Stream Continuity – Technical Review Checklist for Meeting the MA Stream Crossing Standards for Non-Coastal Stream Crossing Retrofits

FIELD DATA COLLECTION AND STRUCTURE SELECTION

Version - June 2024

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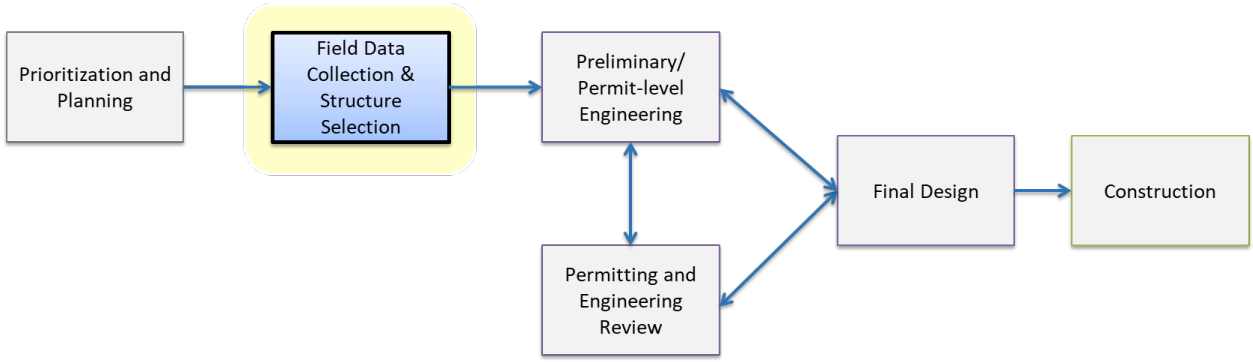
INTRODUCTION

Intended Purpose of this Review Checklist

This internal tool was developed by the Massachusetts Division of Ecological Restoration (DER) to provide consistent review of deliverables received as part of ongoing DER funded culvert/small culvert/bridge replacement and stream restoration projects. During tool development of this checklist DER realized it may be beneficial for this review checklist to be provided to recent grant award recipients and partners to help support ongoing projects. DER intends to incorporate this review checklist into an online toolkit that is currently in development, but we would appreciate receiving comments you have on this checklist at DERculverts@mass.gov with "Field Data Collection and Structure Selection Checklist" in the subject line.

Where Field Data Collection Fits in the Culvert Replacement Process

Field data collection and structure selection are typically the first step in the design process once a culvert has been identified and prioritized for replacement. The diagram below shows the simplified phases of a culvert replacement project. Project development, prioritization, and planning may be necessary before field data collection in order to identify high-priority culverts and develop preliminary funding proposals.



FIELD DATA COLLECTION SUMMARY AND STRUCTURE TYPE SELECTION

The field data collection memo and structure type selection consolidate information gathered from the site investigation, geotechnical evaluation, hydrologic and hydraulic study, and the existing condition topographic survey. We thought it was prudent to start with the "target deliverables" but background on specific tasks are provided in subsequent sections.

Field Data Collection Memo

A written structure recommendation has been completed. A Field Data Collection Memo (i.e., a Design Memo) should include the following details:

- **Summary of Site Characteristics**
  - Existing site conditions and description of how site conditions will impact the project (e.g., design, permitting, and construction)
  - Summary of long profile including vertical adjustment potential (VAP) and potential for erosion and head-cutting
  - Bankfull width measurements
  - Assessment of stream bed material
  - Description of critical infrastructure
- **Summary of Engineering Analyses**
  - Summary of hydrologic and hydraulic analysis (see additional required information under "Hydrologic and Hydraulic Study")
  - Summary of geotechnical analysis (see additional required information under "Geotechnical Evaluation")
  - Traffic analysis (as required or applicable for construction purposes)
- **Summary of Structure Alternatives Analysis**
  - Include explicit recommended structure type and design basis
  - See additional required information under "Structure Alternatives Analysis" above
- **Summary of Proposed Structure**
  - Large scale draft plans (pending scope this may be existing conditions only with sketches for proposed conditions)
  - Conceptual design of streambed
  - Explicitly state whether the proposed design requires Chapter 85 review
  - Recommendations for next steps detailing requirements for final design and permitting (including a list of anticipated permits, ideally with impact thresholds) of a compliant crossing
  - Discussion on anticipated time of year restrictions and potential archeological impacts

