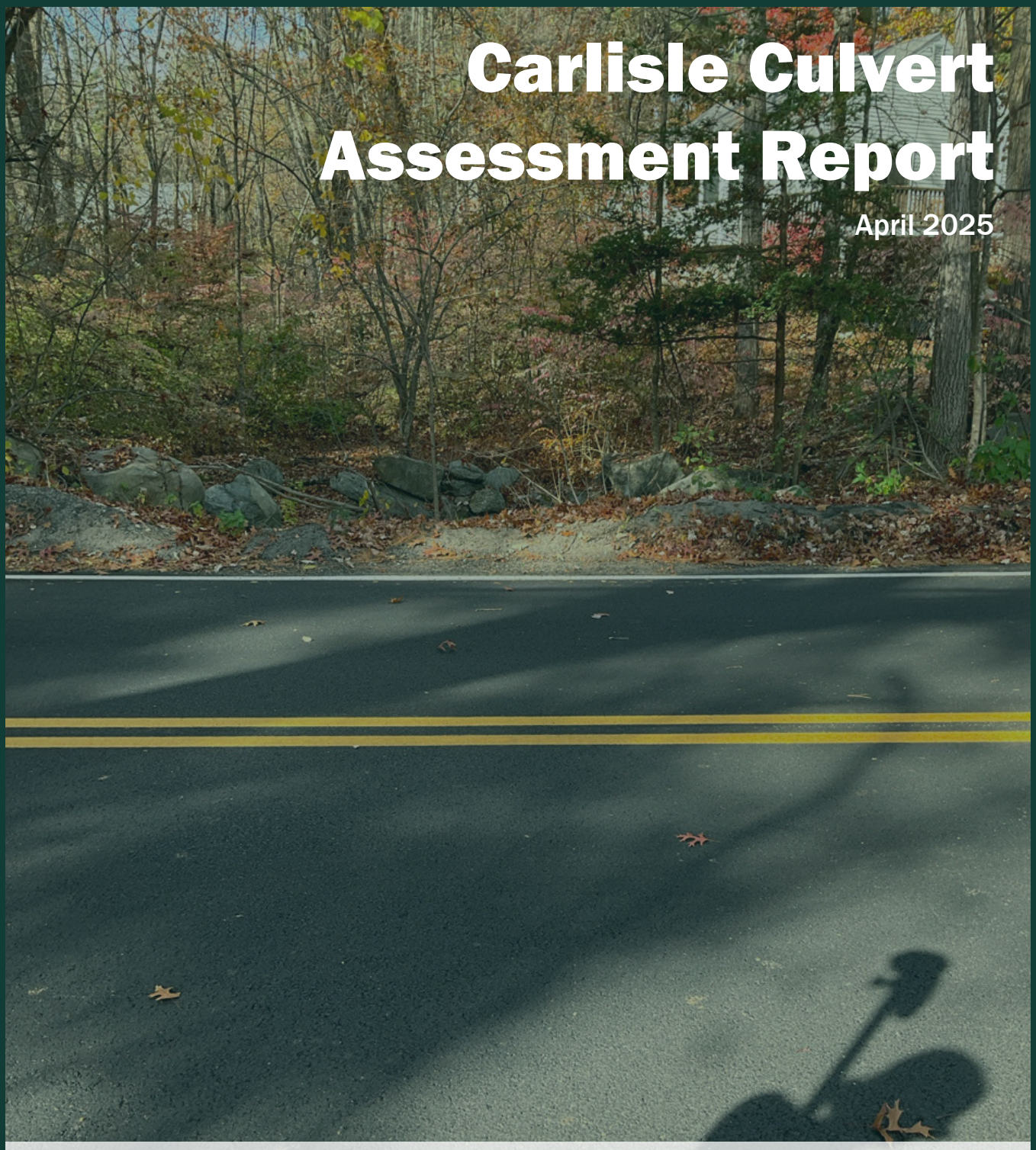
Carlisle Culvert Assessment Report

April 2025



Prepared for:

Town of Carlisle
66 Westford Street
Carlisle, MA 01741

Prepared by:

Nitsch Engineering
2 Center Plaza, Suite 430
Boston, MA 02108

Nitsch Engineering
Celebrating 35 Years!

Acknowledgments

TOWN OF CARLISLE

Ryan McLane, Town Administrator
Julie Mercer, Town Planner
James Hall, Superintendent of Public Works

NITSCH ENGINEERING

Matthew Styckiewicz, PE, Project Manager
Brian Creamer, AICP, Deputy Director of Resilience Planning & Design
Sam Daigle, EIT, Structural Designer
Nicolas Peterson, GISP, GIS Specialist
Mengyao Li, AICP, Planner

Contents

List of Figures

List of Tables

1. Introduction and Purpose

Nitsch Engineering (referred to as Nitsch) was retained by the Town of Carlisle to perform a Culvert Management Study of the Town's culvert system. The purpose of this study was to take inventory of the town-maintained culverts, perform a structural assessment of each culvert, and identify any culverts with poor or failing structural integrity. The following report is intended to help Town officials prioritize culvert upgrades and rehabilitation in their town. Recommendations for maintenance and rehabilitation procedures to improve the condition of these outstanding culverts are provided. These recommendations are preliminary and may need to be refined as the rehabilitation process unfolds. This report also provides a capital investment analysis to assist with municipal capital planning and budgeting for culvert rehabilitation.

This report contains a description of the existing conditions analysis, including both the GIS data gathering and culvert assessment procedures. Nitsch has identified 12 "high risk" culverts (Section 3 and Section 4) to be prioritized for rehabilitation. Although none of these culverts pose an imminent threat to the Town's infrastructure, they should be monitored to ensure their condition does not deteriorate further. An assessment summary has been created for each of these culverts to highlight their respective deficiencies.

In addition to the 12 high risk culverts, Nitsch has identified 71 obstructed culverts (Section 5). Many of these culverts are small diameter pipes that are partially or fully buried. Although these culverts are not considered to be structurally compromised, they should be cleared out to prevent flooding in the event of significant rainfall. A list of obstructed culverts is provided on page 45.

Nitsch has also identified 32 culverts as structurally deficient (Section 6), but not critical. Many of these culverts have small diameter pipes, are located on minor roads, or have structural damage that is moderate instead of severe. Although these culverts are not considered critical, it is recommended that they be monitored for deteriorating conditions, so they do not become critical. A list of non-critical culverts is provided on page 51.

2. Existing Conditions Analysis

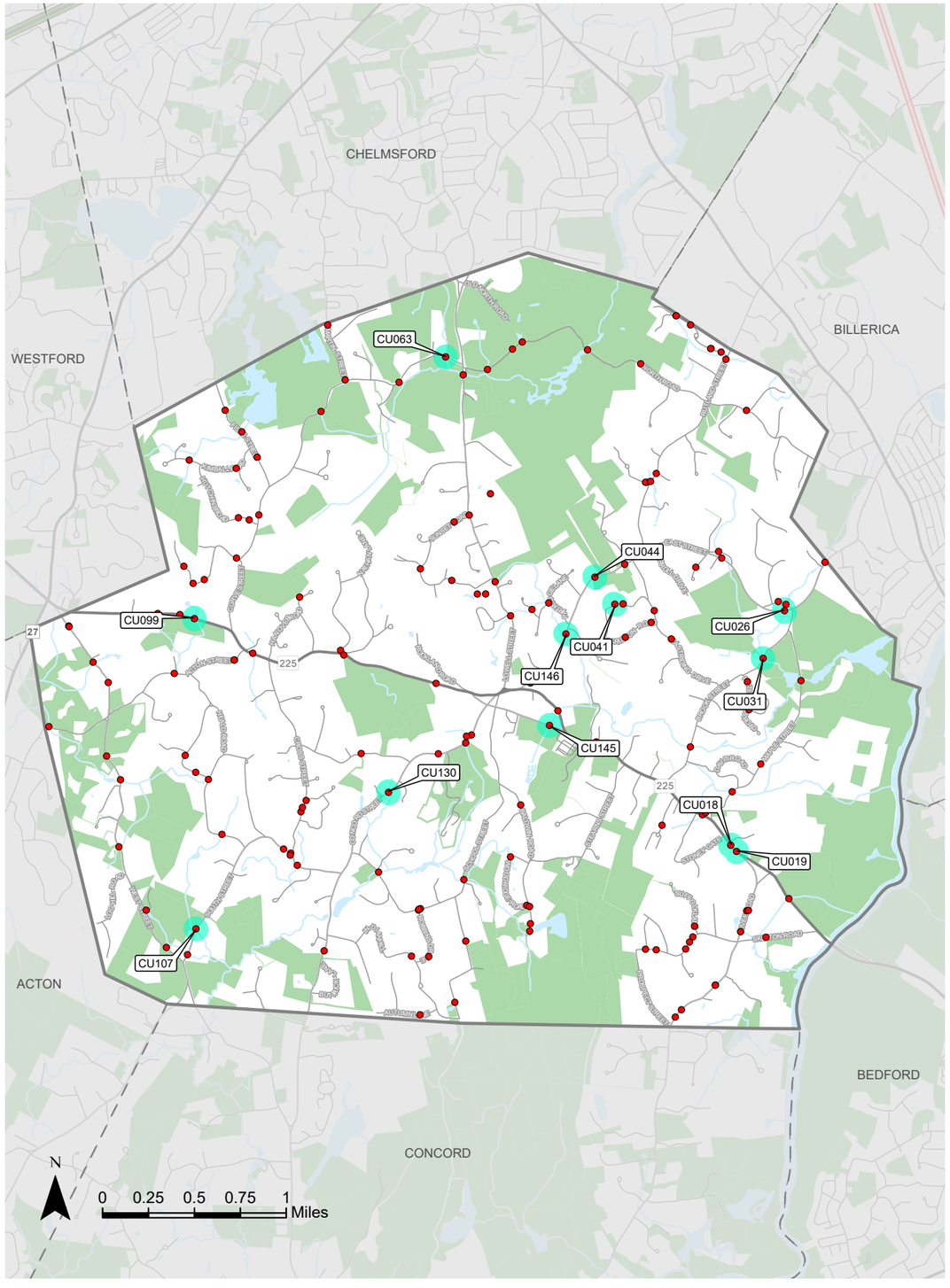
Fg 1. Nitsch Team Assessing Culverts Across the Town

Nitsch performed a culvert existing conditions analysis, which includes an update of the Town's culvert GIS database, and an assessment for all Town maintained culverts. In total, Nitsch assessed 157 culverts across the Town of Carlisle. The structural components for each culvert were given a risk rating ranging from "Good" to "Failing". Most of the culverts were rated as "Satisfactory", "Fair", or "Poor" overall, with some outliers in the "Good" and "Failing" categories. Below are descriptions of the culvert analysis criteria used in the assessment process.

Culvert Size by Roadway Type

Culvert Pipe Widths	Major Collector	Minor Collector	Local Road	Other	*Total*
Unknown	1	1	7	0	*9*
6'' to 12''	4	9	38	2	*53*
12'' to 24''	9	13	27	2	*51*
24'' to 32''	4	1	14	0	*19*
32'' to 48''	2	6	10	0	*18*
48''+	1	0	6	0	*7*
Total	*21*	*30*	*102*	*4*	***157***

Table 1. Culvert Size by Roadway Type



Fg 2. Locus Map

2.1 Collection Means and Method

The first step in the assessment process was to identify all known and potential culvert locations in Carlisle. The Town provided Nitsch with GIS data from prior assessments taken in 2023. This data included culvert locations, notes for finding culvert ends, and descriptions of structural conditions. The existing culvert points were plotted on a map of Carlisle using the GIS software ArcGIS. With this existing culvert data, Nitsch grouped the culverts based on their proximity to one another and planned an efficient route for assessment.

