Quality Assurance Project Plan for Development of a Comprehensive State Monitoring and Assessment Program for Wetlands in Massachusetts

2007-2010

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Project Management

1.1 Distribution List

MassDEP, Director Wetlands & Waterways Program – Lealdon Langley
MassDEP, Wetland Program Chief – Michael Stroman
MassDEP, Environmental Analyst, MassDEP Project Manager – Lisa Rhodes
MassDEP, Supervisor Watershed Planning Program – Rick Dunn
MassDEP, Technical Reviewer, Arthur Screpetis
MassDEP, Quality Assurance Officer – Richard Chase
EPA, -- Mathew Schweisburg
EPA, -- Jeanne Voorhess
EPA, -- Edward Reiner
EPA, ---Steve DiMattei
UMass Project Manager - Dr. Kevin McGarigal
UMass QA Manager – Scott Jackson
UMass Forest Field Manager - Kasey Rolih
UMass Wetland Field Manager – Theresa Portante
UMass Computer Data QA Manager – Brad Compton

1.2 Project/Task Organization

The participating individuals and/or organizations and their roles include:

Jeanne Voorhees – EPA Project Manager – oversee involvement of EPA personnel and project commitments
Steve DiMattei- EPA QA Officer- participates in the development and implementation of QA/QC procedures for the project
Lisa Rhodes - MassDEP Project Manager – oversees the involvement of MassDEP personnel and project commitments
Richard Chase – MassDEP QA Officer – participates in the development and implementation of QA/QC procedures for the project
Arthur Screpetis – MassDEP Advisor/Reviewer – participates in the development and implementation of QA/QC procedures for the project
Lealdon Langley – MassDEP Advisor/Reviewer – participates in data review and decision-making relative to RAM development, CAPS modifications and site selection for field work.
Michael Stroman – MassDEP Advisor/Reviewer – participates in data review and decision-making relative to RAM development, CAPS modifications and site selection for field work
Rick Dunn – MassDEP Advisor/Reviewer – participates in data review and decision-making relative to RAM development, CAPS modifications and site selection for field work
Dr. Kevin McGarigal - UMass Project Manager – oversees the involvement of UMass personnel and project commitments, inspects data for inconsistencies and makes necessary corrections
Scott Jackson – UMass Quality Assurance Manager – responsible for overall quality assurance; periodically conducts internal audits and coordinates any external audits.
Kasey Rolih – UMass Vegetation Field Manager – responsible for field and laboratory data

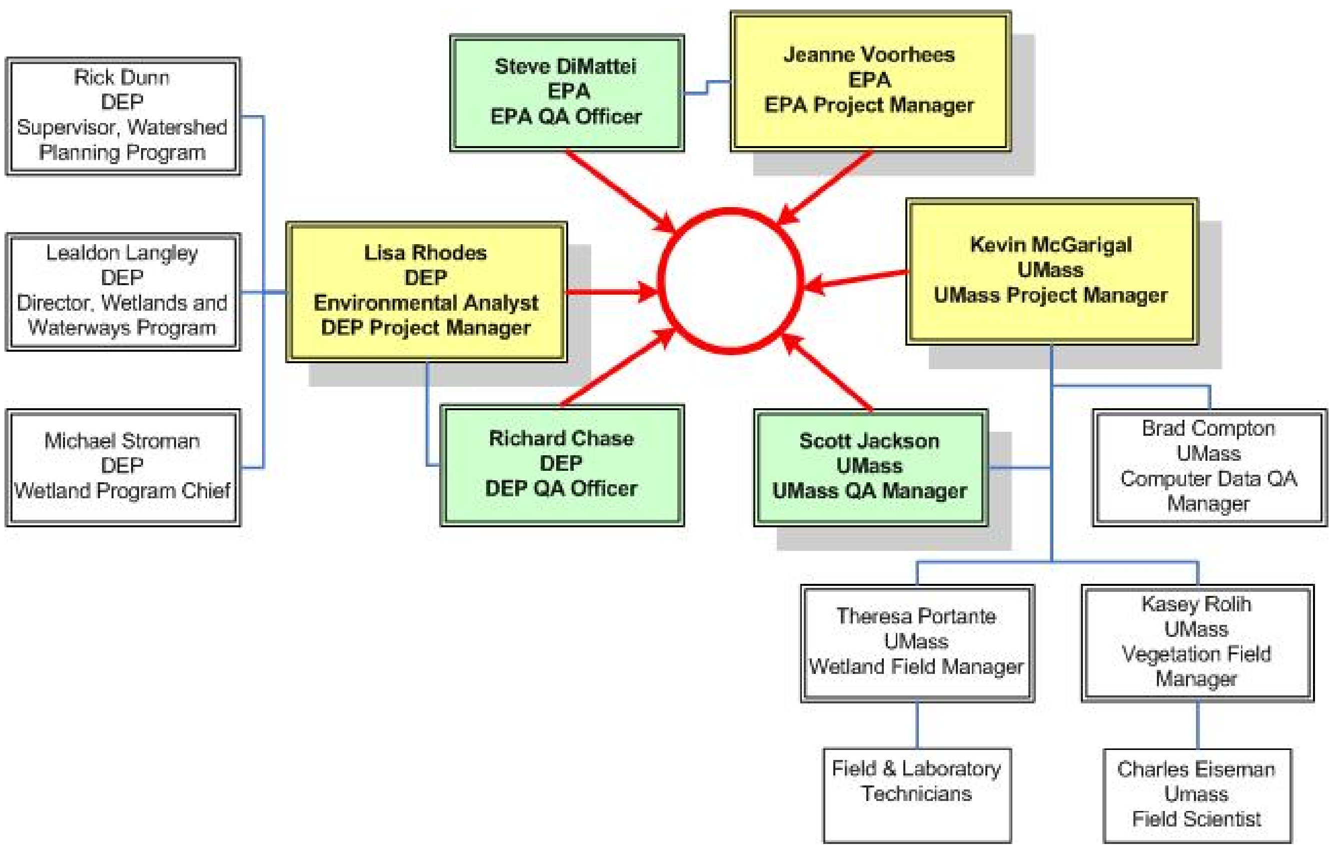
collection for lichens, bryophytes and other vegetation, scheduling, training and managing vegetation field sampling crew, field and laboratory quality assurance, and data transcription to database

Theresa Portante – UMass Wetland Field Manager – responsible for field and laboratory data collection for wetland communities, scheduling, training and managing wetland field sampling crew, field and laboratory quality assurance, and data transcription to database

Brad Compton – UMass Computer Data Quality Assurance Manager – responsible for GIS protocol for selecting sampling locations, data transcription processes, database management, computer backup and software QAQC.

Charles Eiseman – UMass Field Scientist – responsible for field sample collection.

Project Organization Chart



1.3 Problem Definition/Background

The goal of this Massachusetts wetland monitoring and assessment strategy is to develop a plan that validates and/or better directs the state's commitment to protect the physical, chemical and biological integrity of Massachusetts' wetlands. Implementation of this monitoring and assessment strategy will increase our understanding of wetland health through the development of criteria to assess designated use impairment, and collection of monitoring data to validate our findings. Our strategy will allow us to report on the status and trends of wetlands across the state, while we develop more intense assessment of specific watersheds, chosen for rapid assessment and monitoring. Ultimately, it is our goal to assess the cumulative impacts of development pressure and how degradation of the buffer zone affects the health of wetlands.

