# Quality Assurance Project Plan for Demonstration Project: Prioritizing Stream Crossing Improvements using CAPS and WIRE


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# 1.0 Project Management

## 1.1 Distribution List

MassDEP, Director Wetlands & Waterways Program – Lealdon Langley
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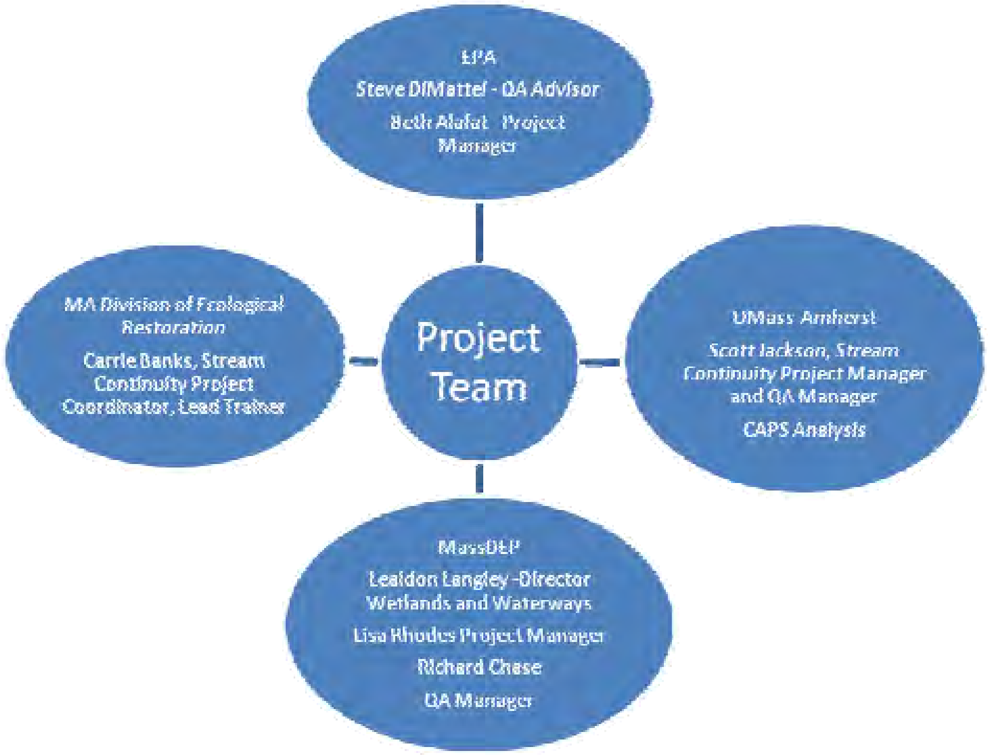
MassDEP, Wetland QA Advisor/Field Scientist – Michael McHugh
MassDEP Section Chiefs – Rachel Freed, Liz Kouloheras, Bob McCollum, Phil Nadeau
MassDEP, Circuit Rider Coordinator – Nancy Lin
MassDEP, Circuit Riders, Survey Coord.–Christine Odiaga, Pam Merrill, Mark Stinson
MassDEP Survey Team Leaders and Technicians: MassDEP Staff; Volunteer Organizations such as towns and watershed associations
UMass Project and QA Manager, Scott Jackson
Div. of Ecological Restoration (DER), Stream Continuity Project Coord., Carrie Banks
EPA Regional Director, Mathew Schweisberg
EPA Project Manager, Beth Alafat
EPA, QA Manager, Steve DiMattei

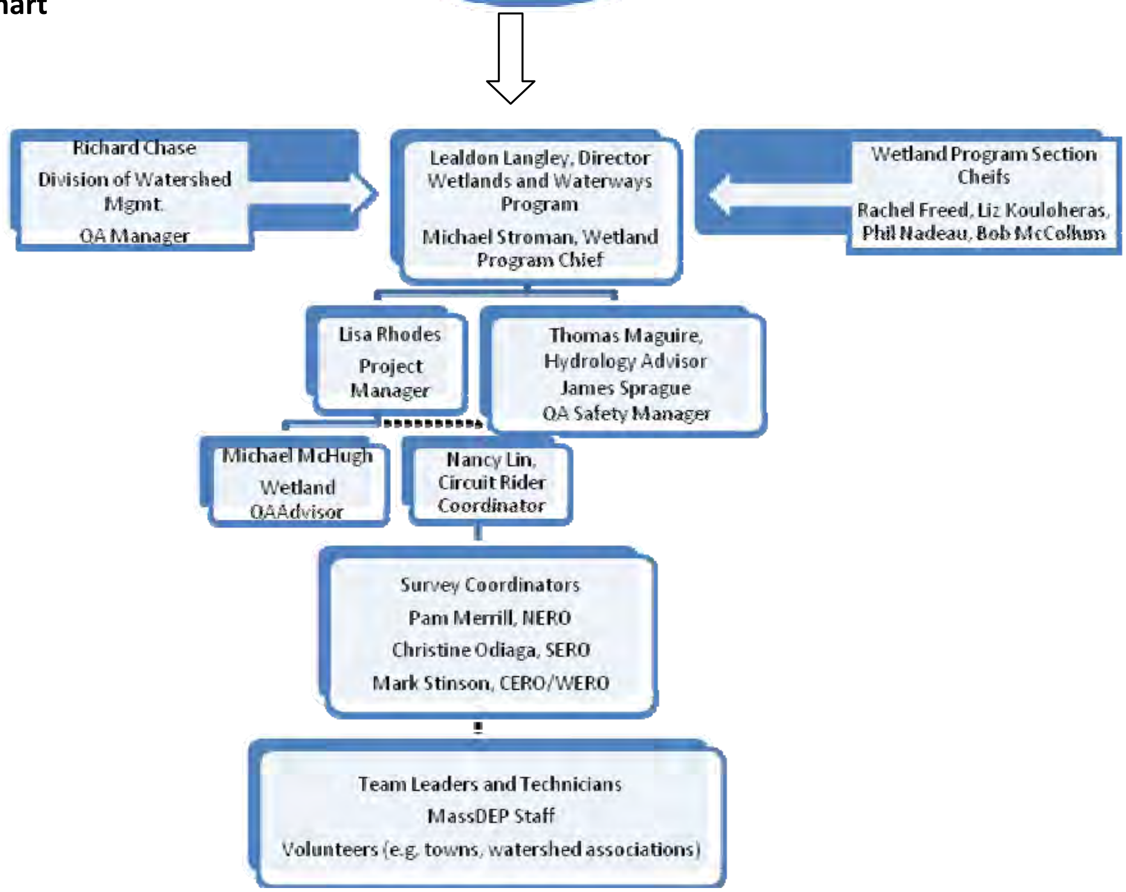
## 1.2 Project/Task Organization

The participating individuals and/or organizations and their roles include:
Lealdon Langley – MassDEP Advisor/Reviewer – participates in data review and decision-making relative to study development.
Michael Stroman – MassDEP Advisor/Reviewer – participates in data review and decision-making relative to study development.
Lisa Rhodes - MassDEP Project Manager, oversee the involvement of MassDEP personnel and project commitments; QAPP Development.
Richard Chase – MassDEP QA Officer – participates in the development and implementation of QA/QC procedures for the project.
Michael McHugh – MassDEP Wetland Program QA Advisor; QAPP development; Stream Assessment
Nancy Lin – Circuit Rider Coordinator
Christine Odiaga, Pam Merrill, Mark Stinson – Circuit Riders, Survey Coordinators
MassDEP Team Leaders and Technicians: Conduct Stream Assessments
Volunteers: Conduct Stream Assessments
Scott Jackson – UMass Project and QA Manager - Lead in study methodology development, participation in data review and decision-making and site selection for field work;
Carrie Banks – DER Stream Continuity Project Coordinator; MassDEP Trainer
Beth Alafat – EPA Project Manager – Oversee Grant commitments
Steve DiMattei- EPA QA Officer- participates in the development and implementation of QA/QC procedures for the project.

## Section 1.2.1 Project Organization




## Chart



## 2.0 Problem Definition/Background

As long linear ecosystems, rivers and streams are particularly vulnerable to fragmentation. A number of human activities can disrupt the continuity of river and stream ecosystems, dams and roads being the most common. Many culverts that are currently in place were designed primarily for the purpose of moving water under a roadway with little or no consideration given to how that crossing impacts natural ecological processes. Poorly designed and/or installed culverts can impact stream ecosystems in many ways such as creation of physical barriers to movement by aquatic organisms, causing excessive velocities, creating insufficient water depth, and promoting turbulence. In 2000, UMass-Amherst convened a variety of agencies and organizations including the Nature Conservancy (TNC), and The Massachusetts Division of Ecological Restoration (MADER) to discuss the impact of road-stream crossings on fish and other aquatic organisms. These Agencies and others formed the River and Stream Continuity Project (http://www.streamcontinuity.org/).

