cfm and log in. Click on **Add-Edit-View Observers** in the dark green naviga

b. Make sure the person is not already listed on that page. If the observer is not already listed then click on the **Add New Lead Observer** link

c. You will have to choose a username for your observer. We encourage you to use the initial of their first name plus last name (e.g. jsmith) b may be prompted to choose something different. Observers woni¿½t be able to change their username, so choose something they will rem

d. Send instructions to your new observers: Send the observer this message (replacing xxxx with username):

"Welcome to the North Atlantic Aquatic Connectivity Collaborative (NAACC). You have been added to the new NAACC database and may sta

Please follow this link to access the Online Web Learning (OWL) platform and activate your account: http://owl.oit.umass.edu/partners/umas address and a code will be sent to that address. **Be sure to use the same email address that I used to send you this message.** When you have crea *Login Page*. There, use your username and your newly created password to log in to the site. Your username is: xxxxxxx. If you are unable

After you have logged in follow the instructions and click on Trainings. You will want to take the Protocol Training. There are 16 units to this to pass, and can be revisited for review as desired.

After you have activated your account you can log out and later return to the Training by using this link: http://owl.oit.umass.edu/partners/u

2. Observer Certification

When an observer has attended a Field Training and/or shadowed an experienced observer on 20 crossing assessments, submit the informa

https://docs.google.com/forms/d/1ZJl4gQCX4jTpxaBSUVU6CCsNgMM-Y9KWjxg0AY3p_lo/viewform

This informs UMass that the observer has fulfilled those certification requirements.

3. Elevation to Coordinator

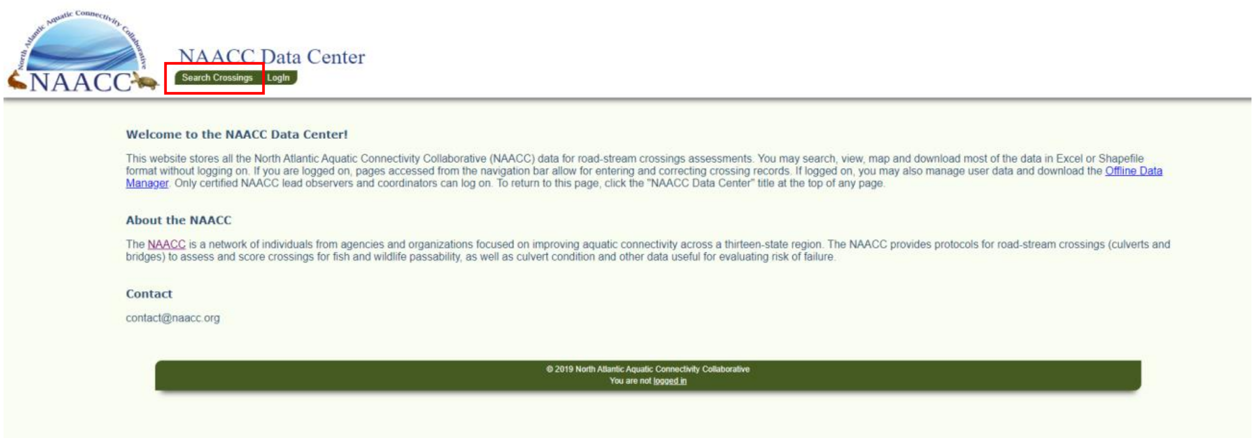
If you would like to elevate one of your "children" to L1 Coordinator status, make sure that he/she has passed the Coordinator Training and form . If you would like to be elevated to L2 Coordinator status please email contact@naacc.org.

When the Field Training form is filled out, the Central Coordinator at UMass documents the Training Requirement on the OWL site and the observer and her/his coordinator will receive an email that the observer is certified and can start logging in to the database and entering tidal survey data.