The specific goal of the Massachusetts *Wetland Monitoring & Assessment Program* is to develop a Site Level Assessment Methodology (SLAM) to assess freshwater wetland condition and to calibrate (and over time validate) the innovative computer program developed by UMass-Amherst (the Conservation Assessment & Prioritization System (CAPS)), and adopted by MassDEP, to predict ecological integrity on a landscape-scale. (For CAPS information and documentation go to www.masscaps.org). MassDEP intends to use CAPS, together with a Rapid Assessment Methodology (RAM) and intensive SLAM, to help guide policy, regulation and management actions. Also, Massachusetts will develop data to be incorporated into EPA's 2011 National Wetland Condition Assessment.

1.4 Project/Task Description

Summary of Work

Within our proposed strategy, we intend to develop and deploy a Level 1 (Landscape Assessment), Level 2 (RAM) and Level 3 (Intensive Site Assessment) *Wetlands Monitoring and Assessment Program* for Massachusetts in four phases (see Table 1.1 below). The CAPS approach described in detailed below is distinguished in several important ways.

First, recognizing that there are others out there focusing on understanding the relationship between site-based stressors and condition and the development of RAMs, we propose to focus initially on understanding the relationships between landscape-based stressors and ecological condition. Landscape-based assessment is our particular strength and probably the most significant contribution we can make to the community of agency and academic scientists working on wetlands assessment and monitoring. Although others (e.g., Ohio) are investigating the relationship between landscape metrics and condition, their landscape-based assessments lack the sophistication and rigor that CAPS can provide. For example, Ohio uses a single landscape-base metric (Landscape Disturbance Index) that lacks any distance-weighting function. CAPS uses up to 21 landscape-based metrics, many of which contain sophisticated distance-weighting functions.

Second, recognizing that much (but not all) of the existing work done in other states has focused on emergent wetlands (and salt marshes in Massachusetts), we propose to focus our work initially in forested and/or shrub wetlands. Forested and shrub wetlands make up the vast majority of wetlands in Massachusetts and are the most difficult to model using aquatic-based metrics (e.g., water quality, aquatic invertebrates). Because they typically lack permanent standing water, forested wetlands and many shrub wetlands are more integrated into the surrounding terrestrial landscape (e.g., forested wetlands can be viewed ecologically as both wetlands and forests). Therefore, it is necessary not only to look at how the surrounding landscape can negatively affect the physical-chemical characteristics of wetlands, but how the landscape can support components of the wetland biota that may be shared between wetland and terrestrial systems.

Third, recognizing the uncertainty surrounding the choice of effective indicators of ecological condition in forested and shrub wetlands, we propose to evaluate various taxonomic groups for their potential to yield IBIs for assessing condition. These may include lichens, algae, plants, invertebrates (terrestrial as well as aquatic), amphibians, and birds. The IBIs will be used to create a SLAM for a particular wetland type that can be used to understand the relationship between ecological condition and various stressor metrics. Note that SLAMs differ from RAMs in that they may be more intensive than rapid assessments in order to be rigorous enough to test and calibrate landscape-based stressor metrics. Once we have tested and modified (as necessary) the landscape-based assessment methodology (CAPS) then we will be positioned to use the work being done by others and the SLAMs produced by our work to optionally develop one or more RAMs. RAMs based on condition metrics rather than stressor metrics will then be able to fulfill our original expectations of identifying relationships between landscape-based assessments (CAPS scores) and conditions on the ground (RAM-scores).

The research and development of CAPS entails four basic steps (Table 2), which can be followed in any ecological setting (or for any wetland type), as follows:

Table 1.1. CAPS research and development steps.

CAPS R&D Step	Description
1. Conduct preliminary landscape-level assessment	Conduct preliminary landscape-level (level 1) assessment based on CAPS metrics; i.e., derive IEI.
2. Establish stressor-condition relationships	Establish stressor-condition relationships based on intensive empirical field studies for each ecological setting or unique wetland type
2a. Literature review	Review existing literature to identify potential stressor-condition relationships and useful field methods
2b. Pilot study	Conduct pilot study to screen potential condition variables and IBI's and develop a draft SLAM
2c. Operational study	Conduct full scale operational study to establish stressor-condition relationships. Revise assessment tools (CAPS and

	SLAM) as necessary to optimize performance
3. Develop RAM (if appropriate)	Develop RAM from SLAM, if possible
4. Implement long-term monitoring	Implement long-term monitoring program to validate CAPS prediction and account for time lags

Phase 1 involves conducting a preliminary landscape-level assessment. This is a critical first step because the landscape-level assessment can serve as a comprehensive (statewide) assessment of ecological integrity until the empirically established stressor-condition models have been developed in Phase 2. In addition, the GIS-derived landscape metrics are prerequisite for sampling in Phase 2 to empirically establish the stressor-condition relationships. Phase 1 does not involve field data collection.

The second phase of work involves establishing specific stressor-condition relationships firmly grounded on empirical observations – this is the most important step of R&D since failure to establish these relationships undermines the scientific credibility of the entire monitoring and assessment program.

The first stage of each stressor-condition study (phase 2a) involves a review of existing literature to identify potential stressor-condition relationships and useful field methods. The purpose of this step is to take full advantage of what others have already done to identify important stressor-condition relationships. Carefully attention will be given to the transferability of results from other studies in other geographic areas including use of preliminary field work to determine the practicality of using various stressor metrics contained in existing methodologies from other states.

Field data collection for Phase 2a took place in 2007 and included two components: a deciduous forest component and a wetland component focusing on shrub swamps and forested wetlands. CAPS is a comprehensive approach to landscape-level ecological assessment that models ecological value for both aquatic/wetland and terrestrial ecosystems. Calibration of these landscape-based assessment models requires field data collection in representative terrestrial (deciduous forest) and wetland (shrub swamp and forested wetland) systems. Among aquatic/wetland communities, shrub swamp and forested wetlands were selected because we expect to find a broader range of stressors in these drier and more accessible wetlands (e.g. ATV use, dumping, ditching). Each of these components will include data collection to achieve two objectives: community characterization and condition assessment based on the evaluation of local stressors.

Implementation of Phase 2b took place in 2008 with Phase 2c taking place in 2009.Field work will focus on forested wetlands. This work involves the development of Indices of Biological Integrity (IBI) and a Site-Level Assessment Methodology (SLAM) to provide information about ecological condition for testing and calibrating the CAPS predictions and modifying (as needed) the CAPS models.