Structure Alternative Analysis

A structure alternative analysis has been completed and recommendations have been discussed with the project sponsor(s) and a preferred structure type has been determined. Structure analysis should include discussion on how each alternative meets the following variables of the Massachusetts Stream Crossing Standards:

- **Types of crossings evaluated:** bridges, three-sided box or arch culverts with open bottoms are preferred
- **Embedment:** culverts with a closed bottom should be embedded into the streambed a minimum of 2 feet or 25 percent of the culvert height or diameter, whichever is greater
- **Crossing span:** culvert span should be 1.2 times the stream channel's bankfull width, and at minimum two alternatives meeting or exceeding 1.2 times bankfull width are preferred.
- **Openness:** culvert openness ratio (culvert cross-sectional area divided by culvert length) should be greater than or equal to 0.82 to ensure that the culvert is wide and high relative to its length
- **Substrate:** culvert bottoms should be natural and match the upstream and downstream substrate
- **Water depth and velocity:** water depths and velocities at the culvert are comparable to those in the natural upstream and downstream channels

The structure type selection must also include an explicit recommendation for the preferred structure type and the justification for the selection. Ideally a description of how the following items were taken into account when determine the culvert replacement alternatives is included:

- Site or other engineering design constraints
- Ease of construction
- Structure lifespan
- Potential for erosion and head-cutting based on profile
- Stream stability and risk of stream channel adjustment
- Benefits of upstream and downstream habitat
- Storm flow conveyance
- Geomorphic compatibility
- Impacts to wetlands that can be avoided or would occur with each alternative
- Impacts to trees with diameters greater than 6-inches that can be avoided or would occur with each alternative
- Potential to affect property or infrastructure
- Applicability of local, state, and federal regulations and permit reviews
- Cost of replacement, including order-of-magnitude option of cost

Note: While this information will be included in the field data collection memo, it is recommended for the applicant and DER to have the opportunity to weigh in on proposed conclusions from the structure type selection prior to writing the field data collection memo.

SITE INVESTIGATION (SITE RECONNAISSANCE, STREAM ASSESSMENT, AND RESOURCE DELINEATION)

Field Resource Areas Delineation

Resource areas have been delineated a minimum of 100 feet in each quadrant (along road and stream). Should include, as applicable: Ordinary High Water, Inland Bank, Bordering Vegetated Wetlands, Bordering Land Subject to Flooding, Isolated Land Subject to Flooding, Coastal Resources or Buffers, Local Wetland Buffers). Photographs and field notes of the resource areas have been completed for completion of USACE determination forms, and USACE forms have been prepared.

> ***Note: Buffers, including Riverfront Area, are typically computed in GIS or CAD in the office versus delineated in the field, but all should be shown on the base map/drawings. Many municipalities have specific buffers called out in their local ordinances.***

Reference Reach

Reference reach(es) with similar stream characteristics (e.g., drainage area, watershed slope, and land use) is/are identified outside the influence area of partial or full barriers to natural stream processes. These barriers include the existing culvert structure, nearby dams, berms, other culverts, and/or bedrock outcrops, and their related scour pools, retained waters, or other features that change the stream's dimensions and functions. Longitude/Latitude are recorded and/or the reference reach is marked on survey plans or other figure(s). In addition, at least two photos are taken showing stream characteristics including streambed mix, any larger 'key pieces' and that are present in the stream system or other distinct features.

> ***Note: if a reference reach cannot be identified at the stream the study structure is located, a reference reach can be identified at a nearby reach with similar drainage area, slope, and land cover.***

Streambed Evaluation

Pebble counts have been conducted to represent the gradation of the streambed (if streambed is low-gradient silty soils, pebble count may not apply, and grab samples may be more appropriate that include grain size and hydrometer tests). Pebble counts and/or grab sampling have been completed. Photos taken for the Reference Reach may also include streambed mix of the reference reach, ideally with a measuring tape in frame.

> ***Note: A pebble count should be performed at the reference reach outside the influence of the existing structure or other in-stream barriers.***

The goal of the streambed evaluation is to describe conditions of the stream bed surface layer to design the streambed surface once a new culvert is constructed to support habitat and sediment transport. The stream bed surface typically consists of an armored stream bed layer that is coarser than underlying substrate material. If a scour analysis is required, a scour grab sample is recommend of the stream substrate with the armored layer (typically the top 6-inches of streambed) removed since the bed is anticipated to be mobile during large storm events, and the top of the streambed surface often isn't representative for the majority of the scour depth through the stream substrate.