The goals of the River and Stream Continuity Project are: 1) Develop technical guidance and standards for river/stream crossings: 2) Create a systems for prioritizing crossing structures for upgrade or replacement (In a separate project, the "Critical Linkages" project, UMass-Amherst is collaborating with TNC to use the UMass Conservation Assessment and Prioritization System (CAPS) model as a tool to protect existing habitat connections and prioritize locations of existing crossings where restoration would provide the best ecological improvement (See Appendix A); and 3) Establish a program to inventory road-stream crossing structures and assess the extent to which they are a barrier to fish and wildlife passage. Since its creation in 2000, the River and Stream Continuity Project has:

- Compiled extensive information about fish and wildlife passage requirements, culvert design standards, and methodologies for evaluating barriers to fish and wildlife passage
- Developed the " Massachusetts River and Stream Crossing Standards" to facilitate river and stream continuity as well as fish and wildlife passage http://www.nae.usace.army.mil/reg/Stream/MA_RiverStreamCrossingStandards.pdf);
- Created a field protocol for volunteer assessment of road-stream crossings, including data forms, instructions, and training materials;
- Developed a system for scoring crossing structures for their effects on river and stream continuity and aquatic organism passage based on volunteer assessments;
- Created an online database for data on road-stream crossings collected by volunteers. All crossings are geo-referenced and information from the database can be easily used in a GIS to depict the location and score of all assessed structures in Massachusetts;
- Developed a system for prioritizing all mapped stream segments in Massachusetts into three categories based on information about their importance for protecting rare and endangered species, cold-water fisheries, and anadromous fish runs, designation as a wild and scenic river or inclusion within a designated "Area of Critical Environmental Concern." Based on this system a statewide GIS coverage for the classification of "High Quality Waters" for Massachusetts rivers and streams was created (more detail below).
- Coordinated volunteer assessments of road-stream crossings throughout Massachusetts as well as other New England states

- Initiated demonstration projects to mitigate known barriers to aquatic organism passage on high-priority streams
- Developed workshops, presentations and other educational material on the subject of river and stream continuity and the Massachusetts River and Stream Crossing Standards

The development of technical guidance and standards, establishment of a system for prioritizing structures for upgrade or replacement, and a protocol assessing and scoring road-stream crossing structures have been met. The ability to use these road-stream crossing data in CAPS, however, won't be fully realized until a substantial number of crossings have been evaluated and entered into the Continuity Database. MassDEP will work with The River and Stream Continuity Project to train MassDEP staff including its Circuit Riders, and other volunteers such as municipalities and watershed organizations to assess 600 stream crossing structures divided evenly between three specific sub-watersheds using the field protocol developed by the River and Stream Continuity Project. The assessments will expand the online stream continuity database www.streamcontinuity.org/cdb2. A poster and booklet will be updated by DER to reflect the revised standards http://www.mass.gov/dfwele/der/freshwater/rivercontinuity/guidancedoc.htm). MassDEP's data management system, WIRe, can now geospatially display projects with proposed stream crossings. By using the combination of the WIRe and Stream Continuity databases, MassDEP can identify and condition projects with best potential to increase river and stream continuity.

## 3.0 Project/Task Description

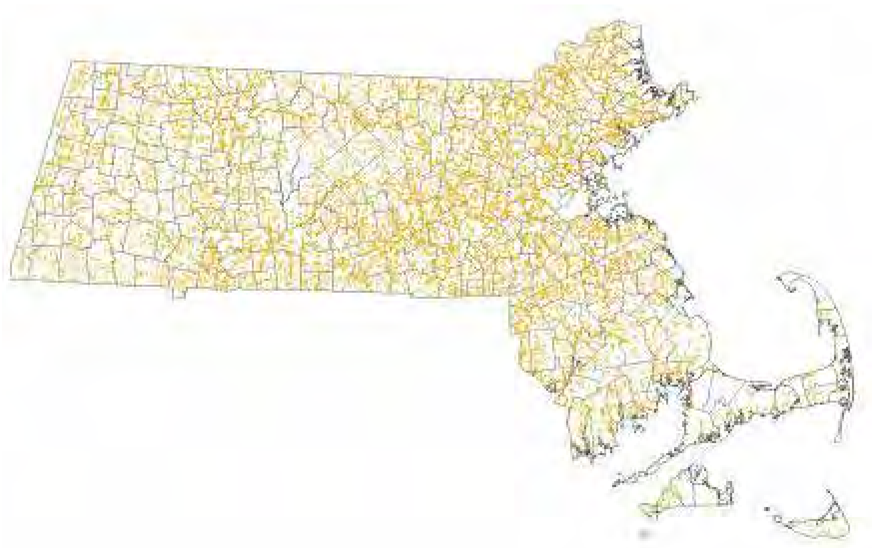
*Selection of Sub-Watersheds for Study*

Development of the planning process outlined above involved input from academic researchers, field scientists, regulatory and resource agencies and private non-profit organizations. The consensus of those discussions was the need to develop geospatially accurate field verified data on the actual conditions of river/stream crossing structures in various areas of Massachusetts. Because of the estimated 36,636 stream crossings statewide, this proposal identified specific sub watersheds within which to focus the assessments that are feasible to complete with the available resources. MassDEP Circuit Riders from the regional offices will serve as Survey Coordinators (those who organize the field surveys) and MassDEP wetlands staff and volunteers will serve as Survey Team Leaders, and Technicians (those who conduct the survey). GPS will be used to obtain geospatial data locating the crossing on the landscape and field measurements utilizing tape measures will be taken to document stream crossing condition during the low flow period. In addition, photographic records will be captured of each inlet and outlet of each crossing assessed. The specifics of this sampling methodology are presented in Chapter 7 and Appendices B and C, below. Although the current (as of this writing) data form and instructions are included in the Appendices if the River and Stream Continuity Project updates these materials during the course of the project we will adopt those updated materials. These data will be used to identify projects that have the best potential to increase river and stream continuity and landscape connectivity.

There are an estimated 36,636 road and stream crossings in Massachusetts. In order to survey stream crossings, a map identifying such features had to be developed. Because stream centerlines were digitized at varying densities, resulting in bias that affected the CAPS aquatic connectedness metric, all streams with a watershed of less than 74 acres (ac) were eliminated. Elimination of these watershed portions has the effect of removing parts of the smaller headwater streams throughout, while making stream density more consistent. This also resulted in the loss of a number of predicted road-stream crossings, leaving a total of 20,970 stream crossings that are evaluated by the CAPS model. Thus, we will only be assessing the crossings in our selected watersheds that are within the 20,970 data layer (i.e. sub-watersheds greater than 74 acres). The 20,970 crossing data layer was developed by UMass starting with the MassGIS networked hydro centerline data layer (http://www.mass.gov/mgis/watrshed.htm) and the NHD stream centerlines (http://nhd.usgs.gov/data.html). Those data were then edited in the following manner:

1. The stream network was edited to correct a significant number of breaks in the connectivity of the stream network;
2. Dense networks of channels in cranberry bogs where deleted;
3. Ditches in salt marshes where deleted;
4. Stream mouths were extended all the way to the ocean;
5. Stream centerlines were added in areas that were identified as upland to represent smaller ($1^{st}$ and $2^{nd}$ order) streams;
6. Stream centerlines where burned into the flow grid;
7. All streams with a watershed of less than 30 ha (74 acres) were deleted. The 30 ha threshold was determined by trial and error until we found the minimum size necessary to produce consistent stream mapping across the state (i.e. eliminate boundary effects in the base hydrography data)
8. The stream data were then overlain with the MassDOT Roads layer (http://www.mass.gov/mgis/eotroads.htm) and the MassGIS Trains layer (http://www.mass.gov/mgis/trains.htm). The points where streams data cross roads and/or railroad lines were identified as crossings. 20,970 such crossings were identified in Massachusetts.

Figure 3.1 (a): Statewide coverage of 20,970 CAPS stream crossings



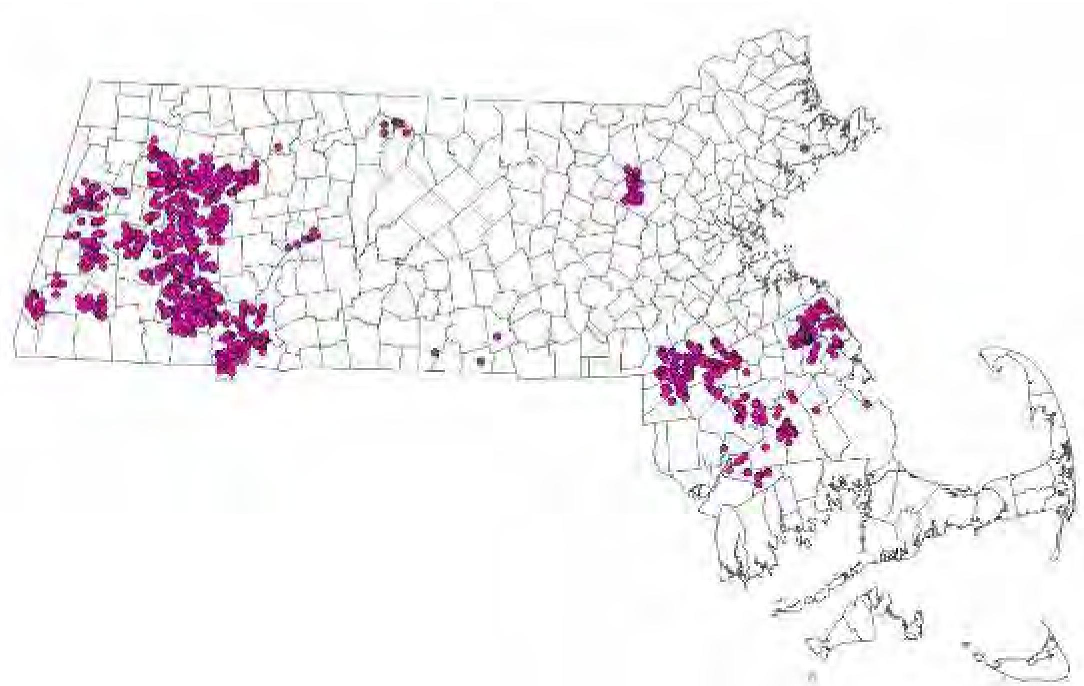
The purpose of this project is to conduct assessments on a minimum of 600 stream crossings. This effort will not only add to the total crossings in the database, but is designed to inform us as to the reliability of the CAPS model predictions without full coverage of stream assessments, and to prioritize the stream crossings for improvement in the sub-watersheds studied. Thus, the goal is to assess all stream crossings within each sub-watershed selected. To select sub-watersheds the following parameters were considered: Awareness of areas of the state where stream assessments have been conducted; MassDEP regions where circuit riders are available (i.e. NERO, SERO, and WERO[1]); presence of "high quality streams"; identification of "best case points;" and approximately 200 crossings per sub-watershed. Details are as follows.