Much (but not all) of the existing work done in other states has focused on emergent wetlands (and salt marshes in Massachusetts). Therefore, we propose to focus our work initially in forested wetlands. Forested wetlands make up the vast majority of wetlands in Massachusetts and are the most difficult to model using aquatic-based metrics (e.g., water quality, aquatic invertebrates). Because they typically lack permanent standing water, forested wetlands are more integrated into the surrounding terrestrial landscape (e.g., they can be viewed ecologically as both wetlands and forests). Therefore, it is necessary not only to look at how the surrounding landscape can negatively affect the physical-chemical characteristics of wetlands, but how the landscape can support components of the wetland biota that may be shared between wetland and terrestrial systems. In a separate phase of the wetlands assessment and monitoring program (with its own QAPP), conducted in cooperation with Massachusetts Office of Coastal Zone Management and MassDEP, we began work in 2009 on a similar project in coastal salt marshes.

Due to the uncertainty surrounding the choice of effective indicators of ecological condition in forested wetlands, we propose to implement this pilot study to evaluate various taxonomic groups for their potential to yield IBIs for assessing condition. These include lichens, algae, vascular plants, bryophytes, and invertebrates (terrestrial as well as aquatic). The IBIs will be used to create a Site-Level Assessment Methodology (SLAM) for forested wetlands that can be used to understand the relationship between ecological condition and various stressor metrics. Note, SLAMs differ from RAMs in that they may be more intensive than rapid assessments in order to be rigorous enough to test and calibrate landscape-based stressor metrics. Once we have tested and modified (as necessary) the landscape-based assessment methodology (CAPS) then we will be positioned to use the work being done by others and the SLAMs produced by our work to optionally develop one or more RAMs.

Field data collection for Phases 2b and 2c involves sampling of several biotic communities to determine if 1) there is a dose-dependent response in various attributes of the biological community to stressors within the landscape and 2) to validate/calibrate the ecological integrity metrics that are utilized in the CAPS model. Characterization of the wetland and assessment of its biological condition will be conducted in the field by assessing algae, macroinvertebrates, vascular plants, bryophytes, epiphytic macrolichens and habitat characterization.

This QAPP provides detail for Phases 2a,2b and 2c of this project. General information for phases 1, 3 and 4 are provided, but without reference to specific data collection procedures. Data collection procedures for phases 3 will be developed after the results of phases 1 and 2 have been evaluated. The QAPP will be amended as needed to accommodate later phases as protocols and procedures for that work are developed. Additional detail on phase 2c data collection is contained within the attached Standard Operating Procedures (Appendix H).

Products

The final products for this project will be:

- Statewide Level 1 assessment of all natural communities (terrestrial, wetland and aquatic) with results made available for each watershed
- Indices of Biological Integrity (IBI) for use in Level 3 assessment throughout Massachusetts

- Site Level Assessment Methodology (Level 3) for freshwater wetland communities
- Reports summarizing assessments conducted in select watersheds

Table 1.2 Anticipated Schedule for Implementation (dependent on funding – to date, funding has been committed for phases 1 & 2)

Project Phase	Date	SLAM	CAPS	General
Phases 1 & 2a	June 30, 2007	Select field plots; Establish sampling protocols		
	July-Sept, 2007	Field data collection		
	May 15, 2008	Draft wetland SLAM for use in 2008 field season	Level 1 Assessment completed for Connecticut Valley and areas west	Annual status report
Phase 2b: forested wetlands	April 30, 2008	Select field plots for SLAM field work		
	May-Sept, 2008	Field data collection (forested wetland pilot study)		
	Apr 30, 2009	Final forested wetland SLAM for use in operational study		Annual status report
Phase 2c: forested wetlands	April 30, 2009	Select field plots for Phase 2c Operational Study		
	May-Sept, 2009	Field data collection (forested wetland operational study)		
	Dec 31, 2009		Level 1 Assessment completed statewide	
	Apr 30, 2010	Results of forested wetland operational study	Results of CAPS calibration process for Forest and Forested Wetland communities	Final report on Level 1 (CAPS) and Level 3 (SLAM) assessments for forested wetlands

Geographical Location of Field Tasks

Phases 2a and 2b took place in Western Massachusetts. Phase 2c will take place in Central and Eastern Massachusetts. Phase 2a work involving deciduous forest communities took place in the Deerfield River watershed in order to sample both northern hardwood and transitional hardwood forest types. Wetland field work associated with Phase 2a occurred in the Westfield River watershed and Phase 2b work took place in the Chicopee River watershed where there was an appropriate mix of urban, suburban, and relatively undeveloped areas. Phase 2c work will be conducted in the Concord (Sudbury-Assabet-Concord) and Miller's River watersheds.

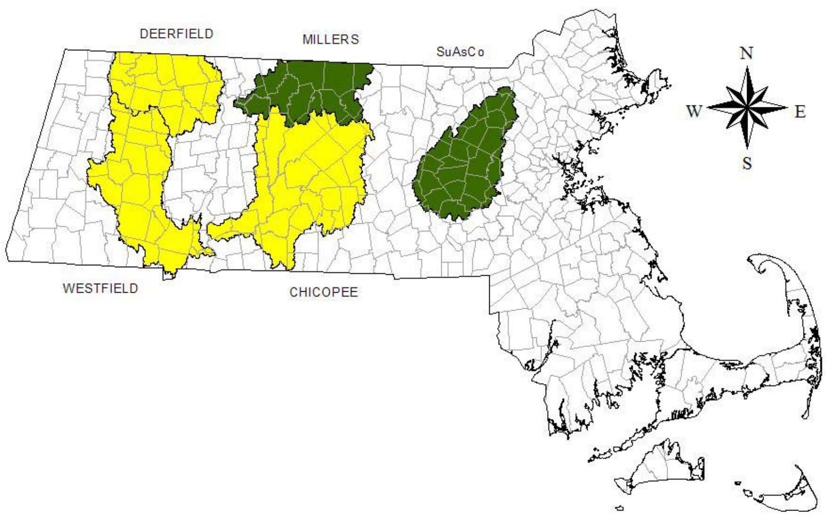


Figure 1.1 Location of Deerfield, Westfield and Chicopee River watersheds, where phase 2a and 2b work took place and the SuAsCo and Miller's River watersheds where Phase 2c will be conducted.

1.5 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 through sampling, measurement of function, and data management to ensure the data quality meets those standards (Clairain et al. 1997) and is overseen by the Quality Assurance Manager and Project Managers.

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 (Taylor 1985). 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, 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.

Specific details are included in the Standard Operating Practices for each of the components of this project.

