



2023

Sturbridge Culvert Assessments

(federal-aid eligible roads)

Written by: Zack Blais | Associate Transportation Planner | zblais@cmrpc.org



Disclaimer

Notice of Nondiscrimination Rights and Protections to Beneficiaries

Federal Title VI/Nondiscrimination Protections

The Central Massachusetts Metropolitan Planning Organization (CMMPO) hereby states its policy to operate its programs, services and activities in full compliance with federal nondiscrimination laws including Title VI of the Civil Rights Act of 1964 (Title VI), the Civil Rights Restoration Act of 1987, and related Federal and State statutes and regulations. Title VI prohibits discrimination in federally assisted programs and requires that no person in the United States of America shall, on the grounds of race, color, or national origin, including limited English proficiency, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving federal assistance.

Related federal nondiscrimination laws administered by the Federal Highway Administration, the Federal Transit Administration, or both prohibit discrimination on the basis of age, sex, and disability. These protected categories are contemplated within the CMMPO's Title VI programs consistent with federal and state interpretation and administration. Additionally, the CMMPO provides meaningful access to its programs, services, and activities to individuals with limited English proficiency, in compliance with us department of transportation policy and guidance on federal executive order 13166.

State Nondiscrimination Protections

The CMMPO also complies with the Massachusetts Public Accommodation Law, M.G.L. c272 §§ 92a, 98, 98a, prohibiting making any distinction, discrimination, or restriction in admission to or treatment in a place of public accommodation based on race, color, religious creed, national origin, sex, sexual orientation, disability or ancestry. Likewise, CMMPO complies with the Governor's Executive Order 526, Section 4, requiring all programs, activities and services provided, performed, licensed, chartered, funded, regulated, or contracted for by the state shall be conducted without unlawful discrimination based on race, color, age, gender, ethnicity, sexual orientation, gender identity or expression, religion, creed, ancestry, national origin, disability, veteran's status (including Vietnam-era veterans), or background.

Filing a Complaint

Individuals who feel they have been discriminated against in violation of Title VI or related federal nondiscrimination laws, must file a complaint within 180 days of the alleged discriminatory conduct to:

- *Ms. Janet Pierce, Executive Director*
- *Central Massachusetts Regional Planning Commission (CMRPC)*
- *1 Mercantile Street*
- *Suite 520*
- *Worcester, MA 01608*
- *(508) 756-7717*

To file a complaint alleging violation of the state's public accommodation law, contact the Massachusetts Commission Against Discrimination (MCAD) within 300 days of the alleged discriminatory conduct at:

- *Massachusetts Commission Against Discrimination (MCAD)*
- *One Ashburton Place, 6th floor*
- *Boston, MA 02109*
- *(617) 994-6000*
- *TTY: (617) 994-6196*

Translation

English: If this information is needed in another language, please contact the CMRPC/CMMPO Title VI Specialist at (508) 756-7717.

Spanish: Si necesita esta información en otro lenguaje, favor contactar al especialista de Título VI de CMRPC/CMMPO al (508) 756-7717.

French: Si vous avez besoin d'obtenir une copie de la présente dans une autre langue, veuillez contacter le spécialiste du Titre VI de CMRPC/CMMPO en composant le (508) 756-7717.

Portuguese: Caso esta informação seja necessária em outro idioma, favor contatar o Especialista em Título VI do CMRPC/CMMPO pelo fone (508) 756-7717.

Vietnamese: Nếu bạn cần thông tin bằng ngôn ngữ khác, xin vui lòng liên lạc với Tiêu đề VI Chuyên CMRPC/CMMPO tại (508) 756-7717.

Chinese: 如果用另一种语言需要的信息, 请联系第六章专门CMRPC/CMMPO (508) 756-7717。

Afrikaans: As jy inligting nodig het in 'n ander taal, kontak asseblief die Titel VI Spesialis CMRPC/CMMPO by (508) 756-7717.

ADA/ 504 Notice of Nondiscrimination

The CMMPO does not discriminate on the basis of disability in admission to its programs, services, or activities; in access to them; in treatment of individuals with disabilities; or in any aspect of their operations. The CMMPO also does not discriminate on the basis of disability in its hiring or employment practices.

This notice is provided as required by Title II of the American with Disabilities Act of 1990 (ADA) and Section 504 of the Rehabilitation Act of 1973. Questions, complaints, or requests for additional information regarding ADA and Section 504 may be forwarded to:

- Ms. Janet Pierce, Executive Director
- Central Massachusetts Regional Planning Commission
- 1 Mercantile Street, Suite 520
- Worcester, MA 01608
- (508) 756-7717

Table of Contents

1. Background	2
1.1. NAACC	2
1.2. Assessments	4
1.3. ArcGIS Online Dashboard	4
1.4. Grants and Future Repairs	4
2. Definitions	5
2.1. Culvert	5
2.2. Small Bridge	5
2.3. Bridge	5
2.4. CMRPC Culvert Assessments	5
3. Culvert Inventory and Results	7
3.1. Overview	7
3.2. Culvert Results	7
4. Moving Forward	13
4.1. Recommendations	13
4.2. Funding	13
4.3. Training Opportunities	15
Appendices	16
Appendix 1: NAACC Non-Tidal Aquatic Connectivity Stream Crossing Survey Field Form	17
Appendix 2: NAACC Non-Tidal Aquatic Connectivity Scoring System	23

List of Tables and Figures

Tables

Table 1: NAACC Roles, Responsibilities, and Training Requirements	3
Table 2: NAACC Culvert Aquatic Passability Scoring Categories	6
Table 3: Town of Sturbridge Assessment Results	8
Table 4: Culvert Prioritization List (by staff)	13
Table 5: Culvert Funding Opportunities	14

Figures

Figure 1: Town of Sturbridge Assessment Results by Barrier	7
Figure 2: Town of Sturbridge Culvert Assessments Map	12

1. Background

The Central Massachusetts Regional Planning Commission (CMRPC) began its Culvert Assessment Program in FFY 2021 as part of its Unified Planning Work Program (UPWP). As part of CMRPC's other data collection efforts, culvert assessments focus primarily on federal-aid eligible roads in the planning region. The purpose of this program is to help communities build resiliency through flood risk protection and mitigation by identifying culvert locations and prioritizing undersized culverts for replacement or restoration. This is especially important as the impacts from climate change and severe weather become increasingly frequent and many culverts are undersized relative to current stream flows. The [CMRPC Water Module](#) provides more detail regarding the threats of climate change and the impacts of vulnerable culverts on transportation infrastructure, emergency services, inland buildings, economic loss, and more.

To assess culverts staff have received training and guidance from the North Atlantic Aquatic Connectivity Collaborative (NAACC) – a network focused on the aquatic passability at road-stream crossings. See section 1.1 for more details.

The goal of the CMRPC culvert assessments and inventory for the Town of Sturbridge is to provide a detailed list, report, and interactive mapping platform to help town officials identify and plan for culvert replacement or repairs.

1.1. North Atlantic Aquatic Connectivity Collaborative (NAACC)

The NAACC began in 2015 with startup funding from the North Atlantic Landscape Conservation Cooperative (NALCC) and US Department of the Interior (DOI) Hurricane Sandy Mitigation funds. The funds were used by the University of Massachusetts Amherst to convene a group of partners to develop a unified protocol for assessing aquatic passability at road-stream crossings and develop a programmatic infrastructure to support crossing assessments. As part of its efforts, the NAACC has:

- Developed a unified protocol, data form, scoring system, and database for road-stream crossing assessments to identify bridges and culverts that are problematic from an aquatic connectivity perspective.
- Launched in-person and online training and certification program to ensure data quality.
- Created online database for crossing assessment data.
- Developed web-based tools.
- Encouraged and supported efforts to conduct crossing assessments throughout the region.

The NAACC has separate protocols for both non-tidal and tidal streams, and they partner with the Massachusetts Division of Ecological Restoration (DER) to provide training and advise the group.