*Assessments Conducted to Date*

The River and Stream Continuity Project has already trained volunteer organizations to conduct stream crossing assessments across the state over a period of several years. As of November 17, 2011, 1,368 of the 20,970 crossings in Massachusetts have been assessed by volunteer organizations and individuals.

[1] The Central Regional Office of MassDEP (CERO) currently does not have a Circuit Rider assigned due to budget constraints; however MassDEP will attempt to complete stream crossing assessments in the Central region.

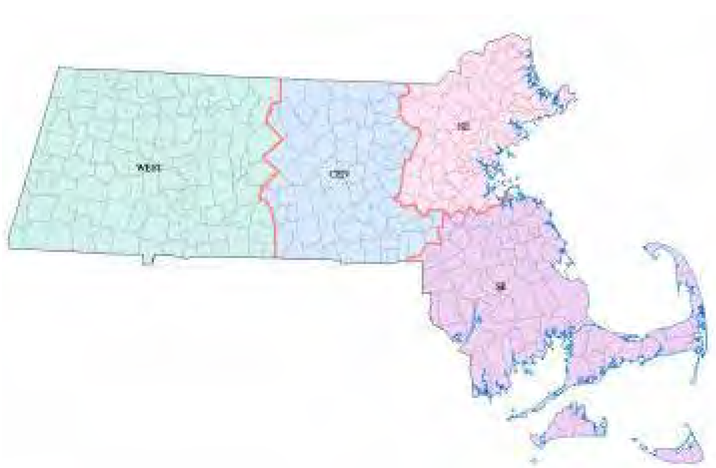
Figure 3.1 (b): Stream Crossings Assessed as of November 17, 2011 (note that assessments conducted in the Quabbin Reservoir Watershed are not shown).



*MassDEP Regions*

The assessments to be conducted were evenly distributed between the three regional offices of MassDEP where circuit riders are available. While there is no circuit rider in CERO, a subwatershed was selected that straddles the boundary of CERO/WERO since MassDEP's intention is to complete assessments in all four regions.

Figure3.1 (c): MassDEP Regions



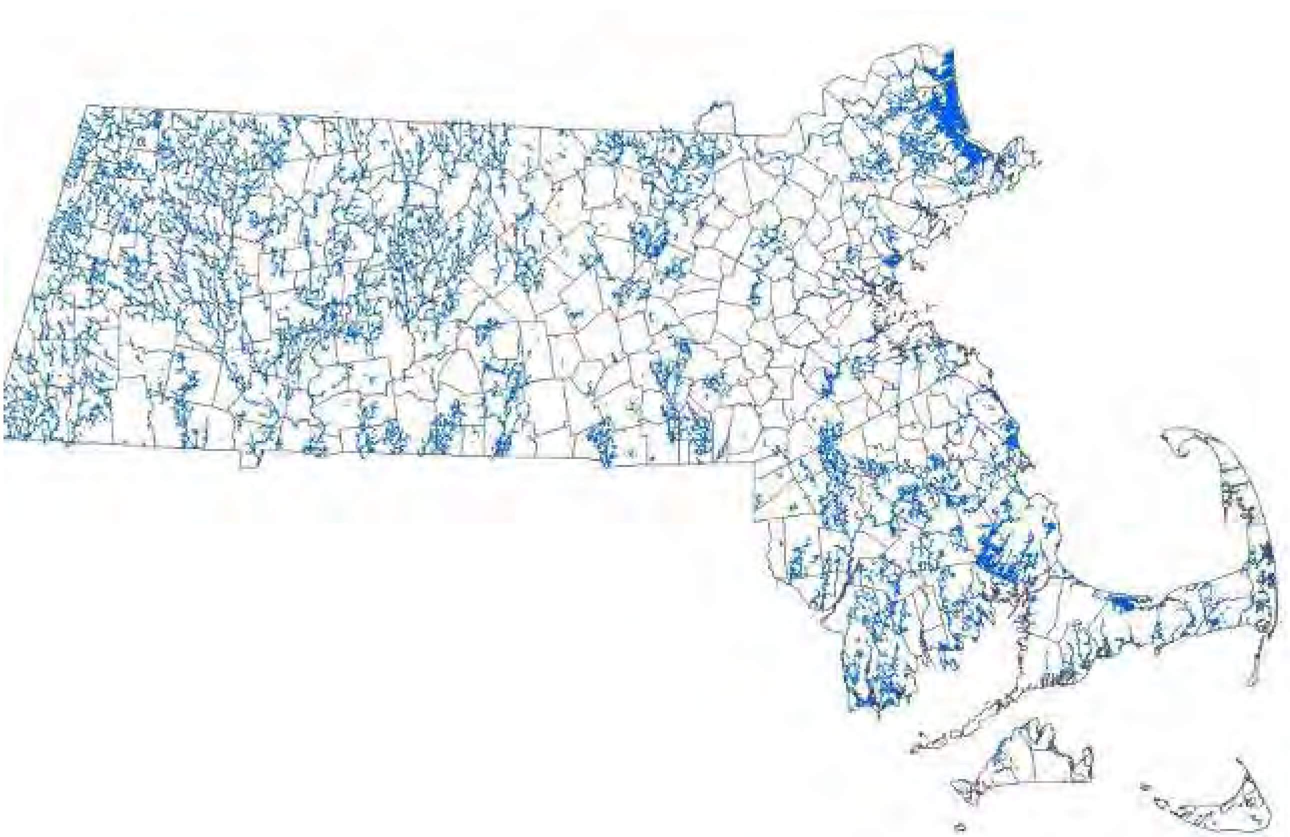
*High Quality Streams*

The “High Quality Streams” data layer was developed by the Stream Continuity Project using the following sources:

- MA Natural Heritage and Endangered Species Program Living Waters Core Habitats (November 2003)
- MA NHESP BioMap Core Habitats (June 2002)
- Areas of Critical Environmental Concern (EOEEA)
- Cold Water Fisheries where Brook Trout populations are “categorized as “intact” and have a contributing watershed of 0.5 sq. mi (approximately 320 acres) or more (Eastern Brook Trout Joint Venture 2006)
- Anadromous Fish Runs from MA Division of Marine Fisheries with supplemented data from the U.S.Fish and Wildlife Service for the Connecticut River Watershed.

Sub-watersheds selected for this study included as many high quality streams as possible so that the assessments would also facilitate improvements to those streams.

Figure 3.1 (d) High Quality Streams



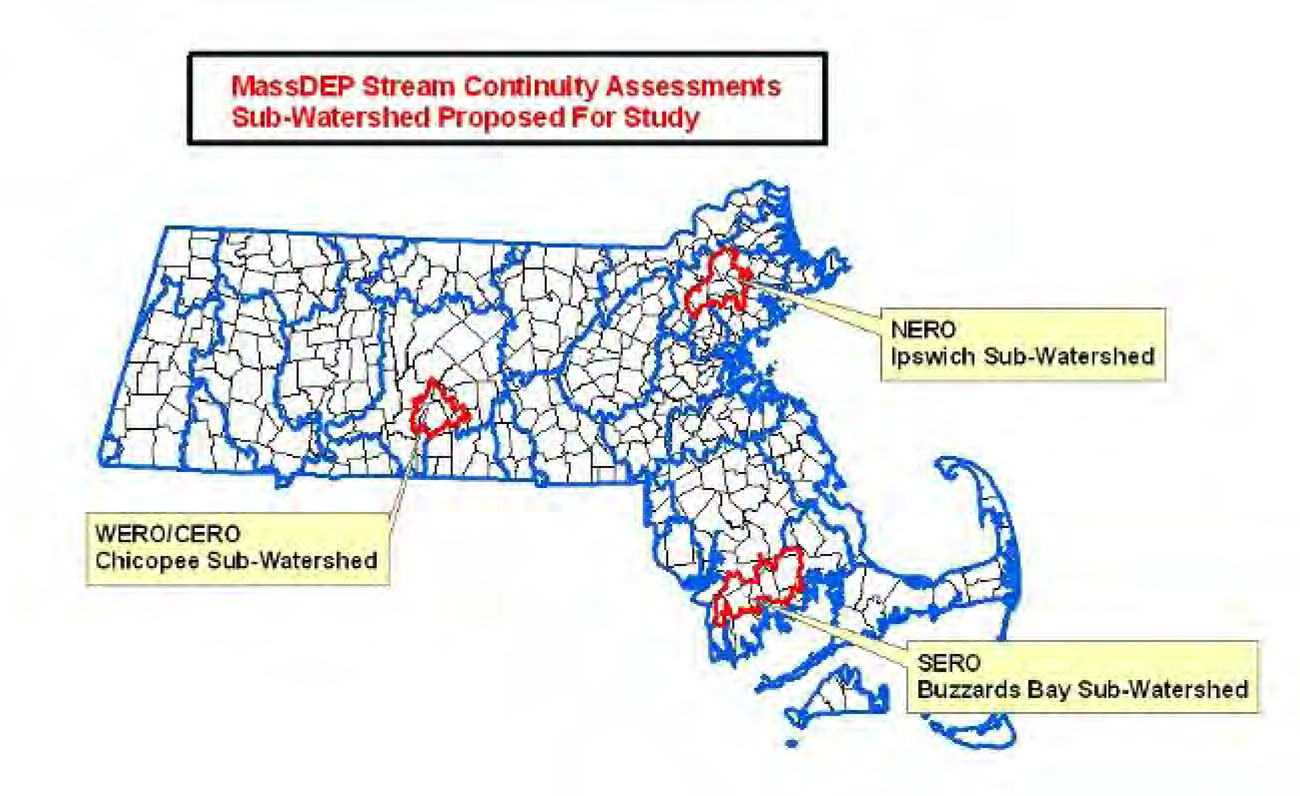
*Best Case Crossing Points*

The “Best Case” crossing point data layer was developed by the UMass using the CAPS model. This data layer identifies 2,395 crossings that are the best opportunities to improve aquatic connectedness along the centerline of streams, rivers, water bodies and wetlands statewide via crossing upgrade or replacement based on the Critical Linkages analyses (See Appendix A).