Table 1.3. Data Quality Objectives

Parameter	Units	MDL	RDL	Expected Range	Accuracy (+/-)	Precision
Water Conductivity	µS/cm	1	5	50-500 µS/cm	+/- 1% full scale + 1 digit	Relative Percent Difference (RPD) less than 20% of mean
Water pH	S.U.	NA	NA	4-8 pH	+/- 0.3 pH	Standard deviation less than 10% of mean
Water temperature	^{o}C	NA	NA	15-35 C	+/- 1 C	Standard deviation less than 20% of mean
Water quality degradation (obvious spills, excessive algae, direct discharge from agriculture, septic or sewage treatment systems)	Presence/absence;	NA	NA	Present/absence;	NA	100% agreement on presence/absence among separate observers
Wetland hydrology	Inundated or dry; Percent cover of surface water; Average depth of surface water Sheet or Channelized flow; Depth to groundwater	NA	NA	Inundated/dry; 0-100% (based on five cover classes); 0-3m; Sheet/channelized; 0-50 cm	NA	Within 10% among separate observers for surface water depth and depth to groundwater; 100% agreement on cover class among separate observers for percent cover
Depth to Groundwater	Cm	NA	NA	0-80 cm	2 cm	Repeat measurements

Parameter	Units	MDL	RDL	Expected Range	Accuracy (+/-)	Precision
						with 1 cm of each other
Hydrological alteration (culvert, dam, weir, storm water inputs, fill, ditching, channelization, beaver dam)	P/A of Water control structures;	NA	NA	Present/absent;	NA	100% agreement among separate observers for presence/absence
Wetland soils	Horizon depth/thickness; Matrix color; Percent of soil made up of redoximorphic features; Color of redoximorphic features	NA	NA	0-50 cm; NA; 0-40%; NA	100% accuracy of soil color based on visual comparison with Munsell chart. Estimated thickness +/- 2 cm; Estimated percent redoximorphic features +/- 5%	100% agreement among separate observers for soil color; within 10% for horizon depth/thickness and percent redoximorphic features
Soil alteration (filling, plowing, grading, grazing, dredging, sedimentation, vehicle use)	Presence/absence;	NA	NA	Present/absence	NA	100% agreement on presence/absence among separate observers
Topographic complexity	Number of "pits" per 100 m	NA	NA	0-20 "pits"	NA	Within +/- 1 "pits" among separate observers
Vascular plants & ferns	Percent cover by species (or genus if species ID is not possible)	NA	NA	0-100%	100% accuracy of identification at either species or genus level; Percent cover +/- 5%	Percent cover within 5% among separate observers
Invasive plants	Species presence; Percent cover by	NA	NA	0-5; 0-100 %	100% accuracy of identification to species	Percent cover within 5%

Parameter	Units	MDL	RDL	Expected Range	Accuracy (+/-)	Precision
	species				level	among separate observers
Epiphytic macrolichens	Species present; Percent cover by species	NA	NA	0-10; 0-90%	100% accuracy of identification to species level based on spot checks by trained project staff and/or experts (as applicable)	Percent cover within 5% among separate observers
Earthworms	Species presence; Individuals detected by species	NA	NA	0-5; 0-50	90% accuracy of identification	>90% of confirmation samples positively confirmed by expert(s)
Wetland site stressors (trails & roads, trash/litter, dumping)	Presence/absence;	NA	NA	Presence/absence;	NA	100% agreement on presence/absence among separate observers
HGM Classification (wetland)	Class & subclass	NA	NA	NA	100% accuracy of classification based on spot checks by trained project staff and/or experts (as applicable)	100% agreement among separate observers
Cowardin et al. classification (wetland)	System, subsystem, class, water regime, modifiers	NA	NA	NA	100% accuracy of classification based on spot checks by trained project staff and/or experts (as applicable)	100% agreement among separate observers

Parameter	Units	MDL	RDL	Expected Range	Accuracy (+/-)	Precision
Location by coordinates (GPS)	Degrees and decimal minutes	NA	NA	NA	0 – 10 m Dependent upon a variety of environmental factors	Repeated readings to verify coordinates essentially the same
Bryophytes	Species present; Percent cover by species	NA	NA	0-20; 0-90%	100% accuracy of identification to species level based on spot checks by trained project staff and/or experts (as applicable)	Percent cover within 5% among separate observers
Macroinvertebrates	Species presence; Relative abundance	NA	NA	0-50; 0-90%	100% accuracy of identification to order; 90% accurary of identification at the genus/species level	>90% of confirmation samples positively confirmed by expert(s)
Algae (water column, substrate & leaf litter)	Species presence; Relative abundance	NA	NA	0-20; 0-90%	90% accuracy of identification of diatoms to species	>90% of confirmation samples positively confirmed by expert(s)

MDL = Method Detection Limit
RDL = Reporting Detection Limit

1.6 Special Training/Certification

Field crew members will have sufficient previous training and experience to reliably conduct field data collection or they will receive training from the UMass QA Manager and/or other project scientists with relevant expertise. All Field Managers and Field Scientists will receive training from the QA Manager on appropriate QA/QC procedures. The UMASS QA Manager will keep a list of those trained along with the dates that the training occurred (i.e. documentation to show who was trained and when). Additional detail is included in the Standard Operating Practices for each component of this project.

1.7 Documents and Records

The most current approved version of the QA Project Plan will be provided to the appropriate personnel by the UMass QA Manager. All data collected will be maintained in raw form (field data forms) or electronic data (collected via Palm computers) for at least five years in the UMass project manager's laboratory at the University of Massachusetts. The QAPP and SOPs will be dated to distinguish among different versions in case there are revisions made over the course of the project. The Project Manager will include all reports of the project status on the annual report, including any problems and the proposed recommended solutions. Annual status reports and final reports will be provided in electronic form to everyone on the distribution list. Hard copies of reports will be maintained at UMass and MassDEP for at least five years. Results of the assessments and analyses as well as GIS data generated over the course of the project will be provided to MassDEP and EPA.

Quality Control records including confirmation samples positively confirmed by experts will be maintained at UMass for at least five years. Where appropriate, QC records will be summarized in progress reports or the project final report. Details about the CAPS modeling approach including data input and output files will be covered by a separate QAPP.

2.0 Data Generation and Acquistion

2.1 Sampling Process Design (Experimental Design)

Phase 2a

Sampling sites were selected via a stratified random process in a representative geographic area for which Level 1 assessment has been completed. Data collection focused on deciduous forest, shrub swamp, and forested wetland communities. Field data collection was successfully completed in 2007 and involved the assessment and estimation of various field-based metrics for purpose of either 1) characterizing the natural community being sampled or 2) assessing the ecological condition of the site.

Phase 2b

Sampling sites for SLAM pilot study were selected via a stratified random process to represent a broad range of geographic and ecological conditions.

Field data collection was conducted using the draft SLAM developed in phase 2a. Field data collection involved sampling several biotic communities to determine if 1) there is a dose-dependent response in various attributes of the biological community to stressors within the landscape and 2) to validate/calibrate the ecological integrity metrics that are utilized in the CAPS model.

Characterization of the wetland and assessment of its biological condition was conducted in the field by assessing algae, macro-invertebrates, vascular plants, bryophytes, epiphytic macrolichens and habitat characterization.

Results from the phase 2b pilot study were used to refine the SLAM for use in the operational study (phase 2c).

Phase 2c

Phase 2c of the forested wetland stressor-condition study involves an operational study based on the pilot study to firmly establish stressor-condition relationships. The steps involved are essentially identical to those described above for the pilot study, except that the geographic scope of the study will expand to other areas of the state and the ecological attributes sampled and the sampling methods employed (i.e., the SLAM) will be those determined to be optimal based on the pilot study.

This step also involves revising the assessment tools (CAPS and SLAM) as necessary to optimize their performance. We anticipate that each step of each stressor-condition study in phase 2 will lead to new insights into stressor-condition relationships and warrant changes in the assessment tools, including revisions of the CAPS metrics (e.g., dropping/adding metrics and modifying the parameterization of existing metrics) and modifications of the SLAM (e.g., details of the IBI's).