To ensure data quality NAACC has set up a hierarchy of roles to maintain training, assessments, and data. It has broken these roles down into three main categories, as summarized in **Table 1** on the following page:

Table 1: NAACC Roles, Responsibilities, and Training Requirements

Roles	Responsibilities	Training Requirements
L3 (Level 3) Coordinator	<ul style="list-style-type: none"> • Update field protocols • Create/update scoring systems • Develop QA/QC procedures • Maintain the online database • Spread news/updates to NAACC community • Enter, edit, and remove data, and add/edit coordinators and observers 	n/a
L2 (Level 2) Coordinator	<ul style="list-style-type: none"> • Oversee surveys in their geographic area • Recruit and supervise L1 Coordinators • Coordinate training • Ensure implementation of QA/QC procedures • Enter and edit data, and add/edit observers 	<ul style="list-style-type: none"> • Certification as a Lead Observer • Online Coordinator training unit • Must pass online Coordinator training unit test
L1 (Level 1) Coordinator	<ul style="list-style-type: none"> • Recruit and supervise Lead Observers to assess road-stream crossings • Create maps and determine survey locations • Establish standards and expectations for safety • Ensure adherence to protocols and QA/QC procedures • Field audit 10% of a Lead Observer's first 50 records • Review and approve data entered into database • Enter and edit data, and add/edit observers 	<ul style="list-style-type: none"> • Certification as a Lead Observer • Online Coordinator training unit • Must pass online Coordinator training unit test
Lead Observer	<ul style="list-style-type: none"> • Lead survey teams • Coordinate survey materials and schedules • Collect field data • Match survey locations to xycodes • Ensure assessments are done safely • Enter data into online database 	<ul style="list-style-type: none"> • Classroom training either online or in-person (4 hours) • Must pass online test • In-person field training (1 day) • Shadow a certified Lead Observer (20 crossings)

Currently, CMRPC staff have one L1 Coordinator and a few Lead Observers to assess and enter data into the NAACC online database. CMRPC partners with appropriately trained individuals at NAACC to train interested people within our region each year. This is extremely helpful because there are so many culverts to assess in the CMRPC region. According to GIS data provided by the NAACC, there are over 5,000 culverts in the CMRPC region, and the large majority of these culverts have not been assessed using their protocols. As was mentioned, CMRPC staff only assess culverts along federal-aid eligible roads, which leaves many culverts unassessed. By having municipal staff members trained to be NAACC Lead Observers, this allows our communities to become a part of the process and work with us to assess all culverts in their community using NAACC protocols!

1.2. Assessments

Culvert assessments were conducted in 2022 and 2023. CMRPC staff visited all known locations along federal-aid eligible roads that were located in the NAACC GIS inventory to conduct an assessment of the culvert. Assessments included the verification of the culvert location, NAACC non-tidal field assessment, and associated photos of the inlet, outlet, upstream, and downstream (if possible). The data collected during these assessments can be found both in this report as well as in an ArcGIS Online Dashboard (see Section 1.3). Not included in the CMRPC culvert assessment efforts were:

- Inspection of bridges (these are regularly inspected by MassDOT)
- Inspection of the interior of the culverts
- Hydraulic analysis or structural analysis
- Inspection of culverts along Interstates or dangerous areas along state routes
- Inspection of culverts along non-federal aid eligible roadways

1.3. ArcGIS Online Dashboard

In addition to this report, which includes a table and a map, CMRPC has developed an interactive ArcGIS Online Dashboard using the data. The Dashboard includes a map, interactive filters to view individual barrier types or zoom to individual culvert locations, a search bar to search for streets and addresses, a basemap switcher, and the ability to zoom in and out on the map.

The Dashboard is available for public use and is a great resource for the town to map and identify assessed and non-assessed culverts.

[Click here to view the Dashboard.](#)

1.4. Grants and Future Repairs

The NAACC scoring system can be used to help identify culverts that may be in need of repairs or replacement. The barrier types can be used to determine which culverts should be prioritized relative to the others. Section 4 will review some recommendations for priority culverts based on these scores. In addition, culvert projects can be very costly and difficult for a town to afford. Section 4 will also review grant opportunities to help fund culvert repair and replacement projects. And finally, Section 4 will also outline resources that help provide technical assistance for culvert repair or replacement projects.

2. Definitions

2.1. Culvert

According to MassDOT, a culvert is a structure with a span of less than 10 feet in length that supports a roadway or other access way over a stream or waterbody.¹

There are about 210 culverts in the Town of Sturbridge.

2.2. Small Bridge

According to MassDOT, a small bridge is a structure with a span between 10 feet and 20 feet that supports a roadway or other access way over a water body or stream. These are categorized as "BRI" structures. According to MassDOT, the first complete inspection of the short span bridge inventory is in progress.¹

2.3. Bridge

According to MassDOT, a bridge is a structure with a span of 20 feet or greater. These are categorized as National Bridge Inventory (NBI) structures. MassDOT inspects NBI bridges on a bi-annual basis.¹

There are 39 bridges and small bridges in the Town of Sturbridge according to the MassDOT Bridge Inspection Management System (BIMS). 34 of these are bridge (NBI) structures and five (5) are small bridge (BRI) structures.²

The bridge structures that are located along the federal-aid eligible roadways were not assessed by CMRPC staff as MassDOT completes their own inspections on those structures.

2.4. CMRPC Culvert Assessments

CMRPC used the **NAACC Non-Tidal Aquatic Connectivity Stream Crossing Survey Data Form** (see **Appendix 1** for a copy of the form). to assess culvert structures in the Town of Sturbridge. CMRPC digitized the paper form into an ArcGIS Survey123 to improve field data collection and overall efficiency. In addition to images of the inlet, outlet, upstream, and downstream, data that is collected for an assessment includes:

- Crossing type
- Flow conditions
- Alignment
- Scour pool
- Structure material
- Outlet dimensions
- Inlet dimensions
- Length
- Internal Structures
- Substrate
- Physical barriers
- Water depth/velocity
- Dry passage/height above dry passage

¹ <https://www.mass.gov/doc/massachusetts-culverts-and-small-bridges-working-group-report/download>

² <https://geo-massdot.opendata.arcgis.com/maps/7008c8d283f64612b1267e2b36867fd3>

The completed assessment data for a culvert is then uploaded to the [NAACC Data Center](#) where it receives scoring for Aquatic Passability and Barrier Type (see **Appendix 2** to review the scoring system). CMRPC uses the numeric scoring system defined by the NAACC to record and map the condition of culverts. For mapping purposes, NAACC bases the following narrative descriptors for different ranges of aquatic passability in **Table 2** below.

Table 2: NAACC Culvert Aquatic Passability Scoring Categories

Aquatic Passability Score	Barrier Type
1.00	No Barrier
0.80 - 0.99	Insignificant Barrier
0.60 - 0.79	Minor Barrier
0.40 - 0.59	Moderate Barrier
0.20 - 0.39	Significant Barrier
0.00 - 0.19	Severe Barrier

It is important to note that the relationship between these categories and the actual passability for fish and other aquatic organisms is relatively unknown and is still a fruitful area for future research. The concept of aquatic passability is complicated and includes many variables that make it difficult to create a definitive scoring system. The best way to approach these aquatic passability scores and barrier types is that they represent the degree to which a crossing deviates from an ideal.

The NAACC Data Center includes an individual assessment report for each culvert, which has its images, data, and scoring results. See **Table 3** in Section 3.2 and search by crossing code to find a culvert on the NAACC Data Center.

3. Culvert Inventory and Results

3.1. Overview

As was previously mentioned, there are about 210 culverts in the Town of Sturbridge and 38 culverts and bridge structures along federal-aid eligible roads. None of these structures had been assessed using NAACC protocols before CMRPC staff began their assessments last year.