Bankfull Width Measurements

A minimum of three (3) bankfull width measurements have been conducted both upstream and downstream of the structure (6 total, outside the limits of the existing crossing and within the reference reach). Average these measurements to determine bankfull width. Provide a map (site plan or separate figure) showing the locations of the bankfull width measurements to identify the location and show on long profile and label (for instance, BW01, BW02 etc.).

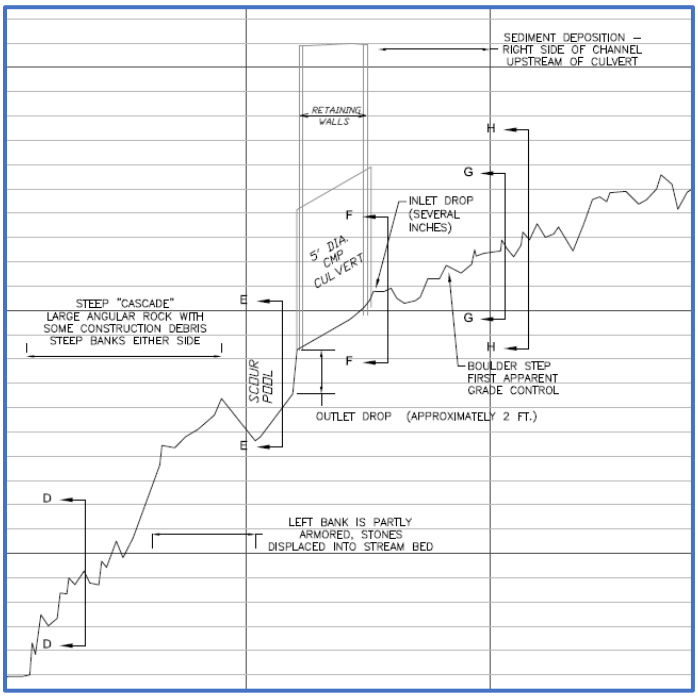
Note: Site conditions including anthropogenic features (e.g., dams and culverts) or natural conditions (e.g., bedrock outcrop or stream confluence) may not allow for natural bankfull width measurements. In these cases only measurements upstream or downstream may be appropriate, and a minimum of three (3) bankfull width measurements are recommended. Typically measurements approximately 10 to 20 bankfull widths away from anthropogenic features are recommended for determining a representative bankfull width.

Graphic: *Bankfull width location map example*

Longitudinal Profile Stream Sketch

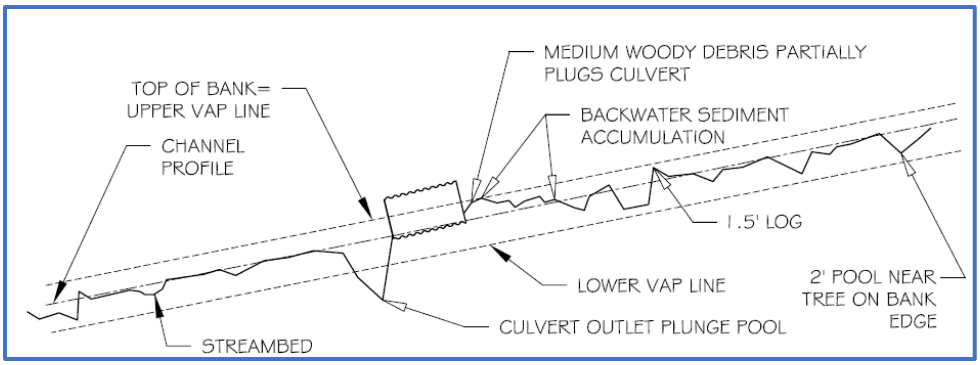
A stream sketch has been conducted within the limits of stream survey of the longitudinal profile ('long profile') for a minimum of 500 feet (300 feet upstream and 200 feet downstream of the crossing). Features such as boulders, step-pools, riffle systems, debris, fallen trees, types of streambed material within stream (i.e. sand, silt, gravel, cobbles, boulders, etc.), and bankfull width measurement locations have been recorded in stream sketch.

Note: While MassDOT does not currently (as of September 2023) require a longitudinal profile, Section 1.1.5 of the LRFD Bridge Manual (available at Bridge Manual - LRFD - Part 1 - Chapter 1 (Section 1.1.5)) recommends extending bathymetry and hydraulic models a minimum of 500 feet upstream and downstream of the crossing, although a frequency of survey points is not specified.