Characterization of the wetland and assessment of its biological condition will be conducted in the field by assessing algae, macro-invertebrates, vascular plants, bryophytes, epiphytic macrolichens and habitat characterization. Phase 2c field data collection will take place in 2009 and will include:

- Location (GPS)
- Hydrology (percent cover surface water; average and maximum depth of surface water; depth to groundwater)
- Water geochemistry (pH, temperature, conductivity)
- Water/air temperature (Degrees C)
- Topographic complexity (micro-topographic depressions per 100 m)
- Vascular plants (species, percent cover)
- Bryophytes (species, percent cover)
- Epiphytic macro-lichens (species, percent cover)
- Algae (species, relative abundance)
- Earthworms (species, relative abundance)
- Other macroinvertebrates (species, relative abundance)

- Water quality degradation (obvious spills, excessive algae, direct discharge from agriculture, septic or sewage treatment systems)
- Hydrological alteration (culvert, dam, weir, storm water inputs, fill, ditching, channelization, beaver dam)
- Soil alteration (filling, plowing, grading, grazing, dredging, sedimentation, vehicle use)
- Wetland site stressors (trails & roads, trash/litter, dumping)

Results from Phases 2b and 2c will be used to calibrate the CAPS metrics and refine the SLAM for use in future studies.

Future Phases

Planning has not yet been completed for future phases of the work beyond implementation of phases 1 and phases 2a-c for forested wetlands. Options for future work include:

- Implementing phases 2a-c for another wetland type (e.g., shrub swamp, emergent marsh)
- Creation of a Rapid Assessment Methodology (RAM) for forested wetlands
- Initiating a long-term monitoring program for forested wetlands

The measurement procedures specified in the next section of the sampling protocol and attached SOPs describe how conditions for individual sites are measured. The sampling and measurement procedure sections include documentation and QA/QC procedures to ensure that the data are collected correctly and are reproducible. The data management procedures are the final section of the sampling protocol. These procedures set how the data will be formatted for analyses and archived. Data management includes ensuring that the data are complete and correct. The following sections and attached SOPs describe these sections of the sampling protocol in more detail.

2.2 Sampling Methods

The Phase 2a assessment work involved a minimal amount of sample collection and relied principally on environmental data generated by the field assessment and estimation of environmental parameters. Checklists and field data forms were used to document stressors and indicators of degradation in the proximity of the randomly selected forest and wetland sites. In addition, information on vegetative, hydrological and topographic characteristics wass collected to characterize the natural communities being sampled. Consistent with a rapid assessment approach the evaluation of many condition parameters involved choosing the most appropriate category or range of observation (e.g. vegetative cover classes). Use of transects and time-constrained sampling was used to standardize effort. Additional detail is included in the Standard Operating Procedures (SOP) for each component of this project.

Phase 2b survey work related to SLAM development and the development of IBIs involved a mixture of 1) field estimation of environmental parameters, 2) detail measurements in the field and 3) sample collection for laboratory analysis or species identification. Use of transects and time-constrained sampling was used to standardize effort. Details on survey and sampling procedures are detailed in the corresponding SOP.

Field data collection associated with Phase 2c will be very similar to procedures used in Phase 2b. As a result the SOP for Phase 2b (Appendix H) has been revised and updated to serve as the SOP for Phase 2c fieldwork.

In some cases data gathered in the field will be entered onto field data forms and entered later into one or more Access databases. Data forms may also be programmed into palm computers and taken into the field. Data can only be entered in appropriate boxes with drop down menus to minimize data entry errors (typos and misspellings). A hardcopy will also be taken into the field as backup in case of problems with the palm computers. The field survey coordinator will review data for completeness and accuracy prior to downloading it into the laboratory database. Data will be downloaded from the field computer directly into the laboratory database which will help to minimize data entry errors. Data will be cross-checked for errors by the Field Manager and double-checked for completeness by the Computer Data QA Manager.

Table 2.1 Phase 1 Data Collection

Matrix	Parameter	Method	Units	Sample Holding Container	Method Sample Preservative	Maximum Holding Time
Water	Conductivity	pH/Conductivity/C meter	µS/cm	NA	NA	NA
Water	PH	pH/Conductivity/C meter	SU	NA	NA	NA
Water	Temperature	pH/Conductivity/C meter	^{o}C	NA	NA	NA
Wetland	Water quality degradation (obvious spills, excessive algae, direct discharge from agriculture, septic or sewage treatment systems)	Observation along transects	Presence/absence;	NA	NA	NA
Wetland	Wetland hydrology	Observation and depth recordings along transects; Observation of water in a shallow groundwater monitoring well located at the lowest elevation within the assessment area	Inundated or dry; Percent cover of surface water; Average & maximum depth of surface water Sheet or Channelized flow; Depth to groundwater	NA	NA	NA
Wetland	Hydrological alteration (culvert, dam, weir, storm water inputs, fill, ditching, channelization, beaver dam)	Observation along transects and along stream channels leading in and out of wetland assessment area	Water control structures;	NA	NA	NA
Wetland	Wetland soils	Observation of soil pits at	Horizon	NA	NA	NA

Matrix	Parameter	Method	Units	Sample Holding Container	Method Sample Preservative	Maximum Holding Time
soils		plot center and midpoint of each of four transect lines	depth/thickness; Matrix color; Percent redoximorphic features; Color of redoximorphic features			
Wetland	Soil alteration (filling, plowing, grading, grazing, dredging, sedimentation, vehicle use)	Observation along transects	Presence/absence;	NA	NA	NA
Wetland	Topographic complexity	Assessed along transects	Micro-topographic depressions > $1 m^2$ per 100 m	NA	NA	NA
Wetland or Forest	Vascular plants & ferns	Percent cover will be estimated using the line-intercept method or by use of 2 m subplots every 10 m along transects; species lists will be supplemented using time-constrained sampling throughout the assessment area	Percent cover by species (or genus if species ID is not possible)	Plastic bag	NA	48 hours
Wetland or Forest	Invasive plants	Percent cover will be estimated using the line-intercept method; species lists will be supplemented using time-constrained	Species presence; Percent cover by species	Plastic bag	NA	48 hours

Matrix	Parameter	Method	Units	Sample Holding Container	Method Sample Preservative	Maximum Holding Time
		sampling throughout the assessment area				
Forest & wetland trees	Epiphytic macrolichens	Ocular estimation of percent lichen cover on trees using a 10 or 15-factor prism to select trees within a 30 m plot	Species present; Percent cover by species	Plastic bag	NA	One week
Wetland	Wetland site stressors (trails & roads, trash/litter, dumping)	Observation along transects	Presence/absence;	NA	NA	NA
Wetland	HGM Classification (wetland)	Observation from plot center	Class & subclass	NA	NA	NA
Wetland	Cowardin et al. classification (wetland)	Observation from plot center	System, subsystem, class, water regime, modifiers	NA	NA	NA
Wetland or Forest	Location by coordinates (GPS)	Garmin GPS Unit from plot center	Degrees and decimal minutes	NA	NA	NA
Wetland soils	Earthworms	Searches of soil excavated for pitfall traps and midden counts	Species presence; Individuals detected by species	Plastic or glass jars	70% isopropyl alcohol	One week
Wetland	Bryophytes	Percent cover estimated in eight $1m^2$ quadrats (2 per transect); species lists will be supplemented using time-constrained sampling throughout the assessment area	Percent cover by species (or genus if species ID is not possible)	Plastic bag	NA	48 hours
Wetland	Hydroperiod	A combination of HOBO Pendant temperature/light data recorders placed in	Number of growing season days with standing water	NA	NA	NA