Staff completed culvert assessments along federal-aid eligible roads in the Town of Sturbridge. These included:

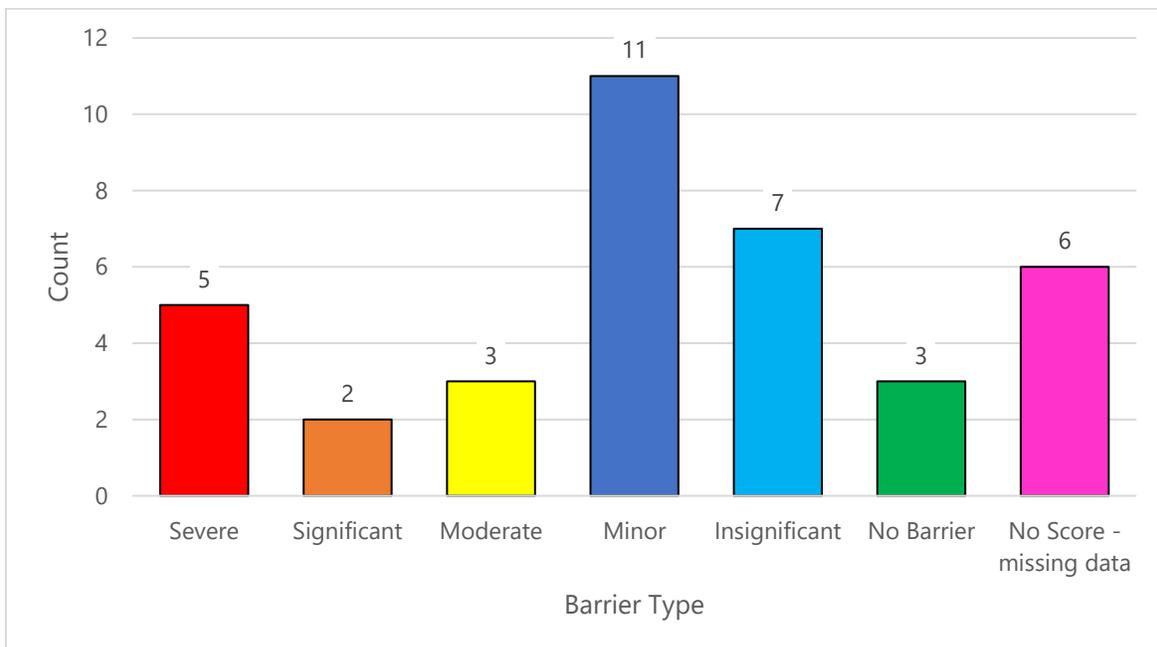
- Charlton Road (Route 20)
- Main Street (Route 20)
- Main Street (Route 131)
- Brookfield Road (Route 148)
- Podunk Pike (Route 49)
- Mashapaug Road
- Haynes Road
- Fiske Hill Road
- Hall Road
- Holland Road
- Warren Road
- New Boston Road

Staff do not consider Interstates as part of data collection efforts.

3.2. Culvert Results

In total, CMRPC staff assessed 37 locations along the federal-aid eligible roads mentioned in the previous Section 3.1. This also includes six (6) other culverts that staff were only able to partially assess because the inlet or outlet was inaccessible. These are scored as “no score – missing data” below. **Figure 1** below shows these assessed structures grouped by Barrier Type, as previously defined in Section 2.4.

Figure 1: Town of Sturbridge Assessment Results by Barrier



Below, **Table 3** summarizes the results for each assessment. The table includes the NAACC Crossing Code, Road Name, Aquatic Passability Score, Barrier Type, and if the culvert is within a flood zone (FEMA 100 year and 500 year). There were several locations on the NAACC GIS layer that did not have any culverts. Those locations are also noted in the table. The crossing code can be clicked to view the structure on the NAACC Data Center for a full report of the structure, including its images and assessment data.

Table 3: Town of Sturbridge Assessment Results

Crossing Code <i>click to view record on NAACC Data Center</i>	Road	Score	Barrier Type	Flood Zone	Notes
xy4209283572126964	Holland Road	0.03	Severe Barrier	No	
xy4208536672131757	Holland Road	0.08	Severe Barrier	No	
xy4211468272107400	Main Street (Route 20)	0.10	Severe Barrier	No	Buried Stream - could not find outlet
xy4216031072128935	Brookfield Road (Route 148)	0.19	Severe Barrier	No	
xy4207483772080367	Mashapaug Road	0.19	Severe Barrier	No	Inlet is in private property
xy4211252672128039	Main Street (Route 20)	0.27	Significant Barrier	Yes	
xy4213460772125277	Brookfield Road (Route 148)	0.27	Significant Barrier	Yes	Located on the dirt road just off of Brookfield Road
xy4211678272055196	Fiske Hill Road	0.43	Moderate Barrier	No	
xy4214804272131752	Warren Road	0.55	Moderate Barrier	Yes	
xy4216572472032790	Podunk Pike (Route 49)	0.60	Moderate Barrier	No	
xy4210169372122015	Holland Road	0.60	Minor Barrier	No	
xy4212709472121089	Brookfield Road (Route 148)	0.61	Minor Barrier	No	
xy4212030072060322	Charlton Road (Route 20)	0.64	Minor Barrier	No	
xy4212976072081152	New Boston Road	0.64	Minor Barrier	Yes	
xy4212809972048720	Charlton Road (Route 20)	0.68	Minor Barrier	No	

Sturbridge Culvert Assessments

Crossing Code <i>click to view record on NAACC Data Center</i>	Road	Score	Barrier Type	Flood Zone	Notes
xy4216081772070941	New Boston Road	0.68	Minor Barrier	No	
xy4211207572068941	Hall Road	0.70	Minor Barrier	Yes	
xy4211734872064411	Charlton Road (Route 20)	0.71	Minor Barrier	No	
xy4216041972128953	Brookfield Road (Route 148)	0.71	Minor Barrier	No	
xy4211301472100074	Main Street (Route 20)	0.75	Minor Barrier	Yes	Construction was recently completed on this structure.
xy4212394872054549	Fiske Hill Road	0.76	Minor Barrier	Yes	
xy4208466372133162	Holland Road	0.80	Insignificant Barrier	No	
xy4208786072062870	Main Street (Route 131)	0.83	Insignificant Barrier	No	
xy4210804072071370	Hall Road	0.83	Insignificant Barrier	Yes	
xy4214932672038094	Podunk Pike (Route 49)	0.84	Insignificant Barrier	Yes	
xy4207483372085059	Mashapaug Road	0.85	Insignificant Barrier	Yes	Short span bridge
xy4206955572097296	Mashapaug Road	0.87	Insignificant Barrier	No	Outlet side headwall starting to collapse.
xy4210563372076157	Main Street (Route 131)	0.92	Insignificant Barrier	Yes	Short Bridge
xy4210958672118520	Holland Road	1	No Barrier	Yes	Bridge - Bridge Adequate
xy4211142672091621	Main Street (Route 20)	1	No Barrier	Yes	Short Bridge - Bridge Adequate
xy4211191072134565	Main Street (Route 20)	1	No Barrier	Yes	Short Bridge - Bridge Adequate
xy4208572072057495	Main Street (Route 131)	1	No Barrier	-	No Crossing - there is no crossing at this location
xy4211152772091583	Main Street (Route 20)	1	No Barrier	-	No Crossing - this is a duplicate crossing code
xy4211406672117419	Holland Road	1	No Barrier	-	No Crossing - there is no crossing at this location