With the existing culvert locations established, Nitsch began updating the attributes of the GIS data. The EOS Arrow Gold+ GPS device was used to plot end points and accurately measure barrel lengths. In the field, the GPS device would connect via Bluetooth to an iPad equipped with the ArcGIS app. Once located in the field, culvert ends were plotted in ArcGIS by holding the GPS device next to the opening and adding a data point to the map. A culvert barrel was then drawn between the end points.

Nitsch used two types of objects to represent the culvert components: dots and lines. A yellow dot represents an inlet, and a blue dot represents an outlet. A black line connecting the two end points represents the culvert barrel. In some cases, catch basins connected to the culvert barrel were marked with a brown dot. A lone brown dot represents a location where the date collected in 2023 had shown a known or potential culvert structure, but no structure was found in the field in 2024.

The culvert end point and barrel features contained associated forms to store assessment information. End point forms included fields for inlet/outlet designation, and culvert barrel recordability. Normally, the bulk of assessment data was recorded in the culvert barrel form, including component materials, dimensions, and condition ratings. In the case that one side of the culvert was unrecordable, assessment data could be stored in the end point form by selecting “No” for the culvert barrel recordability field. The assessment criteria are described further in Section 2.3 and Section 2.4 below. Both the barrel and end points housed photos of the existing conditions of the structure.

Nitsch’s naming convention numbers culverts based on order of assessment. For example, the first culvert barrel recorded was named “CU001”, and the last “CU156”. End point names were given a suffix to differentiate between inlets and outlets. Culvert inlets were given the suffix “_I” and outlets were given the suffix “_O”. So, for example, the first inlet recorded was named “CU001_I”.

2.2 Definitions

Risk Definition	
Structural Risk	Risk of failure based on the structural condition of the culvert. This rating considers the structural condition of the culvert pipe, headwall, and embankments.
Hydraulic Risk	Risk of failure based on how much water a crossing can handle before collapsing, overtopping, or washing out.
Geomorphic Risk	Risk of failure based on the likelihood of sediment, woody debris, and channel adjustment of the culvert pipe.
Overall Risk	Risk of failure of the culvert based on a weighted average of the three ratings above. In general, structural risk is weighed more highly than the other two risk categories.

2.3 General Criteria

Nitsch evaluated the following criteria of each culvert:

General Criteria	
Roadway Material, Width, and Condition	The material and width of the roadway and the condition of the roadway material.
Culvert Shape	The shape of the culvert.
Culvert Size and Length	The total length and cross-sectional dimension of the culvert barrel. For circular culverts, the diameter of the culvert was recorded for both width and height. For rectangular or elliptical culverts, height and width of the culvert were documented in their respective fields.
Culvert Material	The material that composes the culvert barrel.
Depth Below Roadway	The depth from the top of the culvert barrel to the roadway grade.
Embankment Type	Describes the general composition of the culvert embankments.
Embankment erosion	The level of erosion affecting the culvert embankments, from none to severe.
Headwall Type	The material that composes the culvert headwalls.
Obstructions	The type of obstructions and level of obstruction of the culvert pipe, if any.
Scour Level & Location	The level and location of scour, if any.
Water Level & Flow	The amount of water in the culvert and level of water flow, if any.
Disruption Potential	Potential concerns for traffic and emergency services in the case of culvert failure rated on a scale of 0 to 5, 0 being no traffic disruption and 5 being severe traffic disruption. Culverts located on dead end roads and roadways with the highest traffic volumes received the highest ratings.
Environmental Concerns	Potential concerns about environmental issues of the current culvert rated on a scale of 0 to 5, 0 being no environmental concerns and 5 being severe environmental concerns.
Hydraulic Concern	Identified culvert end conditions that could cause hydraulic issues. In a perched end condition, the pipe is significantly higher than the stream bed. In a below grade end condition, the pipe is significantly lower than the stream bed.

2.4 Structural Criteria

Embankment

Condition of the culvert embankments based on visual evidence of vegetation overgrowth, erosion, sediment spilling over or through headwalls or tree roots.

Good - Consists of:
- No to very minor erosion
- No vegetation overgrowth
- No tree or root growth affecting the integrity of the structure

Satisfactory - Exhibits one or more of the following:
- Minor erosion
- Minor amounts of sediment spilling over and/or through the headwall
- Very minor vegetation growth
- Very minor tree and/or root growth that does not affect the integrity of the structure

Fair - Exhibits one or more of the following:
- Moderate erosion
- Moderate amounts of sediment spilling over and/or through the headwall
- Minor to moderate vegetation overgrowth
- Minor tree and/or root growth affecting the integrity of the structure

Poor - Exhibits one or more of the following:
- Moderate to severe erosion
- Moderate to severe sediment spilling over and/or through the headwall
- Moderate vegetation overgrowth
- Moderate tree and/or root growth affecting the integrity of the structure

Failing - Exhibits one or more of the following:
- Severe erosion
- Severe sediment spilling over and/or through the headwall
- Moderate to heavy vegetation overgrowth
- Moderate to severe tree and/or root growth affecting the integrity of the structure

Headwall

Condition of the culvert headwalls based on visual evidence of moss, cracking or spalling, missing or collapsed stones, or voids in mortar, and signs of rotation.

Good - Dependent on wall material, consists of:
- No to very minor cracks
- No to minor scaling due to water
- No to minor spalling
- No to minor missing stones, missing mortar or voids between stones
- No moss growth
- No signs of rotation

Satisfactory - Dependent on wall material, exhibits one or more of the following:
- Sporadic areas of minor cracks or spalling
- Minor scaling due to water
- Minor missing mortar or voids between stones
- No to very minor stones missing that do not affect the integrity of the structure
- Minor moss growth
- No signs of rotation

Fair - Dependent on wall material, exhibits one or more of the following:
- Minor to moderate cracks/spalls
- Minor to moderate scaling due to water
- Minor to moderate missing mortar, voids between stones, stones missing that does not affect integrity
- Minor to moderate moss growth
- No to very minor signs of rotation

Poor - Dependent on wall material, exhibits one or more of the following:
- Moderate cracks/spalling
- Moderate scaling due to water
- Moderate missing mortar/voids between stones
- Moderate missing/collapsing stones that do not affect integrity of the wall
- Moderate moss growth
- Minor to moderate signs of rotation

Failing - Dependent on wall material, exhibits one or more of the following:
- Severe cracks/spalling
- Severe scaling due to water
- Severe missing mortar/voids between stones
- Severe stones missing/collapsing/collapsed that does not affect the integrity of wall and culvert
- Severe moss growth
- Moderate to severe signs of rotation

Culvert Barrel

Condition of the culvert barrel based on visual evidence of rust, erosion, cracking or spalling, exposed rebar, section loss, missing or collapsed sections, separation of joints and seams, structural misalignment, cross section deformations and obstructions.

Good - Depending on pipe material, consists of:
- No cracks, dents/spalls, or damage
- No to very minor surface rust
- No scaling due to high water or exposed rebar
- No obstructions around the inverts/within the culvert
- No shifts in culvert lengths, separation between joints, or settlement
- No scour

Satisfactory - Depending on pipe material, exhibits one or more of the following:
- No to very minor cracks, dents/spalls, minor scaling due to water, and/or damage
- Minor surface rust and/or exposed rebar
- No to minor obstructions around the inverts/within the culvert
- No shifts in culvert lengths or settlement
- No to minor scour separation between joints

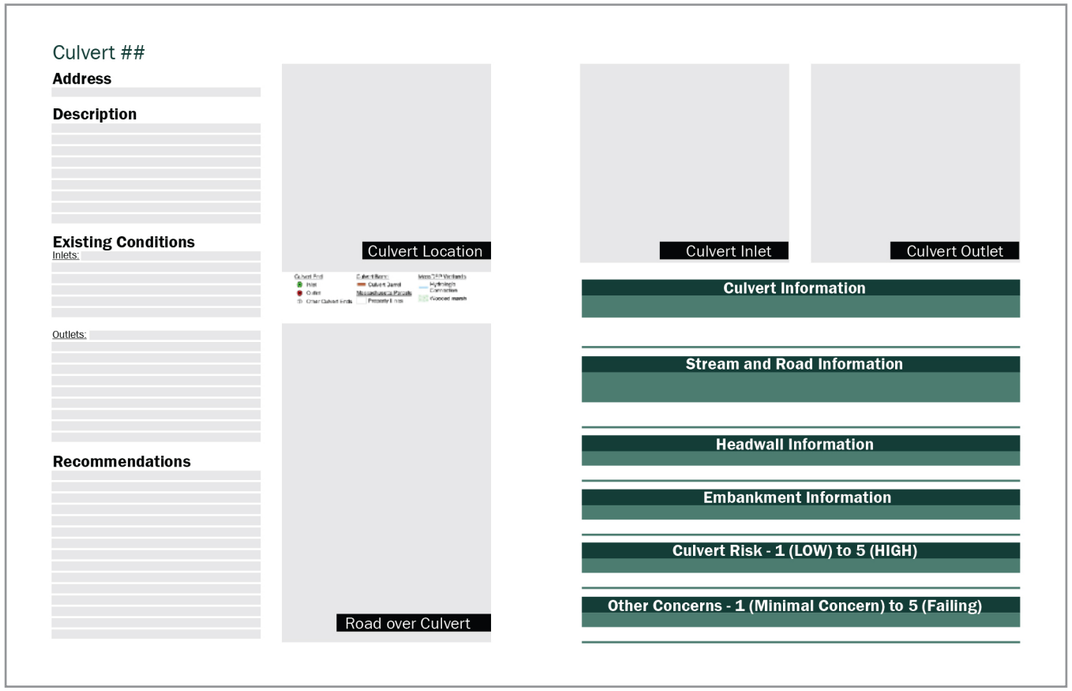
Fair - Depending on pipe material, exhibits one or more of the following:
- Minor to moderate cracks, dents/spalls, and/or damage that does not affect integrity of the structure
- Moderate surface rust, scaling due to high water, and/or exposed rebar
- Minor obstructions around the inverts/within the culvert
- Minor to moderate shifts in culvert lengths, separation between joints, or settlement
- Minor to moderate scour

Poor - Depending on pipe material, exhibits one or more of the following:
- Moderate cracks, dents/spalls, and/or damage that does affect integrity of the structure
- Moderate to severe surface rust, scaling due to high water, and/or exposed rebar
- Moderate obstructions around the inverts/within the culvert
- Moderate shifts in culvert lengths, separation between joints, or settlement
- Moderate to severe scour

Failing - Depending on pipe material, exhibits one or more of the following:
- Severe cracks, dents/spalls, and/or damage that does affect integrity of the structure
- Severe surface rust, scaling due to high water, section loss, and/or exposed rebar
- Severe obstructions around the inverts/within the culvert impeding water flow
- Severe shifts in culvert lengths, separation between joints, or settlement
- Severe scour leading to structural distress from undermining

3. Primary High Risk Structures

Nitsch has identified 4 primary “high risk” culverts to be prioritized for rehabilitation. Although none of these culverts pose an imminent threat to the Town’s infrastructure, they should be monitored to ensure their condition does not deteriorate further. An assessment summary has been created for each of these culverts to highlight their respective deficiencies. These summaries follow the same layout and structure as shown in the diagram below.