Figure 3.1 (e) Best Case points

By considering all the data above, three sub-watersheds were identified that provide the requisite number of culverts for assessment (i.e. 200 per region) while maximizing best case points on the highest quality stream (see figure on next page).

Figure 3.1 (f): Study Watersheds




More detailed maps of each sub-watershed are as follows:

Figure 3.1 (g): Ipswich sub-watershed-locus

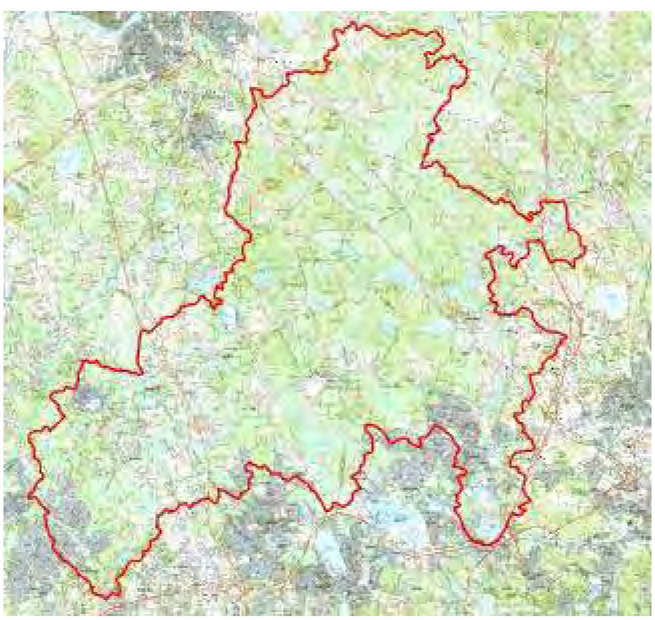
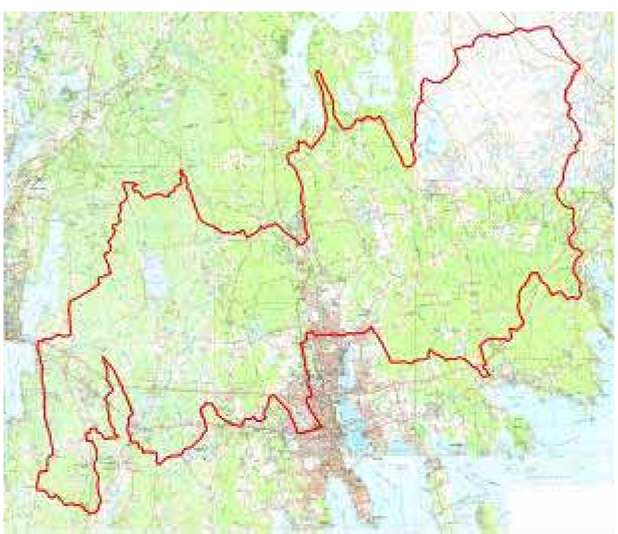


Figure 3.1(h) Ipswich sub-watershed: High quality streams, best case points, and stream crossings:

| # Crossings | # Best Case Crossings[2] |
|---|---|
| **214** | 6 |

Figure 3.1 (i): Buzzards Bay sub-watershed-Locus



[2] While this figure may seem low, many of the high quality streams in this region are in coastal areas and not subject of this study.

Figure 3.1 (j): Buzzards Bay sub-watershed-High Quality Streams, Best Case Points, and stream crossings

| # Crossings | # Best Case Crossings |
|---|---|
| **228** | 48 |

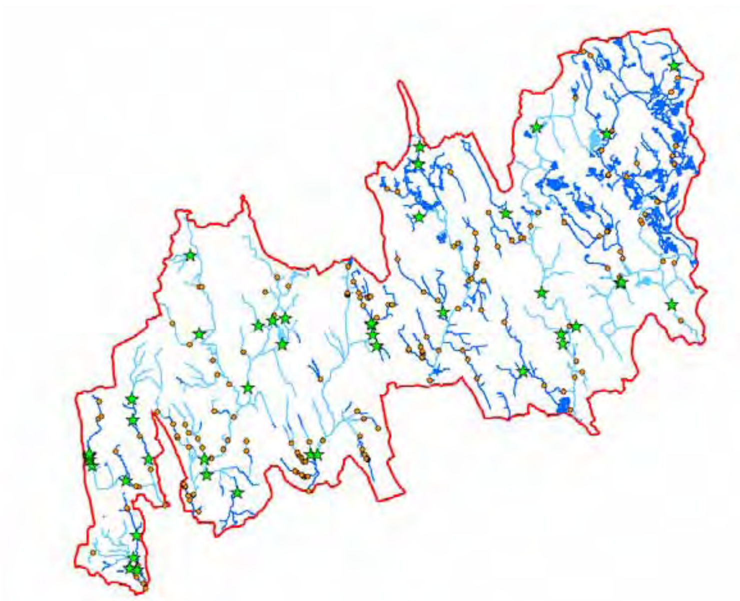
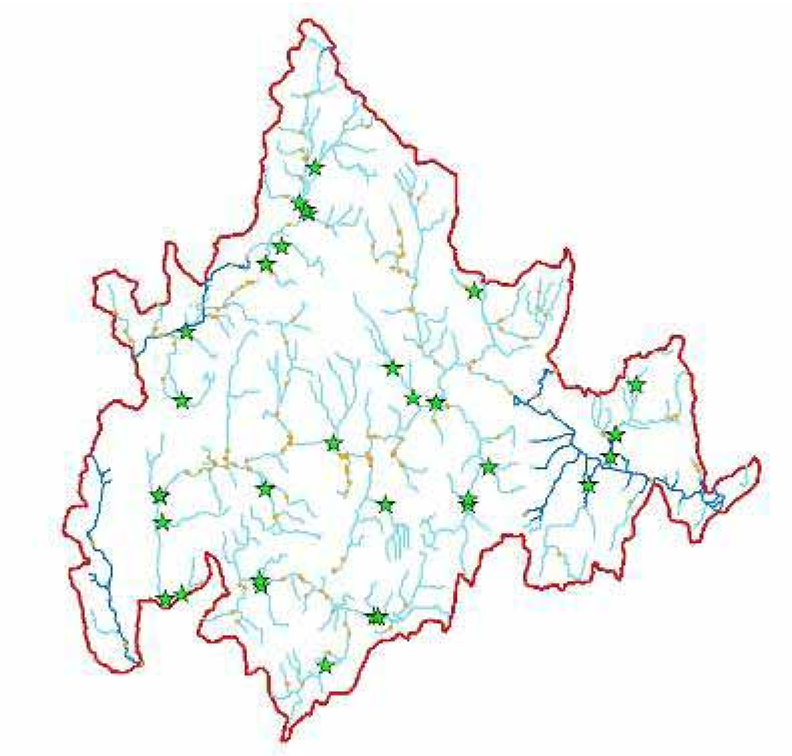


Figure 3.1 (k): Chicopee sub-watershed-Locus

Figure 3.1 (l): Chicopee sub-watershed-High Quality Streams, best case points, and stream crossings

| # Crossings | # Best Case Crossings |
|---|---|
| **198** | 33 |



*Assessment Overview, Timeframes and Schedule*

It is the goal of this project to conduct a comprehensive survey of all CAPS stream crossings, including bridges, within each sub-watershed. Other crossings in the state will be assessed if time allows or if convenient.

Each sub-watershed will have a Survey Coordinator who will organize and track surveys that are conducted within their respective watershed. Survey Coordinators will provide maps, equipment, field data forms, and training to the Survey Team Leaders and Technicians. They will assign specific areas within the watershed where surveys will be conducted in order to minimize travel time and avoid duplicate efforts. All assessments will be done during typical low-normal streamflow conditions. Before authorizing crossings to be assessed, Survey Coordinators will determine whether typical low-normal streamflow conditions are present. . Typical low-normal flow conditions are presumed to be present between the lowest 20$^{th}$ and 50$^{th}$ percentile flow durations. Streamflow from June 1 to September30$^{th}$ is presumed to be at lowest 20$^{th}$ to 50$^{th}$ percentile flow duration. Streamflow conditions from October to May 31st will be determined by Survey Coordinator in consultation with the Hydrology Advisor by comparing flow duration against the most recently available real time streamflow data for respective watershed (i.e. USGS Real Time Flow Data on web at http://waterdata.usgs.gov/ma/nwis/rt).[3] Field conditions may also be assessed by observers to determine whether streamflow is in typical low-normal range, by observing water surface in stream in relation to staining in culverts or other bankfull indicators. Assessments shall not be conducted during or within 24 hours of a rain event that has deposited greater than one inch of rain within a 24- hour period. Local weather stations, rain gauges, or NOAA weather data (http://water.weather.gov/ahps/) may be used to confirm such a rain event. While Survey Coordinators may assign crossings to be assessed ahead of time, they should only authorize assessments during typical low-normal flow conditions and should suspend assessments as needed if flow conditions become too high or too low. Survey Coordinators should consult with the Hydrology Advisor if there are any questions. If Survey Team Leaders or Technicians conduct a site visit where the outlet drop is obscured by higher streamflow, if streamflow is excessively low or stream is dry, they should postpone the assessment and return when flow conditions are more appropriate.