Graphic: *Longitudinal ("long") profile example 1*

The long profile should clearly show scour/pool depths and show the computed the vertical adjust potential (VAP) line following the methodology outlined in Chapter 5 and 6 of the USDA Forest Service Stream Simulation manual, available at Stream Simulation Manual, to compute the anticipated the maximum anticipated aggradation and degradation based on the long profile.



Graphic: *Longitudinal ("long") profile example 2 with Vertical Adjustment Potential (VAP) lines showing maximum anticipated aggradation and degradation (modified from 5.16 of the USDA Forest Service Stream Simulation Manual)*

Desktop Analysis

A desktop analysis has been performed identifying potential designations and habitat that can impact design (e.g., critical habitats, Areas of Critical Environmental Concern, Outstanding Resource Waters, and proximity to Wild and Scenic Rivers).

Roadway Site Reconnaissance

An investigation of the road was performed that documents road fill height/clearance (the distance from the top of the roadway to the streambed), utilities (underground and above ground), stream roadway geometry (approach angle and nearby stream sinuosity), construction access constraints (particularly those impacting equipment), potential staging areas (areas contractors could store equipment and materials during construction), and possible impacts to public or private property (including access).

GEOTECHNICAL EVALUATION

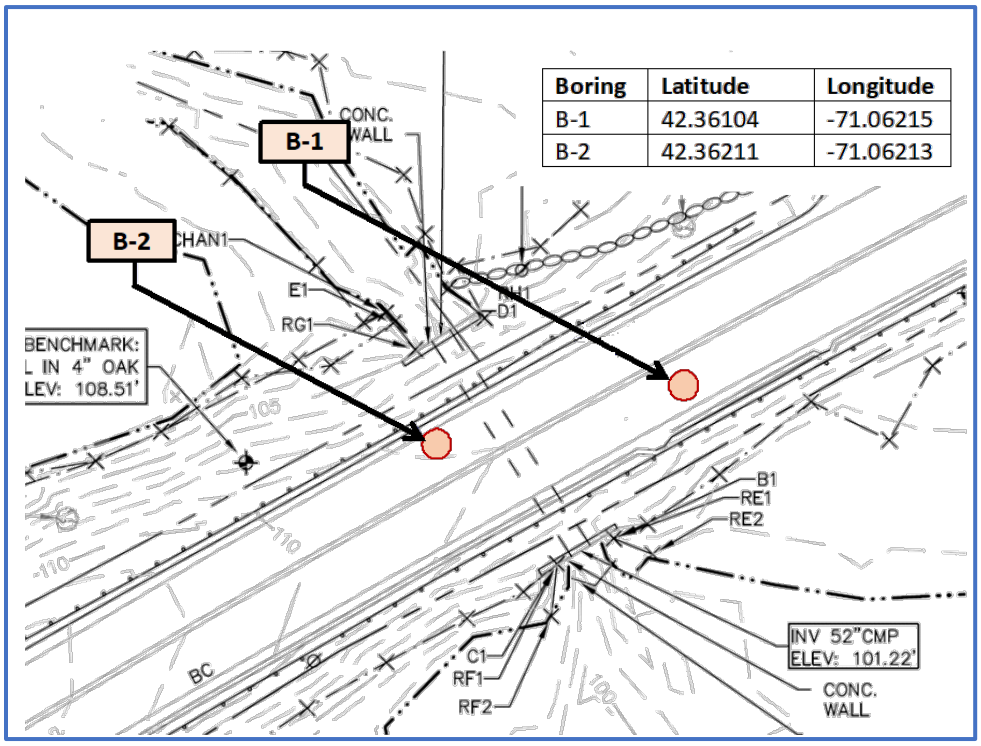
Geotechnical Memo

A geotechnical memo was completed highlighting the findings from all subsurface exploration including determined soil bearing capacity, suitability of soils, impact of water table, likelihood of need for soil amendments, acceptability of shallow foundations versus deep foundation (for three-sided box culvert), etc.