Fg 3. High-Risk Culvert Assessment Summary Layout

3.1 Culvert CU026

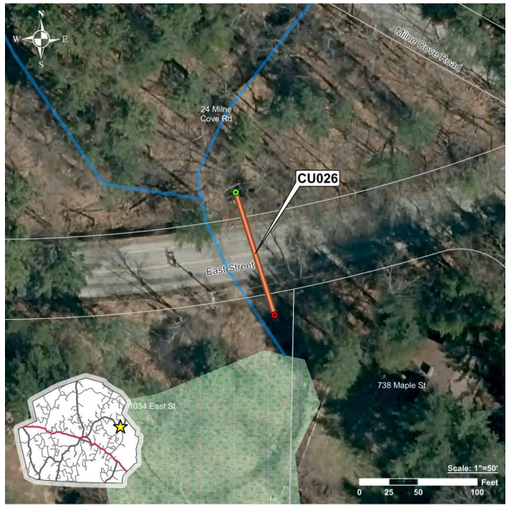
Address
East Street

Introduction
Culvert CU026 carries waterflow under East Street, a Minor Collector, through a 42-inch corrugated metal pipe. The water level was approximately 5% of the culvert capacity and was flowing at the time of assessment. The culvert received a Failing assessment of the inlet and a Poor assessment of the outlet, resulting in a high risk of failure. Culvert CU026 is considered a Critical Culvert based on its high risk of failure and moderate traffic disruption if the structure were to fail.

Existing Conditions
Inlet: The inlet embankment condition was Poor with moderate erosion near the base of the headwall and trees growing in close proximity. The concrete headwall was split down the center of the wall above the pipe. Both pieces of the headwall had rotated around the pipe away from each other. The headwall was given a Failing rating. The pipe at the inlet was in Poor condition with rust and section loss at the bottom of the pipe.

Outlet: The outlet embankment condition was Poor with heavy vegetation overgrowth around the headwall and sediment spilling over the top of the wall. The concrete headwall was observed to be in Poor condition. The pipe at the outlet extended approximately 10 ft past the headwall and was given a Failing rating due to major section loss and rust at the bottom of the pipe.

Recommendations
Potential repair options include a full replacement with excavation and removal of the existing culvert, and regrading and scour protection at the outlet of culvert. This option would need structural, hydraulic, and geotechnical engineering design to support the replacement.




Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
42	42	80	Corrugated Metal Pipe	Round	Moderate	None	Failing	

Stream and Road Information

Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Flowing	5%	Parallel	East St	Major Road	<45 Degrees	10	Good	32	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Failing	Concrete	Poor	

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Vegetated, trees	Moderate	Poor	

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	4	4	4

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
2	Major Roadway	2	Low openness ratio	

3.2 Culvert CU041

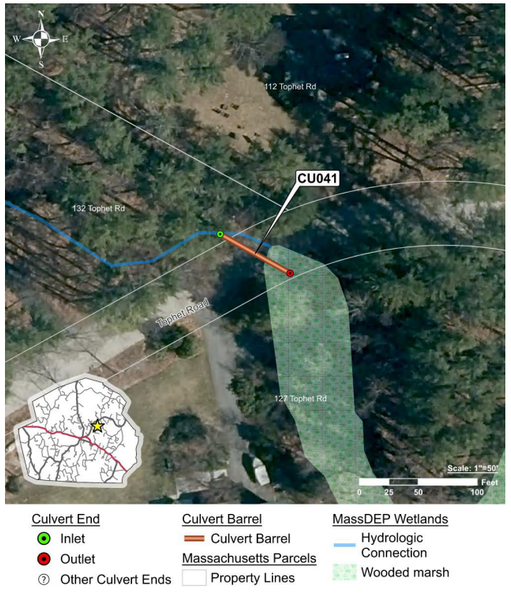
Address
Tophet Road

Introduction
Culvert CU041 carries waterflow from a season stream under Tophet Road, a Local Road, through a 30-inch corrugated metal pipe. The culvert received a Failing assessment of the inlet and a Poor assessment of the outlet, resulting in a high risk of failure. Culvert CU041 is considered a Critical Culvert based on it's high risk of failure.

Existing Conditions
Inlet: The inlet embankments were poorly vegetated and Failing due to severe erosion on both sides of the headwall. The precast concrete headwall had moderate scaling and spalling at the bottom of wall and was in Poor condition. The corrugated metal pipe had severe rust and sections loss of the bottom 50% of the pipe approximately. The overall rating of the inlet was Failing.

Outlet: The outlet had rock embankments that were in Fair condition. The precast concrete headwall had moderate scaling and spalling at the bottom of wall and was in Poor condition. The corrugated metal pipe had severe rust and moderate section loss on the lower half of the pipe. The overall rating of the outlet was Poor.

Recommendations
Potential repair options include full culvert replacement, with re-grading and scour protection of the embankments.




Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
30	30	35	Corrugated Metal Pipe	Round	Moderate	None	Failing	

Stream and Road Information

Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Dry	Dry	Parallel	Tophet Rd	Minor St or Rd	<45 Degrees	5	Satisfactory	21	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Poor	Concrete	Poor	

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated	Severe	Failing	Rock embankment at outlet

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	3	4	4

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
2	None	2	Low openness ratio	

3.3 Culvert CU044

Address
East Street

Introduction
Culvert CU044 carries waterflow under East Street, a Minor Collector, through a 36-inch reinforced concrete pipe. The culvert received a Failing assessment of the inlet and a Poor assessment of the outlet, resulting in a high risk of failure. Culvert CU044 is considered a Critical Culvert based on its high risk of failure and significant traffic disruption if it were to fail.

Existing Conditions
Inlet: The embankment condition at the inlet was Poor with minor erosion. The headwall was in Poor condition with full depth spalling at the bottom of wall. The pipe was in Fair condition with some moss and scaling on the bottom half of the pipe. The overall rating of the inlet was Poor.

Outlet: The embankment condition at the outlet was Poor with vegetation overgrowth and sediment spilling over the headwall. The headwall was in Failing condition as the entire left half of the headwall was missing. There was also scour present at the bottom of the intact section of the headwall. Similar to the inlet, the pipe was in Fair condition. The overall rating of the outlet was Failing.

Recommendations
Potential repair options include full headwall replacements, with clearing overgrowth and revegetation of the embankments to stabilize the slope and minimize erosion.


Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
36	36	48	Reinforced Concrete Pipe	Elliptical	Moderate	None	Poor	

Stream and Road Information

Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Dry	Dry	Parallel	East St	Major Road	Perpendicular	5	Satisfactory	22	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Failing	Concrete	Poor	

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated	Moderate	Poor	

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	2	3	3

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
3	Major road	2	Low openness ratio	

3.4 Culvert CU146

Address
East Street

Introduction
Culvert CU146 carries waterflow under East Street, a Minor Collector, through a 36-inch reinforced concrete pipe. The water level of the pipe was approximately 5% of the culvert capacity with stagnant flow at the time of assessment. The culvert received a Satisfactory assessment of the inlet and a Failing assessment of the outlet, resulting in a high risk of failure. Culvert CU146 is considered a Critical Culvert based on its high risk of failure and moderate traffic disruption if the structure were to fail.

Existing Conditions
Inlet: The inlet has poorly vegetated embankments in Poor condition due to moderate vegetation overgrowth. The concrete headwall appeared to be in Satisfactory condition with no cracks or spalls. The pipe at the inlet was in Satisfactory condition with minor scaling but no visible cracks or exposed rebar.

Outlet: The outlet has poorly vegetated embankments in Fair condition due to minor vegetation overgrowth. The concrete headwall was Failing with signs of rotation and severe full depth spalling at the bottom of wall. Similar to the inlet, the pipe itself was in Satisfactory condition.

Recommendations
Potential repair options include concrete headwall replacement at the outlet and clearing vegetation overgrowth and revegetation of the embankments to stabilize the slope and minimize erosion.


Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
36	36	38	Reinforced Concrete Pipe	Round	None	None	Satisfactory	

Stream and Road Information

Rainfall (in/past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Stagnant	5%	Parallel	East St	Major Road	Perpendicular	3	Satisfactory	23	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Satisfactory	Concrete	Failing	Severe full depth spalling at bottom of headwall at outlet, signs of rotation

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated, stone	Moderate	Poor	Moderate vegetation overgrowth

Culvert Risk - 1 (LOW) to 5 (HIGH)

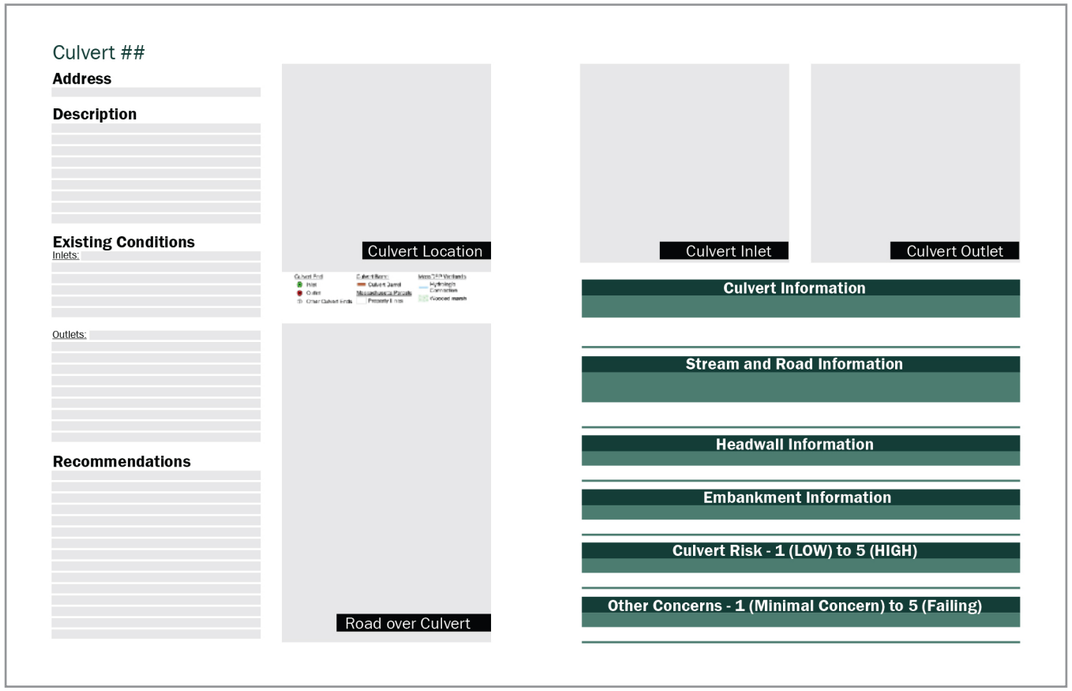
Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	1	4	4

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
3	Major road	2	Low openness ratio	

4. Secondary High Risk Structures

Nitsch has identified 8 secondary “high risk” culverts to be prioritized for rehabilitation. Although none of these culverts pose an imminent threat to the Town’s infrastructure, they should be monitored to ensure their condition does not deteriorate further. An assessment summary has been created for each of these culverts to highlight their respective deficiencies. These summaries follow the same layout and structure as shown in the diagram below.



4.1 Culvert CU018

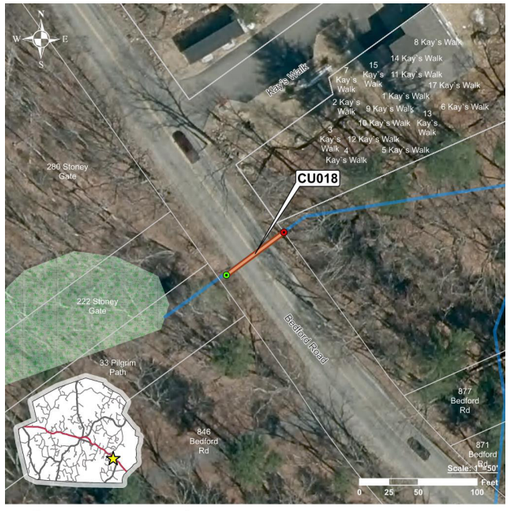
Address
Bedford Rd (MA-225)

Description
Culvert CU018 carries waterflow under roadway Bedford Road, a Major Collector, through an 18-inch iron pipe. The water level was dry at the time of assessment. The culvert received a Poor assessment of the inlet and a Failing assessment of the outlet, resulting in a high risk of failure. Culvert CU018 is considered a Critical Culvert based on its high risk of failure and significant traffic disruption if the structure were to fail.