This project is a continuation of the goals of the River and Stream Continuity Project and specifically addresses the use of the CAPS Critical Linkages project to prioritize culverts needing improvement. The data from this project will also be used to test the CAPS model to determine the extent of actual stream assessments that are needed to obtain reliable results. CAPS scenario analysis is used to estimate the improvement in aquatic connectedness that would result from a culvert replacement. These scenario analyses help us identify crossings that should be a high priority for replacement (i.e. where we will get the most ecological benefit). Where field data are not available the CAPS approach uses modeled passability scores to determine landscape resistance in its aquatic connectedness metric. The scenario analyses are likely to be substantially improved by using scores based on field assessments in place of the modeled scores. What is not yet clear is whether we need to assess all crossings in a given area to gain that benefit or whether a more strategic approach (e.g. assess only high-priority sites) would provide satisfactory results. To resolve this issue we plan to run the scenario analyses for targeted sub-watersheds using three approaches and comparing the results.

1. CAPS mapped stream crossings, all modeled, none assessed
2. CAPS mapped stream crossings, high-priority crossings assessed, all others modeled
3. CAPS mapped stream crossings, all crossings assessed, none modeled

[3] The full record flow duration curve and not the daily flow duration percentage will be used, as the daily value could obscure outlet drops or physical flow impediments that would otherwise be visible at lower stream discharges. The Hydrology Advisor will develop the gage flow duration curves beforehand, so when calls come in, it would be a simple lookup process, but in same river basins, upstream and downstream gages may need to be weighted by drainage area to determine the result. For headwater streams, it will be less problematic, because they have smaller drainage areas, where the low flow effect on culverts passing stream flow is apparent through a longer part of the year than downstream culverts with larger watersheds.

The project management will consist of the following: Project Manager responsible for overseeing all aspects of the project; UMass Project and QA Manager and DER Stream Continuity Project Coordinator to Provide training to Stream Assessment Coordinators; UMass Project and QA Manager maintain the master database of all data that has been gathered; Survey Coordinators to coordinate the assessments within designated sub watersheds by providing training and assigning targeted crossings to Survey Team Leaders and Technicians, and entering field data into the master database; and Survey Team Leaders and Technicians to conduct the actual field assessments.

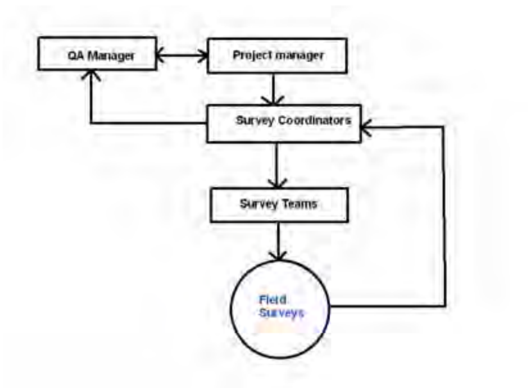



Figure 3.2 Project Management and Data Development Flow Chart

The field surveys will obtain latitude and longitude coordinates of the actual crossing in the field (via GPS) and document the type, size, and condition of the crossing. The field survey data will be entered by Survey Coordinators (or Survey Team Leaders that are approved by the MassDEP or UMass Project Managers) into the database maintained by the UMass Project and QA Manager. The database will calculate an Aquatic Passage Score and determine the extent to which given stream crossings pose a barrier to fish passage, wildlife, or aquatic organisms. The findings will be used to refine ecological assessments under the Massachusetts Conservation Assessment and Prioritization System (CAPS),[4] help prioritize crossings most suitable for ecological improvements, and identify potential mitigation projects.

## 4.0 Deliverables

Once all assessments are completed, UMass will conduct a CAPS analysis on all crossings in the three sub-watersheds. We can then compare results of CAPS analyses for:

- CAPS modeled scores for all crossings
- Partially assessed and partially modeled scores for CAPS crossings
- Assessed scores for all CAPS crossings

[4] CAPS reports submitted to EPA include *DRAFT – A Framework for Ecosystem Monitoring and Assessment: The Conservation Assessment and Prioritization System (CAPS), December 11, 2007; Conservation Assessment and Prioritization System(CAPS)Western Massachusetts Assessment – Final Report May 19, 2008*; and *Conservation Assessment and Prioritization System (CAPS) Preliminary Statewide Massachusetts Assessment – June 2, 2009.* Reports were authored by UMass-Amherst. *CAPS QAPP is due June 2012.See* www.masscaps.org

This will give us an opportunity to see how much we gain by assessing all crossings vs. only a portion of the crossings within a watershed. The analysis will also prioritize stream crossings for the best ecological improvement.

The final product will be a report that provides detailed and statistically robust information about the prioritization of stream crossings in three sub-watersheds in Massachusetts, and about the need for comprehensive assessments versus CAPS modeling reliability. The final deliverable will also include 600 stream assessments to be added to the River and Stream Continuity Project Database

The schedule for implementation is:

- QAPP Development: November 1, 2011 – February 28, 2012
- Acquire Equipment: March 2012
- Train Staff and volunteers, Identify Targeted Crossings: November 1, 2011 – April, 2012
- Conduct Assessments: June 1, 2012 – September 30, 2012 (or as low flow conditions exist)
- Conduct an evaluation of the ability to complete the targeted number of assessments (600) with in the target time frame, since the feasibility of completing the project may depend on factors outside our control, such as weather extremes, availability of volunteers, etc.- September 1, 2012. If it appears the time frame needs to be extended due to such constraints, all project partners will be notified.
- Develop Protocol to Identify Active Stream Crossing Projects in WIRE; CAPS Analysis; Write Report: September 30, 2012 – June 30, 2013
- Final Report: June 30, 2013

## 5.0 Quality Objectives and Criteria

QA/QC is laid out in the assessment sampling protocol as a system of audits, standard procedures, and training for each section of the data collection and management plan. These activities and procedures begin with the assessment protocol conceptualizations, where the data requirements are determined, and continue throughout all phases of the project to ensure the data quality meets those standards. Quality assurance is overseen by the Project Manager.

Along with proper methodologies, confidence in the quality of the data is critical in the subsequent assessment protocol development stages as well as during assessment protocol application. Therefore, quality assurance procedures must be incorporated into the assessment protocol and used in a reliable and consistent manner to provide reproducible data with known statistical properties. In addition to the standardized sampling, measurement, and data handling procedures listed above, the assessment protocol includes a statement of data quality standards and methods for: 1) training, 2) internal data audits, and 3) external data audits for which the Project Manager is responsible for coordinating.

Before quality assurance methods to maintain data quality standards can be developed, the quality standards must be determined. Terms used to express data quality standards and examples of the QA/QC used to assure those standards are given below (Sherman et al. 1991):

1) *Precision* - is a measure of mutual agreement among individual measurements of the same variable, usually under prescribed similar conditions. Data precision of the assessment protocol can be checked through the use of replicate field measurements and standard procedures.

2) *Accuracy* - is the degree to which a measurement reflects the true or accepted value of the measured parameter. It is a measure of the bias in a system. Accuracy depends on the technique used to measure a parameter and the care with which it is executed. Standard procedures and QA audits are used to maintain data accuracy.

3) *Completeness* - is a measure of the amount of valid data actually obtained compared with the amount that was expected to be obtained under normal conditions. Ideally, 100% of the data should be collected. Data may be incomplete due to incomplete data collection, lost or damaged data forms, or errors in data transcription.

4) *Representativeness* - expresses the degree to which data accurately and precisely represent a characteristic of the parameter measured. Representativeness is established by proper site selection and appropriate spatial arrangement of sampling areas (i.e. site selection stratified by frequency distribution of selected metrics).

5) *Comparability* - expresses the confidence with which one data set can be compared to another. Collection of data by different investigators is the primary cause of variability in the data. Standardized procedures, internal QA audits, and training minimize variability in the data. Field testing of the assessment models will be used to determine the level of comparability achieved.

Table 5.1 Data Quality Objectives

| Parameter | Units | Expected Range (ft) | Accuracy (+/-) | Precision |
|---|---|---|---|---|
| **Culvert Length** | **feet** | **8-200** | **+/- 0.5** | **100% Agreement** |
| **Bridge Length** | **feet** | **12-200** | **+/-0.5** | **100% Agreement** |
| **Culvert Width and Height** | **feet** | **1-20** | **+/- 0.1** | **100% Agreement** |
| **Bridge Width and Height** | **feet** | **10 or greater** | **+/- 0.1** | **100% Agreement** |
| **Location by Coordinates (GPS)** | **Decimal Degrees** | **NA** | **<15meters** | **Repeated readings to verify coordinates essentially the same** |
| **Crossing Observations** | **Presence/absence** | **NA** | **NA** | **95% Agreement among separate Observers** |

## 6.0 Special Training/Certification

All MassDEP staff serving as Survey Coordinators, Survey Team Leaders or Technicians have undergone or will undergo training conducted by the DER Stream Continuity Project Coordinator. Additional training will be conducted as needed by the MassDEP Project Manager, UMass Project and QA Manager, the DER Stream Continuity Project Coordinator and/or the MassDEP Wetland Program Quality Assurance Advisor. Training includes classroom study of assessment protocols and field training which includes practice in actual measurement methodology, proper decontamination procedure (to prevent the spread invasive species), and safety protocol. It is anticipated that MassDEP Circuit Riders, as Survey Coordinators, will then be able to train additional volunteer Survey Team Leaders or Technicians as they are identified. All Survey members on this project will have received training by the DER Stream Continuity Project Coordinator, UMass Project and QA Manager, Stream Assessment Coordinators or the MassDEP Wetland Program QA Manager prior to participating in crossing assessments.