> ***Note: if Chapter 85 Review is expected (see MassDOT BRI Determination, typically a culvert opening of 10 feet or greater), it is recommended to prepare the geotechnical memorandum following the format required in the LRFD Bridge manual, possibly with placeholders for information/analyses to be performed during preliminary design.***
>
> ***Section 1.2 of the LRFD Bridge Manual (available at Bridge Manual - LRFD - Part 1 - Chapter 1 (Section 1.2)) provides a general overview of boring requirements and Section 2.5.2 of LRFD manual (available at Bridge Manual - LRFD - Part 1 - Chapter 2 (Section 2.5.2)) provides the required outline.***

Borings

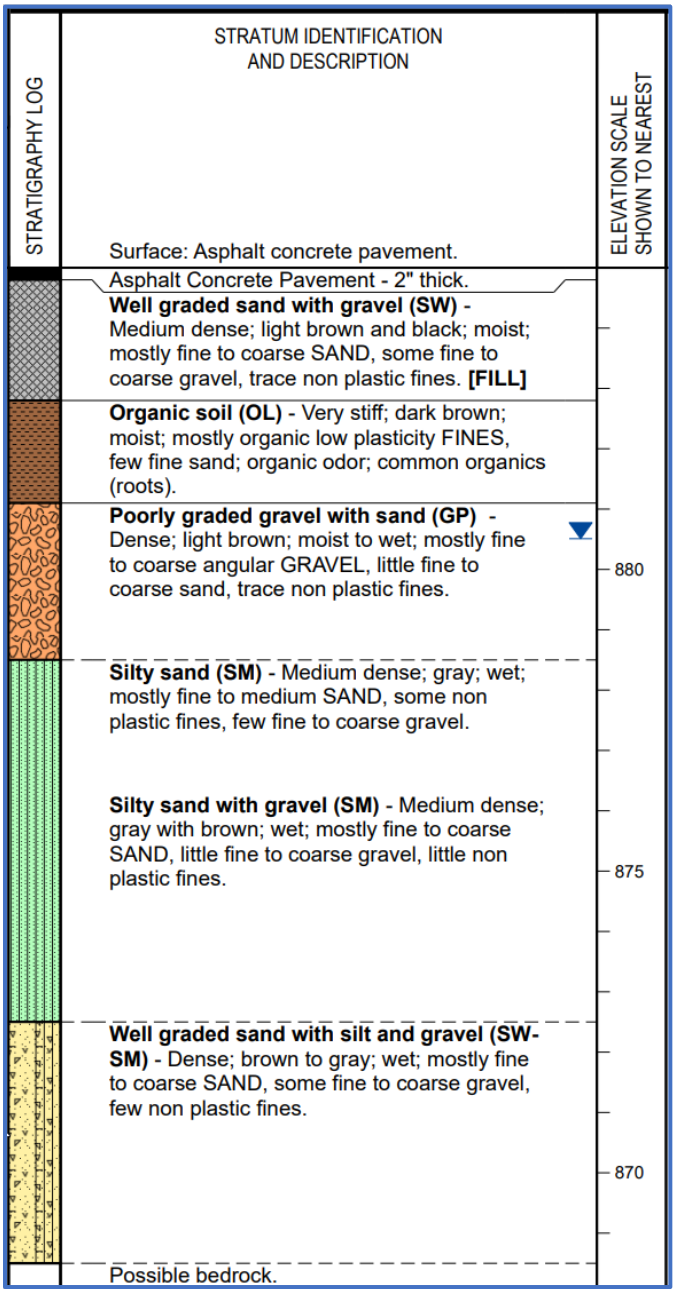
A minimum of two borings located on either side of the replacement structure location (ideally with one boring in each lane although avoiding utilities may dictate location) has been performed. A boring log sketch is included with latitude and longitude coordinates noted.



Graphic: *Boring log sketch example*

Boring Logs

Complete boring logs included. Soil samples were taken every 5 feet for each boring. If bedrock was encountered, at least one 10-foot rock core and sample was collected.



Graphic: *Boring log example*

Soil Samples

Soil samples were sent out for testing and, at a minimum, the following tests were conducted: USCS Classification, Determination of Density (Unit Weight) of Soil Specimens, Particle Size Analysis, Moisture Content of soil and rock, and Atterberg Limits. If bedrock was encountered and a rock core was collected, a Rock Quality Designation (RQD) Test was conducted to determine the quality of rock.

HYDROLOGIC AND HYDRAULIC STUDY

Hydrology and Hydraulics Methods Memo

A Hydrologic and Hydraulic summary/memo has been completed outlining proposed methods for modeling hydrologic and hydraulic existing and proposed conditions **prior** to performing the analysis. DER recommends using at minimum two hydrologic methods to compare flow estimates (e.g., regression and stream gage, or stream gage and rainfall runoff).