Sturbridge Culvert Assessments

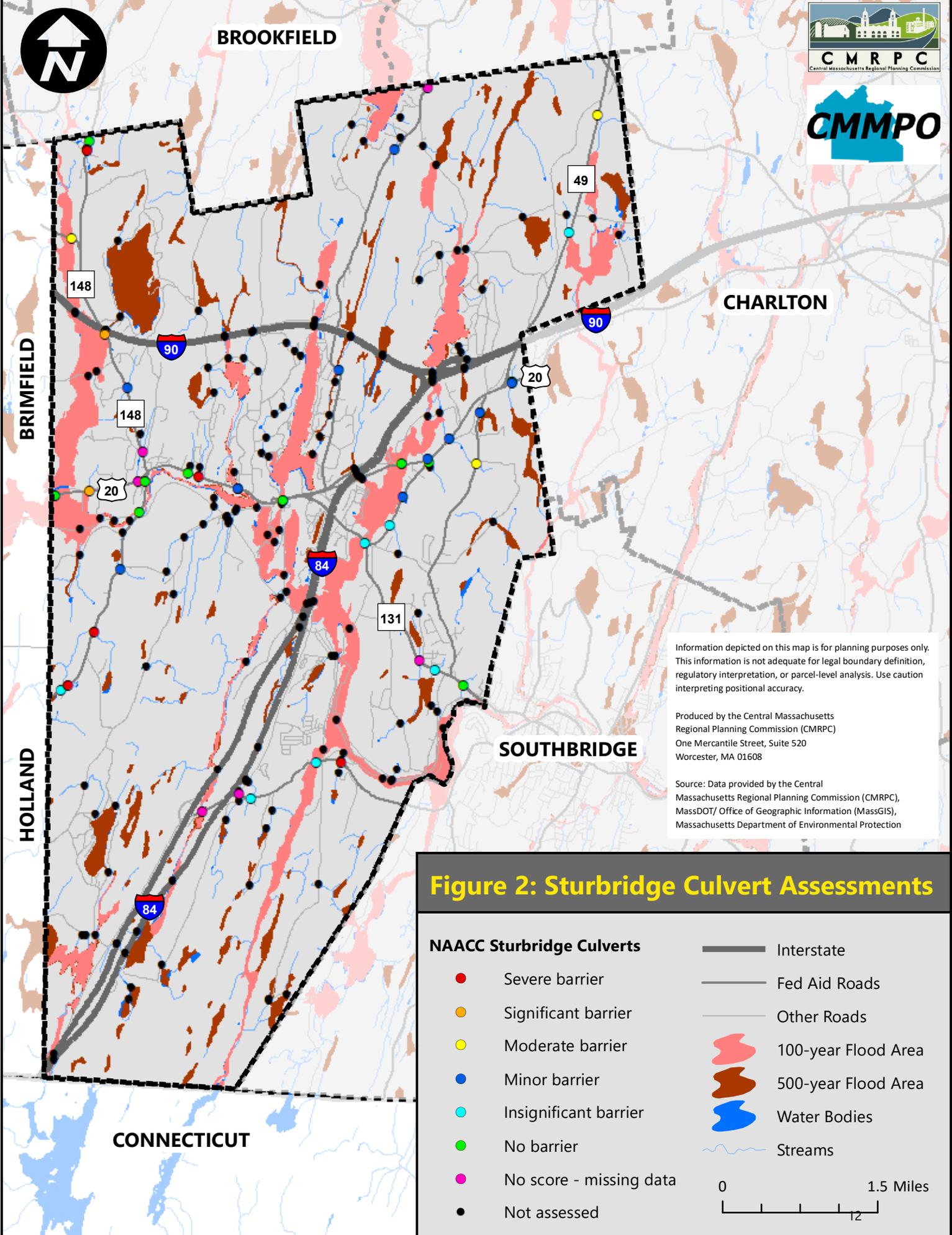
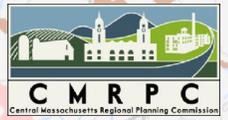
Crossing Code <i>click to view record on NAACC Data Center</i>	Road	Score	Barrier Type	Flood Zone	Notes
xy4211523572109387	Main Street (Route 20)	1	No Barrier	-	No Crossing - there is no crossing at this location
xy4211665772069281	Charlton Road (Route 20)	1	No Barrier	-	No Crossing - this is a duplicate crossing code
xy4211698372064239	Hall Road	1	No Barrier	-	No Crossing - this is a drainage pipe, not a culvert
xy4212825872048717	Charlton Road (Route 20)	1	No Barrier	-	No Crossing - this is a duplicate crossing code
xy4212833072048716	Charlton Road (Route 20)	1	No Barrier	-	No Crossing - this is a duplicate crossing code
xy4216047072128934	Brookfield Road (Route 148)	1	No Barrier	-	No Crossing - there is no crossing at this location
xy4216156772128521	Brookfield Road (Route 148)	1	No Barrier	-	No Crossing - there is no crossing at this location
xy4206766372106359	Haynes Road	-	No Score - Missing Data		Partially Inaccessible - Cannot locate outlet; culvert is near the Pilot Travel Center
xy4207025672099485	Mashapaug Road	-	No Score - Missing Data		Partially inaccessible - could not find outlet
xy4208914472065787	Main Street (Route 131)	-	No Score - Missing Data		Partially inaccessible - could not find inlet
xy4211405872118933	Main Street (Route 20)	-	No Score - Missing Data		Partially Inaccessible - Cannot locate outlet
xy4211807172118054	Brookfield Road (Route 148)	-	No Score - Missing Data		Partially inaccessible - Could not find outlet
xy4216953772064860	New Boston Road	-	No Score - Missing Data		Partially inaccessible - could not locate outlet

Following the culvert assessments there were five (5) severe barriers, two (2) significant barriers, three (3) moderate barriers, eleven (11) minor barriers, seven (7) insignificant barriers, and three (3) no barriers. The ten (10) locations that are highlighted orange on the table are not mapped since they were not found in the field, are duplicate crossing codes, or ended up being a drainage pipe instead of a culvert. As previously mentioned, there were also another six (6) locations that were no score – missing data because they were partially inaccessible and could not be fully assessed. There was one small bridge along Charlton Road (Route 20), xy4211655972069267, that was completely inaccessible for assessment because of water levels being too deep. The issues here were communicated with town staff, who are already aware of the structure and the issues it experiences. Finally, it is important to note that while the culvert on Mashapaug Road, xy4206955572097296, resulted in an insignificant barrier score, the outlet side of the culvert is starting to collapse and should receive more attention than its score represents. Please view the images for this culvert.

Figure 2 on the following page shows a map of the assessment results in the Town of Sturbridge.



BROOKFIELD



Information depicted on this map is for planning purposes only. This information is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analysis. Use caution interpreting positional accuracy.

Produced by the Central Massachusetts Regional Planning Commission (CMRPC) One Mercantile Street, Suite 520 Worcester, MA 01608

Source: Data provided by the Central Massachusetts Regional Planning Commission (CMRPC), MassDOT/ Office of Geographic Information (MassGIS), Massachusetts Department of Environmental Protection

Figure 2: Sturbridge Culvert Assessments

NAACC Sturbridge Culverts

- Severe barrier
- Significant barrier
- Moderate barrier
- Minor barrier
- Insignificant barrier
- No barrier
- No score - missing data
- Not assessed

- Interstate
- Fed Aid Roads
- Other Roads
- 100-year Flood Area
- 500-year Flood Area
- Water Bodies
- Streams



4. Moving Forward

4.1. Recommendations

After assessing the culvert structures, knowing when and which culverts to replace or repair is an important next step. While it is important to begin reviewing the culverts that received scores between severe and moderate barriers, it is equally as important to review every culvert because the NAACC scoring structure does not focus as much on aspects of culvert structure conditions (i.e., rusting, crushing, or structural integrity) and the scoring system relies on many variables. **Table 4** below lists several culverts that staff are recommending to prioritize for potential repair, replacement, and related flood prevention improvements (i.e., debris removal).

Table 4: Culvert Prioritization List (by staff)

Crossing Code <i>click to view record on NAACC Data Center</i>	Road	Barrier
xy4209283572126964	Holland Road	Severe Barrier
xy4208536672131757	Holland Road	Severe Barrier
xy4216031072128935	Brookfield Road (Route 148)	Severe Barrier
xy4207483772080367	Mashapaug Road	Severe Barrier
xy4211252672128039	Main Street (Route 20)	Significant Barrier
xy4211678272055196	Fiske Hill Road	Moderate Barrier
xy4212030072060322	Charlton Road (Route 20)	Minor Barrier
xy4212976072081152	New Boston Road	Minor Barrier
xy4216041972128953	Brookfield Road (Route 148)	Minor Barrier
xy4208466372133162	Holland Road	Insignificant Barrier
xy4206955572097296	Mashapaug Road	Insignificant Barrier

4.2. Funding

Funding for the repair and replacement of culvert and small bridge structures can be a substantial challenge for many municipalities. However, there are several federal and state funding programs that help support culvert repair or replacement projects. A popular program in Massachusetts that is included in the table below is the Massachusetts Culvert Replacement Municipal Assistance (CRMA) Grant Program. Staff highly suggest that the Town of Sturbridge staff consider this grant program when thinking of applying for culvert repair or replacement funding after reviewing these results. The CRMA Grant Program is administered by the Massachusetts Division of Ecological Restoration (DER) and awards projects that aim to repair or replace undersized, perched, and/or degraded culverts located in areas of high ecological value and improve flood resiliency. On the following page, **Table 5** summarizes relevant federal and state sources to fund culvert repair or replacement projects.