## 7.0 Documents and Records

The Project Manager will ensure that all Survey Team members are provided with a copy of the approved QAPP. All drafts, comments on drafts, and responses to those comments have been retained by the Project Manager and are available for review upon request.

Field assessments will consist of paper field data forms to be filled out in the field by the survey team. Those field notes will be submitted to Survey Coordinators, who will then enter the data into the master database off of the hard copy field forms. Additionally, specific Survey Team Leaders may be designated to enter stream assessment data in the same manner. Copies of the field data forms and photos will be scanned and kept in an electronic file. These electronic and hard copies shall be stored for the duration of the project by the Survey Coordinators in a shared file established by the Wetland QA Advisor.

In addition to the CAPS analysis of the data, the final report will include the link to the electronic database of river/stream crossings that have been assessed, which will contain the data gathered in the field, including site photographs. It will be available in an electronic format at: http://www.streamcontinuity.org/cdb2/. Paper copies (print outs) will be made available upon request.

# 8.0 Data Generation and Acquisition

## 8.1 Data Collection

Once assigned a given site (or sites), stream assessment team members then conduct the assessments following protocols developed by the River and Stream Continuity Project as described below. The assessments consist of collecting the following information:

- GPS coordinates(lat/long, decimal degrees) of the actual crossing using the GPS provided;
- Documenting the road surface and road type (paved/unpaved; single lane/multilane);
- The crossing type (Ford, bridge, open bottom arch, single culvert, multiple culverts)
- The condition of the crossing (excellent/fair/poor)
- Whether or not the stream appears to support fish
- The height of the crossing structure (from water surface level to the roof inside the structure)
- The height (in inches) of any inlet drop;
- The height in inches of any outlet drop, as well as the outlet type (freefall/cascade)
- The presence of armoring (i.e. rip rap) at the outlet;
- Determining whether the crossing is embedded and if yes, the substrate;
- The presence of any physical barriers to fish;
- The degree to which the crossing span constricts the flow of water
- How the crossing impacts water velocity and depth;
- The comparative slope of the crossing (visually, with respect to upstream and downstream slopes);
- The shape of the crossing (round, elliptical, or box);
- The dimensions of culverts/bridge cells

The above data will be gathered for each crossing structure (i.e. culvert or bridge cell) at any given crossing (i.e. where a crossing involves multiple culverts, the data will be gathered for each culvert). Two photographs of each inlet and outlet of each culvert will be taken. At each inlet and outlet, one photo will be taken of the crossing in its existing condition. A second photo of the same composition will also be taken with a whiteboard/paper/blackboard prop containing the crossing code ID #, date, and inlet/outlet to document the crossing location.

Appendix B: *Instruction Guide for Field Data Form* provides a detailed description of the methodologies to conduct the measurements outlined above.

Appendix C: *Field Data Form* is the Field Data Form for recording the information.

Table 8.1 Data Collection

| Data | Method | Units | Sample Holding Container | Method Sample Preservative | Minimum Holding Time |
|---|---|---|---|---|---|
| Crossing Length | Measurement in Field | feet | NA | NA | NA |
| Culvert Dimensions | Measurement in Field | feet | NA | NA | NA |

## 8.2 Data Handling and Custody

Prior to leaving the site, the survey team will ensure that the field data form is filled out appropriately and completely and photos are taken in accordance with protocol. The survey team shall present the originals to the Survey Coordinator. The Survey Coordinator will scan copies of the field notes and prepare photos for digital storage. These records will be kept for the duration of the project. Upon receipt of the original field data forms the Survey Coordinator will enter the data into the Continuity Database. The Wetland QA Advisor will maintain a MassDEP database which will include the tracking of survey team assignments and the status of the assessments. The master River and Stream Continuity Project database will house the field assessment data and is maintained by the University of Massachusetts-Amherst.

## 8.3 Quality Control

Survey Coordinators are responsible for quality control of the data received from the Survey Team Leaders and Technicians and entered into the database. Survey Coordinators will perform quality control checks on data they receive from survey teams. Incomplete data forms will be referred back to the survey team who will be required to return to the site to gather the missing information. Data will not be entered "from memory". In the event the GPS coordinates appear inaccurate or incomplete, the site will be revisited and the coordinates will be re-captured. This will require field checking the data on the field form to ensure that the revisit occurs at the same site as the original survey. Survey Team Leaders that are approved for data entry will be responsible for quality control of data they enter into the database. While entering data into the database, Survey Coordinators and any designated Survey Team Leaders will:

- Review each field sheet and check for errors and omissions, contact the Stream Assessment Team member immediately with questions, then correct the field sheet (cross out and write next to, never erase). If needed to solve an inconsistency in data, the Survey Coordinator will go back to the crossing to confirm accuracy.
- Compare the GPS coordinates with the crossing ID. If they do not match, the volunteer may have gone to the wrong location. If there is any doubt about which crossing was surveyed, the Survey Coordinator should check the crossing in the field.
- Review photographs and ensure that they are of sufficient quality to see important details (such as outlet drop), are properly labeled, and are in the correct format and file size. If photos need to be retaken the Survey Coordinator should request that the stream assessment team member revisit the site, or the Survey Coordinator must revisit the site. If for any reason, photographs of the inlet and/or outlet cannot not be obtained (i.e. conditions unsafe, etc.), it should be noted in the comment field.
- Upload data to the database once any errors or omissions on the field data form are corrected. Data entry will be noted on the field data form.

- Data entry will be reviewed and corrected as needed and the review noted on the field data form

In addition, Survey Coordinators will independently verify 10% of all surveys in each sub-watershed to ensure data is being gathered in compliance with this QAPP and accurately reflects the actual onsite conditions. Since each sub-watershed consists of approximately 200 sites, each Survey Coordinator will need to verify approximately 20 sites to confirm that that the data on the field data form accurately reflects the onsite conditions within their assigned sub-watershed. Since there are three sub-watersheds chosen for assessment, this will result in approximately 60 total sites undergoing this QC procedure. See Appendix C for a detailed description of the QC process.

### 8.4 Instrument/Equipment Testing, Inspection, and Maintenance

All equipment will be calibrated in accordance with the manufacturer's recommendations. A link to the user manual for the GPS unit is attached as Appendix E and Tips for GPS Use are attached as Appendix F. A link to the User manual for the camera is also attached as Appendix G. All equipment will be inspected for defects at the time of its purchase. Any defective equipment will be replaced. The Stream Assessment Coordinator will inspect all equipment for defects prior to assigning field assessments. Any defective equipment will be replaced prior to conducting the field assessments.

## 9.0 Problem Solving

Geospatial data will be gathered via a Garmin eTrex GPS unit. These units are designed for use in forested environments, thus signal acquisition is not anticipated to be a problem. It is recommended that the user turn on the GPS unit at the site prior to conducting the assessment or at least for 5 minutes prior to collecting the latitude and longitude data. In the event that no signal, or insufficient signal strength, is received an offset point will be utilized. The GPS operator will move along the road (staying along the side of the road) until a signal of sufficient strength is received. The GPS operator shall use a compass and determine the bearing (true north) along the road that he/she is heading, and shall use a tape measure to measure the distance. The field data form will reflect that an offset point was utilized and the bearing and distance shall be recorded.

In cases where an unmapped crossing is found in the field, and the crossing is on a stream with a watershed area greater than 30 ha (i.e. a CAPS mapped stream), the stream should be assessed. On the Field Data Form, survey team members will write Field Data Form "Unmapped Crossing" at the top of the form and the crossing # field should be left blank. Additional information on the form should identify the crossing location including GPS coordinates, town name, stream name, road name, and location The Survey Coordinators will provide blank Field Data Forms to Survey Team Leaders and Technicians in case they encounter unmapped crossings, and will forward all Field Data Forms for unmapped crossings to the UMass Project and QA Manager for assignment of a stream crossing code.

If an atypical crossing is encountered, such as one that does fit any anticipated conditions outlined in the Field Data Form User Guide (Appendix B), all measurements will be conducted as close to the approved methodology as possible, using best professional judgment. The survey team should note on the top of the field data form that the crossing is atypical. The data from atypical crossings will not be entered into the master database until those data have been referred to and approved by the Wetland Program QA Advisor.

# 10.0 Assessment and Oversight

### Reports to Management

Survey Coordinators will send status reports to the Project Manager and copy the Wetland Program QA Advisor every 30 days during the survey period.  These reports will document the number of sites completed, their location, goals for the month ahead, and problems encountered.

# 11.0 Data Validation and Usability

## Data Review, Verification, Validation

The Wetland Program QA Advisor will conduct a final QA/QC check on all data that has been entered to the database to ensure completeness and consistency with existing protocols.

All data that were gathered will be available to stakeholders and the general public via the River and Stream Continuity Project Website: http://www.streamcontinuity.org/cdb2/

## Reconciliation with User Requirements

It is not uncommon for methods to change as new situations arise and must be incorporated into the data set. The data and methods will be periodically inspected for inconsistencies or user conflicts and will be documented and if possible, corrected. If corrections are not possible, documentation will be included for interpretation during subsequent analyses.

## 12.0 SAFETY

All staff will be trained in and must follow the safety rules listed below.