Hydrologic and Hydraulic Analysis Summary

A Hydrologic and Hydraulic summary/memo has been completed. This may be included in the Field Data Collection memo or provided in a separate memo or report.

> ***Note: If Chapter 85 Review is expected (see MassDOT BRI Determination, typically a culvert opening of 10 feet or greater), it is recommended to prepare a Hydraulic Design Report following the format required in the LRFD Bridge manual. Note: If Chapter 85 Review is expected (see MassDOT BRI Determination, typically a culvert opening of 10 feet or greater), it is recommended to prepare a Hydraulic Design Report following the format required in the LRFD Bridge manual, possibly with placeholders for information/analyses to be performed during preliminary design.***
>
> ***Section 1.3 of the LRFD Bridge Manual (available at Bridge Manual - LRFD - Part 1 - Chapter 1 (Section 1.3)) provides a general overview of requirements and Section 2.6.2 of LRFD manual (available at Bridge Manual - LRFD - Part 1 - Chapter 2 (Section 2.6)) provides the required outline.***

Hydrology and Hydraulic (H&H) Model

A Hydrology and Hydraulic (H&H) model of the existing stream has been prepared. This includes running the model to determine peak flows and water surface elevations of the stream under existing and proposed conditions. Hydrologic methods to estimate flood flows include, but are not limited to: TR-55, Bulletin 17C Gage Analysis, Regional Regression Equations, etc. Two common hydraulic models for culvert and small bridge design are the U.S. Army Corps of Engineers HEC-RAS modeling software and SRH-2D modeling software.

Modeled Storms

The following frequency storm events were modeled during the H&H evaluations: 50%, 20%, 10%, 4%, 2%, and 1% Annual Exceedance Probability (also known as the 2-Year, 5-Year, 10-Year, 25-Year, 50-Year, 100-Year). The 0.5% and/or 0.2 % AEP(200- and/or 500-year frequency storm event) may be required if MassDOT Chapter 85 is required (see ***MassDOT BRI Determination***, typically a culvert

opening of 10 feet or greater) depending on the roadway functional classification, as shown in Table 1.3.4-1 of the LRFD Manual (available at **Bridge Manual - LRFD - Part 1 - Chapter 1 (Section 1.3.4)**).

Climate change should be included in the analysis during these initial project phases.

Determine FEMA SFHA

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for the study area is discussed. If the site is located within or in proximity to a FEMA Special Flood Hazard Area (SFHA) (Zone A, AE, X, etc.) a copy of the FIRM or FIRMette (reduced version of the FIRM) is provided.

FEMA Requirements

If applicable, FEMA requirements have been met:

- Document "no increase ("no rise") in the Base Flood Elevation (BFE) (an increase of 0.00 or less)
- If a rise of 0.01 feet or greater is anticipated, either the net cut fill needs to be modified to reduce the rise or it will be necessary to prepare a Conditional Letter of Map Revision (CLOMR) prior to construction and a Letter of Map Revision (LOMR) post construction. If a CLOMR is required, the appropriate costs and timelines need to be included.

EXISTING CONDITIONS TOPOGRAPHIC SURVEY

Benchmarks

Permanent benchmarks (minimum of 2) have been established in X ("easting"), Y ("northing"), and Z (elevation) directions with datums clearly described.

Roadway Features

Detailed topographic survey of roadway features has been completed. This includes: edge of pavement, roadway centerline, existing guardrail, sign posts, utility poles, etc.

Boring Locations

Boring Locations are included in the base map.

Utilities

If applicable, onsite utilities and all utility poles have been surveyed and are included in the base map.

Existing Structure

Existing structure features surveyed including the headwalls and wingwalls, inverts upstream and downstream, the span of the structure, and the rise of the structure.