Table 5: Culvert Funding Opportunities

Funding Opportunity	About	Link
Culvert Replacement Municipal Assistance (CRMA) Grant	For communities in Massachusetts interested in replacing an undersized, perched, and/or degraded culvert located in an area of high ecological value. Funding encourages applicants to replace aging culverts with better designed crossings that meet improved structural and environmental design standards and flood resiliency criteria. Projects are required to meet the goals of the Massachusetts Stream Crossing Standards.	https://www.mass.gov/how-to/culvert-replacement-municipal-assistance-grant-program
Municipal Vulnerability Preparedness (MVP) Grant Program	The MVP grant program provides support for communities in Massachusetts to identify climate hazards, assess vulnerabilities, and develop action plans to improve resilience to climate change. Communities that complete the MVP process are eligible for MVP Action Grant funding to implement priority actions identified through the MVP planning process.	https://resilientma.mass.gov/mvp/
Municipal Small Bridge Program	For communities in Massachusetts for the replacement, preservation, and rehabilitation of eligible bridges. Bridges must be on local public ways and must be on the State Bridge Inventory with a span between 10-20 feet.	https://www.mass.gov/municipal-small-bridge-program
National Culvert Removal, Replacement, and Restoration Grant Program	Awards grants to eligible entities (tribes, states, and local government) for projects for the replacement, removal, and repair of culverts or weirs that meaningfully improve or restore fish passage for anadromous fish species.	https://www.fhwa.dot.gov/engineering/hydraulics/culverthyd/aquatic/culvertaop.cfm
CMMPO Transportation Improvement Program (TIP)	The TIP is a planning document that lists all highway, bridge, transit, and intermodal projects in Central Massachusetts that are programmed to receive federal-aid funding. Projects that improve air quality and safety, projects of regional and statewide significance, and non-federal aid projects fully funded by the state are included in the TIP. Use MassDOT MaPIT to initiate new projects to be considered for the TIP.	https://www.mass.gov/info-details/massdot-highway-initiating-a-project

Funding Opportunity	About	Link
Building Resilient Infrastructure and Communities (BRIC)	FEMA/MEMA annual grant program to implement hazard mitigation projects that reduce risks from disasters and natural hazards. There is an added focus on infrastructure projects benefiting disadvantaged communities, nature based solutions, and climate resilience and adaptation. The funds are administered through MEMA. Culverts are eligible for this grant.	https://www.mass.gov/service-details/building-resilient-infrastructure-and-communities-bric-flood-mitigation-assistance-fma-grant-programs
Flood Mitigation Assistance (FMA) Program	FEMA/MEMA annual grant program to reduce or eliminate long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the National Flood Insurance Program (NFIP).	https://www.mass.gov/service-details/building-resilient-infrastructure-and-communities-bric-flood-mitigation-assistance-fma-grant-programs
Hazard Mitigation Grant Program (HMGP)	Massachusetts provides funding to projects that reduce loss of life, protect natural resources, property, infrastructure, public health, and the economy from natural hazards and climate change impacts through hazard mitigation and climate adaptation projects. Provides funding after a disaster to help reduce or eliminate risk to lives and property from natural hazards. Among the eligible projects includes drainage and culvert improvements. Funding is available to all communities.	https://www.mass.gov/service-details/building-resilient-infrastructure-and-communities-bric-flood-mitigation-assistance-fma-grant-programs

4.3 Training Opportunities

There are about 177 culvert locations throughout the Town of Sturbridge that are not along federal-aid eligible roads and were not assessed by staff. There is still a lot of work to be done and there is opportunities for town officials to complete NAACC Lead Observer training to assess local culverts throughout town, as well as keep up with the culverts that have already been assessed.

If you are interested and would like to complete NAACC Lead Observer training please contact Zack Blais, Transportation Associate Planner, at zblais@cmrpc.org.

Appendices

Appendix 1

This appendix includes the NAACC Non-Tidal Aquatic Connectivity Stream Crossing Survey Field Form that is used by CMRPC staff to conduct the culvert assessments. An individual must be certified as a NAACC Lead Observer in order to fill out this form, plug the information into the NAACC Data Center, and receive a score for the crossing (i.e., barrier type).



AQUATIC CONNECTIVITY 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) _____ Lead Observer _____

Town/County _____ Stream _____

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** _____

Photo IDs INLET _____ OUTLET _____ UPSTREAM _____ DOWNSTREAM _____ OTHER _____

Flow Condition NO FLOW TYPICAL-LOW MODERATE HIGH **Crossing Condition** OK POOR NEW UNKNOWN

Tidal Site YES NO UNKNOWN **Alignment** FLOW-ALIGNED SKEWED (>45°) **Road Fill Height** (Top of culvert to road surface; bridge = 0) _____

Bankfull Width (Optional) _____ **Confidence** HIGH LOW/ESTIMATED **Constriction** SEVERE MODERATE SPANS ONLY BANKFULL/ ACTIVE CHANNEL

Tailwater Scour Pool NONE SMALL LARGE SPANS FULL CHANNEL & BANKS

Crossing Comments

STRUCTURE 1

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED **Outlet Armoring** NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

Outlet Drop to Water Surface _____ **Outlet Drop to Stream Bottom** _____ **E. Abutment Height** (Type 7 bridges only) _____

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

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

ADDITIONAL CONDITIONS

Slope % (Optional) _____ **Slope Confidence** HIGH LOW **Internal Structures** NONE BAFFLES/WEIRS SUPPORTS OTHER _____

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

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

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

Dry Passage through Structure? YES NO UNKNOWN **Height above Dry Passage** _____

Comments

STRUCTURE 2

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED Outlet Armoring NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

Outlet Drop to Water Surface _____ Outlet Drop to Stream Bottom _____ E. Abutment Height (Type 7 bridges only) _____

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

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

ADDITIONAL CONDITIONS

Slope % (Optional) _____ Slope Confidence HIGH LOW Internal Structures NONE BAFFLES/WEIRS SUPPORTS OTHER _____

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

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

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

Dry Passage through Structure? YES NO UNKNOWN Height above Dry Passage _____

Comments

STRUCTURE 3

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED Outlet Armoring NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

Outlet Drop to Water Surface _____ Outlet Drop to Stream Bottom _____ E. Abutment Height (Type 7 bridges only) _____

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

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

ADDITIONAL CONDITIONS

Slope % (Optional) _____ Slope Confidence HIGH LOW Internal Structures NONE BAFFLES/WEIRS SUPPORTS OTHER _____

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

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

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

Dry Passage through Structure? YES NO UNKNOWN Height above Dry Passage _____

Comments

STRUCTURE 4

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED Outlet Armoring NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

Outlet Drop to Water Surface _____ Outlet Drop to Stream Bottom _____ E. Abutment Height (Type 7 bridges only) _____

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

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

ADDITIONAL CONDITIONS

Slope % (Optional) _____ Slope Confidence HIGH LOW Internal Structures NONE BAFFLES/WEIRS SUPPORTS OTHER _____

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

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

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

Dry Passage through Structure? YES NO UNKNOWN Height above Dry Passage _____

Comments

STRUCTURE 5

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED Outlet Armoring NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

Outlet Drop to Water Surface _____ Outlet Drop to Stream Bottom _____ E. Abutment Height (Type 7 bridges only) _____

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

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

ADDITIONAL CONDITIONS

Slope % (Optional) _____ Slope Confidence HIGH LOW Internal Structures NONE BAFFLES/WEIRS SUPPORTS OTHER _____

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

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

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

Dry Passage through Structure? YES NO UNKNOWN Height above Dry Passage _____

Comments

STRUCTURE 6

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED Outlet Armoring NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

Outlet Drop to Water Surface _____ Outlet Drop to Stream Bottom _____ E. Abutment Height (Type 7 bridges only) _____