- Fieldwork will not be conducted during or immediately after heavy rain events or unsafe conditions such as electrical storms or high wind events. Special attention shall be given to Department of Public Health warnings and outbreak locations for West Nile Virus and Eastern Equine Encephalitis (EEE). Practice "safety first".
- Sampling will always be conducted by two or more persons, unless otherwise approved by the Survey Coordinator.
- Assessments may not be conducted outside of the aforementioned specified timeframe of June through September or during conditions other than low flow conditions without approval of the Hydrology Advisor.
- Each survey team must carry fully charged cell phones or other emergency communication devices while conducting field work. It is recommended they be waterproof or stored in a waterproof case or bag.
- All vehicles are to be parked off road as far as possible. If parked on the edge of the road a safety pylon or equivalent shall be placed near the rear bumper closest to the road.
- If there is no safe access to a site, the site assessment will be abandoned. Active railroad crossings and interstate highway crossings are typically considered to have unsafe access. Culverts that meet the confined space definition shall not be entered. A confined space is any space that meets the following three criteria: 1) that has limited or restricted means of entry or exit; 2) is large enough for a person to enter to perform tasks; and 3) is not designed or configured for continuous occupancy. Any decision to abandon a site must be reported to the Survey Coordinator who in turn, must report to the Project Manager. Safety concerns for abandoning the site will be detailed in a report.
- Flagging tape will be used to mark access point locations for safe exit, in instances where such locations could be difficult to find as deemed appropriate by field crew.
- A pre-field review of the crossing shall be conducted to determine if the subject stream/river is subject to any dam release. If so, the dam release schedule shall be consulted.
- Assessments shall not be conducted in waterways that are subject to the ebb and flow of tides.
- Good judgment will be used in selecting clothes and personal protection items. Common items needed include: high visibility safety vests, extra clothing, sunshade, sunscreen, hats, insect repellent, and waterproof knee boots— or chest waders with appropriate restriction waist belt or quick release hip waders for highest anticipated

depths. Any staff not dressed appropriately for field work should not participate in the survey. Proper footwear is a must (e.g., no "flip-flops" for field work).

- Good judgment will be used in walking on marsh surfaces; ditches will be circumvented, or when deemed possible, crossed with caution. A wading staff or equivalent shall be used to probe water depth when entering unknown waters.
- A safety bag shall accompany all site visits and shall contain, at a minimum, the following items:
    - First aid kit
    - Emergency fresh potable water – 1 liter
    - Throwable, floatable, high visible rope – 50 feet minimum
    - Whistle
    - Insect repellant
    - Signal mirror
- While the majority of the crossings are likely to be on public lands, private property will be respected using the following guidelines.
    - If property is in close proximity to buildings or other heavily used areas, or if crossing private property is necessary to reach an assessment site, landowner permission will be sought
    - Posted property will not be accessed without permission of the landowner
    - Otherwise, sampling will proceed without any special effort to gain landowner permission

All personal and field equipment shall be cleaned and decontaminated upon exiting the water and before entering a new stream to prevent the spread of invasive species such as Didymosphenia *geminata*, commonly known as didymo or rock snot. Personal clothing checks shall be conducted for deer & dog ticks

**DISINFECTION PROCEDURES – Disinfect prior to moving to another water body, watershed, or upstream site**

There are a number of disinfection techniques that will kill most aquatic invasive species and fish and wildlife pathogens, including Didymo. Solutions of bleach or dishwashing detergent products are suggested as they provide the best combination of availability, cost AND effectiveness against Didymo as well as other aquatic invasive species and fish and wildlife pathogens, such as whirling disease. Choose the appropriate agent based on the actual items requiring disinfection (i.e. bleach solutions will destroy some items). It is recommended that all disinfected equipment be rinsed on dry land, away from state waters. It is preferable to drain used solutions into treated wastewater (e.g. pour down a sink drain).

Non-absorbent items (boats, canoes, rubber waders, 'hard-sided' objects)

- **Dishwashing Detergent**: soak and scrub for at least one minute in 5% solution (add 6.5oz of detergent with water to make one gallon). 'Green' products are less effective and not recommended for disinfecting.
- **Bleach**: soak or spray all surfaces for at least one minute in 2% household bleach (2.5oz with water added to make one gallon). Bleach solutions must be replaced daily to remain effective.
- **Hot Water**: soak for at least one minute in very hot water (above 140°F – hotter than most tap water) OR for at least 20 minutes in hot water kept above 120°F (hot tap water, uncomfortable to touch).
- **Drying**: Drying will kill Didymo, but slightly moist environments will support some organisms for months. This approach should only be used for gear that can be left in the sun for extended periods of time (i.e. a canoe that's left in the yard for several days between uses).

Absorbent items require longer soaking times to allow thorough penetration into the materials. Felt-soled waders, for example, are difficult and take time to properly disinfect, and therefore shall not be used. Other absorbent items include clothing, wetsuits, sandals with fabric straps, or anything else that takes time to dry out. The thicker and denser a material, the longer it will require for adequate disinfection. Because of these concerns, absorbent materials, including felt soled waders, shall not be used.

A simple, portable DISINFECTION KIT might include:

- Large trash can and/or medium sized Rubbermaid-type bin for soaking wading boots
- Large stiff bristle brush for scrubbing
- Spray bottle(s) or herbicidal pump spray can(s)
- Graduated cylinder or measuring cup
- 5% detergent solution and/or 2% bleach Solution

## 13.0 APPENDICES

Appendix A: Critical Linkages Report

Appendix B: User's Guide for Field Data Form

Appendix C: Field Data Form

Appendix D: Survey Coordinator Responsibilities

Appendix E: GPS User Manual

Appendix F: Camera User Manual

# APPENDIX A: CRITICAL LINKAGES REPORT

**(Separate file)**

# APPENDIX B

# Users Guide for Field Data Form

# (Separate file)

## Appendix C:  Field Data Form

## (Separate File)

# APPENDIX D

# Continuity Project Coordinators Guidelines

**Project Organization**

Level 1: Grand (National) Coordinators (Scott Jackson, UMass) **NC**
Level 2: MassDEP Project Coordinator (Lisa Rhodes, MassDEP; Mike McHugh QA Advisor), Stream Continuity Project Coordinator (Carrie Banks, DER) **PC**
Level 3: Survey Coordinators (Nancy Lin, Christine Odiaga, Pam Merrill, Mark Stinson) **SC**
Level 4: Team Leaders (MassDEP Staff – to be determined) **TL**
Level 5: Field Volunteers **FV** or Technicians **FT** (To be determined)

Coordinators must abide by the rules in this document

**Partners Responsibilities**

NC

- Oversee program and create master documents such as field data sheet and instructions
- Maintain database and give PCs & SCs database rights
- NCs can add coordinators and observers into the database
- NCs can make corrections to all records in the database
- Oversee assignment of crossing codes; keep master coverage of crossings with ID codes and make it available online as a link on stream continuity website
- Host online database
- Provide training to PCs and others as needed

PC

- Receive extensive training on field and database protocols and expectations for coordinators
- Oversee surveys in their state or in their multi-state project
- Facilitate assignment of crossing codes in their state
- Recruit, supervise and train SCs and others as needed
- Give SCs database rights
- Regularly provide to NCs a list of their coordinators who have database privileges
- PCs can add observers and coordinators into the database
- PCs can make corrections to records in the database for their state(s)
- Facilitate creation of GIS maps for their state or project area
- Do some random spot checking of database entry

- Archive digital crossing photos and paper documents

SC (Nancy Lin, Christine Odiaga, Pam Merrill, Mark Stinson)

- Receive extensive training on field and database protocols and expectations for coordinators
- Organize local surveys
- Recruit and train team leaders & volunteers
- Provide survey teams with maps, equipment, and forms/instructions
- Designated point-of-contact for TLs, FVs and FTs
- Document crossings that are not on the state GIS map (or any errors in the map crossings) and report to PC
- Fill out gray portion of field data sheets (Coordinator, Crossing ID, Flow condition[5] + stream, road, town)
- Enter data and photos into database
- SCs can make corrections to records for which they are listed as "coordinator"
- SCs can add observers to database
- Check paperwork and photos handed in by TLs, FVs and FTs
- Field check 10% of all surveys to ensure that FVs/FTs are doing a good job
- Resolve errors/questions with TLs or PCs; visit sites if necessary

TL (MassDEP Staff and other volunteers)

- Receive extensive training on field assessment protocols
- Lead team of 1 or 2 other volunteers (coordinate survey materials, set meeting locations and times)
- Ensure the safety of all members of the survey team
- Participate in surveys on regular basis

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[5] Typical low-normal flow conditions are presumed to be present between the lowest 20th and 50th percentile flow durations. Streamflow from June 1 to September30th is presumed to be at lowest 20th to 50th percentile flow duration. Streamflow conditions from October to May 31st will be determined by Survey Coordinator in consultation with the Hydrology Advisor by comparing flow duration against the most recently available real time streamflow data for respective watershed (i.e. USGS Real Time Flow Data on web at http://waterdata.usgs.gov/ma/nwis/rt).[5] Field conditions may also be assessed by observers to determine whether streamflow is in typical low-normal range, by observing water surface in stream in relation to staining in culverts or other bankfull indicators. Assessments shall not be conducted during or within 24 hours of a rain event that has deposited greater than one inch of rain within a 24- hour period. Local weather stations, rain gauges, or NOAA weather data (http://water.weather.gov/ahps/) may be used to confirm such a rain event. While Survey Coordinators may assign crossings to be assessed ahead of time, they should only authorize assessments during typical low-normal flow conditions and should suspend assessments as needed if flow conditions become too high or too low. Survey Coordinators should consult with the Hydrology Advisor if there are any questions. If Survey Team Leaders or Technicians conduct a site visit where the outlet drop is obscured by higher streamflow, if streamflow is excessively low or stream is dry, they should postpone the assessment and return when flow conditions are more appropriate.