Access Town-specific Images and Data on Road-stream Crossings

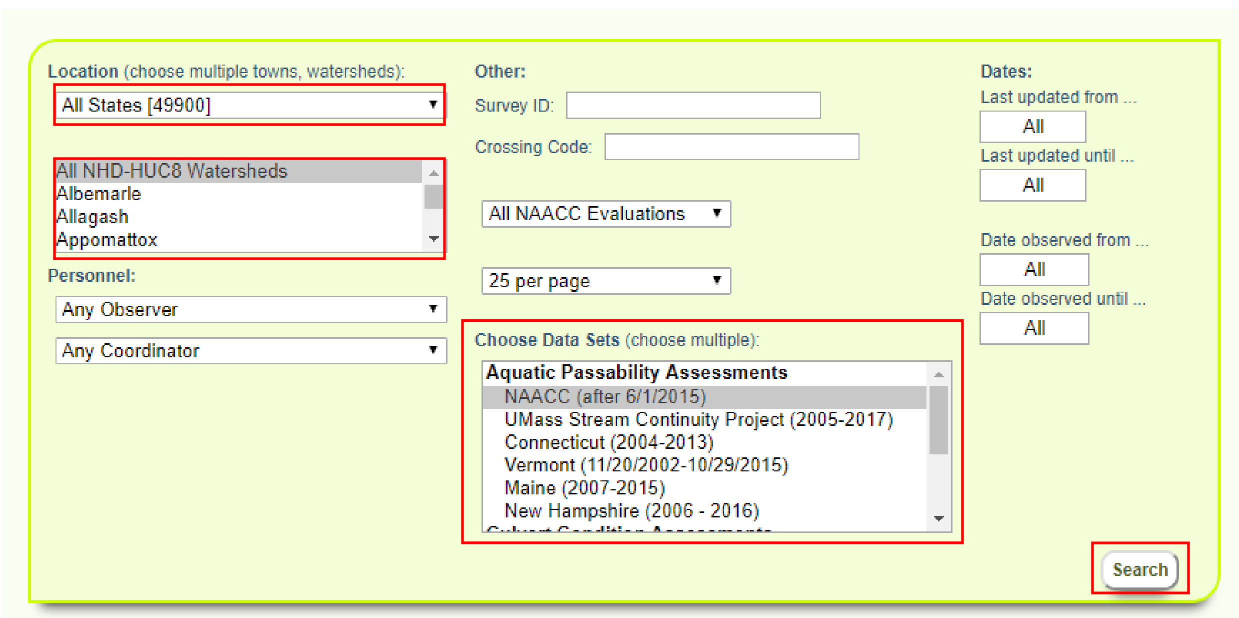
1. Go to https://naacc.org/naacc_data_center_home.cfm

2. Choose **Search Crossings**



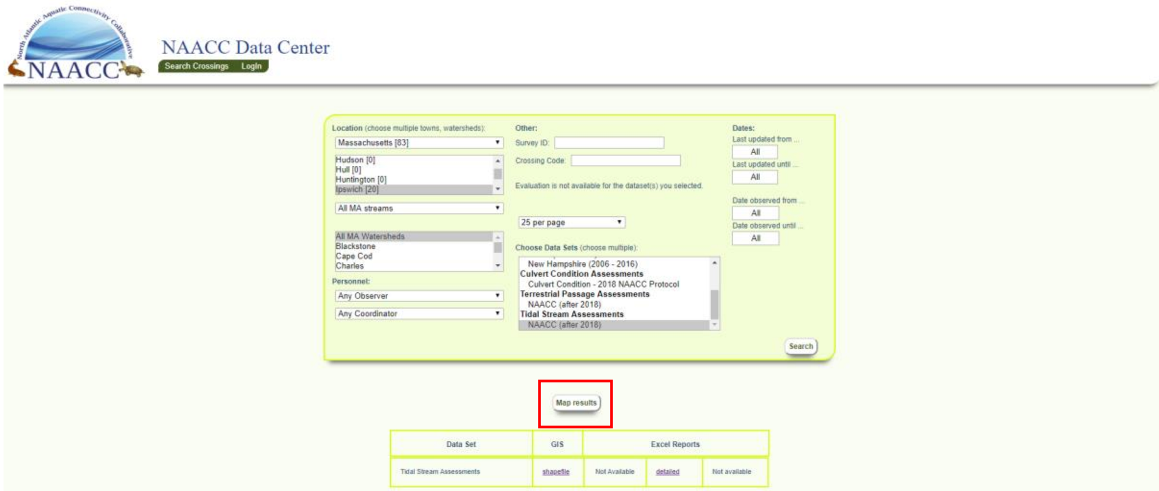
3. Select your State and Town.