Existing Conditions
Inlet: The embankment condition at the inlet was Poor with vegetation overgrowth and sediment spilling over the headwall. The concrete headwall was in Poor condition with moderate spalling along the top of the wall. The pipe received a satisfactory rating. The overall rating of the inlet was Poor.

Outlet: The embankment condition at the outlet was Poor with moderate to heavy vegetation overgrowth and sediment spilling over the headwall. The headwall was in Failing condition with signs of rotation, spalling along the bottom of wall, cracking along the front face of wall, and moderate moss growth. The pipe received a satisfactory rating, but was around 90% obstructed with leaves, sticks, and sediment. The overall rating of the outlet was Failing.

Recommendations
Potential repair options include headwall replacement at the outlet, spall repair at the inlet headwall, clearing out overgrowth and re-vegetation to stabilize slope and minimize erosion, and cleaning out or jetting of the pipe.



Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
18	18	45	Other - see notes	Round	None	Fallen headwall stones at outlet, branches and leaves and sediment at inlet	Satisfactory	Flat iron pipe

Stream and Road Information

Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Dry	Dry	Parallel	MA-225	Numbered Route	<45 Degrees	4.5	Good	26	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Poor	Concrete	Failing	

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated, tree roots, sedimentation	Moderate	Poor	

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	3	3	3

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
4	Major Roadway	2	Low openness ratio	

4.2 Culvert CU019

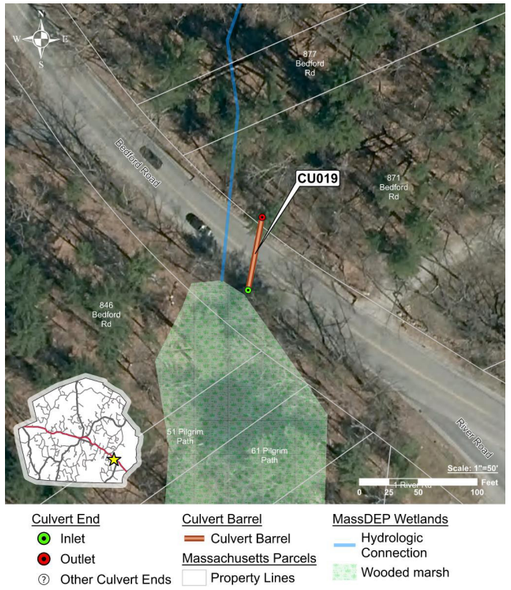
Address
Bedford Rd (MA-225)

Introduction
Culvert CU019 carries waterflow under Bedford Rd, a Major Collector, through an 18-inch reinforced concrete pipe. The water level was dry at the time of assessment. The culvert received a Fair assessment of the inlet and a Failing assessment of the outlet, resulting in a high risk of failure. Culvert CU019 is considered a Critical Culvert based on its high risk of failure and significant traffic disruption if the structure were to fail.

Existing Conditions
Inlet: The embankment condition at the inlet was Poor with moderate erosion along the sides of the headwall. The concrete headwall was in Fair condition with minor cracks, minor spalling at the bottom of wall, and minor moss growth. The pipe received a Fair rating due to moderate spalling within the pipe. The overall rating of the inlet was Fair.

Outlet: The embankment condition at the outlet was Poor with moderate to heavy vegetation growth and sediment spilling over the headwall. The headwall was in Failing condition with signs of rotation, cracking along the front face of wall, spalling along the bottom of wall, and moderate moss growth. The pipe received a Fair rating due to moderate spalling within the pipe. The overall rating of the outlet was Failing.

Recommendations
Potential repair options include headwall replacement at the outlet, spall and crack repair at the inlet headwall, and revegetation of the embankments to stabilize slope and minimize erosion.




Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
18	18	46	Reinforced Concrete Pipe	Round	None	Stones obstructing outlet and 90% filled with sediment , minor stick and debris at inlet	Fair	

Stream and Road Information

Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Dry	Dry	Parallel	MA-225	Numbered Route	<45 Degrees	4	Good	26	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Fair	Concrete	Failing	Stones falling off of top of headwall at outlet

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated	Moderate	Poor	

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	4	3	3

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
3	Major Road	2	Low openness ratio	

4.3 Culvert CU031

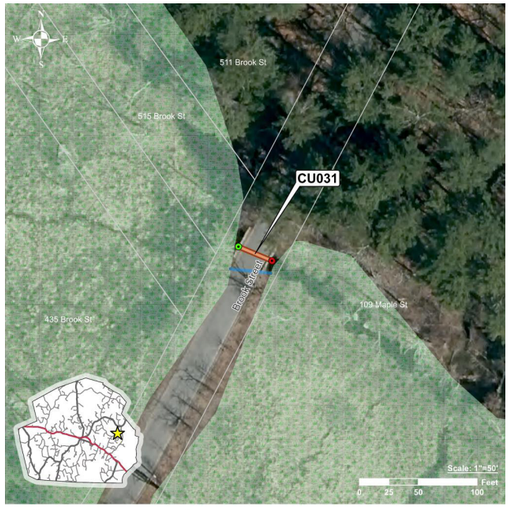
Address
Brook Street

Introduction
Culvert CU031 carries waterflow from a marsh under Brook Street, a Local Road, through a 96-inch wide, 48-inch-high corrugated metal pipe arch. The water level of the pipe was around 5% of the culvert capacity and was stagnant at the time of assessment. The culvert received a Poor assessment of the inlet and a Poor assessment of the outlet, resulting in a high risk of failure. Culvert CU041 is considered a Critical Culvert based on its high risk of failure and moderate traffic disruption due to long detour if the structure were to fail.

Existing Conditions
Inlet: The inlet was in Poor condition and susceptible to erosion due to poorly vegetated embankments cause by overgrowth. The stone headwall was in Poor condition was observed to be leaning away from the roadway. The pipe at the inlet was unobstructed with moderate rust and minor section loss and was given a Poor rating.

Outlet: The outlet is in Poor condition and susceptible to erosion due to poorly vegetated embankments cause by overgrowth. The stone headwall was in Poor condition was observed to be leaning away from the roadway, similar to the inlet. The pipe at the outlet was unobstructed with moderate rust and minor section loss and was given a Poor rating. Moderate scour was observed at the outlet and within the pipe.

Recommendations
Potential repair options include clearing overgrowth and revegetation of the embankments to stabilize the slope and minimize erosion, resetting stone headwalls, and spin cast liner in the pipe.




Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information								
Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
48	96	23	Corrugated Metal Pipe	Arch	Moderate	None	Poor	Section loss on pipe, open bottom corrugated metal arch

Stream and Road Information										
Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Stagnant	5%	Parallel	Brook St	Minor St or Rd	Perpendicular	1	Fair	19	Asphalt

Headwall Information				
Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Stone	Poor	Stone	Poor	Both headwall leaning away from roadway

Embankment Information			
Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated	Moderate	Poor	

Culvert Risk - 1 (LOW) to 5 (HIGH)			
Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	1	4	4

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)				
Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
2	Long detour	2	No banks	

4.4 Culvert CU063

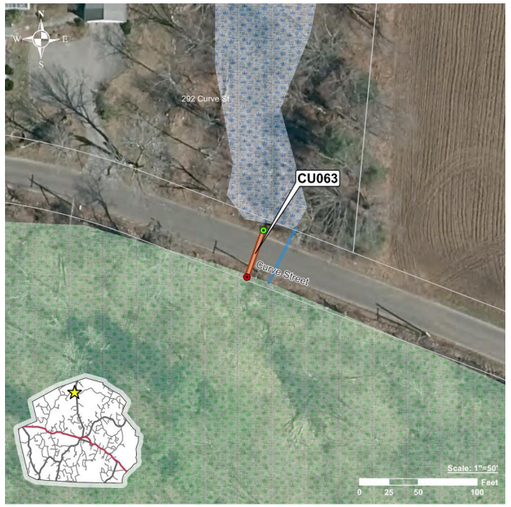
Address
Curve Street

Introduction
Culvert CU063 carries waterflow under Curve Street, a Local Road, through a 30-inch corrugated metal pipe. There was no water recorded at the time of the assessment. The culvert received a Poor assessment of the inlet and a Poor assessment of the outlet, resulting in a high risk of failure. Culvert CU063 is considered a Critical Culvert based on its high risk of failure and moderate traffic disruption due to long detour if the structure were to fail.

Existing Conditions
Inlet: The inlet had a mix of poorly vegetated and stone embankments in Poor condition due to moderate vegetation overgrowth. The stone headwall was Poor with moderate missing stones. The pipe at the inlet was in Poor condition with major rusting and section loss at the inlet in the pipe.

Outlet: The outlet had no embankments but had stone wingwalls in Fair condition with minor vegetation growth around and on top of the walls. The stone headwall was Fair with slight rotation but no missing stones. Similar to the inlet, the pipe itself was in Poor condition due to rust and section loss.

Recommendations
Potential repair options include spin cast lining inside the pipe if a hydraulic analysis shows the pipe is adequate in size. Otherwise, a full replacement would be needed.




Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information								
Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
30	30	31	Corrugated Metal Pipe	Round	None	Sediment at outlet , branches inside pipe, but most of pipe is unobstructed	Poor	Major section loss and rusting at both inlet and outlet

Stream and Road Information										
Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Dry	Minimal	Parallel	Curve St	Minor St or Rd	Perpendicular	2.67	Satisfactory	18	Asphalt

Headwall Information				
Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Stone	Poor	Stone	Fair	Vegetation overgrowth around both headwalls

Embankment Information			
Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Stones and poorly vegetated	None	Poor	No embankments at outlet, stone / poorly vegetated at inlet

Culvert Risk - 1 (LOW) to 5 (HIGH)			
Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	2	3	3

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)				
Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
2	Long detour	2	Low openness ratio	

4.5 Culvert CU099

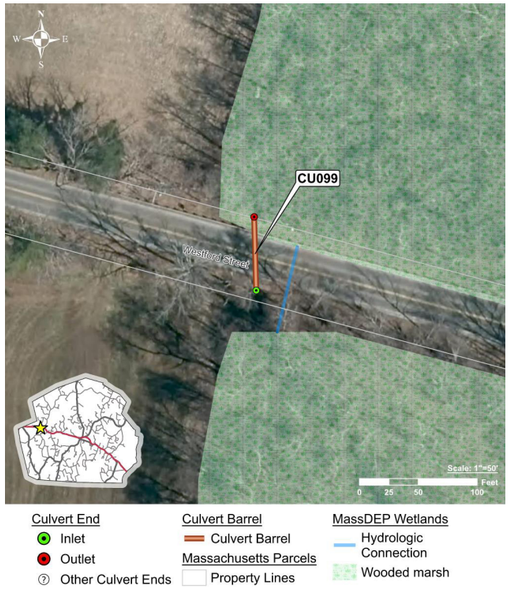
Address
Westford Street (MA-225)

Introduction
Culvert CU099 carries waterflow under Westford Street, A Major Collector, through a 24-inch reinforced concrete pipe. There was no water recorded at the time of the assessment. The culvert received a Poor assessment of the inlet and a Poor assessment of the outlet, resulting in a high risk of failure. Culvert CU099 is considered a Critical Culvert based on its high risk of failure and significant traffic disruption due to the traffic volume and long detour if the structure were to fail.