Matrix	Parameter	Method	Units	Sample Holding Container	Method Sample Preservative	Maximum Holding Time
		deepest areas of standing water and iButton temperature recorders positioned outside of water/depressions				
Wetland (water and air)	Temperature	HOBO Pendant temperature/light data recorders and iButton temperature recorders	Degrees C	NA	NA	NA
Wetland	Algae	Leaf scrubbing, water sampling, sediment sampling	Species presence Relative abundance (% of sample)	Plastic or glass jars	M3 fixative	Five years
Wetland	Macroinvertbrates	Stovepipe sampler, emergence traps, pitfall traps	Species presence Relative abundance (% of sample)	Plastic or glass jars	95% ethanol and kept cool	Five years

2.3 Sample Handling and Custody

Vascular plant, bryophyte and lichen collections will be limited to species that cannot be identified in the field. For species that cannot be positively identified in the field samples will be collected for lab identification and photographed for digital preservation. Taxonomic identification at the species level (preferred) or genus level (if species identification is not possible) will be achieved in the laboratory through the use of field guides, technical keys, and reference to regional herbaria housed at research universities such as UMass. Samples will be labeled in the field with the plant ID (e.g. “unknown sedge #1”) site location, date, and person who collected the sample, and assigned a code in the laboratory for use in digital preservation.

Figure 2.1 Vegetation Sample Label

CAPS-RAM Development Project
Vegetation Sample Label

Plant ID ______________________

Site location ______________________

Date ______________________

Collected by ______________________

Figure 2.2 Chain of Custody Log for Vegetative Samples

CAPS-RAM Development Project
Vegetation Sample Log

Site location	Date	Plant ID	Collector

Relinquished by: ______________________ Date ______________

Received by: ______________________ Date ______________

Figure 2.3 Example Lichen/Bryophyte Voucher Label

Herbarium of the University of Massachusetts, Amherst
BRYOPHYTES or LICHENS of The Chicopee Watershed

Taxon: ____

PlotID: ______________________________ **Subplot/Transect#** ____________________

State: ______**County:** ______________________________ **Town:**______________________
UTM e: __ __ __ __ __ __ **UTM n:** __ __ __ __ __ __ __ **Zone:** _______ **Datum: NAD 83**

Substrate & Site Characteristics (circle all that apply):

Soil: mineral soil, gravel, sand, loam, silt, clay, litter, duff, humus, peat, moss, or litter-fall
Rock type: granitic, serpentine, metamorphic, sedimentary, volcanic, or calcareous
Rock feature: outcrop, boulder, cliff, crevice, ledge, talus, or under-hang
Tree or Shrub: species: ______________________________ **location:** base, trunk, branch, root, stump, snag, recently fallen tree, rotten log (**decay class:** ____), bark, wood, or tree root-wad
Light: full sun, partial shade, full shade **Elevation:** ________ **ft. Slope** ___ ___ **% Aspect:** ___ ___ ___°
Habitat: bog/fen, dense/open/cut forest, lake/pond, meadow, seep, spring, swamp, waterfall stream/creek/river (intermittent), wetland, seasonally wet area, splash zone, or submerged
Site Moisture Regime: dry, mesic, moist, or wet

Collector: ______________________________**Coll. No.** _____________ **Date:** ______________

Verified by: ___________________ **Date:** ____________ **Notes:** ________________________

Separate algae samples will be collected from sediment, leaf litter and the water column for each sample location. Samples will be preserved with M3 fixative (Potassium Iodide, Iodine (optional), glacial acetic acid, 25% formalin) and stored until resources are available to identify the specimens. All algae samples will be recorded on the algae sample login form before storage in the lab. Samples will be stored in a dark area until funding is available for identification.

Figure 2.4 Algae Sample Label

Algae Sample	
Date:	Plot ID:
Sample ID:	Collector ID:
Comments:	

Figure 2.5 Benthic Algae Sample Label

Benthic Algae Sample	
Date:	Plot ID:
Sample ID:	Collector ID:
Surface Area:	Amt. of M3 added:
Comments:	

Figure 2.6 Phytoplankton Sample Label

Phytoplankton Sample	
Date:	Plot ID:
Sample ID:	Collector ID:
Amt. of M3 added:	
Comments:	

Earthworms will be collected into 70% isopropyl alcohol and kept cool until transfer to the lab for permanent preservation in 10% formalin. Samples will be labeled in the field with plot ID, data, and name of surveyor. Worms will remain in formalin for at least 24 hours before being permanently stored in 70% isopropyl alcohol. Ten percent of earthworm samples will be sent to an outside expert to confirm identifications.

Figure 2.7 Earthworm Sample Label

CAPS-RAM Development Project
Earthworm Sample Label

Plot ID ______________________

Subplot ID ___________________

Date ________________________

Collected by __________________

Figure 2.8 Chain of Custody Log for Earthworm Samples

CAPS-RAM Development Project
Earthworm Sample Log

Plot ID	Subplot ID	Date	Collector

Relinquished by: ____________________________ Date _____________

Received by: _______________________________ Date _____________

Other macro-invertebrates will be collected into 95% isopropyl alcohol and kept cool until transfer to lab for permanent preservation. Samples will be labeled with the plot ID, date, surveyor, and collection method. They will be sorted and identified to order in the lab. Samples will be preserved and held in the lab until resources are available to identify the macroinvertbrates to genus and species (if possible).

Figure 2.9 Pit Trap Macro-invertebrate Sample Label

Pitfall Sample	
Date Set:	Date Collected:
Plot ID:	Sample ID:
Comments:	

Figure 2.10 Stovepipe Macroinvertebrate Sample Label

Stovepipe Sample	
Date:	Plot ID:
Sample ID:	Collector ID:
Comments:	

Figure 2.11 Emergence Trap Macroinvertebrate Sample Label

Emergence Trap Sample	
Date Set:	Date Collected:
Plot ID:	Sample ID:
Collector ID:	
Comments:	

2.4 Analytical Methods

Laboratory Analysis

Laboratory analysis will be limited to sorting of biological samples (earthworms, other macro-invertebrates, algae, lichens, bryophytes and vascular plants) and microscopic examination for purposes of taxonomic identification.

Data Analysis

The overarching goal of the data analysis is to determine whether CAPS IEI and the component ecological integrity metrics (e.g., habitat loss, connectedness, etc.) are related to observed ecological conditions, and to further quantify the magnitude and nature of those relationships. To accomplish this goal, we will use a variety of statistical methods including principally quantile regression (Cade et al. 1999) and a custom analytical method based on the method of indicator species analysis (Dufrene and Legendre 1997). The data input for both analytical methods will be a list of the sample points and the corresponding values for each of the CAPS metrics and a suite of variables representing the presence or standardized abundance of each species or group of species and/or one or more derived biotic indices (e.g., Simpson's diversity index).