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

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

ADDITIONAL CONDITIONS

Slope % (Optional) _____ Slope Confidence HIGH LOW Internal Structures NONE BAFFLES/WEIRS SUPPORTS OTHER _____

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

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

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

Dry Passage through Structure? YES NO UNKNOWN Height above Dry Passage _____

Comments

STRUCTURE 7

Structure Material METAL CONCRETE PLASTIC WOOD ROCK/STONE FIBERGLASS COMBINATION

OUTLET

Outlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED Outlet Armoring NONE NOT EXTENSIVE EXTENSIVE

Outlet Grade (Pick one) AT STREAM GRADE FREE FALL CASCADE FREE FALL ONTO CASCADE CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Outlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

Outlet Drop to Water Surface _____ Outlet Drop to Stream Bottom _____ E. Abutment Height (Type 7 bridges only) _____

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

INLET

Inlet Shape 1 2 3 4 5 6 7 FORD UNKNOWN REMOVED

Inlet Type PROJECTING HEADWALL WINGWALLS HEADWALL & WINGWALLS MITERED TO SLOPE OTHER NONE

Inlet Grade (Pick one) AT STREAM GRADE INLET DROP PERCHED CLOGGED/COLLAPSED/SUBMERGED UNKNOWN

Inlet Dimensions A. Width _____ B. Height _____ C. Substrate/Water Width _____ D. Water Depth _____

ADDITIONAL CONDITIONS

Slope % (Optional) _____ Slope Confidence HIGH LOW Internal Structures NONE BAFFLES/WEIRS SUPPORTS OTHER _____

Structure Substrate Matches Stream NONE COMPARABLE CONTRASTING NOT APPROPRIATE UNKNOWN

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

Structure Substrate Coverage NONE 25% 50% 75% 100% UNKNOWN

Physical Barriers (Pick all that apply) NONE DEBRIS/SEDIMENT/ROCK DEFORMATION FREE FALL FENCING DRY OTHER

Severity (Choose carefully based on barrier type(s) above) NONE MINOR MODERATE SEVERE

Water Depth Matches Stream YES NO-SHALLOWER NO-DEEPER UNKNOWN DRY

Water Velocity Matches Stream YES NO-FASTER NO-SLOWER UNKNOWN DRY

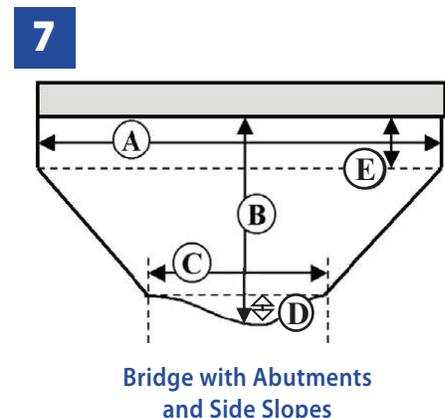
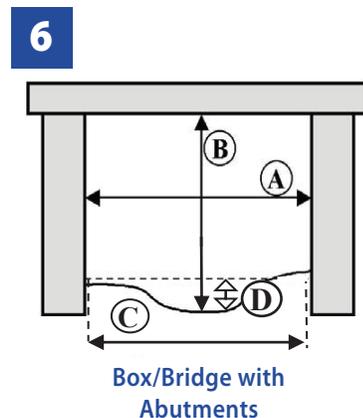
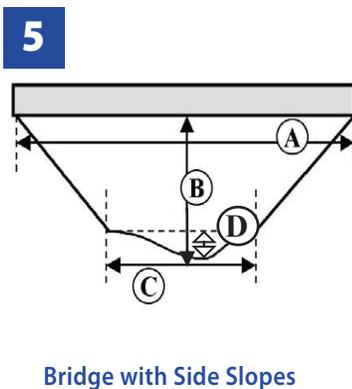
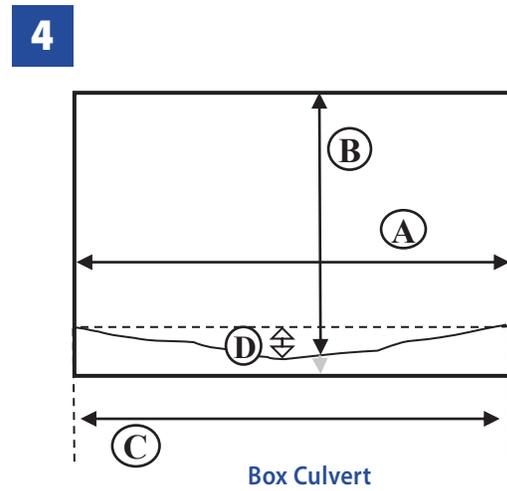
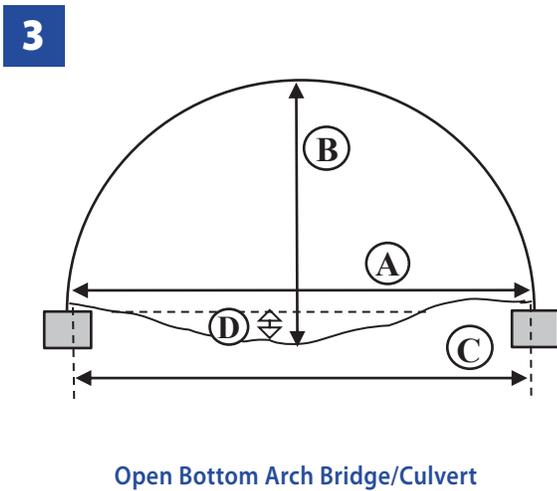
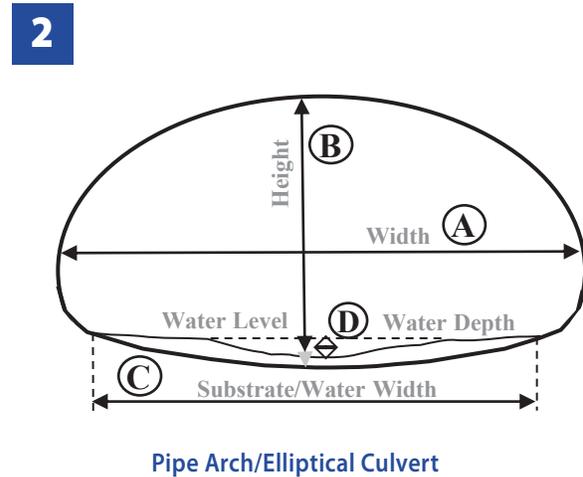
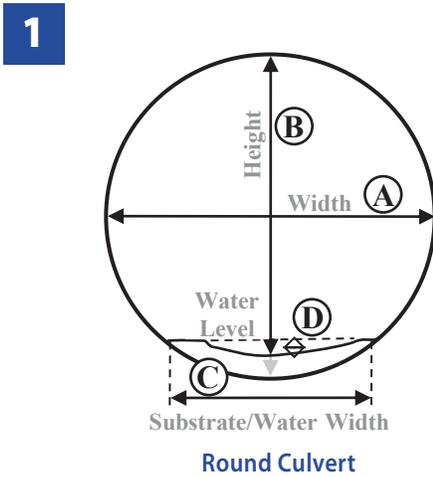
Dry Passage through Structure? YES NO UNKNOWN Height above Dry Passage _____

Comments

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 appropriate 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).



Appendix 2

This appendix includes the NAACC document that explains the scoring system involved in evaluating aquatic passability at road-stream crossings. This scoring system was adopted by the NAACC Steering Committee in November 2015.

Scoring Road-Stream Crossings as Part of the North Atlantic Aquatic Connectivity Collaborative (NAACC)

Adopted by the NAACC Steering Committee
November 10, 2015

INTRODUCTION

The North Atlantic Aquatic Connectivity Collaborative (NAACC) was launched in 2015 with a rapid assessment protocol for evaluating aquatic passability at road-stream crossings and an online database (<https://www.streamcontinuity.org/cdb2>) for storing and scoring data collected using this protocol. Two scoring systems are proposed to evaluate aquatic passability at road-stream crossings. The first is a coarse screen for use in classifying crossings into one of three categories: “Full AOP” (Aquatic Organism Passage), “Partial AOP,” and “No AOP.” The second system is an algorithm for computing an aquatic passability score, ranging from 0 (low) to 1 (high), for each road-stream crossing. These two scoring systems are not particular to any taxonomic or functional group but instead seek to evaluate passability for the full range of aquatic organisms likely to be found in rivers and streams.