Existing Conditions
Inlet: The embankment condition at the inlet was Poor with heavy vegetation overgrowth, erosion around the headwall, and sediment spilling over the top of wall. The headwall was in Poor condition, with spalling and moss growth along the face of the wall. The pipe at the inlet was in Fair condition due to moderate scaling inside the pipe. The overall rating of the inlet was Poor.

Outlet: The embankment condition at the outlet was Fair to Poor, with moderate vegetation overgrowth and sediment spilling over the headwall. The headwall was in Poor condition with a substantial crack down the center of the wall above the pipe and spalling along the face of the wall. The pipe at the outlet was in Fair condition due to moderate scaling inside the pipe. The overall rating of the outlet was Poor.

Recommendations
Potential repair options include headwall replacements, clearing overgrowth and revegetation of the embankments to stabilize the slope and minimize erosion.




Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
24	24	46	Reinforced Concrete Pipe	Round	None	None	Fair	Pipe in fair condition, headwalls poor

Stream and Road Information

Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Dry	Dry	Parallel	MA-225	Major Road	<45 Degrees	4.5	Good	23	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Poor	Concrete	Poor	Moss, cracks, erosion at base of headwall

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated, roots	Moderate	Poor	Vegetation overgrowth, erosion. Inlet is worse, outlet could be fair

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	1	2	2

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
2	Major road	2	Low openness ratio	

4.6 Culvert CU107

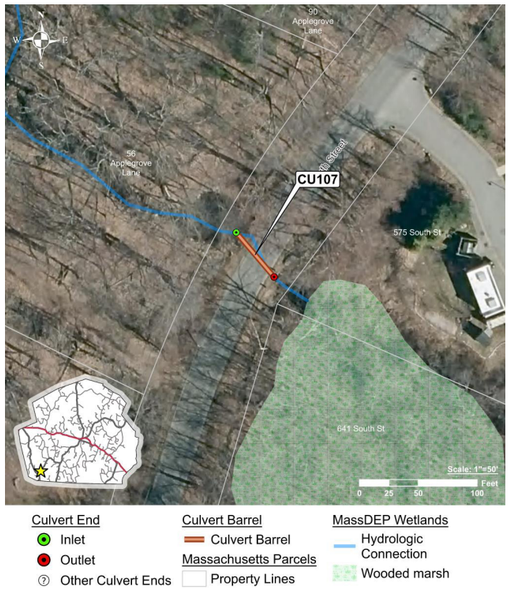
Address
South Street

Introduction
Culvert CU107 carries waterflow under South Street, a Minor Collector, through a 24-inch corrugated metal pipe. There was no water recorded at the time of the assessment. The culvert received a Fair assessment of the inlet and outlet headwalls and embankments but received a Poor assessment rating of the pipe itself, resulting in a high risk of failure. Culvert CU107 is considered a Critical Culvert based on its high risk of failure and moderate traffic disruption due to long detour if the structure were to fail.

Existing Conditions
Inlet: The embankments at the inlet were in Fair condition. The headwall was in Fair condition with minor missing stones that did not affect the integrity of the structure. The pipe at the inlet was in Poor to Failing condition, with severe section loss and rust.

Outlet: The embankments at the outlet were in Fair condition with vegetation overgrowth and sediment seeping through the headwall. The headwall was in Fair condition with minor missing or collapsing stones that did not affect the integrity of the structure. The pipe at the outlet was in Poor to Failing condition, with severe section loss and rust from the edge of the outlet to approximately 3 ft within the pipe. Beyond that, rust was observed with no visible section loss within the pipe.

Recommendations
Potential repair options include resetting the stone headwalls and spin cast lining inside the pipe if a hydraulic analysis shows the pipe is adequate in size. Otherwise, a full replacement would be needed.



Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
24	24	37	Corrugated Metal Pipe	Round	None	None	Poor	Headwalls fair. Major section loss and rusting at inlet/ outlet to ~3 ft in. Inside of pipe has rust but no visible section loss

Stream and Road Information

Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Dry	Dry	Parallel	South St	Minor St or Rd	Perpendicular	3.67	Satisfactory	18	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Stone	Fair	Stone	Fair	Some headwall stones sagging at outlet

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated, stone	Moderate	Fair	

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
1	1	3	3

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
2	Long detour	2	Low openness ratio	

4.7 Culvert CU130

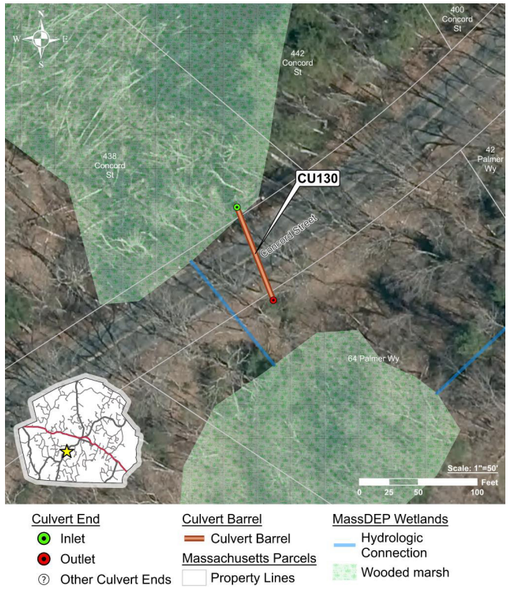
Address
426 Concord St

Introduction
Culvert CU130 carries overflow from a wetland area under Concord Street, a Major Collector, through an 18-inch reinforced concrete pipe. The culvert received a Failing assessment of the inlet, and a Fair assessment of the outlet, resulting in a high risk of failure. Culvert CU130 is considered a Critical Culvert due to the risk of failure and significant traffic disruptions if the structure were to fail.

Existing Conditions
Inlet: The embankment condition was Failing with severe erosion around headwall. Minor spalling was observed at the concrete headwall with minor signs of rotation. Moderate spalling was observed at bottom of RCP pipe. The overall rating of the inlet was Failing.

Outlet: The embankment condition was Fair with moderate erosion on both sides of the headwall. The concrete headwall was in Fair condition with minor spalling observed at the base of the headwall. The pipe was approximately 40% obstructed with sediment and leaves at the outlet. The overall condition of the outlet was Fair.

Recommendations
Potential repair options include replacement of the inlet headwall, re-grading and scour protection of the embankments, and sediment jetting inside the pipe.



Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
18	18	62	Reinforced Concrete Pipe	Round	Severe	Sediment and leaves	Poor	Minor to moderate spalling at bottom of pipe

Stream and Road Information

Rainfall (in/past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
1.3	Stagnant	5%	Parallel	Concord St	Major Road	Perpendicular	10	Satisfactory	24	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Poor	Concrete	Fair	Minor spalling, Inlet headwall exhibits minor rotation

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated	Severe	Failing	Inlet is failing with severe erosion, outlet is fair with moderate erosion

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
2	2	3	3

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
3	Major roadway	2	Low openness ratio	

4.8 Culvert CU145

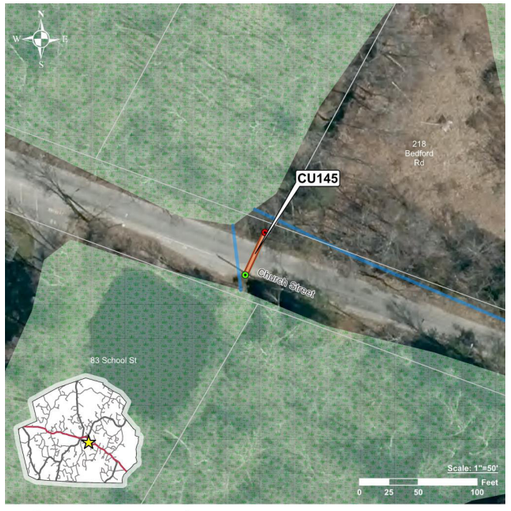
Address
Church Street

Introduction
Culvert CU145 carries waterflow from a small stream under Church Street, a Minor Collector, through a 16-inch steel pipe. Church Street is a one-way road that serves Carlisle High School. The water level of the pipe was around 50% of the culvert capacity with stagnant flow. The culvert received a Poor assessment of the inlet and a Poor assessment of the outlet, resulting in a high risk of failure. Culvert CU145 is considered a Critical Culvert based on its high risk of failure and, because it is a one-way road in a school zone, moderate traffic disruption if the structure were to fail.

Existing Conditions
Inlet: The inlet has poorly vegetated embankments in Poor condition due to vegetation overgrowth and severe erosion on the right side of the headwall. The concrete headwall appeared to be in Satisfactory condition with no cracks or spalls. The pipe at the inlet had moderate rust and was obstructed with sediment and leaves.

Outlet: The outlet has poorly vegetated embankments in Fair condition due to minor vegetation overgrowth. The concrete headwall appeared to be in Satisfactory condition with no cracks or spalls. The pipe at the outlet was in Poor condition with separation between joints, significant vertical misalignment, moderate rust, but was unobstructed.

Recommendations
Potential repair options include re-grading the embankment, scour protection, and excavation to reset the misaligned pipe sections.




Road over Culvert


Culvert Inlet


Culvert Outlet

Culvert Information

Height (in)	Width (in)	Length (ft)	Type	Shape	Scour Level	Obstruction Type	Structure Condition	Culvert Notes
16	16	29	Other - see notes	Round	None	Sediment and leaves at inlet	Poor	Steel pipe, Separation between joints, moderate rust

Stream and Road Information

Rainfall (in/ past 24 hrs)	Water Flow	Water Level	Culvert Alignment to Stream	Road Name	Road Classification	Culvert Alignment to Road	Culvert Depth Beneath Rd (ft)	Road Condition	Road Width (ft)	Road Surface Type
0	Stagnant	50%	Parallel	Church St	Minor St or Rd	Perpendicular	1.5	Good	21	Asphalt

Headwall Information

Headwall Inlet Type	Headwall Inlet Condition	Headwall Outlet Type	Headwall Outlet Condition	Headwall Notes
Concrete	Satisfactory	Concrete	Satisfactory	

Embankment Information

Embankment Type	Embankment Erosion	Embankment Condition	Embankment Notes
Poorly vegetated	Severe	Poor	Minor vegetation overgrowth

Culvert Risk - 1 (LOW) to 5 (HIGH)

Geomorphic Risk	Hydraulic Risk	Structural Risk	Overall Risk of Failure
2	3	3	3

Other Concerns - 1 (MINIMAL CONCERN) to 5 (FAILING)

Traffic Concern	Disruption Potential	Environmental Concern	Environmental Issues	Notes
3	One-way road in a school zone	2	Low openness ratio	

5. Obstructed Culverts

5.1 List of Obstructions

Below is a list of culverts that were not observed to have significant structural damage, but would greatly benefit from removal of vegetation overgrowth and obstructions within the pipe:

List of Obstructions	
Culvert CU001 – Nowell Farme Rd	Obstructed with leaves and sediment.
Culvert CU003 – Nowell Farme Rd	Obstructed with Sediment. Neighbor reported flooding around culvert.
Culvert CU004 – Nowell Farme Rd	50% obstructed with sediment at the outlet.
Culvert CU011 – River Rd	Obstructed with leaves.
Culvert CU015 – Bedford Rd	Obstructed with minor sediment and large branches at the inlet.
Culvert CU016 – Private Property	No obstruction at inlet, outlet unidentifiable, presumed to be completely buried.
Culvert CU020 – Bedford Rd	Outlet unidentifiable, potentially full of sediment or buried. Stones blocking outlet location.
Culvert CU021 – Maple St	Obstructed with leaves.
Culvert CU022 – Maple St	No structure observed but evidence of ground flow. Culvert may be fully obstructed with sediment and leaves.
Culvert CU023 – Maple St	Obstructions due to beaver activity and broken beaver fence.
Culvert CU033 – Cragie Cir	Obstructed with sediment and leaves.
Culvert CU035 – East Riding Dr	Minor leaves and sediment within the pipe and 1 ft of sediment at the outlet.
Culvert CU036 – Carleton Rd	Sediment obstruction at the outlet and within the pipe. The outlet is half full of sediment.
Culvert CU037 – East Riding Dr	Inlet is 75% full of sediment, full obstruction within the pipe is likely.
Culvert CU043 – East St	Both the inlet and outlet are 75% obstructed with sediment and leaves.
Culvert CU048 – Rutland Rd	Obstructed with sediment, approximately 80% of the pipe is buried.
Culvert CU050 – Patch Meadow Ln	Obstructed with branches and leaves. Vegetation overgrowth at the inlet, no obstructions at the outlet.