Quantile regression is used to estimate functional relations near the boundaries of data distributions and for analyzing effects of ecological limiting factors, where the relevant rates of change estimated are near the extremes of distributions. We will use linear and nonlinear quantile regression, as appropriate, to examine the relationship between each CAPS metric and the extremes of each of the biotic response variables. Based on our preliminary analysis, we expect the upper extremes of abundance of some taxa to be strongly related to the ecological integrity gradient, even though the mean shows no relationship, indicating that perhaps ecological integrity as measured primarily effects the ability of some species to achieve high levels of abundance.

Indicator species analysis is typically used to identify species that are significant indicators of discrete habitat types or conditions based on their relative abundance across habitat types and their ubiquity of occurrence across samples within each habitat type. Here, we will develop a custom application of this basic method based on a similar method being developed by Dr. Mathew Baker at the University of Maryland, Baltimore, called Taxa Indicator Threshold Analysis (TITAN). Briefly, our approach involves subdividing samples into low versus high integrity plots based on a sequentially advancing threshold in values of the ecological integrity metric under consideration (e.g., IEI) and computing indicator species values for each species or species' group. Through a combination of bootstrap and Monte Carlo randomization procedures, we will identify which species are significant indicators of the ecological integrity gradient, the threshold in ecological integrity value that leads to the greatest indication of the gradient, and the level of uncertainty in the threshold delineation (both in terms of the magnitude of the indication and the location of the threshod).

2.5 Quality Control

Quality Control will be maintained throughout the project through the following measures. Additional detail is provided in the SOPs for specific project components.

- Thorough review of comparable methodologies from other states and development of comprehensive field data collection methodologies (completeness, comparability)
- Computer aided use of stratified random sampling procedures for site selection (accuracy, representativeness)
- Use of standardized sampling procedures such as transect and time-constrained

sampling (precision, accuracy, representativeness)
- Prompt review and documentation of any changes to the SOPs (precision, accuracy, comparability)
- Use of highly qualified field scientists (precision, accuracy, comparability)
- Rigorous training and mentoring of less experienced technicians (precision, accuracy, comparability)
- Use of internal checks to assess the level of inter-observer variability in data collection (precision, accuracy, comparability)
- Use of replicate sampling and assessment of standard error among sample values for pH, temperature, conductivity and turbidity (precision, accuracy, representativeness)
- External validation of species identification for taxa with which the field crew has had limited prior experience; minimum of 10% of samples (precision, accuracy)
- Daily checks to ensure that data forms are completely filled out (completeness)

It is important to maintain consistency in data collection and handling methods throughout the effort. It is not uncommon for methods to change as new situations arise and must be incorporated into the data set. The Quality Assurance Manager is responsible for periodically inspecting the methods used and inconsistencies will be documented and if possible, corrected. Any significant changes will be made in coordination with MassDEP and EPA. If corrections are not possible, documentation will be included with the reference data for interpretation during subsequent analyses and model variable calibration. Documentation adds credence and provides defensibility to technically sound measurements (Taylor 1985).

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

Field equipment will be inspected by the UMass Field Manager each day before going out to collect field data. At the field site equipment will be tested prior to data collection to ensure that it is working properly. Equipment will be subject to regular maintenance as needed and as recommended by the manufacturer.

Table 2.2 Instrument/Equipment Calibration, Inspection, Testing and Maintenance.

Equipment	Calibration	Inspection/testing	Maintenance
Oakton Instruments pH/CON 10 pH/Conductivity/C Meter	Temperature: calibrate when probe is replaced or if meter yields erratic or inaccurate readings; pH: 3-point (4.0, 7.0, 10.0) calibration will take place at least weekly; Conductivity: A 4- point calibration spanning the entire range of detection will take place at least weekly; All calibration will be done according to manufacturer's recommendations (see attached manual, Appendix F)	Daily inspection for damage or other problems; Instrument will be tested each day to ensure that it is working properly A check standard with mid-range values will be used at the end of each field day to test for instrument drift	Conductivity probe will be replaced at the end of each season. The meter and probe will be maintained according to manufacturer's recommendations (see attached manual, Appendix F)
Garmin GPS 12 GPS Unit	NA	Units will be inspected daily for damage or other problems; units will be tested monthly using known locations	Keep batteries charged and in good condition; clean as needed
Various microscopes	NA	Daily inspection for damage or other problems	Clean, replace light source as needed
Various digital cameras	NA	Daily inspection for damage or other problems	Recharge or replace batteries as needed; clean as needed
Tungsten™ E2 Handheld Computer	NA	Daily inspection for damage or other problems Check battery charge before setting out for the field	Recharge batteries Clean as necessary
HOBO Pendant data loggers	Prior to placement according to manufacturer's recommendations (Appendix J)	Inspection for damage or other problems prior to placement	Recharge or replace batteries as needed; clean as needed
DS1921G Thermochron iButton	Prior to placement according to manufacturer's recommendations (Appendix M)	Inspection for damage or other problems prior to placement	Recharge or replace batteries as needed; clean as needed
Hanna HI 991300 Portable pH/EC/Temp Meter	All calibration will be done according to manufacturer's recommendations (see attached manual, Appendix N)	Daily inspection for damage or other problems; Instrument will be tested each day to ensure that it is working properly A check standard with mid-range values will be used at the end of each field day to test for instrument drift	Conductivity probe will be replaced at the end of each season. The meter and probe will be maintained according to manufacturer's recommendations (see attached manual, Appendix N)

2.7 Instrument/Equipment Calibration and Frequency

Sampling instruments will be calibrated on a regular basis as recommended by the manufacturer (see table 2.2).

2.8 Inspection/Acceptance of Supplies and Consumables

All laboratory and field supplies will be inspected and either accepted or rejected for use by the UMass Field Managers. See specific SOPs for a list of supplies and consumables.

2.9 Non-Direct Measurements

Peer-reviewed literature and final agency reports will be used as supporting documentation in this study. Sampling site selection will make use of MassDEP mapped wetlands data (1:12,000 based on photography from 1999 to 2000) and land cover maps compiled by UMass as part of Level 1 assessment of western Massachusetts.

2.10 Data Management

Data will be collected in the field and either entered onto field data sheets or palm-style, field computers (depending on the availability of field computers). Data sheets will be returned to the laboratory and stored for data entry at a later date. Data entry screens will be formatted to resemble the field data form and drop-down menus used to reduce data entry errors. All data will be reviewed for data entry errors and corrected. Data from field computers will be downloaded into the laboratory database within 24 hours. Any data lost due to computer malfunction will be replaced by re-sampling the same site location. The Computer Data QA Manager will regularly inspect the data to monitor for data transfer problems. The database (MS Access) will be backed-up nightly to a detached hard drive.