- Submit completed datasheets to Survey Coordinator

FV/FT (MassDEP Staff and other volunteers)

- Receive basic training on field assessment protocols
- Assist in collection of data for one or more crossings
- Take photographs of crossings and assists in collection of data
- Time commitment varies, e.g., may volunteer 1 day or multiple days
- Must be accompanied by a Team Leader when conducting surveys

**Communication among Partners**

- There is a project web site at http://www.streamcontinuity.org/
- A "Contact Us" link will be added to the navigation bar, with an email address dedicated to the project. (Messages will be screened by National Coordinators.)
- A stream continuity listserv will be created for everybody involved in the project where they can send questions and suggestions. A link to join the listserv will be added to the website.
- Coordinators get an ID and password from their PC once trained. PCs must send list of their coordinators who have database privileges regularly to NC.

**Training**

- UMass will assemble training documents (PowerPoint presentations, photos, volunteer instructions, and tip sheets) with the help of seasoned PCs.
- A Toolbox link will be added to the "Assessing Crossing Structures" page on the website, and will include all survey tools, handbooks, example photos and will be updated regularly by UMass
- UMass will train any new PCs
- PCs train SCs, who then train team leaders and volunteers. They adapt the training tools to their region/watershed as needed

**Data Entry**

Log on to the Massachusetts Stream Road Crossing Online Inventory web site (http://www.streamcontinuity.org/cdb2/).

You will need a Login ID and password. Contact the PC or NC (if there is no PC for your region) who will assign one to you.

1. Add observers (your team leaders, field volunteers or technicians) if they are not already in the database.

2. Click on "Add Crossing."
3. Choose your name from the drop-down list of coordinators.
4. Continue entering data, the fields are listed in the same order as on the field data sheets.

Some data entry tips:

- If there is only one culvert or bridge cell at the crossing, click on "Finish." If there is more than one culvert/cell, choose "Add another culvert" (even if this is a multi-cell bridge).
- When finished, the next step is to enter photographs if available. **The image must be a gif or jpeg and be less than 200KB in size.**
- Before uploading photos, re-label them with the crossing ID + date (yyyymmdd) + I or O for inlet or outlet (e.g., xy1234561234567891-20100713-I).
- Only two photos per crossing, unless SC determines that more are needed. In that case, add a letter at the end (e.g., xy1234561234567891-20100713-Ia and xy1234561234567891-20100713-Ib).

For consistency and to facilitate searches, use this format to enter data:

- No abbreviations in stream and road names (spell out Brook, Street, Highway)
- Use the words Unnamed and Unknown for streams and roads that have no name and for those whose name you do not know, respectively
- A person different from the one who entered the data should proof data entry
- Once data entry has been proofed or corrected, it can be validated (uploaded to database) [this is a new feature planned for implementation in the near future].

**Data Reports**

- Click on Reports, then choose which records you want to see by choosing options in the top section
- Click on Search; Choose one Export option: Simple (Basic descriptive information and the crossing scores or Meaningful (Crossing scores plus more detailed descriptive information including variables used to derive the crossing score). This will create a csv file with the desired data that can be opened in Excel.

**Quality Control**

The database will be public and used to make important decisions, so it's critical that the data be 100% accurate (or as close as we can get). With that goal in mind, follow these steps:

- SCs review each field sheet and check for errors and omissions. SCs contact the appropriate TL right away with questions, then correct the field data sheet (cross out and write next to, never erase). If the problem is not resolved with TL, SC goes back to the crossing.
- One important check is to compare the GPS coordinates with the crossing ID. If they do not match, the volunteer may have gone to the wrong location. If there is any doubt about which crossing was surveyed, the SC should check the crossing in the field at this point.
- SCs check photographs and ensure that they are of good enough quality to see important details (such as outlet drop) and are properly labeled. If photos need to be retaken, ask TL to go back and retake, or SC will go to the site and take new photos.
- SCs are to field check 10% of the assessed crossings to ensure that FVs/FTs are doing a good job and that protocols are being followed.
- A person different from the one who entered the data should proof data entry
- Once data entry has been proofed or corrected, it can be validated (uploaded to database) [this is a new feature planned for implementation in the near future].

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**Photo Protocol:**

Two options to ensure proper labeling of photos:

- Use a whiteboard/paper/blackboard & chalk to write the crossing code ID #, date, and inlet/outlet on and to incorporate into photos.
- Alternatively you can use whiteboard or paper as above, but instead of incorporating in photograph of crossing, take a photo of it just before taking the crossing photo.
- GPS units are now mandatory so we can be sure volunteers are at the correct crossing.

**Coordinates Protocol:**

- GPS units are now mandatory so we can be sure volunteers are at the correct crossing.
- Set GPS units to lat/long and either WGS84 or NAD1983.
- Coordinates should be collected in decimal degrees with as many decimal places as are available (minimum of five decimal places).
- If GPS coordinates are recorded as DD/MM/SS on the data sheet then it is the responsibility of the Coordinator to transform them into decimal degrees before entering them into the database (To go from DD MM SS to decimals use http://www.fcc.gov/mb/audio/bickel/DDDMMSS-decimal.html).

**Crossing ID Assignment Protocol:**

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

- When an unmapped crossing is encountered in the field survey teams should write “Unmapped crossing #__” (providing a unique number for each unmapped crossing) at the top of the field data form. Later the Survey Coordinator should forward the record to the National Coordinators for assignment of a crossing code. Survey teams will need to be provided with blank data sheets in case they encounter unmapped crossings.

# APPENDIX E GPS USER MANUAL

GPS Users Guide:

http://www8.garmin.com/products/manual.jsp?product=010-00190-00

# APPENDIX F
# TIPS FOR GPS USE
### BY UMASS-AMHERST 8/9/11

Satellites

GPS satellites transmit signals to your GPS unit that contain 3 different bits of information--a pseudorandom code, ephemeris data and almanac data. The pseudorandom code is simply an I.D. code that identifies which satellite is transmitting information. You can view this number on your GPS unit's satellite page, as it identifies which satellites it's receiving.

Ephemeris data, which is constantly transmitted by each satellite, contains important information about the status of the satellite (healthy or unhealthy), current date and time. This part of the signal is essential for determining a position.

The almanac data tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits almanac data showing the orbital information for that satellite and for every other satellite in the system.

Handheld GPS units like Garmin or Magellan give a horizontal accuracy of about 3 meters. Your handheld receiver needs to "see" at least 4 satellites to obtain a good position. The more satellites, the more widely distributed the satellites, and the stronger the signal strength the better!

Many units, such as the Garmin eTrex or Garmin GPS72H, have a GPS Information Page where you can view the satellite configuration, strength, estimated accuracy, and the location format. This is the page you want to be looking at when deciding if you will record the location for that point at that moment or not.

Look at the satellite screen on the GPS information page on your unit to see the signal strength and geometric position of the satellites. The number of bars and how high they are will tell you the strength.

a. It is recommended that you turn the GPS on at least 10 minutes prior to recording your position or, better yet, if you have rechargeable batteries (and spares) leave the GPS on all day while you are working in the field. That will ensure that the GPS has up to date ephemeris information and has had sufficient time to lock onto all satellites that are above the horizon.

b. Before you record your position try to get 6 but no less than 4 satellite signals. The satellite map on this page will show you the satellite configuration. Try to get widely distributed satellites.

c. Some units are WAAS (Wide-Area Augmentation System)-enabled. Turn OFF WAAS unless you have an open view of the southern horizon. If WAAS is enabled without a clear view of the southern horizon accuracy could be reduced because the unit will be constantly trying to find WAAS satellites.

1. Position

Stand with your handheld GPS unit in a good spot. For culverts, if possible stand in the road above the culvert. Do not stand down in the stream channel. Anything blocking the receiver's satellite reception will lower the quality of the signal. You can't do anything about canopy cover but make sure there is as little blocking the GPS from receiving signals as possible (your body, a big rock, a bridge, building, vehicle etc). Hold it up over your head if need be.

2. Accuracy

Accuracy usually refers to horizontal accuracy. Accuracy is how close you are to a real-world location, also called the offset or error. On most handheld GPS units it is represented by an "error buffer" such as +/- 10m. The Garmin eTrexH reports its accuracy on the Satellite Page with a message "Looking for Satellites," then "Ready to Navigate, Accuracy: 8m"

Do not record the point unless the accuracy is 10m or LESS (about 33 feet). If you can't get 10m wait until you do. Most of the time waiting for 15 minutes or less will get you a better position.

3. Batteries - make sure they are fully charged

4. If your GPS has mapping software use it to help verify your position.

**Setting the GPS format:**

1. Map Datum: It is best to use datum WGS84 but NAD 83 (North American Datum 1983) or NAD 83 Conus are acceptable as well.

2. Location Format: Use projection Latitude-Longitude decimal-degrees (hddd.ddddd or dd.ddd) with 6 decimals if possible

**Dealing with weak or no signal:**

In the event that no signal, or insufficient signal strength, is received an "offset point" can be utilized. The GPS operator can move along the road (staying along the side of the road) until a signal of sufficient strength is received. That will typically be a more open area, where satellite signals are not obscured but tree canopy or other obstructions. The GPS operator can then use a compass and determine the bearing (true north) along the road that he/she is heading, and shall use a tape measure to measure the distance. By noting the distance and bearing, the actual point (the crossing) can be located based on the reference point (the point where the GPS signal was received). The field data form will reflect that an offset point was utilized and the bearing and distance shall be recorded.

Adapted in part from: http://www8.garmin.com/aboutGPS/

# APPENDIX G: CAMERA USER MANUAL

Camera Users Guide:

http://www.olympusamerica.com/cpg_section/cpg_support_manuals.asp?id=1544