NAACC COARSE SCREEN

Table 1 below identifies characteristics and conditions that allow crossings to be classified as providing “Full AOP,” “Reduced AOP,” or “No AOP.”

Table 1. NAACC Coarse Screen

Metric	Flow Condition	Crossing Classification		
		Full AOP	Reduced AOP	No AOP
		<i>If all are true</i>	<i>If any are true</i>	<i>If any are true</i>
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

The primary objective of the coarse screen is to identify those crossings that are likely to be a barrier to most or all species and those that are likely to provide something close to full aquatic organism passage. If it is necessary to get a better feel for how bad those crossing are that are labeled as “reduced AOP” one can use the numeric scoring system.

NAACC NUMERIC SCORING SYSTEM

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 three steps: (1) generating a component score for each predictor variable, (2) combining these predictions with a weighted average to generate a composite score for the crossing, and (3) assigning a final score based on the minimum of the composite score or the component score for the *outlet drop* variable.

Variables Used

Crossing assessments are generally done during “typical low-flow conditions.” Some variables are important for assessing conditions at the time of the survey; others provide indirect evidence of likely conditions at higher flows.

Inlet Grade: The position of the structure invert relative to the stream bottom at the inlet.

Outlet Drop: Outlet drop is based on the variable *Outlet Drop to Water Surface* unless the value for *Water Depth Matches Stream* = “Dry” in which case outlet drop is based on the variable *Outlet Drop to Stream Bottom*.

Physical Barriers: This variable covers a wide variety of circumstances ranging from obstructions to dewatered culverts or bridge cells that represent physical barriers to aquatic organism passage.

Constriction: The relative width of the crossing compared to the width of the stream. “Severe” = <50%, “Moderate” = 50-100%; other options include “Spans Only Bankfull/Active Channel” and “Spans Full Channel & Banks.” *Constriction* is an indirect indicator of potential velocity issues at higher flows.

Water Depth: Water depth in the structure relative to water depths found in the natural channel at the time of survey.

Water Velocity: Water velocity in the structure relative to water velocities found in the natural channel at the time of survey.

Scour Pool: Presence/absence of a scour pool at the crossing outlet and size relative to the natural stream channel. *Scour Pool* is an indirect indicator of potential velocity issues at higher flows. *Scour pool* is included solely as an indicator of velocities at higher flows. It is not based on the effects of the pool itself which can actually be positive for fish passage.

Substrate Matches Stream: An assessment of whether the substrate in the structure matches the substrate in the natural stream channel. *Substrate Matches Stream* is used to evaluate how a discontinuity in substrate might inhibit passage for species that either use substrate as the medium for travel (e.g., mussels) or require certain types of substrate for cover during movements (e.g., crayfish, salamanders, juvenile fish).

Substrate Coverage: Degree to which a crossing structure is covered by substrate. *Substrate Coverage* is directly related to passability for some aquatic species that require substrate or that tend to avoid areas that lack cover. It is also an important element of roughness that can create areas of low-velocity water (boundary layers) utilized by weak-swimming organisms. *Substrate Coverage* is also an indirect indicator of potential velocity issues at higher flows.

Openness: Cross-sectional area of the structure opening divided by the structure length (distance between inlet and outlet) measured in feet. *Openness* is calculated for both the inlet and outlet and the lower value is assigned to the structure. If there are multiple structures at a crossing the value for the structure with the highest *Openness* is assigned to the crossing as a whole. Turtles are believed to be affected by the *Openness* of a crossing structure; other species may be affected as well.

Height: Maximum height of the crossing structure. This variable is parameterized so that it only comes into play for very small structures.

Outlet Armoring: Presence/absence of streambed armoring (e.g., riprap, asphalt, concrete) at the outlet and the relative amount of armoring. Armoring is considered “extensive” if the length (upstream to downstream) of the streambed that is armored is greater or equal to half the bankfull width of the natural stream channel. *Outlet Armoring* is an indirect indicator of potential velocity issues at higher flows.

Internal Structures: Presence/absence of structures inside a culvert or bridge (e.g. weirs, baffles, supports). The *Internal Structures* variable is used in the scoring algorithm as it relates to the potential for creating turbulence within a crossing structure. To the extent that *Internal Structures* physically block the movement of aquatic organisms it is covered by the *Physical Barriers* variable.

Step 1: Component Scores

The component scores are not meant to equate to passability. In each case the component score is intended to cover the full range of problems (assessable by our protocol) associated with that variable: from 0 (worst case) to 1 (best case). For *inlet grade*, having an inlet drop or perched inlet is the worst case among the options, thus they score "0." This is not meant to say that all structures with inlet drops are impassible. The effect of *inlet grade* on passability scores is controlled by the weight it is given in computing the composite score (see Step 2 below).

Scoring categorical predictors is simply a matter of assigning a score for each possible category. Table 2 lists all of the categorical predictors and the scores associated with each category.

Scoring continuous predictors requires a function to convert the predictor to a score. There are three continuous predictors and three associated functions. The functional forms used were chosen because they have shapes desired by the expert team or because they fit the series of points specified by the expert team. Appendix A includes the r code defining each of these functions (“x” is the measured value for each variable).

The scoring equation for *Openness* is:

$$(1) s_o = a(1 - e^{-kx(1-d)})^{1/(1-d)}$$

Where S_o is the score for openness, $a=1$, $k=15$, and $d = 0.62$ when openness is recorded in feet.

The equation for Height is:

$$(2) s_h = \min\left(\frac{ax^2}{b^2 + x^2}, 1\right)$$

Where S_h is the component score for height, $a = 1.1$, and $b=2.2$ when height is recorded in feet.

The equation for Outlet Drop is:

$$(3) s_{od} = 1 - \frac{ax^2}{b^2 + x^2}$$

Where S_{od} is the Outlet Drop component score, $a=1.029412$, and $b=0.51449575$ when outlet drop is recorded in feet.

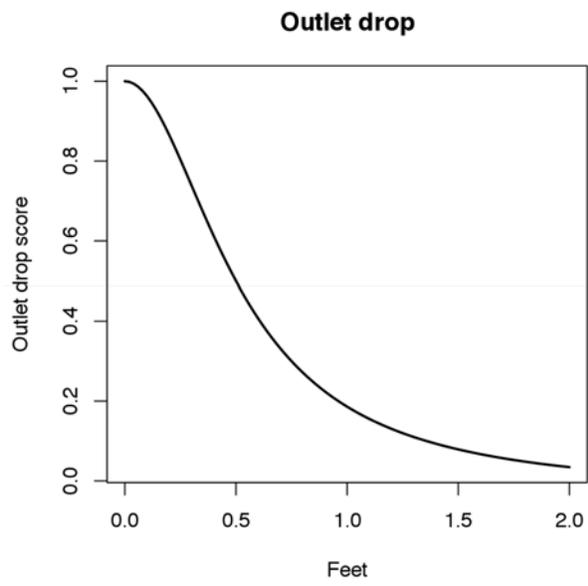
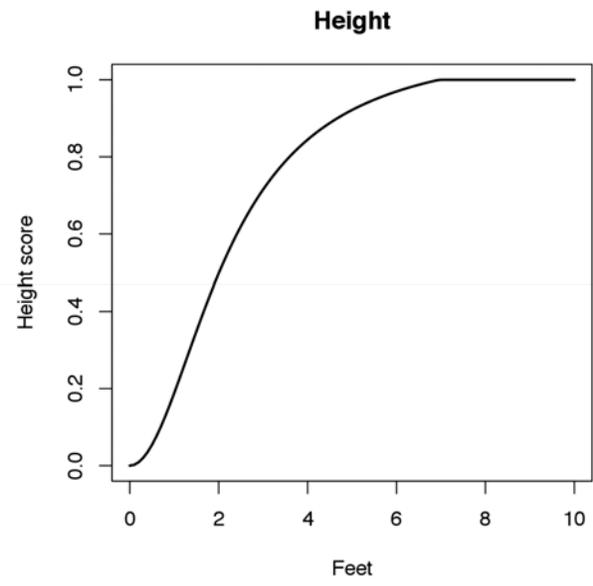
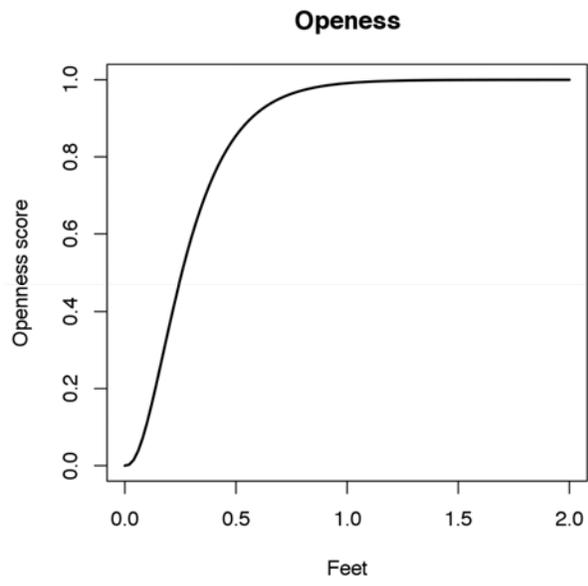