Fg 4. Culvert CU109 - Outlet 20% Obstructed

Fg 5. Culvert CU036 - Outlet 50% Obstructed

Fg 6. Culvert CU135 - Inlet 75% Obstructed

Fg 7. Culvert CU139 - Outlet Fully Obstructed

Fg 8. Culvert CU050 - Vegetation Overgrowth

Fg 9. Culvert CU154 - Outlet Blocked by Branches

Culvert CU053 – Patch Meadow Ln	Obstructed with sediment.
Culvert CU054 – Patch Meadow Ln	Tree lodged inside the pipe.
Culvert CU055 – Patch Meadow Ln	Both inlet and outlet are obstructed with branches and leaves.
Culvert CU056 – North Rd	Obstructed with leaves and branches.
Culvert CU058 – North Rd	Minor obstruction due to branches at the inlet.
Culvert CU059 – North Rd	Obstructed with leaves and sediment.
Culvert CU060 – North Rd	Inlet is obstructed with sediment and leaves. Outlet is unidentifiable and is likely buried.
Culvert CU061 – North Rd	Inlet is obstructed with branches and leaves; outlet is obstructed with sediment.
Culvert CU067 – Martin St	Outlet is 75% obstructed with sediment. Catch basin connected to pipe is covered with leaves.
Culvert CU070 – Lowell St	Inlet headwall is collapsed or completely buried. Pipe is obstructed with sediment, leaves, and rocks.
Culvert CU071 – Elizabeth Ridge Rd	Obstructed with sediment, leaves and branches.
Culvert CU073 – Private DPW Rd	Obstructed with sediment and leaves, cannot see through the pipe.
Culvert CU074 – Martin St	Leaves obstructing the inlet.
Culvert CU075 – Fiske St	Inlet 80% obstructed, outlet 20% obstructed with sediment and leaves.
Culvert CU076 – Fiske St	Severe vegetation growth obstructing the outlet.
Culvert CU081 – Hutchins Rd	Obstructed with sediment, leaves, and branches.
Culvert CU082 – Curve St	Obstructed with branches and sediment.
Culvert CU083 – Forest Park Rd	Inlet is 50% obstructed with sediment and leaves.
Culvert CU084 – Evergreen Ln	Fallen tree branches obstructing the outlet. No obstructions inside the pipe.
Culvert CU085 – Evergreen Ln	Outlet is completely obstructed or buried with leaves and sediment.
Culvert CU086 – Carlisle Pines Rd	Pipe is 25% obstructed with sediment and leaves.
Culvert CU087 – West St	Pipe is 50% obstructed with sediment and leaves.
Culvert CU088 – West St	Inlet could not be located, likely completely obstructed by sediment and fallen branches.
Culvert CU094 – Acton St	Pipe is 75% obstructed at the inlet and 90% obstructed at the outlet with sediment.
Culvert CU097 – Westford Rd	There is a log stuck inside the pipe.
Culvert CU098 – Westford Rd	Pipe is 80% obstructed with sediment. Below grade condition at the outlet.

Culvert CU100 – Westford Rd	Pipe is 80% obstructed with sediment and leaves at the inlet. Below grade condition at the outlet.
Culvert CU102 – Westford Rd	Embankment at the inlet has collapsed and is obstructing the pipe.
Culvert CU103 – Westford Rd	Obstructed with sediment.
Culvert CU109 – Judy Farm Rd	Pipe at the outlet is 20% obstructed with sediment.
Culvert CU112 – South St	Obstructed with leaves.
Culvert CU113 – South St	Pipe at the outlet is almost completely obstructed with sediment and leaves.
Culvert CU114 – Private Driveway	Obstructed with sediment and leaves.
Culvert CU117 – Cross St	Minor obstruction of inlet with sediment and leaves, no obstructions at the outlet.
Culvert CU118 – Pedestrian Path	Obstructed with sediment and leaves.
Culvert CU119 – Concord St	Pipe is 30% obstructed at the outlet with sediment.
Culvert CU120 – Autumn Ln	Pipe is 80% obstructed at the outlet with sediment.
Culvert CU121 – Eastbrook Rd	Cannot see through the culvert, obstructed with sediment and leaves.
Culvert CU122 – Robbins Dr	Obstructed with leaves.
Culvert CU123 – Autumn Ln	Pipe is about 10% obstructed with leaves and sediment.
Culvert CU125 – Robbins Dr	Pipe is 40% obstructed with leaves and sediment at the outlet, no obstructions at the inlet.
Culvert CU126 – Russell St	Minorly obstructed with leaves at the inlet, no obstructions at the outlet.
Culvert CU127 – Bellows Hill Rd	Pipe could not be located. Visible headwalls but no signs of pipe, likely buried.
Culvert CU133 – Concord St	Pipe at the outlet is 70% obstructed with sediment, leaves and branches. Property owner had concerns about flooding.
Culvert CU135 – Concord St	Pipe at the inlet is 50% obstructed with sediment and leaves.
Culvert CU136 – Baldwin Dr	Pipe is 15% obstructed with sediment and leaves.
Culvert CU138 – Woodridge Rd	Obstructed with sediment and leaves.
Culvert CU139 – Baldwin Dr	Pipe is completely obstructed with sediment at the outlet.
Culvert CU141 – Baldwin Dr	Pipe at the outlet is completely buried, rocks obstructing pipe at the inlet.
Culvert CU143 – Bedford Rd	No visible culvert pipe, below grade or buried on both sides.
Culvert CU144 – Bedford Rd	Metal grate and bunches of leaves blocking the inlet.
Culvert CU147 – East St	Pipe is 50% obstructed with sediment.
Culvert CU154 – Lowell St	Fallen tree and vegetation growth obstructing outlet.
Culvert CU156 – Private Driveway	Large stones and branches obstructing the outlet.

6. Non-Critical Structurally Deficient Culverts

6.1 Non-Critical Structures

In addition to the 12 critical structures listed in Section 3 and Section 4, Nitsch identified 32 culverts with notable structural deficiencies that were not considered critical due to their opening sizes, location, or the type of structural damage observed. For example, a 12” diameter culvert on a Local Road may have received a Poor condition rating, but due to its size and location was deemed non-critical. Below is a list of non-critical structures that would benefit from less urgent structural repair or replacement, along with a brief description of the observed conditions:

List of Obstructions	
Culvert CU009 – River Rd	12” corrugated metal pipe in poor condition due to rust and section loss
Culvert CU010 – River Rd	12” CMP in poor condition due to rust and section loss
Culvert CU012 – River Rd	Stone headwall at outlet is failing with collapsed stones
Culvert CU015 – Bedford Rd	28” round CMP in Poor condition due to rust and section loss, with stone headwalls in Poor condition due to missing or collapsed stones.
Culvert CU016 – None	24” round CMP in Poor condition due to rust and section loss.
Culvert CU020 – Bedford Rd	Failing outlet stone headwall due to headwall stones collapsing and unrecognizable outlet. Headwalls stones potentially blocking barrel, or barrel is completely buried.
Culvert CU021 – Maple St	Poor stone headwalls due to missing and collapsed headwall stone. Poor embankments due to moderate erosion, sediment seeping over headwalls, and vegetation overgrowth.
Culvert CU022 – Maple St	No discernible culvert structure, but there is a stone headwall at the outlet location and evidence of ground flow. It is possible that the culvert has collapsed.
Culvert CU028 – East St	48” round CMP in Poor condition due to rust and minor section loss on the bottom half of the pipe.
Culvert CU033 – Craigie Cir	16” round CMP in Poor condition due to rust and section loss and the inlet and outlet. No headwalls.
Culvert CU037 – East Riding St	18” round CMP in Poor condition due to rust.
Culvert CU047 – Rutland St	Failing inlet stone headwall due to significant missing stones. Embankment in poor condition due to erosion.
Culvert CU052 – Rutland St	Failing outlet stone headwall due to missing or collapsed stones. Embankment in poor condition due to vegetation overgrowth. Traffic barriers leaning away from the road.
Culvert CU053 – Patch Meadow Ln	Failing inlet stone headwall due to collapsed stones. Pipe in poor condition due to moss growth.

Fg 10. Culvert CU015 - Rust and Section Loss

Fg 11. Culvert CU073 - Spalling Pipe

Fg 12. Culvert CU061 - Section Loss

Fg 13. Culvert CU047 - Missing Headwall Stones

Culvert CU061 – North Rd	32” round CMP in Poor condition due to rust and section loss at the bottom of the pipe.
Culvert CU067 – Martin St	16” round CMP in Poor condition due to moderate deformation at the outlet. Stone headwall at the outlet also in Poor condition due to collapsing stone.
Culvert CU070 – Lowell St	12” round CMP in Poor condition due to rusting and section loss at the inlet. Failing stone headwall at the outlet due to collapsed stones covering outlet. Pipe at outlet is unrecognizable.
Culvert CU073 – Private DPW Road	Failing headwalls at both the inlet and outlet due to eroded soil and tree roots growing through the headwalls. 24” round RCP in Poor condition due to moderate spalling inside the pipe.
Culvert CU083 – Forest Park Rd	24” Round CMP in Poor condition due to rust and section loss. Stone headwall at inlet in Poor condition due to missing and collapsed stones, and sedimentation and vegetation overgrowth seeping over the wall.
Culvert CU087 – West St	12” round CMP in Poor condition due to rust. Embankments in poor condition due to erosion.
Culvert CU094 – Acton St	Stone headwall at the inlet in Poor condition due to missing stones.
Culvert CU098 – Westford Rd	Stone headwall at the outlet is Failing due to collapsed headwall stones covering the inlet.
Culvert CU102 – West St	Embankment at inlet in Failing condition. Sediment and vegetation overgrowth have collapsed over the inlet pipe.
Culvert CU112 – South St	16” round CMP in Poor condition due to rust and section loss at the outlet.
Culvert CU114 – Private Driveway	30” round CMP in Poor condition due to rust and section loss at the inlet.
Culvert CU115 – South St	16” round CMP in Poor condition due to rust and major section loss at the bottom of the pipe at the outlet.
Culvert CU122 – Robbins Dr	16” round CMP in Failing condition due to severe rust and section loss.
Culvert CU127 – Bellows Hill Rd	Stone headwall in Failing condition due to collapsed stones at the inlet. No visible pipe under either headwall, possibly collapsed.
Culvert CU133 – Concord St	12” round CMP in Failing condition due to major rust and section loss at the outlet.
Culvert CU137 – Woodridge Rd	16” round CMP in Poor condition due to severe rust and section loss at the outlet. Mortared stone headwall in Poor condition at the outlet due to voids in mortar, missing stones, and moss growth.
Culvert CU138 – Woodridge Rd	12” round CMP in Poor condition due to moderate rust and section loss at the outlet.
Culvert CU141 – Baldwin Rd	Stone headwall at the inlet in Poor condition due to collapsed stones covering the inlet. Embankment in Failing condition and has collapsed over the outlet.
Culvert CU144 – Bedford Rd	36” round CMP in Poor condition due to moderate rust and significant section loss in the bottom of the pipe at the inlet and outlet. No observed section loss inside the pipe.
Culvert CU154 – Lowell St	Embankment at the outlet in Failing condition due to severe erosion of the stream banks past the outlet, severe vegetation overgrowth, and fallen trees.