3.0 Assessment and Oversight.

3.1 Assessments and Response Actions.

Quality assessment techniques include internal and external audits (Sherman et al. 1991). These serve to ensure that the QC procedures are being followed and are effective in maintaining data quality. Internal checks and external audits will be used to determine whether the goals for accuracy and precision listed in Table 1.3 are being met. The UMass Project and QA Managers will be notified when internal checks indicate that these goals are not being met. The UMass Project Manager will then take immediate steps to remedy the situation and the UMass QA Manager will document any discrepancies and deviations from the QAPP. If changes to the QAPP are required the UMass QA Manager will consult with the EPA and MassDEP Project and QA Managers.

1) Internal checks - Internal checks will be incorporated into all phases of data collection and management. Equipment condition will be checked at each site prior to sampling and entries on field computer will be reviewed by the Field Manager for completeness before leaving each site.

2) External audit - External validation of species identification for taxa with which the field

crew has had limited prior experience. When such validation is warranted a minimum of 10% of samples will be checked. Results of external audits will be included in annual project reports.

Deficiencies and other non-conforming conditions will be addressed by the UMass Project Manager. Corrective actions will be verified and documented by the UMass Quality Assurance Manager.

3.2 Reports to Management

The Project Manager will include all reports of the project status on the annual report, including any problems and the proposed recommended solutions. Reports will include available preliminary or final Quality Control information as well as a discussion of any deviations from the QAPP.

4.0 Data Validation and Usability

4.1 Data Review, Verification, and Validation

The Computer Data QA Manager will analyze the data to look for outliers and anomalous data using frequency plots and statistical analyses. In the development or implementation of scoring algorithms sensitivity analyses will be used to decide whether to use particular variables and evaluate and adjust the parameter weighting schemes. A peer-review workshop of scientists experienced in wetland assessment will be held to review data and data analysis.

4.2 Verification and Validation Methods

Assessment depends on the complete and accurate transference of the field data from the data sheets and field computers to the laboratory network computers and spreadsheets (Clairain et al. 1997). With the exception of data entry and the transfer of data from field computers, only one person (the Computer Data QA Manager) will manage the data sets. Comparison of the raw data with data in the database will be conducted to confirm proper transfer of data as well as any qualification or censoring of data.

4.3 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.

Phases 2a and 2b have been successfully completed allow the project to proceed to Phase 2c. If the data collected in phase 2c allows for this project to proceed to the data collection procedures for a broader application of the SLAM or to phase3, then the project goals for phase 2c will have been met. If this is not the case, then the project team will meet to decide what additional steps, if any, will be taken to complete Phase 2c.

The final SLAM will be based on an evaluation of the usefulness and user-friendliness of field variables and methods. CAPS validation and modification will ensure credible and accurate landscape level assessments leading to more cost effective methods for assessing and evaluating wetlands statewide.

5.0 References

Cade BS, Terrell JW, and Schroeder RL. 1999. Estimating effects of limiting factors with regression quantiles. Ecology 80: 311-323.

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Appendix A

Standard Operating Procedures: Assessment of Forest Communities

(This appendix is available as file "104-QAPP-UMass-CAPS-RAM Appendix A Sept 21 2007.pdf" on final QAPP CD containing all appendices)

Appendix B

Forest Field Data Forms

(This appendix is available as file “104-QAPP-UMass-CAPS-RAM Appendix B Sept 21 2007.pdf” on final QAPP CD containing all appendices)

Appendix C

Standard Operating Procedures: Assessment of Wetland Communities

(This appendix is available as file “104-QAPP-UMass-CAPS-RAM-Appendix C Sept 21 2007.pdf” on final QAPP CD containing all appendices)

Appendix D

Wetland Field Data Forms

(This appendix is available as file “104-QAPP-UMass-CAPS-RAM Appendix D Sept 21 2007.pdf” on final QAPP CD containing all appendices)

Appendix E

Manual for the LaMotte Turbidimeter 2008

(This appendix is available as file "104-QAPP-UMass-CAPS-RAM Appendix E July 13 2007.pdf" on final QAPP CD containing all appendices)

Appendix F

Instruction Manual for the Oakton Instruments pH/CON 10 pH/Conductivity/C Meter

(This appendix is available as file "104-QAPP-UMass-CAPS-RAM Appendix F July 13 2007.pdf" on final QAPP CD containing all appendices)

Appendix G

Modifications to the Wetland SOP and Data Sheets for Field Work from September 21 through 30, 2007

(This appendix is available as file “104-QAPP-UMass-CAPS-RAM Appendix G Sept 21 2007.pdf” on final QAPP CD containing all appendices)

Appendix H

Standard Operating Procedures: Assessment of Forested Wetland Communities

(This appendix is available as file “104-QAPP-UMass-CAPS-Updated Appendix-H-December 30 2009.doc” on final QAPP CD containing all appendices)

Appendix I

Forested Wetland Field Data Forms

(This appendix is available as file "104-QAPP-UMass-CAPS-Appendix-I-May 2, 2008.pdf" on final QAPP CD containing all appendices)

Appendix J

Instruction Manual for the HOBO Pendant Temperature/Light Data Logger

(This appendix is available as file “104-QAPP-UMass-CAPS-Appendix-I-May 2, 2008.pdf” on final QAPP CD containing all appendices)

Appendix L

Forested Wetland Field Data Forms: 2009

(This appendix is available as file “104-QAPP-UMass-CAPS-Appendix L-Oct 5 2009.pdf” on final QAPP CD containing all appendices)

Appendix M

Instruction Manual for the DS1921G Thermochron iButton

(This appendix is available as file "104-QAPP-UMass-CAPS-Appendix M-May 7 2009.pdf" on final QAPP CD containing all appendices)

Appendix N

Instruction Manual for the Hanna HI 991300 Portable pH/EC/TDS/Temperature Meter

(This appendix is available as file "104-QAPP-UMass-CAPS-Appendix N-May 7 2009.pdf" on final QAPP CD containing all appendices)

Appendix O

Instruction Manual for the Tungsten™ E2 Handheld Computer

(This appendix is available as file “104-QAPP-UMass-CAPS-Appendix O-May 7 2009.pdf” on final QAPP CD containing all appendices)

Appendix P

Assessment of Wetland Communities: Macroinvertebrate Analysis

(This appendix is available as file "104-QAPP-UMass-CAPS-Appendix-P-May 19 2009.doc" on final QAPP CD containing all appendices)

Appendix Q

Standard Operating Procedures: Mapping Anthropogenic Ditches in Salt Marshes of Massachusetts

(This appendix is available as file “104-QAPP-UMass-CAPS-Appendix-Q-June 15 2009.doc” on final QAPP CD containing all appendices)

Appendix R

Standard Operating Procedures: Using Aerial Photo Interpretation for Identifying and Characterizing Tidal Restrictions Affecting Salt Marsh

(This appendix is available as file “104-QAPP-UMass-CAPS-Appendix-R-December 30 2009.doc” on final QAPP CD containing all appendices)

Appendix S

Assessment of Wetland Communities: Ground-Dwelling Bryophyte Identification

(This appendix is available as file “104-QAPP-UMass-CAPS-Appendix S-December 30 2009.doc” on final QAPP CD containing all appendices)

Appendix T

Standard Operating Procedures: Photo Interpretation of Coastal Structures

(This appendix is available as file “104-QAPP-UMass-CAPS-Appendix T-February 8 2010.doc” on final QAPP CD containing all appendices)