Figure 1. Continuous predictor variables

Table 2. Component scores for categorical variables used in calculating the crossing score

parameter	level	score
Constriction	severe	0
Constriction	moderate	0.5
Constriction	spans only bankfull/active channel	0.9
Constriction	spans full channel and banks	1
Inlet grade	at stream grade	1
Inlet grade	inlet drop	0
Inlet grade	perched	0
Inlet grade	clogged/collapsed/submerged	1
Inlet grade	unknown	1
Internal structures	none	1
Internal structures	baffles/weirs	0
Internal structures	supports	0.8
Internal structures	other	1
Outlet armoring	extensive	0
Outlet armoring	not extensive	0.5
Outlet armoring	none	1
Physical barriers	none	1
Physical barriers	minor	0.8
Physical barriers	moderate	0.5
Physical barriers	severe	0
Scour pool	large	0
Scour pool	small	0.8
Scour pool	none	1
Substrate coverage	none	0
Substrate coverage	25%	0.3
Substrate coverage	50%	0.5
Substrate coverage	75%	0.7
Substrate coverage	100%	1
Substrate matches stream	none	0
Substrate matches stream	not appropriate	0.25
Substrate matches stream	contrasting	0.75
Substrate matches stream	comparable	1
Water depth	no (significantly deeper)	0.5
Water depth	no (significantly shallower)	0
Water depth	yes (comparable)	1
Water depth	dry (stream also dry)	1
Water velocity	no (significantly faster)	0
Water velocity	no (significantly slower)	0.5
Water velocity	yes (comparable)	1
Water velocity	dry (stream also dry)	1

Some notes about the component scores

1. The option "clogged/collapsed/submerged" for *inlet grade* is an option surveyors use to indicate that it was not possible to measure the structure's dimensions. If the inlet is clogged or collapsed enough to affect passability it will be covered under *physical barriers*. This is why it receives a "1" instead of a "0", because problems associated with this option are covered by the *physical barriers* variable.
2. The rationale for giving a component score of "1" to "unknown" for *inlet grade* is similar to that for "clogged/collapsed/submerged." It is hard to know how to interpret "unknown." However, if conditions at the inlet are creating a physical barrier to passage it will be covered under *physical barriers*.
3. We included *inlet grade* as a variable in addition to *physical barriers* because inlet drops create both velocity and physical barrier (jump barrier) issues. The physical barrier issues are covered by the *physical barriers* variable. The *inlet grade* variable captures the velocity issues at the inlet. Perched inlets can create depth issues at low flows (if water can't get into the structure inlet). These may not be apparent at the time of the survey. Thus, the presence of a perched inlet is a concern even if it doesn't represent a physical barrier ("dry") at the time when the survey is conducted.
4. The variable *internal structures* is included to account for turbulence issues. There is likely to be turbulence associated with weirs and baffles when these are included inside crossing structures. If they also create physical barriers they will be covered by the *physical barriers* variable. They are often included in structures to help aquatic organism passage but they sometimes do more harm than good and may be good for some species while creating problems for others. The inclusion of well-designed weirs or baffles is likely to improve the component scores for water depth and water velocity. They get docked a little in our scoring system for introducing turbulence.
5. It is difficult to know how to score the "other" option under *internal structures* because it is difficult to know what, if any, impact these other structures will have on turbulence. If, however, they represent a physical barrier they will be covered under the *physical barriers* variable.

Step 2: Weighted Composite Scores

An expert team of nine people provided input on how the variables should be weighted based on best professional judgement. The weights used with the component scores are listed in table 3. The weights are simply the means of the nine weights for each variable provided by the experts. We display the weights out to three decimal places not to suggest that we know the weights to this level of precision but to reduce overall error in the model by not introducing an additional source of error (rounding error). The composite score is the sum of the products of each component score and its weight.

Table 3. Weights associated with each parameter in the scoring algorithm.

<u>parameter</u>	<u>weight</u>
Outlet drop	0.161
Physical barriers	0.135
Constriction	0.090
Inlet grade	0.088
Water depth	0.082
Water velocity	0.080
Scour pool	0.071
Substrate matches stream	0.070
Substrate coverage	0.057
Openness	0.052
Height	0.045
Outlet armoring	0.037
Internal structures	0.032

Step 3: Final Aquatic Passability Score

The final Aquatic Passability Score is the lower of either the composite score or the *Outlet Drop* component score. The rationale for this is that although many factors can affect aquatic organism passage, when an outlet drop is above a certain size it becomes the predominant factor that determines passability.

$$\text{Aquatic Passability Score} = \text{Min}[\text{Composite Score}, \text{Outlet Drop score}]$$

Mapping Aquatic Passability Scores

For mapping purposes, we assigned narrative descriptors for different ranges of aquatic passability as follows.

Descriptor	Aquatic Passability Score(s)
No barrier	1.0
Insignificant barrier	0.80 – 0.99
Minor barrier	0.60 – 0.79
Moderate barrier	0.40 – 0.59
Significant barrier	0.20 – 0.39
Severe barrier	0.00 – 0.19

People often ask about the relationship between these categories and actual passability for fish and other aquatic organisms. At this point the relationship is unknown and we regard it as a fruitful area for future research. The concept of aquatic passability is complicated and includes: variation in the swimming and leaping abilities of individuals within a species (what proportion of the population can pass), variability in passage requirements for a broad diversity of species that inhabit rivers and streams (what proportion of species can pass), and the timing of passability (for what proportion of the year is the structure passable).

For now, the best way to consider the aquatic passability scores is that they represent the degree to which crossings deviate from an ideal. We assume that those crossings that are very close to the ideal (scores > 0.6) will present only a minor or insignificant barrier to aquatic organisms. Those structures that are farthest from the ideal (scores < 0.4) are likely to be either significant or severe barriers. These are, however, arbitrary distinctions imposed on a continuous scoring system and should be used with that in mind.

APPENDIX A - R code for continuous scoring functions.

```
#-----#
# define function for Openness score calculation
#-----#
calc.openness.score <- function(x){
  # Using von Bertalanffy functional form (Bolker pg 97)
  a = 1
  k = 15
  d=0.62
  return(a * (1-exp(-k*(1-d)*x))^(1/(1-d)))
  # note exp is based on e not 10.
}

#-----#
# Define Function for Calculating Height Scores
#-----#
calc.height.score <- function(x){
  a <- 1.1
  b <- 2.2
  # Use Holling Type II function (Bolker pg 92):
  result <- a*x^2/(b^2 + x^2)
  result[result > 1] <- 1 # Truncate results to 1
  return(result)
}

#-----#
# Define Function for Calculating Outlet Drop Scores
#-----#
calc.outlet.drop.score <- function(x){
  a <- 1.029412
  b <- 0.51449575
  score <- 1 - a*x^2/(b^2 + x^2)
  score[x > 36] <- 0
  return(score)
}
```