7. Repair Recommendations

Repair techniques vary for culverts based on the level of structural risk or obstruction that the culvert exhibits. Routine maintenance is the lowest level of effort, generally used for low-structural-risk culverts with obstructions or vegetation overgrowth. Structural replacement is the highest level of effort, reserved for high-structural-risk culverts where the existing structure is unsalvageable. Below are descriptions of each level of maintenance and repair techniques that are commonly used.

7.1 Culvert Cleanout, Clearing, and Routine Maintenance

Routine maintenance is used for culverts that have a low structural risk but are obstructed or where vegetation overgrowth has destabilized the embankments. Common repairs for routine maintenance include:

- Clearing brush and overgrowth, and seeding embankments to improve stability.
- Removing branches, sediment and obstructions from culvert pipes to improve water flow. Obstructions such as sediment and leaves within culvert pipes are often removed by jet blasting water through the pipe. Larger obstructions such as logs and tree branches may need to be removed manually.
- Restacking stones and pointing mortar for stone headwalls.

7.2 Structural Repair

Structural repair is used for culverts that have a medium to high structural risk. Typically, this applies to culverts where the structural risk is concentrated at the embankments or headwalls instead of the pipe itself. If the culvert pipe is damaged but has a large hydraulic opening, structural repairs may also apply. Common structural repair techniques include:

- Spin cast lining culvert pipes, which involves spraying concrete throughout the inside of the pipe using a spinning nozzle to avoid disruption of the road above. This option lessens the hydraulic opening of the pipe and may not be possible for smaller diameter pipes.
- Headwall repairs: repairing spalls and cracks, resetting headwalls that are sliding or rotating, restacking stone headwalls.
- Full headwall replacement. If the condition of the headwall is unsalvageable, but the condition of the pipe is fair to satisfactory, replacing only the headwall may suffice. This option is often of similar cost to repairing large spalls in concrete walls.
- Re-grading embankments and seeding to minimize erosion.
- Excavating and resetting misaligned pipes.

Fg 14. Culvert Cleaning & Vegetation Removal (© HCL)

Fg 15. Embankment Repair (© Geosynthetica)

Fg 16. Spin Cast Lining (© National Plant Services)

Fg 17. Weston Culvert Replacement (© Wright-Pierce)

7.3 Structural Replacement

Structural replacements are reserved for culverts with high structural risk where most of the structure, specifically the pipe itself, is failing or unsalvageable. This technique is the most disruptive to traffic and typically the most expensive option. Structural replacements for culverts include:

- Road closure.
- Excavation of the existing culvert.
- Placement of a new pipe and headwalls.
- Grading and re-vegetating embankments.
- Repaving the road.

There are two types of structural replacements: emergency replacements, and full design replacements. Emergency replacements are reserved for culverts that have already failed or are on the verge of failure. If a culvert is deemed to be in a state of emergency, the permitting and design processes can be expedited. Often, emergency replacements are temporary and are required to be followed by a fully designed replacement unless they can be shown to be structurally and hydraulically adequate. Full design replacements have more in-depth permitting and design processes, and usually require design phase services, borings, and hydraulic analyses.

8. Capital Investment Analysis

8.1 Yearly, Low-Cost Maintenance

Yearly routine cleanout and clearing is recommended for obstructed culverts to ensure proper operation and prevent flooding. A full list of culverts which are currently obstructed is presented in Section 5.1. It is likely that these culverts are most susceptible to sedimentation and obstructions, and will be the same culverts that will routinely require yearly cleanouts. Yearly cleanout and clearing includes work such as jet cleaning obstructed culverts, brush clearing overgrown inlets and outlets, and manual removal of larger obstructions.

Yearly Cost to Clean out Culverts

As mentioned above, the common technique for cleaning out obstructed culverts is jet blasting water through the pipe. The estimated cost of a high-pressure water jet is $1,000 per day. From the assessment data, the total count of obstructed culverts is 71 culverts (see Section 5.1 above for the full list of obstructions). At an estimated rate of 4 culverts per day, the total jetting time is approximately 19 days, with **a cost to clean out culverts of approximately $19,000.**

Yearly Cost of Removing Sticks and Branches, and Clearing Vegetation Overgrowth

In addition to sediment and leaves within culvert pipes, some culverts had sticks, branches, and other types of obstructions crowding the inlets and outlets of the pipes. Many of these culverts require brush clearing at the inlets and outlets to provide access for clearing and jetting. Routinely clearing brush at inlets and outlets is also considered good practice for establishing vegetated slopes and stabilizing the embankments. Clearing brush and removing obstructions can be performed with a crew of 3 laborers, conservatively. Assuming this clearing is done in conjunction with the culvert jetting, the time to complete the clearing totals 19 days, or 3.8 weeks. From RS Means data, the weekly rate for a general-purpose laborer is approximately $2,800. **The total cost to clear vegetation overgrowth and remove sticks and branches is approximately $31,920.**

A yearly budget of $51,000 should be allocated for the cleanout and clearing of the town's culverts.

8.2 Routine Maintenance and Repairs (Anticipated in the Next 10 Years)

Maintenance of Non-Critical Culverts

32 of the culverts (see Section 6.1 above) that Nitsch assessed were observed to have embankment, headwall, and/or pipe conditions of Poor or worse. As described in Section 6, these structures were deemed "non-critical" due to their size or location. Nitsch recommends routine maintenance or repairs be performed on these structures within the next 10 years to extend their overall service life, and reduce the likelihood of structural or hydraulic failure. Generally, these repairs consist of patching spalls in concrete headwalls and pipes, resetting or repointing of stone headwalls, patching corrosion holes in steel pipes, and minor regrading or stabilization of embankments. Additionally, we recommend the inspection of these culverts again in three to five years to confirm that their condition has not become critical. The average 2025 cost of routine maintenance or repairs for these culverts is approximately $30,000 per culvert. The 2025 cost of inspection and updated GIS data is

approximately $90,000. The total cost to perform all the recommended routine maintenance and repairs for all 32 culverts in 2025 would be approximately $960,000. Amortizing these costs over 10 years, and including inflation, **Nitsch recommends allocating $118,000 per year over the next ten years for the routine maintenance and inspection of these structures.**

Additional culverts that are currently in satisfactory condition may transition to poor, or worse, in the next ten years and this number is subject to increase based on the rate at which other culverts are added to this list.

8.3 Primary Repairs or Replacements (Anticipated in the Next 5 Years)

Nitsch recommends that four of the twelve high risk culverts (referred to as “primary critical culverts”) be addressed within the next five years, including: CU026, CU044, and CU146 on East St; CU041 on Tophet Rd (see Section 3 for full assessment details).

Headwall Replacement and Embankment Re-grading

Two of the primary critical culverts were observed to have headwalls in unsalvageable condition and embankments in need of re-grading and erosion control. The primary culverts in need of headwall replacement or embankment re-grading include: CU044 inlet/outlet and CU146 outlet. The cost for headwall replacement and embankment re-grading, including excavation of the headwall and embankment, placement of a new headwall, and erosion control is approximately $150,000 per culvert end. At a cost of approximately $150,000 per culvert end, **the total 2025 cost to replace headwalls and re-grade embankments of the primary critical culverts is $450,000.**

Structural Culvert Replacement

Full structural replacement is the most expensive repair option. If failure of the existing culvert occurs, replacement consists of a temporary emergency replacement followed by a fully designed permanent replacement. If replacement occurs before failure, the temporary emergency replacement can be avoided. Nitsch performed an emergency replacement of culvert CU151 in 2024. The replaced Culvert CU151 is a 30” round reinforced concrete pipe, with concrete headwalls, and rip rap embankments. Based on the design fee and bid data for this replacement, **the total cost for a temporary emergency replacement of a culvert of similar size is approximately $190,000.** For culverts requiring larger opening, the cost of construction will increase. **The total cost for a permanent full design replacement of a culvert of similar size is approximately $380,000.**

Two of the primary critical culverts are candidates for full structural replacement: CU026, CU041. If these culverts are replaced before failure occurs, they would not need a temporary emergency replacement and could proceed as a permanent full design replacement, **the total cost to replace these culverts is approximately $760,000.**

Total Cost of Primary Repairs

The total 2025 cost to repair or replace the four primary critical structures identified in this report is approximately $1,210,000. Nitsch recommends that the Town of Carlisle perform the recommended repairs for these culverts within the next five years. Amortizing these costs over five years, and including inflation, **Nitsch recommends that the Town budget $261,000 per year over the next five years for the repair or replacement of the four primary critical structures.**

8.4 Secondary Repairs or Replacements (Anticipated in the 6 to 13 Years)

Nitsch recommends that the remaining eight high risk culverts (referred to as “secondary critical culverts”) be addressed within the eight years after the four primary culverts are addressed. Secondary critical culverts include: CU018 and CU019 on Bedford Rd, CU031 on Brook St, CU063 on Curve St, CU099 on Westford St, CU107 on South St, CU130 on Concord St, and CU145 on Church St (see Section 4 for full assessment details).

Headwall and Embankment Repair

Four of the secondary critical culverts were observed to have moderate defects in concrete and stone headwalls, including spalling and cracking, and collapsing or missing stones. The embankments of these culverts also had moderate to heavy vegetation overgrowth in need of clearing and seeding for stabilization. The culverts in need of headwall/embankment repair include: CU018 inlet, CU019 inlet, CU031 inlet/outlet, CU130 outlet. At a cost of approximately $50,000 per culvert end, **the total 2025 cost for repairing headwalls and embankments of the secondary critical culverts is $250,000.**

Headwall Replacement and Embankment Re-grading

Five of the secondary critical culverts were observed to have headwalls in unsalvageable condition. Some of these culverts also had embankments in need of re-grading and erosion control. The culverts in need of headwall replacement or embankment re-grading include: CU018 outlet, CU019 outlet, , CU099 inlet/outlet, CU130 inlet, and CU145 inlet. The cost for headwall replacement and embankment re-grading, including excavation of the headwall and embankment, placement of a new headwall, and erosion control is approximately $150,000 per culvert end. At a cost of approximately $150,000 per culvert end, **the total 2025 cost to replace headwalls and re-grade embankments of the secondary critical culverts is $900,000.**

Excavation and Resetting of Misaligned Culverts

One of the secondary critical culverts, CU145, was observed to have significant vertical misalignment of a pipe section on the outlet side. **The total cost to excavate and reset the misaligned pipe is approximately $150,000.**

Spin Cast Linning of Culvert Pipes

One of the secondary critical culverts, CU031, was observed to have structural damage inside the pipe that may be possible to be repaired with spin cast lining. **The total cost to spin cast line one culvert pipe is approximately $50,000.**

Structural Culvert Replacement

Full structural replacement is the most expensive repair option. If failure of the existing culvert occurs, replacement consists of a temporary emergency replacement followed by a fully designed permanent replacement. If replacement occurs before failure, the temporary emergency replacement can be avoided. Nitsch performed an emergency replacement of culvert CU151 in 2024. The replaced Culvert CU151 is a 30” round reinforced concrete pipe, with concrete headwalls, and rip rap embankments. Based on the design fee and bid data for this replacement, the **total cost for a temporary emergency replacement of a culvert of similar size is approximately $190,000.** For culverts requiring larger opening, the cost of construction will increase. **The total cost for a permanent full design replacement of a culvert of similar size is approximately $380,000.**

Two of the secondary critical culverts are candidates for full structural replacement: CU063, and CU107. If these culverts are replaced before failure occurs, they would not need a temporary emergency replacement and could proceed as a permanent full design replacement, **the total cost to replace these culverts is approximately $760,000.**

Total Cost of Secondary Repairs

The total 2025 cost to repair or replace the eight secondary critical structures identified in this report is approximately $2,110,000. Nitsch recommends that the Town of Carlisle perform the recommended repairs for these culverts within the next 13 years, after the primary repairs have been addressed. Amortizing these costs over eight years starting in 2030, and including inflation, **Nitsch recommends that the Town budget $297,000 per year for the repair or replacement of the eight secondary critical structures.**

Summary of Capital Investment Cost Estimates	
Repair or Mainteneance Type	**Anticipated Cost per Year**
Culvert Clean Out and Clearing (ongoing)	$31,920
Maintenance of Non-Critical Culverts (ongoing)	$118,000
Repairs to Primary Critical Culverts (next 5 years)	$261,000
Repairs to Secondary Critical Culverts (next 6-13 years)	$297,000

Table 2. Summary of Capital Investment Cost Estimates

8.5 Grant and Funding Sources for Culvert Replacement

Nitsch researched relevant grant opportunities to determine potential funding streams for the Town to pursue, summarized in the following matrix. Based on the anticipated culvert-related needs the Town may submit for grant support, Nitsch has provided a general alignment score for each respective grant opportunity, ranging from high alignment to not aligned. This alignment score is based on the amount of funding allocated to the grant program, eligible activities, and grant program priorities.