4. Tidal Crossing Data: Under **Tidal Stream Assessments** select *NAACC (after 2018)*

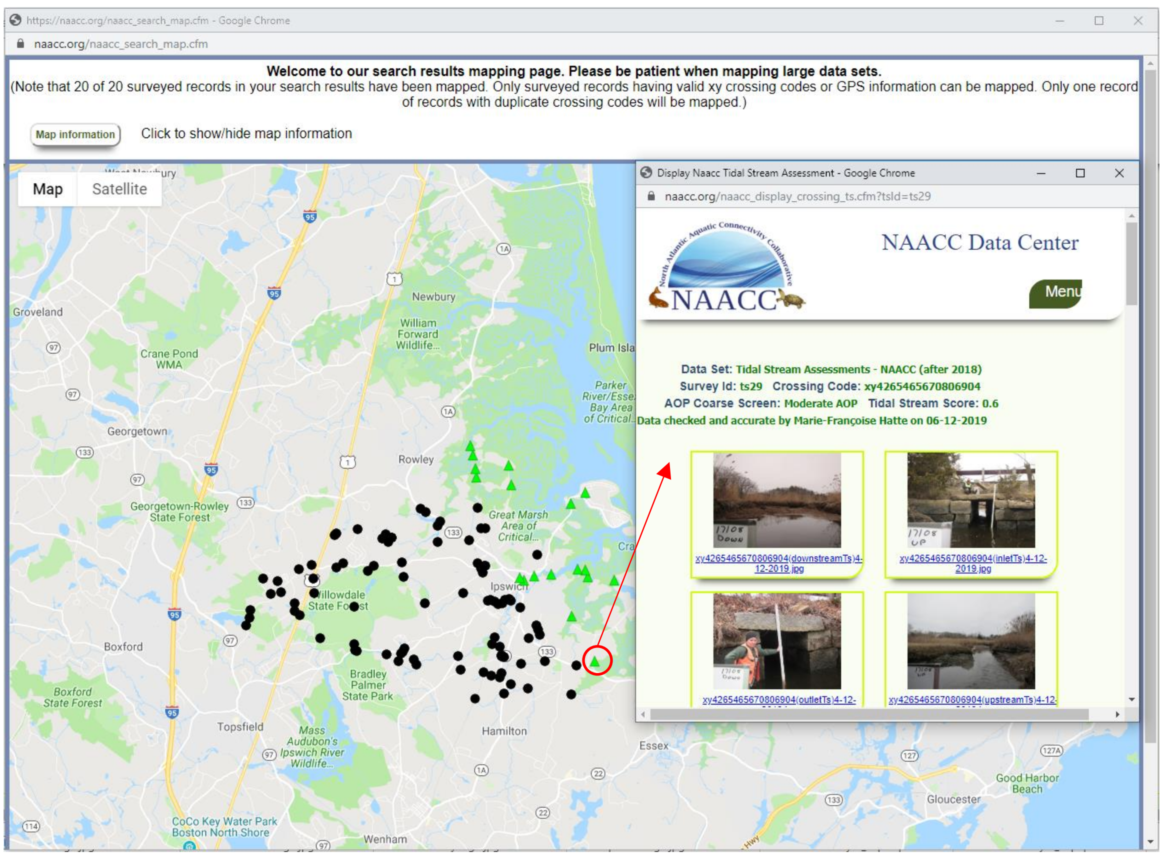


5. Click Search to retrieve data.

6. Choose **Map Results** to access a map of all crossing in selected region.



7. Click on a Green Triangle (Tidal Crossing Data) or a Colored Square/ Circle for Non-Tidal data, to access the **images** for that site.



8. Under **GIS** download a *Shapefile* to upload crossing data to your preferred mapping software.

9. Under **Excel Reports** download *Detailed* for an excel file with crossing data.