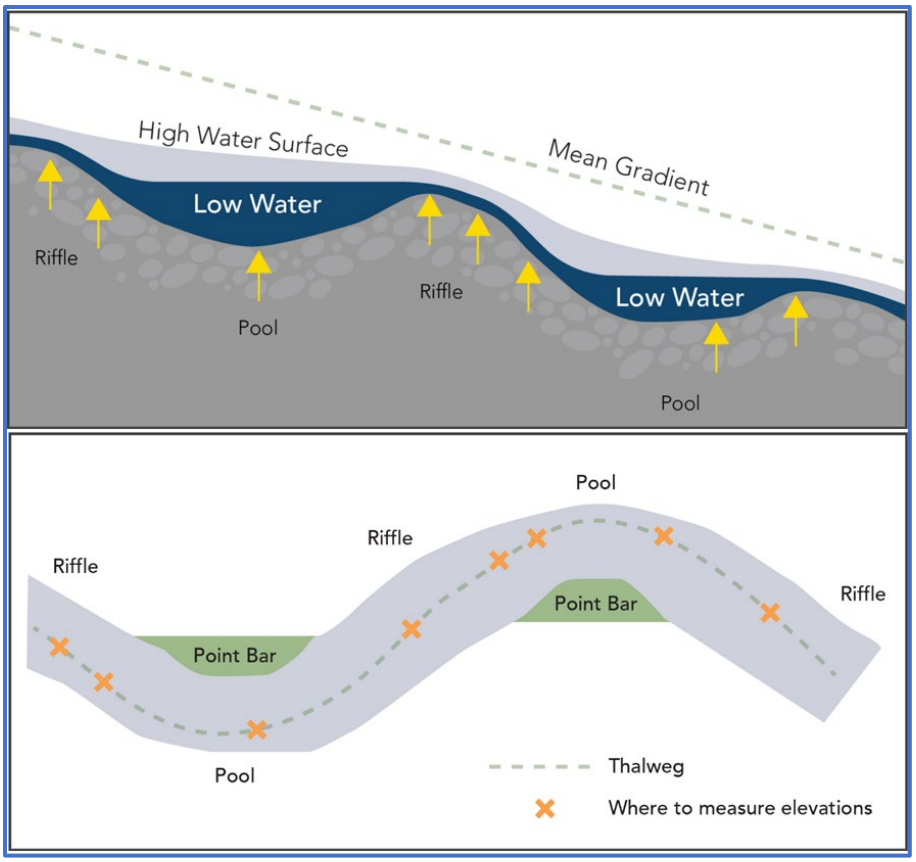
Trees

Any trees within project limits have been surveyed and the size of each tree has been recorded. Any trees with a minimum diameter of 6-inches should be noted on drawings as they are considered potential habitat for the **Northern Long-Eared Bat**. This information will be used for contract costs and permitting.

Thalweg

A minimum of 500 feet of the stream's thalweg (the deepest channel points along the entire length of the stream, not necessarily following the centerline of the stream) has been measured upstream and downstream of the crossing location (this number may vary based on the site). This becomes the basis for the stream long-profile.

> ***Note: MassDOT recommends obtaining 500 feet of stream bathymetric survey upstream and downstream in Section 1.1.5 of the LRFD Bridge Manual (available at Bridge Manual - LRFD - Part 1 - Chapter 1 (Section 1.1.5)). Normally 20-30x bankfull width is a good rule of thumb with a 300' minimum upstream and 200' minimum downstream.***



Graphic: *Thalweg Location*

Cross-Sections

A minimum of three (3) stream cross-sections upstream and downstream have been surveyed (total of 6 cross-sections). These cross-sections extend outwards into the existing floodplain to develop a representative hydraulic model.

> ***Note: MassDOT requirements for modeling vary. See section 1.1.5 of the LRFD Bridge Manual (available at Bridge Manual - LRFD - Part 1 - Chapter 1 (Section 1.1.5)).***

Note: The extent of the cross sections outside the bank and into the floodplain should be determined by the engineering/scientist performing hydraulic modeling, and may be augmented with elevations from LiDAR outside the project limits above the bank elevation.

Right-of-Way

Property lines and Right-of-Way (ROW) research has been completed and has been added to the Plan set.

Note: Property ownership issue are not uncommon, and the sooner ownership concerns can be identified the better.

CAD/D Plan

A Computer Aided Drafting/Design (CAD/D) base map has been created based on topographic survey.

Note: If Chapter 85 Review is expected (see MassDOT BRI Determination, typically a culvert opening of 10 feet or greater), line types, symbols, and scales are recommended to meet the MassDOT Highway Division CAD Standards.

DER intends to incorporate this review checklist into an online toolkit that is currently (as of June 2024) in development, and we would appreciate receiving comments you have on this checklist at DERculverts@mass.gov with "Field Data Collection and Structure Selection Checklist" in the subject line.