The matrix also lists the typical season for each grant deadline and the most recent application deadline in *italics*. Due to annual funding variability, the Town should monitor grant agencies for updates and changes.

Grant Program	Grant Administering Agnecy	Projected Application Due Date	Alignment	Notes
Small Town Road Improvements to Enhance Public Safety (STRAP) Grant (Within the MassWorks Infrastructure Program)	Massachusetts Executive Office of Economic Development (EOED)	Application due in late Spring (*June*)	High	EOED offers the STRAP grant through the Rural Development Fund (RDF), which provides funding specifically to municipalities with a population density of 500 persons per square mile or a total population less than 7,000. The STRAP grant may be used to fund the design, engineering, permitting and construction of road improvements, including projects that address public safety concerns, such as dangerous road conditions or imminent collapse of a culvert. Grants in this category are typically between $50,000 and $500,000. Unlike other infrastructure grants under the MassWorks Infrastructure Program, the STRAP grant is not directly tied to private investment, making the funding opportunity well aligned with the Town's needs.
Municipal Vulnerability Preparedness (MVP) Action Grant	Massachusetts Executive Office of Energy and Environmental Affairs (MA EEA)	Application due in Spring (*April*)	Moderate/High	The MVP grant provides funding to communities that seek to advance priority climate adaptation actions to address climate change impacts. Projects eligible for funding under the MVP grant include planning, design, permitting, construction, and on-the-ground implementation. Previous cycles of the MVP Grant Program have funded various culvert projects, including planning assessments, design, and construction; in Nitsch's experience, culvert-related projects funded by the MVP program often incorporate environmental design standards for flood resiliency, innovative nature-based approaches, or extensive community engagement processes. The MVP grant program prioritizes projects that increase equitable outcomes for Environmental Justice populations, build community capacity, conduct robust community engagement, employ innovative or nature-based solutions utilizing climate change data, or incorporate regional solutions. Individual projects can request up to $3 million, while regional projects can request up to $5 million. The 2026 Fiscal Year MVP grant cycle includes dedicated funding for rural and small communities, like the Town of Carlisle, and waives match requirements for these communities.
Culvert Replacement Municipal Assistance (CRMA) Grants	Massachusetts Division of Ecological Restoration	Application due in early Spring (*March*)	Moderate	The CRMA grant program provides funding to municipalities for the design and construction of culvert replacement projects located in areas of high ecological value and intent for the replacement culvert to meet improved structural and environmental design standards for flood resiliency. Some of the culverts assessed in this project, particularly those located on perennially flowing streams and waterways, would be eligible for DER Culvert Replacement Grants. Grants are competitively awarded to applicants whose culvert replacement projects show the highest ecological value. Winning projects are generally in areas of high ecological value, that intent to restore natural stream flow, improve wildlife or fish passage, and meet the latest Stream Crossing Standards. DER does consider whether a culvert poses a public safety risk when awarding grants, but it is not a primary consideration, and the project must show some other aspects of improvement to ecological value.

Table 3. Grant and Funding Sources Matrix

Grant Program	Grant Administering Agnecy	Projected Application Due Date	Alignment	Notes
(*continued*) Culvert Replacement Municipal Assistance (CRMA) Grants	(*continued*) Massachusetts Division of Ecological Restoration	(*continued*) Application due in early Spring (*March*)	(*continued*) Moderate	(*continued*) DER does not generally pay the full cost of design or construction; the grants are meant to be an incentive for municipalities to consider investing in more ecological solutions for their planned culvert replacements. DER anticipates that other funding will be required to complete the project and often requires applicants to report other known sources of funding. Winning projects are given a list of design tasks which must be met by the designer or record. These tasks typically include design performed by a licensed engineer, a wetland survey by a certified wetland scientist, geotechnical investigation including soil borings, hydraulic analysis by a hydraulic engineer, and that the proposed structure meet the Stream Crossing Standards to the greatest extent possible. Culverts that meet the Stream Crossing Standards are generally three-sided box culverts or arch culverts which provide a natural bottom, which do not constrict the natural flow of the stream, and which provide dry banks for wildlife passage. Pipes and other small four-sided culverts do not meet the Stream Crossing Standard. In Nitsch's experiences, the cost of design and construction of culverts in compliance with the Stream Crossing Standards cost considerably more than a traditional pipe culvert. Often, the additional costs associated with meeting the requirements of a DER Culvert Replacement Grant exceed the amount provided by the grant.
MA Chapter 90 Funding	Massachusetts Department of Transportation (MassDOT)	Annual - Request basis	Moderate	Chapter 90 is a funding program administered by MassDOT annually that provides municipalities with funding for improvements and investments to local transportation systems, including culvert projects. Chapter 90 funds may only be used for projects on locally owned or accepted roadways (i.e. private ways or MassDOT-owned roads are not eligible). Funding is distributed to municipalities across the Commonwealth based on a proportional formula that considers local road mileage, population, and employment. Chapter 90 funds can be used for construction, preservation, and improvement projects that create or extend the life of capital facilities. Eligible Chapter 90 costs include construction, equipment, and consultant services, including conducting surveys or assisting with environmental permitting. Additionally, municipalities must work with a MassDOT State Aid Engineer (SAE) to utilize Chapter 90 funding on eligible transportation projects. When a municipality identifies a project for which it intends to use Chapter 90 funds, the initial step is to submit a Project Request to MassDOT. This request is submitted online via the Massachusetts Project Intake Tool (MaPIT) that collects comprehensive information about the proposed project, including the scope of work, location, cost, and environmental data. Generally, projects receive approval between one and three weeks.
Building Resilient Infrastructure and Communities (BRIC) Grant	FEMA/Massachusetts Emergency Management Agency (MEMA)	Sub-application due in early spring (*March*)	Moderate	The BRIC grant program is a competitive annual FEMA Hazard Mitigation Assistance Grant funded by FEMA and administered through a partnership with MEMA. Typically, funds are allocated to each state, and municipal governments are "sub-applicants" to their respective state emergency management agency. Statewide, Massachusetts receives $2 million in BRIC funding to allocate to sub-applicants. The BRIC grant funds hazard mitigation projects, which are designed to increase resilience and public safety, reduce injuries and loss of life, and reduce damage and destruction to property, critical facilities, and infrastructure from the impacts of natural hazards. The intent of BRIC grant program is to shift the focus of federal investments away from reactive, post-disaster spending and to encourage proactive investments to bolster resilience. The BRIC grant prioritizes innovative, risk-informed hazard mitigation projects, such as multi-hazard resilience or nature-based solutions.

Table 3. Grant and Funding Sources Matrix (Continued)

Grant Program	Grant Administering Agnecy	Projected Application Due Date	Alignment	Notes
Public Infrastructure to Support Commercial/ Industrial Growth and Public Infrastructure to Support Mixed-Use Development (Within the MassWorks Infrastructure Program)	EOED	Application due in late Spring (*June*)	Moderate/Low	Grants within the MassWorks Infrastructure category fund improvements to infrastructure that support and encourage private investment in the community, primarily commercial and mixed-use developments. Eligible activities include design, engineering, permitting, and construction for road improvements, including culvert projects. Projects that support and/or facilitate new growth are most competitive in this category, making it less aligned than other grant opportunities for the Town of Carlisle. Grants in this category are typically between $50,000 and $500,000.
Hazard Mitigation Grant Program (HMGP)	MEMA	Sub-application due in early Winter (*December*)	Low	The HMGP grants provide funds to assist state agencies, local governments, federally-recognized tribes, and certain non-profit organizations to implement long-term, all-hazards related mitigation measures after a major disaster declaration. Similar to the BRIC grant, funds are allocated to each state, and municipal governments are “sub-applicants” to their respective state emergency management agency. The HMGP is not intended to fund repair, replacement, or deferred maintenance activities. While HMGP grants could be used to fund culvert improvements following a major hazard, Nitsch Engineering recommends that the Town pursue alternative funding opportunities to proactively address necessary culvert repairs, upgrades, and maintenance.
Municipal Small Bridge Program	MassDOT	Application due in Winter (*February*)	Not aligned	The MassDOT Small Bridge Program assists municipalities with the replacement of municipally owned small bridges by providing in-house design services and overseeing construction. The program only aids with the replacement of “BRI” designated bridges, which are bridges or culvert structures that have a span length between 10 feet and 20 feet. None of the culverts assessed by Nitsch Engineering as part of this assignment met these criteria and would not be eligible for aid from the MassDOT Small Bridge Program.
National Culvert Removal, Replacement, and Restoration Grants	Federal Highway Association (FHA)	Application due in early Fall (*September*)	Not aligned	The National Culvert Removal, Replacement, and Restoration Grant Program (Culvert Aquatic Organism Passage (AOP) Program) is a competitive grant program that awards grants to eligible entities for projects for the replacement, removal, and repair of culverts or weirs that meaningfully improve or restore fish passage for anadromous fish (i.e. describes fish born in freshwater who spend most of their lives in saltwater and return/migrate to freshwater to spawn). None of the culverts assessed by Nitsch as a part of this assignment meet these criteria avnd would not be eligible for aid from the program.

Table 3. Grant and Funding Sources Matrix (Continued)

Alternate Funding Opportunities

To supplement potential grant funding, the Town could also consider pursuing a Congressional Earmark from the Town’s representatives. Congressionally directed spending (CDS) is designed to provide one-time funding to high-impact, community-based projects in Massachusetts and is typically allocated to a specific project in a specific location. CDS requests are discretionary and are authorized via a provision written into an appropriations bill. These requests are typically due in early Spring (late March/early April)..


© Town of Carlisle

9. Conclusions

Nitsch Engineering took inventory and assessed 157 culverts across the Town of Carlisle. Most structures were given a “Fair” or better assessment, however 44 of these structures received “Poor” or worse assessments and were analyzed further for risk based on location and attributes. Twelve culverts were deemed to be in “critical condition” and pose a significant risk to town infrastructure if failure were to occur.

Recommendations and estimated costs for repairs and replacements of the critical culverts can be found in previous sections of this report. The cost of routine maintenance of obstructed and non-critical structures was also provided. Nitsch recommends that the Town of Carlisle address the repair of primary critical structures over the next five years, and the maintenance and inspection of secondary and non-critical structures over the next fifteen years.